PAPER-1 COLOR C0DE : PINK

24th NATIONAL CERTIFICATION EXAMINATION
FOR
ENERGY MANAGERS & ENERGY AUDITORS - SEPTEMBER, 2024
PAPER - 1 : GENERAL ASPECTS OF ENERGY MANAGEMENT & ENERGY AUDIT

Date : 28.09.2024 Timings : 09:30-12:30 HRS Duration : 3 HRS Max. Marks : 150

Section – I: OBJECTIVE TYPE **Marks: 50 x 1 = 50**

1. **Which entity is responsible for implementing the Energy Conservation Act 2001?**
   a) Ministry of Renewable Energy
   b) **Bureau of Energy Efficiency (BEE)**
   c) Central Pollution Control Board
   d) National Productivity Council

2. **Which of the following is a measure included in the Energy Conservation Act 2001?**
   a) Energy audits
   b) Energy-saving certificates
   c) Standards and labelling
   d) **All of the above**

3. **Calculate the energy consumed by a 200-watt appliance used for 5 hours a day over 30 days.**
   a) 30 kWh
   b) 27000 kCal
   c) 6500 kJ
   d) 30 kJ/h

4. **Which of the following is a non-renewable energy source?**
   a) Solar
   b) Wind
   c) Biomass
   d) **Coal**

5. **How is energy efficiency typically improved in industrial processes?**
   a) Reducing production rates
   b) **Optimizing equipment performance**
   c) Increasing labour
   d) None of the above

6. **Which of the following is a typical step in an energy audit?**
   a) Data collection
   b) Analysis
   c) Reporting
   d) **All of the above**

7. **Which tool is commonly used for measuring power factor ?**
   a) Thermometer
   b) Hygrometer
   c) Anemometer
   d) None of the above

8. **What is the payback period in energy management?**
   a) Time taken to identify savings
   b) Time taken to report savings
   c) **Time taken to recover the investment through savings**
   d) All of the above

9. **Which of the following is a method for financing energy efficiency projects?**
   a) Loans
   b) Leasing
   c) Performance contracting
   d) **All of the above**

10. **What is the primary financial metric used to evaluate energy projects?**
    a) Gross margin
    b) **Net present value (NPV)**
    c) Revenue
    d) Operating income

11. **Which principle is energy monitoring and targeting based on?**
    a) Energy consumption is constant
    b) **You can't manage what you don't measure**
    c) Energy consumption is unpredictable
    d) Production rate has no effect

12. **Calculate the reduction in CO_2 emissions if energy efficiency measures save 1000 kWh, assuming 0.8 kg CO_2/kWh.**
    a) 800 kg
    b) 1250 kg
    c) 625 kg
    d) 1000 kg

13. Which of the following is not true, equivalent to 1 atm pressure?

    a) 1 atm = 101.3 kPa
    b) 1 atm = 10332 mmWC
    c) 1 atm = 14.7 psi
    d) 1 atm = 0.98 kg/cm2

14. Redwood Seconds is measure of _____

    a) Density
    b) Viscosity
    c) Specific Gravity
    d) Flash Point

15. For calculating plant energy performance which of the following data is not required
    a) Current year production
    b) Capacity Utilization
    c) Reference year production
    d) Reference year Energy use

16. The internal rate of return is discount rate for which NPV is
    a) Positive
    b) Zero
    c) Negative
    d) All of the above

17. Transit time method is used in which of the instrument
    a) Lux Meter
    b) Ultrasonic Flow Meter
    c) Pitot Tube
    d) Fyrite

18. Which of the following GHG has the longest atmospheric life time
    a) Carbon dioxide (CO2)
    b) Sulphur Hexafluoride (SF6)
    c) Chloroflurocarbons (CFC)
    d) Perfluorocarbons (PFC)

19. What is the heat content of 500 liters of water at 6°C in terms of the basic unit of energy in kilojoules?
    a) 12000
    b) 3000
    c) 500
    d) None of the above

20. The number of moles of water contained in 72 grams of water is
    a) 2
    b) 3
    c) 4
    d) 5

21. Which of the following is not objective of Demand Side Management?
    a) Managing Demand by DISCOM to reduce peak demand
    b) Increasing Load of Generator to meet Peak demand
    c) Reducing Capital need for Power Capacity Expansion
    d) None of the above

22. Which of the following has the lowest energy content in terms of MJ/kg
    a) LPG
    b) Diesel
    c) Bagasse

d) Furnace Oil

23. Heat transfer in an air-cooled condenser occur predominately by
    a) Conduction
    b) Convection
    c) Radiation
    d) All of the above

24. The force field analysis in energy action planning considers
    a) Positive forces only
    b) Negative Forces only
    c) No forces
    d) Both Positive and Negative forces

25. To arrive at the relative humidity at a point we need to know _____ of air
    a) DBT
    b) WBT
    c) Dew point
    d) Both A and B

26. Which statement is false regarding Critical path
    a) CP is longest duration path
    b) It identifies minimum time to Complete the project
    c) Activities lies on it cannot be delay
    d) It is maximum time required to complete the project

27. The roto axis is aligned with wind direction in windmill by _____control?
    a) Yaw
    b) Pitch
    c) Disc Break
    d) Both A and B

28. For activity in project, Latest start time is 8 weeks and Latest Finish time is 12 Weeks. If the earliest finish time is 9 Weeks, Slack time for the activity is
    a) 1 Week
    b) 3 Weeks
    c) 4 Weeks
    d) 7 Weeks

29. Which techniques takes care of time value of money in evaluation
    a) Payback Period
    b) IRR
    c) NPV
    d) Both B and C

30. If asset depreciation is considered, then the net operating cash inflow will be
    a) Lower

b) Higher
c) No effect
d) None of the above

31. One Silicon cell in PV modules typically produces
a) 0.5 V
b) 1.0 V
c) 1.5 V
d) 2.0 V

32. When the evaporation of water from wet substance is zero, the relative humidity of air is likely to be
a) 0%
b) 50%
c) 100%
d) Unpredictable

33. The energy conversion efficiency of solar cell does not depend on
a) Solar Energy Insolation
b) Inverter
c) Area of the Solar Cell
d) Maximum Power Output

34. Energy Intensity is ratio of
a) Fuel Consumption/GDP
b) GDP/Fuel Consumption
c) GDP/Energy Consumption
d) Energy Consumption/GDP

35. In inductive and resistive combination circuit, the resultant power factor under AC supply will be
a) Less than Unity
b) More than Unity
c) Zero
d) Unity

36. If wind speed triples, the energy output from wind turbine will be
a) 3 Times
b) 6 Times
c) 9 Times
d) None of the above

37. If we heat air without changing absolute humidity, % relative humidity will
a) Increase
b) Decrease
c) No change
d) Can't Say

38. Among which of the following fuel the difference between the GCV and NCV is maximum
    a) Coal
    b) Furnace Oil
    c) Natural Gas
    d) Rice Husk

39. Which among the following factors is most appropriate for adopting EnMS?
    a) To improve their energy efficiency
    b) To reduce cost
    c) To increase productivity
    d) Systematically manage their energy use

40. The Ozone layer in stratosphere act as an efficient filter for
    a) UV-B Rays
    b) UV-C Rays
    c) X- Ray
    d) Gamma Rays

41. An induction motor with 30 kW rating and efficiency of 85% in its name plate means
    a) It will draw 35.29 kW at full load
    b) it will always draw 30 kWat full load
    c) it will draw 25.5 kW at full load
    d) it will draw 28.23 kW at full load

42. Which of the following macro factors is used in the sensitivity analysis of project finance
    a) Change in Tax rate
    b) Change in O & M Cost
    c) Change in Debt : equity Ratio
    d) Change in forms of Financing

43. An indication of Sensible heat content in air-water vapour mixture is
    a) Wet bulb temperature
    b) Dry bulb temperature
    c) dew point temperature
    d) density of air

44. Energy content in 2500 kgs of coal with a calorific value of 4000 kcal/ kg in terms of toe would be
    a) 1 toe
    b) 10 toe
    c) 100 toe
    d) 1000 toe

45. Reserve per production (R/P) is estimated as
    a) Reserves remaining at end of year X production in the year
    b) Reserves remaining at end of year / production in the year
    c) production in year / Reserves remaining at end of the year

d) None of the above

46. In a fuel cell, ___ combines with ____ to generate electricity and ____ comes out as a by-product.
    a) Hydrogen, Oxygen, water
    b) Hydrogen, Nitrogen, nitrous oxide
    c) Carbon, hydrogen, methane
    d) Carbon, oxygen, carbon dioxide

47. A manufacturing plant consumes 5 tonnes of coal (CV = 4000 kCal/ kg) to produce 25 tonnes of cement. The Specific Energy Consumption (SEC) of the plant shall be
    a) 100 kcal/ kg of cement
    b) 200 kcal/ kg of cement
    c) 400 kcal/ kg of cement
    d) 800 kcal/ kg of cement

48. A solution of common salt in water is prepared by adding 25 kg of salt to 100 kg of water. The concentration of salt in this solution as a weight fraction shall be
    a) 10%
    b) 15%
    c) 20%
    d) 25%

49. An electric iron of power 2000 watts is used for a total of 120 minutes per month. Compute its monthly electricity consumption
    a) 2.0 kWh
    b) 2.4 kWh
    c) 4.0 kWh
    d) 24.0 kWh

50. The dryness fraction (x) of superheated steam will be
    a) x = 0.8
    b) x = 0.9
    c) x = 1
    d) x = 0

..... End of Section I .....

Section – II: SHORT DESCRIPTIVE QUESTIONS **Marks: 8 x 5 = 40**

(i) Answer all **Eight** questions
(ii) Each question carries **Five** marks

S1	a) Lower energy intensity of a country need not necessarily mean higher energy efficiency. Explain? b) Why is energy intensity expressed taking into account purchase power parity?

	Solution: **a) Page No 17** **b) Page No 18**
S2	a) Differentiate between commercial and non-commercial energy with an example for each. b) Differentiate between renewable and non-renewable energy with an example for each. **Solution:** **a) Page No 2** **b) Page No 3**
S3	a) Write down the parameters, which can be measured by the following instruments. • Stroboscope • Sling Psychrometer • Fyrite • Pitot Tube b) An electric resistive heater consumes 3.6 MJ when connected to a 200 V supply for one hour. Find the rating of the heater and the current drawn from the supply. **Solution:** a) Stroboscope – Non Contact Speed measurement Sling Psychrometer – Dry and wet bulb temperature Fyrite – To measure O2 and CO2 Pitot Tube – To measure pressure in gas ducts **b)** Energy=power x time Power=Energy / time = 3.6×10^6 J/(60 x 60) = 1kW Current = Power / Voltage = 1000 W/200V = 5 Ampere
S4	A 10 HP rated induction motor, with nameplate details indicating 415V, 12 amps, and a power factor (PF) of 0.9, is being audited. During the audit, the monitoring equipment displays a reactive power of 2 kVAr and a power factor of 0.758. Calculate the percentage loading of the motor at the time of the test. **Solution:** $PF = kW/KVA$ (1) $(KVA)^2 = (kVAr)^2 + (kW)^2$ (2) Given kVAr = 2 and PF=0.758 Solve for kW in eqn (2) using eqn (1) we get, kW measured = 2.32kW

	Motor rated input kW= 1.732VIcos ₵ = 1.732*0.415*12*0.9=7.76 kW Percentage loading of motor= kW measured /rated input kW * 100 = 2.32/7.76 * 100 =**29.88%**
S5	A renovation and modernization (R&M) program of a 1 MW coal-fired thermal power plant was carried out to enhance the operating efficiency from 28% to 32%. The specific coal consumption was 0.7 kg/kWh before R&M. For 7000 hours of operation per year and assuming coal quality remains the same, calculate a) The coal saving per year in tonnes b) The expected avoidance of CO2 into the atmosphere in Tons/year if the emission factor is 1.3 kg CO2/kg coal. **Solution:** a) Coal consumption per kWh with 32 % efficiency = 28 x 0.7 / 32 = 0.61 kg/kWh Saving in coal = (7000 x 1000 x (0.7 – 0.61) = 630000 kg b) Expected Avoidance = 63000 x 1.3 = 819 Tons/year
S6	A drilling machine drawing continuously 5 kW of input power and with an efficiency of 50%, is used in drilling a bore in an aluminum block of 5 kg of mass. A portion of energy imparted to the block is lost to surroundings and the balance is absorbed by the block in its uniform heating. A 45 °C rise in temperature of the block was observed at the end of 100 seconds and the specific heat of aluminum block is 900 J/kgK. What percentage of drilling machine output power is lost to the surroundings? **Solution:** Power input to the drilling machine = 5kW Power output of drilling machine = 5 x 0.5 = 2.5 kW Energy used in drilling of bore, Q = 2.5x1000x100 = 250000 J Effective energy absorbed by block,Q' = m x c p x (temp rise)= 5*900*45 = 202500J Percentage of energy utilized for heating = 202500/250000= 81% Percentage of energy lost to surroundings = 100-81= **19%**
S7	Calculate the investment of the project having IRR of 16% and having respective annual savings of Rs 15,000, Rs. 18,000 and Rs. 20,000 at the end of the first, second and third year.

	Solution: NPV = (15000/1.16)+18000/(1.16x1.16)+(20000/(1.16x1.16x1.16)) = 12931 + 13377 + 12813 = 39,121/-
S8	In a heat exchanger steam is used to heat 5 kL/ hour of furnace oil from 30^0C to 90^o C. Specific heat of furnace oil is 0.22 kcal/ kg/^{O}C and the specific gravity of furnace oil is 0.95. a) How much steam per hour is required, if steam used is having latent heat of 510 kcal/kg? b) If steam cost is Rs.3.40/kg and electrical energy cost is Rs.6/kWh, which type of heating would be more economical in this particular case? **Solution:** a) Total heat required = m Cp ΔT = (5 x1000x 0.95) * 0.22 * (90-30) = 62,700 kcal/hr Latent heat of steam = 510 kcal/kg Amount of steam required = 62700/510 = **123 kg/hr** b) Steam cost = 123 x Rs.3.40 = Rs.**417.9/hr** Amount of electricity required = 62700/860 = 72.9 kWh Cost of electricity = 72.9 x Rs. 6 = Rs.**437.4/ hr** **Steam heating will be more economical**

..... End of Section II .....

Section – III: LONG DESCRIPTIVE QUESTIONS Marks: 6 x 10 = 60

(i) Answer all Six questions
(ii) Each question carries Ten marks

L1	a) A cement plant is planning for ISO 50001 certification. Write a goal, objective and target for meeting the requirements of energy management system (b) For an energy efficiency project, define (i) net operating cash inflows (ii) Economic life (iii) Salvage value c) Compare between NPV and IRR **Solution:** a) Book 1, Page 157 b) Book 1, Page 173

	c) Book 1, Page 172
L2	a) You are part of the team responsible for evaluating the total energy consumption of a manufacturing plant. This plant operates around the clock and has substantial heating and cooling needs due to its production processes. It sources energy from electricity purchased from the grid, furnace oil for thermic fluid heaters, coal for steam boilers, High-Speed Diesel for diesel generators, and Liquefied Petroleum Gas for ovens. To determine if the plant qualifies as a designated consumer under EC Act, list down the data required for assessing the MTOe. (5 Marks) b) An energy manager in a factory has gathered following data to arrive at the plant energy performance. Reference year (2022) energy use was 20 million kcal and production factor (PF) for the current year (2023) is 0.9. While the current year's energy use is 19 million kcal. What is the plant energy performance of the factory for the year 2023? State the inference. (5 marks) **Solution:** a)

Energy Source	Description	Unit of Measurement
Electricity	Purchased from grid	kWh
Furnace Oil	Used for thermic fluid heater	Liters
Coal	Used for steam boiler	Metric tons
HSD (High-Speed Diesel)	Used for diesel generators	Liters
LPG (Liquefied Petroleum Gas)	Used for ovens	Kilograms

b)

Given:

Reference year energy use (2022) = 20 million kcal

Production factor (PF) for the current year (2023) = 0.9

Reference year energy equivalent = Reference year energy use × Production factor

=20 million kcal X 0.9

=18 million kcal

To calculate the plant energy performance for the year 2023:

$$\text{Plant Energy Performance} = \frac{\text{Reference Year Equivalent} - \text{Current Years Energy use}}{\text{Reference Year Equivalent}} \times 100$$

$$= \frac{18-19}{18} \times 100 = -5.56\%$$

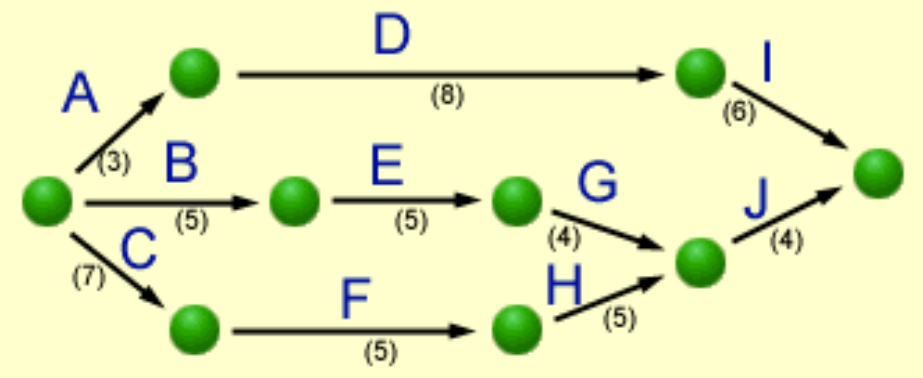
Inference:

	The plant energy performance has decreased by 5.56% in 2023 compared to the reference year energy use in 2022. This indicates that the factory's energy efficiency has worsened, as it consumed 5.56% more energy than expected based on the production factor.
L3	a) Draw PERT chart for the following task, dependency and duration. b) Find the critical path c) Calculate expected project duration

Task	Predecessors Tasks (Dependencies)	Expected Time as Calculated (Weeks)
A	-	3
B	-	5
C	-	7
D	A	8
E	B	5
F	C	5
G	E	4
H	F	5
I	D	6
J	G - H	4

Solution:

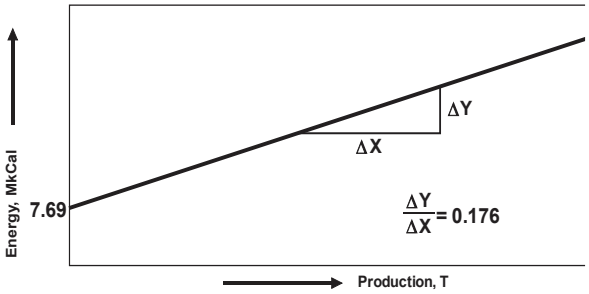
a)



b) The critical path is through activities C, F, H, J

c) The expected project duration is 21 weeks (7+5+5+4)

L4	An evaporator is to be fed with 5000 kg/hr of a solution having 0.5 % solids. The feed is at 38°C, and is to be concentrated to 1% solids. Steam is entering at a total enthalpy of 640 kcal/kg and the condensate leaves at 100 °C. Enthalpies of feed are 38.1 kCal/kg, product solution is 100.8 kCal/kg and that of the vapour is 640 kCal/kg. Find the mass of vapour formed per hour and the mass of steam used per hour. **Solution:** **Mass of vapour** Feed= 5000 kg/hr @ 0.5 solids

	Solids = 5000 x 0.5/100 = 25 kg/hr $Mass_{out}$ x 1/100 = 25 $Mass_{out}$ = 2500 kg/hr Vapour formed = 5000-2500 = 2500 kg/hr Thick liquor = 2500 kg/hr **Steam Consumption** Enthalpy of Feed = 5000 x 38.1 = 190500 kcal Enthalpy of the thick liquor = 100.8 x 2500 = 252000 kcal Enthalpy of vapour = 640 x 2500 = 16,00,000 kcal **Heat Balance** Heat input by steam + Heat in Feed = Heat out in vapour + Heat out in thick liquor [M x (640-100) + 38.1 x 5000] = 1600000 + 252000) M x 540 = 1661500 M= 3076.8 kg/hr
L5	Using the details given below, construct the CUSUM table and calculate the annual savings in MTOE, considering 10,000 kcal/kg of fuel.  Solution:

Month	Electrical Power in kWh	Production (T)
Apr	90981	493
May	94993	335
Jun	88010	297
Jul	85374	493
Aug	88741	381
Sep	88450	479
Oct	90780	585
Nov	82216	440
Dec	90612	318
Jan	85672	234
Feb	74939	239
Mar	83823	239

Month	Electrical Power in kwhr	Total Energy in mkcal (y) Eact	Production (x)	Ecal (0.176 X +7.69=Y) in mkcal-Base Line	Eact-Ecal in mkcal	Cusum in mkcal
Apr	90981	78.24	493	94	-16	-16
May	94993	81.69	335	67	15	-1
Jun	88010	75.69	297	60	16	15
Jul	85374	73.42	493	94	-21	-6
Aug	88741	76.32	381	75	2	-5
Sep	88450	76.07	479	92	-16	-21
Oct	90780	78.07	585	111	-33	-53
Nov	82216	70.71	440	85	-14	-68
Dec	90612	77.93	318	64	14	-54
Jan	85672	73.68	234	49	25	-29
Feb	74939	64.45	239	50	15	-14
Mar	83823	72.09	239	50	22	8

Savings in MTOe = 8 x 10^6 / 10^7
= 0.8 MTOe

L6 You are evaluating a multi-phase investment project with the following cash flows in over a 5-year period. The project includes an initial investment of Rs.20 Lakhs, an additional investment of Rs.5 Lakhs in Year 3, and a salvage value of Rs.3 Lakhs at the end of Year 5. The yearly savings are given below:

Year	Cash Flow (Rs. Lakhs)
1	6
2	7
3	4
4	9
5	12

Calculate the Internal Rate of Return (IRR) for the project.

Solution:

The cash flows for each year are as follows:

Year	Cash Flow (Rs. Lakhs)
0	-20
1	6
2	7
3	-1 (4-5)
4	9
5	15 (12+3)

The IRR is the discount rate that makes the Net Present Value (NPV) of these cash flows equal to zero.

$$NPV = -20 + \frac{6}{(1+r)^1} + \frac{7}{(1+r)^2} + \frac{-1}{(1+r)^3} + \frac{9}{(1+r)^4} + \frac{15}{(1+r)^5} = 0$$

Let's start with, say r=15% or 0.15.

$$\begin{aligned} NPV &= -20 + \frac{6}{(1+0.15)^1} + \frac{7}{(1+0.15)^2} + \frac{-1}{(1+0.15)^3} + \frac{9}{(1+0.15)^4} + \frac{15}{(1+0.15)^5} \\ &= -20 + \frac{6}{1.15} + \frac{7}{1.3225} + \frac{-1}{1.520875} + \frac{9}{1.74900625} + \frac{15}{2.0113571875} \\ &= -20 + 5.217 + 5.293 + (-0.657) + 5.146 + 7.457 \\ &= -20 + 22.456 = 2.456 \end{aligned}$$

Since the NPV is positive, we need a higher rate. Let's try $r = 20\%$ or 0.20.

$$\begin{aligned} NPV &= -20 + \frac{6}{(1+0.20)^1} + \frac{7}{(1+0.20)^2} + \frac{-1}{(1+0.20)^3} + \frac{9}{(1+0.20)^4} + \frac{15}{(1+0.20)^5} \\ &= -20 + \frac{6}{1.20} + \frac{7}{1.44} + \frac{-1}{1.728} + \frac{9}{2.0736} + \frac{15}{2.48832} \\ &= -20 + 5 + 4.861 + (-0.578) + 4.339 + 6.027 \\ &= -20 + 19.649 = -0.351 \end{aligned}$$

Since the NPV is negative, we need a slightly lower rate. Let's try $r = 19\%$ or 0.19.

$$NPV = -20 + \frac{6}{(1+0.19)^1} + \frac{7}{(1+0.19)^2} + \frac{-1}{(1+0.19)^3} + \frac{9}{(1+0.19)^4} + \frac{15}{(1+0.19)^5}$$
$$= -20 + \frac{6}{1.19} + \frac{7}{1.4161} + \frac{-1}{1.684319} + \frac{9}{2.0043401} + \frac{15}{2.384163719}$$
$$= -20 + 5.042 + 4.942 + (-0.594) + 4.490 + 6.292$$
$$= -20 + 20.172 = 0.172$$

Since the NPV is positive, we need a slightly hi[illegible]er rate. Let's try $r = 19.2\%$ or 0.192.

$$NPV = -20 + \frac{6}{(1+0.192)^1} + \frac{7}{(1+0.192)^2} + \frac{-1}{(1+0.192)^3} + \frac{9}{(1+0.192)^4} + \frac{15}{(1+0.1}$$
$$= -20 + \frac{6}{1.192} + \frac{7}{1.421664} + \frac{-1}{1.693737088} + \frac{9}{2.01797351296} + \frac{15}{2.40449389128}$$
$$= -20 + 5.035 + 4.924 + (-0.591) + 4.458 + 6.239$$
$$= -20 + 20.065 = 0.065$$

Since the NPV is positive but close to zero, we continue refining our guess slightly higher until we zero in on the IRR. With iterative refinement, we would zero in on an IRR of approximately 19.32%.

By interpolation Method

NPV at 20% = -0.351

NPV at 19% = 0.172

IRR = Lower rate + $\frac{\text{NPV at lower rate x (Higher rate-lower rate)}}{\text{(NPV at lower rate – NPV at higher rate)}}$

IRR = 19 + $\frac{0.172 \text{ x } (20\text{-}19)}{(0.172 - (-0.351)}$

IRR = 19 + $\frac{0.172}{0.523}$

IRR = 19 + 0.32 = 19.32%

Paper 1 Code: Pink

23rd NATIONAL CERTIFICATION EXAMINATION
FOR
ENERGY MANAGERS & ENERGY AUDITORS -MARCH, 2023

PAPER - 1 : GENERAL ASPECTS OF ENERGY MANAGEMENT & ENERGY AUDIT

Date : 25.03.2023 Timings : 09:30-12:30 HRS Duration : 3 HRS Max. Marks : 150

General instructions :

- *Please check that this question paper contains **8** printed pages*
- *Please check that this question paper contains **64** questions*
- *The question paper is divided into three sections*
- *All questions in all three sections are compulsory*
- *All parts of a question should be answered at one place*

Section – I: OBJECTIVE TYPE **Marks: 50 x 1 = 50**

(i) Answer all **50** questions
(ii) Each question carries **one** mark
(iii) Please hatch the appropriate oval in the OMR answer sheet with **HB pencil only,** as per instructions

1.	Which of the following is a primary energy source? A) **Coal** B) Electricity C) Producer gas D) Steam
2.	Which among the following is considered as renewable source of energy? **A) Tidal** B) Coal C) Nuclear D) Natural Gas
3.	The nodal agency for implementing Energy Conservation Act in India is _____. A) Bureau of Electrical Efficiency B) National Productivity Council C) Central Electricity Authority D) **Bureau of Energy Efficiency**
4.	1 mole of sulphur react with X moles of H_2SO_4 to form Y moles of H_2O and Z moles of SO_2 then (X/Y) + Z is _____. A) 2 B) **4** C) 1 D) 3
5.	Under the Standard's and Labeling (S&L) Scheme of the BEE, A) Building codes are prescribed for commercial buildings B) Industries are required to meet specific energy targets **C) Energy Star labels are affixed on appliances** D) LED Lamps are distributed
6.	The objective of energy management includes _____. A) Minimizing energy costs B) Minimizing waste

	C) Minimizing environmental degradation D) **All of the above**
7.	The name plate kW or HP of a motor indicates _____. A) Input power drawn **B) Output power** C) Max input power D) Minimum input power
8.	Which of the following gas has high Global warming potential? A) Carbon dioxide B) Ozone C) Methane D) **Nitrous oxide**
9.	Which of the following industry/sector is not notified as a designated consumer as per EC Act-2001? A) Pulp & Paper B) **Automobile** C) Chlor-Alkali D) Fertilizer
10.	A gaseous mixture contains 7.50 gms of H_2 and 3.25 gms of O_2 and 5.55gms of N_2 the Mole fraction of N_2 is _____. A) 0.34 B) 0.03 C) 0.0294 D**) 0.049**
11.	If the NPV of an investment is Rs.10000 when calculated at a discount rate of 10%. What is the future value of the investment for a period of 2 years. A) **12100** B) 12000 C) 12110 D)12101
12.	What is the expected time, when the optimistic time, most likely time and pessimistic time are 10, 20 and 30 respectively. A) 10 **B) 20** C) 22 D) 21
13.	A 230V, 100 W rated Incandescent bulb is operated at a constant voltage of 200V. The powerconsumption of the bulb is _____. A) 80W **B) 76W** C) 87W D) 100W
14.	The input current drawn by 3-ph 10 kW induction motor is 20 Amps at 0. 8 pf. The input voltageis 410V.The motor efficiency is _____. A) 86% B)90% **C) 88%** D) None of the above
15.	ROI should be always_____than borrowing interest rate for economic feasibility of any project. A) Lower B) Equal C) No relation **D) Higher**
16.	If 3500 kJ of heat is supplied to 22 kgs of ice at 0^oC, how many kg of ice will melt into water at 0^oC (latent heat of melting is 330 kJ/kg). A) **10. 606 Kg** B) 12 Kg C) 22 Kg D) 15 Kg
17.	A dry feed contains 7% moisture was feed to a water spray chamber to increase the moisture content to 35% in the dry feed. The output feed quantity coming from the spray chamber is _____. A) 0.5 kg/kg of input feed **B) 1.43 kg /kg of input feed** C) 1.48 kg/kg of input feed D) 2.66 kg/kg of input feed

18.	Which among the following fuels has the highest calorific value? A) Coal B) Diesel C) **Hydrogen** D) Natural Gas
19.	In an industry the electricity consumed for a period is 1,10,000 kWh. The production in the period is 12,000 tons with a variable energy consumption of 6 kWh/Ton. The fixed kWh of the plant is _____. A) 35000 **B) 38000** C) 32000 D) 36000
20.	Large scattering on production versus energy consumption trend line indicates _____. A) Poor process monitoring B) Good level of control **C) Poor level of control** D) None of the above
21.	Which of the following is true with respect to IRR? A) If IRR is high than the current interest rate, the investment is not attractive B) If between two projects the project with low IRR would be more attractive **C) IRR is the discount rate at which the NPV is zero** D) All of the above
22.	ESCerts cannot be _____. A) Bought B) Sold C) Banked for next cycle D) **Traded directly between DC's**
23.	Which of the following is the duty of an Energy Manager? A) Establish energy conservation cell B) Analyze equipment performance C) Develop and manage training programmes on energy efficiency **D) All of the above**
24.	Law of conservation of mass can be expressed by the following equation: A) Products = Raw Materials + Waste Products + Stored Products + Losses B) Products = Raw Materials + Waste Products + Stored Products – Losses C) Raw Material = Products + Waste Products + Stored Products - Losses **D) Raw Materials = Products + Waste Products + Stored Products + Losses**
25.	Formula for computing energy savings as part of Measurement & Verification is _____. A) Energy Savings = Base year energy use + post-retrofit energy use +/ - Adjustments **B) Energy Savings = Base year energy use - post-retrofit energy use +/ - Adjustments** C) Energy Savings = post-retrofit energy use – base year energy use +/ - Adjustments D) None of the above
26.	The vacuum recorded in a steam power plant is 720 mmHg and the atmospheric pressure is 760 mmHg. The absolute pressure in kg/cm^2 is _____. A) 0.526 **B) 0.053** C) 5.26 D) None of the above

27.	The amount of electricity in kWh used to heat 150 liters of water from 20 ºC to 60 ºC through resistance heating is _____. A) 0.698 kWh B) 698 kWh **C) 6.98 kWh** D) 69.8 kWh
28.	PERT/CPM provides which of the following: A) Predicts the time required to complete the project B) Shows activities which are critical for completing the project as per the schedule C) Graphical view of the project **D) All of the above**
29.	Which of the following is not a common normalizing factor for industrial facilities? A) Input B) Output C) Product type **D) Maintenance cost**
30.	Which of the following is correct? A) Gantt chart is commonly used for scheduling the tasks and tracking the progress. B) Gantt charts are developed using bars. C) The length of the Gantt chart shows how long the task is expected to be completed. **D) All of the above**
31.	The efficiency (%) for a thermodynamic process with E(input)= 100 units and Loss=55 units will be _____. A) 10% B) **45**% C) 55 % D) Data Insufficient
32.	In _____, hot water from a geo-thermal well flows to a heat exchanger where the hot water is used to heat a working fluid with low boiling temperature. A) Flash steam power **B) Binary cycle power plant** C) Dry steam power plants D) None of the above
33.	Upon doubling the length of a wind turbine blade, its power generation: A) No Change in power generation B) Gets increased by two times C) **Gets increased by four times** D) Gets increased by Eight times
34.	The dryness (x) fraction of dry saturated steam is _____. A) x = 0.87 B) x = 0.9 C) **x = 1** D) x = 0
35.	Speed of wind at which a wind turbine shuts down automatically so as to avoid damage is known as _____. A) Betz Constant B) Cut-in wind speed C) **Cut-off wind speed** D) Rated wind speed

36.	Power derived from the flowing water is _____. A) Directly proportional to flow rate & inversely proportional to its head **B) Directly proportional to both its flow rate as well as its head** C) Inversely proportional to flow rate & directly proportional to its head D) Inversely proportional to both its flow rate as well as its head
37.	For a Proton-exchange membrane fuel cell, choose the correct match: A) Anode- Methanol; Cathode – Oxygen B) **Anode- Hydrogen; Cathode – Oxygen** C) Anode- Synthetic Gas; Cathode – Oxygen D) None of the above
38.	Ten units of electricity are equivalent to _____. A) 10 ToE B) 10 kCal C) 10 KJ D) **8600 kCal**
39.	Factors influencing energy consumption in any organization include _____. A) Operational Hours B) Units of Production C) Usage Behavior D) **All of the above**
40.	When the evaporation of water from a wet substance is zero, the relative humidity of air is likely to be _____. A) 0% B) 10% C) 50% D) **100%**
41.	Monocrystalline and polycrystalline are types of _____. A) Geothermal heat pumps B) Electrical vehicle battery cell C) **Solar PV panels** D) None of above
42.	Which of the following statements are true for renewable energy? I) Methane gas produced in landfill sites, escapes into air and is a source of greenhouse gas emission. II) Magma is a solid core in earth layer and is used to produce hot water. III) Energy production from ocean waves is steady and predictable compared to wind and solar energy. IV) Wattage output of wind turbine is rated in terms of peak Watt (W_p). **A) I & IV** B) II & IV C) III & IV D) I &III
43.	Which among the following statement is correct about wind energy? A) We can convert 100% of wind energy to electricity B) Wind turbine extracts energy by increasing wind speed **C) Theoretically wind turbine can convert 59% of wind energy to electricity.** D) If wind speed doubles power output of wind turbine increases by 100%
44.	Select the incorrect statement related to energy basics _____. A) Superheating is a process of heating vapor above evaporation temperature. **B) Pump is used to move the fluid in process of natural convection.** C) Calorific value is a measure of energy content of organic matter of fuel. D) Internal resistance of a fluid is measured as viscosity of a fluid.

45.	"Paper industry in Ghaziabad got its boiler audited and report generated", This statement refers to _____. A) Preliminary energy audit B) Detailed energy audit C) **Targeted energy audit** C) None of the above
46.	Select the wrong statement for financial analysis _____. A) Simple Payback is a measure of how long it will be before the investment makes money B) Return on Investment (ROI) and Internal Rate of Return (IRR) enable comparison with other investment options C) Net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over a period of time **D) Depreciation and payback are two deciding factors about the time value of money.**
47.	Why radiation heat transfer is prominent in applications like boiler and furnace? A) It does not require medium B) Heat transfer is proportional to T^4 C) It uses electromagnetic waves to transfer heat **D) All of above**
48.	Temperature of steam will be highest in following condition at same pressure _____. A) Wet steam B) Saturated steam C) **Superheated steam** D) At all stages temperature is same
49.	The Specific heat is high for _____. A) Lead B) **Water** C) Mercury D) Alcohol
50.	Which of the following is used for Bio-Diesel production? **A) Jatropha** B) Light Diesel Oil C) High Speed Diesel D) Shale Oil

..... End of Section I .....

Section – II: SHORT DESCRIPTIVE QUESTIONS **Marks: 8 x 5 = 40**

(i) Answer all **Eight** questions
(ii) Each question carries **Five** marks

S-1.	In a paper industry the daily (24 hours) energy consumption is taken for analysis. The daily energy consumption is 50,000 kWh, out of which 20,000 kWh is from its captive generation using a back pressure steam turbine and the rest is being purchased from grid. The paper industry uses 100 tons of imported coal for captive

	cogeneration system and 2 kl of HSD for material handling. **(5 Marks)** (Consider GCV of imported coal as 6900 Kcal/Kg; HSD: 49574.08 KJ/Kg; Density of HSD is 0.8263 kg/liter) a) Calculate the percentage share of energy sources used based on consumption on daily basis in MTOE. b) Calculate the energy consumption in terms of MTOE for the plant /year? If the plant operates for 7500 hours. c) Comment, whether this industry qualifies to be notified as Designated consumer?
Ans	Daily energy consumption (kWh) 50000 Own generation (kWh) 20000 Net drawl from the grid (kWh) 30000 Energy from Grid (MTOE) 2.58 Imported Coal Consumption (tons) 100 GCV of imported coal (kCal/Kg) 6900 Energy from coal (MTOE) 69 Energy from HSD (KL) 2 HSD (kg) 1652.6 GCV of HSD (kCal/Kg) 11859.83 Energy from HSD (MTOE) 1.96 Total (MTOE)/ day 73.5 a) % Share of Energy from Grid 3.51 % Share of Energy from Charcoal 93.83 % Energy from HSD 2.67 b)Total (MTOE)/ Annum 22981.24 c) The industry does not fall under the category of designated consumer as the annual consumption is less than 30000 MTOE.
S-2.	Write about the following: a) Name three combustible constituents of producer gas. **(3 Marks)** b) Give an example of Goal, Objective and Target set under ISO 50001 **(2 Marks)**
Ans	a) Refer Guidebook-1, Page 275-276 b) Refer Guidebook-1, Page 158-159
S-3.	a) Name three factors influencing external energy benchmarking? **(3 Marks)** b) List two energy benchmarking parameters. **(2 Marks)**
Ans	a & b) Refer Guidebook-1, Page 98-100
S-4.	Write a short note on the following: a) Renewable Purchase Obligation. **(2 Marks)** b) List three benefits of Demand Side management (DSM) **(3 Marks)**

Ans

a) Refer Guidebook-1, Page 44-45
b) Refer Guidebook-1, Page 38

S-5. Match the following:

A. Fyrite	4. Speed
B. Combustion gas analyser	2. CO
C. Psychrometer	3.Wet bulb temperature
D. Stroboscope	1. CO2
E. Ultrasonic Flowmeter	5.Transit time

Ans

A. Fyrite	1. CO_2
B. Combustion gas analyser	2. CO
C. Psychrometer	3. Wet bulb temperature
D. Stroboscope	4. Speed
E. Ultrasonic Flowmeter	5. Transit time

S-6. Calculate the production factor and plant Energy performance from the below mentioned data and comment on the result? **(5 Marks)**

1.	Reference year Energy consumption	10 Million Kcal	Reference year Production in MT	90,000 MT
2.	Current Year Energy consumption	8 Million Kcal	Current year production in MT	70,000 MT

Ans

Production factor = Current year Production / Reference year Production

= 70000 MT / 90000 MT

= 0.78

Reference Energy Equivalent is

= Reference year energy consumption X production factor

= 10 x10^6 kCalx0.78

= 7.8 million Kcal

Plant Energy Performance

= (Reference year equivalent-current year energy consumption) / Reference year equivalent X100

= (7.8-8) / 7.8 X100

= -2.56%

As the plant energy performance is negative the plant energy manager has to take the corrective action to improve the plant energy performance.

S-7.	A shell and tube heat exchanger is used to increase the temperature of furnace oil from a temp of 60 ^{o}C to 120 ^{o}C using steam as the heating medium. The oil flow rate is 3500 kl/hr. The density of furnace oil is 0.89 kg/liter. Calculate the amount of steam required in t/hr to heat the furnace oil, if the specific heat of furnace oil is 0.5 kCal/kg^{o}C. The total enthalpy of steam is 2733 kJ/kg. The condensate is leaving the heat exchanger at 397 kJ/kg.
Ans	$M_{\text{fuel oil}} C_{p\ \text{of fuel oil}} (T_{out} - T_{in})$ = Mass flow rate of steam x Enthalpy of cond. of steam Mass flow rate of steam(T/Hr.) = $\frac{3500 \times 1000 \times 0.89 \times 0.5 \times (120-60)}{((2733-397)/4.187) * 1000}$ = 167.5 T/Hr.
S-8.	A VFD is to be installed for a fan. The initial investment is 3 lakh rupees and cashflow at the end of 1st, 2nd and 3rd year are 1.2 lakh, 1.5 lakh and 1.5 lakh rupees respectively. Calculate NPV at 10 % discount rate and check that weather this project is feasible or not?
Ans	NPV = {-3,00,000 + (120,000/1.10) + [150,000/$(1.1)^2$] +[150,000/$(1.1)^3$]} = (-300000 + 109090 + 123967 + 112697) = +45,754.00 NPV is positive therefore, the proposed investment for VFD is viable.

..... End of Section II .....

Section – III: LONG DESCRIPTIVE QUESTIONS **Marks: 6 x 10 = 60**

(i) Answer all **Six** questions
(ii) Each question carries **Ten** marks

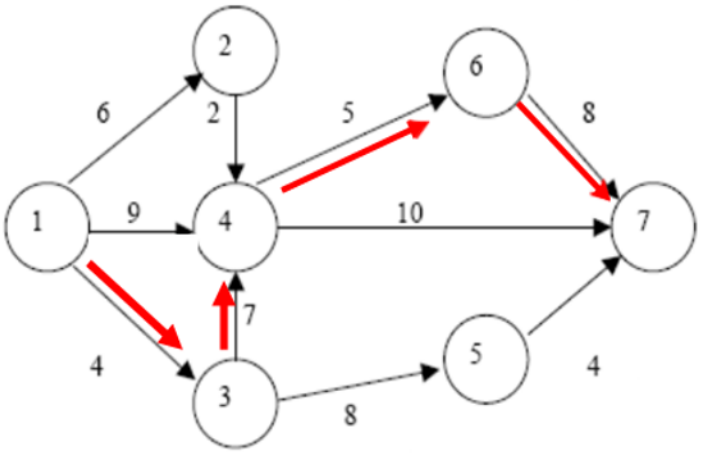
L-1	An R & D project has a list of tasks to be performed whose time estimates are given in the Table.

Activity i j	Activity Name	T_0	t_m (in days)	t_p
1-2	A	4	6	8
1-3	B	2	3	10
1-4	C	6	8	16
2-4	D	1	2	3
3-4	E	6	7	8
3-5	F	6	7	14
4-6	G	3	5	7
4-7	H	4	11	12
5-7	I	2	4	6
6-7	J	2	9	10

Draw the project network and find the critical path.

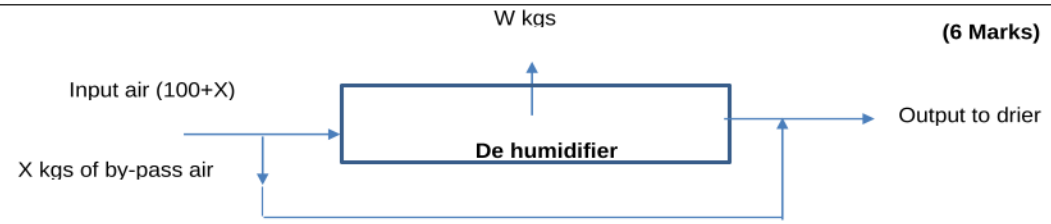
Ans	

Activity	T_o	T_m	T_p	T_a
1-2	4	6	8	6
1-3	2	3	10	4
1-4	6	8	16	9
2-4	1	2	3	2
3-4	6	7	8	7
3-5	6	7	14	8
4-6	3	5	7	5
4-7	4	11	12	10
5-7	2	4	6	4
6-7	2	9	10	8



From the network diagram, the critical path is identified as 1-3, 3-4, 4-6, 6-7 with a project duration of (4+7+5+8) = 24 days

L-2 A) In an industry, de-humidified air containing 0.0089 kg H_2O/kg air is required to be fed to a dryer for textile drying. The atmospheric air has an specific humidity of 0.02 kg H_2O/kg air. The atmospheric air is to be passed through a de-humidifying system that reduces the absolute humidity to the desired level. The de-humidifying system installed in the industry has the capacity to reduce the absolute humidity to 0.0005 kg H_2O/kg air. Therefore, to get the desired humidity of 0.0089 kg H_2O/kg air at the de-humidifying system outlet, a part of fresh atmospheric air by-passes and mixed at the outlet of de-humidification system. Find out the mass of water removed per 100 Kg of air feed to the dehumidifier and the percentage of by-passed air. **(4 Marks)**



(6 Marks)

B) The waste acid contains 30% H_2SO_4, 35 % HNO_3 and 35% water. The Waste acid is to be concentrated to contain 39% H_2SO_4 and 42% HNO_3 by addition of concentrated Sulphuric acid containing 98% H_2SO_4 and concentrated Nitric acid containing 72% HNO_3. Calculate the quantities of three acids to be mixed to get 1000 kg of desired mixed acid. **(6 Marks)**

Ans

A)

De-humidified air containing (kg H_2O/Kg air)	0.0089
Atmospheric air humidity (kg H_2O/Kg air)	0.02
Humidity of air after de-humidifier (kg H_2O/kg air)	0.0005
Desired Humidity (kg H_2O/Kg air)	0.0089
Dehumidifier input (kg)	100
Input Moisture to humidifier (kg)	2
Output Moisture to humidifier (kg) (100*0.0005)	0.05
Removed Moisture (kg)	1.95

Assuming by-pass quantity as x kg, moisture balance at mixing point

Moisture of 100 kg air at outlet + Moisture of x kg = Moisture of mixer (100+x) kg

0.05 kg + (x * 0.02) = (0.0089* (100+x)

x kg of air by-pass	75.68
Total mass of input air (kg) (100+75.67)	175.68
Percentage of air by-passes (%)	43.08

B)

Basis 1000 Kgs of Desired Mix

Let us assume that X, Y and Z are the waste acid, concentrated sulphuric acid, concentrated Nitric acid.

We know that from mass balance X+Y+Z =1000 kg --------(1)

From the material balance of H_2SO_4

$$0.3X+0.98Y=0.39x1000 \quad \text{---------(2)}$$

From the Material balance of HNO_3

$$0.35X+0.72Z=0.42x1000 \quad \text{---------(3)}$$

Solving (1), (2) & (3) equations give

X=90.1 Kg; Y=370.4 Kg; Z=539.5kg

L-3 For the data given in below table, using CUSUM technique comment on the annual energy savings at the end of twelfth month. If the cost of oil is Rs.95/liter calculate the cost savings per unit of production.

	Specific Energy Consumption (SEC) (Lts. Oil / unit of production)	
Month	Actual Consumption	Predicted Consumption
January	1025	1000
February	1050	1000
March	950	1000
April	1000	1000
May	975	1000
June	925	1000
July	975	1000
August	900	1000
September	1050	1000
October	1025	1000
November	1000	1000
December	950	1000

Ans Energy Savings using CUSUM -

Actual Consumption (Lts. Oil / unit of production)	Predicted Consumption (Lts. Oil / unit of production)	Difference (Actual-Predicted) (Lts. Oil / unit of production)	CUSUM Savings (Lts. Oil / unit of production)
1025	1000	25	25
1050	1000	50	75
950	1000	-50	25
1000	1000	0	25
975	1000	-25	0
925	1000	-75	-75
975	1000	-25	-100
900	1000	-100	-200

	1050	1000	50	-150
	1025	1000	25	-125
	1000	1000	0	-125
	950	1000	-50	-175

Annual energy savings of 175 lts / unit of production.

Annual cost savings = 175 x 95 = Rs 16,625/ unit of production

L-4

A) A 2 MW captive power plant operating at a load factor of 90% consumes 0.8 kg of coal for every kWh of energy generated. The coal contains 40% of carbon with a GCV of 4200 kCal/kg. Now the boiler is being fired with the sawdust containing 30% carbon with a GCV of 3600 kCal/kg. Due to this modification to generate same kWh of energy 0.9 kg of sawdust is being used.

Calculate the Annual CO_2 emissions reduction that the plant would gain due to this, if the plant operates for 7000 hours/year? (One kg of carbon after complete combustion produces 3.67 kg of CO_2) **(6 Marks)**

B) In a building it was proposed to install a roof top solar system to meet the electrical requirements of the building. The total monthly billing units are 1000 units. The cost of tariff is Rs.6/kWh. The total roof area of the building is 1200 sq. ft including the shading area of 20%. **(4 Marks)**

i. Calculate the capacity of solar panels in kW that can be installed if 1 kW of roof top solar system requires 10 sq.mts of shadow free area. (1 sq.mt = 10.7369 sq.ft)
ii. Calculate the annual energy generated for 365 days from the roof top solar panels if the sunshine hours are 5.5 hours/day.

Ans

A)

Capacity of power plant (kW)	2000
Load factor	0.9
Specific Coal Consumption (kg/kWh)	0.8

Co_2 Emission (kg/hr) = Generation (kWh) *Specific Coal Consumption (kg/kWh) * % C *3.67 kg Co_2/ kg C

CO_2 Emission from Coal (kg/hr)	2113.92
Specific Sawdust Consumption (kg/kWh)	0.9
CO_2 Emission from sawdust (kg/hr)	1783.62

	Reduction in CO_2 due to fuel substitution (kg/hr) 330.3 Annual CO_2 emission reduction (T/yr) 2312.1 B) I. Area of the Roof is 1200 sq. ft Shading area is 20 % of roof area = 20% of 1200 sq. ft = 240 sq. ft Available area for installing solar panels is = 1200-240 sq. ft = 960 sq. ft Given that 1 KW of roof top solar system requires 10 Sq.mts of shadow free area. Hence, for 960 sq. ft requires We know that 1 sq.mt = 10.7369 sq.ft 89.4112 sq.mt = 960 sq. ft If 1 kW requires 10 Sq.mt of shadow free area then in 89.4112 sq.mts of roof area 8.94112 kW of capacity of roof top system can be installed. II. Annual Energy Generated from the installed roof top system: =8.94112 x 5.5 x 365 =17949.2984 kWh
L-5	A) Fill in the blanks as follows: **(5 Marks)** 1. The current drawn by an electric kettle having resistance of 25 Omhs and receiving supply at 250 Volts is _____. 2. In three-phase system kW will be equal to KVA if the power factor is _____. 3. The specific gravity of water is _____. 4. The change in heat content of a substance, when its physical state is changed without change in temperature is called _____ heat. 5. Specific heat of water is 1 kCal/kg ^{0}C or _____ kCal/kg ^{0}K B) Briefly explain PAT Scheme and list 5 sectors covered under the scheme. **(5 Marks)**
L5 Ans	A)Fill in the blanks as follows: **(5 Marks)** 1. 10 amps 2. 1

	3. 1 4. Latent heat 5. 1 kCal/kg ^{0}K B) Refer guide book 1, page no 40-41
L-6	Write a short note on the following 1. Working principle of fuel cell — 4 Marks 2. Carbon sequestration — 3 Marks 3. Availability based tariff — 3 Marks
Ans	1. Refer guide book 1, page no 281 2. Refer guide book 1, page no 243 3. Refer guide book 1, page no 20

..... End of Section III .....

Paper 1 Pink

22nd NATIONAL CERTIFICATION EXAMINATION
FOR
ENERGY MANAGERS & ENERGY AUDITORS - JULY, 2022

PAPER - 1 : GENERAL ASPECTS OF ENERGY MANAGEMENT & ENERGY AUDIT

Date : 30.07.2022 Timings : 09:30-12:30 HRS Duration : 3 HRS Max. Marks : 150

Section – I: OBJECTIVE TYPE **Marks: 50 x 1 = 50**

1.	Energy security measure includes_____. a) fully exploiting domestic energy resources b) diversifying energy supply source c) substitution of imported fuels for domestic fuels to the extent possible d) **all of the above**
2.	The process of capturing CO_2 from point sources and storing them is called_____. **a) carbon sequestration** b) carbon sink c) carbon capture d) carbon adsorption
3.	The retrofitting of a variable speed drive in a plant costs Rs 2 lakh. The annual savings is Rs 0.4 lakh. The maintenance cost is Rs. 0.05 lakh/year. The return on investment is a) 25% b) 22.5% c) 24% **d) 17.5%**
4.	2000 kJ of heat is supplied to 500 kg of ice at 0^oC. If the latent heat of fusion of ice is 335 kJ/kg then the amount of ice in kg melted will be _____. a) 1.49 b) 83.75 **c) 5.97** d) None of the above
5.	The number of moles of water contained in 27 kg of water is_____. a**)** 5 b) 3 c) 4 d)**1.5**
6.	Which of the following GHGs has the longest atmospheric life time? a) CO_2 b) CFC c) Sulfur Hexafluoride (SF_6) **d) perfluorocarbon (PFC)**
7.	An indication of sensible heat content in air-water vapour mixture is a) wet bulb temperature c) density of air b) dew point temperature **d) dry bulb temperature**
8.	Which of the following comes under mandatory labeling program a) Diesel Generators b) Ceiling fan **c) Tubular Fluorescent Lamps** d) Pumps
9.	Find the future value of Rs. 1,000 at an interest rate of 10% in 10 years' time.

	a) **Rs. 2,594** b) Rs. 386 c) Rs. 349 d) Rs. 10,000
10.	In a drying process, moisture is reduced from 50% to 30%. Initial weight of the material is 100 kg. Calculate the weight of the final product in kg a) 80 b) 86 **c) 71.4** d) 74.3
11.	Energy intensity is the ratio of _____. a) Fuel consumption / GDP b) GDP/fuel consumption c) GDP/ energy consumption d**) Energy consumption / GDP**
12.	As per primary commercial energy consumption mix in India, the fuel dominating the energy production mix in India is a) Natural gas b) Oil **c) coal** d) Nuclear energy
13.	An activity has an optimistic time of 15 days, a most likely time of 18 days and a pessimistic time of 27 days. What is the expected time? a) 60 days b) 20 days **c) 19 days** d) 18 days
14.	Bio-gas generated through anaerobic process mainly consists of a) Only methane b) **Methane and carbon dioxide** c) Only ethane d) None of these
15.	Which of the following is not a part of energy audit as per the Energy Conservation Act, 2001? a) Monitoring and analysis of energy use b) Verification of energy use c) Submission of technical report with recommendations **d) Ensuring implementation of recommended measures followed by review**
16.	Which of the following statements are true regarding simple payback period? a) Considers impact of cash flow even after payback period b) Takes into account the time value of money c) Considers cash flow throughout the project life cycle **d) None of the above**
17.	What percentage of the sun's energy can silicon solar panels convert into electricity? a) 30% **b) 15%** c) 75% d) 50%
18.	Non-contact speed measurements can be carried out by a) Tachometer **b) Stroboscope** c) Oscilloscope d) Speedometer
19.	The amount of energy transfer from a higher temperature to a lower temperature is measured in a) **kcal** b) Watt c) Watts per second d) none of the above

20.	The amount of electricity required to heat 200 litres of water from 30°C to 70°C through resistance heating is a)0.93 kWh **b) 9.3 kWh** c) 930 kWh d) 8 kWh
21.	A process requires 100 kg of fuel with a calorific value of 5000 kcal/kg for heating with a system efficiency of 83 %. The loss would be a) 235,000 kCal **b) 85,000 kCal** c) 103680 kCal d) 415,000 kCal
22.	The internal rate of return is the discount rate for which the NPV is a) Always positive b) Always negative c) negative or positive d) **None of the above**
23.	The producer gas consists of a) CO b) H_2 c) CH_4 d) **All of the Above**
24.	Which of the following with respect to fossil fuels is true? a) Reserve / Production (R/P) ratio is a constant once established b) R/P ratio varies every year with only changes in production c) R/P ratio varies every year with only changes in reserves **d) R/P ratio varies every year with changes in both production and reserves**
25.	Air velocity in the ducts can be measured by using _____ and manometer a) Orifice meter b) Bourden gauge **c) Pitot tube** d) Anemometer
26.	Which industry among the following is not a designated consumer as per EC Act-2001? a) Fertilisers b) Chlor alkali c) Cement **d) Sugar**
27.	Propane is an example of stored _____ energy a)Nuclear b) Radiant **c) Chemical** d) Mechanical
28.	Statement not applicable to TOD (Time of the Day) in electricity tariff structure? a) Higher energy charges during peak period b) It is an incentive to maximize off- peak consumption c) It is an incentive to minimize peak time power draw from the grid by consumers **d) It is a disincentive for Distribution Company**
29.	In a heat treatment furnace the material is heated up to 1053 K from ambient temperature of 303 K. Considering the specific heat of material as 0.125 kCal / kg °C, what is the energy content gained by one kg of material after heating? **a) 94 kCal** b) 250 kCal c) 350 kCal d) 100 kCal
30.	The top two commercial energy consuming sectors in our country are_____. a) Industry and Agriculture b) Agriculture and Transport c) Residential and Industry d) **Industry and Transport.**

31.	The quantity of heat required to convert one kg of a liquid into vapour without change of temperature is called a) latent heat of fusion b) specific heat c) sensible heat d) **Latent heat of Evaporation**
32.	Acid rain is caused by the release of which of the following components: a) **SOx and NOx** b) SOx and CO_2 c) CO_2 and NOx d) Ozone
33.	Inexhaustible energy sources are known as: a) Primary energy b) Secondary energy c) Commercial energy d) **Renewable energy**
34.	The energy consumed by a 55 kW motor loaded at 40 kW over a period of 4 hours is: a) 220 kW b) 220 kWh **c) 160 kWh** d) 160 kW
35.	3.6 units of electricity is equivalent to _____ of kCal of heat units: a) 680 b) 860 **c) 3096** d) 3600
36.	If feed of 100 tons per hour at 5% concentration is fed to a crystallizer, the rate in tons per hour of the product obtained at 25% concentration is equal to: a) 40 **b) 20** c) 25 d) 100
37.	Which of the following is not a common normalizing factor in industrial facilities? a) Input b) Output **c) Maintenance cost** d) Product type
38.	The technique not used for scheduling the tasks and tracking of the progress of energy management projects is called_____. a) CPM b) PERT c) Gantt chart **d) CUSUM**
39.	Which of the following statements about critical path analysis is true? **a) The critical path is the longest path through the network** b) The critical path is the shortest path through the network c) Tasks with float can never be a task on critical path d) none of the above
40.	Which of the following most closely represents the heat content of 1 kg of LPG: a) 8000 kilo Calorie

	b) 12500 kilo Joule c) **12500 kilo Calorie** d) 8000 kilo Joule
41.	Specific energy consumption is defined as: a) Energy consumption per month b) Annual energy consumption c) Energy consumed per unit of fuel burnt d) **Energy consumed per unit of production**
42.	The annual MTOE limit for chloroalkali industry to be a designated consumer is _____ a) 30000 b) 3000 c) 7500 d) **12000**
43.	As per ECBC, EPI calculation includes _____. a) Solar photovoltaic Energy b) Grid energy purchased c) captive DG power d) **b and C**
44.	The nodal agency at centre for implementing the Energy Conservation Act in India, is _____. a. Central Electricity Authority b. Central Electricity Regulatory Commission **c. Bureau of Energy Efficiency** d. National Productivity Council
45.	As per Energy Conservation Act, 2001 appointment of BEE Certified Energy Manger is mandatory for _____. a. All commercial buildings b. All State designated agencies c. All large Industrial consumers **d. All designated consumers**
46.	A list of instruments and what they measure are given below. Which is the incorrect among this list ? a. Gas analyzer – CO **b. Lux Meter- Lumens** c. Manometer- Pressure d. Tachometer – Speed
47.	The ISO Series pertaining to the Energy Management System is _____. a. ISO 9001 b. ISO 14001 c. ISO 27000

	d. ISO 50001
48.	"Toe" stands for_____. a) Total oil equivalent b) Tons of effluent c) Tons of energy equivalent **d) Tons of oil equivalent**
49.	Sensitivity analysis is an assessment of_____. a) Profits b) Losses **c) Risks** d) All of the above
50.	Micro hydro will generate _____ a) less than 10 kW **b) 11kW up to 100 kW** c) 101 kW to 2 MW d) None of the above

..... End of Section I .....

Section – II: SHORT DESCRIPTIVE QUESTIONS **Marks: 8 x 5 = 40**

(i) Answer all **Eight** questions
(ii) Each question carries **Five** marks

S-1.	a. Explain energy performance contracting and their types? 3 Marks b. Explain the role of ESCOS in energy performance contracting? 2 Marks
S-1.	Ans: a. Refer Guide Book 1- Pg 178 b. Refer Guide Book 1- Pg 177
S-2.	Calculate the Net Present Value over a period of 4 years for a project with an investment of Rs 70,000 at the beginning of the first year and another investment of Rs 70,000 at the beginning of the second year and fuel cost saving of Rs 65,000 in second year and Rs. 60,000 each in third and fourth year. The discount rate is 12%.
S-2.	Ans: NPV = –70,000 – (70,000/1.12) + [65,000/(1.12x1.12) + [60000/(1.12x1.12x1.12) + 60,000/(1.12 x1.12x1.12x1.12)] = –70000 –62,500 + [51,818 + 42707 + 38,131] =156
S-3.	The rating of a single phase electric geyser is 2000 Watts, at 230 Volt. Calculate: a) Rated current 1 Mark b) Resistance of the geyser in Ohms 1 Mark c) Actual power drawn in kW when the measured supply voltage is 210 Volts 3 Marks

S-3.	Ans: a)Rated Current of the Geyser, I = P/V= 2000/230 = 8.696 Ampere b)Resistance Value R = V/I = 230/8.696 = 26.45 Ohms c)Actual Power drawn at 210 Volts = (V/R)*V = (210/26.45)*210/1000 =1.67 kW or (210/230)^2 x 2000/1000 =1.67 kW
S-4.	What are ESCerts and explain the basis for their issuance and trading under PAT scheme?
S-4.	Refer Guide book-1 – Page no 40-41
S-5.	List any five equipment and appliances covered under the Standards and Labelling (S&L) Scheme of the BEE
S-5.	Refer Guide book-1 – Page no 37. Any five among 19 appliances under the S&L Scheme (4 mandatory and 15 voluntary)
S-6.	(i) What is Solar Constant and Solar Insolation? 2 Marks (ii) A 375 Watt solar panel of the size 1.20 m x 1.50 m is installed in a solar photovoltaic power plant on a roof top area of a structure having dimensions of 10 m x 15 m. What will be the panel conversion efficiency if the solar insolation is 1000 Watt per square meter? 3 Marks
S-6.	(a) Refer Guide Book 1- Pg 263 (b) Maximum power output (Pm) = 375 W Solar Insolation (E) = 1000 W/m^2 Area of the solar cell (A) = 1.2x1.5 = 1.8 m^2 Energy Conversion Efficiency (n) = ((Pm/E x A)) x 100 = (375/ (1000x1.8)) x 100 = 20.83 The panel conversion efficiency is 20.83%
S-7.	A sample of coal is found to contain 64% carbon and 24% ash. The refuse obtained at the end of combustion is analyzed and found to contain 8% carbon and the rest is ash. Compute the percentage of the original carbon unburnt in the refuse.
S-7.	Coal: Carbon=64%, Ash=24% Refuse: Carbon=8%, Ash= 92% Assuming basis of the coal as 100 kg. The key is, Ash amount remains same in refuse as well as coal. So, Mass of carbon in coal = 64 kg Mass of ash in coal = 24 kg Mass of ash in refuse = 24 kg So, Mass of refuse = (100/92) x 24 = 26.087 kg Mass of carbon is refuse = (8/100) x 26.087 = 2.087 kg Percentage of original carbon remaining unburnt is refuse = (2.087/64) x 100

	= 3.26 %
S-8.	A. Write a short note on enhanced greenhouse effect? 3 Marks b. An office replaces its existing lighting system comprising of 10 CFL (30 Watt each) with equal number of LED (10 Watt each). If the average use (operational hours per lamp) is 2000 hours per annum, calculate the annual energy savings, the annual monetary savings as well as the payback period. Take the cost of LED lamp as Rs. 60 per lamp and the tariff as Rs.9 per kWh. 2 Marks
S-8.	a) Refer guidebook-1, page no 242 b) Annual Savings in Energy (kWh) = 10 X (30-10) X 2000 / 1000 = 400 Annual Savings in Money (INR) = 400 X 9 = 3600 Total Investment = 60 X 10 = 600 Payback Period = 600 / 3600 = 0.16 years or 2 months

..... End of Section II .....

Section – III: LONG DESCRIPTIVE QUESTIONS **Marks: 6 x 10 = 60**

(i) Answer all **Six** questions
(ii) Each question carries **Ten** marks

L-1	A proposed project requires an initial capital investment of Rs. 100 Lakhs. The cash flows generated by the project are shown in the table below : Year: 0 | 1 | 2 | 3 | 4 Cash Flow (Rs.in Lakhs): 100 | 30 | 30 | 40 | 45 (a) If the cost of fund is available at 11% for the project, calculate internal rate of return (IRR) for the given project. (6 Marks) (b) What are the limitations of Return on Investment (ROI) technique? (2 Marks) (c) What are the advantages of Simple Payback period technique? (2 Marks)
L-1 S	(a) The internal rate of return is the value of 'r' which satisfies the equation: 0 = -100 + 30/ (1+r) + 30/ (1+r) ^2 + 40/ (1+r) ^3 + 45/ (1+r) ^4 To begin with, Taking r = 12% Then, RHS = -100 + 30/ (1+.12) + 30/ (1+.12) ^2 + 40/ (1+.12) ^3 + 45/ (1+.12) ^4 = -100 + 26.78+ 23.91+ 28.47 + 28.59 = 7.77

Taking r = 15%

Then, RHS = -100+ 30/ (1+.15) + 30/ (1+.15) ^2 + 40/ (1+.15) ^3 + 45/ (1+.15) ^4

= -100 + 26.08 + 22.68 + 26.30+ 25.72

= 0.78

Taking r = 16%

Then, RHS = -100 + 30/ (1+.16) + 30/ (1+.16) ^2 + 40/ (1+.16) ^3 + 45/ (1+.16) ^4

= -100 + 25.86 + 22.29 + 25.62 + 24.85

= -1.36

So, it is ascertained that value of 'r' lies between 15 and 16 and that too slightly towards 15.

Now, using interpolation method,

r = 15 + [(0.80) x (16-15) / (0.80– (-1.36)]

= 15.37

So, the internal rate of return (IRR) is 15.37%.

(b) Refer guidebook-1, page no 165

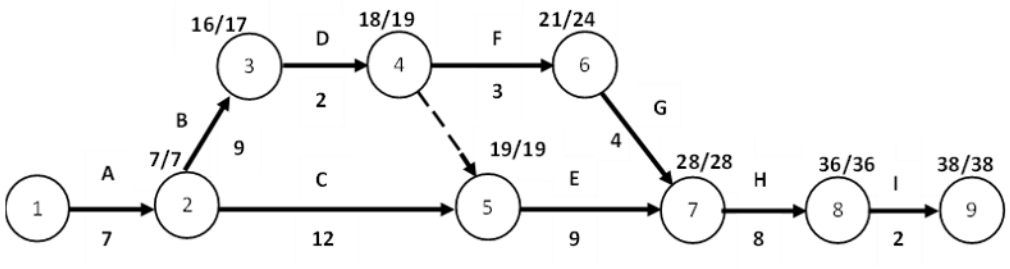
(c) Refer guidebook-1, page no 166

L-2 For the following activities, durations and predecessor relationships is given in the table below:

	Activity Description	Immediate Predecessor(s)	Optimistic (Weeks)	Most Likely (Weeks)	Pessimistic (Weeks)
1	A	-	4	7	10
2	B	A	2	8	20
3	C	A	8	12	16
4	D	B	1	2	3
5	E	D,C	6	8	16
6	F	D	2	3	4
7	G	F	4	4	4
8	H	E,G	4	8	12
9	I	H	1	2	3

Each 2 Marks

a) Draw the network
b) Calculate expected time for all tasks
c) Determine all possible paths and their estimated durations.
d) Identify the critical path.
e) For Task F, find out the Earliest Start (ES), Earliest Finish(EF), Latest Start (LS) and Latest Finish(LF).

L-2 S	a) Network  b) Expected duration of tasks (T_e) = (Optimistic + 4 x Most Likely + Pessimistic) /6 $T_eA = 7$ $T_eB = 9$ $T_eC = 12$ $T_eD = 2$ $T_eE = 9$ $T_eF = 3$ $T_eG = 4$ $T_eH = 8$ $T_eI = 2$ c) All the paths in the network and durations: Path 1 : A-B-D-F-G-H-I = 7+9+2+3+4+8+2 = 35 Path 2 : A-C-E-H-I = 7+12+9+8+2 = 38 Path 3 : A-B-D-E-H-I = 7+9+2+9+8+2 = 37 d) Path 2 : A-C-E-H-I is a critical path e) For Task F Earliest start of Activity = 18 Earliest Finish = 21 Latest Start = 21 Latest Finish = 24
L-3	The production through a paper machine is 300 tonnes per day (TPD). Inlet and outlet dryness to paper machine is 50% and 95% respectively. Evaporated moisture temperature is 80 °C. To evaporate moisture, the steam is supplied at 3.5 kg /cm^2. Latent heat of steam at 3.5 kg /cm^2 is 513 kcal/kg. Assume 24 hours/day operation and estimate the following: Each 5 Marks i) Quantity of moisture to be evaporated in kg/hr ii) Steam quantity required for evaporation in kg/hour. Note: Consider enthalpy of evaporated moisture as 632 kcal/kg.
L-3 S	Production through paper machine = 300 TPD = 12.5 TPH (tonnes per hour) Inlet dryness to paper machine = 50% Outlet dryness from paper machine = 95% i) Estimation of moisture to be evaporated:

Paper weight in final product = 12.5 x 0.95 = 11.875 TPH
Weight of moisture after dryer = (12.5-11.875) = 0.625 TPH
Paper weight before dryer on dry basis = 11.875 TPH
Weight of moisture before dryer = ((11.875) x (100/50)) – 11.875) = 11.875 TPH
Evaporated moisture quantity : 11.875 - 0.625 = 11.25 TPH = 11,250 kg per hour.

ii) Input steam quantity required for evaporation
Evaporated moisture temperature = 80 °C
Enthalpy of evaporated moisture = 632 kcal/kg
Heat available in moisture (sensible & latent) = 632 x 11,250 = 7,110,000 kcal /hour
For evaporation minimum equivalent heat available should be supplied from steam
Latent Heat available in supply steam (at 3.5 kg/cm^2 (g)) = 513 kCal/kg
Quantity of steam required = 7,110,000/ 513 kg per hour = 13,859.6 kg per hour=13.86 TPH.

L-4. a. Use CUSUM technique to develop a table and to calculate energy saving for 6 months period. For calculating total energy saving average production can be taken as 4500 MT per month. Refer to field data given in the table below: 6 Marks

MONTH	ACTUAL SEC KWH/MT	PREDICTED SEC kWh/MT
April	1301	1400
May	1308	1400
June	1315	1400
July	1320	1400
August	1325	1400
September	1355	1400

b. List any two ozone depleting substances (ODS) and Green House Gases (GHG). 4 Marks

A.

Month	Actual SEC	Predicted SEC	Sec Diff (Act-Predict)	CUSUM Saving
April	1301	1400	-99	-99
May	1308	1400	-92	-191
June	1315	1400	-85	-276
July	1320	1400	-80	-356
August	1325	1400	-75	-431
Sept	1355	1400	-45	-476

Saving in energy consumption over period of Six Months = 476 * 4500
= 21,42,000 kWh

	B. Refer Guide Book-1, Page no 239 and Page No 243
L - 5	Explain the following a. Comparative label 2 marks b. Endorsement label 2 marks c. Minimum energy performance standard 2 marks d. Explain the difference between standards and labelling 4 marks
	a. Comparative label - Refer Guidebook-1, Page no 36 b. Endorsement label - Refer Guidebook-1, Page no 36 c. Minimum energy performance standard - Refer Guidebook-1, Page no 36 d. Explain the difference between standards and labelling - Refer Guidebook-1, Page no 35 & 36
L - 6	Each 5 Marks a) List down any five energy audit instruments and parameters they are used to measure. b) List five energy security measures.
	a) Refer Guidebook-1, Page no 104 to 110 b) Refer Guidebook-1, Page no 20 to 22

..... End of Section III .....

21st NATIONAL CERTIFICATION EXAMINATION
FOR
ENERGY MANAGERS & ENERGY AUDITORS

PAPER - 1 : GENERAL ASPECTS OF ENERGY MANAGEMENT & ENERGY AUDIT

Date : 25.09.2021 Timings : 09:30-12:30 HRS Duration : 3 HRS Max. Marks : 150

General instructions :

- *Please check that this question paper contains **8** printed pages*
- *Please check that this question paper contains **64** questions*
- *The question paper is divided into three sections*
- *All questions in all three sections are compulsory*
- *All parts of a question should be answered at one place*

Section -I: OBJECTIVE TYPE **Marks : 50x1=50**

1.	What is the heat content of the 200 liters of water at 50°C in terms of the basic unit of energy in kilo Joules (kJ) a) 3000 b) 4187 c) 1000 **d) 41870**	d
2.	$C_2H_4 + xO_2$ ------> $2CO_2 + yH_2O$, what is the value of x + y? a) 2 b) 3 **c) 5** d) 8	c
3.	What is the "TOE" of 125 Ton of coal which has GCV of 4000 kcal/kg a) 40 **b) 50** c) 400 d) 500	b
4.	Infrared thermometer is commonly used to measure: **a) Surface temperature** b) Flue gas temperature c) Steam Temperature d) Hot water temperature	a
5.	Power in a 3 phase AC system is a) 3 x Voltage x Current b) Voltage x Current c) 1.73 x Voltage x Current **d) None of the above**	d
6.	Which industry among the following is not a designated consumer as per EC Act-2001? a) fertilizers b) chlor alkali c) cement **d) nuclear power stations**	d
7.	Star rating is a _____ program of BEE a) Demand Side Management b) Integrated Energy Policy **c) Standards & Labeling** d) National Mission for enhanced energy efficiency	c
8.	Energy consumption per unit of GDP is called as: a) energy elasticity **b) energy intensity** c) energy per capita d) none of above	b
9.	To maximize the combustion efficiency, it is required to _____ in the flue gas?	b

	a) maximize O_2 **b) maximize CO_2** c) minimize CO_2 d) maximize NO_x	
10.	An electric heater of 230 V, 10 kW rating is installed for hot water generation in a hospital. The consumption per hour at 200 V is a) 10 kWh b) 8.7 kWh c) 13.23 kWh **d) 7.56 kWh**	d
11.	A sensitivity analysis is carried out for an energy saving project to make an assessment of a) cash flows **b) risks due to assumptions** c) capital investment d) best financing source	b
12.	The specific gravity of water is expressed as_____. **a) 1** b) 1 kg/m^3 c) 1 g/cc d) 1000 kg/m^3	a
13.	An activity in a project is having an optimistic time of 8 days, a most likely time of 15 days and a pessimistic time of 16 days. Its expected time of completion is **a) 14 days** b) 13 days c) 12 days d) none of the above	a
14.	From an activity in a project, latest start time is 8 weeks; latest finish time is 12 weeks. The slack time for the activity is_____. a) 1 week b) 5 weeks c) 4 weeks **d) none of the above**	d
15.	Which of the following is not a greenhouse gas? a) Water Vapour **b) SO_2** c) CO_2 d) CH_4	b
16.	The period when maximum sunlight is available is called? a) Solar constant b) Solar insolation **c) Solar window** d) none of the above	c
17.	If wind speed increases by three times, energy output from wind mill will be _____. a) 3 times higher **b) 27 times higher** c) 8 times higher d) none of the above	b
18.	A solution of common salt is prepared by adding 25 kg of salt to 100 kg of water. The weight fraction of solution is_____. **a) 20%** b) 25% c) 4% d) none of the above	a
19.	The number of moles in 90 kg of water is _____. **a) 5** b) 18 c) 2 d) none of the above	a
20.	A factory has a fixed energy consumption of 2,000 kWh/month and it consumes a total of 38,000 kWh/month for manufacturing 90,000 units of the product. The variable energy consumption in kWh/unit is_____. **a) 0.4** b) 2.4 c) 2.5 d) none of the above	a

21.	If wet bulb and dry bulb temperatures read the same, the relative humidity is_____. a) 0% b) 50% **c) 100%** d) none of the above	c
22.	1 kWh is equivalent to a) 86000 cal b) 10000 Wh **c) 3.6 MJ** d) none of the above	c
23.	Which of the following data is not used for calculating Plant Energy Performance? a) Reference year energy use b) Production factor c) Current year energy use **d) Maximum electrical demand**	d
24.	Non-contact flow measurement can be carried out by _____. a) Orifice meter b) Turbine flow meter **c) Ultrasonic flow meter** d) Magnetic flow meter	c
25.	Which of the following means 'continuous improvement'? a) Seiton **b) Kaizen** c) Seiso d) Kanban	b
26.	54 kg of water is mixed with 0.34 moles of salt to make a solution. The mole fraction of the solution is _____. **a) 0.1** b) 18.36 c) 158.8 d) none of the above	a
27.	What is the future value of a cash flow at the end of the 6th year, if the Present Value is Rs. 2 Lakhs and the interest rate is 9%? a) 3,28,540 **b) 3,35,420** c) 2,84,980 d) none of the above	b
28.	A temperature of -40°F will be _____°C? a) 0 b) -10 **c) -40** d) none of the above	c
29.	Unit of maximum demand is_____. a) kVAh **b) kVA** c) kVAr d) kWh	b
30.	The ISO standard for energy management system is_____. a) ISO 9001 **b) ISO 50001** c) ISO 14000 d) ISO 14001	b
31.	The depletion of ozone layer is caused mainly by _____. a) Nitrous oxide b) Carbon dioxide **c) Chlorofluorocarbon** d) Methane	c
32.	The presure of 1 atm is equal to _____. a) 10.1325 bar **b) 101.3 kpa** c) 1.033 mH_2O d) none of the above	b
33.	For the purpose of calculating TOE for a designated consumer the calorific value of oil is taken as a) 10500 kcal/kg **b) 10000 kcal/kg**	b

	c) 5000 kcal/kg	d) 8700 kcal/kg	
34.	1 BTU is equal to		
	a) 252 Joule	**b) 252 cal**	b
	c) 3600 kcal	d) 3.5 W	
35.	When the current leads the voltage in an AC electrical circuit, it is caused mainly due to		
	a) Inductive load	b) Resistive load	c
	c) Capacitive load	d) none of the above	
36.	The power indicated in the name plate of a motor denotes _____.		
	a) minimum kW drawn by the motor	b) maximum kW drawn by the motor	d
	c) maximum kVA drawn by the motor	**d) none of the above**	
37.	The law of conservation of energy is related with		
	a) third law of thermodynamics	b) second law of thermodynamics	c
	c) first law of thermodynamics	d) none of the above	
38.	The producer gas is basically _____.		
	a) only CH_4	b) only CO and CH_4	c
	c) CO, H_2 and CH_4	d) only CO and H_2	
39.	Return on investment (ROI) is _____.		
	a) initial investment/annual return	b) annual cost/capital cost	c
	c) annual net cash flow/capital cost	d) none of the above	
40.	The process of capturing CO_2 from point sources and storing them is called _____		
	a) carbon sequestration	b) carbon sink	a
	c) carbon capture	d) carbon adsorption	
41.	The typical efficiency of a solar cell in the field is		
	a) 12-15%	b) 25-30%	a
	c) 45-50%	d) 80-85%	
42.	Capacity utilization factor of a solar PV power plant is in the range of _____.		
	a) 80-85%	b) 60-65%	c
	c) 18-20%	d) less than 10%	
43.	Contact type speed measurement can be carried out by _____		
	a) Tachometer	b) Stroboscope	a
	c) Oscilloscope	d) Odometer	
44.	The "superheat" of steam is expressed as_____. **a) degrees centigrade above saturation temperature** b) degrees centigrade above critical temperature of the steam c) degrees centigrade below the boiling point of water d) all of the above		a
45.	The electrical power unit GigaWatt (GW) may be expressed as		
	a) 1,000,000,000 MW	**b) 1,000 MW**	b
	c) 1,000 kW	d) 10,000 W	
46.	Which of the following is not true of liquid fuels?		
	a) the viscosity of a liquid fuel is a measure of its internal resistance to flow		c
	b) the viscosity of all liquid fuels decreases with increase in its temperature		

	c) higher the viscosity of liquid fuels, higher will be its heating value d) viscous fuels need heat tracing	
47.	Which one of the following is not the duty of an energy manager under EC Act ? a) Report to BEE and state level designated agency once a year b) Prepare an annual activity plan **c) Conduct energy audit** d) Prepare a scheme for efficient use of energy	c
48.	Which one is not an energy consumption benchmark parameter? a) kcal/kWh of electricity generated **b) kg/deg. C** c) kW/ton of refrigeration d) kWh/kg of yarn	b
49.	300 liters of water in a tank is heated from 30°C to 70°C by using a direct steam with an enthalpy of 600 kcal/kg. The mass in kg of steam used is_____. a) 10 b) 200 c) 40 **d) none of the above**	d
50.	Which of the following is not a unit of energy ? a) Joule b) Calorie **c) Watt** d) BTU	c

*********End of Section -I*********

Section – II: SHORT DESCRIPTIVE QUESTIONS **Marks: 8 x 5 = 40**

(i) Answer all **Eight** questions
(ii) Each question carries **Five** marks

S-1 a)	**List three types of performance contracting offered by ESCO and state the differences of each type. 3 Marks**
	Refer Guidebook-1, Page 178
S-1 b)	**What is the need for normalizing data, while establishing baseline energy use? 2 Marks**
	Refer Guidebook-1, Page 142
S-2 a)	**Why is an evacuated tube collector more efficient than a flat plate collector for solar water heating system? 2 Marks**
	Refer Guidebook-1, Page 264-265
S-2 b)	**Explain the term Betz limit related to wind turbines 2 Marks**
	Refer Guidebook-1, Page 273
S-2 c)	**Define capacity factor of a wind turbine 1 Mark**
	Refer Guidebook-1, Page 274
S-3	**Explain the concept of fuel substitution with three examples. 5 Marks**
	Fuel substitution is basically substituting existing fossil fuel with, less cost/less polluting fuel, such as, natural gas, biogas and locally available agro-residues. Fuel substitution is applicable in all sectors of the Indian economy. Few examples of fuel substitution • Natural gas for cooking and industrial use in place of LPG. • Replacement of coal by coconut shells, rice husk etc.

	• Replacement of diesel/petrol by CNG, in automobiles • Replacement of LDO by LSHS • Replacement of electrical heaters by steam heaters • Replacement of steam based hot water by solar systems
S-4	**A 10 HP rated induction motor having name plate details of 415 V, 12 amps and 0.9 PF is being tested for an audit. Input measuring instrument display was showing 2 kVAr and PF of 0.758. Determine the percentage loading of the motor during the test. 5 Marks**
	$kW = KVA * PF$ (1) $(KVA)^2 = (kVAr)^2 + (kW)^2$ (2) Given kVAr = 2 and PF=0.758 Solve for kW in eqn (2) using eqn (1) we get, $kVA = kW/PF$; $PF = kW/kVA$; $(KVA)^2 = (kVAr)^2 + (kW)^2$; $(kW/pf)^2 = (kVAr)^2 + (kW)^2$ $(kW)^2 = pf^2 (kVAr)^2 + pf^2 (kW)^2$ $(kW)^2 - pf^2 (kW)^2 = pf^2 (kVAr)^2$ $(kW)^2 (1- pf^2) = pf^2 (kVAr)^2$ $(kW)^2 = (pf^2 *(kVAr)^2)/ ((1- pf^2))$ $kW = \sqrt{ (pf^2 *(kVAr)^2)/ ((1- pf^2))}$ $= ((pf *(kVAr))/ ((1- pf^2))^{0.5}$ =(0.758*2)/((1-0.758^2))^0.5 = 2.32 kW **(Or)** Cos θ = 0.758 Tan θ = 0.86 kW = kVAr / Tan θ = 2/0.86 = 2.32 kW kW = 2.32 kW Motor rated input kW= $\sqrt{3}$*V*I*Cos θ = 1.732*0.415*12*0.9=7.76 kW Percentage loading of motor= kW measured /rated input kW * 100 = 2.32/7.76 * 100 = **29.88%**
S-5 a	**Calculate the Net Present Value of a project at a discount rate of 16% with an investment of Rs. 50,000 at the beginning of the first year and savings of Rs. 15,000, Rs. 18,000 and Rs. 20,000 respectively at the end of the first, second and third year. 3 Marks**
	NPV = -50,000+(15000/1.16)+18000/(1.16x1.16)+(20000/(1.16x1.16x1.16)) = -50,000 + 12931 + 13377 + 12813 = (- **10879)**
S-5 b	**State whether the project is viable or not? 2 Marks**
	As NPV is negative the project is not viable.
S-6 a	**List at least two factors affecting external energy bench marking of energy intensive processes. 2 Marks**
	The factors affecting external benchmark could be: • Scale of operation • Vintage of technology • Raw material specifications • Product specifications
S-6 b	**Compute the plant energy performance of a brewery unit for the current year based on the following data 3 Marks**

		Time frame	**Production Level**	**Gross energy for the production level**
		Reference year	1,00,000 Barrels	35 Trillion Joules
		Current year	1,10,000 Barrels	38 Trillion Joules

Production Factor = Current year production / Reference year production

= 110000 / 100000

= 1.1

Reference year Energy Use = 35 Trillion Joules

Current year Energy Use = 38 Trillion Joules

Reference year Equivalent energy Use = (Reference year energy use) x (production factor)

= 35 x 1.1

= 38.5 Trillion Joules

Plant Energy Performance = (Reference year Equivalent energy use- Current year Energy use) x100 / Reference year Equivalent energy use

= (38.5-38) x100 / 38.5

= 1.31% (improvement)

S-7 **A furnace shell has to be cooled from 95°C to 45°C. The mass of the furnace shell is 4 tonnes. The specific heat of the furnace shell is 0.122 kcal/kg.°C. Water is available at 30°C. The maximum permissible increase in water temperature is 5°C. Ignoring the heat loss, compute the quantity of water required to cool the furnace. 5 Marks**

Mass of furnace shell (m) = 4000kg

Specific heat of furnace shell (Cp) = 0.122 kcal/kg °C

Temperature of shell before cooling (T1) = 95 °C

Desired temp of shell after cooling (T2) = 45 °C

Total heat that has to be removed from the furnace = m x Cp x (T1-T2)

= 4000*0.122*(95-45)

= 24400 kcal

Quantity of water required (Q) =?

Specific heat of water = 1 kcal/kg °C

Inlet cooling water outlet temperature = 30 °C

Maximum cooling water outlet temperature = 35 °C

Heat removed by water = Qx1x(35-30)

= 5Q

5 Q = 24400

Q = 24400/5

Q= 4880 kg

S-8 **A University is interested in installing a Solar Roof Top PV (SPV) system under net metering system. It has a total roof top area of 1200 Sq. meters, where the shading effect is 20% of the total area.**

Assuming 1 kWp SPV panel requires 10 sq meter area and the peak output is for 5 hours per day, calculate the following.

S-8 a **How much kWp of Solar PV system can you suggest? 2 Marks**

(1200x (1- 0.2)) / 10 = 96 kWp

S-8 b **How much would be the daily generation in kWh/day/kWp? 2 Marks**

(96 x 5)/96 = 5 kWh/day/kWp

S-8 c **How many kg of CO_2/ year is avoided for 250 days operation, if the CO_2 emission factor is 0.82 kg/kWh. 1 Mark**

96 kWp x 5 x 250 x 0.82 = 98,400 kg CO_2/year

..... End of Section II .....

Section – III: LONG DESCRIPTIVE QUESTIONS **Marks: 6 x 10 = 60**

(i) Answer all **Six** questions
(ii) Each question carries **Ten** marks

L-1 a) **What is the relevance of molten salt tanks in a typical solar power tower? 2 Marks**

Molten salt tanks provide an efficient low-cost medium to store thermal energy. Molten salt from the cold salt tank is pumped through the central receiver where it is heated to 566 °C. The heated salt from the receiver is stored in the hot salt thermal storage tank. Cold salt at 288 °C flows back to the cold salt thermal storage tank and is re-used.

L-1 b) **Explain how parabolic trough collectors work? 4 Marks**

Refer Guidebook-1, Page 267

L-1 c) **Explain the difference between on grid and off grid solar PV systems? 4 Marks**

Refer Guidebook-1, Page 268 & 269

L-2 a) **Explain how Ozone layer is beneficial to life on earth and how it is getting destroyed? 5 Marks**

Refer Guidebook-1, Page 238 & 239

L-2 b) **What are the adverse effects of the melting of mountain glaciers on the eco system? 3 Marks**

It disturbs the ocean eco-system. Fresh water from melting ice caps desalinates the oceans besides raising the sea levels and flooding the low-lying areas near to coast/river beds. This will disturb the ocean currents which regulate the temperature. Also, the cooling property of white ice caps which reflect heat back into space is curtailed, thus contributing to further warming of the earth.
Refer Guidebook-1, Page 247

L-2 c) **State the advantages and limitations of IRR as a tool for project financial analysis 2 Marks**

Refer Guidebook-1, Page 172

L-3 a) **In a cement plant the various forms of energy consumed are mentioned in the table below:**

Source of Energy	Qty	Heat Value
Pet Coke consumed in kiln	200 TPD	6500 kcal/kg
HSD consumed in the plant	5 kL/day	10200 kcal/kg
Electricity purchased from Grid	80000 kWh/day	860 kcal/kWh
Electricity "generated" from CPP	2 MW	
Heat rate of CPP		3770 kcal/kWh
Load factor of CPP	90 %	
GCV of Coal		4000 kCal/kg
Density of HSD	0.9 kg/L	
Annual operating days of the plant	330 Days/yr	

Calculate the following:

i. **Total energy input in kcal per day 2 Marks**

Source of Energy	Qty	Heat Value	Formula

	Pet Coke consumed in kiln	200	TPD	6500	kcal/kg	= 200*1000*6500 = 1300000000 kcals/day
	HSD consumed by earth moving equipment	5	kL/day	10200	kcal/kg	= 5*1000*0.9*10200 = 45900000 kcals/day
	Electricity purchased from Grid	80000	kWh/day	860	kcal/kWh	= 80000*860 = 68800000 kcals/day
	Electricity generated from CPP	2	MW			
	Heat rate of CPP			3770	kcal/kWh	
	Load factor of CPP	90	%			
	Density of HSD	0.9	kg/L			
	Annual operating days of the plant	330	Days/yr			
	Heat input to CPP	= (2 MW*1000) *Load Factor, 0.9* CPP Heat Rate 3770* 24 hrs/d				= 162864000 kcals/day
	Total heat input per day	= 1300000000 +45900000+68800000+162864000				= 1577564000 kcals/day

ii. **Annual energy input in TOE (Tonnes of Oil Equivalent)** **3 Marks**

$$Annual\ TOE = \frac{1577564000}{10^7} \times 330 = 52060\ TOE/annum$$

iii. **Coal consumption per day for CPP in TPD** **4 Marks**

$$Coal\ requirement\ for\ CPP = \frac{CPP,MW\ \times 1000\ \times CPP\ Load\ factor\ \times CPP\ Heat\ Rate}{GCV\ of\ Coal\ \times 1000}$$

$$= \frac{2\ \times 1000\ \times 0.9\ \times 3770}{4000\ \times 1000} = 1.697\ TPH$$

$$Coal\ Requirement\ for\ CPP\ per\ day = Coal\ requirement\ for\ CPP\ per\ hour\ \times 24$$

$$= 1.697 \times 24 = 40.716\ TPD$$

iv. **Whether the unit qualifies as a designated consumer or not?** **1 Mark**

As the annual consumption is greater than 30,000 TOE for a cement plant, this unit will be considered as a Designated consumer.

L-4 a) **In a food processing plant, the monthly production related variable energy consumption was 1.9 times the production and the non-production related fixed energy consumption was 14,000 kWh per month upto December of the previous year. In the month of January, a series of energy conservation measures were implemented. Using CUSUM technique, develop a table and calculate the energy savings for the subsequent 6 months period upto the month of June from the data given below:** **7 Marks**

Month	Production (kg)	Actual Energy Consumption (kWh)
Jan	62000	113600
Feb	71000	139000
Mar	75000	158000
Apr	59000	119300
May	62000	123700
Jun	73000	143600

L4 a

Month	Production	Actual energy	Predicted energy	Ea-Ep	CUSUM

	(P)	consumption (Ea)	Consumption (Ep) =1.9*P+14000		
Jan	62000	113600	131800	-18200	-18200
Feb	71000	139000	148900	-9900	-28100
Mar	75000	158000	156500	1500	-26600
Apr	59000	119300	126100	-6800	-33400
May	62000	123700	131800	-8100	-41500
Jun	73000	143600	152700	-9100	-50600

L-4 b) **Mention three commonly used financial tools for evaluating economic viability of an energy conservation measure? 3 Marks**

L4 b) 3 main tools used are:

- Pay-back period
- Return on Investment
- Present value method

L-5 **A company invests Rs.12 lakhs and completes an energy efficiency project at the beginning of year 1. The firm is investing its own reserve money and expects an internal rate of return (IRR) of at least 12% on constant positive annual net cash flow of Rs. 3 lakhs, over a period of 5 years, starting with year 1.**

L-5 a) **Will the project meet the firm's expectations? 3 Marks**

Use the NPV formula with d = 0.12 and check to what extent NPV > 0 at n = 5 years.

	Cash out flow	Cash in flow
Year 0	-1200000	0
Year 1		300000
Year 2		300000
Year 3		300000
Year 4		300000
Year 5		300000

NPV for 12% discount rate

$$= -1{,}200{,}000 + \frac{300{,}000}{1.12^1} + \frac{300{,}000}{(1.12)^2} + \ldots\ldots\frac{300{,}000}{(1.12)^5}$$

= - 1,200,000 + 267857.1+239158.2+213534.1+190655.4+170228.1= (-) 118567

From the table above it is seen that, NPV is negative at 12%, and the project will not meet the firm's expectations. (3 marks)

L-5 b) **What is the IRR of this measure? (Use the interpolation formula for obtaining the nearest IRR value, interpolation formulae is**

$$= (\textit{lower discount rate}\ \%) + \left\{\frac{(\textit{NPV at Lower discount rate}) \times (\textit{Higher discount rate}\ \% - \textit{Lower discount rate}\ \%)}{(\textit{NPV at Lower discount rate} - \textit{NPV at Higher discount rate})}\right\}$$

7 Marks

This means that the IRR of 12% must be selected smaller in order to have NPV = 0

The iterations for NPV at discount rates of 8%, 7% and 7.929% is given below:

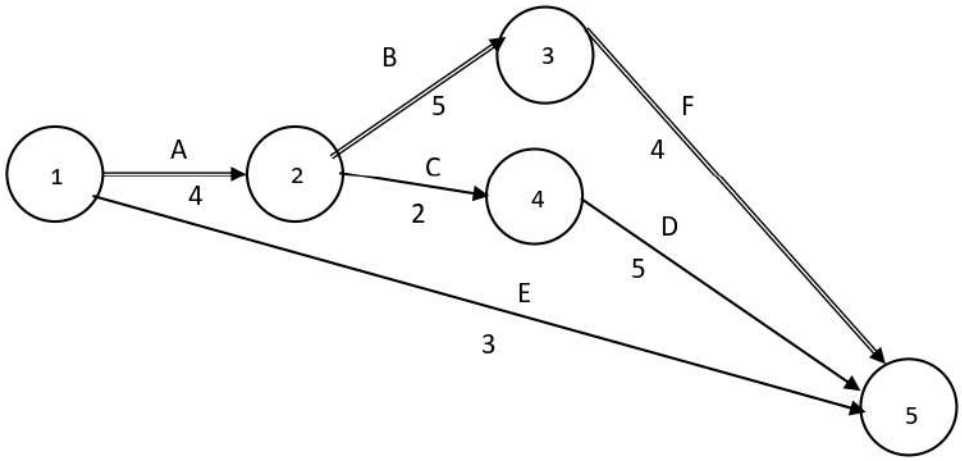
Discount Rate							
12%		8%		7%		7.929%	
0.12		0.08		0.07		0.07929	
Cash Flow	Year Ref	Cash Flow	Year Ref	Cash Flow	Year Ref	Cash Flow	Year Ref
-1200000	0	-1200000	0	-1200000	0	-1200000	0
267857.1	1	277777.8	1	280373.8	1	277960.5	1
239158.2	2	257201.6	2	262031.6	2	257540.2	2
213534.1	3	238149.7	3	244889.4	3	238620	3

190655.4	4		220509	4		228868.6	4		221089.8	4
170228.1	5		204175	5		213895.9	5		204847.4	5
-118567			-2186.99			30059.23			57.82047	

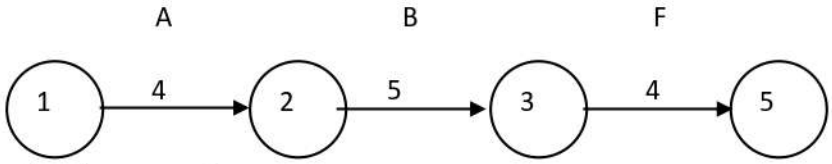
By iterations for total NPV at 12%, 8%,7% & 7.9%, the NPV is tending towards zero between 7.5 to 7.9% discount rate.

L-6 a) **Construct a CPM diagram for the data given below** **4 Marks**

Activity	Precedent	Time, weeks
A	Start	4
B	A	5
C	A	2
D	C	5
E	Start	3
F	B	4
Finish	D, E, F	--



L-6 b) **Identify the critical path** **2 Marks**



Total time on critical path: 13 weeks

L-6 c) **Also compute the earliest start, earliest finish, latest start & latest finish of all activities** **4 Marks**

Early start (ES), Early Finish (EF), Latest start (LS), Latest finish (LF) are:

S.no	Activity	Duration	ES	EF	LS	LF
1	A	4	0	4	0	4
2	B	5	4	9	4	9
3	C	2	4	6	6	8
4	D	5	6	11	8	13
5	E	3	0	3	10	13
6	F	4	9	13	9	13

..... End of Section III .....

Paper 1 Code : GREEN

20th NATIONAL CERTIFICATION EXAMINATION FOR ENERGY MANAGERS & ENERGY AUDITORS – September, 2019

PAPER – 1: General Aspects of Energy Management & Energy Audit

Section - I: OBJECTIVE TYPE **Marks: 50 x 1 = 50**

1.	Which of the following statement is true regarding the EC act? a) **Designated consumers have to appoint Energy managers with prescribed qualifications.** b) State Designated Agencies have to appoint Energy auditor with prescribed qualifications. c) Designated consumer has to get an energy audit conducted by a certified energy Manager. d) Designated consumer has to get an energy audit conducted by the State Designated Agency
2.	Which of the following statements regarding evacuated tube collectors (ETC) are true? i) ETC can reach high temperatures upto 150°C ii) because of vacuum between two concentric glass tubes, higher amount of heat is retained in ETC iii) heat loss due to conduction back to atmosphere from ETC is high iv) performance of evacuated tube is highly dependent upon the ambient temperature a) i & iii b) ii & iii c) i & iv **d) i & ii**
3.	How much power you would expect to generate from a river-based mini hydropower with flow of 40 litres/second, head of 12 metres and system efficiency of 55%. a) 872 kW **b) 2.59 KW** c) 264 kW d) none of the above
4.	Which among the following has the highest flue gas loss on combustion due to Hydrogen in the fuel? **a) Natural gas** b) furnace oil c) coal d) light diesel oil
5.	Energy in one Tonne of Oil Equivalent (toe) corresponds to a) 4.187 GJ b) 1.162 MWh c) 10,000 kcal **d) none of the above**
6.	Assume CO_2 equivalent emissions by the use of a 40 W fluorescent lamp are of the order of 60 g/hr. If it is replaced by a 20 W LED lamp then the equivalent CO_2 emissions will be a) nil, as LED does not emit CO_2 **b) 30 g/hr** c) 20 g/hr d) 1200 g/hr
7.	Under the Energy Conservation Act, the designated consumer is required to get the mandatory energy audit conducted by a) certified energy manager b) certified energy auditor c) **accredited energy auditor** d) BEE
8.	Stroboscope is an instrument for measuring a) steam flow b) composition of flue gas c) **speed** d) pressure
9.	The benchmarking parameter for a vapour compression refrigeration system is a) kW / kg of refrigerant used b) kcal / m^3 of chilled water c) BTU / TR d) **kW / TR**
10.	If 1 kWh of electrical energy is used to heat 10 kg of ice at 0° C, what will be the temperature of water after melting? (Latent heat of fusion of ice is 80 kcal/kg) a) 0°C **b) 6°C** c) 86°C d) none of the above
11.	If feed of 15 tonnes per hour at 6% concentration is fed to an evaporator, the product obtained at

	30% concentration is equal to ____ tonnes per hour. **a) 3** b) 9 c) 0.9 d) 4.5
12.	The discount rate is used as an input in determining _____. **a) NPV** b) IRR c) payback period d) all of the above
13.	The rate of energy transfer from a higher temperature to a lower temperature is measured in a) kcal **b) Watt** c) Watts per second d) none of the above.
14.	The cost of an economizer is Rs. 2 lakhs. The simple payback period (SPP) in years considering annual savings of Rs 1,10,000 and annual maintenance cost of Rs 10,000 is _____. a) 1.8 b) 2.5 **c) 2** d) 0.5
15.	1 kg of wood contains 15% moisture and 5% hydrogen by weight. How much water is evaporated during complete combustion of 1kg of wood? **a) 0.6 kg** b) 200 g c) 0.15 kg d) none of the above
16.	In an industry the average electricity consumption is 10 lakh kWh for a given period. The average production is 90,000 tons with a specific electricity of 10 kWh/ton for the same period. The fixed electricity consumption for the plant is **a) 1,00,000 kWh** b) 9,90,000 kWh c) 10,000 kWh d) none of the above
17.	The cost of retrofitting a humidification system with an energy efficient one costs Rs. 20 lakhs. The net annual cash flow is Rs. 5 lakhs. The return on investment is _____. 18% **b) 25%** c) 15% d) 33.33%
18.	The theoretical amount of electricity required to heat 500 litres of brine solution with a specific gravity of 1.2 and specific heat of 1 kcal/kg K from 30^{o}C to 70 ^{o}C through resistance heating is_____ a) **27.9 kWh** b) 23.3 kWh c) 20 kWh d) none of the above
19.	In project financing, sensitivity analysis is applied because a) almost all the cash flows involve uncertainly b) it evaluates how sensitive the project is to change in the input parameters c) it assesses the impact of 'what if one or more factors are different from what is predicted' d) **it is applicable to all the above situations**
20.	A process requires 120 kg of fuel with a calorific value of 4800 kcal/kg for heating with a system efficiency of 82 %. The loss would be_____. 576000 kcal b) 472320 kcal c) **103680 kcal** d) 480000 kcal
21.	Which of the following is true? **a) The internal rate of return is the discount rate for which the NPV is Zero** b) NPV is the internal rate of return for which the discount rate is Zero c) The discount rate is the internal rate of return for which NPV is positive d) NPV is the discount rate for which internal rate of return is positive
22.	Having energy policy _____ a) satisfies regulations b) **shows top management commitment** c) indicates energy audit skills d) Ensures ISO 50001 certification
23.	Which of the following is **not true** of fuels cells? a) **they consume electricity** b) they are fuelled by hydrogen c) they have an electrolyte c) produce water and heat

24.	Which of the following has the highest Reserve to Production (R/P) ratio in India? a) Lignite b) Petroleum **c) Coal** d) Natural gas
25.	SI unit for energy is_____ a) Watt b) Kilogram c) Newton d) **Joule**
26.	Which of the following has the lowest energy content in terms of MJ/kg? a) LPG b) Diesel c) Furnace Oil d) **Coal**
27.	Which of the following industries has the highest Specific Electrical Energy Consumption? **a) Aluminum** b) Sugar c) Paper & Pulp d) Cement
28.	Select the wrong statement. a) Energy Efficiency and Energy Conservation are distinct and interrelated b) **Unscheduled power interruption is an Energy conservation measure** c) Productivity improvements leads to energy conservation d) Energy Efficiency is an integral part of energy conservation
29.	_____ in Centre and_____ _ in States are mandated to implement the provisions of The Energy Conservation Act, 2001 a) BEE and NPC b) BEE and DISCOM c) BEE and SERC d) **BEE and SDA**
30.	Energy Conservation Building Code (ECBC) sets; **a) Minimum Energy Efficiency Standards for design and Construction of Buildings** b) Green Building Rating System c) Municipal DSM Regulations d) Incentives for energy efficient buildings
31.	Which of the following is one of the schemes of BEE under Energy Conservation Act ? **a) Standards and Labelling** b) Availability based Tariff c) Standard of Performance of DISCOMs d) Renewable Energy Certificates
32.	Which one of the following is **not** a Designated Consumer category under PAT ? a) Paper and Pulp Industries b) Cement Plants c) Chlor Alkali Plants d) **Sugar Plants**
33.	Steam contains 10% moisture by mass, its dryness fraction x is _____. 0.1 b. 1 c. **0.9** d. None of the above

34.	Which of the following has highest Global Warming Potential? a) **SF_6** b) CO_2 c) CH_4 d) N_2O
35.	Which of the following is **not** true? a) Primary energy is converted to secondary energy in industries **b) Secondary energy is converted to primary energy in industries** c) Coal is primary energy d) Electricity is secondary energy
36.	Which primary energy is used as a feedstock in fertilizer industry? a) Steam **b) Natural gas** c) Electricity d) All of the above
37.	Bio-gas generated through anaerobic process mainly consists of a) only methane b) M**ethane and carbon dioxide** c) only ethane d) only carbon dioxide
38.	Which of the following statements are true? i) Rice husk is a source of secondary energy ii) nuclear energy is non-renewable energy iii) electricity is basically a convenient form of primary energy iv) steam is a convenient form of secondary energy a) (ii) & (iii) b) (i) & (iii) **c) (ii) & (iv)** d) (ii) & (i)
39.	Trillion cubic meters is a unit normally used for a) Crude oil b) Lignite c) Bituminous coal d) **Natural Gas**
40.	Which of the following will have maximum value when expressed as MTOE (Metric Tonne of Oil Equivalent)? a) **1000 tonnes of furnace oil** **b)** 10,000 kWh of electrical energy b) 1000 tonnes of bituminous coal d) 1000 tonnes of lignite
41.	Which of the following is **not true** of natural gas? a) **Requires more excess air compared to oil** b) Consists mainly of methane c) Becomes liquefied when cooled to -161^oC d) All of the above
42.	In a boiler, substitution of coal with rice husk will definitely lead to_____. a) energy conservation b) energy efficiency c) both energy conservation and energy efficiency **d) GHG reduction**
43.	For determining the Energy intensity at the national level, which of the following are **not required?** (i) Gross domestic product (ii) Total final consumption, (iii) R/P ratio in years (iv) Prevailing prices of various fuels a) (i) & (iv) b) (i) & (ii) **c) (iii) & (iv)** d) (i) & (iv)
44.	A building intended to be used for commercial purpose will be required to follow Energy conservation building code under Energy Conservation Act, 2001 provided its a) connected load is 120 kW and above b) contract demand is 100 kVA and above **c) connected load is 100 kW and above or contract demand is 120 kVA and above** d) connected load is 500 kW and contract demand is 600 kVA
45.	Which of the following is true of DSM?

	a) results in energy and/or demand reduction b) enables end-users to better manage their load curve c) can improve the profitability of power supply company **d) All of the above**
46.	An induction motor with 11 kW rating and a rated power factor of 0.9 in its name plate means a) it will draw 12.22 kW at full load b) it will draw 11 kW at full load c) it will draw 9.9 kW at full load **d) it will deliver 11 kW at full load**
47.	The unit used for determining a designated consumer is _____. a) million tonnes of oil equivalent per year b) metric tonnes of oil equivalent per month **c) metric tonnes of oil equivalent per year** d) million tonnes of oil equivalent per month
48.	Which of the following statements are true regarding simple payback period? a) considers impact of cash flow even after payback period b) takes into account the time value of money c) considers cash flow throughout the project life cycle **d) determines how quickly invested money is recovered**
49.	Global warming will **not** result in_____ a) melting of the ice caps b) increasing sea levels **c) severe damage to ozone layer in stratosphere** d) unpredictable climate patterns
50.	The process of capturing CO_2 from point sources and storing them is called _____. a) **carbon sequestration** b) carbon sink c) carbon Capture d) carbon absorption

……. End of Section – I …….

Section – II: SHORT DESCRIPTIVE QUESTIONS **Marks: 8 x 5 = 40**

Each question carries **Five** marks

S1	An industry intends to invest Rs. 5,00,000 in a new energy saving project. The cash flows expected are: Year 1 : Rs.2,00,000 Year 2 : Rs.3,00,000 Year 3 : Rs.2,00,000 The expected return is 10%. Evaluate the Net Present Value and comment on the feasibility of the project? **Solution:** NPV = {-500,000+(200,000/1.10)+[300,000/$(1.1)^2$]+[200,000/$(1.1)^3$]} = (-500,000+181818+247934+150263) = 80015 NPV is positive Rs. 80,015; therefore, the proposed investment for the new energy saving project is viable and attractive.

S2	Write short note on **<u>any one</u>** of the following. a) ISO 50001 **(Book 1 - Page 157 & 158)** b) Energy Security (**Book 1 - Page 20 to 22)**
S3	A continuous centrifuge separates 36,000 kg of whole milk containing 4% fat in 6-hour period into skim milk with 0.40% fat and cream with 40 % fat. Find out the flow rates of whole milk, cream and skim milk using mass balance. **Ans:** **Mass in** Total mass flow of whole milk = 36000/6 = 6000 kg per hour. Fat per hour = 6000 x 0.04 = 240 kg/hr. Therefore, Water plus solids other than fat = (6000-240) kg per hr. = 5760 kg per hr. **Mass out :** Let the mass of cream be X kg then its total fat content is 0.40X. The mass of skim milk is (6000 - X) and its total fat content is 0.0040 (6000 - X) **Material balance on fat:** Fat in = Fat out 6000 x 0.04 = 0.0040(6000 - X) + 0.40X; solving this, X = 545 kg/hr So that the flow of cream is 545 kg / hr and skim milk (6000- 545) = 5455 kg/hr.
S-4	A water pumping station fills a tank at a fixed rate. The head and flow rate are constant and hence the power drawn by the pump is always same. The pump delivers 80 litres per second. The power consumption was measured as 84 kW. Calculate the energy consumption for pumping 2880 kL of water to the reservoir.
Ans	Time taken to pump water in hours = $\frac{(2880 \times 10^3 \text{ lit})}{(80 \text{ lit/s} \times 3600 \text{ sec/hr})}$ = 10 hours Power required to pump water = 84 kW Energy consumption = 84 x 10 hrs = 840 kWh
S-5	A conveyor delivers coal with a width of 0.9 m and coal bed height of 0.15 m at a speed of 0.8 m/s. Determine the coal delivery in tons per hour considering the coal density as 1.1 ton/m^3.
Ans	Volume of coal delivered per hour = Area x Length travelled per second = 0.9 m x 0.15 m x 0.8 m/s

	= 0.108 m^3/s = 0.108 x 3600 = 388.8 m^3/hr Coal delivery rate = 388.8 m^3/hr x 1.1 t/m^3 = 427.7 tonnes/hr
S-6	In a textile industry, 25,000 kg/hr water is currently being heated from 28 ^oC to 80 ^oC by indirect heating of steam in dyeing machines. It is proposed to recover heat from the hot effluent and generate hot water at 45 ^oC which would be further raised to 80 ^oC by steam. Estimate the reduction in steam in kg/hr considering the latent heat of steam as 520 kcal/kg in both the cases.
Ans	**Ans:** **Without heat recovery** Heating required (Q_1) = $mC_p\Delta T$ = 25000 x 1 x (80-28) = 13,00,000 kcal/hr Steam required = 13,00,000 / 520 = 2500 kg/hr **After heat recovery** Heating required (Q_2) = 25000 x 1 x (80 – 45) = 8,75,000 kcal/hr Steam required = 8,75,000 / 520 = 1682.7 kg/hr Reduction in steam required = 2500 - 1682.7 = 817.3 kg/hr
S7	Briefly explain the difference between flat plate collector and evacuated tube collector. **(Book 1, Page 264-265)**
S8	a) What is solar constant and solar insolation? **(3 Marks)** b) Which of them determines the amount of electrical energy that can be produced per unit area of solar panel on any given day? **(2 Marks)** **(Book 1, Page 263 – 264)**

------- End of Section - II ---------

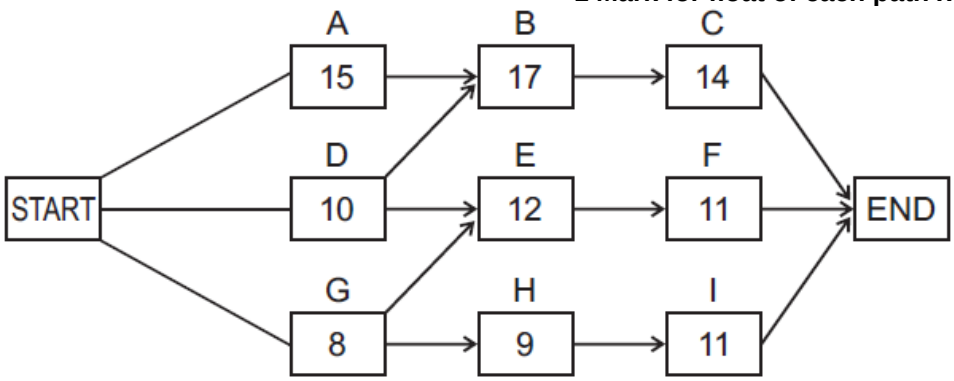
Section – III: LONG DESCRIPTIVE QUESTIONS Marks: 6 x 10 = 60

(i) Answer all **Six** questions
(ii) Each question carries **Ten** marks

L1	a) A sample of fuel being used in a boiler is found to contain 40% carbon and 23% ash. The refuse obtained after combustion is analyzed and found to contain 7% carbon & the rest is ash. Compute the percentage of the original carbon in fuel which remains as unburnt in the refuse. (5 Marks) b) During an ESP performance evaluation study, the inlet gas stream to ESP is 2,89,920 Nm3/hr and the dust loading is 5,500 mg/ Nm3. The outlet gas stream from ESP is 3,01,100 Nm3/hr and the dust loading is 110 mg/Nm3. How much fly ash is collected in the system in kg/hr? (5 Marks)
	a) Let the quantity of Refuse sample = 100 kg Amount of unburnt Carbon in Refuse = 7 kg Amount of Ash in the Refuse = 93 kg Total ash in the fuel that has come into the Refuse = 23% of fuel 93 kg of Ash corresponds to 23% ash in the fuel Therefore, quantity of total raw fuel = 93 / 0.23 = 404.35 kg Quantity of original Carbon in the fuel = 0.40 x 404.35 = 161.74 kg Quantity of unburnt fuel in Refuse = 7 kg %age of the original carbon unburnt in the refuse = (7 / 161.74) x 100 = 4.32% b) Based on Mass balance, Inlet gas stream dust = Outlet Gas stream dust + Fly ash i) Inlet gas stream flow = 289920 NM3/hr Dust Concentration = 5500 mg/NM3 Inlet dust quantity = 289920 x 5500 / 1000000 = 1594.56 kg/hr ii) Outlet dust quantity = 301100 (NM3/hr) x 110 (mg/NM3) x 1 / 1000000 = 33.12 kg/hr iii) Fly Ash = Inlet gas stream dust – Outlet gas stream dust = 1594.56 – 33.12 = 1561.44 kg/hr
L2	Write short note on **<u>any two</u>** of the following. (Each 5 Marks) a) Benchmarking, **(Book 1, Page 98 – 100)** b) DSM, **(Book 1, Page 38)** c) TPM, **(Book 1, Page 154 – 155)**

L3 Based on the following network diagram, identify the total number of paths with duration, critical path, and float for each path.

1 Mark each path x 5 = 5 Mark
1 Mark for identifying critical path = 1 Mark
1 Mark for float of each path x 4 = 4 Mark



Solution:

The above network diagram has five paths; the paths and their duration are as follows:

Start -> A -> B -> C-> End, duration: 46 days.
Start ->D -> E ->F -> End, duration: 33 days.
Start -> D -> B -> C -> End, duration: 41 days.
Start -> G ->H ->I -> End, duration: 28 days.
Start -> G -> E ->F -> End, duration: 31 days.

Since the duration of the first path given below is the longest, it is the critical path.

Start -> A -> B -> C-> End, duration: 46 days.

The float on the critical path is zero.

The float for the second path "Start ->D -> E ->F -> End" =
Duration of the critical path – duration of the path "Start ->D -> E ->F -> End" = 46-33 = 13
Hence, the float for the second path is 13 days.

Using the same process, we can calculate the float for other paths as well.
Float for the third path = 46 – 41 = 5 days.
Float for the fourth path = 46 – 28 = 18 days.
Float for the fifth path = 46 – 31 = 15 days.

L4 In the washing process of an automobile plant, electricity is being used to heat 5000 litres/hr of water by 8 ^{0}C. The industry is planning to convert from Electrical heating to LPG heating.

Other Parameters:

Annual operating hours	= 6000 hours
Efficiency of indirect heating with LPG	= 85%
Efficiency of electrical heating	= 95%
Calorific value of LPG	= 12,000 kcal/kg
Landed cost of LPG	= Rs.60/kg
Cost of electricity	= Rs.8/kWh

a) If electrical heating is replaced with LPG heating, with an investment is Rs.15 lakhs, compute the simple payback period. (6 Marks)
b) Also, calculate the CO_2 emissions in both the cases considering the emission factors for LPG as 3

	tons of CO_2/Ton of LPG and Electricity as 0.81 tons of CO_2/MWh. (4 Marks)
Ans	a). Water flow rate = 5000 Litres/hr Temperature rise = 8 ^oC Useful Heat Required = (5000 x 1 X 8) = 40,000 kcal/hr Equivalent LPG consumption = 40000/(12000 x 0.85) = 3.92 kg/hr Hourly Cost of Operating with LPG = 3.92 x 60 **= Rs.235 / hr** Equivalent electricity consumption = 40000/ (860 * 0.95) = 48.96 kW Hourly Cost of operating with electricity = 48.96 x 8 **= Rs.391.68/ hr** Difference in hourly operating cost = Rs. (391.68 – 235) = Rs.156.68/ hr Annual monetary savings = Rs.156.68/ hr x 6000 hrs/yr = Rs.9,40,080/ yr Investment = Rs.15,00,000 Simple payback period = Rs. 15,00,000/ Rs.9,40,080/ yr = 1.6 yr a) Annual CO_2 Emission with electrical heating = 48.96 kW x 6000 x (0.81 kg CO_2/kWh) = 237946 kg CO_2/ yr = 237.95 tonnes CO_2/ yr Annual CO_2 emission with LPG heating = 3.92 kg LPG/hr x 6000 hr/yr x (3 kg CO_2/kg LPG) = 70560 kg CO_2/yr = 70.6 tonnes CO_2/yr Thus, by converting from electricity to LPG use, there is a huge advantage, not only in operating cost but also in reduced CO_2 emissions.
L5	A company has got the following two energy saving project investment options: <u>Option A:</u> Investment envisaged is Rs. 40 lakhs with an annual return of Rs. 12 lakhs; life of the project is 5 years. Calculate IRR. <u>Option B</u>: A project having IRR of 12% **Which option should the company select?**
	<u>Option A:</u> Investment = Rs. 40 lakh Annual Return = Rs. 12 lakh Life of project = 5 years 0 = (-) 40 + (12) [1/ $(1 + i)^1$ + 1/ $(1 + i)^2$ + 1/ $(1 + i)^3$ + 1/ $(1 + i)^4$ + 1/ $(1 + i)^5$] IRR **= 15.24 %** Based on IRR, the Option A has higher IRR value and the company may opt for Option A.

L6 Match the following:

1.	Biomass	a.	Radiation
2.	CNG	b.	Distribution Loss Reduction
3.	HVDS	c.	Oxidation
4.	Cement	d.	Sankey Diagram
5.	Combustion	e.	ISO 50001
6.	Energy Balance	f.	Designated consumer
7.	kWh/ton of product	g.	Transport
8.	Objectives, targets & action plans	h.	Carbon neutral
9.	Performance Contracting	i.	Benchmarking
10	Surface Heat Loss	j.	ESCO

(Each 1 Mark)

Solution:

1. Biomass : Carbon neutral
2. CNG : Transport
3. HVDS : Distribution Loss Reduction
4. Cement : Designated consumer
5. Combustion : Oxidation
6. Energy Balance : Sankey Diagram
7. kWh/ton of product : Benchmarking
8. Objectives, targets & action plans : ISO 50001
9. Performance Contracting : ESCO
10. Surface Heat Loss : Radiation

-------- End of Section - III ---------

19th NATIONAL CERTIFICATION EXAMINATION
FOR
ENERGY MANAGERS & ENERGY AUDITORS – SEPTEMBER, 2018

PAPER – 1: GENERAL ASPECTS OF ENERGY MANAGEMENT & ENERGY AUDIT

Section – I: OBJECTIVE TYPE

Marks: 50 x 1 = 50

(i) Answer all **50** questions
(ii) Each question carries one mark
(iii) Please hatch the appropriate oval in the OMR answer sheet **HB pencil only**, as per instructions

1.	Which among the following is not a renewable source of energy? a) Bagasse b) Rice husk c) **Nuclear** d) Wind
2.	What is shale Oil? a) **Sedimentary rock containing solid bituminous materials** b) Heavy black viscous oil combination of clay, sand, water and bitumen c) A form of naturally compressed peat d) combustible brownish-black sedimentary rock
3.	Which of the following has the lowest energy content in terms of MJ/kg a) LPG b) Diesel c) **Bagasse** d) Furnace oil
4.	_____ and _____ consume major share of Natural Gas consumption in India. a) Domestic sector and Transport sector b) Transport sector and Fertilizer Industry c) **Power Generation and Fertilizer Industries** d) Domestic Sector and Fertilizer Industries
5.	The sector consuming major share of energy in India a) Agriculture Sector b) Transport Sector c) **Industrial Sector** d) Domestic Sector
6.	Which of the following designated consumer has the lowest energy intensity? a) **Aluminium** b) Iron and Steel c) Cement d) Chlor alkali
7.	Which of the following is not a Demand Side Management measure? a) Implementing Time of the Day (ToD) Electricity Tariff b) **Maximizing fossil fuel based energy utilization** c) Replacement of inefficient electrical appliances d) Use of ice bank system
8.	Which of the following does not meet the Designated Consumer criteria? a) Pulp and Paper Industries with minimum annual energy consumption of 30,000 TOE. b) Cement Industries with minimum annual energy consumption of 30,000 TOE. **c) Chlor- Alkali Industries with minimum annual energy consumption of 7500 TOE.**

	d) Textile Industries with minimum annual energy consumption of 3000 TOE.
9.	The kW or HP of a motor given on the name plate indicates a) The shaft output of the motor at part load b) **The shaft output of the motor at full load** c) The input power to the motor at the best efficiency point d) The input power to the motor at any load
10.	Which of the following has the highest Specific Heat? a) Steel b) Aluminium c) Copper d) **Water**
11.	Heat transfer in an air cooled condenser occurs predominantly by a) conduction b) **convection** c) radiation d) none of the above
12.	Definition of Energy Audit as per EC Act does not include: a) **Creation of an Energy Management System (EnMS)** b) evaluation of Techno-economics c) Verification, monitoring and analysis of energy use d) Action plan required for energy saving
13.	The ISO standard for Energy Management System is a) ISO 14001 b) **ISO 50001** c) ISO 9001 d) ISO 18001
14.	To arrive at the relative humidity at a point we need to know_____of air a) dry bulb temperature b) wet bulb temperature c) enthalpy d) **both a & b**
15.	As per Energy Conservation Act, 2001 appointment of BEE Certified Energy Manger is mandatory for a) all State designated agencies b) all large Industrial consumers c) **all designated consumers** d) all commercial buildings
16.	A waste heat recovery system requires Rs. 50 lakhs investment and Rs. 2 lakhs per year to operate and maintain. If the annual savings is Rs. 22 lakhs, the payback period will be a) 2.28 years b) **2.5 years** c) 3 years d) 10 years
17.	~~What is the heat content of the 200 liters of water at **500ºC** in terms of the basic unit of energy in Kilo Joules~~ ~~a) 30000 b) 23880~~ ~~c) 10000 d) 41870~~ **Note: 1 Mark is awarded to all candidate who have attempted this question.**
18.	Which of the following GHGs has the longest atmospheric life time a) CH4 b) SF6 c) CFC d) **PFC**
19.	Which of the following is used for non-contact measurement of temperature a) Thermocouples b) **Infrared Thermometer** c) Leaf type contact probe d) All of the above
20.	The force field analysis in energy action planning considers a) Positive forces only b) negative forces only c) **Both negative and positive forces** d) no forces

21.	Which of the following equation is used to calculate the future value of the cash flow? a) NPV $(1 - i)^n$ b) NPV / $(1 - i)^n$ c) **NPV $(1 + i)^n$** d) NPV/ $(1 + i)^n$
22.	For investment decision, ROI must always be _____ prevailing interest rate. a) Lower than b) **Higher than** c) Equal to d) No relation
23.	Large scattering on production versus energy consumption trend line indicates a) **Poor process control** b) Inefficient equipment c) Inefficient process d) None of the above
24.	Frequency of energy audit for designated consumers is_____ a) once in a year b) once in two years c) **once in three years** d) Once in five years
25.	The rotor axis is aligned with the wind direction in a wind mill by _____ control a) **yaw** b) pitch c) disc break d) all of the above
26.	Producer gas basically comprises of a) **CO, H_2 and CH_4** b) Only CH_4 c) CO and CH_4 d) Only CO and H_2
27.	The lowest theoretical temperature to which water can be cooled in a cooling tower is a) Difference between DBT and WBT of the atmospheric air b) Average DBT and WBT of the atmospheric air c) DBT of the atmospheric air d) **WBT of the atmospheric air**
28.	In a solar thermal power station Molten salt is preferred as it provides an efficient low cost medium to store _____ energy a) Electrical b) **Thermal** c) Kinetic d) Potential
29.	From Voltage, Amps and Power factor given in the name plate of a motor, one can calculate _____. a) Rated output power b) Shaft power c) **Rated input power** d) Both (b) & (c)
30.	RPM of an electric motor is measured using ___. a) Ultrasonic meter b) **Stroboscope** c) Lux meter d) Rotameter
31.	If asset depreciation is considered, then net operating cash inflow would be a) **lower** b) higher c) no effect d) none of the above
32.	Which of the following comes under Capital cost in a project? a) Design cost b) Installation cost c) Commissioning cost d) **All of the above**
33.	Energy consumption per GDP is termed as ___. a) Energy factor b) **Energy intensity** c) Energy Efficiency index d) All of the above
34.	A three phase induction motor is drawing 10 Ampere at 440 Volts. If the operating

	power factor of the motor is 0.9 and the efficiency of the motor is 95%, then the mechanical shaft power of the motor is a) 3.76 KW b) 4.18 KW c) **6.51 KW** d) 7.21 KW
35.	For an activity in a project, Latest start time is 8 weeks and Latest finish time is 12 weeks. If the earliest finish time is 9 weeks, Slack time for the activity is ____. a) **3 weeks** b) 4 weeks c) 1 week d) none of the above
36.	The amount of CO_2 produced in complete combustion of 18 Kg of Carbon is _____. a) 50 b) 44 c) **66** d) 792
37.	Which mode of heat transfer does not require medium? a) Natural convection b) Forced convection c) **Radiation** d) Conduction
38.	If the fixed energy consumption of a company is 2000 kWh per month and the line slope of the energy (y) versus production (x) chart is 0.3, then the energy consumed in kWh per month for a production level of 60,000 tons/month is _____. a) 16,000 KWh b) 18,000 KWh c) 22,000 KWh d) **none of the above**
39.	Which technique takes care of time value of money in evaluation? a) payback period b) IRR c) NPV d) **Both (b) & (c)**
40.	The heat rate of a power plant is expressed as a) kWh/kg of steam b) **kCal/kWh** c) kg of steam / kg of fuel d) kWh / kVA
41.	Which equipment does not come under mandatory labelling program? a) Room Air conditioners b) Frost free refrigerator c) **Induction motors** d) Distribution transformer
42.	Furling speed of wind turbine indicates ____ a) **Cut out speed** b) Cut in speed c) Rated speed d) None of the above
43.	One Silicon cell in a PV module typically produces a) **0.5 V** b) 1 V c) 2 V d) 12 V
44.	The input to a fuel cell is. a) Electricity b) **Hydrogen** c) Oxygen d) All of the above
45.	The production factor is defined as the ratio of a) **current year production to the reference year production** b) current year production to the reference month production c) reference month production to the current month production d) reference year production to the current year production
46.	To reduce the distribution losses within a plant, the capacitors should be located a) **Closest to the load** b) Farthest from the load c) In the substation d) Before the billing meter
47.	Absolute pressure is measured as a) Gauge pressure – Atmospheric pressure

	b) **Gauge pressure + Atmospheric pressure** c) Gauge pressure / Atmospheric pressure d) none of the above
48.	The dryness (x) fraction of superheated steam is taken as a) x= 0 b) x= 0.9 c) x= 0.87 d) **x= 1**
49.	When the evaporation of water from a wet substance is zero, the relative humidity of the air is likely to be a) 0% b) **100%** c) 50% d) unpredictable
50.	Which of the following type of collector is used for low temperature systems? a) **Flat plate collector** b)Line focusing parabolic collector c) Parabolic trough collector d) None of the above

……. End of Section – I ……..…..

Section – II: SHORT DESCRIPTIVE QUESTIONS **Marks: 8 x 5 = 40**

(i) Answer all **Eight** questions
(ii) Each question carries **Five** marks

S-1	List five equipment and appliances covered under Standards and Labelling program.
Ans	**Refer BEE Guide Book 1- Page No 37**
S- 2	State true or false (each carries 1 mark) a) When it is raining, there is a substantial difference between the dry and wet bulb temperatures. b) The specific gravity of light diesel oil is given in kg/m^3 c) The major constituent of LNG is propane d) Evaporative cooling of space requires use of refrigerant R134a e) HSD needs preheating to increase viscosity
Ans	a) False b) False c) False d) False e) False
S – 3	For installing a recuperator in a furnace, the plant has assessed the following time estimates Optimistic Time : 2.5 weeks Most Likely Time : 3 weeks Pessimistic Time : 3.5 weeks Find out the "Expected Time", "Standard Deviation" and "Variance" to complete the activity (**2 +1.5+1.5 Marks**)

Ans	Expected time = (Optimistic Time + 4 X Most Likely Time + Pessimistic Time) / 6 = (2.5 + 4 x 3 + 3.5)/ 6 = 3 Standard Deviation = (3.5-2.5)/6 = 1/6 = 0.167 Variance = {(PT-OT/6)} ^{2} = 1 / 36 = 0.0278
S-4	A thermal power plant uses 0.72 kg of coal to generate one KWh of electricity. If the coal contains 38% carbon by weight, calculate the amount of CO_2 emission/KWh under complete combustion.
Ans	Amount of carbon present in coal = 0.72 * 38/100 = 0.2736 kg As per chemical reaction, C + O_2 = CO_2 1 kg of carbon generates 44/12 kg of carbon dioxide (CO2) under complete combustion Amount of CO2 generation while generating one KWh of electricity = 0.2736 * 44/12 = 1.0032 Kg/KWh
S-5	A solar photovoltaic power plant is installed with 350 Watts panel of size 1.5 m x 1.5 m in roof top area of a building having dimension of 9 m x 10m. If solar insolation is 1,000 W/m^2, calculate the panel conversion efficiency?
Ans	Area of solar cell = 1.5 x 1.5 = 2.25 m^2 Efficiency = (350 /(2.25 x 1000)) x 100 = 15.6 %
S – 6	A paint drier requires 75.4 m^3/min of air at 93°C, which is heated in a steam-coil unit. How many kg of steam at 4 bar does this unit require per hour? The density of air is 1.2 kg/m^3 and specific heat of air is 0.24 kcal/kg°C. The ambient temperature is 32°C.

Pressure bar	Temperature °C	Enthalpy kcal/kg		
		Water	Evaporation	Steam
4	143	143	510	653

Ans	Solution: Air flow rate = 75.4 m^3/min * 60 = 4524 m^3/hr Air flow rate = 4524 * 1.2 = 5428.8 kg/hr Sensible heat of air = m * Cp * ΔT = 5428.8 * 0.24 * (93-32) = 79477.6 kcal/hr Latent heat of Steam = 510 Kcal/kg Steam required = 79477.6 / 510 Steam required = 156 kg/hr

S – 7	An ESCO company is required to invest in a waste heat recovery project, which is expected to yield an annual saving of Rs.10,00,000 and the life of the equipment is 7 years. If the ESCO expects 30% IRR on this project, calculate the investment required to be made.
Ans	The PV of the Annual Savings of Rs.1,000,000 per year: $0 = -\frac{\text{Investment}}{(1+0.3)^0} + \frac{1000000}{(1+0.3)^1} + \frac{1000000}{(1+0.3)^2} + \frac{1000000}{(1+0.3)^3} + \frac{1000000}{(1+0.3)^4} + \frac{1000000}{(1+0.3)^5} + \frac{1000000}{(1+0.3)^6} + \frac{1000000}{(1+0.3)^7}$ or Investment = Rs.1,000,000/year (P/AIN Factor) = Rs.1,000,000/year (2.8021) = Rs. 2,802,100 Thus, we can pay Rs.2,802,100 for the Waste Heat Exchanger and still have a positive NPV.
S – 8	In a textile plant monthly energy consumption is 7,00,000 kWh of electricity , 40 kL of furnace oil (specific gravity=0.92) for thermic fluid heater, 360 tonne of coal for steam boiler and 10 kL of HSD (specific gravity= 0.885) for material handling equipment. Compute the energy consumption in terms of Metric Tonne of Oil Equivalent (MTOE) for the plant. Given Data: (1 kWh = 860 kcal, GCV of coal= 3450 kCal/kg, GCV of furnace oil= 10,000 kcal/kg, GCV of HSD= 10,500 kcal/kg, GCV of rice husk= 3100 kcal/kg, 1 kg oil equivalent = 10,000 kcal)
Ans	Aggregate Energy Use= (40000 x0.92x 10000) + (360000 x 3450) + (7, 00,000 x 860) + (10,000x 0.885 x 10,500). MTOE = $\frac{(36.8 \times 10^7) + (124.2 \times 10^7) + (60.2 \times 10^7) + (9.2925 \times 10^7)}{10^7}$ = 230.5 Metric Tonnes of Oil Equivalent per month Energy consumption of the textile plant = 230.5 x 12 = 2766 MTOE

……. End of Section – II …….

Section – III: LONG DESCRIPTIVE QUESTIONS Marks: 6 x 10 = 60

(i) Answer all **Six** questions
(ii) Each question carries **Ten** marks

<table>
<tr><td>L - 1</td><td>Describe the stages of Gasification of Biomass process with a pictorial diagram and reaction equations?</td></tr>
<tr><td>Ans</td><td>Refer BEE Guide Book 1- Page No 275-276</td></tr>
<tr><td>L – 2</td><td>a. Explain briefly three types of Performance Contracting? (6 Marks)
b. What are the drawbacks of ESCO? (4 Marks)</td></tr>
<tr><td>Ans</td><td>Refer BEE Guide Book 1- Page No.178</td></tr>
<tr><td>L - 3</td><td>a) Write down the steps for computing energy savings using CUSUM over a period. (4 Marks),
b) Develop a table using a CUSUM technique to calculate energy savings for 8 months period for a production level of 2000 MT per month. Refer to field data given in the table below. (6 marks)
<table>
<tr><th>Month</th><th>Actual SEC kWh/MT</th><th>Predicted SEC kWh/MT</th></tr>
<tr><td>May</td><td>1225</td><td>1250</td></tr>
<tr><td>June</td><td>1227</td><td>1250</td></tr>
<tr><td>July</td><td>1240</td><td>1250</td></tr>
<tr><td>Aug</td><td>1245</td><td>1250</td></tr>
<tr><td>Sep</td><td>1238</td><td>1250</td></tr>
<tr><td>Oct</td><td>1257</td><td>1250</td></tr>
<tr><td>Nov</td><td>1248</td><td>1250</td></tr>
<tr><td>Dec</td><td>1264</td><td>1250</td></tr>
</table></td></tr>
<tr><td>Ans</td><td>a) Steps for CUSUM analysis:
Refer BEE Guide Book 1 Page No. 229

b) Estimate the savings accumulated from use of the heat recovery system.
<table>
<tr><th>Month</th><th>Actual SEC kWh/MT</th><th>Predicted SEC kWh/MT</th><th>Difference (Actual SEC - Predicted SEC) kWh/MT</th><th>CUSUM Savings kWh/MT</th></tr>
<tr><td>May</td><td>1225</td><td>1250</td><td>-25</td><td>-25</td></tr>
<tr><td>June</td><td>1227</td><td>1250</td><td>-23</td><td>-48</td></tr>
</table></td></tr>
</table>

	July	**1240**	**1250**	**-10**	**-58**
	Aug	**1245**	**1250**	**-5**	**-63**
	Sep	**1238**	**1250**	**-12**	**-75**
	Oct	**1257**	**1250**	**+7**	**-68**
	Nov	**1248**	**1250**	**-2**	**-70**
	Dec	**1264**	**1250**	**+14**	**-56**

Positive savings i.e. savings in energy consumption over a period of eight months are 56 x 2000 = 112,000 kWh

L – 4 In a Chlor-Alkali plant, an evaporator was designed to concentrate 500 kg of liquor containing solids of 7% w/w (weight by weight) to 45% solids w/w in the output. Presently the output from evaporator has 30% solids w/w. The energy manager suggested overhauling the evaporator to achieve the design rate of solids w/w in the output. Calculate the percentage improvement in water removal in the evaporator after overhauling of the evaporator.

Ans

Amount of feed (input) to the evaporator = 500 Kg
Concentration of solids in feed = 7 wt%
Amount of solids in feed (input) = 500 * 7 /100
= 35 Kg

<u>Present scenario :</u>
Concentration of solids in product (output) = 30 wt% = 0.3
<u>Mass balance across the evaporator :</u>
Amount of product (output) from the evaporator = 35 / 0.3
= 116.7 Kg

Water vapour removed from the evaporator is = 500 – 116.7
= 383.3 Kg

<u>Design scenario :</u>
Concentration of solids in product (output) = 45 wt% = 0.45
<u>Mass balance across the evaporator :</u>
Amount of product (output) from the evaporator = 35 / 0.45
= 77.8 Kg

Water vapour removed from the evaporator is = 500 – 77.8
= 422.2 Kg

Incremental water removal achieved is = 422.2 – 383.3
= 38.9 Kg

% increase in water removal = 38.9 / 383.3 * 100
% improvement in water removal after overhaul = 10.14 %

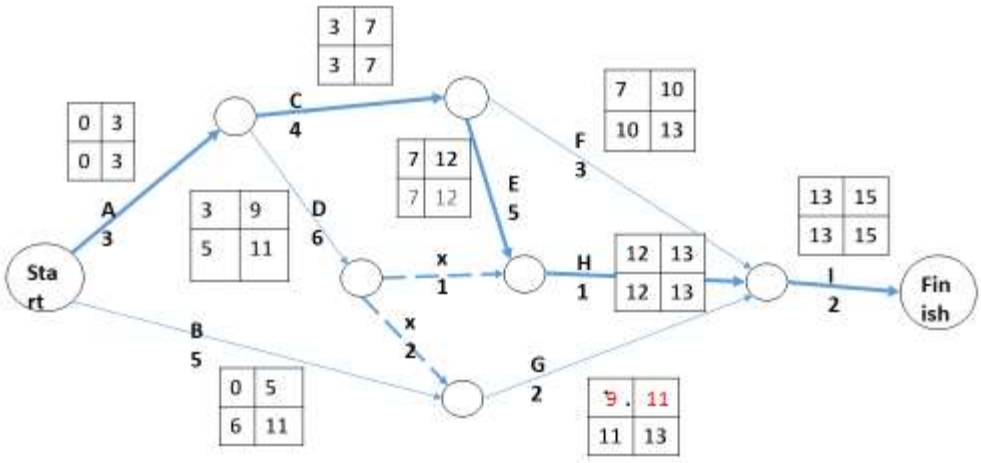
L -5 A process plant is planning to implement a waste heat recovery project. The various activities from procurement to commissioning are given in the table below along with their duration and dependency.

Activity	Predecessor	Time in Weeks
A.	-	3
B.	-	5
C.	A	4
D.	A	6
E.	C	5
F.	C	3
G.	B & D	2
H.	D & E	1
I.	F,G,H	2

a) Construct a PERT/CPM network diagram for the above project. **(5 Marks)**
b) Compute the earliest start, earliest finish, latest start, latest finish and slack for all the activities **(3 Marks)**
c) Compute the project duration. **(1 Mark)**
d) Identify the critical activities and the critical path(s). **(1 Mark)**

Ans

a) PERT/CPM network diagram for a project



b) Early start (ES), Early Finish (EF), Latest start (LS), Latest finish (LF) and slack for all the activities.

Activity	Duration	ES	EF	LS	LF	Slack (LS-ES) or (LF-EF)
A	3	0	3	0	3	0
B	5	0	5	6	11	6
C	4	3	7	3	7	0
D	6	3	9	5	11	2
E	5	7	12	7	12	0

F	3	7	10	10	13	3
G	2	9	11	11	13	2
H	1	12	13	12	13	0
I	2	13	15	13	15	0

X1 and X2 are dummy activities

c) Critical Path : A- C- E- H- I

d) Total time on critical path (project duration) : 15 weeks

L- 6

A medium size chemical plant receives electricity from grid and also generates electricity from coal based Captive Power Plant (CPP). Coal is also used for process requirements. The fine coal from CPP is sold to neighboring plant. The annual energy details are given below:

Electricity purchased from grid	5 MU
Electricity exported to grid	11 MU
Power generation from CPP	36 MU
Power Supplied from CPP to Process plant	25 MU
Fine coal sold to neighboring unit	1000 ton
Coal used for process plant	5000 ton
GCV of coal	4500 kcal/kg
Heat rate of CPP	3500 kcal/kWh
Annual Operating Hours	7200

Calculate

a. Energy usage in TOE (Tons of oil equivalent) (5 Marks)
b. Coal used in CPP (3 Marks)
c. Calculate the CPP operating power in MW. (2 Marks)

Ans

Energy usage in TOE (Tons of oil equivalent)

- Grid electricity Imported = (5 x 10^6 kWh)x (860 kcal/kWh) = (+) 43 x 10^8 kcals/year
- Power generated from CPP = (36 x 10^6 kWh)x (3500 kcal/kWh) = (+) 1260 x 10^8 kcals/year
- Coal imported for process = (5000 x 10^3 kg)x (4500 kcal/kg) = (+) 225 x 10^8 kcals/year
- Power exported to grid = (11 x 10^6 kWh)x (3500 kcal/kWh) = (-) 385 x 10^8 kcals/year
- Coal fines exported to neighbour = (1000 x 10^3 kg)x (4500 kcal/kg) = (-) 45 x 10^8 kcals/year
- Net annual energy consumption = (43+1260+225)-(385+45) = (+) 1098 x 10^8 kcals/year

a. Energy usage in TOE = (1098 x 10^8 kcals/year) / (10^7) = 10980 MTOE
(1 MTOE = 10^7 kcals)

b. Coal used in CPP = ((36 x 10^6 kWh)x (3500 kcal/kWh)) / (4500 kcal/kg)
= 28 x 10^6 kgs Coal/ Year
= (28 x 10^6)/10^3 = 28000 Tons Coal/ Year

c. Calculate the CPP operating MW = (36 x 10^6 kWh/year)/ (7200 hrs/year)
= 5000 kW
= 5 MW

……. End of Section – III ……

18th NATIONAL CERTIFICATION EXAMINATION FOR ENERGY MANAGERS & ENERGY AUDITORS – September, 2017

PAPER – 1: GENERAL ASPECTS OF ENERGY MANAGEMENT & ENERGY AUDIT

Date: 23.09.2017 Timings: 0930-1230 HRS Duration: 3 HRS Max. Marks: 150

General instructions:

- *Please check that this question paper contains **11** printed pages*
- *Please check that this question paper contains **64** questions*
- *The question paper is divided into three sections*
- *All questions in all three sections are compulsory*
- *All parts of a question should be answered at one place*

Section – I: OBJECTIVE TYPE

Marks: 50 x 1 = 50

(i) Answer all **50** questions
(ii) Each question carries one mark
(iii) Please hatch the appropriate oval in the OMR answer sheet with Black Pen, as per instructions

1.	Which of the following is not a greenhouse gas ? a) CFCs **b) SO_2** c) PFC d) SF_6
2.	Bio-gas generated through anaerobic process mainly consists of a) only methane **b) methane and carbon dioxide** c) only ethane d) none of these
3.	In a boiler, fuel substitution of coal with rice husk results in a) energy conservation b) energy efficiency c) both energy conservation and energy efficiency **d) carbon neutrality**
4.	A building intended to be used for commercial purpose will be required to follow Energy conservation building code under Energy Conservation Act, 2001 provided its a) connected load is 120 kW and above b) contract demand is 100 kVA and above **c) connected load is100 kW and above or contract demand is 120 kVA and above**

	d) connected load is 500 kW and contract demand is 600 kVA
5.	Which of the following is not a part of energy audit as per the Energy Conservation Act, 2001? a) monitoring and analysis of energy use b) verification of energy use c) submission of technical report with recommendations **d) ensuring implementation of recommended measures followed by review**
6.	Which of the following criteria is a responsibility of Designated Consumer? a) designate or appoint an accredited Energy Auditor **b) adhere to stipulated energy consumption norms and standards as notified** c) submit the status of energy consumption information every three years d) conduct energy audit through a certified energy auditor periodically
7.	Which of the following is an energy security measure? a) fully exploiting domestic energy resources b) diversifying energy supply source c) substitution of imported fuels for domestic fuels to the extent possible **d) all of the above**
8.	Which of the following statements are true? i) reactive current is necessary to build up the flux for the magnetic field of inductive devices ii) some portion of reactive current is converted into work iii) the cosine of angle between kVA and kVAr vector is called power factor iv) the cosine of angle between kW and kVA vector is called power factor **a) i & iv** b) ii & iii c) i & iii d) iii & iv
9.	Which of the following statements regarding evacuated tube collectors (ETC) are true? i) ETC is used for high temperatures upto 150^{O}C ii) because of use of vacuum between two concentric glass tube, higher amount of heat is retained in ETC iii) heat loss due to conduction back to atmosphere from ETC is high iv) performance of evacuated tube is highly dependent upon the ambient temperature i & iii b) ii & iii c) i & iv **d) i & ii**

10.	Which among the following has the highest flue gas loss on combustion due to Hydrogen in the fuel? **a) natural gas** b) furnace oil c) coal d) light diesel oil
11.	Assume CO_2 equivalent emissions by the use of a 60 W incandescent lamp are of the order of 60 g/hr. If it is replaced by a 5 W LED lamp then the equivalent CO_2 emissions will be a) nil **b) 5 g/hr** c) 12 g/hr d) 300 g/hr
12.	The benchmarking parameter for a vapour compression refrigeration system is a) kW / kg of refrigerant used b) kcal / m^3 of chilled water c) BTU / Ton of Refrigeration **d) kW / Ton of Refrigeration**
13.	The rate of energy transfer from a higher temperature to a lower temperature is measured in a) kcal **b) Watt** c) Watts per second d) none of the above.
14.	Energy sources which are inexhaustible are known as a) commercial energy b) primary energy **c) renewable energy** d) secondary energy
15.	1 kg of wood contains 15% moisture and 5% hydrogen by weight. How much water is evaporated during complete combustion of 1kg of wood? **a) 0.6 kg** b) 200 g c) 0.15 kg d) none of the above
16.	The internal rate of return is the discount rate for which the NPV is a) positive **b) zero** c) negative d) less than 1
17.	As per Energy Conservation Act, 2001, a BEE Certified Energy Manger is required to be appointed/designated by the a) state designated agencies b) all industrial consumers **c) designated consumers** d) electrical distribution licensees
18.	The process of capturing CO_2 from point sources and storing them is called_____ **a) carbon sequestration** b) carbon sink c) carbon capture d) carbon adsorption
19.	Which of the following has the highest specific heat? a) lead b) mercury **c) water** d) alcohol
20.	The retrofitting of a variable speed drive in a plant costs Rs 2 lakh. The annual savings

	is Rs 0.5 lakh. The maintenance cost is Rs. 5,000/year. The return on investment is a) 25% **b) 22.5%** c) 24% d) 27.5%
21.	_____is a statistical technique which determines and quantifies the relationship between variables and enables standard equations to be established for energy consumption. **a) linear regression analysis** b) time-dependent energy analysis c) moving annual total d) CUSUM
22.	The power generation potential in mini hydro power plant for a water flow of 3 m^3/sec with a head of 14 meters and with a system efficiency of 55% is **a) 226.6 kW** b) 76.4 kW c) 23.1 kW d) none of the above
23.	Which of the following two statements are true regarding application of Kaizen for energy conservation? i) Kaizen events are structured for reduction of only energy wastes ii) Kaizen events engage workers in such a way so that they get involved in energy conservation efforts iii) Implementation of kaizen events takes place after review and approval of top management iv) In a Kaizen event, it may happen that small change in one area may result in significant savings in overall energy use **a) ii & iv** b) i & iii c) iii & iv d) i & iv
24.	The electrical power unit Giga Watt (GW) may be written as a) 1,000,000 MW **b) 1,000 MW** c) 1,000 kW d) 1,000,000 W
25.	The producer gas basically consists of a) Only CH_4 b) CO & CH_4 **c) CO, H_2 & CH_4** d) Only CO & H_2
26.	Which of the following statements is correct regarding 'float' for an activity? a) Time between its earliest start time and earliest finish time b) Time between its latest start time and latest finish time c) Time between latest start time and earliest finish time **d) Time between earliest finish time and latest finish time**
27.	The Energy Conservation Act,2001 requires that all designated consumers should get energy audits conducted periodically by a) certified energy manager b) certified energy auditor

	c) accredited energy auditor d) state Designated Agencies
28.	The term missing in the following equation $(kVA)^2 = (kVA \cos phi)^2 + (?)^2$ is a) cos phi b) sin phi **c) kVA sin phi** d) kVArh
29.	2000 kJ of heat is supplied to 500 kg of ice at 0^oC. If the latent heat of fusion of ice is 335 kJ/kg then the amount of ice in kg melted will be a) 1.49 b) 83.75 **c) 5.97** d) None of the above
30.	An electric heater draws 5 kW of power for continuous hot water generation in an industry. How much quantity of water in litres per min can be heated from 30^oC to 85^oC ignoring losses?. **a) 1.3** b) 78.18 c) 275 d) none of the above
31.	An electric heater consumes 1000 Joules of energy in 5 seconds. Its power rating is: **a) 200 W** b) 1000 W c) 5000W d) none of the above
32.	The quantity of heat required to raise the temperature of a given substance by 1 ^oC is known as: a) sensible heat b) specific heat **c) heat capacity** d) latent heat
33.	Which of the following parameters is not considered for external Bench Marking? a) scale of operation **b) energy pricing** c) raw materials and product quality d) vintage of technology
34.	A sling psychrometer is used to measure : a) only dry bulb temperature b) only wet bulb temperature **c) both a & b** d) relative humidity
35.	The number of moles of water contained in 36 kg of water is ---------- **a) 2** b) 3 c) 4 d) 5
36.	A process electric heater is taking an hour to reach the desired temperature while operating at 440 V. It will take ------- hours to reach the same temperature if the supply voltage is reduced to 220 V. a) 2 b) 3 **c) 4** d) 5
37.	In a manufacturing plant, following data are gathered for a given month: Production - 1200 pieces; specific energy consumption - 1000 kWh/piece; variable energy consumption - 950 kWh/piece. The fixed energy consumption of the plant for the month

	is ------- a) 6,000 kWh b)10,000 kWh c) 12,000 kWh **d) 60,000 kWh**
38.	Which of the following GHGs has the longest atmospheric life time? a) CO_2 b) CFC c) Sulfur Hexafluoride (SF_6) **d) perfluorocarbon (PFC)**
39.	The component of electric power which yields useful mechanical power output is known as a) apparent power **b) active power** c) reactive power d) none of the above
40.	An oil fired boiler is retrofitted to fire coconut shell chips. Boiler thermal efficiency drops from 82% to 70%. What will be the percentage change in energy consumption to generate the same output a) 12% increase b) 14.6% increase c) 17.1% decrease **d) 17.1% increase**
41.	A three phase induction motor is drawing 16 Ampere at 440 Volts. If the operating power factor of the motor is 0.90 and the motor efficiency is 92%, then the mechanical shaft power output of the motor is a) 12.04 kW **b) 10.09 kW** c) 10.97 kW d) None of the above
42.	The energy conversion efficiency of a solar cell does not depend on a) solar energy insolation **b) inverter** c) area of the solar cell d) maximum power output
43.	To maximize the combustion efficiency, which of the following in the flue gas needs to be done? a) maximize O_2 **b) maximize CO_2** c) minimize CO_2 d) maximize CO
44.	An indication of sensible heat content in air-water vapour mixture is a) wet bulb temperature b) dew point temperature c) density of air **d) dry bulb temperature**
45.	Which of the following is false? a) electricity is high-grade energy b) high grade forms of energy are highly ordered and compact **c) low grade energy is better used for applications like melting of metals rather than heating water for bath**

	d) the molecules of low grade energy are more randomly distributed than the molecules of carbon in coal
46.	Which of the following is not applicable to liquid fuels? a) the viscosity of a liquid fuel is a measure of its internal resistance to flow. b) the viscosity of all liquid fuels decreases with increase in its temperature **c) higher the viscosity of liquid fuels, higher will be its heating value** d) viscous fuels need heat tracing
47.	The cost of replacement of inefficient chiller with an energy efficient chiller in a plant was Rs. 10 lakh .The net annual cash flow is Rs 2.50 lakh .The return on investment is: a) 18% b) 20% c) 15 % **d) none of the above**
48.	Which one is not an energy consumption benchmark parameter? a) kcal/kWh of electricity generated **b) kg/ ^{o}C.** c) kW/ton of refrigeration d) kWh/kg of yarn
49.	The contractor provides the financing and is paid an agreed fraction of actual savings achieved. This payment is used to pay down the debt costs of equipment and/or services. This is known as a) traditional contract b) extended technical guarantee/service c) performance Contract **d) shared savings performance contract**
50.	In project financing ,sensitivity analysis is applied because a) almost all the cash flow methods involve uncertainty b) of the need to assess how sensitive the project to changes in input parameters c) what if one or more factors are different from what is predicted **d) all the above situation**

…… End of Section – I ……

Section – II: SHORT DESCRIPTIVE QUESTIONS **Marks: 8 x 5 = 40**

(i) Answer all **Eight** questions
(ii) Each question carries **Five** marks

S-1	Explain Time of Day (TOD) Tariff and how it is beneficial for the power system and consumers?
Ans	➢ In Time of the Day Tariff (TOD) structure incentives for power drawl during off-peak hours and disincentives for power drawl during peak hours are built in. Many

	electrical utilities like to have flat demand curve to achieve high plant efficiency. ➢ ToD tariff encourage user to draw more power during off-peak hours (say during 11pm to 5 am, night time) and less power during peak hours. Energy meter will record peak, off-peak and normal period consumption, separately. ➢ TOD tariff gives opportunity for the user to reduce their billing, as off peak hour tariff is quite low in comparison to peak hour tariff. ➢ This also helps the power system to minimize in line congestion, in turn higher line losses and peak load incident and utilities power procurement charges by reduced demand ***……..5 marks*** ***(each point consider 1.5 marks)***
S- 2	In a chemical factory where dyes are made, wet cake at 30 ^{O}C consisting of 60% moisture is put in a dryer to obtain an output having only 5% moisture, at atmospheric pressure. In each batch about 120 kgs of material is dried. a. The quantity of moisture removed per batch. b. What is the total quantity (sensible & latent) of heat required to evaporate the moisture, if the latent heat of water is 540 kcal/kg at atmospheric conditions, Ignore heat absorbed by the solids c. Find the quantity of steam required for the drying process (per batch), if steam at 4 kg/cm^2 is used for generating hot air in the dryer and the dryer efficiency is 80%. Latent heat of steam at 4 kg/cm^2 is 520 kcal/kg.
Ans	Given that • Qty of material dried per batch - 120 Kgs • Moisture at inlet - 60% a. The quantity of moisture removed per batch. • Water quantity in a wet batch - 120 x 0.6 = 72 Kgs. • Quantity of bone dry material - 120 – 72 = 48 Kgs. • Moisture at outlet - 5% • Total weight of dry batch output - 48/0.95 = 50.5 Kgs. • Equivalent water in a dry batch - 50.5 - 48 = 2.5 Kgs.

	• Total water removed in drying - 72 – 2.5 = 69.5 Kgs./batch …….1.5 marks b. The total quantity of heat required to evaporate the moisture. To evaporate the moisture at atmospheric pressure, the material has to be first heated up to 100 ^{O}C. The total heat required would be; Sensible heat - 72 x 1 x (100 – 30) = 5040 Kcal/batch Latent heat - 69.5 x 540 = 37530 Kcal/batch Total heat required - 5040 + 37530 = 42570 Kcal/batch …….2 marks c. The quantity of steam required for the drying process Dryer Efficiency - 80% Heat input to dryer - 42570/0.8 = 53212.50 Kcal/batch Latent heat in 4 Kg/cm^2 steam - 520 Kcal/Kg Steam quantity required - 53212.50 / 520 = 102.3 Kgs / batch …….1.5 marks
S-3	Explain PAT scheme and why it is a market based mechanism?
Ans	Perform, Achieve and Trade (PAT) Scheme is a market based mechanism to enhance cost effectiveness of improvements in energy efficiency in energy-intensive large industries and facilities, through certification of energy savings that could be traded. The genesis of the PAT mechanism flows out of the provision of the Energy Conservation Act, 2001 (amended in 2010). The key goal of PAT scheme is to mandate specific energy efficiency improvements for the most energy intensive industries in sectors as listed below. **Sector** 1. Aluminium 2. Cement 3. Chlor-Alkali 4. Fertilizer 5. Iron and Steel 6. Pulp and Paper 7. Textile 8. Thermal Power Plant

	The energy intensity reduction target mandated for each unit is depended on its operating efficiency and the specific energy consumption reduction target is less for those who are more efficient and more for the less efficient units. Further, the scheme incentivizes units to exceed their specified SEC improvement targets. To facilitate this, the scheme provides the option for industries who achieve superior savings to receive energy savings certificates for this excess savings, and to trade the additional certified energy savings certificates with other designated consumers who can utilize these certificates to comply with their specific energy consumption reduction targets. Energy Savings Certificates (ESCerts) so issued will be tradable at Power Exchanges. The scheme also allows units which gain ESCerts to bank them for the next cycle of PAT, following the cycle in which they have been issued. The number of ESCerts which would be issued would depend on the quantum of energy saved over and above the target energy savings in the assessment year. After completion of baseline audits, targets varying from unit to unit ranging from about 3 to 7% are set and need to be accomplished during the 3 year cycle; after which new cycle with new targets will be proposed. Failing to achieve the specific energy consumption targets in the time frame would attract penalty for the non-compliance under Section 26 (1A) of the Energy Conservation Act, 2001 (amended in 2010). For ensuring the compliance with the set targets, system of verification and check-verification will be carried out by empanelment criteria of accredited energy auditors. …….5 marks ***Refer Book 1: Pg no 40-41***
S-4	Give a short description about Availability Based Tariff (ABT).
Ans	Introduction of availability based tariff(ABT) and scheduled interchange charges for power was introduced in 2003 for interstate sale of power , have reduced voltage and frequency fluctuation • It is a performance-based tariff system for the supply of electricity by generators owned and controlled by the central government. • It is also a new system of scheduling and dispatch, which requires both generators and beneficiaries to commit to day - ahead schedule. • It is a system of rewards and penalties seeking to enforce day ahead pre-committed schedules, though variations are permitted if notified one and a half hours in advance. • The order emphasizes prompt payment of dues , non-payment of prescribed charges will be liable for appropriate action. …….5 marks

S –5

In a heat treatment shop, steel components are heat-treated in batches of 80 Tons. The heat treatment cycle is as follows;

- Increase temperature from 30 ^{O}C to 850 ^{O}C in 3 hours.
- Maintain 850 ^{O}C for 1 hour (soaking time).
- Cool the material to 60 ^{O}C in 4 hours.

a) Calculate the efficiency of the furnace, if the specific heat of steel is 0.12 kcal/kg^{O}C and fuel oil consumption per batch is 1400 litres.

- GCV of fuel oil - 10200 kcal/kg,
- Cost of fuel oil - Rs. 46,000/kL,
- Sp. gr. of fuel oil - 0.92.

b) Due to high cost of oil, the plant management decides to convert to a lower operating cost LPG fired furnace lined on the inside with ceramic fibre insulation and with an operating efficiency of 80%, for same requirement. The investment towards installation of the new furnace is Rs. 50 lakhs. Calculate the Return on Investment, if the plant operates two batches per day and 250 days in a year.

- Cost of LPG - Rs. 75/kg,
- GCV of LPG - 12500 kcal/kg.

Ans

Quantity of steel treated per batch - 80 Tons

a. Efficiency of Furnace:

Useful heat supplied to steel - 80000 x 0.12 x (850 – 30)
= 7872000 kcal/batch
…….1 mark

Total heat supplied by fuel - 1400 x 0.92 x 10200
= 13137600 kcal/batch

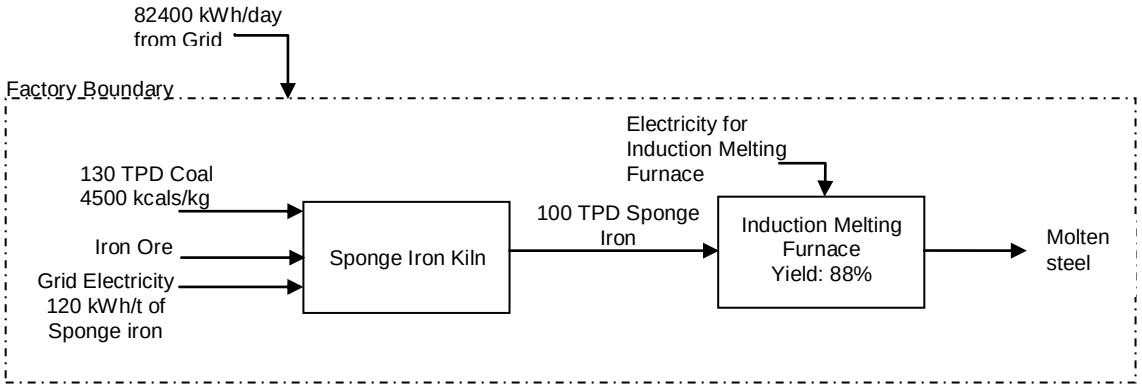
Efficiency of Furnace - 7872000/12067824 = 59.9%
…….1 mark

b. Return on Investment (RoI):

Cost of operating fuel oil furnace - 1400 x 46 = Rs. 64400/batch

Efficiency of new LPG furnace - 80%

Heat supplied in new LPG furnace - 7872000/0.8

	= 9840000 kcal/batch Equivalent LPG consumption - 9840000/12500 = 787.2 kg/batch …….1 mark Cost of operating LPG Furnace - 787.2 x 75 =Rs. 59040/batch Cost saving per batch - 64400 – 59040 =Rs. 5360/- Annual cost saving - 5360 x 2 x 250 =Rs. 26,80,000/- …….1 mark Investment for new furnace - Rs. 50 Lakhs Return on Investment (RoI) - (26.8/50)*100 = 53.6% …….1 mark
S – 6	In a 100 TPD Sponge Iron plant, the sponge iron is fed to the Induction melting furnace, producing molten steel at 88% yield. The Energy consumption details are as follows: Coal Consumption : 130 TPD GCV of coal : 4500 kcal/kg Power Purchased from Grid : 82400 kWh / day Specific Energy consumption for Kiln producing Sponge Iron: 120 kWh / ton sponge iron  Calculate the following 1. Specific Energy Consumption of Induction melting furnace in terms of kWh/ton of molten steel 2. Specific Energy Consumption of the entire plant, in terms of kcal/kg of molten steel (product). 3. Total Energy Consumption of Plant in Tons of Oil Equivalent (TOE)

Ans	a) Specific Energy Consumption of Induction Melting Furnace Molten Steel Production from the Induction melting furnace per day = 100 x 88/100 = 88 TPD Total Energy Consumption of the Plant = 82400 kWh Electrical Energy Consumption in Sponge Iron Making = 120 x 100 = 12000 kWh per day Electrical Energy Consumption in Induction Melting Furnace = 82400-12000 = 70400 kWh/day …….1 mark **Specific Energy Consumption of Induction Melting Furnace= 70400 / 88** **= 800 kWh/ton of molten steel** …….1 mark b)Total Energy Consumption of the Plant: (82400x860) + (130x1000x4500) = (70864000+585000000) = 655864000 kcal/day …….1 mark Specific Energy Consumption in terms of kcal/kg of Molten metal **=655864000/88000 =7453 kcal/kg of molten metal** …….1 mark c) Total Energy consumption of Plant in ToE **= 655864000/10^7 = 65.586 ToE** …….1 mark
S- 7	A manufacturing industry plans to improve its energy performance under PAT through implementation of an energy conservation scheme. After implementation, calculate the Plant Energy Performance (PEP) with 2015-16 as the reference year. What is your inference? Given that: • The current year (2016-17) Annual Production – 28,750 T , • Current year (2016-17) Annual Energy Consumption– 23,834 MWh, • Reference year (2015-16) production - 34,000 T, • Reference year (2015-16) Energy consumption - 27,200 MWh.
Ans	Production factor (PF) = 28750/34000 = 0.846 …….1 mark Ref year equivalent energy (RYEE) = Ref Year Energy Use (RYEU) x PF = 27,200 x 0.846= 23011MWh

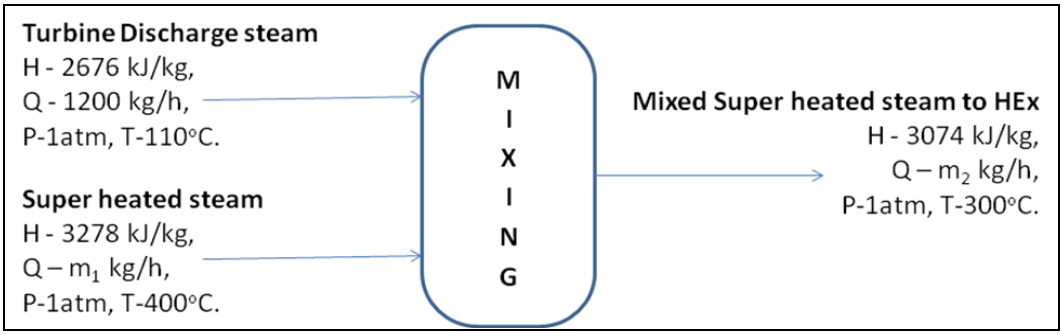
	……1 mark PEP = (RYEE – current year energy)/RYEE = (23011 – 23834)/23011 = (-) 0.0369 ie (-) 3.7 % ……1.5 marks Since the PEP is negative, it implies that the energy conservation measure did not yield reduction in energy consumption, action to be taken to improve the plant performance. ……1.5 marks
S-8	List down any five Designated Consumers notified under the Energy Conservation Act.
Ans	(1) Aluminium, (2) Cement, (3) Chloralkali, (4) Fertiliser, (5) Steel, (6) Pulp & Paper, (7)Thermal Power Plants, (8) Textile, (9) Railways. ……5 marks (any 5 of the above and each one carries one mark)

…… End of Section – II ……

Section – III: LONG DESCRIPTIVE QUESTIONS

Marks: 6 x 10 = 60

(i) Answer all **Six** questions
(ii) Each question carries **Ten** marks

L - 1	Saturated steam at 1 atm is discharged from a turbine at 1200 kg/h. Superheated steam at 300 ^{0}C and 1 atm is needed as a feed to a heat exchanger. To produce it, the turbine discharge stream is mixed with superheated steam at 400 ^{0}C, 1 atm and specific volume of 3.11 m^3/kg. Calculate the amount of superheated steam at 300 ^{0}C produced and the volumetric flow rate of the 400 ^{0}C steam. 
Ans	**Solution** **1. Mass balance of water** $1200 + m_1 = m_2$ …… (1) ……1 mark **2. Energy balance** (1200 kg/h)(2676 kJ/kg) + m_1(3278 kJ/kg)

= m_2(3074 kJ/kg) …… …. (2)

…….1 mark

Eqs. (1) and (2) are solved simultaneously
3211200 + 3278m_1 = (1200 + m_1)3074
m_1 = 2341.2 kg/h
m_2 = 1200 + 2341.2 = 3541.2 kg/h **(superheated steam produced)**

…….4 marks

3. Volumetric flow rate of 400°C steam

The specific volume of steam at 400 C and 1 atm is 3.11 m^3/kg. The volumetric flow rate is calculated as follows:
(2341.2 kg/h)(3.11 m^3/kg)
= 7281.1 m^3/h

…….4 marks

L –2

The energy consumption and production patterns in a chemical plant over a 9 month period is provided in the table below;

Month	1	2	3	4	5	6	7	8	9
Production in Tonnes / month	493	297	381	479	585	440	234	239	239
Energy Consumption MWh /month	78.2	75.7	76.3	76.1	78.1	70.7	73.7	64.4	72.1

Estimate the cumulative energy savings at end of the 9th month and give your inference on the result ? (consider 9 month data for evaluation for predicted energy consumption)

Ans

It is required to use the equations $Y = mX + C$ and

$$nC + m\Sigma X = \Sigma Y$$
$$c\Sigma X + m\Sigma X^2 = \Sigma XY$$

Month	**X = Production in Tonnes / month**	**Y =Energy Consumption MWh /month**	**X^2**	**XY**
1	493	78.2	243049	38574.12
2	297	75.7	88209	22479.51
3	381	76.3	145161	29076.88
4	479	76.1	229441	36436.09
5	585	78.1	342225	45671.42
6	440	70.7	193600	31110.53
7	234	73.7	54756	17240.63
8	239	64.4	57121	15402.96
9	239	72.1	57121	17228.98
	3387	**665.3**	**1410683**	**253221**

Therefore, the normal equations become;

$9c + 3387m = 665.3$ …….i

$3387C + 1410683m = 253221.1$ ……. ii

…….2 marks

$c = (665.3-3387m)/9$

Substituting in Eq. ii,

$m = 0.021$ and

$c = 66.1$

The best-fit straight line equation is;

$y = 0.021x + 66.1$

…….3 marks

Month	Production in Tonnes / month x	E_{actual}	E_{cal} Y = 0.021x + 66.1	Difference	CUSUM
1	493	78.2	76.45	1.75	1.75
2	297	75.7	72.34	3.36	5.11
3	381	76.3	74.10	2.20	7.31
4	479	76.1	76.16	-0.06	7.25
5	585	78.1	78.39	-0.28	6.97
6	440	70.7	75.34	-4.64	2.33
7	234	73.7	71.01	2.69	5.01
8	239	64.4	71.12	-6.72	-1.71
9	239	72.1	71.12	0.98	-0.73

…….4 marks

Since the CUSUM value at the end of 9th month is negative, the plant has not achieved any net energy savings and action has to be taken to determine reason for no performance of the encon option.

…….1 mark

L - 3

Explain the following

a) Dry Bulb Temperature and Wet bulb Temperature

b) Maximum Demand and Power Factor

c) Gross Calorific Value & Net Calorific Value

d) 5S & Return of Investment (ROI)

e) CUSUM

Ans

a) Dry Bulb Temperature and Wet bulb Temperature

- Dry bulb Temperature is an indication of the sensible heat content of air-water vapour mixtures
- Wet bulb Temperature is a measure of total heat content or enthalpy. It is the temperature approached by the dry bulb and the dew point as saturation occurs.

…….2 marks

b) Maximum Demand and Power Factor

- Maximum demand is maximum KVA or KW over one billing cycle
- Power Factor Cosθ = kW/ KVA or kW = kVA cos θ

…….2 marks

c) Gross Calorific Value & Net calorific Value:

- Gross calorific value assumes all vapour produced during the combustion process is fully condensed.
- Net calorific value assumes the water leaves with the combustion products without being fully condensed.
- The difference being the latent heat of condensation of the water vapour produced during the combustion process.

…….2 marks

d) 5S:

Housekeeping. Separate needed items from unneeded items. Keep only what is immediately necessary item on the shop floor.

Workplace Organization. Organize the workplace so that needed items can be easily and quickly accessed. A place for everything and everything in its place.

Cleanup. Sweeping, washing, and cleaning everything around working area immediately.

Cleanliness. Keep everything clean in a constant state of readiness.

Discipline. Everyone understands, obeys, and practices the rules when in the plant.

…….1 mark(any one of the above is sufficient)

d) **Return on Investment:**

ROI expresses the annual return from project as % of capital cost.

This is a broad indicator of the annual return expected from initial capital investment,

expressed as a percentage.

……1 mark

e) **Cumulative Sum (CUSUM) Technique:**

- Difference between expected or standard consumption with actual consumption data points over baseline period of time.
- Follows a fixed trend unless something (energy saving measure, deterioration in performance..) happens
- Helps calculation of savings/losses till date after changes

……2 marks

L – 4 Answer the following

S. No	Statement	Chose the correct answer OR Fill-in-the-blanks
1	Fyrite measures CO_2, O_2 and SO_2	True/False
2	Ultrasonic Flow Meter uses the principle of____& ____	Fill in the blanks
3	Non Contact Infrared Thermometer cannot measure temperature of objects placed in hazardous places	True/False
4	To measure the RPM of a Flywheel, _____ type of RPM meter is used and for a visible shaft-end _____ type of RPM meter is used.	Fill in the blanks
5	In a switch yard, _____ instrument is used to identify the loose joints and terminations	Fill in the blanks
6	Every Designated Consumer shall have its first energy audit conducted by _____ Energy Auditor within _____ months of notification issued by the Central Government	Fill in the blanks
7	280 kcal/ hr is equivalent to _____Watts and 3.5 bar is equivalent to _____kPa	Fill in the blanks
8	One metric ton of oil equivalent is to _____MW	Fill in the blanks
9	1 kg of Coal, consisting of 30% of Carbon produces _____ kg of CO_2	Fill in the blanks

	10	In a gasification system the reduction zone is above the combustion zone	True/False

Ans

Sr No	Statement	Chose the correct answer OR Fill-in-the-blanks	Solution
1	Fyrite measures CO_2, O_2 and SO_2	True/False	False
2	Ultrasonic Flow Meter uses the principle of____& ____	Fill in the blanks	Transit Time; Doppler Effect
3	Non Contact Infrared Thermometer cannot measure temperature of objects placed in hazardous places	True/False	False
4	To measure the RPM of a Flywheel, _____ type of RPM meter is used and for a visible shaft-end _____ type of RPM meter is used.	Fill in the blanks	Stroboscope; Tachometer
5	In a switch yard, _____ instrument is used to identify the loose joints and terminations	Fill in the blanks	Thermal imager or IR gun
6	Every Designated Consumer shall have its first energy audit conducted by _____ Energy Auditor within _____ months of notification issued by the Central Government	Fill in the blanks	Accredited ; 18 months
7	280 kcal/ hr is equivalent to _____Watts and 3.5 bar is equivalent to _____kPa	Fill in the blanks	325.6 Watts; (280x4.187x1000/3600) 350 kPa (3.5 x100)
8	One metric ton of oil equivalent is to _____MW	Fill in the blanks	11.62 MW (1x1000x10000/(860x1000)
9	1 kg of Coal, consisting of 30% of Carbon produces _____ kg of CO_2	Fill in the blanks	1.1 [(44/12)x(0.3]
10	In a gasification system the reduction zone is above the combustion zone	True/False	False

	……10 marks(each one carries one mark)
L - 5	A company has to choose between two projects whose cash flows are as indicated below; Project 1: i. Investment – Rs. 15 Lakhs ii. Annual cost savings – Rs. 4 lakhs. iii. Bi-annual maintenance cost – Rs. 50,000/- iv. Reconditioning and overhaul during 5^{th} year: 6 lakhs v. Life of the project – 8 years vi. Salvage value – Rs. 5 lakhs Project 2: vii. Investment – Rs. 14 Lakhs viii. Annual cost savings – Rs. 3.5 lakhs. ix. Annual Maintenance cost – Rs. 20,000/- x. Reconditioning and overhaul during 4th year: 5 lakhs xi. Life of the project – 8 years xii. Salvage Value- 2 lakhs Which project should the company choose? The annual discount rate is 12%.

Ans

Year	Project 1			Project 2		
	Outgo	Saving	NPV	Outgo	Saving	NPV
0	15.0	0	=-15.0	14.0	0	= -14
1	0	4.0	= (4 / (1+.12)^1 = 3.571	0.2	3.5	= (3.3 / (1+.12)^1 = 2.95
2	0.5	4.0	= (3.5 / (1+.12)^2 = 2.79	0.2	3.5	= (3.3 / (1+.12)^2 = 2.63
3	0	4.0	= (4 / (1+.12)^3 = 2.84	0.2	3.5	= (3.3 / (1+.12)^3 = 2.35
4	0.5	4.0	= (3.5 / (1+.12)^4 = 2.22	5	3.5	= (-1.5 / (1+.12)^4 = -0.95
5	6	4.0	= (-2 / (1+.12)^5 = -1.13	0.2	3.5	= (3.3 / (1+.12)^5 = 1.87
6	0.5	4.0	= (3.5 / (1+.12)^6 = 1.77	0.2	3.5	= (3.3 / (1+.12)^6 = 1.67
7	0	4.0	= (4 / (1+.12)^7 = 1.81	0.2	3.5	= (3.3 / (1+.12)^7 = 1.49
8	0.5	9 *(4+5)*	= (8.5 / (1+.12)^8 = 3.43	0.2	5.5 *(3.5+2)*	= (5.3 / (1+.12)^8 = 2.14
NPV			= + 2.301	@12%		= + 0.15

NPV Project 1 is higher than Project 2. Hence project 1 is preferred.

……10 marks

L- 6

A project activity has several components as indicated below;

S. No.	Activity	Preceded by	Duration (in Weeks)
1	A	-	8
2	B	A	6
3	C	A	12
4	D	B	4
5	E	D	5
6	F	B	12
7	G	E& F	9
8	H	C	8
9	I	F & H	5
10	J	I & G	6

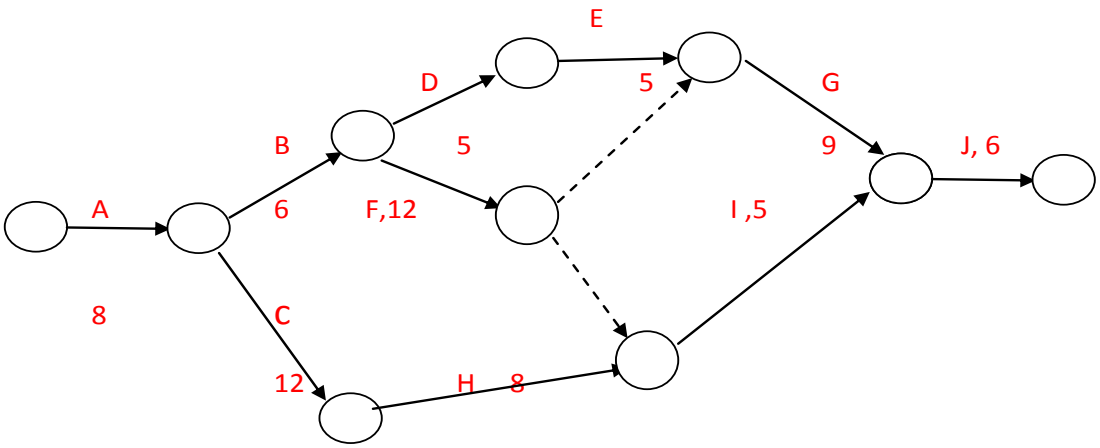
d. Prepare a PERT chart, estimate the duration of the project and identify the critical path.

e. What are the Earliest Start, Latest Start and Total Float of activity 'H'?

f. What would be the project duration if activity 'H' got delayed by 3 weeks?

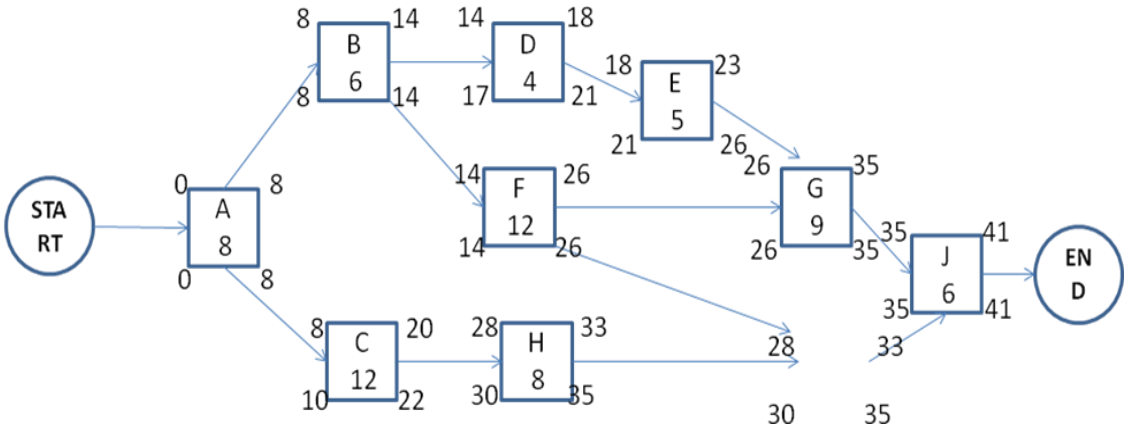
Ans

PERT Diagram based on Activity on Arrow



OR

PERT Diagram based on Activity on Node



……6 marks

a. Critical Path: A-B-F-G-J

……1 mark

b. Estimated Project Duration: 41 weeks

	……1 mark c. For activity H, Early Start is 20, Latest Start is 22 and Total Float is 2 weeks. ……1 mark d. Project duration will be 42 weeks- a delay of 1 week. ……1 mark

…… End of Section – III ……

17th NATIONAL CERTIFICATION EXAMINATION FOR ENERGY MANAGERS & ENERGY AUDITORS – September, 2016

PAPER – 1: GENERAL ASPECTS OF ENERGY MANAGEMENT & ENERGY AUDIT

Date: 24.09.2016 Timings: 0930-1230 HRS Duration: 3 HRS

General instructions:

- *Please check that this question paper contains **8** printed pages*
- *Please check that this question paper contains **64** questions*
- *The question paper is divided into three sections*
- *All questions in all three sections are compulsory*
- *All parts of a question should be answered at one place*

Section – I: OBJECTIVE TYPE

1.	The energy intensity of countries that rely on import of carbon-intensive goods when compared with those producing it, would in all probability be a) Higher **b) Lower** c) Almost equal d) No correlation
2.	If a 2 KW immersion heater is used to heat 30litres of water at 30^{O}C, what would be the temperature of water after 15 minutes? Assume no losses in the system a) 87.3 ^{O}C **b) 44.3^{O}C** c) 71.3 ^{O}C d) none of the above
3.	Which of the following statements regarding ECBC are correct? i) ECBC defines the norms of energy requirements per cubic metre of area ii) ECBC does not encourage retrofit of Energy conservation measures iii) ECBC prescribes energy efficiency standards for design and construction of commercial and industrial buildings iv) One of the key objectives of ECBC is to minimize life cycle costs (construction and operating energy costs) a) i b) ii c) iiii **d) iv**
4.	Verification and Check-verification under PAT will be carried out by a) Designated consumers b) Accredited energy auditors c) Certified energy auditor d) **Empanelled accredited energy auditors**
5.	Which of the following enhances the energy efficiency in buildings? a) Light pipes

	b) Triple glaze windows c) Building integrated solar photovoltaic panels **d) All of the above**
6.	Energy is consumed by all sectors of the economy but at different proportions. Which sector in India is the largest consumer? a) Agriculture c). Commercial b) **Industrial** d). Domestic
7.	M & V audit under PAT is carried out a) Immediately after the baseline audit b) Every year following the baseline audit c) **At the end of each PAT cycle** d) Before the baseline audit
8.	Which of the following sector is not covered under PAT? a) Chlor-alkali c) Cement b) Aluminum d) **Commercial buildings**
9.	A solar _____ is connected and packaged in a solar _____, which in turn is linked with others in sequence in a solar _____. a) module, cell, array b) array, module, sequence c) module, array, sequence **d) cell, module, array**
10.	At Standard Atmospheric Pressure, specific enthalpy of saturated water, having temperature of 50^{o}C will be _____ kCal/kg. a) **1** b) 50 c) 100 d) none of the above
11.	In a drying process product moisture is reduced from 60% to 30%. Inlet weight of the material is 200 kg. Calculate the weight of the outlet product. a) 80 b) 120.5 c) **114.3** d) none of the above
12.	Which among the following factor(s) is most appropriate for adopting EnMS? a) To improve their energy efficiency b) To reduce costs c) To increase productivity d) **Systematically manage their energy use**
13.	Which energy source releases the most climate-altering carbon pollution per kg? **a). Oil** b). Coal c). Rice husk d). Bagasse
14.	What is the future value of Rs.1000/- after 3 years, if the interest rate is 10% a**) Rs. 1331** b) Rs.1610 c) Rs.3221 d) none of the above
15.	Having a documented energy policy in industry

	a) Satisfies regulations b) **Reflects top management commitment** c) Indicates availability of energy audit skills d) None of the Above
16.	Red wood seconds is a measure of a) Density b) **Viscosity** c) Specific gravity d) Flash point
17.	Which amongst the following sources of electricity has the highest installed capacity in India ? a)Gas b) Nuclear c) Oil d) **Renewables**
18.	Energy Intensity is the ratio of a) **Fuel Consumption / GDP** b) GDP/Fuel Consumption c) GDP/ Energy Consumption d) Energy Consumption / GDP
19.	If Heat Rate of Power plant is 3000 kCal/kWh then efficiency of Power plant will be **a) 28.67%** b) 35% c) 41% d) None of the above
20.	In a solar thermal power station , molten salt which is a mixture of 60% sodium nitrate and 40% potassium nitrate is used. It is preferred as it provides an efficient low cost medium to store _____ a. Electrical energy **b. Thermal energy** c. Kinetic energy d. Potential energy
21.	For every 10°C rise in temperature, the rate of chemical reaction doubles. When the temperature is increased from 30°C to 70°C, the rate of reaction increases _____ times. a) 8 b) 64 **c) 16** d) none of the above
22.	The producer gas is basically **a. CO, H_2 and CH_4** b. Only CH_4 c. CO and CH_4 d. Only CO and H_2
23.	The essential elements of monitoring and targeting system is a) Recording b) Reporting c) Controlling d) **All of the above**
24.	One energy saving certificate (ESCerts) under PAT is equivalent to a. one ton of carbon b. one MWh of electricity c. one ton of coal **d. one ton of Oil equivalent**
25.	In an industry the billed electricity consumption for a month is 5.8 lakh kWh. The fixed electricity consumption of the plant is 30000kWh and with a variable electricity

	consumption of 11 kWh/ton. Calculate the production of the industry a) **50000 tonnes** b**)** 60000 tonnes c) 58000 tonnes d) None of the above
26.	If the reactive power drawn by a particular load is zero it means the load is operating at a) Lagging power factor b**) Unity power factor** c) Leading power factor d) none of the above
27.	Capital cost are associated with a) Design of Project b) Installation and Commissioning of Project c) Operation and Maintenance cost of project d) **both a and b**
28.	Any management would like to invest in projects with a**)** Low IRR b) Low ROI c) Low NPV of future returns **d) none of the above**
29.	The kilowatt-hour is a unit of a) power **b) work** c) time d) force.
30.	Which among the following is a green house gas? a) Sulphur Dioxide b) Carbon Monoxide c) NO_2 **d) Methane**
31.	The internal rate of return is the discount rate for which the NPV is a. Positive **b. Zero** c. Negative d. Less than 1
32.	Greenhouse effect is caused by natural affects and anthropogenic effects. If there is no natural greenhouse effect, the Earth's average surface temperature would be around _____°C. a) 0 b) 32 c) 14 **d) - 18**
33.	The quantity of heat required to raise the temperature of a given substance by 1 ^{o}C is known as: a) sensible heat b) specific heat **c) heat capacity** d) latent heat
34.	The Metric Tonne of Oil Equivalent (MTOE) value of 125 tonnes of coal having GCV of 4000 kcal/kg is a) 40 **b) 50** c) 100 d) 125
35.	A mass balance for energy conservation does not consider which of the following a. Steam b. water **c. Lubricating oil** d. Raw material
36.	A sling psychrometer is capable of measuring

	a) only dry bulb temperature b) only wet bulb temperature **c) both dry and wet bulb temperature** d) absolute humidity
37.	Which of these is not true of payback period a. Simple to calculate **b. Considers cash flow beyond the payback period** c. Shorter the period the better d. Does not take into account, time value of money
38.	To judge the attractiveness of any investment, the energy auditor must consider a) Initial capital cost b) Net operating cash inflows c) salvage value **d) all the above**
39.	In a cumulative sum chart if the graph is going up, it means **a. Energy consumption is going up** b. Energy consumption is going down c. Specific energy consumption is coming down d. No inference can be made
40.	Doppler effect principle is used in the following instrument a) lux meter **b) ultrasonic flow meter** c) infrared thermometer d) flue gas analyzer
41.	In a coal fired boiler, hourly consumption of coal is 1300 kg. The ash content in the coal is 6%. Calculate the quantity of ash formed per day. Boiler operates 24 hrs/day. a) 216 kg b) 300 kg c) **1872 kg** d) none of the above
42.	Liquid fuel density is measured by an instrument called a) Tachometer b) hygrometer c) anemometer **d) none of the above**
43.	A comparison of the trapping of heat by CO_2 and CH_4 is that **a) CH_4 traps 21 times more heat in the atmosphere than does CO_2** b) CO_2 traps 21 times more heat in the atmosphere than does CH_4 c) the same amount of heat is trapped by both CO_2 and CH_4 d) none of the above
44.	Diagrammatic representation of input and output energy streams of an equipment or system is known as a) mollier diagram b) **sankey diagram** c) psychrometric chart d) balance diagram
45.	ISO 50001:2011 provides a framework of requirements for organizations to: a) Develop a policy for more efficient use of energy b) Measure the results c) Fix targets and objectives to meet the policy **d) all of the above**
46.	A three phase induction motor is drawing 16 Ampere at 440 Volts. If the operating power factor of the motor is 0.90 and the motor efficiency is 92%, then the mechanical shaft power output of the motor is **a) 12.04 kW** b) 10.09 kW c) 10.97 kW d) None of the above
47.	Absolute pressure is a. Gauge pressure **b. Gauge pressure + Atmospheric pressure** c. Atmospheric pressure d. Gauge pressure - Atmospheric pressure
48.	In a chemical process two reactants A (300 kg) and B (400 kg) are used. If conversion is 50% and A and B react in equal proportions, the mass of the product formed is.

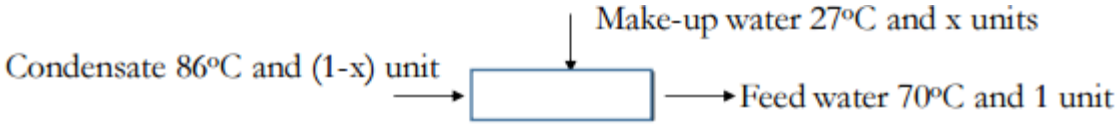
	a) 300 kg b) 350 kg c) 400 kg d) none of the above
49.	What is the expected power output in watts from a wind turbine with 6m diameter rotor, a coefficient of performance 0.45, generator efficiency 0.8,a gear box efficiency 0.90 and wind speed of 11m/sec a. 4875 watts b. 1100 watts **c. 7312 watts** d. 73.12 kW
50.	The lowest theoretical temperature to which water can be cooled in a cooling tower is a. Difference between DBT and WBT of the atmospheric air b. Average DBT and WBT of the atmospheric air c. DBT of the atmospheric air **d. WBT of the atmospheric air**

…… End of Section – I ……

Section – II: SHORT DESCRIPTIVE QUESTIONS

S-1	**Give relationship between Absolute and Gauge pressures. Give 4 different units used in pressure measurement**.
Ans	*Absolute pressure* is zero-referenced against a perfect vacuum, so it is equal to *gauge pressure* plus *atmospheric pressure*. *Gauge pressure* is zero-referenced against ambient *air pressure*, so it is equal to *absolute pressure* minus *atmospheric pressure*. (Negative signs are usually omitted) Absolute Pressure = Prevailing Atmospheric Pressure + Gauge Pressure (***NOTE: also please refer guide book-1 pg-70***) The four units of pressure measurement are: i) Pascal ii) kg / cm^2 iii) Atmospheric iv) mm of mercury v) Meters of water column vi) Pounds / $inch^2$
S- 2	**A plant is using 6 tonnes / day of coal to generate steam . The calorific of coal is 3300 kcal/kg. The cost of coal is Rs 4200/tonne . The plant substitutes coal with agro-residue , as a boiler fuel, which has a calorific value of 3100 kcal/kg and costs Rs 1800/tonne. Calculate the annual cost savings at 300 days of operation, assuming the boiler efficiency remains same at 72% for coal and agro residue as fuel.**
Ans	Useful energy to generate steam by 6 tonnes of coal per day = 6000 x 3300 x 0.72 = 14256000 kcal/day

	To deliver 14256000kcal/day , daily amount of rice husk required = 14256000 =6387 kg/day 3100 x 0.72 Daily saving = 6000 x 4200 - 6387 x 1800 1000 1000 = 25200-11497 = Rs 13703/- Annual saving=13703 x 300 =Rs 41,10,900/-
S – 3	**Explain how an ESCO model works?**
	ESCOs are usually companies that provide a complete energy project service, from assessment to design to construction or installation, along with engineering and project management services and financing. The ESCO will usually offer the following performance contract options. • Fixed fee • Shared Savings • Guaranteed savings
S-4	**The annual fuel cost of boiler operation in a plant is Rs.10 Lakhs. The boiler with 65% efficiency is now replaced by a new one with 78% efficiency. What is the annual cost savings**?
	Existing efficiency =65% Proposed efficiency=78% Annual fuel cost =Rs. 10 Lakhs Annual cost savings = annual fuel cost *(1-(Eff_O/Eff_N)) = 10 x ((1-(0.65/0.78)) =Rs. 1,66,667 per annum
S-5	**A tank containing 600 kg of kerosene is to be heated from 10°C to 40°C in 20 minutes, using 4 bar (g) steam. The kerosene has a specific heat capacity of 2.0 kJ/kg °C over that temperature range. Latent heat of steam (hfg) at 4.0 bar g is 2108.1 kJ/kg. The tank is well insulated and heat losses are negligible.** **Determine the steam flow rate in kg/hr.**
	Q = 600 kg x 2 kJ/kg^{O}C x (40-10)^{O}C/(1200) = 30 kJ/sec Therefore mass of steam = 30 kJ/sec x3600 / 2108 .1 kJ/kg = 51.23 kg/h
S – 6	**Feed water is provided to a boiler at 70^{o}C from the feed water tank. The temperature of condensate water returning to the tank is 86^{o}C, while the**

	temperature of makeup water is 27°C. Determine the amount of condensate water that can be recovered?
	 • Performing a mass & heat balance yields, • (i.e : $mCpdT_{Cond} + mCpdT_{MakeUp} = mCpdT_{FeedWater}$) (27)(x)(1)+ (86)(1-x)(1) = 70(1)(1) • Therefore, x = 0.27 **or** 27% of make-up water. • Hence, condensate recovered = 73%
S – 7	**In a textile manufacturing unit, wet cloth is dried in a stenter. The cloth entering the stenter has a moisture of 52% while that leaving the stenter is 96% dry. If the production rate (output) from the stenter is 200 Kg/hr, what is the quantity of steam required per hour, if the steam enters the stenter with an enthalpy of 660 kcal/kg. The condensate leaving the stenter is at 170°C Consider drying to take place at atmospheric pressure where the latent heat of water is 540 Kcal/Kg.**
	Stenter output = 200 kgs/hr Bone dry cloth in output = 200 X 0.96 = 192 kgs. Moisture in output = 8 kgs. Moisture in input = 52% Bone dry cloth in input = 48% Total weight of input cloth = 192/0.48 = 400 kg/hr Quantity of water evaporated = 400 – 200 = 200 kg/hr Assuming sensible heat in steam at 170 ^{O}C = 170 kcal/kg Quantity of steam required = (200 X 540)/(660 – 170) = 220.4 kg/hr
S – 8	**The average monthly electricity consumption in an Aluminium producing unit is 12.35 lac kWh. The other energy sources used in the manufacturing process are Furnace oil (GCV-9660 kcal/Ltr) and HSD (GCV-9410 kcal/Ltr). If the annual fuel oil consumption is 5760 kL of Furnace oil (sp. gr. 0.92) and 720 kL of HSD (sp. gr. 0.88), determine if the unit qualifies as a Designated Consumer under the EC Act?**
	1 Mtoe = 1 x 10^7 kcal Annual electrical energy consumption = 12.35 x 12 = 148.2 lac Kwh Equivalent heat energy = (148.2 x 10^5 x 860)/(1 x 10^7) = 1274.52 Mtoe _(i) Annual Furnace oil consumption = 5760 kL Equivalent heat energy = (5760 x 1000 x 9660)/(1 x 10^7) = 5564.16 Mtoe _(ii) Annual HSD consumption = 720 kL Equivalent heat energy = (720 x 1000 x 9410)/(1 x 10^7) = 677.52 Mtoe _(iii) Total annual energy consumption = 1274.52 + 5564.16 + 677.52 = 7516.2 Mtoe To be a designated consumer, the minimum annual energy consumption (in aluminium sector)

	should be 7500 Mtoe. As the plant exceeds this threshold limit, it qualifies to be a designated consumer.

……. End of Section – II ……..…..

Section – III: LONG DESCRIPTIVE QUESTIONS

L - 1	**The integrated paper plant has produced 119366 MT of paper during the year 2012-13. The management has implemented various energy conservation measures as part of PAT scheme and reduced the specific energy consumption from 53 GJ/ tonne of product to 50 GJ/tonne of product. The actual production during the assessment year (2014-15) is 124141 MT. Calculate the plant energy performance and state your inference.**
Ans	Reference year production = 119366 MT Reference year specific energy consumption = 53 GJ/tonne of product Assessment year production = 124141 MT Assessment year specific energy consumption = 50 GJ/tonne of product $Production\ Factor\ = \frac{Assessment\ year's\ production}{Reference\ year's\ production}$ production factor = (124141 / 119366) = 1.04 $Reference\ year's\ energy\ consumption, GJ$ $= Reference\ year's\ specific\ energy\ consumption, \frac{GJ}{MT}\ X\ Reference\ year'sProduction, MT$ = 53 x 119366 = 6326398 GJ $Assessment\ year's\ energy\ consumption, GJ$ $= Assessment\ year's\ specific\ energy\ consumption, \frac{GJ}{MT}\ X\ Assessment\ year'sProduction, MT$ =50 x 124141 = 6207050 GJ $Reference\ year's\ equivalent\ energy\ use, GJ$ $= Reference\ year's\ energy\ consumption, GJ\ X\ Production\ factor$ = 6326398 GJ x 1.04 =6579454 GJ $Plant\ Energy\ performance, \%$ $= \frac{Reference\ year's\ equivalent - Assessment\ years\ energy}{Reference\ year's\ equivalent\ energy}\ x\ 100$ = ((6579454 - 6207050) / 6579454)x 100 = 5.66% $Plant\ Energy\ performance, \% \ = 5.66$ Inference : plant energy performance is positive and hence the plant is achieving energy savings.
L – 2	**a) A 20 kW, 415V, 38A, 4 pole, 50 Hz, 3 phase rated squirrel cage induction motor has a full load efficiency and power factor of 88% and 0.85 respectively. An energy auditor measures the**

following
operating data of the motor.

1) **Supply voltage= 408V**
2) **Current drawn= 30A**
3) **PF=0.83**

Find out the following at motor operating conditions.

1) **Power input in kW**
2) **% motor loading**

b) List five energy saving measures in your home

Ans

a) 1) Power input = 1.732*408*30*0.83
= 17.60 kW

2) % motor loading = [17.60/(20/0.88)]*100
= [(17.60/22.73)]*100
= 77.43%

b)

- Replacement of inefficient electric lamps with efficient electric lamps
- Using star labeled household appliances like A/c's, Refrigerator,Lamps,Fans
- Using Solar water heating systems for hot water requirements to minimize use of electric geysers
- Using Solar PV systems for electricity generation
- Proper ventilation maximizing the use of natural light
- Switching off all equipment when not required
- Using pressure cooker for cooking food
- Maximizing the use of low fire burner (SIM) in the gas stove
- Using A/Cs at setpoint of 21^{o}C-23^{o}C instead of 16^{o}C
- Placing the fridge so that the rear (condenser coils) are located where there is proper air flow.

L - 3

The cash flows in two different energy conservation projects are given in the table below. Please help the management of an infrastructure company to decide which project to invest in as the management is interested in investing in only one project. The company is likely to consider any project which gives a minimum return on investment of 18%. Please justify your choice.

(Amount in Rs.)

	Project A		**Project B**	
Investment	17,50,000/-		12,00,000/-	
Year	**Expenses**	**Savings**	**Expenses**	**Savings**
1		4,00,000		4,50,000
2		4,00,000		4,00,000
3		4,00,000		3,50,000
4		4,00,000		3,00,000
5	1,00,000	6,00,000		2,50,000
6		6,00,000		2,00,000
7		6,00,000		1,16,650

	8		3,80,300		

Ans

As the investments required in both the cases as well as their durations are different, the prudent method to compare the two projects would be to calculate their NPV.

a) NPV of Project A @ 18% = (-1750000 / $(1+0.18)^0$) + (4,00,000 / $(1+0.18)^1$) +(4,00,000 / $(1+0.18)^2$) +(4,00,000 / $(1+0.18)^3$)+ (4,00,000 / $(1+0.18)^4$) +((6,00,000-100000) / $(1+0.18)^5$)+ (6,00,000 / $(1+0.18)^6$) +(6,00,000 / $(1+0.18)^7$)+ (3,80,300 / $(1+0.18)^8$) = 57,367

b) NPV of Project B @ 18% = (-1200000 / $(1+0.18)^0$) + (4,50,000 / $(1+0.18)^1$) +(4,00,000 / $(1+0.18)^2$) +(3,50,000 / $(1+0.18)^3$)+ (3,00,000 / $(1+0.18)^4$) +(2,50,000 / $(1+0.18)^5$)+ (2,00,000 / $(1+0.18)^6$) +(1,16,650 / $(1+0.18)^7$) = 57370

Since both the projects are having the same NPV at 18%, both the projects are worth considering. However, by increasing the rate 20% if one of the projects shows higher NPV, that project would be the choice between the two.

c) NPV of Project A @ 20% = (-1750000 / $(1+0.2)^0$) + (4,00,000 / $(1+0.2)^1$) +(4,00,000 / $(1+0.2)^2$) +(4,00,000 / $(1+0.2)^3$)+ (4,00,000 / $(1+0.2)^4$) +((6,00,000-100000) / $(1+0.2)^5$)+ (6,00,000 / $(1+0.2)^6$) +(6,00,000 / $(1+0.2)^7$)+ (3,80,300 / $(1+0.2)^8$) = (-) 56734

d) NPV of Project B @ 20% =(-1200000 / $(1+0.2)^0$) + (4,50,000 / $(1+0.2)^1$) +(4,00,000 / $(1+0.2)^2$) +(3,50,000 / $(1+0.2)^3$)+ (3,00,000 / $(1+0.2)^4$) +(2,50,000 / $(1+0.2)^5$)+ (2,00,000 / $(1+0.2)^6$) +(1,16,650 / $(1+0.2)^7$) = 3.86

As the NPV of project B at 20% is higher than that of Project A, Project B is recommended.

L – 4

The energy consumption pattern in a steel re rolling mill over 8 month period is provided in the table below;

Month	Production (Tons)	Coal Consumption (Tons)
1	488	422
2	553	412
3	455	411
4	325	363
5	488	438
6	585	426
7	455	414
8	419	396

Estimate,

i) Fixed energy consumption in the Mill.

ii) Expected coal consumption for a production of 600 Tons/month.

Ans

To establish the relationship between Production & Coal consumption, it is necessary to derive the best-fit line for which the following normal equation are used (see page 218 of book 1)

$$Cn + m\sum x = \sum y$$
$$c\sum x + m\sum x^2 = \sum xy$$

n	x	y	x^2	xy
1	488	422	238144	205936
2	553	412	305809	227836
3	455	411	207025	187005
4	325	363	105625	117975
5	488	438	238144	213744
6	585	426	342225	2 9 10
7	455	414	20702	188370
8	419	396	175561	165924
Total	**3768**	**3282**	**1819558**	**1556000**

Therefore, the normal equations become;

$8c + 3768m = 3282$ …….i

$3768c + 1819558m = 1556000$ …… ii

$c = (3282 - 3768m) / 8$

Substituting in Eq. ii,

$m = 0.23$ and

$c = 316$

The best-fit straight line equation is;

$$y = 0.23x + 316$$

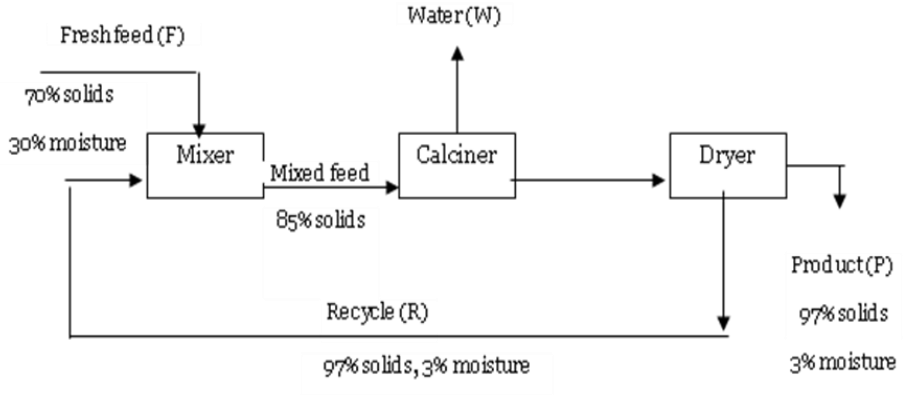
i) The fixed energy consumption in the Mill = 316 Tons of coal/month

ii) The expected coal consumption for a production of 600 Tons,

$= 0.23 \times 600 + 316 = 454$ Tons

L - 5 **Explain PAT Scheme and its potential impact?**

Ans **Perform, Achieve and Trade (PAT) Scheme** is a market based mechanism to enhance cost effectiveness of improvements in energy efficiency in energy-intensive large industries and facilities, through certification of energy savings that could be traded.

	The key goal of PAT scheme is to mandate specific energy efficiency improvements for the most energy intensive industries. The scheme builds on the large variation in energy intensities of different units in almost every sector. The scheme envisages improvements in the energy intensity of each unit covered by it. The energy intensity reduction target mandated for each unit is dependent on its operating efficiency: the specific energy consumption reduction target is less for those who are more efficient, and is higher for the less-efficient units. Further, the scheme incentivizes units to exceed their specified SEC improvement targets. To facilitate this, the scheme provides the option for industries who achieve superior savings to receive energy savings certificates for this excess savings, and to trade the additional certified energy savings certificates with other designated consumers(energy intensive industries notified as Designated Consumers under the Energy Conservation Act and included under PAT Scheme) who can utilize these certificates to comply with their specific energy consumption reduction targets. Energy Savings Certificates (ESCerts) so issued will be tradable at Power Exchanges. The scheme also allows units which gain ESCerts to bank them for the next cycle of PAT, following the cycle in which they have been issued. The number of ESCerts which would be issued would depend on the quantum of energy saved over and above the target energy savings in the assessment year (for 1stCycle of PAT, assessment year is 2014-15). After completion of baseline audits, targets varying from unit to unit ranging from about 3 to 7% have been set and need to be accomplished by 2014-15 and after which new cycle with new targets will be proposed. Failing to achieve the specific energy consumption targets in the time frame would attract penalty for the non-compliance under Section 26 (1A) of the Energy Conservation Act, 2001 (amended in 2010). For ensuring the compliance with the set targets, system of verification and check-verification will be carried out by empanelment criteria of accredited energy auditors.
L- 6	**In a particular drying operation, it is necessary to hold the moisture content of feed to a calciner to 15% (w/w) to prevent lumping and sticking. This is accomplishing by mixing the feed having 30% moisture (w/w) with recycle stream of dried material having 3% moisture (w/w). The dryer operation is shown in fig below. What fraction of the dried product must be recycled?** 
	Let F indicate quantity of feed

	R indicate quantity of recycle P indicate quantity of product **Based on solid content at Mixer** 0.7F + 0.97R = 0.85 (F + R) Hence R =1.25 F ……..(1) **Based on solid content at Drier** 0.85 (F + R) = 0.97 (P + R) 0.85 (F + 1.25F) = 0.97 P + (0.97 x 1.25 F) 1.91 F = 0.97 P + 1.21F 0.7 F = 0.97 P Hence F = 1.386 P ……(2) Substituting (2) in (1) for obtaining Recycle quantity in terms of Product R = (1.25 x 1.386 P) = 1.7325 P ……..(3) Product plus Recycle is P + R = (P + 1.7325 P) = P(1 + 1.7325) = 2.7325 P ……...(4) R (as a fraction of dried product) = {(1.7325 P) / (2.7325 P)} x (100) = 63.4%

……. End of Section – III ……

16th NATIONAL CERTIFICATION EXAMINATION FOR ENERGY MANAGERS & ENERGY AUDITORS – September, 2015

PAPER – 1: GENERAL ASPECTS OF ENERGY MANAGEMENT & ENERGY AUDIT

Date: 19.09.2015 Timings: 0930-1230 HRS Duration: 3 HRS Max. Marks: 150

General instructions:

- *Please check that this question paper contains **11** printed pages*
- *Please check that this question paper contains **64** questions*
- *The question paper is divided into three sections*
- *All questions in all three sections are compulsory*
- *All parts of a question should be answered at one place*

Section – I: OBJECTIVE TYPE **Marks: 50 x 1 = 50**

(i) Answer all **50** questions
(ii) Each question carries one mark
(iii) Please hatch the appropriate oval in the OMR answer sheet with Black Pen, as per instructions

1.	Which one is not a consequence of global warming a) rise in global temperature b) rise in sea level c) food shortage and hunger d) <u>fall in global temperature</u>
2.	Which of the following will not be a major component of mass balance a) steam b) water c) raw materials d) <u>lubricating oil</u>
3.	Which of the following terms does not refer to specific energy consumption a) kWh/ton b) kCal/ton c) kJ/kg d) <u>kg/kCal</u>
4.	Which of the following GHGs has the longest atmospheric life time a) CO_2 b) Sulfur Hexafluoride (SF_6) c) CFC d) <u>Per FluoroCarbon (PFC)</u>
5.	Which of the following comes under mandatory labeling programme a) diesel Generators b) induction motors <u>c) tubular Fluorescent Lamps</u> d) LED lamps
6.	Transit time method is used in which of the instrument a) lux meter b) <u>ultrasonic flow meter</u> c) pitot tube d) fyrite
7.	To improve the boiler efficiency, which of the following needs to be done

	a) maximize O_2 in flue gas b) <u>maximize CO_2 in flue gas</u> c) minimize CO_2 in flue gas d) maximize CO in flue gas
8.	The simplest technique for scheduling of tasks and tracking the progress of energy management projects is called a) <u>Gantt chart</u> b) CPM c) PERT d) WBS
9.	The ratio of wind power in the wind actually converted into mechanical power and the power available in the wind is about a) 75% b) <u>59%</u> d) 44% e)10%
10.	The quantity of heat required to raise the temperature of 1 kg of water by 1 ^{O}C is termed as a) latent heat b) one kilojoule c) <u>one kilo calorie</u> d) none of the above
11.	The present value of Rs. 1,000 in 10 years' time at an interest rate of 10% is a) Rs. 2,594 b) <u>Rs. 386</u> c) Rs. 349 d) Rs. 10,000
12.	The number of moles of water contained in 54 kg of water is ---------- a) 2 **b) <u>3</u>** c) 4 d) 5
13.	The monthly electricity bill for a plant is Rs. 100 lakhs which accounts for 45% of the total monthly energy bill. How much is the plant's monthly energy bill a) <u>Rs 222.22 lakhs</u> b) Rs 45 lakhs c) Rs 138 lakhs d) None of above
14.	The major share of energy loss in a thermal power plant is in the a) generator b) boiler c) <u>condenser</u> d) turbine
15.	The ISO standard for Energy Management System is a) ISO 9001 b) <u>ISO 50001</u> c) ISO 140001 d) None of the above
16.	The indicator of energy performance in a thermal power plant is a) heat rate (kCal/kWh) b) % aux. power consumption c) specific coal consumption d**)** <u>all the above</u>
17.	The fixed energy consumption for the company is 1,000 kWh. The slope in the energy – production chart is found to be 0.3. Find out the actual energy consumption if the production is 80,000 Tons a) <u>25,000</u> b) 24,000 c) 26,000 d) 23,000
18.	The cost of replacement of inefficient compressor with an energy efficient compressor in a plant was Rs 50 lakhs. The net annual cash flow is Rs 12.5 lakhs. The return on investment is a) 15% b) 20% c) <u>25%</u> d) 19.35%
19.	The contractor provides the financing and is paid an agreed fraction of actual savings achieved. This payment is used to pay down the debt costs of equipment and/or services. This is known as a)traditional contract b) extended technical guarantee/service c) performance contract d) <u>shared savings performance contract</u>

20.	PERT/CPM provides which of the following benefits a) predicts the time required to complete the project b) shows activities which are critical to maintaining the schedule c) graphical view of the project d) all the above
21.	Input fuel of fuel cell a) petrol b) hydrogen c) nitrogen d) natural gas
22.	In India power sectors consumes about_____% of the coal produced a) 75% b) 50% c) 25% d) 90%
23.	In an industry the average electricity consumption is 5.8 lakhs kWh for the period, the average production is 50,000 tons with a specific electricity of 11 kWh/ton for the same period. The fixed electricity consumption for the plant is a) 58000 kWh b) 30000 kWh c) 80000 kWh d) none of the above
24.	In a drying process, moisture is reduced from 60% to 30%. Initial weight of the material is 200 kg. Calculate the weight of the product a) 104 b) 266.6 c) 130 d) 114.3
25.	In a DG set, the generator is consuming 400 litres per hour diesel oil. If the specific fuel consumption of this DG set in 0.30 litres/kWh at that load then what is the kVA loading of the set at 0.6 power factor a) 1200 KVA b) 2222 KVA c) 600 KVA d)1600 KVA
26.	In a 50 Hz AC cycle, the current reverses directions _____ times per second a) 50 times b) 100 times c) Two times d) 25 times
27.	If we heat the air without changing absolute humidity, % relative humidity will a) increase b) decrease c) no Change d) can't say
28.	If the pressure of water is 0.7 kg/cm^2 then boiling point will be approximately a) 100 b) 73 c) 114 d) Can't say
29.	If heat rate of power plant is 860 kcal/kWh then the cycle efficiency of power plant will be a) 41% b) 55% c**) 100%** d) 86%
30.	If air consists of 77% by weight of nitrogen and 23% by weight of oxygen, the mean molecular weight of air is a) 11.9 b) 28.8 c) 17.7 d) insufficient data
31.	How much power generation potential is available in a run of river mini hydropower plant for a flow of 40 liters/second with a head of 24 metres. Assume system efficiency of 60% a) 5.6 kW b) 9.4 kW c) 4.0 kW d) 2.8 kW
32.	Fuel cell using methanol as anode and oxygen as cathode is

	a) proton exchange membrane fuel cell b) phosphoric acid fuel cell b) alkaline fuel cell d) direct methanol fuel cell
33.	For expressing the primary energy content of a fuel in tonnes of oil equivalent (toe) which of the following conversion factors is appropriate a) toe=1x10^6 kcal b) toe=116300 kwh c) toe=41.870 GJ d) all the above
34.	For calculating plant energy performance which of the following data is not required a) current year's production b) reference year's production c) reference year energy use d) capacity utilization
35.	ESCerts cannot be a) bought b) sold c) banked for next cycle d) traded directly between DCs
36.	Energy intensity is the ratio of a) fuel consumption / GDP b) GDP/fuel consumption c) GDP/ energy consumption d) energy consumption / GDP
37.	Costs associated with the design, planning, installation and commissioning of a project are a) variable costs b) capital costs c) salvage value d) none of the above
38.	At standard atmospheric pressure, specific enthalpy of saturated water, having temperature of 50 ^{O}C will be _____ kcal/kg a) 1 b) 50 c) 100 d) Can't say
39.	AT & C losses means a) administration transmission and commercial b) aggregate technical and commercial c) average technical and commercial d) none of the above
40.	As per primary commercial energy consumption mix in India, the fuel dominating the energy production mix in India is a) natural gas b) oil c) coal d) nuclear energy
41.	An oil-fired boiler operates at an excess air of 6 %. If the stoichiometric air fuel ratio is 14 then for an oil consumption of 100 kg per hour, the flue gas liberated in kg/hr would be a)1484 b) 1584 c) 106 d) 114
42.	An activity has an optimistic time of 15 days, a most likely time of 18 days and a pessimistic time of 27 days. What is the expected time a) 60 days b) 20 days **c**) 19 days d) 18 days
43.	Among which of the following fuels, the difference between the GCV and NCV is maximum a) coal b) furnace Oil c) natural gas d) rice husk
44.	A waste heat recovery system costs Rs. 54 lakhs and Rs. 2 lakhs per year to operate and maintain. If the annual savings is Rs. 20 lakhs, the payback period will be

	a) 8 years b) 2.7 years c) 3 years d) 10 years
45.	A process requires 10 Kg of fuel with a calorific value of 5000 kcal/kg. The system efficiency is 80% and the losses will be a) 10000 kcal b) 45000 kcal c) 500 kcal d) 2000 kcal
46.	A centrifugal pump draws 12 m^3/hr. Due to leakages from the body of the pump a continuous flow of 2 m^3/hr is lost. The efficiency of the pump is 55%. The flow at the discharge side would be a) 12 m^3/hr b) 10 m^3/hr c) 5.5 m^3/hr d) 6.6 m^3/hr
47.	A 400W lamp was switched on for 10 hours per day. The supply volt is 230V (current= 2 amps & PF= 0.8). What is the energy consumption per day a) 3.68 kWh b) 6.37 kWh c) 0.37 kWh d) 4.0 kWh
48.	20 m^3 of water is mixed with 30 m^3 of another liquid with a specific gravity of 0.9. The volume of the mixture would be a) 47 m^3 b) 48 m^3 c) 50 m^3 d) 53 m^3
49.	100 tons of coal with a GCV of 4200 kcal/kg can be expressed in 'tonnes of oil equivalent' as a) 42 b) 50 c) 420 d) 125
50.	1 kg of wood contains 15% moisture and 7% hydrogen by weight. How much water is evaporated during complete combustion of 1 kg of wood a) 0.78 kg b) 220 grams c) 0.15 kg d) 0.63 kg

……. End of Section – I ……..

Section – II: SHORT DESCRIPTIVE QUESTIONS **Marks: 8 x 5 = 40**

(i) Answer all **Eight** questions
(ii) Each question carries **Five** marks

S-1	A gas fired water heater heats water flowing at a rate of 20 litres per minute from 25^0 C to 85^{o}C. If the GCV of the gas is 9200 kcal/kg, what is the rate of combustion of gas in kg/min (assume efficiency of water heater as 82%)
	Solution: Volume of water heated = 20 liters/min Mass of water heated = 20 Kg/min Heat supplied by gas * efficiency = Heat required by water. … 1 mark Mass of gas Kg/min * 9200 * 0.82 = 20 Kg/min * 1 kcal/Kg/^{o}C)* (85-25)^{o}C

	… 1 mark Mass of gas Kg/min = (20*1*60)/ (9200*0.82) = 0.159 Kg/ min. …. 3 marks
S-2	Calculate the net present value over a period of 3 years for a project with the following data. The discount rate is 12%.

Year	Investment (Rs)	Savings (Rs)
0	75,000	
1		25,000
2		75,000
3	50,000	75,000
4		35,000

	Ans: NPV = - 75,000 + 25,000/(1+0.12) + 75,000/$(1+0.12)^2$ + (75,000 – 50,000)/$(1+0.12)^3$ …… 3 marks = -75,000 + 22,321 + 59,789 + 17, 794 = 24,904 Rs. …… 2 marks
S-3	In a process plant, an evaporator concentrates a liquor containing solids of 6% by w/w (weight by weight) to produce an output containing 30% solids w/w. calculate the evaporation of water per 500 kgs of feed to the evaporator.
	Solution : Inlet solid contents = 6 % Output solid contents = 30% Feed = 500 kgs Inlet solid content in kg in feed = 500 x 0.06 = 30 kg …… 1 mark Outlet solid content in kg = 30 kg …… 1 mark Quantity of water evaporated = [500 – {(30 / 30) x 100}] = 400 kg. …… 3 marks
S-4	List down at least five schemes of BEE under the Energy Conservation Act – 2001
	Ans: Schemes of BEE under the Energy Conservation Act - 2001 are as follows: • Energy conservation building codes (ECBC) • Standards and labeling (S&L) • Demand side management (DSM) • Bachat Lamp Yojana (BLY) • Promoting energy efficiency in small and medium enterprises (SME's) • Designated consumers • Certification of energy auditors and energy managers

	….. (5 marks for any of the above five schemes)
S-5	What parameters are measured with the following instruments? a) Pitot tube b) Stroboscope c) Fyrite d) Psychrometer e) Anemometer
	Ans: a. Pitot tube — Static, Dynamic and Total Pressure of Gas b. Stroboscope — Speed, RPM c. Fyrite — CO_2 % or O_2 % d. Psychrometer — Dry Bulb Temperature and Wet Bulb Temperature e. Anemometer — Air or wind velocity …… (1 mark each)
S-6	What are ESCerts and explain the basis for their issue and trading under PAT scheme ?
	PAT scheme provides the option for industries who achieve superior savings to receive energy savings certificates for this excess savings, and to trade the additional certified energy savings certificates with other designated consumers (energy intensive industries notified as Designated Consumers under the Energy Conservation Act and included under PAT Scheme) who can utilize these certificates to comply with their specific energy consumption reduction targets. Energy Savings Certificates (ESCerts) so issued will be tradable at Power Exchanges. The scheme also allows units which gain ESCerts to bank them for the next cycle of PAT, following the cycle in which they have been issued. ….. (5 marks)
S–7	Pressure of a nitrogen gas supplied to an oil tank for purging is measured as 100 mm of water gauge when barometer reads 756 mm of mercury. Determine the volume of 1.5 kg of this gas if it's temperature is 25 ^{0}C. Specific gravity of mercury: 13.6. Take R = 8.3143 kJ/(kMol x K)
	Ans: Nitrogen pressure = 100 mm of Water Gauge = 100 / 13.6 = 7.353 mm of Hg **…..** (0.5 mark) Absolute Temperature, T = 25 + 273 = 298 K, Mass = 1.5 kg & Barometric pressure = 756 mm of Hg. Absolute pressure = 756 + 7.353 = 763.353 mm of Hg **…..** (0.5 mark) Pressure, P = Density, (kg/m^3) x Gravity, g (m/s^2) x Mtr of Liquid, h (Mtr) / 1000 = (13,600 x 9.81 x 0.763)/1000 = 101.79 kPa

	….. (1.5 marks) Molar mass of Nitrogen = 28 kg/kMol. Number of kMol, n = Mass / Molar Mass = 1.5/ 28 = 0.0536 kMol **……**(1 mark) Using the ideal gas equation and putting the above values; PV = nRT 101.79 x V = 0.0536 x 8.3143 x 298 V = 1.395 m^3 **…..** (1.5 marks)
S–8	Distinguish between designated agency and designated consumer as per energy conservation act 2001
	Ans: Designated Agency: Designated agency means an agency which coordinates, regulates and enforces of Energy Conservation Act 2001within a state. ..… (2.5 marks) Designated Consumer: Designated consumer means any users or class of users of energy in the "energy intensive industries and other establishments" specified in Schedule as designated consumer. ..… (2.5 marks)

……. End of Section – II ……..

Section – III: LONG DESCRIPTIVE QUESTIONS

Marks: 6 x 10 = 60

(i) Answer all **Six** questions
(ii) Each question carries **Ten** marks

L - 1	a) A furnace heating steel ingots is fired with oil having a calorific value of 10,500 kCal/kg and efficiency of 75%. Calculate the oil consumption per hour when the throughput of the furnace is 50 TPH and the temperature of the finished product is 600 ^oC. Take ambient temperature as 30 ^oC and Specific Heat of Steel as 0.12 kCal/kg ^oC b) In Steel industry, different types of gases are generated during steel making process. Volumetric Flow rate and Calorific Values of each gases are:

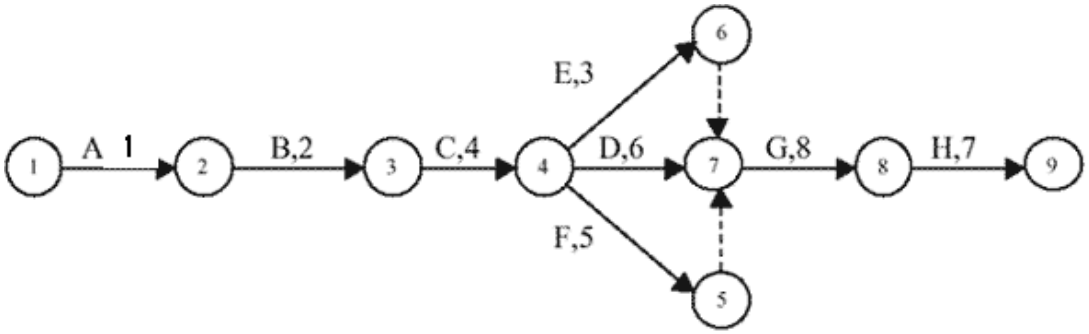
Type of Gas	Flow (SM^3/hr)	CV (kCal/SM^3)
Coke Oven Gas	75,000	4,000
COREX Gas	50,000	2,000
BOF Gas	55,000	1,500
Blast Furnace Gas	80,000	700

	All these gases are mixed in the gas mixer before combustion. Find out the Calorific Value (in kCal/SM^3) of mix gas.
	Ans: a) Oil Consumption / hr $= \frac{50\ (TPH) \times 0.12\ (kCal/kg\ ^oC) \times (600 - 30)\ (^oC)}{0.75\ (\%) \times 10{,}500\ (kCal/kg)}$ = 0.43 TPH (5 marks) b) Total flow of Mix Gas = 75,000 + 50,000 + 55,000 + 80,000 = 2,60,000 SM^3/hr (1 mark) CV of Mix Gas = [(75,000 x 4,000) + (50,000 x 2,000) + (55,000 x 1,500) + (80,000 x 700)] / 2,60,000 = 2,071 kCal/SM^3 (4 marks)
L – 2	A) Briefly explain the following terms with respect to energy management? I. Normalizing II. Benchmarking B) Explain the meaning of Fuel and Energy substitution with examples.
	Ans: A) I) Normalizing: The energy use of facilities varies greatly, partly due to factors beyond the energy efficiency of the equipment and operations. These factors may include weather or certain operating characteristics. Normalizing is the process of removing the impact of various factors on energy use so that energy performance of facilities and operations can be compared. …… (3 marks) II) Benchmarking: Comparison of energy performance to peers and competitors to establish a relative understanding of where our performance ranks. …… (2 marks) B) Fuel and Energy substitution with examples:

	Substituting existing fossil fuels/energy with more efficient and / or less cost/less polluting fuel. ….. (1 mark) Few examples of fuel substitution ▪ Natural gas is increasingly the fuel of choice as fuel and feedstock in the fertilizer, petrochemicals, power and sponge iron industries. ▪ Replacement of coal by coconut shells, rice husk etc. ▪ Replacement of LDO by LSHS …… (2 marks) Few examples of energy substitution ✓ Replacement of electric heaters by steam heaters. ✓ Replacement of steam based hot water by solar systems. …… (2 marks)
L - 3	The details of activities for a pump replacement project is given below: a) Draw a PERT chart b) Find out the duration of the project c) Identify the critical path.

Activity	Immediate Predecessors	Time (days)
A	-	1
B	A	2
C	B	4
D	C	6
E	C	3
F	C	5
G	D, E, F	8
H	G	7

Ans:

	 …..(6 marks) Duration = 28 days ….. (2 marks) Critical Path: A-B-C-D-G-H ….. (2 marks)
L – 4	The production capacity of a paper drying machine is 500 TPD and is currently operating at an output of 480 TPD. To find out the steam requirement for drying, the Energy Manager measures the dryness of the paper both at inlet and outlet of the paper drying machine which found to be 60% and 95% respectively. The steam is supplied at 4 kg/cm^2, having a latent heat of 510 kCal/kg. The evaporated moisture temperature is around 100 ^{0}C having enthalpy of 640 kCal/kg. Plant operates 24 hours per day. Assume only latent heat of steam is being used for drying the paper and neglect the enthalpy of the moisture in the wet paper. i) Estimate the quantity of moisture to be evaporated per hr. ii) Input steam quantity required for evaporation per hr.
	Ans: Output of the drying machine = 480 TPD with 95% dryness. Bone dry mass of paper at the output = 480 x 0.95 = 456 TPD …. (2 marks) Since the dryness at the inlet is 60%, Total mass of wet paper at the inlet = (456 x 100) / 60 = 760 TPD …..(2 marks) Moisture evaporated per hour = (760 – 480)/ 24 = 11.67TPH ….(3 marks) Mass of Steam, m = (11.67 x 640)/ 510 = 14.6 TPH …..(3 marks)
L - 5	Use CUSUM technique to develop a table and to calculate energy savings for 8 months period. For calculating total energy saving, average production can be taken as 6,000 MT per month. Refer to field data given in the table below.

Month	Actual SEC, kWh/MT	Predicted SEC, kWh/MT
May	1311	1335
June	1308	1335
July	1368	1335
Aug	1334	1335
Sept	1338	1335
Oct	1351	1335
Nov	1322	1335
Dec	1320	1335

Ans

Month	Actual SEC, kWh/MT	Predicted SEC, kWh/MT	Diff = (Act - Pred) (- = Saving)	CUSUM (- = Saving)
May	1311	1335	-24	-24
June	1308	1335	-27	-51
July	1368	1335	33	-18
Aug	1334	1335	-1	-19
Sept	1338	1335	3	-16
Oct	1351	1335	16	0
Nov	1322	1335	-13	-13
Dec	1320	1335	-15	-28

…..(7 marks)

Savings in energy consumption over a period of eight months are 28 x 6000 =<u>1,68,000 kWh</u>

…..(3 marks)

L-6 Write short notes on?

1. Time of the day tariff
2. Comparative label
3. Endorsement label
4. Benefits of ISO 50001

Solution:

1) In Time of the Day Tariff (TOD) structure incentives for power drawl during off-peak

hours and disincentives for power drawl during peak hours are built in.

- Many electrical utilities like to have flat demand curve to achieve high plant efficiency.
- ToD tariff encourage user to draw more power during off-peak hours (say during 11pm to 5 am, night time) and less power during peak hours. Energy meter will record peak and off-peak consumption and normal period separately.
- ToD tariff gives opportunity for the user to reduce their billing, as off peak hour tariff is quite low in comparison to peak hour tariff.
- This also helps the power system to minimize in line congestion, in turn higher line losses and peak load incident and utilities power procurement charges by reduced demand

….. (2.5 marks)

2) Comparative label: allow consumers to compare efficiency of all the models of a product in order to make an informed choice. It shows the relative energy use of a product compared to other models available in the market.

….. (2.5 marks)

3) Endorsement label: define a group of products as efficient when they meet minimum energy performance criteria specified in the respective product schedule/regulation/statutory order.

….. (2.5 marks)

4) ISO 50001 will provide the following benefits

- A framework for integrating energy efficiency into management practices
- Making better use of existing energy-consuming assets
- Benchmarking, measuring, documenting, and reporting energy intensity improvements and their projected impact on reductions in greenhouse gas (GHG) emissions
- Transparency and communication on the management of energy resources
- Energy management best practices and good energy management behaviours
- Evaluating and prioritizing the implementation of new energy-efficient technologies
- A framework for promoting energy efficiency throughout the supply chain
- Energy management improvements in the context of GHG emission reduction projects.

….. (2.5 marks)

……. End of Section – III ……..

15th NATIONAL CERTIFICATION EXAMINATION FOR ENERGY MANAGERS & ENERGY AUDITORS – August, 2014

PAPER – 1: General Aspects of Energy Management & Energy Audit

Date: 23.08.2014 Timings: 09:30-12:30 HRS Duration: 3 HRS Max. Marks: 150

Section - I: OBJECTIVE TYPE **Marks: 50 x 1 = 50**

a) Answer all **50** questions
b) Each question carries **one** mark
c) Please hatch the appropriate oval in the OMR answer sheet with Black Pen or HB pencil

1.	A geothermal field may yield a) dry steam b) wet steam c) hot air d) all of these
2.	Which of the following is not a greenhouse gas ? a) CFCs b) SO_2 c) PFC d) SF_6
3.	Bio-gas generated through anaerobic process mainly consists of a) only methane b) methane and carbon dioxide c) only ethane d) none of these
4.	Which of the following statements are true? i) bagasse is a source of secondary energy ii) beneficiated coal belongs to primary energy iii) electricity is basically a convenient form of primary energy iv) steam is a convenient form of secondary energy a) (ii) & (iii) b) (i) & (iii) c) (ii) & (iv) d) (ii) & (i)
5.	Natural gas contains a) methane, ethane and propane in equal proportions b) only butane and propane in equal proportions c) methane, propane and pentane in equal proportions d) mostly methane and minor amounts of other gases
6.	Which issue is not addressed by Integrated Energy Policy? a) consistency in pricing of energy b) scope for improving supply of energy from varied sources c) energy conservation Research and Development

	d) <u>reducing price of energy</u>
7.	Which of the following statement is not true regarding energy security? a) <u>impaired energy security will not affect agricultural output</u> b) energy security is strengthened by avoiding dependence upon imported energy c) diversifying energy supply from different countries strengthen energy security d) strengthening energy security requires increasing exploration to find oil and gas reserves
8.	In a boiler substitution of coal with rice husk leads to a) energy conservation b) energy efficiency c) both energy conservation and energy efficiency d) <u>carbon emission reduction</u>
9.	A building intended to be used for commercial purpose will be required to follow Energy conservation building code under Energy Conservation Act, 2001 provided its a) connected load is 120 kW and above b) contract demand is 100 kVA and above c) <u>connected load is100 kW and above or contract demand is 120 kVA and above</u> d) connected load is 500 kW and contract demand is 600 kVA
10.	Which of the following is not a part of energy audit as per the Energy Conservation Act, 2001? a) monitoring and analysis of energy use b) verification of energy use c) submission of technical report with recommendations d) <u>ensuring implementation of recommended measures followed by review</u>
11.	Which of the following criteria is a responsibility of Designated Consumers? a) designate or appoint an accredited Energy Auditor b) <u>adhere to stipulated energy consumption norms and standards as notified</u> c) submit the status of energy consumption information every three years d) conduct energy audit through a certified energy auditor periodically
12.	Which of the following is an energy security measure? a) fully exploiting domestic energy resources b) diversifying energy supply source c) substitution of imported fuels for domestic fuels to the extent possible d) <u>all of the above</u>
13.	An induction motor with 11 kW rating and efficiency of 90% in its name plate means a) <u>it will draw 12.22 kW at full load</u> b) it will always draw 11 kW at full load

	c) it will draw 9.9 kW at full load d) nothing can be said about how much power it will draw as motor power factor is not given
14.	Which of the following statement is true regarding maximum demand controller? a) maximum demand controller enables a way of 'shaving' the peaks in the consumer load profile b) maximum demand controller enables a way of improving the system power factor c) enables a way for using more electrical energy at lower total cost of energy without investment in expansion of power supply d) maximum demand controller is installed by concerned utility at customer premises
15.	Which of the following statements are true? i) reactive current is necessary to build up the flux for the magnetic field of inductive devices ii) some portion of reactive current is converted into work iii) the cosine of angle between kVA and kVAr vector is called power factor iv) the cosine of angle between kW and kVA vector is called power factor a) i & iv b) ii & iii c) i & iii d) iii & iv
16.	Which of the following is a standard for Energy Management System? a) ISO 14001 b) ISO 9001 c) ISO 18001 d) ISO 50001
17.	Which of the following statements are true regarding simple payback period? a) considers impact of cash flow even after payback period b) takes into account the time value of money c) considers cash flow throughout the project life cycle d) determines how quickly invested money is recovered
18.	Which of the following statements are true regarding CPM? i) work breakdown structure are used to list the activities in the project as a first step in CPM ii) CPM takes into account variation in the completion time and average time is used for any activity iii) if the project is to finish earlier, it is necessary to focus on activities other than critical path iv) critical path is the longest path in the network. a) i & iv b) i & iii c) ii & iv d) iii & iv
19.	Which of the following statements is not correct? Global warming will result in:

	a) melting of the ice caps b) increasing sea levels c) <u>severe damage to ozone layer in stratosphere</u> d) unpredictable climate patterns
20.	The process of capturing CO_2 from point sources and storing them is called a) <u>carbon sequestration</u> b) carbon sink c) carbon Capture d) carbon absorption
21.	Which of the following statements are true regarding wind turbine? i) wind power varies as cube of rotor size ii) wind power varies as cube of wind velocity iii) wind speed has more influence on wind power than turbine area iv) practical maximum amount of energy in the wind that can be collected by wind turbine rotor is about 79% a) i & ii b) <u>ii & iii</u> c) iii & iv d) ii & iv
22.	Which of the following statements regarding evacuated tube collectors (ETC) are true? i) ETC is used for high temperatures upto 150^oC ii) because of use of vacuum between two concentric glass tube, higher amount of heat is retained in ETC iii) heat loss due to conduction back to atmosphere from ETC is high iv) performance of evacuated tube is highly dependent upon the ambient temperature a) i & iii b) ii & iii c) i & iv d) <u>i & ii</u>
23.	What percentage of the sun's energy can silicon solar panels convert into electricity? a) 30% b) <u>15%</u> c) 75% d) 50%
24.	How much theoretical power you would expect to generate from a river-based mini hydropower with flow of 20 litres/second and head of 12 metres a) <u>2.35kW</u> b) 2.44MW c) 1.67kW d) none of the above
25.	Which among the following has the highest flue gas loss on combustion due to Hydrogen in the fuel ? a) <u>natural gas</u> b) furnace oil c) coal d) light diesel oil
26.	Energy in one Tonne of Oil Equivalent (toe) corresponds to a) 4.187 GJ b) 1.162 MWh c) 1 Million kcal d) <u>none of the above</u>
27.	Tonnes of Oil Equivalent energy consumption / GDP in Million US $ is termed as a) <u>energy intensity</u> b) per capita oil consumption c) per capita energy consumption d) energy performance

28.	Assume CO_2 equivalent emissions by the use of a 60 W incandescent lamp are of the order of 60 g/hr. If it is replaced by a 5 W LED lamp then the equivalent CO_2 emissions will be a) nil b) 5 g/hr c) 12 g/hr d) 300 g/hr
29.	Under the Energy Conservation Act, the designated consumer is required to get the mandatory energy audit conducted by a) certified energy manager b) certified energy auditor c) accredited energy auditor d) in-house engineer
30.	If the relative humidity of air is 100%, then which of the following statements is correct a) only dew point & wet bulb temp. are same b) only dew point & dry bulb temp. are same c) only wet bulb & dry bulb temp. are same d) all dew point , wet bulb & dry bulb temp. are same
31.	Among which of the following fuel is the difference between the GCV and NCV maximum? a) coal b) furnace oil c) natural gas d) rice husk
32.	Non-contact speed measurements can be carried out by a) tachometer b) stroboscope c) oscilloscope d) speedometer
33.	Which of the following instrument is used for assessing combustion efficiency ? a) lux Meter b) pitot tube & manometer c) ultrasonic flow meter d) fyrite
34.	The benchmarking parameter for a vapour compression refrigeration system is a) kW / kg of refrigerant used b) kcal / m^3 of chilled water c) BTU / Ton of Refrigeration d) kW / Ton of Refrigeration
35.	If 800 kcal of heat is supplied to 20 kg of ice at 0^o C, how many kg of ice will melt into water at 0^oC. (Latent heat of fusion of ice is 80 kcal/kg) a) 1 kg b) 4 kg c) 10 kg d) 20 kg
36.	If feed of 100 tonnes per hour at 5% concentration is fed to a crystallizer, the product obtained at 25% concentration is equal to ____ tonnes per hour. a) 15 b) 20 c) 35 d) 40

37.	The return on investment (ROI), is expressed as a) annual cost / capital cost b) (first cost / first year benefits) x 100 c) NPV / IRR d) (annual net cash flow x 100) / capital cost
38.	The rate of energy transfer from a higher temperature to a lower temperature is measured in a) kCal b) Watt c) Watts per second d) none of the above.
39.	Cost of a new heat exchanger is Rs. 1.5 lakh. The simple payback period (SPP) in years considering annual savings of Rs 60,000 and annual maintenance cost of Rs 10,000 is a) 0.4 b) 2.5 c) 3 d) 6
40.	Energy sources which are inexhaustible are known as a) commercial energy b) primary energy c) renewable energy d) secondary energy
41.	1 kg of wood contains 15% moisture and 5% hydrogen by weight. How much water is evaporated during complete combustion of 1kg of wood? a) 0.6 kg b) 200 g c) 0.15 kg d) none of the above
42.	In an industry the average electricity consumption is 5.8 lakh kwh for a given period. The average production is 50000 tons with a specific electricity of 11 kwh/ton for the same period. The fixed electricity consumption for the plant is a) 58000 kWh b) 30000kWh c) 80000kWh d) none of the above
43.	The cost of replacement of inefficient compressor with an energy efficient compressor in a plant costs Rs. 8 lakhs. The net annual cash flow is Rs. 2 lakhs. The return on investment a) 18% b) 20% c) 15% d) none of the above
44.	The amount of electricity required to heat 100 litres of water from 30^{o}C to 70 ^{o}C through resistance heating is a) 0.465 kWh b) 4.65 kWh c) 465 kWh d) 2 kWh
45.	In project financing, sensitivity analysis is applied because a) almost all the cash flows involve uncertainly b) it evaluates how sensitive the project is to change in the input parameters c) it assesses the impact of 'what if one or more factors are different from what is predicted' d) it is applicable to all the above situations
46.	A process requires 120 kg of fuel with a calorific value of 4800 kcal/kg for heating with a system efficiency of 82 %. The loss would be a) 576000 kcal b) 472320 kcal c) 103680 kcal d) 480000 kcal

47.	The internal rate of return is the discount rate for which the NPV is a) positive b) zero c) negative d) less than 1
48.	Having energy policy a) satisfies regulations b) shows top management commitment c) indicates energy audit skills d) adds to the list of number other policies
49.	The producer gas is basically a) CO, H_2 and CH_4 b) only CH_4 c) only CO and CH_4 d) only CO and H_2
50.	The time between its earliest and latest start time, or between its earliest and latest finish time of an activity is a) delay time b) slack time c) critical path d) start time

……. End of Section – I …….

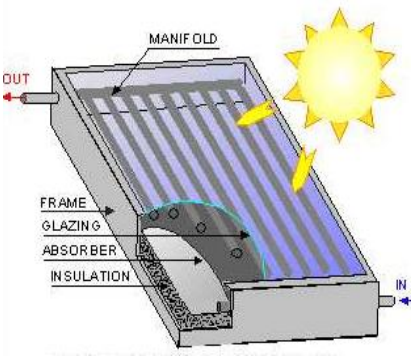
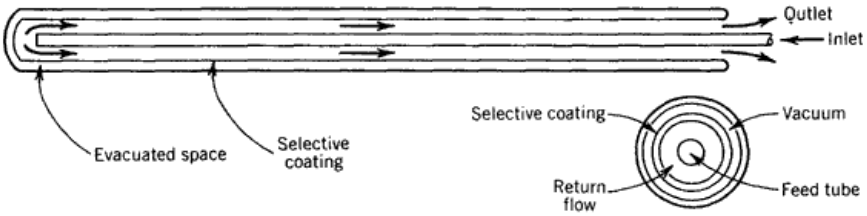
Section – II: SHORT DESCRIPTIVE QUESTIONS **Marks: 8 x 5 = 40**

(i) Answer all **Eight** questions
(ii) Each question carries **Five** marks

S-1	Calculate Net Present Value over a period of 3 years for a project with an investment of Rs 70,000 at the beginning of the first year and second investment of Rs 70,000 at the beginning of the second year and fuel cost saving of Rs 95,000 in second and third year. The discount rate is 14%
Ans	NPV = –70,000 – (70000/1.14) + [95000/(1.14x1.14)] + [95000/(1.14x1.14x1.14)] = –70000 – 61404 +73099 + 64122 = –131404 +137221 = Rs 5817/-
S-2	A water pumping station fills a reservoir at a fixed rate. The head and flow rate are constant and hence the power drawn by the pump is always same. The pump operates at 100 m head and delivers 250 litres per second. The power consumption was measured as 300 kW. Calculate energy consumption to pump 13,500 kL of water to the reservoir.
Ans	Time taken to pump water in hours = $\frac{13{,}500 \times 10^3 \text{ L}}{250 \text{ L/s} \times 3600 \text{ sec/hr}}$ = 15 hours Power required to pump water = 300 kW

	Energy consumption = 300 x 15 =4500 kWh
S-3	A conveyor delivers coal with a width of 1 m and coal bed height of 0.25 m at a speed of 0.5 m/s. Determine coal delivery in tons per hour considering coal density of 1.1 ton/m^3.
Ans	Volume of coal delivered per hour = area x length travelled per second =1 m x 0.25 m x 0.5 m/s = 0.125 m^3/s = 450 m^3/hr Coal delivery rate = 450 m^3/hr x 1.1 t/m^3 = 495 t/hr
S-4	In a process industry, 12,000 kg/hr water is currently being heated from 18^{o}Cto 80^{o}C by indirect heating of steam. An opportunity has been identified which would preheat the inlet water to 45^{o}C to reduce the steam required. Estimate the reduction in steam in kg/hr considering latent heat of steam as 520 kcal/kg in both the cases.
Ans	**Without heat recovery** Heating required (Q_1) = $mC_p\Delta T$ = 12,000 x 1 x (80-18) = 744,000 kcal/hr Steam required = 744,000 / 520 = 1431 kg/hr **After heat recovery** Heating required (Q_2) = 12,000 x 1 x (80 – 45) = 420,000 kcal/hr Steam required = 420,000/520 = 808 kg/hr Reduction in steam required = 1431 - 808 = 623 kg/hr
S-5	Write short notes on **any two** of the following: a) Building envelope b) Standards and Labeling c) Demand Side Management (DSM)
Ans	(a) Building envelope includes all components of building exposed to outside environment such as outside doors, windows, roofs etc. Its main purpose is to protect employees from outside environment.

	(b) **Standards and Labeling** (Page -35): There is a wide variation in energy consumption of similar products by various manufacturers. Also information on energy consumption is often not easily available. Standards and Labeling (S&L) has been identified as a key activity for energy efficiency improvement. The S&L program, when in place, would ensure that only energy efficient equipment and appliances would be made available to the consumers. Standards: Energy-efficiency standards are procedures and regulations prescribing the energy performance of energy-consuming products. The sale of products that are less energy efficient than minimum standards, often called Minimum Energy Performance Standards (MEPS) may be prohibited. For establishing the standards, agreed testing protocols (test procedures) are defined and value of energy performance is determined. Labels: Energy-efficiency labels are informative labels affixed to manufactured products to describe the product's energy performance (usually in the form of energy use, efficiency). These labels give consumers the data necessary to make informed purchases. Star rating is a system initiated by BEE to determine energy efficiency of an appliance. Label indicates the energy efficiency levels through the number of stars highlighted in colour on the label. It is being applied to many products such as refrigerators, TVs, ACs and so on. (c) Demand Side Management (Page -36) : Demand Side Management (DSM) means managing of the demand for power, by utilities / Distribution companies, among some or all its customers to meet current or future needs. DSM programs result in energy and / or demand reduction. For example, under this process, the demand can be shifted from peak to off peak hours thereby reducing the need for buying expensive imported power during peak hours. DSM also enables end-users to better manage their load curve and thus improves the profitability. Potential energy saving through DSM is treated same as new additions on the supply side in MWs. DSM can reduce the capital needs for power capacity expansion.
S6	a) Briefly explain why combustion of biomass fuels is considered as carbon neutral? b) Name five energy intensive industries having annual energy consumption of 30,000 metric tonne of oil equivalent and above, notified as designated consumers under the EC Act 2001

Ans	a) The CO_2 emitted by combustion of biomass fuels is largely balanced by the absorption/capture of carbon dioxide during its growth. b) 1. Thermal Power Stations 2. Fertilizer 3. Cement 4. Iron & Steel 5. Pulp & Paper
S7	Briefly explain the difference between flat plate collector and evacuated tube collector.
Ans.	(Page 260-261) Flat plate collector: ❖ The most common collector is called a flat-plate collector. ❖ Heat the circulating fluid to a temperature of about 40-60°C. ❖ Usually comprises of copper tubes welded to copper sheets (both coated with a highly absorbing black coatings) with toughened glass sheet on top for cover and insulating material at the bottom. The entire assembly is placed in a flat box.  **Solar Flat Plate Collector** Evacuated tube collector: ❖ Used For higher temperatures. ❖ Evacuated tube collector is less dependent upon ambient temperature unlike flat plate collector and its efficiency does not drop with ambient temperature. ❖ Evacuated glass tubes are used instead of copper in which case a separate cover sheet and insulating box are not required. ❖ Can reach high temperatures upto 150°C  **Evacuated Tube Collector** 

S8	A sample of coal being used in a boiler is found to contain 60% carbon and 23% ash. The refuse obtained after combustion is analysed and found to contain 7% carbon & the rest is ash. Compute the percentage of the original carbon in coal which remains as unburnt in the refuse.
Ans	Let the quantity of Refuse sample =100 kg Amount of unburnt Carbon in Refuse = 7 kg Amount of Ash in the Refuse = 93 kg Total ash in the coal that has come into the Refuse = 23% of coal 93 kg of Ash corresponds to 23% ash in the coal Therefore, quantity of total raw coal = 93 / 0.23 = 404.35 kg Quantity of original Carbon in the coal = 0.60 x 404.35 = 242.61 kg Quantity of unburnt coal in Refuse = 7 kg %age of the original carbon unburnt in the refuse = (7 / 242.61) x 100 = 2.89%

------- End of Section - II ---------

Section – III: LONG DESCRIPTIVE QUESTIONS **Marks: 6 x 10 = 60**

(i) Answer all **Six** questions
(ii) Each question carries **Ten** marks

L1	In pre-treatment process of a plating section of an engineering industry, LPG was being used indirectly to heat 6000 litres/hr of water by 10^0C. The industry is planning to convert from LPG to electrical heating. **Other data:** Annual operating hours = 3000 hours Efficiency of indirect heating with LPG = 85% Calorific value of LPG = 11000 kcal/kg, Landed cost of LPG = Rs.75/kg Cost of electricity = Rs.6/kwh. a) If LPG is replaced with electrical heating with an investment is Rs.1.5 lakhs, compute simple payback period. b) Calculate the CO_2 emissions in both the cases. Consider emission factors for LPG as 3 tons of CO_2/Ton of LPG and Electricity as 0.81 tons of CO_2/MWh

Ans

Water flow rate	6000 Litres/hr
Temperature rise	10^oC
Heat provided with LPG	(6000 x 10)=60000 kCal/hr
LPG consumption	60000/(11000 x 0.85) =6.4 kg/hr
Annual LPG consumption	6.4 x 3000 = 19.2 Tons/yr
Annual CO_2 emission with LPG heating	19.2 x 3 =57.6 t CO_2
Cost of heating with LPG	19.2 x 1000 x 75 = Rs.14.4 lakhs/annum
Electricity equivalent of LPG	(60000/860) = 70 kW 70 x 3000 = 210 MWh
Average cost of electricity	Rs. 6/kWh
Cost of electrical heating	(70 x 6) = Rs. 420/hr 420 x 3000 = Rs.12.6 lakhs
Annual CO_2 emission with electrical heating	210 x 0.81 =170 t CO_2
Annual cost savings	(14.4-12.6)
Potential annual savings	Rs.1.8 lakhs
Investment for electrical heating	Rs.1.5 lakhs
Payback period	1.5/1.8 0.83 years (< 10 months)

L2

A project has the following activities, precedence relationships, and time estimates in weeks:

Activity	Immediate Predecessors	Optimistic Time	Most Likely Time	Pessimistic Time
A	-	15	20	25
B	-	8	10	12
C	A	25	30	40
D	B	15	15	15
E	B	22	25	27
F	E	15	20	22
G	D	20	20	22

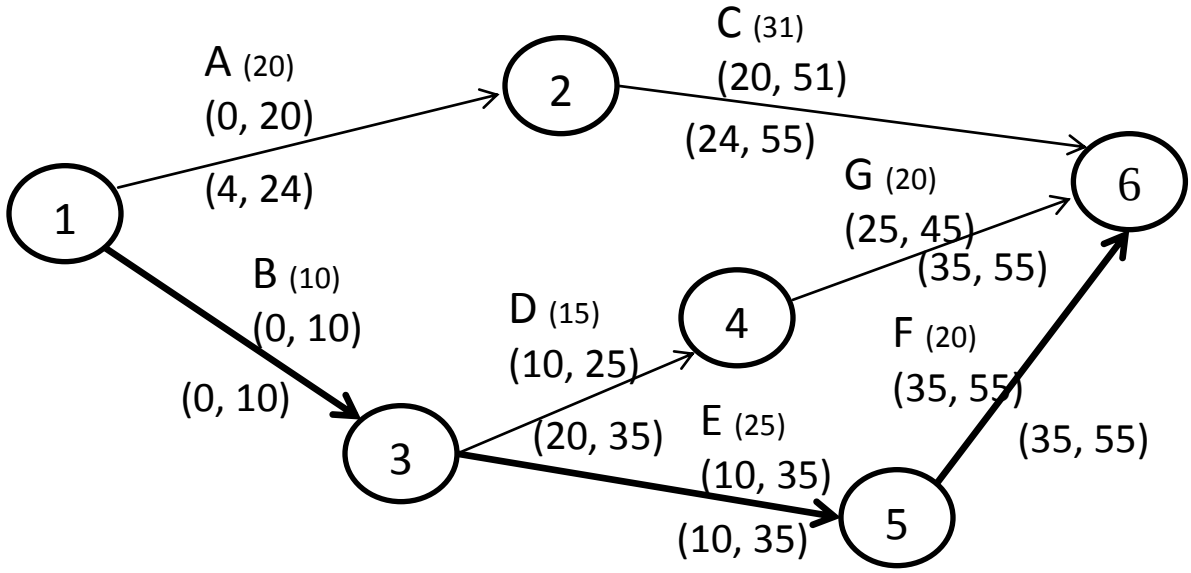
a) Draw the network diagram (expected time may be rounded to the nearest whole number)
b) Identify the critical path and
c) Determine the project duration.

ANS

(a) **Expected Time calculation**:

Activity	Immediate Predecessors	T_o	T_m	T_p	Expected Time T_e
A	-	15	20	25	20
B	-	8	10	12	10
C	A	25	30	40	30.8
D	B	15	15	15	15
E	B	22	25	23	24.8
F	E	15	20	22	19.5
G	D	20	20	22	20.3

a)Network PERT Diagram



b)**Critical Path : B-E-F**

c)Project Duration : 55 weeks

L3

A company has got following two investment options:

Option A:. Investment envisaged Rs. 40 lakhs with an annual return of Rs. 8 lakhs; Life of the project is 10 years

Option B: Investment envisaged Rs. 24 lakhs; Annual return Rs. 5 lakhs; Life of the project is 8 years

Calculate IRR of both the options and suggest which option the company should select.

	Option A: Investment = Rs. 40 lakh Annual Return = Rs. 8 lakh Life of project = 10 years $0 = [(-) 40 \times 10^5] + [(8 \times 10^5) / (1 + 0.15)^1] + [(8 \times 10^5) / (1 + 0.15)^2] + ---------- + [(8 \times 10^5) / (1 + 0.15)^9] + [(8 \times 10^5) / (1 + 0.15)^{10}]$ **= 15.12 %** Option B: Investment = Rs. 24 lakh Annual Return = Rs. 5 lakh Life of project = 8 years $0 = [(-) 24 \times 10^5] + [(5 \times 10^5) / (1 + 0.13)^1] + [(5 \times 10^5) / (1 + 0.13)^2] + ---------- + [(5 \times 10^5) / (1 + 0.13)^7] + [(5 \times 10^5) / (1 + 0.13)^8]$ **= 13.04 %** Based on IRR, the Option A has higher IRR value and the company may opt for Option A.
L4	Write short note on **any two** of the following a) Energy Service Companies (ESCOs) b) Sensitivity analysis for financing of energy conservation projects c) Sankey diagram
Ans	a) **Energy Service Companies** (ESCOs) : page -171 ESCOs are usually companies that provide a complete energy project service, from assessment to design to construction or installation, along with engineering and project management services, and financing. Depending on the company's capability to manage the risks (equipment performance, financing, etc.) the company will delegate some of these responsibilities to the ESCO. In general, the amount of risk assigned to the ESCO is directly related to the percent savings that must be shared with the ESCO. *For example, a lighting retrofit has a high probability of producing the expected cash flows, whereas a completely new process does not have the same "time tested" reliability. If the in-house energy management team cannot manage this risk, performance contracting may be an attractive alternative*. The ESCO will usually offer the following common types of contracts: • Fixed fee • Shared savings

- Guaranteed savings

Services offered by an ESCO usually include:

- ✓ An investment grade energy audit to identify energy and operational savings opportunities, assess risks, determine risk management/mitigating strategies, and calculate cost-effectiveness of proposed measures over time.
- ✓ Financing from its own resources or through arrangements with banks or other financing sources.
- ✓ The purchase, installation and maintenance of the installed energy efficient equipment; possibly maintenance on all energy-consuming equipment.
- ✓ New equipment training of operations and maintenance (O&M) personnel.
- ✓ Training of O&M personnel in energy-efficient practices.
- ✓ Monitoring of the operations and energy savings, so reduced energy consumption and operation costs persist.
- ✓ Measurement and savings verification; and
- ✓ A guarantee of the energy savings to be achieved.

b) Sensitivity analysis for financing of energy conservation projects : (page168 -169)

Many of the cash flows in the project are based on assumptions that have an element of uncertainty. The cash flows such as capital cost, energy cost savings, maintenance costs can usually be estimated fairly accurately. Even though these costs can be predicted with some certainty, it should always be remembered that they are only estimates. Cash flows in future years normally contain inflation components and project life itself can vary significantly.

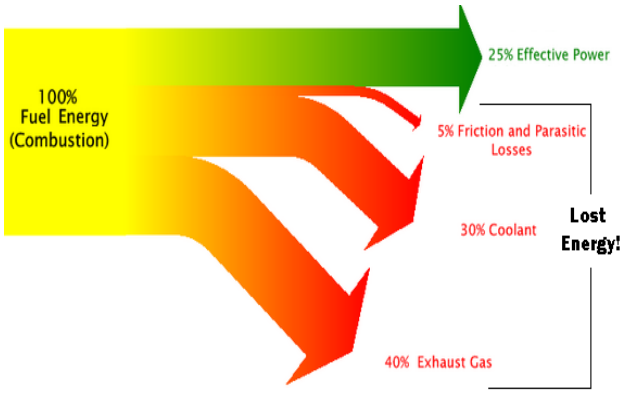
Sensitivity analysis is an assessment of risk. Because of the uncertainty in assigning values to the analysis, it is recommended that a sensitivity analysis be carried out - particularly on projects where the feasibility is marginal. How sensitive is the project's feasibility to changes in the input parameters? What if one or more of the factors in the analysis is not as favourable as predicted? How much would it have to vary before the project becomes unviable? What is the probability of this happening?

Sensitivity analysis is undertaken to identify those parameters that are both uncertain and for which the project decision taken through the NPV or IRR is sensitive. The effect of switching values of key variables required for the project decision (from acceptance to rejection) can be compared with the post evaluation results of similar projects. Sensitivity and risk analysis should lead to improved project design, with mitigation actions against major sources of uncertainty involved.

The various micro and macro factors / variables that are considered for the sensitivity analysis are listed below.

Micro factors:

- ✓ Operating expenses (various expenses items)
- ✓ Capital structure
- ✓ Costs of debt, equity
- ✓ Changing of the forms of finance e.g. leasing
- ✓ Changing the project life

	Macro factors: Macro economic variables are the variable that affects the operation of the industry of which the company operates. They cannot be changed by the firm's management. Macro economic variables, which affect projects, include among others: ✓ Changes in interest rates ✓ Changes in the tax rates ✓ Changes in the accounting standards e.g. methods of calculating depreciation ✓ Changes in depreciation rates ✓ Extension of various government subsidized projects e.g. rural electrification ✓ General employment trends e.g. if the government changes the salary scales ✓ Imposition of regulations on environmental and safety issues in the industry ✓ Energy price change ✓ Technology changes c) **Sankey diagram**: (page - 127) The Sankey diagram is very useful tool to represent an entire input and output energy flow in any energy equipment or system such as boiler generation, fired heaters, furnaces after carrying out energy balance calculation. Usually the flows are represented by arrows. The width of the arrows is proportional to the size of the actual flow. Better than numbers, tables or descriptions, this diagram represents visually various outputs (benefits) and losses so that energy managers can focus on finding improvements in a prioritized manner. The Figure shows a Sankey diagram for an internal combustion engine. From the Figure, it is clear that exhaust flue gas losses are a key area for priority attention. Since the engines operate at high temperatures, the exhaust gases leave at high temperatures resulting in poor system efficiency. Hence a heat recovery device such as a waste heat boiler has to be necessarily part of the system. The lower the exhaust temperature, higher is the system efficiency.  **Sankey Diagram for an Internal Combustion Engine**
L5	a) Calculate the annual energy savings and simple payback from replacing standard existing motor with energy efficient motor versus rewinding the existing motor. The data given: • Average cost of rewinding =Rs 6500 • Cost of new high efficient motor =Rs 37000 • Efficiency after rewound of standard motor =87% • Efficiency of energy efficient motor = 94% • Operating hours = 7200 hrs

	• % loading of motor = 82% • Power cost = Rs 5.2 / kWh • Name plate rating of motor = 20 kW b) During an air pollution monitoring study, the inlet gas stream to a bag filter was 200,000 m^3 per hour. The outlet gas stream from the bag filter was little bit higher at 220,000m^3 per hour. The dust load at the inlet was 5 g/m^3 and at the outlet 0.2 g/m^3. How much dust in kg/hour was collected in the bag filter bin?
	a) Solution: Energy cost savings (Rs/year) =[(KW)*(% loading)*{(100/efficiency of rewound standard motor)-(100/efficiency of energy efficient motor)}*(Hrs/annum)*(Rs/kwh)] = 20*0.82*7200*[(100/87)-(100/94)]*5.2 =118080*[1.1494-1.0638]*5.2 =52560/- Simple payback period = [(Rs 37000-Rs 6500)/52560] = 7 months b) Dust (gas in) = dust (in gas out) + dust (in bin) 200000 x 5 = 220000 x 0.2 + X X = 1000000 – 44000 = 956000 gm/hr **= 956 Kg/hr**
L6	Write short note on **<u>any two</u>** of the following. a) 5S b) KAIZEN c) ISO 50001 d) TPM
Ans	**a) 5S**: (page-145) 5S, abbreviated from the Japanese words **Seiri, Seiton, Seiso, Seiketsu, and Shitsuke**, are simple but effective methods to organize the workplace. The 5S, translated into English are: **housekeeping, workplace organization, cleanup, maintain cleanliness, and discipline**. They can be defined as follows: • **Housekeeping.** Separate needed items from unneeded items. Keep only what is

immediately necessary item on the shop floor.

- **Workplace Organization.** Organize the workplace so that needed items can be easily and quickly accessed. A place for everything and everything in its place.
- **Cleanup.** Sweeping, washing, and cleaning everything around working area immediately.
- **Cleanliness.** Keep everything clean in a constant state of readiness.
- **Discipline.** Everyone understands, obeys, and practices the rules when in the plant.

Implementing 5S methods in the plant would help the company to reduce waste hidden in the plant, improve the levels of quality and safety, reduce the lead time and cost, and thus increase Company's **profit**.

b) KAIZEN: (page -147)

"KAIZEN", is a practice developed by Japanese for increasing productivity. KAIZEN is the Japanese word made up of two components.

KAI – Change
ZEN – Good (for the better)
KAIZEN – Change for the better or continuous improvement.

KAIZEN means continuous improvement involving everyone – Managers and Workers alike. It emphasizes improvement on working standard through small, gradual improvement. Its philosophy assumes that our way of working life, our social life or our human life – deserves to be constantly improved.

Kaizen events focuses on reducing various forms of wastes and often energy reduction result from projects that focus on an area or a process. For example, a project that was implemented to reduce colouring chemicals in a plastic industry resulted in small changes in plant layout and material flow to its use. This ended up in big reduction in amount of forklift travelled and fuel used in the forklift.

Implementation:

Step-1: Identification of a problem, i.e. waste, defect or something not working. The operator writes and describes the problem
Step-2: Operator later develops an improvement idea and goes to immediate supervisor
Step-3: Supervisor / Kaizen team members review it and encourage immediate action and fills up the Kaizen form
Step-4: The idea is implemented & checked.
Step-5: The operator is rewarded.

c) ISO 50001: (page -151)

ISO 50001 will establish a framework for industrial plants, commercial facilities or entire organizations to manage energy. The document is based on the common elements found in all of ISO's management system standards, assuring a high level of compatibility with ISO 9001 (quality management) and ISO 14001 (environmental management).

Energy Management System enables an organization to take a systematic approach in order to achieve continual improvement of energy performance, energy efficiency and

energy conservation.

An energy management system addresses:

- Energy supply;
- Measurement;
- Documentation and reporting of energy use; and
- Procurement & design practices for energy-using equipment, systems and processes.

To simply put it, ISO 50001 is "*saying what you do and doing what you say".*

d) TPM : (page -148)

Total productive maintenance (TPM) is the method that focuses on optimizing the effectiveness of manufacturing equipment. TPM builds upon established equipment-management approaches and focuses on team-based maintenance that involves employees at every level and function.

The goal of TPM is to build a robust organisation by maximizing production system efficiency (overall effectiveness).

- TPM addresses the entire production system lifecycle and builds a concrete, shop floor-based system to prevent all losses. It aims to eliminate all accidents, defects, and breakdowns.
- TPM involves all departments from production to development, sales, and administration.
- Everyone participates in TPM, from the top executive to shop floor employees.
- TPM achieves zero losses through overlapping team activities.

-------- End of Section - III ---------

14th NATIONAL CERTIFICATION EXAMINATION FOR ENERGY MANAGERS & ENERGY AUDITORS – August, 2013

PAPER – 1: General Aspects of Energy Management & Energy Audit

Date: 24.08.2013 Timings: 09:30-12:30 HRS Duration: 3 HRS Max. Marks: 150

Section - I: OBJECTIVE TYPE **Marks: 50 x 1 = 50**

a) Answer all **50** questions
b) Each question carries **one** mark
c) Please hatch the appropriate oval in the OMR answer sheet with Black Pen or HB pencil, as per instructions

	As per Energy Conservation Act, 2001, a BEE Certified Energy Manger is required to be appointed/designated by the a) state designated agencies b) all industrial consumers c) **<u>designated consumers</u>** d) electrical distribution licensees
	The type of energy possessed by a charged capacitor is a) kinetic energy b) **<u>electrostatic</u>** c) potential d) magnetic
	The process of capturing CO_2 from point sources and storing them is called _____. a) **<u>carbon sequestration</u>** b) carbon sink c) carbon capture d) carbon adsorption
	What is the heat content of 200 liters of water at 5°C in terms of the basic unit of energy in kilojoules ? a) 3000 b) 2388 c) 1000 **d) <u>4187</u>**
	Nameplate kW rating of a motor indicates a) input to the motor **b) <u>rated output of the motor</u>** c) no-load input to the motor d) rated input to the motor
	Which of the following has the highest specific heat? a) lead b) mercury **c) <u>water</u>** d) alcohol
	What is the average conversion efficiency of a solar photo voltaic cell? a) 22% **b)<u>15%</u>** c) 98% d)50%

	An indication of sensible heat content in air-water vapour mixture is a) wet bulb temperature b) dew point temperature c) density of air **d) <u>dry bulb temperature</u>**
	Which of the following statements with respect to Reserve / Production (R/P) ratio is true? a) is a constant once established b) varies every year with changes in production c) varies every year with changes in reserves **d) <u>varies every year with changes in production and reserves</u>**
	Which issue is not addressed by Integrated Energy Policy of India? a) consistency in pricing of energy b) scope for improving supply of energy from varied sources c) energy conservation, research and development **d) <u>removal of subsidies for energy across all sectors</u>**
	In inductive and resistive combination circuit, the resultant power factor under AC supply will be **a) <u>less than unity</u>** b) more than unity c) zero d) unity
	Which of the following statement is not true regarding energy security? a) impaired energy security can even reduce agricultural output b) energy security is strengthened by minimising dependence on imported energy **c) <u>diversifying energy supply from different countries weaken energy security</u>** d) increasing exploration to find oil and gas reserves improves energy security
	An energy policy at the plant level is to be preferably signed by **a) <u>chief executive</u>** b) energy Manager c) energy auditor d) chief executive with approval of state designated agency
	The energy benchmarking parameter for air conditioning equipment is **a) <u>kW/Ton of Refrigeration</u>** b) kW/ kg of refrigerant handled c) kW/m^3 of chilled water d) kW/EER
	How much carbon dioxide emission will be reduced annually by replacing 60 Watt incandescent lamp with a 15 Watt CFL Lamp, if emission per unit is 1 kg CO_2 per kWh and annual burning is 3000 hours? a) 45 ton b) 3 ton **c) <u>0.135 ton</u>** d) 183 ton
	Which of the following statement is not correct regarding Demand Side Management (DSM)? a) agriculture and municipalities are potential areas for DSM activities b) **<u>savings accrued through DSM cannot be treated as avoided capacity on supply side</u>**

	c) under DSM, demand can be shifted from peak to off peak hours thereby avoiding imported power during peak hours d) DSM programs may result in demand as well as energy reduction
	_____ considers impact of cash flow even after payback period a) **net present value** b) return on investment b) sensitivity analysis d) simple payback period
	Consider two competitive projects entailing investment of Rs.85,000/- . Project A returns Rs.50,000 at the end of each year, but Project B returns Rs.115,000 at the end of year 2. Which project is superior? a) Project A since it starts earning by end of first year itself and recovers cost before end of two years b) Project B since it offers higher return in two years c) both projects are equal in rank d) **insufficient information**
	_____ determines the project viability in response to changes in input parameters. a) Life cycle analysis b) Financial analysis **c) Sensitivity analysis** d) Payback analysis
	Which of the following is false? **a) 1 calorie = 4.187 kJ** b) 1 calorie = 4.187J c) 1000 kWh = 1 MWh d) 860 kcal = 1 kWh
	The annual electricity bill for a plant is Rs 110 lakhs and accounts for 38% of the total energy bill. Furthermore the total energy bill increases by 5% each year. The plant's annual energy bill at the end of the third year will be about _____ **a) Rs 335 lakhs** b) Rs 268 lakhs c) Rs 386 lakhs d) Rs 418 lakhs
	The retrofitting of a variable speed drive in a plant costs Rs 2 lakh. The annual savings is Rs 0.5 lakh. The maintenance cost is Rs. 5,000/year. The return on investment is a) 25% **b) 22.5%** c) 24% d) 27.5%
	For a project to be financially attractive, ROI must always be ___ than interest rate. a) lower **b) higher** c) equal d) no relation
	A sum of Rs 100,000 is deposited in a bank at the beginning of a year. The bank pays 10% interest annually. How much money will be in the bank account at the end of the fifth year, if no money is withdrawn? **a) 161050** b) 150000 c) 155000 d) 160000
	The technique used for scheduling the tasks and tracking of the progress of energy management projects through a bar chart is called

	a) CPM **b) <u>Gantt chart</u>** c) CUSUM d) PERT
	_____is a statistical technique which determines and quantifies the relationship between variables and enables standard equations to be established for energy consumption. a) **<u>linear regression analysis</u>** b) time-dependent energy analysis c) moving annual total d) CUSUM
	Which of the following is not an environmental issue of global significance? a) ozone layer depletion b) global Warning c) loss of Biodiversity **d) <u>suspended particulate Matter</u>**
	The power generation potential in mini hydro power plant for a water flow of 3 m^3/sec with a head of 14 meters with system efficiency of 55% is a) **<u>226.6 kW</u>** b) 76.4 kW c) 23.1 kW d) none of the above
	If the wind speed doubles, energy output from a wind turbine will be: a) 2 times higher b) 4 times higher c) 6 times higher **d) <u>8 times higher</u>**
	Which of the following two statements are true regarding application of Kaizen for energy conservation? i) Kaizen events are structured for reduction of only energy wastes ii) Kaizen events engage workers in such a way so that they get involved in energy conservation efforts iii) Implementation of kaizen events takes place after review and approval of top management iv) In a Kaizen event, it may happen that small change in one area may result in significant savings in overall energy use **a) <u>ii & iv</u>** b) i & iv c) iii & iv d) i & iv
	The electrical power unit Giga Watt (GW) may be written as a) 1,000,000 MW b) **<u>1,000 MW</u>** c) 1,000 kW d) 1,000,000 W
	Which of the following statements regarding TOD tariff is true? a) an incentive to induce user to draw more power during peak period b) discourages user from drawing more power during off peak period c) both a and b are true **d) <u>encourages user to shift load from peak period to off peak period</u>**
	The producer gas basically consists of a) Only CH_4 b) CO & CH_4 **c) <u>CO, H_2 & CH_4</u>** d) Only CO & H_2
	The ozone layer in the stratosphere acts as an efficient filter for ____

	a) UV- B rays b) X-rays c) Gamma rays d) beta rays
	Which of the following macro factors is used in the sensitivity analysis of project finance? **a) Change in tax rates** b) Changes in maintenance cost c) Changes in debt: equity ratio d) Change in forms of financing
	Which among the following has the lowest Global Warming Potential? a) Perflurocarbon b) chloroflurocarbons c) **methane** d) nitrous oxide
	Which of the following statements is correct regarding 'float' for an activity? a) Time between its earliest start time and earliest finish time b) Time between its latest start time and latest finish time c) Time between latest start time and earliest finish time **d) Time between earliest finish time and latest finish time**
	In a cumulative sum (CUSUM) chart, if the graph is going up, then a) nothing can be said b) actual and calculated energy consumption are the same c) energy consumption is reduced **d) specific energy consumption is going up**
	CO_2 measurement in a Fyrite kit is based on a) Weight basis (dry) b) **Volume basis (dry)** c) Weight basis (wet) d) Volume basis (wet)
	The depletion of Ozone layer is caused mainly by _____ a) nitrous oxide b) carbon dioxide c) **choloroflourocarbons** d) methane gas
	Portable combustion analyzers may have in-built chemical cells for measurement of stack gas components. Which combination of chemical cells for measurement of stack gas components is not possible? a) CO, SO_x, O_2 b) **CO_2, O_2** c) O_2, NO_r, SO_x, CO d) O_2, CO
	The Energy Conservation Act,2001 requires that all designated consumers should get energy audits conducted periodically by a) certified energy manager b) certified energy auditor c) **accredited energy auditor** d) state Designated Agencies
	The term missing in the following equation $(kVA)^2 = (kVA \cos phi)^2 + (?)^2$ is a) cos phi b) sin phi c) **kVA sin phi** d) kVArh
	The weight (kg) of the water vapour in each kg of dry air(kg/kg) is termed as : a) **Specific Humidity** b) relative humidity c) humidity d) saturation ratio

	Which of the following tool is made use of to assess the input, conversion efficiency, output, losses, quantification of all material, energy and waste streams in a process or system? a) material balance b) energy balance **c) material and energy balance** **d)** Sankey diagram
	If feed of 100 tonnes per hour at 10% concentration is fed to an evaporator, the product obtained at 25% concentration is equal to ____ tonnes per hour. a) 25 **b) 40** c) 50 d) 62.5
	2000 kJ of heat is supplied to 500 kg of ice at 0°C. If the latent heat of fusion of ice is 335 kJ/kg then the amount of ice in kg melted will be a) 1.49 b) 83.75 **c) 5.97** d) None of the above
	An electric heater draws 5 kW of power for continuous hot water generation in an industry. How much quantity of water in litres per min can be heated from 30°C to 85°C ignoring losses?. **a) 1.3** b) 78.18 c) 275 d) none of the above
	The fixed energy consumption of a company is 2000 kWh per month. The line slope of the energy (y) versus production (x) chart is 0.3. The energy consumed in kWh per month for a production level of 80,000 tons/month is a) 24,000 kWh b) 24,200 kWh **c) 26,000 kWh** d) 38,000 kWh
	The major constituent of natural gas is **a) Methane** b) Ethane c) Propane d) Hydrogen

……. End of Section – I …….

Section – II: SHORT DESCRIPTIVE QUESTIONS **Marks: 8 x 5 = 40**

(i) Answer all **Eight** questions
(ii) Each question carries **Five** marks

S-1	**The rating of a single phase electric geyser is 2000 Watts, at 230 Volt.** **Calculate:** **a) Rated current** **b) Resistance of the geyser in Ohms**

	c) Actual power drawn when the measured supply voltage is 210 Volts
Answer:	a)Rated Current of the Geyser, I = P/V= 2000/230 = 8.7 Ampere b)Resistance Value , R = V/I = 230/8.7= 26.4 Ohms c)Actual Power drawn at 210 Volts = (V/R)*V = (210/26.4) x210 = 1670 Watts OR $(210/230)^2$ x 2000 = 1667 Watts
S-2	**A Diesel Generator performance trial gives specific generation of 3.5 kWh per liter of diesel. The cooling water loss and exhaust flue gas loss as percentage of fuel input are 28% and 32% respectively. The calorific value of diesel is 10,200 kcal/kg. The specific gravity of Diesel is 0.85. Calculate unaccounted loss as percentage of input energy.**
Ans	CV of Diesel = 10,200 kcal/kg Heat in input diesel = 10,200 x 0.85 = 8670 kcal/litre Heat in kWh energy output = 3.5 x 860 = 3010 kcal/litre % of heat used for kWh output = 3010/8670 = 34.72 % Unaccounted loss = 100 – (34.72+28+32) = 5.28 %
S-3	**A renovation and modernization (R&M) program of a 110 MW coal-fired thermal power plant was carried out to enhance the operating efficiency from 28% to 32%. The specific coal consumption was 0.7 kg/kWh before R&M. For 7000 hours of operation per year and assuming the coal quality remains the same, calculate** **a) the coal savings per year and** **b) the expected avoidance of CO_2 into the atmosphere in Tons/year if the emission factor is 1.53 kg CO_2/kg coal**
Ans	a) Specific coal consumption after modernization = 28 x 0.7/32 = 0.6125 kg/kwh Annual savings = (0.7 – 0.6125) x110 x 1000 x 7000/1000 = 67,375 Tonnes per year b) CO2 emission reduction =67,375 x 1.53 = 103083.75 Tonnes of per year
S-4	**Briefly compare NPV and IRR method of financial analysis.**
Ans	In NPV method, NPV is determined by assuming the discount rate (cost of capital). In IRR calculations, we set the NPV as zero and determine the discount rate (internal rate of return) which satisfies this condition.

	The *net present value* method calculates the *present value* of all the yearly cash flows (i.e. capital costs and net savings) incurred or accrued throughout the life of a project and summates them. Costs are represented as negative value and savings as a positive value. The higher the *net present value*, the more attractive the proposed project. The calculation procedure for determining IRR is tedious (iterative) and usually requires a computer spreadsheet. The exact internal rate of return can be found by interpolation or plotting the net present value on a graph. If this discount rate is greater than current interest rate, the investment is sound. NPV is essentially a tool which enables number of different projects to be compared while IRR method is designed to assess whether a single project will achieve a target rate of return. The project is accepted if the net present value is positive and rejected if the net present value is negative. A negative net present value indicates that the project is not achieving the return standard and thus will cause an economic loss if implemented. A zero NPV is value neutral. In IRR, the criterion for selection among alternatives is to choose the investment with the highest rate of return. The internal rate of return figure cannot distinguish between lending and borrowing and hence a high internal rate of return need not necessarily be a desirable feature. Both the NPV and IRR takes into account the time value of money and it considers the cash flow stream in entire project life.
S-5	**When the same quantity of heat is added to equal masses of iron and copper pieces, the temperature of iron piece rises by 15 ^{O}C. Calculate the rise in temperature of copper piece, if the specific heat of iron is 470 J / kg / ^{O}C and that of copper is 390 J / kg / ^{O}C.**
Ans	**Mass of Iron x Sp. Heat Iron x 15 ^{O}C = Mass of Copper x Sp. Heat Copper x (Rise in Temp of Copper ^{O}C)** **Since mass of Iron = Mass of Copper** Sp. Heat Iron x 15 ^{O}C = Sp. Heat Copper x (Rise in Temp of Copper ^{O}C) Sp. Heat of Iron = 470 J / kg / ^{O}C Sp. Heat of Copper = 390 J / kg / ^{O}C Hence, Rise in Temp. of Copper piece = (470 x 15) / 390 **= 18.08 ^{O}C**

S-6	**Write down the parameters, which can be measured by following instruments:** **a) Stroboscope** **b) Sling Psychrometer** **c) Fyrite** **d) Tachometer** **e) Pitot tube**
Ans	a) Stroboscope : Speed (Non Contact) b) Sling Psychrometer : Dry & Wet Bulb Temperatures c) Fyrite : O2 or CO2 in Flue Gases d) Tachometer : Speed (Contact type) e) Pitot tube : Velocity pressure of moving gases
S-7	**An industrial plant is consuming 400 kW of power with a maximum demand of 520 kVA. The demand charge is Rs. 150/-per kVA. Determine the savings possible by improving power factor to 0.95 and payback period if investment on capacitor bank is Rs 1,50,000/-.**
Ans	Present Power Factor : 400 / 520 = 0.77 Present Demand Charges Rs. : 520 * 150 = 78000/- Future Demand with higher PF : 400 / 0.95 =421 kVA Modified Demand Charges : 421 * 150 = Rs. 63150/- Savings =78000 – 63150 = Rs. 14850/- per Month Capacitor Investment =Rs. 1.50,000/- Simple Payback Period =1,50,000 / 14850 =10.1 Months
S-8	**A 100 tonnes per day capacity chlor-alkali plant produced 30,000 tonnes per annum (TPA) of caustic soda with annual energy consumption of 90 million kWh in the reference year 2009-10. During the year 2011-12, the annual production was 25,000 TPA, with an annual energy consumption of 80 million kWh. Calculate the Plant Energy Performance.**
Ans	Production Factor = 25000 / 30000 = 0.833 Reference year energy equivalent = Reference year energy use x Production factor = 90 x 0.833 = 75 million kWh

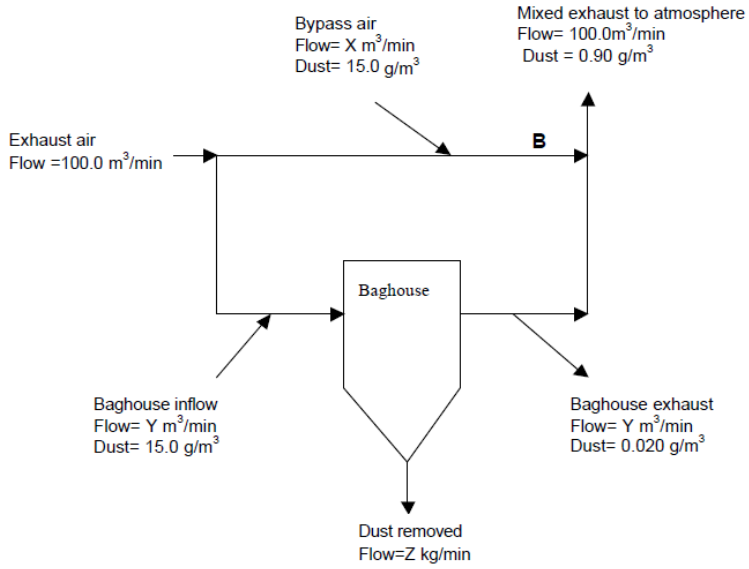
	Excess Energy Consumption in 2011-2012 = 80 – 75 = 5 million kWh Plant Energy Performance (PEP) = [(75 - 80) / 75] x 100 **= (-) 6.67 %** **The performance in the year 2011 – 2012 is poor as compared to the reference year**

------- End of Section - II ---------

Section – III: LONG DESCRIPTIVE QUESTIONS **Marks: 6 x 10 = 60**

(i) Answer all **Six** questions
(ii) Each question carries **Ten** marks

L1	**A bag house is being used to remove dust from an air exhaust stream flowing at 100 m^3/min. The dirty air contains 15 g/m^3 of particles, while the cleaned air from the bag house contains 0.02 g/m^3. The industry's operating permit allows the exhaust stream to contain as much as 0.9 g/m^3.** **For various operating reasons, the industry wishes to bypass some of the dirty air around the bag house and blend it back into the cleaned air so that the total exhaust stream meets the permissible limit. Assume no air leakage and negligible change in pressure or temperature of the air throughout the process.** **Draw a schematic diagram and calculate the flow rate of air through the bag house and the mass of dust collected per day in kg.**
ANS	Draw a flow diagram of the process as shown in Figure 1. In this problem two balances can be made, namely, flow rate of dust in g/m^3 and flow rate of air in m^3/min. Balancing of flow rate of air in m^3/min is possible because the temperature and pressure of air remains constant in the system.



Write a balance for dust around the total system:

Input = Output from bag house +Output in the mixed exhaust

Or

Dust removed from bag house (Z) = 100m^3/min. x 15 g/m^3 —100m^3/min. x 0.90 g/m^3 =1410 g/min.

Or

Daily dust Output = 1410g/min x 24h/1d x 60min/1h x 1kg/1000g= 2030 kg

Write a balance for airflow
100 = X+Y, where X and Yare bypass stream and flow through bag house, respectively.

Write a balance for dust around B:
15X + 0.02Y = 0.9x100

Solving the last two equations
X, the bypass stream = 5.9 m^3/ min.
Y, the flow through bag house = 94.1 m^3/min.

L2

a. Explain the difference between GCV and NCV.

b. A gas fired water heater heats water flowing at the rate of 1.2 M^3 / hour from 20°C to 65°C. If the GCV of the gas is 4x10^7 J/kg, what is the rate of combustion gas in kg/hr. The efficiency of water heater as 80%,

	a. The calorific value is the measurement of heat or energy produced, and is measured either as gross calorific value or net calorific value. **The difference being the *latent heat of condensation of the water vapour* produced during the combustion process.** Gross calorific value (GCV) assumes all vapour produced during the combustion process is fully condensed. Net calorific value (NCV) assumes the water leaves with the combustion products without fully being condensed. b) **Mass of water heated = 1.20 M^3 /hr** **= 1.2 x 1000 / 60 = 20 kg/min** **Heat required by Water = m x Cp x ($t_2 - t_1$)** **= 20 kg/min x 4.187 x 10^3 J/kg/^{0}C x (65-20) °C** **= 3.77 x 10^6 J/min** **Mass of Gas kg/min = 3.77 x 10^6 / 0.8 /(4 x 10^7)** **Mass 0f Gas Required = 0.1178 kg / min** **= 7.068 kg / Hr**
L-3	**Answer any two of the following** **a) Benefits of Monitoring and Targeting system** **b) Duties and responsibilities of energy manager** **c) Energy substitution need not save energy: Explain with an example**
ANS	**a) Benefits of Monitoring and Targeting system** The ultimate goal is to reduce energy costs through improved energy efficiency and management control measures. Other benefits include ✓ Identify and explain an increase or decrease in energy use ✓ Draw energy consumption trends (weekly, seasonal, operational) ✓ Improve energy budgeting corresponding to production plans ✓ Observe how the organization reacted to changes in the past ✓ Determine future energy use when planning changes in operations ✓ Diagnose specific areas of wasted energy ✓ Develop performance targets for energy management programs / energy action plans ✓ Manage energy consumption rather than accept it as a fixed cost that cannot be controlled. **b) Duties and responsibilities of energy manager** **Responsibilities:**

1. Prepare an annual activity plan and present to management concerning financially attractive investments to reduce energy costs.
2. Establish an energy conservation cell within the firm and agree with management about the mandate and task of the cell.
3. Initiate activities to improve monitoring and process control to reduce energy costs.
4. Analyze equipment performance with respect to energy efficiency.
5. Ensure proper functioning and calibration of instrumentation required to assess level of energy consumption directly or indirectly.
6. Prepare information material and conduct internal workshops about the topic for other staff.
7. Improve disseminating of energy consumption data down to shop level or profit center of a firm.
8. Establish a methodology to accurately calculate the specific energy consumption of various products/services or activity of the firm.
9. Develop and manage training programme for energy efficiency at operating levels.
10. Co-ordinate nomination of management personnel to external programs.
11. Create knowledge bank on sectorial, national and international development on energy efficiency technology and management system and information denomination.
12. Develop integrated system of energy efficiency and environmental up gradation.
13. Wide internal and external networking
14. Co-ordinate implementation of energy audit/efficiency improvement projects through external agencies.
15. Establish and / or participate in information exchange with other energy managers of the same sector through association.

Duties of Energy Manager:

1. Report to BEE and State level Designated Agency once a year. The information with regard to energy consumed and action taken in the recommendation of the accredited energy auditor, as per BEE – Format.
2. Establish an improved data recording, collection and analysis system to keep track of energy consumption.
3. Provide support to Accredited Energy Audit Firm retained by the company for the conduct of energy audit.
4. Provide information to BEE as demanded in the Act, and with respect to the tasks given by the mandate, and the job description.
5. Prepare a scheme for efficient use of energy and its conservation and implement such scheme keeping in view the economic stability of the investment in such firm and manner as may be provided in the regulations of the Energy Conservation Act.

c) Energy substitution need not save energy: Explain with an example

The objective of energy substitution may be to reduce the use of costlier energy source to maximize the profit and to improve the efficiency of the process.

Example: Replacement of conventional energy by renewable energy.

The efficiency of fuel oil fired systems will be higher than rice husk fired systems. Hence the total energy input to the systems will increase for rice husk fired systems. Even though material handling cost, specific fuel (energy) consumption increases for rice husk, this is a cheap locally available renewable form of energy which will bring down the fuel cost and transport cost compared to fuel oil.

Hence Energy substitution need not save energy.

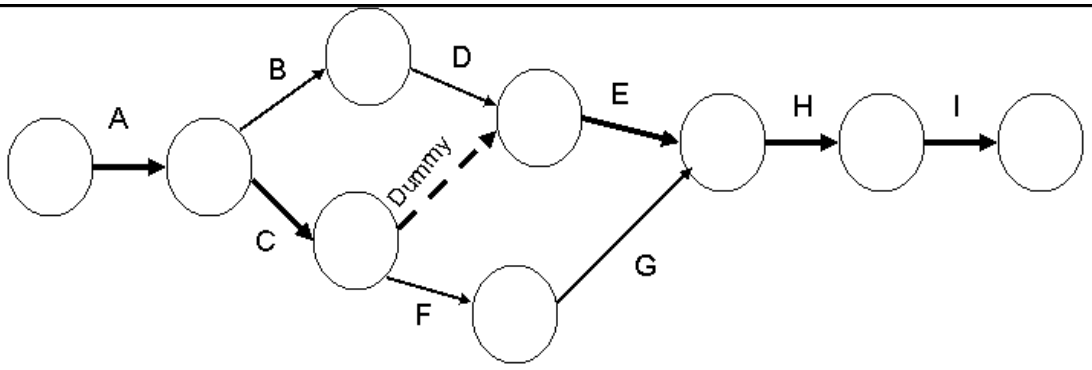
Any other similar example.

L-4 **For the following tasks, durations, and predecessor relationships in the following activity table,**

Activity Description	Immediate Predecessor(s)	Optimistic (Weeks)	Most Likely (Weeks)	Pessimistic (Weeks)
A	---	4	7	10
B	A	2	8	20
C	A	8	12	16
D	B	1	2	3
E	D, C	6	8	22
F	C	2	3	4
G	F	2	2	2
H	E, G	4	8	12
I	H	1	2	3

a) Draw the network
b) **Calculate expected time for all tasks**
c) **Calculate variance for all tasks**
d) **Determine all possible paths and their estimated durations**
e) Identify the critical path

Network diagram is shown below:



Formulas used for filling the above table:

$T_e = (T_o + 4\ T_m + T_p)/6$

? $= (T_p - T_o)/6$

$V = ((T_p - T_o)/6)^2$

Activity Description	Immediate Predecessor(s)	Optimistic (Weeks)	Most Likely (Weeks)	Pessimistic (Weeks)	T_e	Variance
A	---	4	7	10	7	1.00
B	A	2	8	20	9	9.00
C	A	8	12	16	12	1.78
D	B	1	2	3	2	0.11
E	D, C	6	8	22	10	7.11
F	C	2	3	4	3	0.11
G	F	2	2	2	2	0.00
H	E, G	4	8	12	8	1.78
I	H	1	2	3	2	0.11

The critical path is A – C – E – H – I
Duration of critical path is 39 days
.

A - B – D – E – H –I	7+9+2+10+8+2 = 38
A – C – E – H – I	**7+12+10+8+2 = 39**
A – C – F – G – H – I	7+12+3+2+8+2 = 34

The critical path is A – C – E – H – I
Duration of critical path is 39 weeks.

L-5 **Write short notes on any two of the following:**

	a) Advantages of Demand Side Management (DSM) for end user and utility b) **ISO 50001 Energy Management System** **c) Distinction between energy conservation and energy efficiency**
ANS	**a) Advantages of DSM** **End user:** End use demand can be shifted from peak to off peak hours thereby reducing the need for buying expensive energy during peak hours Helps better manage the load curve and thus reduce the demand improve the profitability **Utility:** Energy saving through DSM is treated same as new additions in supply side Can reduce the capital needs for power capacity expansion Improved loading of utility power plants and hence improved efficiency and profitability **b) ISO 50001 features** ISO 5001involves the following features: Goal outlined in Energy policy Objectives to achieve the goal Targets which are more specific than objectives which outlines actual energy conservation measures to be implemented. An objective may have one or more targets. Action plans to implement the targets which outline actions, time frame, responsibility and resources for implementation. All the above with other related documents are audited during internal and external audits. **c) Energy conservation and Energy efficiency** Energy conservation is achieved when energy consumption is reduced in physical terms as a result of productivity increase or technology change. On the other hand, energy efficiency is achieved when energy intensity is reduced in a specific product, process or area of production without affecting the output, consumption or comfort levels. Energy efficiency means using less energy to perform the same function. Energy efficiency promotion will contribute to energy conservation and therefore a part of energy conservation policies.

L-6 **It is proposed to install a heat recovery device in a process industry. The capital cost of installing the device is Rs.2,00,000 and after 5 years its salvage value is envisaged at Rs.15,000. The savings accrued by the heat recovery device are as shown below. Determine the net present value after 5 years for a discount rate of 8%.**

Year	**1**	**2**	**3**	**4**	**5**
Savings (Rs.)	**70,000**	**60,000**	**60,000**	**50,000**	**50,000**

Ans

Year	Discount factor for 8%	Capital Investment (Rs.)	Net savings (Rs.)	Present value (Rs.)
0	1.00	-200000		-200000
1	0.926		70000	+64820
2	0.857		60000	+51420
3	0.794		60000	+47640
4	0.735		50000	+36750
5	0.681		50000 +15000	+44265
				NPV=+44895
It is evident that over a 5-year life-span the net present value of the project is 44895.				

-------- End of Section - III ---------

Paper -1 Set A Solutions

13th NATIONAL CERTIFICATION EXAMINATION FOR ENERGY MANAGERS & ENERGY AUDITORS – September, 2012

PAPER – 1: General Aspects of Energy Management & Energy Audit

Date: 15.09.2012 Timings: 09:30-12:30 Hrs Duration: 3 Hrs Max. Marks: 150

Section - I: OBJECTIVE TYPE **Marks: 50 x 1 = 50**

(i) Answer all **50** questions
(ii) Each question carries **one** mark
(iii) Please hatch the appropriate oval in the OMR answer sheet with Black Pen or HB pencil, as per instructions

1.	The primary energy content of fuels is generally expressed in terms of ton of oil equivalent (toe) and is based on the following conversion factor a) 1 toe=10x10^6 kCal b) 1 toe=11630 kWh c) 1 toe=41870 MJ d) **all the above**
2.	Largest share of global primary energy consumption is from which of the following fuels: a) oil and natural gas **b) coal and oil** c) oil and nuclear d) coal and nuclear
3.	1 kg of wood contains 15% moisture and 7% hydrogen by weight. How much water is evaporated from wood during complete combustion of 1 kg of wood ? **a) 0.78 kg** b) 0.22 kg c) 0.15 kg d) 0.63 kg
4.	**A power utility distributed 1 million 15 Watt CFLs for Rs 15 million, replacing 60 Watt incandescent lamps under Bachat Lamp Yojna. What will be the drop in power in the evening on the demand side, if 80% of the lights are on at that time, assuming similar numbers of incandescent lamps were switched on during the same period?** a) 360 kW b) 12 MW c) **36 MW** d) 60 MW
5.	Which of the following with respect to fossil fuels is true? a) Reserve / Production (R/P) ratio is a constant once established b) R/P ratio varies every year with only changes in production c) R/P ratio varies every year with only changes in reserves

	d) R/P ratio varies every year with changes in both production and reserves
6.	From rated V, A and PF given in the name-plate of a motor , one can calculate: **a) rated input Power** b) rated output Power c) both a & b d) none of these
7.	Air velocity in the ducts can be measured by using _____ and manometer a) orifice meter b) Bourden gauge c) **Pitot tube** d) anemometer
8.	One certified emission reduction (CER) is equivalent to: a) one kg of carbon b) one kg of carbon dioxide c) one ton of carbon d) **one ton of carbon dioxide**
9.	Speed measurement (RPM) of an electric motor is measured with a **a) stroboscope** **b)** ultrasonic meter c) lux meter d) rotameter
10.	How much power generation potential is available in a run of river mini hydropower plant for a flow of 40 liters/second with a head of 24 metres. Assume system efficiency of 60% ? **a) 5.6 kW** **b)** 2.4 kW c) 4.0 kW d) 2.8 kW
11.	A process requires 10 kg of fuel with a calorific value of 5000 kCal/kg. The system efficiency is 80% The losses then will be **a) 10000 kCal** **b)** 45000 kCal c) 40000 kCal d) 20000 kCal
12.	Ratio of average load (kW) to maximum load (kW) is termed as **a) load factor** **b)** demand factor c) form factor d) utilization factor
13.	The ISO standard for Energy Management System is a) ISO 9001 b) **ISO 50001** **c)** ISO 14001 d) none of the above
14.	Material and energy balance is used to quantify **a) material and energy losses** **b)** profit c) cost of production d) all of the above
15.	Which is not a part of " Energy Audit" defined as per the Energy Conservation Act, 2001 a) monitoring and analysis of energy use **b) ensuring implementations of recommended measures followed by review** c) submission of technical report with recommendations d) verification of energy use
16.	Which of the following statements regarding ECBC are correct?

	i) ECBC defines the norms of energy requirements per sq. metre of area taking into account climatic region where building is located ii) ECBC does not encourage retrofit of Energy conservation measures iii) ECBC prescribes energy efficiency standards for design and construction of commercial and industrial buildings iv) One of the key objectives of ECBC is to minimize life cycle costs (construction and operating energy costs) a) i & ii b) i & iii c) ii & iii **d) <u>i & iv</u>**
17.	Which of the following statements regarding BLY (Bachat Lamp Yojana) are correct ? i) BLY aims at large scale replacement of all fluorescent lamps of poor lumen intensity with CFL of high lumen intensity ii) CDM is used as a tool to recover market price difference between lower cost replaced incandescent lamps of 60 W and higher cost CFLs of 11 W iii) BLY involves public, private partnership and DISCOM partnerships iv) DSM is used as a tool to recover market price difference between lower cost replaced incandescent lamps of 60 W and higher cost CFLs of 11 W a) i & ii b) i & iii **c) <u>ii & iii</u>** d) i & iv
18.	The average gross efficiency of thermal power generation on all India bases is about a) **<u>30 – 34%</u>** b) 36 – 38% c) 39 - 41% d) 25 - 28%
19.	Which of the following is not the activity related to restructured APDRP? a) separate feeders for agricultural pumps b) energy auditing at distribution transformer level c) GIS mapping of the network and consumers **d) <u>establishing targets for reducing power consumption</u>**
20.	Assuming total conversion of electrical energy to heat energy, how much heat is produced by a 200 W heater in 5 minutes? a) 200 kJ b) 40 kJ c) 1000 kJ d) **<u>60 kJ</u>**
21.	Which of the following statements regarding DSM is incorrect? a) potential areas for DSM thrust activity are agriculture, domestic and municipalities b) savings accrued through DSM can be treated as new power addition on supply side **c) <u>under DSM, demand can be shifted from off-peak to peak hours thereby avoiding imported power during off peak hours</u>** d) DSM programs may result in demand as well as energy reduction

22.	A motor with 10 kW rating in its name plate, will draw Input power of____ a) 10 kW at full load b) **more than 10 kW at full load** c) less than 10 kW at full load d) 10 kW at 110% of full load
23.	Which of the following statements is not true regarding Maximum Demand Control? a) Maximum demand control offers a way of 'shaving' the peaks and 'filling' the valleys in the consumer load diagram **b) Maximum demand control is carried out by concerned utility at customer premises** c) Maximum demand control focuses on critical load for management d) All of the above
24.	Which of the following statements is false? a) reactive current is necessary to build up the flux for the magnetic field of inductive devices **b) some portion of reactive current is converted into useful work** c) Cosine of the angle between kVA and kW vector is called power factor d) power factor is unity in a pure resistive circuit
25.	Steam leak reduction program can be best achieved through a) Small Group Activities b) Autonomous Maintenance c) TPM d) **All of the above**
26.	Consider two competitive projects A and B each entailing investment of Rs.85,000/- . Project A returns Rs.50,000 at the end of each year, but Project B returns Rs.115,000 at the end of Year 2. Which project is superior? a) project A since it starts earning by end of first year itself and recovers cost before end of two years b) project B since it offers higher return before end of two years c) both projects are equal in rank **d) insufficient information to assess the superiority**
27.	Which of the following statements regarding Internal Rate of Return (IRR) is correct? a) IRR distinguishes between lending and borrowing **b) Internal rate of return is the discount rate at which net present value is equal to zero** c) if the IRR is higher than current interest rate, the investment is not attractive d) between two alternative projects, the project with lower internal rate of return would be considered more attractive

28.	Global warming will not result in a) melting of the ice caps b) increasing sea levels **c) increasing the size of the hole in the ozone layer** d) unpredictable climate patterns
29.	The ozone layer found in the stratosphere: **a) protects against the sun's harmful UV rays** b) can react with atmospheric pollutants to form smog c) is toxic to plants d) is capable of disintegrating fabric and rubber on earth
30.	The process of capturing CO_2 from point sources and storing them is called _____ a) **carbon capture and sequestration** b) carbon sink c) carbon capture d) carbon absorption
31.	Which of the following statements is false regarding wind turbine? a) wind power does not vary as the cross-sectional area of the rotor b) wind power varies as cube of wind velocity c) cut-in wind speed is always less than rated wind speed d) theoretical maximum amount of energy in the wind that can be collected by wind turbine rotor is about 95%
32.	What percentage of the sun's energy falling on a silicon solar panel gets converted into electricity? a) 25% b) **15%** **c)** 75% d) 50%
33.	Which of the following fuels is non-renewable? a) LPG b) lignite c) nuclear d) all of the above
34.	India's share of world oil reserves is _____ a) 5% b) 2% c) **0.5 %** d) 3%
35.	Nuclear power development in India is constrained by a) low % of Uranium in the ore b) inadequate supply of Uranium c) constraints in import of Uranium d) **all of the above**
36.	In a contract when all or part of the savings are guaranteed by contractor, and all or part of the costs of equipment and/or services are paid out of savings as they are achieved, is termed as

	a) traditional contract b) **guaranteed saving performance contract** c) shared saving performance contract d) extended technical guarantee contract
37.	A fuel cell is a) an electromagnetic cell b) a magnetic cell c) **an electrochemical device** d) none of the above
38.	If 3350 kJ of heat is supplied to 20 kg of ice at 0^o C, how many kg of ice will melt into water at 0^o C (latent heat of melting of ice is 335 kJ/kg) a) 1 kg b) 4.18 kg **c) 10 kg** d) 29 kg
39.	If oxygen rich combustion air (25% vol oxygen) is supplied to a furnace instead of normal air (21% vol oxygen), the % CO_2 in flue gases will a) reduce **b) increase** c) remain same d) will become zero
40.	The return on investment (ROI), is expressed as a) annual cost / capital cost b) (first cost / first year benefits) x 100 c) NPV / IRR **d) (annual net cash flow x 100) / capital cost**
41.	The time between its earliest and latest start time, or between its earliest and latest finish time of an activity is a) delay time **b) slack time** c) critical path d) start time
42.	In project management work breakdown structure defines a) temporary endeavour undertaken to create unique product or service **b) the activities to be completed in the projects** c) how realistic were the assumptions underlying the project d) none of the above
43.	The empirical relationship used to plot Production Vs Energy consumption is…… (where Y= energy consumed for the period; C = fixed energy consumption; M = energy consumption directly related to production; X= production for same period). a) X=Y+MC **b) Y=MX+C** c) M=CX+Y d) Y= MX-C
44.	The main constituent of greenhouse gases (GHG) in atmosphere is

	a) CO_2 b) SOx c) nitrogen d) water vapor
45.	The Global Warming Potential (GWP) of nitrous oxide (N_2O) is a) 1 b) 23 c) **300** d**)** 5700
46.	In project management, the critical path in the network is a) the path where activates have slack b) the shortest path c) **the path where no activities have slack** d) none of the above
47.	The cost of a new heat exchanger is Rs. 1.0 lakh. The simple payback period in years considering annual savings of Rs 60,000 and annual operating cost of Rs. 10,000 is a) 0.50 b) 1.66 **c) 2.00** d) 6.00
48.	Of the total natural gas used in India**,** the largest share goes to_____sector. a) petrochemicals b) fertilizers **c) power** d) domestic
49.	What is the future value of Rs. 1000/- after 3 years if the interest rate is 10% ? **a) 1331** **b)** 3000 c) 3300 d) 2420
50.	If the asset depreciation is considered, then net operating cash inflow would be a) higher **b) lower** c) no effect d) none of these

Section – II: SHORT DESCRIPTIVE QUESTIONS **Marks: 8 x 5 = 40**

(i) Answer all **Eight** questions
(ii) Each question carries **Five** marks

S-1	Explain the concept of Bachat Lamp Yojana (BLY)?
ANS	BLY aims at the large scale replacement of inefficient incandescent bulbs in households by Compact Fluorescent Lamps (CFLs). It seeks to provide CFLs to households at the same price to that of incandescent bulbs. Clean Development Mechanism (CDM) is used to recover the cost difference between the market price of the CFLs and the price at which they are sold to households.

	BLY involves public-private partnership between the Government of India, private sector CFL suppliers and State level Electricity Distribution Companies (DISCOMs).
S-2	Briefly explain 'Renewable Purchase Obligation (RPO)' and means by which this requirement can be met ?
ANS	RPO is **Renewable Purchase Obligation** requires each retail seller of electricity to include in its resource portfolio a certain proportion of power is from **renewable sources** such as wind, solar, small hydro or various forms of biomass energy. The retailer can meet this requirement by **owning a renewable energy facility and producing power** or **purchasing power** from another renewable energy facility.
S-3	Give a short description about Availability Based Tariff (ABT).
ANS	Introduction of availability based tariff(ABT) and scheduled interchange charges for power introduced in 2003 for interstate sale of power , have reduced voltage and frequency fluctuation (any three) • It is performance-based tariff system for the supply of electricity by generators owned and controlled by the central government. • It is also a new system of scheduling and despatch, which requires both generators and beneficiaries to commit to day ahead schedule. • It is a system of rewards and penalties seeking to enforce day ahead pre-committed schedules, though variations are permitted if notified one and a half hours in advance. • The order emphasis prompt payment of dues , non-payment of prescribed charges will be liable for appropriate action *Any other relevant points as appropriate may also be given marks*
S-4	In a process plant , an evaporator concentrates a liquor containing solids of 6% w/w (weight by weight) to produce an output containing 30% solids w/w. Calculate the evaporation of water per 400 kgs of feed to the evaporator.
ANS	Inlet solid contents = 6 % Output solid contents=30% Feed=400kgs Solid contents in kg in feed =400 x 0.06 = 24 Kg Outlet Solid contents in kg =**24 kg** quantity of water evaporated=[400 – {(100) x 24}] = 320 30 *Also right* = *24x400/30* = ***320***
S-5	In the management of financial aspects, state what are micro and macro factors and list three factors in each, which influence sensitivity analysis?

ANS	**Micro factors are variables related to the project being implemented and can be influenced** Any three in the following list ü Operating expenses (various expenses items) ü Capital structure ü Costs of debt, equity ü Changing of the forms of finance e.g. leasing ü Changing the project life **Macro factors are variables that affect the operation of industry of which the company operates and cannot be changed by the company management.** Any three in the following list ü Changes in interest rates ü Changes in the tax rates ü Changes in the accounting standards e.g. methods of calculating depreciation ü Changes in depreciation rates ü Extension of various government subsidized projects e.g. rural electrification ü General employment trends e.g. if the government changes the salary scales ü Imposition of regulations on environmental and safety issues in the industry ü Energy Price change
S-6	A plant is using 6 ton/day of coal in a boiler to generate steam at 72% boiler efficiency. The gross calorific value of coal is 3300 kCal/kg. The cost of coal is Rs. 4200/ton . The plant substitutes coal with agro-residue , as a boiler fuel, which has a gross calorific value of 3100 kCal /kg and costs Rs. 1800/ton. The boiler efficiency reduces to 68%. Calculate the annual cost savings for 300 days of operation with agro residue as fuel.
ANS	Useful energy to generate steam by 6 tonnes of coal per day = 6000 x 3300 x 0.72 = 14256000 kcal/day To deliver 14256000kcal/day , daily amount of agro residue required $= \frac{14256000}{3100 \times 0.68}$ **= 6763 kg/day** Daily saving = $\frac{6000}{1000} \times 4200 - \frac{6763}{1000} \times 1800$ = 25200-12173 = Rs 13027/-

	Annual saving =13027 x 300 **=Rs 39,08,100/-**
S-7	Based on local pollution control department norms the maximum limit of dust in the gas stream leaving the industry should not exceed one ton per day. A bag filter was installed to reduce the pollution from the exhaust gas stream. Find out the dust collected in ton per day if the gas stream to the dust collector was entering at the rate of 130,000 m^3 per hour containing 6 g/m^3 and leaving at the rate of 150,000 m^3 per hour, inclusive of ingress of air) containing 300 mg/m^3. Also find out whether, the industry met the pollution norms if the plant operates for 24 hours a day at same capacity.
ANS	Amount of Dust in the inlet stream = 130,000 x 6 = 780,000 grams/hour Amount of Dust in the outlet stream = 150,000 x 0.30 g/hr = 45,000 grams/hour Amount of Dust in the Bag Filter = 780,000 - 45,000 = 735,000 grams/hour x $24/10^6$ = <u>17.64 Tonnes/day</u> Amount of dust leaving the Industry = 45,000 grams / hour x $24/10^6$ = 1.08 Tonnes / day <u>Since it is more than 1 tonne/ day, the industry does not meet the pollution norms</u>
S-8	In an industry the existing winding of a motor has burnt out. Calculate the annual energy savings and simple payback for replacing the burnt out motor with an energy efficient motor of the same capacity instead of rewinding. The data given are • Efficiency after rewinding of burnt out motor - 86% • Cost of rewinding - Rs 7500 • Efficiency of energy efficient motor - 94% • Cost of new energy efficient motor - Rs 42000 • Operating hours/year - 6900 hours • % loading of motor - 82% • Energy cost - Rs 5.2/kWh • Name plate rating of motor - 22 kW
ANS	Energy cost saving (Rs / year)

	=[(kW) x (% loading) x [(1/efficiency of rewound standard motor) - (1/ Efficiency of energy efficient motor)] x (HRS/annum) x (Rs/kwh) =22 x 0.82 x 6900 x 5.2 [(100/86) – (100/94)] =Rs 64055 Simple payback period = [(42000-7500)/64055] =6.5 months

------- End of Section - II ---------

Section – III: LONG DESCRIPTIVE QUESTIONS **Marks: 6 x 10 = 60**

(i) Answer all **Six** questions
(ii) Each question carries **Ten** marks

L-1	An oil fired reheating furnace heats steel billets from 40°C to 1220°C at a furnace efficiency of 28%. The furnace operates for 4700 hours per annum. The GCV of furnace oil is10,000 kCal /kg and density is 0.94kg/litre. The cost of furnace oil is Rs.45 /liter. The specific heat of billets is 0.12 kCal/kg°C. a. Calculate the amount of energy necessary to heat 12 tons of steel billets per hour b. Calculate liters of furnace oil fired per tons of steel billets. c. If the efficiency of the furnace is improved from 28% to 30% by adopting ceramic fibre insulation, calculate the hourly furnace oil cost saving d. What is the simple payback period if the investment is Rs. 20 lakhs ? e. How large could be the investment to improve the efficiency at an internal rate of 16% and per year over 6 years.
ANS	: a) Amount of energy necessary to heat 12 tons of steel billets = m x cp x△t = 12000 Kgs x 0.12 x (1220- 40) kCals/hr **= 16,99,200 Kcals/hr** B) Litres of furnace oil fired per ton of steel billet = [(1699200/12)] = 141600 Kcal/ tonne of billet Input energy per ton of billet = 141160/0.28 = 505714 kcal/ tonne of billet Furnace oil required in kg = 505714 / 10,000 = 50.57 Kg/ tonne of billet Furnace oil required in litres = 50.57 / 0.94 **= 53.79** litres/ tonne of billet

c). Hourly furnace oil cost savings/ton

= 53.79 x [1 – (0.28/0.30)] * Rs 45

= Rs 161.37/tonne

Hourly furnace oil cost savings for 12 tons

= Rs 161.37 *12

=Rs 1936/hr

d). Simple payback period @ 4700 hrs of operation

=20,00,000/1936*4700

= 0.352 yrs or 4.2 months

e) Net cash inflow per annum= 1936*4700

= Rs 91.0 lakhs

$$\text{Investment} = 91.0 \left[\frac{1}{1.16} + \frac{1}{(1.16)^2} + \frac{1}{(1.16)^3} + \frac{1}{(1.16)^4} + \frac{1}{(1.16)^5} + \frac{1}{(1.16)^6} \right]$$

= 91.0 [0.862+ 0.743+0.641+0.552+0.476+0.410]

= Rs. 3.35 crores

L-2

The Energy- production data (for Jan-June, 2011) of an industry follows a relationship : Calculated energy consumption = 0.5 P +220.

A Waste heat recovery system was installed at end of June 2011 and further data was gathered up to December 2011.

Using CUSUM technique, calculate energy savings in terms of ton of oil equivalent (toe) and the reduction in specific energy consumption achieved with the installation of waste heat recovery system.

The plant data is given in the table below.

2011-Month	Actual Energy Consumption, toe/month	Actual production, ton/month
Jan	620	760
Feb	690	960
Mar	635	790
Apr	628	830
May	545	610
Jun	540	670
July	**590**	**760**
Aug	**605**	**820**
Sep	**670**	**940**
Oct	**582**	**750**
Nov	**512**	**610**
Dec	**540**	**670**

ANS

The table below gives values of actual energy consumption Vs. calculated (predicted)

energy consumption from July –Dec. 2011.

Specific energy consumption monitored Vs predicted for each month. The variations are calculated and the Cumulative sum of differences is calculated from Jan-June-2011.

2011-Month	Eact.	Ecal 0.5P+220	Eact - Ecal	CUSUM
July	**590**	600	-10	-10
Aug	**605**	630	-25	-35
Sept	**670**	690	-20	-55
Oct.	**582**	595	-13	-68
Nov.	**512**	525	-13	-81
Dec.	**540**	555	-15	-96

Energy savings achieved = **96 toe**

Reduction in specific energy consumption = 96/4550 = 0.021 toe/tonne of production
(Production for 6 months = 760+820+940+750+610+670 = **4550 tonnes**)

L-3 A proposed energy efficiency improvement project requires an initial investment of Rs.5,00,000 and generates cash flow as given below:

Savings in year	Cash flow (Rs.)
1	120000
2	115500
3	130000
4	116500
5	117250
6	200000

Calculate IRR of the project by interpolation method by taking initial discount rate as 11%.

ANS a) NPV at 11% = $-500000 + 120000/(1+0.11)^1 + 115500/(1+0.11)^2 + 130000/(1+0.11)^3 + 116500/(1+0.11)^4 + 117250/(1+0.11)^5 + 200000/(1+0.11)^6$

= 50157.88

NPV at 16% = $-500000 + 120000/(1+0.16)^1 + 115500/(1+0.16)^2 + 130000/(1+0.16)^3 + 116500/(1+0.16)^4 + 117250/(1+0.16)^5 + 200000/(1+0.16)^6$

= -25176.29

NPV is between 11% and 16%

	IRR with Linear Interpolation I_L = 11% NPV_L = 50157.88 I_U= 16% NPV_U = -25176.29 $IRR = I_L + \frac{(I_U - I_L) \times NPV_L}{(NPV_L - NPV_U)}$ = 0.11 + (0.16-0.11) (50157.88) / [(50157.88 – (- 25176.20)] = 0.11 + (0.05 x 50157.88) / 75334.17 = 0.11 + 2507.894 / 75334.17 = 0.11 + 0.0333 = 0.1433 **= 14.33%**
L-4	Write short notes on **any two** of the following a)BEE's Standards and Labeling programme for equipment and appliances b)Role of ESCOs c)Evacuated tube collector for solar energy applications
ANS	**a) Standards & Labeling** Standards and Labeling would ensure that only energy efficient equipment and appliances would be made available to consumers. Main provisions of S&L are: • Evolve minimum energy consumption and performance standards for notified equipment and appliances • Prevent manufacture, sale and import of equipment which do not meet the standards • Introduce a mandatory labeling scheme for notified equipment and appliances to enable consumers to make informed choices • Spread information on benefits to consumers For establishing standards, agreed testing procedures are defined and values of energy performance are measured.

Energy labels are the best way to implement the standards. They are information affixed to manufactured products to describe the product's energy performance usually in form of energy use or efficiency. These give data to consumers to make informed purchases.

b) Role of ESCOs

Conduct of Investment grade energy audit

Arranging finance

Purchase, installation and maintenance of installed energy efficient equipment

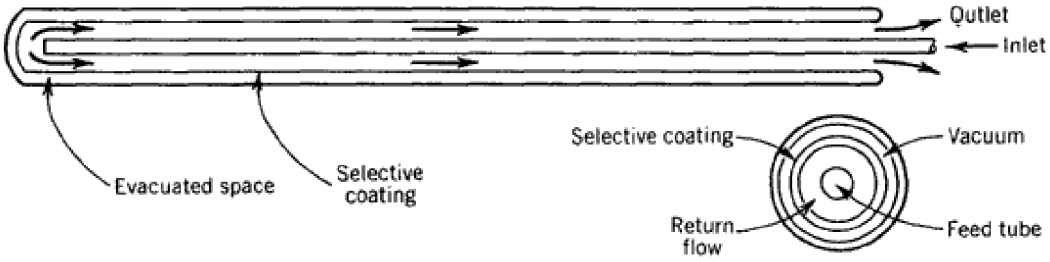
Operation & Maintenance training

Monitoring of operations and energy savings

c) Evacuated Tube Collector

Evacuated tube collector comprises of two concentric glass tubes fused in the ends. The air is evacuated from the gap between the tubes. The evacuated double-walled glass tube provides thermal insulation similar to that of thermally insulated "Thermos" bottle. The outer glass tube is clear, and the surface of the inner glass tube is coated with a special heat material that absorbs the sun's energy.

Sun rays penetrate the outer clear glass and heat energy is absorbed by the inner coated glass. The vacuum permits the heat radiation to enter the outer tube. The absorbent coating on the inner tube converts short wave radiation to long wave radiation thus preventing re-radiation to atmosphere. Since conduction cannot take place in vacuum, heat loss due to conduction back to atmosphere is also prevented. Because of this principle, more heat is trapped compared to a flat plate collector. The heat loss in Evacuated tube collector is less than 10% compared with 40% for a flat plate collector. Water flows in through a third, innermost concentric feeder tube and hot water flows out in the annulus outside the feeder tube in contact with the absorber tube surface. This type of solar collector can reach high temperatures upto 150°C.



L-5

a) Explain in brief the process of gasification of biomass.

b) Find out the conversion efficiency of a gasifier, if 20 kg of wood (having a calorific value of 3200 kCal / kg) produces 46 m^3 of producer gas having an average calorific value of 1000 kCal / $Nm^{3.}$

ANS

a) **Gasification of Biomass**

Biomass contains Carbon, Hydrogen and Oxygen molecules. Complete combustion of Biomass would produce Carbon Dioxide and water vapour, whereas combustion under controlled conditions ie partial combustion produces Carbon Monoxide and Hydrogen, which are combustible gases. The biogas produced through gasification is called as Producer Gas.

Gasification is a partial oxidation of biomass and takes place at temperature of about 1000^{o}C. Partial oxidation is facilitated by supplying air less than the stoichiometric requirements. The products of combustion are gases like Carbon Monoxide, Hydrogen and traces of Methane and non- useful products like tar & dust. The production of these gases is by reaction of water vapour and Carbon Dioxide through a glowing layer of charcoal.

A gasification system consists of 4 main steps:

- § Feeding of Feedstock
- § Gasifier reactions where gasification takes place.
- § Cleaning of resultant gas
- § Utilization of cleaned gas

Biomass Gasifier is a thermo-chemical convertor / reactor where various physical and chemical reactions take place. Biomass is passed through following zones before being converted to high quality producer gas:

- Drying Zone
- Distillation Zone
- Pyrolysis zone
- Combustion Zone
- Reduction Zone

The following reactions take place:

$C + O_2 = CO_2$

$H_2 + ½ O_2 = H_2O$

$C + O_2 = 2CO$

$C + H2O = CO + H_2$

$CO_2 + H_2 = CO + H2O$

$C + 2 H_2 = CH_4$

The Producer gas has relatively a low calorific value ranging from 1000 to 1200 kCal/Nm^3. The conversion efficiency of Gasifier is in the range of 60 – 70%. It can be used for combustion in

a reciprocating engine.

b) Heat Input in the Gasifier = 20 x 3200
= 64000 kCal

Heat Output as Producer gas = 46 x 1000
= 46000 kCal

Conversion efficiency of Gasifier = Heat Output / Heat Input
= 46000 x 100 / 64000
= 71.88 % **Ans**

L-6

a) Construct a PERT/CPM network diagram for a project for which the data is given below

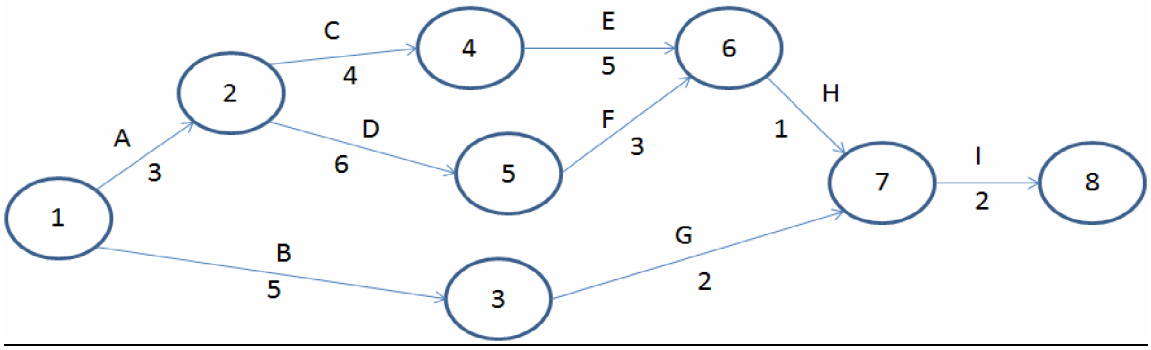
b) Compute the earliest start, earliest finish, latest start, latest finish and slack for all the activities

c) Also compute the project duration, identify critical activities and the critical path(s)

Activity	Predecessor	Time in weeks
A	-	3
B	-	5
C	A	4
D	A	6
E	C	5
F	D	3
G	B	2
H	E,F	1
I	G,H	2

ANS

(a) PERT/CPM Network Diagram



b) **Early start (ES), Early Finish (EF), Latest start (LS), Latest finish (LF)**

Activity	**Duration** (weeks)	**ES**	**EF**	**LS**	**LF**	**Slack**
A	3	0	3	0	3	0
B	5	0	5	6	11	6
C	4	3	7	3	7	0
D	6	3	9	3	9	0
E	5	7	12	7	12	0
F	3	9	12	9	12	0
G	2	5	7	11	13	6
H	1	12	13	12	13	0
I	2	13	15	13	15	0

c) Critical Paths

Two critical paths exist. They are

A-C-E-H-I & **A-D-F-H-I**

Project duration : 15 weeks