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

General instructions:

- *Please check that this question paper contains **10** 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.	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
2.	2000 kJ of heat is supplied to 500 kg of ice at 0^{o}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
3.	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
4.	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
5.	A sling psychrometer is used to measure : a) only dry bulb temperature b) only wet bulb temperature **c) both a & b** d) relative humidity
6.	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
7.	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
8.	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 $30^{o}C$ to $85^{o}C$ ignoring losses?. **a) 1.3** b) 78.18 c) 275 d) none of the above
9.	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**
10.	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**
11.	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
12.	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

13.	Bio-gas generated through anaerobic process mainly consists of a) only methane **b) methane and carbon dioxide** c) only ethane d) none of these
14.	Energy sources which are inexhaustible are known as a) commercial energy b) primary energy **c) renewable energy** d) secondary energy
15.	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**
16.	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**
17.	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**
18.	_____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
19.	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**
20.	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

21.	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**
22.	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**
23.	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
24.	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
25.	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
26.	The internal rate of return is the discount rate for which the NPV is a) positive **b) zero** c) negative d) less than 1
27.	The number of moles of water contained in 36 kg of water is ---------- **a) 2** b) 3 c) 4 d) 5
28.	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
29.	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
30.	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

31.	The quantity of heat required to raise the temperature of a given substance by 1°C is known as: a) sensible heat b) specific heat **c) heat capacity** d) latent heat
32.	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.
33.	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%
34.	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
35.	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
36.	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
37.	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
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.	Which of the following has the highest specific heat? a) lead b) mercury **c) water** d) alcohol
40.	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**

41. 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

42. Which of the following is not a greenhouse gas ?

a) CFCs **b) SO2** c) PFC d) SF6

43. 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

44. 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

45. 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

46. 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

47. 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

48. 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

a) i & iii b) ii & iii c) i & iv **d) i & ii**

49. 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 & iv c) iii & iv d) i & iv

50. Which one is not an energy consumption benchmark parameter?

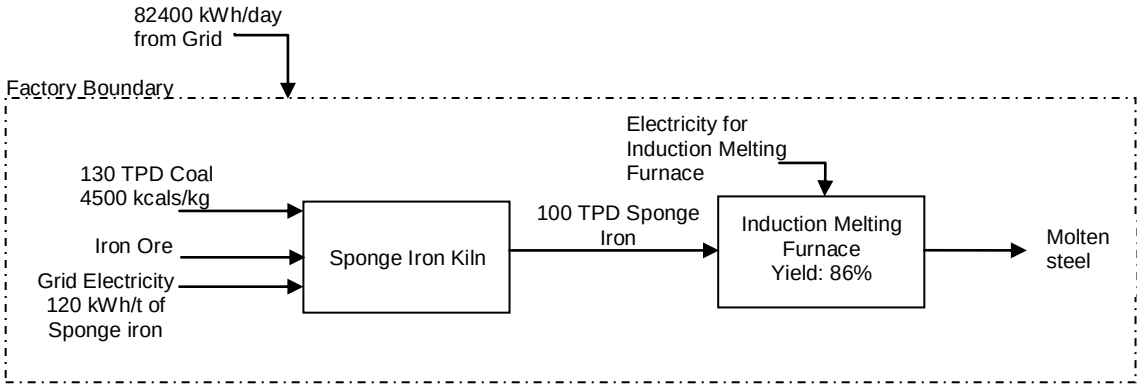
a) kcal/kWh of electricity generated **b) kg/ ^{o}C.**
c) kW/ton of refrigeration d) kWh/kg of yarn

…… 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	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- 2	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 – 34000 T , • Current year (2016-17) Annual Energy Consumption– 27,200 MWh, • Reference year (2015-16) production - 28,750 T, • Reference year (2015-16) Energy consumption - 23,834MWh.
Ans	Production factor (PF) = 34000 / 28750= 1.18 …….1 mark Ref year equivalent energy (RYEE) = Ref Year Energy Use (RYEU) x PF = 23834 x 1.18= 28124.12MWh …….1.5 marks PEP = (RYEE – current year energy)/RYEE = (28124.12 – 27200)/28124.12 = (+) 0.0329 ie (+) 3.3 % …….1.5 marks Since the PEP is positive, it implies that the energy conservation measure had yield reduction in energy consumption. Action has to be taken to improve plant performance. …….1 mark
S- 3	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)
S-4	In a 100 TPD Sponge Iron plant, the sponge iron is fed to the Induction melting furnace, producing molten steel at 86% 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 86/100 = 86 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= 70400/86** **= 818.6 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 **=655864000/86000 =7626.3 kcal/kg of molten metal** …….1 mark c) Total Energy consumption of Plant in ToE **= 655864000/10^7 = 65.586 ToE** …….1 mark
S-5	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 –6	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 8% 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 70%. 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 - 8% • Total weight of dry batch output - 48/0.92 = 52.2 kgs. • Equivalent water in a dry batch - 52.2 - 48 = 4.2 kgs. • Total water removed in drying - 72 – 4.2 = 67.8 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 - 67.8 x 540 = 36612 kcal/batch Total heat required - 5040 + 36612 = 41652 kcal/batch …….2 marks c. The quantity of steam required for the drying process Dryer Efficiency - 70% Heat input to dryer - 41652/0.7 = 59502.86 kcal/batch

	Latent heat in 4 Kg/cm^2 steam - 520 kcal/kg Steam quantity required - 59502.86 / 520 = 114.4 kgs / batch …….1.5 marks
S – 7	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- 8	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 75%, 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 270 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	-	75%
	Heat supplied in new LPG furnace	-	7872000/0.75 = 10496000 kcal/batch
	Equivalent LPG consumption	-	10496000/12500 = 839.68 kg/batch …….1 mark
	Cost of operating LPG Furnace	-	839.68 x 75 =Rs. 62976/batch
	Cost saving per batch	-	64400 – 62976 =Rs. 1424/-
	Annual cost saving	-	1424 x 2 x 270 = Rs. 768960/- …….1 mark
	Investment for new furnace	-	Rs. 50 Lakhs
	Return on Investment (RoI)	-	(7.69/50)*100 = 15.38%

……. 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

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 7th month and give your inference on the result? (Consider 9 month data for evaluation of equation 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
	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

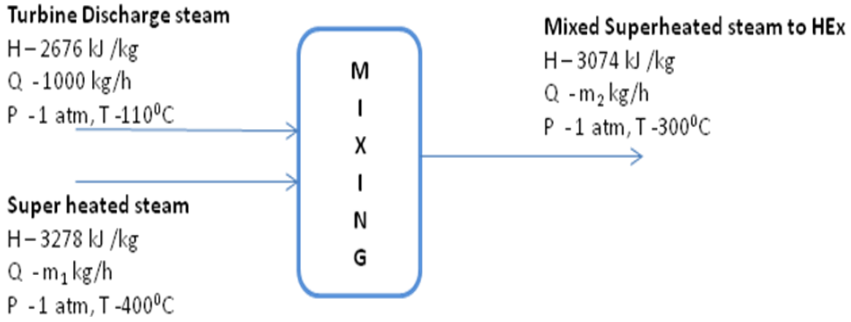
Month	Production in Tonnes / month x	E_{actual}	E_{cal} Y = 0.021x + 66.1	Difference	CUSUM
1	493	78.2	76.36204	1.9	1.9
2	297	75.7	72.26433	3.4	5.3
3	381	76.3	74.02049	2.3	7.6
4	479	76.1	76.06935	0.0	7.6
5	585	78.1	78.28546	-0.2	7.4
6	440	70.7	75.25398	-4.5	2.8
7	234	73.7	70.9472	2.7	5.6

…….4 marks

Since the CUSUM value at the end of 7th month is positive, the plant has achieved net energy savings.

…….1 mark

L –2 Saturated steam at 1 atm is discharged from a turbine at 1000 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

$1000 + m_1 = m_2$ …… (1)

…….1 mark

2. Energy balance

$(1000 \text{ kg/h})(2676 \text{ kJ/kg}) + m_1(3278 \text{ kJ/kg}) = m_2(3074 \text{ kJ/kg})$ …… …. (2)

…….1 mark

Eqs. (1) and (2) are solved simultaneously

$2676000 + 3278m_1 = (1000 + m_1)3074$

	m_1 = 1950.98 kg/h m_2 = 1000 + 1950.98 = 2950.98 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: (1950.98 kg/h)(3.11 m^3/kg) = 6067.55 m^3/h …….4 marks
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.

…….2 marks

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.

…….2 marks

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 can measure temperature of objects placed in hazardous places	True/False
4	To measure the RPM of a visible shaft-end, _____ type of RPM meter is used and for a Flywheel _____ type of	Fill in the blanks

	RPM meter is used.	
5	In a switch yard, thermal imager instrument is used to identify the loose joints and terminations	True/False
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	380 kcal/ hr is equivalent to _____Watts and 4.5 bar is equivalent to _____kPa	Fill in the blanks
8	1.5 metric ton of oil equivalent is to _____MW	Fill in the blanks
9	1 kg of Coal, consisting of 35% of Carbon produces _____ kg of CO_2	Fill in the blanks
10	In a gasification system the reduction zone is below 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 can measure temperature of objects placed in hazardous places	True/False	True
4	To measure the RPM of a visible shaft-end, _____ type of RPM meter is used and for a Flywheel _____ type of RPM meter is used.	Fill in the blanks	Tachometer; Stroboscope
5	In a switch yard, thermal imager instrument is used to identify the loose joints and terminations	True/False	True
6	Every Designated Consumer shall have its first energy audit conducted by _____ Energy Auditor within _____ months	Fill in the blanks	Accredited ; 18 months

	of notification issued by the Central Government		
7	380 kcal/ hr is equivalent to _____Watts and 4.5 bar is equivalent to _____kPa	Fill in the blanks	441.96 Watts; (380x4.187x1000/3600) 450 kPa (4.5 x100)
8	1.5 metric ton of oil equivalent is to _____MW	Fill in the blanks	17.44 MW (1.5x1000x10000/(860x1000)
9	1 kg of Coal, consisting of 35% of Carbon produces _____ kg of CO_2	Fill in the blanks	1.28 [(44/12)x(0.35]
10	In a gasification system the reduction zone is below the combustion zone	True/False	True

…….10 marks (each one carries one mark)

L- 5

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

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

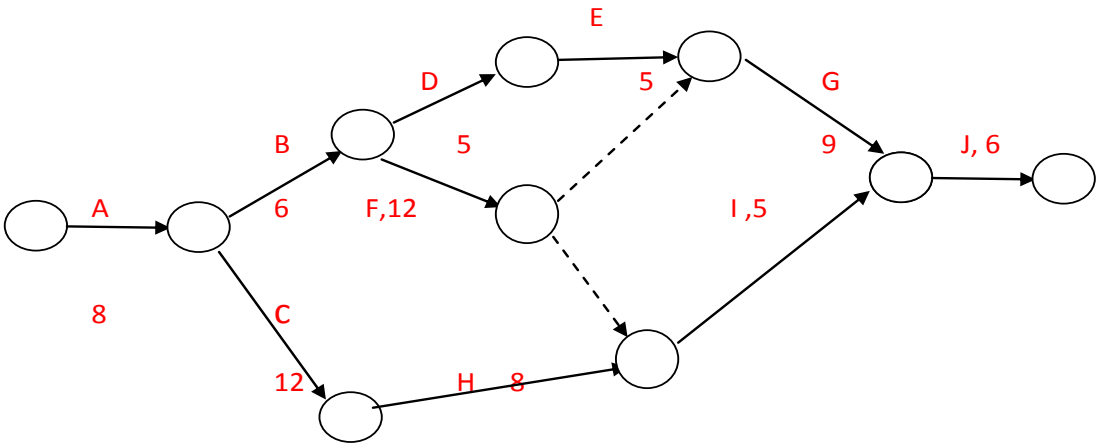
b. What are the Earliest Start, Latest Start and Total Float of activity ‘H’?

c. What would be the project duration if activity ‘H’ got delayed by 3 weeks?

Ans

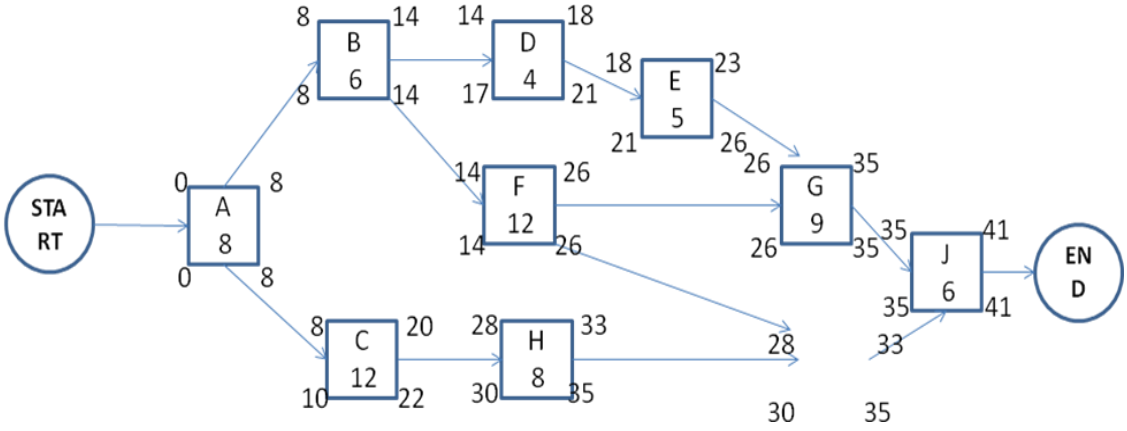
PERT Diagram based on Activity on Arrow

.



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 i.e a delay of 1 week, if activity 'H' got delayed by 3 weeks.

	…….1 mark
L - 6	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. 2 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- 5 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	6 *(4+2)*	$= (5.5 / (1+.12)^8$ $= 2.22$	0.2	8.5 *(3.5+5)*	$= (8.3 / (1+.12)^8$ $= 3.35$
NPV			= + 1.091	@12%		= + 1.36

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

…….10 marks

…… End of Section – III ……