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(To be written by the candidate)

**11th NATIONAL CERTIFICATION EXAMINATION – February, 2011
FOR
ENERGY MANAGERS AND ENERGY AUDITORS**

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

Date: 05.02.2011 Timings: 0930-1230 HRS Duration: 3 HRS Max. Marks: 150

General instructions:

- Please check that this question paper contains **15** 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 or HB pencil, as per instructions.

1.	The Government of India levies Clean Energy Cess on which of the following a) electricity b) coal c) Diesel d) biodiesel
2.	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
3.	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
4.	The quantity of heat required to raise the temperature of a given substance by 1 deg. C is known as: a) sensible heat b) specific heat c) heat capacity d) latent heat
5.	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

Paper 1 – Set A Key

6.	A sling psychrometer is used to measure : a) only dry bulb temperature b) only wet bulb temperature c) both a & b d) relative humidity
7.	A solution of common salt in water is prepared by adding 20 kg of salt to 80 kg of water. The concentration of salt as w/w fraction is: a) 0.1 b) 0.2 c) 0.8 d) 0.6
8.	The number of moles of water contained in 36 kg of water is ----- a) 2 b) 3 c) 4 d) 5
9.	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
10.	The proposed ISO standard for Energy Management System is: a) ISO 9001 b) ISO 50001 c) ISO 14000 d) ISO 14001
11.	To judge the attractiveness of any investment, the project manager must consider: a) Initial capital cost b) Net operating cash inflows c) salvage value d) all the above
12.	Which of the following is not true of natural gas? a) it is denser than air b) contains mainly methane c) can be transported through pipelines d) compressed natural gas can be used in IC engines
13.	Which of the following is not a part of the definition of energy audit as per the Energy Conservation Act 2001? a) verification of energy use b) implementation of energy saving measures c) submission of technical report d) monitoring of energy use
14.	Availability Based Tariff (ABT) is applicable to pricing of : a) oil b) coal c) natural gas d) electricity
15.	Which among the following is not a typical performance contract? a) fixed fee b) liquidation for damage c) shared savings d) guaranteed savings
16.	An activity in a project has an optimistic time of 10 days, a most likely time of 15 days and a pessimistic time of 20 days. Its expected time of completion is----- a) 10 days b) 15 days c) 30 days d) 35 days.
17.	Network diagrams show logic clearly but does not have ----- like Gantt chart. a) nodes b) arrows c) time scale d) events
18.	A chart in Scatter Diagram shows a low degree of scatter. It is indicative of----- a) good fit b) poor fit c) skewed fit d) normal fit
19.	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 -----

Paper 1 – Set A Key

	a) 6,000 kWh b) 10,000 kWh c) 12,000 kWh <u>d) 60,000 kWh</u>
20.	A single CFC molecule can destroy about ----- ozone molecules. a) 10,000 <u>b) 100,000</u> c) 1 million d) 10 million
21.	Which of the following GHGs has the longest atmospheric life time? a) CO ₂ b) CFC c) Sulfur Hexafluoride (SF ₆) <u>d) perfluorocarbon (PFC)</u>
22.	Which of the following is not a commercial form of energy a) Oil b) Lignite c) Electricity <u>d) Solar energy</u>
23.	Which of the following is the least predominant loss in oil fired boiler? a) dry flue gas losses <u>b) heat loss due to moisture in air</u> c) heat loss due to hydrogen in fuel d) none of the above
24.	The component of electric power which yields useful mechanical power output is known as a) apparent power <u>b) active power</u> c) reactive power d) none of the above
25.	Identify the wrong statement a) fuel switching may improve energy efficiency b) fuel switching may reduce energy efficiency c) fuel switching may reduce energy costs <u>d) fuel switching always reduces energy consumption</u>
26.	If a feed of 100 tonnes per hour at 9% concentration is fed to an evaporator, the product obtained at 36% concentration is equal to ____ tonnes per hour. a) 27 <u>b) 25</u> c) 36 d) 45
27.	The annual energy consumption of a plant was 2.00 Lakh GJ in the reference year 2008/2009. In the next year 2009/2010, it was 2.20 Lakh GJ. The plant energy performance (PEP), assuming no change in product mix and output quantity is ____ a) 10% <u>b) - 10%</u> c) -9.1% d) none of the above
28.	In force field analysis of energy action planning, one of the actions below does not fall under positive force? a) high price of energy b) availability of energy efficient technology c) commitment of top management <u>d) lack of awareness</u>
29.	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 <u>d) 17.1% increase</u>
30.	Doppler effect principle is used in which of the following instrument a) lux meter <u>b) ultrasonic flow meter</u> c) infrared thermometer d) flue gas analyzer
31.	ROI must always be _____ borrowing interest rate for economic feasibility of any project

Paper 1 – Set A Key

	a) lower than c) equal to b) higher than d) no relation
32.	The reagent used to absorb CO ₂ in a fyrite is a) chromous chloride c) potassium permanganate b) potassium hydroxide d) pyrogallol
33.	The Critical Path in PERT indicates _____. <u>a) minimum time required for the completion of the project</u> b) delays in the project c) maximum time required for the completion of the project d) none of the above
34.	The Energy Conservation Act, 2001 requires that all the notified designated consumers to get mandatory energy audits conducted by a) a certified energy manager c) a certified energy auditor b) <u>an accredited energy auditor</u> d) a state designated agency
35.	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 c) 10.97 kW b) <u>10.09 kW</u> d) None of the above
36.	As per Energy Conservation Act, 2001 appointment of BEE Certified Energy Manager is mandatory for all a) industrial units c) <u>notified designated consumers</u> b) commercial buildings d) electrical distribution licensees
37.	Which among the following raw materials is used for bio-diesel production a) leaves b) coal c) light Diesel oil (LDO) <u>d) jatropha seeds</u>
38.	Input to Fuel Cell is a) bio-gas <u>b) hydrogen</u> c) oil –gas mix d) oxygen
39.	Wind speed for commercial exploitation for electricity production has to be : a) Up to 15 km/hr b) 15- 18 km/hr <u>c) 25-30 km/hr</u> d) no limit , whatsoever
40.	Which of the following is not a national mission under the Prime Minister's National Action Plan on Climate Change a) national solar mission b) national mission for enhanced energy efficiency <u>c) national mission on CFC alternatives</u> d) national mission for green India
41.	Which among the following renewable energy routes accounts for the maximum contribution to power generation in India <u>a) wind</u> b) geothermal c) solar thermal d) solar PV
42.	Producer gas is basically : a) Only CH ₄ b) CO and CH ₄ <u>c) CO, H₂ and CH₄</u> d) only CO and H ₂
43.	Which of the following is a renewable energy source?

Paper 1 – Set A Key

	a) bitumen <u>b) wood</u> c) nuclear fuels d) lignite
44.	What is the load factor of a continuously operating facility that consumed 400,000 kWh of energy during a 30-day billing period and established a peak demand of 1000 kW? <u>a) 0.55</u> b) 0.40 c) 0.65 d) 0.50
45.	The Global Warming Potential (GWP) of sulfur hexafluoride is a) 1 b) 23 c) 300 <u>d) 22,000</u>
46.	The amount of solar energy that strikes a square meter of the earth's surface in a single day is called a) solar window b) solar constant <u>c) solar insolation</u> d) solar radiation
47.	The energy conversion efficiency of a solar cell does not depend on a) solar energy insolation <u>b) inverter</u> c) area of the solar cell d) maximum power output
48.	The exhaust from a fuel cell would contain a) Hydrogen <u>b) Water vapour</u> c) CO ₂ d) Oxygen
49.	The management tool that focuses on optimizing the effectiveness of manufacturing equipment is a) 5S b) TQM <u>c) TPM</u> d) Kaizen
50.	The following industry/establishment is not covered in the notified list of nine designated consumers under the Energy Conservation Act, 2001 a) chlor alkali b) fertilizer c) paper and pulp <u>d) hydel power station</u>

..... ***End of Section – I***

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Max. Marks: 150

General instructions:

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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 primary and secondary energy with example.

Ans:

Primary energy refers to all types of energy extracted or captured directly from natural resources.

Primary energy is further divided into two distinctive groups:

- i) Renewable (solar energy, wind energy, geothermal, tidal, biomass)
- ii) Non-renewable (coal, oil, natural gas and uranium)

Primary energy is transformed in energy conversion process to more convenient forms of energy such as electricity, steam etc. These forms of energy are called secondary energy.

S-2 Explain what is meant by Renewable Purchase Obligation (RPO).

Ans:

Electricity Act 2003 has made a significant regulatory impact on the use of renewable energy by RPO.

By this, each retail seller of electricity is obligated to include in their resource portfolio a certain proportion of power from renewable energy sources, such as wind, solar, small hydro, bio mass etc. The retailer can meet this obligation either by owning a renewable energy facility or purchasing renewable energy from someone's facility.

Paper 1 – Set A Key

- S-3 An Energy Manager in a factory has gathered following data to arrive at the Plant Energy Performance.

Reference Year (2009) energy use : 12 million kCal
Production Factor (PF) for the current year (2010) : 0.9
Current year's energy : 11 million kCal

What is the Plant energy Performance (PEP) of the factory for the year 2010?
State your inference.

Ans:

$$\begin{aligned}\text{Reference year equivalent energy} &= \text{Reference year energy use} * \text{P.F} \\ &= 12 * 0.9 = 10.8 \text{ MkCal}\end{aligned}$$

$$\text{Plant Energy Performance} = (\text{Reference year equivalent} - \text{current year's energy}) * 100$$

$$\begin{aligned}&\frac{\text{Reference Year equivalent}}{\text{Reference Year equivalent}} \\ &= (10.8 - 11) / 10.8 \\ &= -1.85 \%\end{aligned}$$

Inference: Plant energy performance is marginally negative. Energy manager/plant manger has to take action to improve the performance.

- S-4 An energy saving proposal involves an investment of Rs. 25 lakhs in an industry and is expected to yield an average annual net saving of Rs. 5 lakhs/annum. The cost of borrowing of the investment is 14%. Compute the return on investment for this proposal and state with reason whether the investment is justified

Also, state the limitations of ROI.

Ans:

$$\begin{aligned}\text{The Return On Investment (ROI)} &= 5/25 * 100 = 20\% \\ \text{The cost of borrowing} &= 14\%\end{aligned}$$

Since ROI is higher than interest rate, the proposal is justified.

Limitations of ROI:

- 1) ROI does not take into account for the time value of the money over the period of cash flow.

Paper 1 – Set A Key

2) It does not account for the variable nature of annual net cash flows. The 20% return indicated would be economically valid only if the return is occurring in perpetuity .

S-5 Estimate the expected power output for the following 150 kW rated wind turbine:

Wind turbine blade diameter	:	20 m
Average wind speed	:	15 m/s
Generator efficiency	:	95%
Gear box efficiency	:	90%
Assume: air density	:	1.2 kg/m ³
Coefficient of performance of the blade	:	0.3

Ans:

Expected power output (P) = $\frac{1}{2} \times \text{density} \times A \times C_p \times E_{gr} \times E_{gb} \times V^3$ Watts

$$\begin{aligned} P &= 0.5 \times 1.2 \times \frac{3.14}{4} \times 20^2 \times 0.3 \times 0.95 \times 0.90 \times 15^3 \\ &= 163095 \text{ Watts} \\ &= 163 \text{ kW.} \end{aligned}$$

S-6 What is the need for standards and labeling programme for energy consuming equipment and appliances? Write a short note on star rating programme of BEE for energy consuming equipment and appliances

Ans:

There is a wide variation in energy consumption of similar products by various manufacturers. Also information on energy consumption is often not easily available. This leads to continued manufacture and purchase of inefficient equipment and appliances. Hence the need for standards and labeling.

Star Ratings: Star rating is a system initiated by BEE to determine energy efficiency of an appliance like air conditioner. Depending upon their energy efficiency, they are rated on a scale of 1-5 stars. Star ratings starts from one star (which is the least energy efficient and hence the least money saved) to 5 stars (which is the most energy efficient). Star ratings are affixed on appliances after testing in BEE accredited laboratories. A manufacturer has to register with BEE to get the star ratings, and get their products tested in laboratories. 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.

S-7 List five measures for achieving energy security of a country

Ans:

Some of the strategies that can be used to meet future energy requirements include:

- Reducing energy requirements
 - Improving the efficiency of extraction of fossil fuels
 - Improving fuel efficiency of new coal-fired power plants by adopting new technology (i.e. super critical pulverized fuel fired boilers)
 - Adopting energy efficiency and demand side management
 - Promotion of public transport / mass transport (e.g. metro rail, light rail, monorail etc.) in urban areas
 - Developing renewable energy sources especially solar and wind
- Substituting imported oil/gas with domestic alternatives
 - Ethanol / Biodiesel as substitute for petrol / diesel
 - Biomass gasification for heat or power as alternative to gas / coal
 - Coal-to-oil technology as done in South Africa
- Diversifying energy supply sources
 - Mix of fuel comprising of coal, gas, nuclear, hydro and renewables with no dependence on any particular fuel
 - Sourcing oil / LNG from different countries
 - Importing gas through pipelines passing through countries who also benefit
- Expanding energy resource and developing alternative energy sources
 - Improved Oil Recovery (IOR) and Enhanced Oil Recovery (EOR) for improving exploitation of reserves
 - Recovery of oil and gas from abandoned or marginal fields
 - In-situ coal gasification
 - Capturing Coal Bed Methane (CBM) which escapes from coal seams during mining
 - Conversion of coal to oil
 - Gas to Liquid (GTL)
 - Stepping up exploration to find new reserves (only one-third of oil bearing area explored so far)
 - Equity oil, gas, coal from other countries
 - Setting up energy intensive units (i.e. fertilizer plants) abroad
 - New domestic sources (nuclear –fast breeder reactor, thorium reactors, gas hydrates etc.)
 - Promoting Community Biogas Plants
 - Energy plantations

S-8 What are the qualifications required for an accredited energy auditor under the Bureau of Energy Efficiency Regulations (Qualifications for Accredited Energy Auditors and Maintenance of their list), Regulations 2010 notified under EC Act, 2001?

Ans:

Paper 1 – Set A Key

An Energy auditor shall be qualified to become an accredited energy auditor if he / she-

- (a) is a certified energy manager and has passed the examination in “Energy Performance for Equipment and Utility Systems” conducted by Bureau
- (b) has an experience of five years in energy audit out of which atleast three years shall be in any of energy intensive industries
- (c) has been granted a certificate of accreditation by the Bureau of Energy Efficiency.

Accreditation Advisory Committee constituted by BEE for the purpose of grant of certificate of accreditation shall assess the energy audit experience and competence of energy auditor who has applied for certification of accreditation on the basis of an oral interview.

..... 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 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, and are found to be 60% and 95% respectively.

The steam is supplied at 3.5 kg/cm^2 , having a latent heat of 513 kCal/kg . The evaporated moisture temperature is around 100°C having enthalpy of 640 kCal/kg .

- i) Estimate the quantity of moisture to be evaporated/hr.
- ii) Input steam quantity required for evaporation per hour.

Ans:

- i) Estimation of moisture quantity to be evaporated/hr:

Production rate	= $480/24 = 20 \text{ TPH}$
Inlet dryness to the paper machine	: 60%
Outlet dryness from the machine	: 95%
Paper weight in the final product	= $20 \times 0.95 = 19 \text{ TPH}$
Weight of moisture after dryer	= 1 TPH
Weight of moisture before dryer	

Paper 1 – Set A Key

$$\begin{aligned} &= (19/ 0.60) -19 \\ &= 12.66 \text{ TPH} \\ \text{Evaporated moisture quantity} &= 12.66-1= 11.66 \text{ TPH} \end{aligned}$$

ii) Input steam quantity required for evaporation/Hour

$$\begin{aligned} \text{Evaporated moisture temperature} &= 100 \text{ deg C} \\ \text{Enthalpy of evaporated moisture} &= 640 \text{ kCal/.kg} \end{aligned}$$

$$\begin{aligned} \text{Total Heat available in evaporated moisture (sensible \&latent)} \\ &= 640 * 11,660 \\ &= 7.46 \text{ MkCal/h} \end{aligned}$$

$$\begin{aligned} 3.5 \text{ kg/cm}^2 \text{ steam requirement} &= \frac{\text{heat in the evaporated moisture}}{\text{Latent heat of steam (3.5 kg/cm}^2\text{)}} \\ &= 7,462,400 / 513 \\ &= 14.546 \text{ TPH} \end{aligned}$$

L-2 Explain briefly **any two** of the following

- a) 5S
- b) Kaizen
- c) TPM
- d) TQM

Ans:

a)

5S: '5S' is acronym formed by the first letters 'S' of five Japanese words, meaning, respectively, Housekeeping, workplace organization, clean up, maintain cleanliness and discipline. Implementing 5S method in the work place would help reduce wastes, improve the levels of quality and safety, reduce the lead time and cost and thus helps to increase the profitability of the organization.

b)

Kaizen: 'Kaizen' is a practice developed by Japanese for increasing the productivity of a manufacturing plant. KAIZEN means Change (KAI) for Good (ZEN)

This technique relies on the axiom that there is always scope for improvement involving everyone in the plant right from the Plant Managers down to shop floor workmen. It emphasizes improvement on working standard through small and gradual improvement.

c)

TPM:

Paper 1 – Set A Key

- Total Productive Maintenance (TPM) is the method that focuses on optimizing the effectiveness of manufacturing equipment. TPM builds upon established best practices and focuses on team-based maintenance that involves employees at every level and function. TPM addresses the entire production system lifecycle and builds a concrete, shop floor-based system to prevent all losses, to eliminate all accidents, defects and breakdowns.
- d) TQM

Total Quality Management (TQM) is a process for managing quality. It is associated with the maxim- “doing the right things right, the first time”. Better management of quality complements an Energy Management Program.

TQM involves all people in the organization right from top executive down to bottom level workers. TQM stresses on “Document what you do; then do what you have documented”. TQM requires that Mission and vision statements be written and displayed everywhere to serve as guiding rules for all employees. As per TQM, long-term needs, rather than short-term must be given more emphasis to derive major benefits.

- L-3 In a fertilizer plant, the off-site boiler was revamped to improve the efficiency by spending Rs. 200 lakhs. The discount rate for the company is 15%. The projected cost of saving of fuel was Rs. 40 lakhs/ year. Find out the NPV at the end of 10 years of the operation of the boiler. State your opinion about the usefulness of this investment.

Ans:

$$NPV = -CF_0 / (1+k)^0 + CF_1 / (1+k)^1 + \text{-----} + CF_{10} / (1+k)^{10}$$

Where, CF_0 = cash out flow at the beginning

CF_1 — CF_{10} = cash flow (inward) at the end of each year specified

K = discount rate

For the given project,

CF_0 = Rs. 200 lakhs

Yearly cash inflow= Rs.40 lakhs

Discount rate = 15%

$$NPV = -200 + 40 \left[\frac{1}{(1+0.15)^1} + \text{-----} + \frac{1}{(1+0.15)^{10}} \right]$$

$$-200 + 40 \left[0.869 + 0.756 + 0.657 + 0.571 + 0.497 + 0.432 + 0.376 + 0.326 + 0.284 + 0.247 \right]$$

$$-200 + 40 \times 5.015$$

$$-200 + 200.6$$

$$0.6 \text{ lakh}$$

Paper 1 – Set A Key

Opinion: As the NPV is positive, the project is found to be a viable one. As the fuel price is found to be on increasing trend, the project proves to be even more viable in its course.

- L-4 In a food processing plant the monthly production related (variable) energy consumption was 1.8 times the production and non-production related (fixed) energy consumption was 15,000 kWh per month up to May 2010. In the month of June 2010 a series of energy conservation measures were implemented. Use CUMSUM technique to develop a table and calculate energy savings for the subsequent 6 months period from the data given below

Month	Production (kg)	Actual Energy Consumption (kWh)
Jul' 10	62000	113600
Aug' 10	71000	139000
Sep' 10	75000	158000
Oct' 10	59000	119300
Nov' 10	62000	123700
Dec' 10	73000	143600

Ans:

Month	Production	Predicted energy Consumption	Actual energy consumption	
Jul	62000	126600	113600	-13000
Aug	71000	142800	139000	-3800
Sep	75000	150000	158000	8000
Oct	59000	121200	119300	-1900
Nov	62000	126600	123700	-2900
Dec	73000	146400	143600	-2800
				-16400

Savings for six month period = 16,400 kWh

- L-5 Construct a PERT Diagram for the following project and find out the critical path.

Activity	Duration in weeks	Precedent
A	7	Start
B	3	A
C	1	B
D	8	A

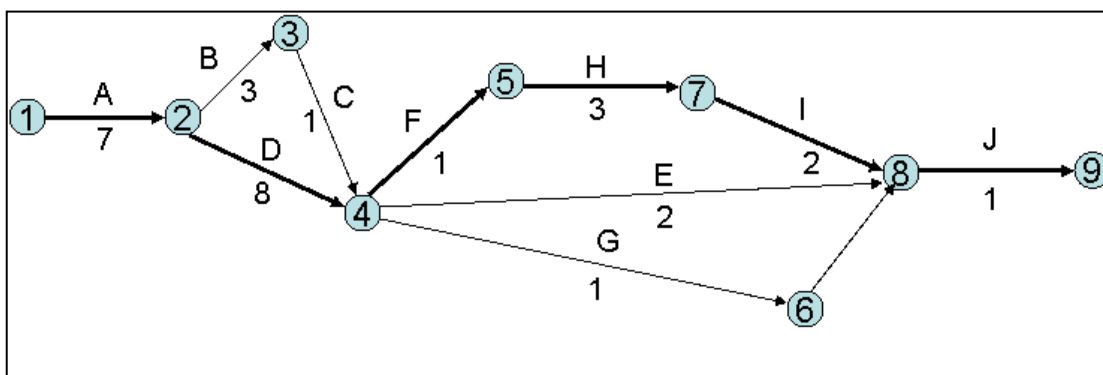
Paper 1 – Set A Key

E	2	D,C
F	1	D,C
G	1	D,C
H	3	F
I	2	H
J	1	E,G,I

- Draw the PERT network,
- What is the critical path?
- What is the total duration required to complete the project?
- What is the available slack in each of the activity?

Ans:

i) PERT network



ii) The critical path is A-D-F-H-I-J.

iii) The project duration is 22 weeks.

iv)

Activity	Expected Time	Earliest Start ES	Earliest Finish EF	Latest Start LS	Latest Finish LF	Float or Slack LS-ES or LF-EF
A	7	0	7	0	7	0
B	3	7	10	11	14	4
C	1	10	11	14	15	4
D	8	7	15	7	15	0
E	2	15	17	19	21	4
F	1	15	16	15	16	0
G	1	15	16	20	21	1
H	3	16	19	16	19	0
I	2	19	21	19	21	0
J	1	21	22	21	22	0

L-6 Write short notes on **any two** of the following

- a) Biomethanation of biomass
- b) Fuel cells
- c) Geothermal energy

Ans:

- a) Biomass can also be converted into bio-methane gas which is composed mainly of methane and carbon dioxide. The process is based on biological digestion / anaerobic digestion (biomethanation) of biomass. This is the only process giving additional advantage of high grade manure as the by-product. The raw materials for biomethanation process include manure, sewage sludge, municipal solid waste, fruit and vegetable waste, food waste, distillery wastes and other biodegradable wastes. Bio-methane can completely replace natural gas for applications using natural gas such as boilers, furnaces, IC engines etc.
- b) Input to a Fuel Cell is hydrogen. Hydrogen combines with oxygen to produce electricity through an electrochemical process with water and heat as by-products.

A Fuel Cell consists of two catalyst coated electrodes surrounding an electrolyte. One electrode is an anode and the other is a cathode. The process begins when hydrogen molecules enter the anode. The catalyst coating separates hydrogen's negatively charged electrons from the positively charged protons. The electrolyte allows the protons to pass through to the cathode, but not the electrons. Instead the electrons are directed through an external circuit which creates electrical current. While the electrons pass through the external circuit, oxygen molecules pass through the cathode. The oxygen and the protons combine with the electrons after they have passed through the external circuit producing water and heat.

- c) For every 100 meters you go below ground, the temperature of the rock increases about 3°C. So, at a depth of about 3000 metres below ground, the temperature of the rock would be hot enough to boil water. Deep under the surface, water sometimes makes its way close to the hot rock and turns into boiling hot water or into steam. The hot water can reach temperatures of more than 148°C. When this hot water comes up through a crack in the earth, it is known as hot spring.

Some of the areas have so much steam and hot water that it can be used to generate electricity. Holes are drilled into the ground and pipes lowered into the hot water. The hot steam or water comes up through these pipes from below ground. A geothermal power plant is like in a regular power plant except that no fuel is burned to heat water into steam.

..... End of Section – III