

- N.B. :** 1) Question – 1 is compulsory. Answer any three questions from remaining.
 2) Assume data if necessary and specify the assumptions clearly.
 3) Draw neat sketches wherever required.
 4) Answer to the sub-questions of an individual question should be grouped and written together i.e. one below the other.

1. Answer the following sub-questions briefly. Each sub-question carries equal marks. (20)

1. What is "Energy Conservation Opportunity (ECO)"?
2. "If the compressor cooling water is being discharged to the sewer, it indicates energy loss"; justify this sentence.
3. What is the significance of "Ratio of energy demand to GDP"?
4. What is the concept of $Q_{H,min}$ and $Q_{C,min}$ in heat exchanger networking?
5. In case of steam turbine generator set, the enthalpies of inlet and exhaust steam are 2795.15 and 2537.20 kJ/kg respectively. The overall efficiency of turbine generator set is 80%. Then calculate theoretical steam rate (TSR) and actual steam rate (ASR) required in kg/kWhr. (1 BTU = 1.055 kJ)
6. Why steam economy in case of multiple effect evaporator is more than that in case of single effect evaporator?
7. What is the concept of 'heat integration' in any process system?
8. How minimum approach temperature (ΔT_{min}) affects on heat transfer area required and utility cost in case of heat exchanger networking?
9. What is the use of an instrument, "blower door attachment" while carrying energy audit of any facility?
10. Explain the concept of "waste heat" with the help of few examples.

2. The process system involves four process streams whose data is as given below. (20)

Stream	1	2	3	4
T_{in} ($^{\circ}C$)	25	20	90	150
T_{out} ($^{\circ}C$)	100	125	60	60
C (kW/ $^{\circ}C$)	6	5	16	5

For $\Delta T_{min} = 25^{\circ}C$ for this system, $Q_{H,min} = 210$ kW and $Q_{C,min} = 165$ kW; Hot pinch temperature = $90^{\circ}C$. Then design a feasible HEN for this system to satisfy minimum utility load.

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3. (a) Explain how to make "steam system" of process plant more efficient. (10)
- (b) Write in detail about concept and methodology of "energy audit". (10)
4. (a) What is distributed generation (DG) cogeneration technology? Write in detail (i.e. working, advantages, disadvantages, applications) about "photovoltaic cells - distributed generation cogeneration technology". (12)
- (b) List out various techniques used to recover waste heat and write in detail about any two of these techniques. (08)
5. Write short note on (20)
- (a) Reboiler flashing in distillation
- (b) Causes of high energy intensity in developing countries
- (c) Energy efficient steps to improve energy efficiency of cooling towers used in facility
- (d) Cogeneration with topping cycle
6. A forward feed triple effect evaporator is used to concentrate dilute solution at rate of 15000 kg/hr. The steam (at 118 °C and 6207 kg/hr) is used as heating source in 1st effect, however in 2nd and 3rd effect vapors generated in previous effect are used as heating source. The latent heat (λ) of steam used in 1st effect is 2207 kJ/kg. Other useful data is as given below: (20)

Data:

	Effect 1	Effect 2	Effect 3
U (W/m ² K)	3000	1650	770
ΔT (°C) (adjusted for cold feed condition)	15	15	36
Vapor generated from (kg/hr)	4176	4356	4594
λ (kJ/kg)	2235	2282	2377

Calculate:

- (i) Boiling point Temperatures in each effect.
- (ii) Heat transfer area in each effect
- (iii) Steam economy