Q.P.CODE: 26760

(Time:3 hour) **[Total marks: 80]**

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 a) Why steam economy is more in case of multiple effect evaporator as compared to single effect evaporator **(5)**

b) What energy steps should be followed when motors are running during periods when the equipment or process they are driving is idle **(5)**

c) Discuss renewable and non-renewable sources of energy with examples **(5)**

d) Discuss co-generation and its advantages **(5)**

2 a) Explain various energy efficient steps to improve energy efficiency of a steam generation system **(12)**

b) Discuss different steps of "detailed energy audit" **(8)**

3 a) Estimate minimum utility requirement of hot and cold and pinch temperature for the process stream given below: **(10)**

ΔT_{min}=15°C

Stream	T^s(°C)	T^t(°C)	mCp (KW/°C)
1	180	80	2
2	130	40	4
3	60	100	8
4	30	120	3.6

b) For the system explained in Q. No. 3 (a), design a Heat Exchanger Network (HEN), both above and below the pinch to meet the minimum utility requirement, without any violation of ΔT_{min} approach. **(10)**

4 a) A forward feed triple effect evaporator is used to concentrate dilute solution. The steam (at 121°C and 4093 kh/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 to 1st effect is 2200 kJ/kg. Other useful data is as given below: **(20)**

	Effect 1	Effect 2	Effect 3
U (W/m^2K)	3100	2000	1100
ΔT (°C) (adjusted for cold feed condition)	18	17	34
Vapor generated (kg/hr)	2480	2660	2858
λ (kJ/kg)	2249	2293	2377

Calculate :

i. Boiling point temperatures in each effect
ii. Heat transfer area in each effect
iii. Steam economy

5 a) A stream of 15,500 lb of saturated steam at 250psig is being expanded through a pressure reducing valve, to obtain process stream at 50psig. Determine the potential for electricity generation if the stream is expanded using single stage back pressure 3600 RPM turbine generator **(8)**

Data given:
Steam rate: 15,500 lb/hr
Inlet steam enthalpy (hi) : 1201.7 Btu/lb
Outlet steam enthalpy (ho): 1090.8 Btu/lb
Turbine speed: 3600 RPM
Corresponding values of theoretical stream rate (TSR) and Actual Steam Rate (ASR) for 3600 RPM are as below:

TSR(lb/KW-hr)	17.5	25	30.7	35.5
ASR(lb/hp-hr)	22.5	32.5	38.5	45

b) Discuss "combined cycle cogeneration "with suitable example **(8)**

c) In case of cogeneration plant what is the definition of the terms "Process Returns (PR)" and "Net Heat to Process (NHP)". **(4)**

6 Write short notes on:

a) Energy auditors tool box **(5)**

b) Direct and indirect benefits of waste heat recovery **(5)**

c) Generalized rule for stream splitting on hot side of pinch to satisfy MER requirement **(5)**

d) Heat pumping in distillation **(5)**

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