Total No. of Questions—**12**]

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S.E. (Mech. Engg.) (First Semester) EXAMINATION, 2011

APPLIED THERMODYNAMICS

(2008 PATTERN)

Time : Three Hours **Maximum Marks : 100**

N.B. **:—** (*i*) Answer Q. Nos. **1** *or* **2**, **3** or **4**, **5** *or* **6** from Section I and Q. Nos. **7** *or* **8**, **9** *or* **10**, **11** *or* **12** from Section II.

(*ii*) Answers to the two sections should be written in separate answer-books.

(*iii*) Use of logarithmic tables, slide rule, Mollier charts, electronic pocket calculator and steam tables is allowed.

(*iv*) Assume suitable data, if necessary.

SECTION I

1. (*a*) State Clausius and Kelvin-Planck statements of second law and prove their equivalence. [8]

(*b*) A reversible heat pump is used to maintain a temperature of 0°C in a refrigerator when it rejects the heat to the surroundings at 27°C. Determine COP of the machine and work input required if the heat removal rate is 25 kW.

If the required input to run the pump is developed by reversible engine which receives heat at 673 K and rejects heat to the atmosphere. Determine overall COP of the system. [8]

Or

2. (*a*) Explain the principle of increase of entropy. [8]

(*b*) A reversible heat engine takes 900 kJ heat from a source at 700 K. The engine develops 350 kJ of network and rejects heat to two low temperature reservoirs at 600 K and 500 K. Determine engine thermal efficiency and heat rejected to each low temperature reservoir by using Clausius inequality. [8]

3. (*a*) Explain the following : [9]

(*i*) Available and unavailable energy

(*ii*) Principal reasons for irreversibility

(*iii*) Helmholtz and Gibbs function.

(*b*) Calculate the decrease in available energy when 20 kg of water at 90°C mixes with 30 kg of water at 30°C, the pressure being taken as constant and the temperature of surrounding is 10°C. (C_p for water 4.18 kJ/kgK). [8]

Or

4. (*a*) A gas has a density of 1.875 kg/m^3 at pressure of 1 bar and temperature of 15°C. A mass of 0.9 kg of this gas requires heat transfer of 175 kJ to raise the temperature from 15°C to 250°C while pressure of the gas remains constant. Determine :

(*i*) Characteristic gas constant

(*ii*) C_p of gas

(*iii*) C_v of gas

(*iv*) Change in internal energy during the process

(*v*) Work. [10]

(*b*) What is throttling ? Give *two* examples. [3]

(*c*) Write expression for heat, work and change in internal energy of ideal gas during constant volume process, in a close system. [4]

5. (*a*) 1 kg of steam at a pressure of 17.5 bar and dryness 0.95 is heated at constant pressure until it is completely dry saturated. Calculate : [9]

(*i*) Increase in volume

(*ii*) Quantity of heat supplied

(*iii*) Change in entropy.

(*b*) Explain with neat sketch working of 'combined separating and throttling' calorimeter for measuring dryness fraction. State the equation for true dryness fraction. [8]

Or

6. (*a*) With the help of T-S diagram, explain the effect of the following parameters on the performance of Rankine cycle :

(*i*) Effect of superheat

(*ii*) Condenser pressure. [8]

(*b*) A steam turbine receives superheated steam at a pressure of 17 bar and having degree of superheat of 110°C. The exhaust pressure is 0.07 bar and expansion of steam takes place isentropically. Calculate :

(*i*) The heat supplied and heat rejected

(*ii*) Network output

(*iii*) Thermal efficiency

(*iv*) Specific steam consumption.

Neglect pump work. [9]

SECTION II

7. (*a*) Explain bomb calorimeter with neat sketch. [8]

(*b*) The ultimate analysis of dry coal burnt in a boiler is C 84%. H_2 9%, and incombustibles 7% by mass. Determine the mass of dry flue gases per kg of coal burnt, if the volumetric composition of flue gas is : [8]

CO_2	8.75%
CO	2.25%
O_2	8%
N_2	81%

Or

8. (*a*) Define HCV and LCV. [5]

(*b*) Explain Orsat's apparatus for exhaust gas analysis. [5]

(*c*) The following results are obtained when sample of gas is tested by gas calorimeter :

Gas burnt in calorimeter = 0.08 m^3

Pressure of gas supply = 5.2 cm of water

Barometer = 75.5 cm of Hg

Temperature of gas = 13°C

Weight of water heated by gas = 28 kg

Temperature of water at inlet = 10°C

Temperature of water of outlet = 23.5°C

Steam condensed = 0.06 kg

Find HCV per m^3 of gas at 15°C and barometric pressure of 76 cm of Hg. [6]

9. (*a*) Explain Vane compressor with sketch. [6]

(*b*) Prove that condition for minimum work required for a two stage reciprocating air compressor is :

$$P_2 = \sqrt{P_1 . P_3}$$

where P_1-intake and P_3-delivery pressure. [8]

(*c*) A single stage, single acting compressor delivers air from 1 bar to 7 bar. Assuming compression follow the law $PV^{1.35}$ = constant and clearance 5% of the swept volume, find volumetric efficiency of a compressor. [4]

Or

10. (*a*) Draw and explain actual PV diagram for single stage reciprocating air compressor. [6]

(*b*) Define :

Isothermal efficiency

Volumetric efficiency

Free air delivered in case of compressor. [6]

(*c*) Free air to be compressed from 1 bar to 15 bar pressure. Two alternatives are available i.e. single stage and multistage compression. Assuming polytropic index 1.3, justify which alternative should be used by calculating work. Assume perfect intercooling. [6]

11. (*a*) State advantages of artificial draught over natural draught in boiler. [5]

(*b*) Explain :

(*i*) Boiler efficiency

(*ii*) Boiler accessories with *three* examples. [5]

(*c*) What is equivalent evaporation ? A boiler evaporates 3.6 kg of water per kg of coal into dry saturated steam at 10 bar. The temperature of feed water is 32°C. Find equivalent evaporation 'from and at 100°C'. [6]

Or

12. (*a*) Explain water level indicator with sketch. [5]

(*b*) Explain heat balance sheet, method of its preparation and significance for a boiler. [5]

(*c*) In a boiler test 1250 kg of coal consumed in 24 hrs. Mass of water evaporated is 13000 kg and mean effective pressure is 7 bar. Feed water temperature was 40°C and heating value of coal is 30,000 kJ/kg. Taking enthalpy of 1 kg of steam at 7 bar as 2570 kJ, find equivalent evaporation per kg of coal and boiler efficiency. [6]