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B. Tech
BEG 1004

Second Semester Examination, 2004

Thermodynamics

Full Marks : 70

Time : 3 hours

Answer **Q. No. 1** which is compulsory and any five from the rest

The figures in the right-hand margin indicate marks

Use of steam tables is permitted

1. **Answer the following in brief and to-the-point (answer of this question are to be written at one place) :** 2 × 10

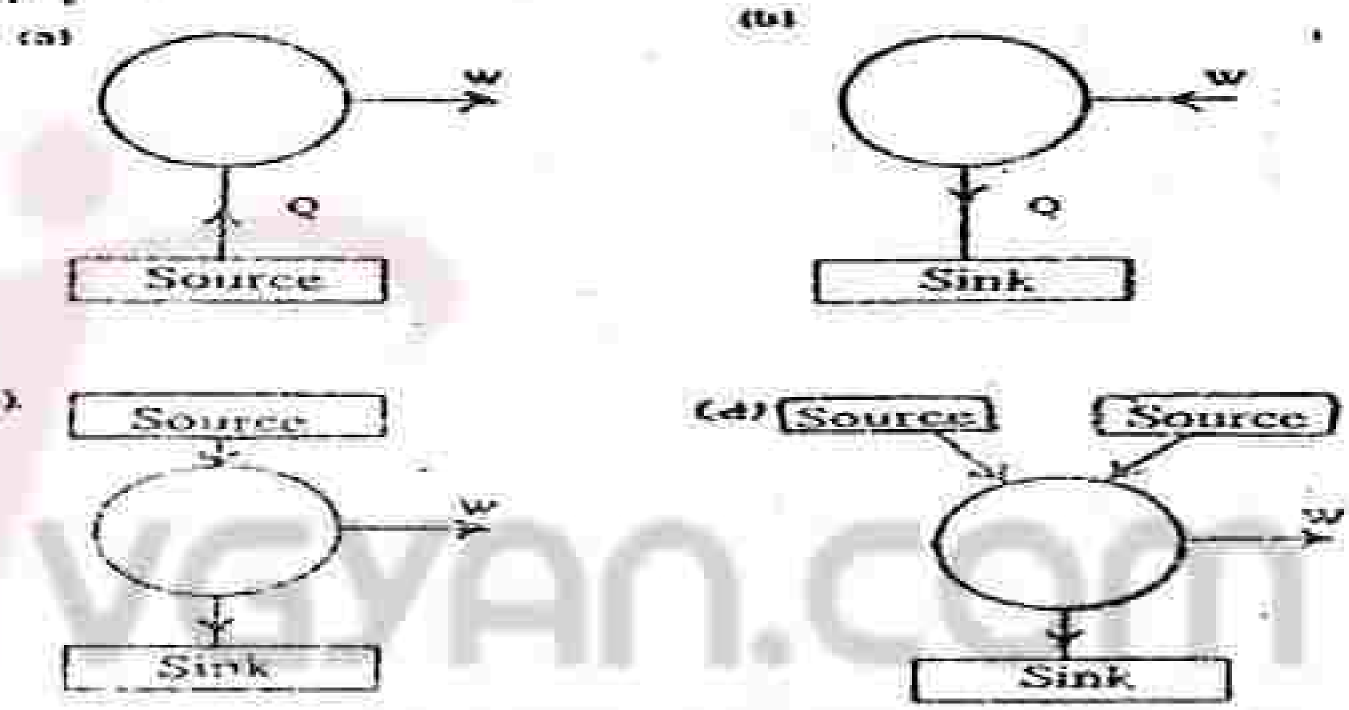
   (*i*) Explain what is meant by thermodynamic equilibrium.

   (*ii*) What is a reversible process ? Which factor cause internal irreversibility ?

   (*iii*) Show that the stored energy of an isolated system remains constant.

(Turn Over)

(*iv*) Which of the following devices are possible and which are impossible according to the Kelvin-Planck statement of the second law ?



(*v*) An inventor claims that he has built an engine working between temperature limits of 1000 K and 400 K and having an efficiency of 70%. Check if his claim is valid.

(*vi*) A diatomic gas (assumed ideal) has a C_p equal to 1·0391 kJ/kg–K. Find the value of its specific gas constant R.

(*vii*) Prove that, for an adiabatic process, $dh = vdp$.

(*viii*) An insulated rigid container has 5 kg of air at 30 °C. A paddle wheel fitted in the container agitates the air and transfers 100 kJ of work to this air. What is the change in internal energy of the air ?

(*ix*) Define the critical point of a liquid. What is the value of h_{fg} at the critical point ?

(*x*) For a cycle it was calculated that

$$\oint \frac{\delta Q}{T} = 0 \cdot 5 \text{ kJ/K}.$$

Is such a cycle possible ? Give reasons for your answer.

2. Two tanks A and B are connected through a valve which is initially closed. Tank A contains 3 kg of air at 2 bars and 30 °C. Tank B has a volume of 1 m^3 and has air at 5 bars, 40 °C. Now the valve is opened and remains open until the air in both tank comes to a uniform state. Heat transfer to the surroundings brings the final temperature to 27 °C. What is the final uniform pressure if the volume of the connecting pipes is neglected ? 10

3. A liquid-vapour mixture of water is initially at a pressure of 10 bars. When this fluid is heated at a constant volume, the process passes through the critical point. Determine the quality at the initial state. 10

4. 10 kg of steam at 5 bar, x = 0·85 undergoes a constant pressure process until the temperature becomes 200 °C. Determine : (*a*) The work done, (*b*) The change in internal energy, (*c*) The heat transferred. 4 + 4 + 2

5. Air enters a compressor at a rate of 0·72 kg/sec and at 1 bar, 290 K. The inlet velocity is 6 m/sec. Air leaves the compressor at 7 bar, 450 K and with a velocity of 2 m/sec. Heat transfer from the compressor to its surroundings occurs at a rate of 3 kW. Calculate the power input to the compressor. 10

6. Two reversible engines are arranged in series as detailed below :

The first engine receives energy from a reservoir at T_H and rejects energy to a reservoir at temperature T. The second engine receives the energy rejected by the first engine from the reservoir at T and rejects energy to a reservoir at temperature T_L. Here $T_H > T > T_L$. Derive an expression for the temperature T in terms of T_H and T_L if the net work of the two engines are equal. 10

7. 2 kg of steam at 4 bars, 80% quality is heated at constant pressure until the temperature is 250 °C. Calculate the heat transfer and the entropy change. If this heat is supplied to the steam from a reservoir at 300 °C, what is the entropy change of the Universe? 3 + 3 + 4

8. Answer any *two* of the following : 5 × 2

(*i*) Under what conditions the work done by a system equals $\int pdV$?

(*ii*) Show that the heat added to a closed system at constant pressure equals the change in enthalpy.

(*iii*) State and explain the principle of increase in entropy.