Seat No.: _____ Enrolment No.______

GUJARAT TECHNOLOGICAL UNIVERSITY

B.E. Sem-III Regular / Remedial Examination December 2010

Subject code: 130405

Subject Name: THERMODYNAMICS

Date: 18 /12 /2010 **Time: 10.30 am – 01.00 pm**

Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **All the Notations bear their conventional meanings.**

Q.1 (a) Define Thermodynamics, system, surrounding, state and process. Also, mention various statements of zeroth, first, second and third law of thermodynamics. **07**

(b) Air at 1 bar and 298.15 K (25°C) is compressed to 5 bar and 298.15 K by two mechanically reversible processes: **07**

i) Cooling at constant pressure followed by heating at constant volume.

ii) Heating at constant volume followed by cooling at constant pressure.

Calculate the heat and work requirements and ΔU and ΔH of the air for each path. The following heat capacities for air may be assumed independent of temperature:

$$C_v = 20.78 \quad \text{and} \quad C_p = 29.10 \text{ J mol}^{-1} \text{K}^{-1}$$

Also assume for air that PV/T is a constant, regardless of the changes it undergoes. At 298.15 K and 1 bar the molar volume of air is 0.02479 $m^3 \, mol^{-1}$.

Q.2 (a) What is the final temperature when heat in the amount of 930 kJ is added to 25 moles of ammonia initially at 260°C in a steady-flow process at approximately 1 atm? **07**

$$C_p^{ig}/R = 1.702 + 9.081 \times 10^{-3}\, T - 2.164 \times 10^{-6}\, T^2 \text{ J/(mol K)}, \text{ T is in K}$$

(b) Express the volume expansivity and the isothermal compressibility as functions of density ρ and its partial derivatives. For water at 50 °C and 1 bar, $k = 44.18 \times 10^{-6}\ \text{bar}^{-1}$. To what pressure must water be compressed at 50°C to change its density by 1 percent? Assume that k is independent of P. **07**

OR

(b) Liquid/Vapour saturation pressure P^{sat} is often represented as a function of temperature by an equation of the form: **07**

$$\log_{10} P^{sat}(\text{torr}) = a - \frac{b}{t(^{o}C) + c}$$

Here, parameters a, b and c are substance-specific constants. Suppose it is required to represent P^{sat} by the equivalent equation:

$$\ln P^{sat}(\text{kPa}) = A - \frac{B}{T(K) + C}$$

Show how the parameters in the two equations are related.

Q.3 (a) For steady flow in a heat exchanger at approximately atmospheric pressure, what is the amount of heat required when 10 moles of SO_2 is heated from 200°C to 1100°C? Heat capacity of SO_2 is given by: **05**

$$C_p^{ig}/R = 5.699 + 0.801 \times 10^{-3} T - 1.015 \times 10^{5} T^{-2} \text{ J/(mol. K)}, \text{ T is in K}$$

(b) The turbines in a hydroelectric plant are fed by water falling from a 50 m height. Assuming 91% efficiency for conversion of potential to electrical energy, and 8% loss of the resulting power in transmission, what is the mass flow rate of water required to power a 200 W light bulb? **05**

(c) If the heat capacity of a substance is correctly represented by an equation of the form, $Cp = A + BT + CT^2$, show that the error resulting when $<Cp>_H$ is assumed equal to Cp evaluated at the arithmetic mean of the initial and final temperatures is $C(T_2 - T_1)^2 / 12$. **04**

OR

Q.3 (a) Derive a mathematical expression of the first law of thermodynamics for a closed system with modern sign conventions. Define and explain internal energy and enthalpy. **07**

(b) Explain Raoult's law. At 303 K the vapour pressures of benzene (1) and toluene (2) are 15.75 kPa and 4.89 kPa respectively. Assuming the validity of Raoult's law, determine the partial pressure and composition of the benzene vapour in equilibrium with a liquid mixture consisting of equal weight of the two components. **07**

Q.4 (a) Derive the formulae for PVT relations, ΔU, W, Q and ΔH for Isothermal, Isobaric, and Isochoric reversible processes for 1 mole of an ideal gas. **07**

(b) A piston/cylinder device contains 5 mol of an ideal gas, Cp = (5/2) R, and C_v = (3/2) R, at 20°C and 1 bar. The gas is compressed reversibly and adiabatically to 10 bar, where the position is locked in position. The cylinder is then brought into thermal contact with a heat reservoir at 20°C, and heat transfer continuous until the gas also reaches this temperature. Determine the entropy change of the gas, the reservoir and ΔS_{Total}. **07**

OR

Q.4 (a) Explain the concept of entropy change in detail. **07**

(b) Estimate the volume occupied by 18 kg of ethylene at 55^0C and 35 bar, Using, **07**

(I) Ideal gas equation.

(II) Van der walls equation of state.

Critical constants of ethylene are 282.3 K and 50.4 bar.

Q.5 (a) Discuss fundamentals of chemical reaction equilibria with examples. **05**

(b) Derive equation of COP (Coefficient of performance) of carnot refrigerator with neat sketch. **05**

(c) Write a short note on thermodynamics diagrams. **04**

OR

Q.5 (a) A mercury manometer used to measure pressure inside a vessel indicates 400 mm. One end of the manometer is exposed to the atmosphere. The atmospheric pressure is 1.01325 bar. Density of mercury is 13.56 x 10^3 kg/m^3 and g = 9.81 m/s^2. What is the absolute pressure in the vessel in N/m^2? **05**

(b) An electric current of 0.5 A from a 12 V supply is passed for 5 minutes through a resistance in thermal contact with saturated water at 1 atm. As a result, 0.798 g of water is vaporized. Assuming that the water vapour behaves ideally, calculate the molar internal energy change and enthalpy change during the process. **05**

(c) For the two-phase systems, derive the Clausius / Clapeyron equation relating latent heat of vapourization directly to the vapour-pressure curve. **04**

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