Seat No.: _____ *Enrolment No._____*

GUJARAT TECHNOLOGICAL UNIVERSITY

B.E. Sem-III Remedial Examination May 2011

Subject code: 130405 **Subject Name: Thermodynamics**

Date: 20-05-2011 **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 and explain the reversible process. Describe reversible expansion of a gas and reversible chemical reaction with necessary diagrams. **07**

(b) Explain PVT behaviour of pure substances with the help of PT and PV diagrams. **07**

Q.2 **(a)** Handbook values for the latent heat of vapourization in J/g are given in the table for benzene at T_n, the normal boiling point. **07**

Component	$\Delta H^{\ell v}$ at T_n (J/g)	$\Delta H^{\ell v}$ at 25°C (J/g)	T_n (K)	P_c (bar)	T_c (K)
Benzene	393.9	433.3	353.2	48.98	562.2

Calculate:

i) the value of the latent heat at T_n by Watson method, given the value at 25°C.

ii) the value of the latent heat at T_n by Riedel equation.

By what percentages do these values differ from the one listed in the table?

(b) A steel casting [C_p = 0.5 kJ kg^{-1} K^{-1}] weighing 40 kg and at a temperature of 450°C is quenched in 150 kg of oil [C_p = 2.5 kJ kg^{-1} K^{-1}] at 25°C. If there are no heat losses, what is the change in entropy of i) the casting ii) the oil, and iii) both considered together? **07**

OR

(b) A gas is confined in a 0.47 m diameter cylinder by a piston, on which rests a weight. The mass of the piston and weight together is 150 kg. The local acceleration of gravity is 9.813 m/s^2 and the atmospheric pressure is 101.57 kPa. Determine: **07**

i) What is the force in newtons exerted on the gas by the atmosphere, the piston and the weight, assuming no friction between the piston and cylinder?

ii) What is the pressure of the gas in kPa?

iii) If the gas in the cylinder is heated, it expands, pushing the piston and weight upward. If the piston and weight are raised 0.83 m, what is the work done by the gas in kJ? What is the change in potential energy of the piston and weight?

Q.3 **(a)** If the heat capacity of a substance is correctly represented by an equation of the form $Cp = A + BT + DT^{-2}$ then show that the error resulting when $\langle Cp \rangle_H$ is assumed equal to Cp evaluated at the arithmetic mean of the initial and final temperatures is: **05**

$$-\frac{D}{T_1 T_2}\left(\frac{T_2 - T_1}{T_2 + T_1}\right)^2$$

(b) Explain the term 'temperature'. Mention different units of temperature and relations among various temperature scales with diagrams. **05**

(c) For steady flow in a heat exchanger at approximately atmospheric pressure, what is the amount of heat required when 12 moles of propane is heated from 250°C to 1200°C? Heat capacity of propane is given by: $Cp^{ig}/R = 1.213 + 28.785 \times 10^{-3}T - 8.824 \times 10^{-6}T^2$ J/(mol. K) , T is in K **04**

OR

Q.3 **(a)** Derive a mathematical expression of the first law of thermodynamics for a steady state steady-flow process between a single entrance and a single exit. **07**

(b) For the system ethyl ethanoate (1)/ n-heptane (2) at 343.15 K, **07**

$\ln \gamma_1 = 0.95x_2^2$ $\quad \ln \gamma_2 = 0.95x_1^2$

$P_1^{sat} = 79.80$ kPa $\quad P_2^{sat} = 40.50$ kPa

Assuming the validity of modified Raoult's law,

i) Calculate P and y_1 for T = 343.15 K and $x_1 = 0.35$

ii) Calculate P and x_1 for T = 343.15 K and $y_1 = 0.75$

Q.4 **(a)** With special reference to mathematical statement of the second law of thermodynamics, justify that "All isentropic processes are adiabatic, but all adiabatic processes are not isentropic." **07**

(b) Reported values for the virial coefficient of isopropanol vapor at 200°C are: **07**

$B = -388$ cm^3 mol^{-1} $\quad C = -26{,}000$ cm^6 mol^{-2}

Calculate V and Z for isopropanol vapor at 200°C and 10 bar by:

i) The ideal-gas equation $\quad$ ii) $Z = \frac{PV}{RT} = 1 + \frac{B}{V} + \frac{C}{V^2}$

OR

Q.4 **(a)** Derive from the first principle $\Delta G° = -RT \ln K$. **07**

(b) A refrigeration system requires 1.5 kW of power for a refrigeration rate of 4 kJ/s. **07**

i) What is the coefficient of performance?

ii) How much heat is rejected in the condenser?

iii) If heat rejection is at 40°C, what is the lowest temperature the system can possibly maintain?

Q.5 **(a)** For an ideal gas prove that $\frac{\Delta S}{R} = \int_{To}^{T} \frac{C_P^{ig}}{R} \frac{dT}{T} - \ln \frac{P}{Po}$. **05**

(b) For and ideal gas with constant heat capacities undergoing a reversible adiabatic (and therefore isentropic) process, prove that: **05**

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$

(c) Derive the following Maxwell's equation from the first principle: **04**

$$\left(\frac{\partial T}{\partial P}\right)_S = \left(\frac{\partial V}{\partial S}\right)_P$$

OR

Q.5 **(a)** An instrument to measure the acceleration of gravity on Mars is constructed of a spring from which is suspended a mass of 0.40 kg. At a place on earth where the local acceleration of gravity is 9.81 m/s^2, the spring extends 1.08 cm. When the instrument package is landed on Mars, it radios the information that the spring is extended 0.40 cm. What is the Martian acceleration of gravity? **05**

(b) Water at 368 K is pumped from a storage tank at the rate of 25 m^3/h. The motor for the pump supplies work at the rate of 2 hp. The water passes through a heat exchanger, where it gives up heat at the rate of 42000 kJ/min and is delivered to a second storage tank at an elevation of 20 m above the first tank. What is the temperature of the water delivered to the second storage tank? Assume that the enthalpy of water is zero at 273 K and the specific heat of water is constant at 4.2 kJ / kg K. **06**

(c) Derive the following thermodynamic relationship: **03**

$$dH = C_P dT + \left[V - T\left(\frac{\partial V}{\partial T}\right)_P\right] dP$$

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