Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

B.E. Sem-IV Remedial Examination Nov/ Dec. 2010

Subject code: 140502

Subject Name: Chemical Engineering Thermodynamics-1

Date: 03 / 12 / 2010 **Time: 03.00 pm – 05.30 pm**

Total Marks: 70

Instructions:

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

Q.1 **(a)** Starting from fundamentals, Derive a mathematical expression of the first law of thermodynamics for a steady state flow process. **07**

(b) A particular quantity of an ideal gas $C_v = (5/2)$ R undergoes the following mechanically reversible steps that together form a cycle. The gas, initially at 1 bar and 300 K, is compressed isothermally to 3 bar. It is then heated at constant P to a temperature of 900 K. Finally; it is cooled at constant volume to its initial state with the extraction of 1,300 J as heat. Determine Q and W for each step of the cycle and for the complete cycle. **07**

Q.2 **(a)** Explain PVT behavior of pure substances with the help of PT and PV diagrams. **07**

(b) Differentiate between ….. **07**

(i) State function Vs Path function

(ii) Reversible process Vs Irreversible process

OR

(b) Nitrogen gas is confined in a cylinder and the pressure of the gas is maintained by a weight placed on the piston. The mass of the piston and the weight together is 100 kg. The acceleration due to gravity is 9.81 m/s^2 and the atmospheric pressure is 1.01325 bar. Assume frictionless piston. Determine: **07**

i) The force exerted by the atmosphere, the piston and the weight on the gas if the piston is 200 mm in diameter.

ii) The pressure on the gas.

iii) If the gas is allowed to expand pushing up the piston and the weight by 500 mm, what is the work done by the gas in kJ?

Q.3 **(a)** Define followings: **03**

(i) Standard heat of formation

(ii) Standard heat of reaction

(iii) Standard heat of combustion

(b) Explain the concept of entropy in brief. **05**

(c) Handbook values for the latent heat of vaporization in J/g are given in the table for the pure liquids at T_n, the normal boiling point. **06**

Component	$\Delta H^{\ell v}$ at T_n (J/g)	T_n (K)	P_c (bar)	T_c (K)
Benzene	393.9	353.2	48.98	562.2
Toluene	363.2	383.8	41.06	591.8

For these substances, calculate the value of the latent heat at T_n by Riedel equation and find out the percentage difference from those listed in the table.

OR

Q.3 **(a)** How much heat is required when 200 g of $CaCO_3$ is heated at atmospheric pressure from 30°C to 700°C? **04**

Data: Cp/R = 12.572 + 2.637 x 10^{-3} T - 3.12 x 10^{5} T^{-2}, T is in K

(b) State and explain various statements of the second law of thermodynamics. **04**

(c) 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? **06**

Q.4 **(a)** Derive the following Maxwell's equation from the first principle: **04**

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

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

(c) Write a short note on Residual properties and Departure functions. **06**

OR

Q.4 **(a)** Starting from energy balance equation and the continuity relation of flow process, show that the maximum velocity attained by a gas in steady state adiabatic flow in a horizontal pipe of a constant cross-sectional area is: - **06**

$$u_{\max}^2 = -V^2\left(\frac{\partial P}{\partial V}\right)_S$$

(b) Explain various types of thermodynamic diagrams in brief. **04**

(c) Derive the following thermodynamic relationship: **04**

$$C_P - C_V = -T\left[\left(\frac{\partial V}{\partial T}\right)_P\right]^2\left(\frac{\partial P}{\partial V}\right)_T$$

Q.5 **(a)** Derive an equation for the COP (coefficient of performance) of Carnot refrigeration cycle. **04**

(b) A Carnot engine is coupled to a Carnot refrigerator so that all of the work produced by the engine is used by the refrigerator in extraction of heat from a heat reservoir at270 K at the rate of 4 kJ/s. The source of energy for the Carnot engine is a heat reservoir at 500 K. if both devices discard heat to the surroundings at 300 K, how much heat does the engine absorb from the 500 K reservoir? **06**

If the actual coefficient of performance of the refrigerator is $\omega = \omega_{carnot}/1.5$ and if the thermal efficiency of the engine is $\eta = \eta_{Carnot}/1.5$, how much heat does the engine absorb from the 500 K reservoir?

(c) Discuss briefly about single and multistage compressors. **04**

OR

Q.5 **(a)** Describe in detail both types of vapor compression refrigeration cycle with the help of neat diagrams. **07**

(b) Explain Cubic equations of state and derive expressions of constants a and b of Vanderwaal's EOS in terms of critical properties of a substance. **07**

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