Seat No.: _____ Enrolment No.______

GUJARAT TECHNOLOGICAL UNIVERSITY

B. E. Sem - IV Examination - June- 2011

Subject code: 140502

Subject Name: Chemical Engineering Thermodynamics - I

Date:08/06/2011 **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.**

Q.1 **(a)** State the various laws of thermodynamics and explain briefly the importance of each law. **07**

(b) i) Distinguish between intensive and extensive properties with suitable example. **04**

ii) Distinguish between state function and path function. **03**

Q.2 **(a)** i) Write a short note on internal energy. **03**

ii) What is heat engine and thermal efficiency of heat engine? **02**

iii) What is heat pump and COP of pump? **02**

(b) Obtain expression to relate Vanderwaal's constant 'a' and 'b' in terms of critical properties. **07**

OR

(b) A reversible heat engine A absorbs energy from a reservoir at T_1 and rejects energy at reservoir T_2. A second reversible engine B absorbs the same amount of energy as rejected by engine A from the reservoir at T_2 and rejects the energy to reservoir at T_3. What is the relation between T_1, T_2 and T_3 if: **07**

i) the efficiency of engine A and B are same.

ii) the work delivered by engines are same.

Q.3 **(a)** What is law of corresponding states? Explain how this law is modified using Pitzer's modification. **06**

(b) One mole of an ideal gas with $C_P = (7/2)R$ and $C_V = (5/2)R$ expands from P_1 = 8 bar and T_1 = 600K to P_2 = 1 bar by each of following paths: **08**

i) constant volume

ii) constant temperature

iii) adiabatically

Assuming mechanical reversibility, calculate Q, W, ΔH and ΔU for each process where R = 8.314 kJ/kmol.K.

OR

Q.3 **(a)** Derive the expression for change in entropy when an ideal gas changes its state from (P_1, V_1, T_1) to (P_2, V_2, T_2). **07**

(b) Hydrocarbon oil is to be cooled from 425 K to 340 K at a rate of 5000 kg/h in a parallel flow heat exchanger. Cooling water at a rate of 10000 kg/h at 295 K is available. The mean specific heats of the oil and water are 2.5 kJ/kg.K and 4.2 kJ/kg.K respectively. **07**

i) Determine the total change in entropy. Is the process reversible.

ii) If a reversible Carnot engine is to be operated receiving the heat from the oil and rejecting the heat to the surroundings at 295 K, how much work would be available?

Q.4 **(a)** The standard heat of reaction at 298K is -42.433 kJ for the reaction C_2H_4 (g) + H_2O (g) → C_2H_5OH (g). **08**

Calculate the heat of reaction at 400 K. The constants in the heat capacity equation $C_p = a + bT + cT^2$ are as given below:

	a	b	c
C_2H_4	11.85	119.75×10^{-3}	-36.53×10^{-6}
H_2O	30.38	9.62×10^{-3}	$+1.19 \times 10^{-6}$
C_2H_5OH	29.27	166.39×10^{-3}	-49.93×10^{-6}

(C_P is in J/mol.K and T in K)

(b) A refrigeration machine operating at a condenser temperature of 290 K needs 1 kW of power per ton of refrigeration. Determine: **06**

i) the coefficient of performance.

ii) the heat rejected to the condenser.

iii) the lowest temperature that can be maintained.

OR

Q.4 **(a)** Discuss about thermodynamic diagrams. **04**

(b) Derive from the first principle **10**

i) $dH = C_p dT + \{V - T(\partial V/\partial T)_P\} dP$

ii) $dS = C_p(dT/T) - (\partial V/\partial T)_P\, dP$

Q.5 **(a)** Explain vapor compression cycle in details with diagrams. **07**

(b) Discuss Joule-Thompson expansion of liquefaction process. **07**

OR

Q.5 **(a)** For flow of fluid through a nozzle, obtain an expression for critical pressure ratio (P_2/P_1) in terms of ratio of specific heats (γ). **07**

(b) Discuss about multistage compression. **07**

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