(v) The pressure of real gases is less than that of ideal gas because of
(a) increase in the number of collisions
(b) finite size of particles
(c) intermolecular attraction
(d) increase in kinetic energy of the molecules.

(vi) The number of degree of freedom for an azeotropic mixture of ethanol and water in vapor-liquid equilibrium is
(a) 3 (b) 2 (c) 1 (d) zero.

(vii) The excess volume of liquid benzene at 35^0C and 1 atm is
(a) 0 (b) 1
(c) always positive (d) always negative.

(viii) For a real solution comprising of two components A and B, the activity coefficient of A (γ_A)
(a) is zero (b) may be positive or negative
(c) is always positive (d) is always negative

(ix) The K factor of a species in ideal solution is the ratio of
(a) partial pressure of the component to its vapour pressure
(b) partial pressure of the component to the total pressure of the solution
(c) vapour pressure of the component to the total pressure of the solution
(d) none of the above

(x) Solution in which intermolecular forces between like molecules are greater than those between unlike molecules
(a) is an ideal solution
(b) shows negative deviation from ideality
(c) shows positive deviation from ideality
(d) none of the above

Group - B

2. (a) Show that for a steady flow process, $\Delta h = Q - W_s$ where, $\Delta h =$ difference between outlet and inlet enthalpy of the fluid, $Q =$ heat transfer per unit mass of the flowing fluid and $W_s =$ mechanical work transfer per unit mass of the flowing fluid.

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7. (a) For a binary liquid mixture at constant temperature and pressure excess Gibbs energy is given by
$G^E/ RT = - (0.4 x_1 + 0.5 x_2) 3x_1x_2$
Does it follow Gibbs-Duhem equation?

(b) At 300 K and 1 bar, the volumetric data for a liquid mixture of benzene and cyclohexane are represented by $V = 109.4 \times 10^{-6} - 16.8 \times 10^{-6} x - 2.64 \times 10^{-6} x^2$, where x is the mole fraction of benzene and V has the units of m^3 / mole. Find the partial molar volume of benzene for its 30 mole% solution in cyclohexane. Find also the partial molar volume of benzene at infinite dilution.

5 + 7= 12

Group - E

8. (a) Deduce the criteria of chemical equilibrium.

(b) Ethanol can be manufactured by hydration of ethylene according to the reaction
$C_2H_4 (g) + H_2O(g) = C_2H_5OH (g)$
The feed to the reactor in which the above reaction takes place is a gas mixture containing 25 mol% ethylene and 75 mol% of steam. Estimate the product composition if the reaction occurs at 393 K and 101.3 kPa. The value of ΔG^0 at 393 K is given to be 4530 J/mol.

5 + 7 = 12

9. (a) Prove that $\Delta G^0 = - RTlnK_a$

(b) What is Joule-Thomson coefficient? Prove that, Joule-Thomson coefficient is given by $\mu = \frac{v}{C_P}(\beta T - 1)$ (Symbols bear usual significance)

6 + 6 = 12

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2016

CHEMICAL ENGINEERING THERMODYNAMICS
(CHEN 2203)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternatives for the following: **10 x 1=10**

(i) The cause of the irreversibility is
(a) mechanical and fluid friction
(b) unrestricted expansion
(c) heat transfer with a finite temperature difference
(d) all of the above.

(ii) A balloon is filled with cold air and placed in a warm room. The balloon is not in thermal equilibrium with the air in the room until
(a) it sinks to the floor (b) it stops expanding
(c) it starts to contract (d) it rises to the ceiling.

(iii) In the polytropic process equation Pv^n = constant, if n is infinitely large, the process is termed as
(a) isochoric (b) isobaric
(c) isothermal (d) adiabatic.

(iv) All spontaneous processes are
(a) reversible (b) irreversible
(c) irreversible and adiabatic (d) adiabatic or isothermal.

(b) A rigid and insulated tank of volume 1 m^3 contains an ideal gas (γ = 1.4) at 1 bar and 298K. The tank is connected to a line carrying the same gas at 10 bar and 298 K. The valve in between the tank and the line is opened allowing the gas to enter into the tank till the gas pressure rises to the line pressure. Determine the final temperature of the gas in the tank and the amount of gas entered into the tank during the filling operation.

6+6= 12

3. (a) Discuss with a schematic diagram the working principle of absorption refrigeration cycle. Determine the efficiency of an ideal absorption refrigeration cycle.

(b) A vapor compression cycle using ammonia as refrigerant is employed in an industry. Cooling water at 288 K enters the condenser at a rate of 0.25 kg/s and leaves at 300 K. Ammonia at 294 K condenses at a rate of 0.5 kg/min. Enthalpy of liquid ammonia at 294K is 281.5 kJ/kg. The compressor efficiency is 90%. Saturated ammonia vapour at 258 K and enthalpy of 1426 kJ/kg enters the compressor. Find out the power required by the compressor and also the refrigeration capacity in tons.

6 + 6 = 12

Group - C

4. (a) What is the physical significance of compressibility factor (z)? Van der waals equation of state is given by $\left(P+\frac{a}{v^2}\right)(v-b)=RT$ where, a and b are the constants related to critical temperature and pressure of real gas. Show that, the Van der waal equation can be represented in dimensionless form as $z=\left(\frac{1}{1-h}\right)-\frac{27}{8}\left(\frac{h}{T_r}\right)$ where, $h=\frac{P_r}{8zT_r}$.(Symbols bear usual significance)

(b) Draw the P-T diagram and P-v diagram of single component system and discuss the significance of critical point and triple point.

8 + 4 = 12

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8 + 4 = 12

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5. In a 1-MW steam power plant, superheated steam at 2800 kPa and 598 K enters the turbine and it is expanded to the condenser pressure of 5 kPa. Assuming an isentropic turbine efficiency of 85% and an isentropic pump efficiency of 80 % determine the following
   i) The ideal Rankine cycle efficiency for the stated conditions
   ii) The thermal efficiency of the plant
   iii) The rate of steam consumption

   The following data are given from steam table :
   Specific volume of saturated liquid at 5 kPa is 1.005×10^{-3} m^3/kg.
   Saturated liquid at 5 kPa has enthalpy and entropy of 138 kJ/kg and 0.4764 kJ/kg K respectively.
   Saturated vapour at 5 kPa has enthalpy and entropy of 2562 kJ/kg and 8.3951kJ/kgK respectively.
   Superheated steam at 2800 kPa and 598 K has enthalpy and entropy of 3063 kJ/kg and 6.6875 kJ/kg K respectively.

4 + 5 + 3 = 12

Group - D

6. (a) Under atmospheric condition the acetone-chloroform azeotope boils at 64.5^0C and contains 33.5 mole% acetone. The vapour pressures of acetone and chloroform at this temperature are 995 mm Hg and 855 mm Hg respectively. Calculate the composition of the vapour at this temperature in equilibrium with a liquid analyzing 11.1 mole% acetone.

   From the following compressibility data for hydrogen at 0^0C determine the fugacity of hydrogen at 1000 atm.

P (atm)	Z	P (atm)	Z
100	1.069	600	1.431
200	1.138	700	1.504
300	1.209	800	1.577
400	1.283	900	1.649
500	1.356	1000	1.720

6 + 6 = 12

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