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(Following Paper ID and Roll No. to be filled in your Answer Book)

PAPER ID : 9043 Roll No.

B. Tech.

(SEM. VII) EXAMINATION, 2007-08

CHEMICAL ENGINEERING THERMODYNAMICS

Time : 3 Hours] *[Total Marks : 100*

Note : *(1) Attempt all questions.*

(2) Steam table and other thermodynamic charts are permitted.

(3) Any missing data may be suitably assumed.

1 Attempt any **four** parts of the following : **5×4=20**

(a) Heat in the amount of 7.5 kJ is added to a closed system while its internal energy decreases by 12 kJ. How much energy is transferred as work ? For a process causing the same change of state but for which the work is zero, how much heat is transferred ?

(b) A system comprised of chloroform 1,4-dioxane and ethanol exists as a two-phase vapour/liquid system at 50°C and 55 kPa. It is found, after the addition of some pure ethanol, that the system can be returned to two-phase equilibrium at the initial T and P. In what respect has the system not changed ? How many phase rule variables must be chosen so as to fix the composition of both phases ?

(c) If 15 kg of H_2O in a 0.4-m^3 container is heated to 400°C, what pressure is developed ?

(d) State and prove the mathematical statement of the second law.

(e) Explain the term "IDEAL WORK".

(f) For an ideal gas, prove that

$$\frac{\Delta S}{R} = \int_{T_0}^{T} \frac{C_v^{ig}}{R} \frac{dT}{T} + \ln \frac{V}{V_0}$$

2 Attempt any **two** parts of the following : **10×2=20**

(a) Calculate the fugacity of ammonia at $t = 200^\circ C$ and $P = 100$ atm if we have

$P(atm)$	20	60	100
$V\ (cm^3)$	1866	570.8	176.7

(b) Reported values of the Virial coefficients for methyl chloride at 100°C are :

$$B = -242.5\ cm^3\ mol^{-1}$$

$$C = 25{,}200\ cm^6\ mol^{-2}$$

Calculate V and Z for methyl chloride vapour at 100°C and 1 bar by

(i) Ideal-gas equation

(ii) By using virial equation truncated to three terms.

(c) Define the following :
Critical temperature of a pure substance, tripple point, law of corresponding states, acentric factor and volume expansivity.

3 Attempt any **four** parts of the following : **5×4=20**

(a) Derive fundamental property relation.

(b) Derive Gibbs / Duhem equation.

(c) Show that $\bar{M}_1 = M + x_2 \frac{dM}{dx_1}$.

(d) Show that $\mu_i^{ig} = G_i^{ig} + RT \ln y_i$.

(e) What is the change in entropy when 0.8 m^3 of N_2 and 0.6 m^3 of CO_2 each at 1 bar and 25°C blend to form a gas mixture at the same conditions ? Assume ideal gases.

(f) Show that $Y_i = \hat{\phi}_i / \phi_i$.

4 Attempt any **two** parts of the following : **10×2=20**

(a) the volume change of mixing (cm^3 mol^{-1}) for the system ethanol (1) / methyl butyl ether (2) at 25°C is given by the equation :

$$\Delta V = x_1 x_2 \left[-1.026 + 0.220 (x_1 - x_2)\right]$$

Given that $V_1 = 58.63$ and $V_2 = 118.46$ cm^3 mol^{-1}, what volume of mixture is formed when 750 cm^3 of pure species I is mixed with 1500 cm^3 of species 2 at 25° C ? What would be the volume if an ideal solution were formed ?

(b) The following is a set of VLE data for the system methanol (1) / water (2) at 333.15 K :

P/kPa	x_1	y_1
19.953	0.0000	0.0000
39.223	0.1686	0.5714
48.852	0.3039	0.6943
56.652	0.4461	0.7742
63.998	0.6044	0.8383
70.229	0.7255	0.8922
84.562	1.0000	1.0000

Basing calculations on modified Raoult's law, find parameter values for the Margules equation that provide the best fit of GE/RT to the data.

(c) Draw and explain any **two** of the following diagram :

(1) Txy diagram for three pressures for two partially miscible liquids.

(2) Pxy diagram for two partially miscible liquids.

(3) Txy diagram for binary system of immiscible liquids.

5 Attempt any **two** of the following questions : **10×2=20**

(a) Derive the following :

(1) $\ln K = \frac{-\Delta G^{\circ}}{RT}$.

(2) $F = 2 - \pi + N - r - s$.

(b) Write notes on any **two** of the fallowing :

(1) Effect of temperature on the equilibrium constant.

(2) Equilibrium conversions for single reactions.

(3) Liquid-phase reactions.

(c) For the ammonia synthesis reaction written :

$$\frac{1}{2}N_2(g) + \frac{3}{2}H_2(g) \rightarrow NH_3(g)$$

with 0.5 mol N_2 and $1.5\ mol$ H_2 as the initial amount of reactants and with the assumption that the equilibrium mixture is an ideal gas, show that

$$\in_e = 1 - \left(1 + 1.299\ K \frac{P}{P^{\circ}}\right)^{-y_2}.$$