25/11/2024 CHEMICAL SEM-III C SCHEME PC QP CODE: 10066625

3 Hours **Total Marks : 80**

N.B. : 1) Question No.1 is compulsory
2) Answer any three questions from remaining questions
3) Each Question carries equal marks.
4) Assume data if necessary and specify assumptions clearly

Q.1 (a) The available nitrogen (N) in the urea (NH_2CONH_2) sample is found to be 45% by weight. Calculate the actual urea content in the sample. [5 marks]

(b) Describe (i) Dalton's law, (ii) Amagat's law, (iii) Raoult's law, (iv) Average molecular weight of gas mixture, and (v) Density of gas mixture. [5 marks]

(c) Define and write the equation of (i) Purge ratio, (ii) Recycle ratio, (iii) Combined feed ratio and (iv) Per pass fractional conversion. [5 marks]

(d) Discuss the extraction unit operation based on material balance without chemical reactions. [5 marks]

Q.2 (a) A chemist is interested in preparing 500 ml of 1 normal, 1molar and 1 molal solution of H_2SO_4. Assuming the density of H_2SO_4 solution to be 1.075 g/cm^3, calculate the quantities of H_2SO_4 to be taken to prepare these solutions. [10marks]

(b) The spent acid from a nitrating process contains 21 % HNO_3, 55 % H_2SO_4 and 24 % H_2O by weight. This acid is to be concentrated to contain 28 % HNO_3 and 62 % H_2SO_4 by addition of concentrated sulphuric acid containing 93 % H_2SO_4 and concentrated nitric acid containing 90 % HNO_3. Calculate the weights of spent acid, concentrated suphuric acid and concentrated nitric acid that must be combine to obtain 1000 kg of the desired mixture. [10marks]

Q.3 (a) 10000 kg/h of solution containing 20 % methanol is continuously fed to a distillation column. Distillate (product) is found to contain 98 % methanol and waste solution from the column carries 1 % methanol. All percentages are by weight. Calculate (i) the mass flow rates of distillate and bottom product and (ii) the percent loss of methyl alcohol. [10marks]

(b) Gaseous benzene (C_6H_6) reacts with hydrogen in presence of Ni catalyst as per the reaction: [10marks]

C_6H_6 (g) + 3 H_2 (g) → C_6H_{12} (g)

30 % excess hydrogen is used above that required by the above reaction. Conversion is 50 % and yield is 90 %. Calculate the requirement of benzene and hydrogen gas for 100 moles of cyclohexane.

Q.4 Obtain an empirical equation for calculating the heat of reaction at any temperature T (in K) for the following reaction: [20marks]

$CO\ (g) + 2\ H_2\ (g) \rightarrow CH_3OH\ (g)$

Using the same expression, calculate the heat of reaction at 773 K.

Data: ΔH^o_R at 298 K = -90.41 kJ/mol

$C_p^o = a + bT + cT^2 + dT^3$, kJ/(kmol.K) or J/(mol.K)

Component	a	b × 10^3	c × 10^6	d × 10^9
CO (g)	29.0277	-2.8165	11.6437	-4.7063
H_2 (g)	28.6105	1.0194	-0.1476	0.769
CH_3OH (g)	21.137	70.843	25.86	-28.497

Q.5 (a) Calculate the standard heat of formation of chloroform gas from its elements using Hess's law. [7 marks]

Data:

$C(s) + O_2(g) \rightarrow CO_2(g)$ ΔH_1 = - 393.51 kJ/mol

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ ΔH_2 = - 285.83 kJ/mol

$\frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g) \rightarrow HCl(aq)$ ΔH_3 = - 167.57 kJ/mol

$CHCl_3(g) + \frac{1}{2}O_2(g) + H_2O(l) \rightarrow CO_2(g) + 3HCl(aq)$ ΔH^o_C = - 509.95 kJ/mol

(b) In production of sulphur trioxide, 100 kmol of SO_2 and 100 kmol of O_2 are fed to a reactor. If the percent conversion of SO_2 is 80, calculate the composition of the product stream on mole basis. [7 marks]

(c) Pure ethylene is heated from 303 K to 523 K at atmospheric pressure. Calculate the heat added per kmol ethylene using the heat capacity data given below: [6 marks]

$C_p^o = 4.1261 + 155.0213 * 10^{-3}\ T - 81.5455 * 10^{-6}\ T^2 + 16.9755 * 10^{-9}\ T^3$, (kJ/kmol.K)

Q.6 (a) Formaldehyde is Produced by dehydrogenation of methanol. [12marks]

$$CH_3OH \rightarrow HCHO + H_2$$

The per pass conversion is 67 %. The product leaving the reactor is fed to a separation unit battery where formaldehyde is separated from methanol and hydrogen. The separated methanol is recycled to the reactor. If the production rate of formaldehyde is 1000 kg/h. Calculate: The combined feed ratio, Recycle ratio and The flow rate of methanol required to the process as fresh feed.

(b) Give the step wise procedure to calculate the reboiler load in a distillation unit. List the parameters required for the computation of the above. [8 marks]
