

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

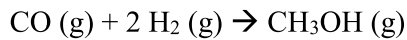
2) Answer any three questions from remaining questions

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, 1 molar 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 sulphuric 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]
- $$\text{C}_6\text{H}_6 (\text{g}) + 3 \text{H}_2 (\text{g}) \rightarrow \text{C}_6\text{H}_{12} (\text{g})$$
- 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 [20marks]
(in K) for the following reaction:



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

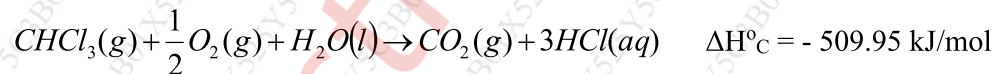
Data: $\Delta H^\circ_{\text{R}}$ at 298 K = -90.41 kJ/mol

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

Component	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
CO (g)	29.0277	-2.8165	11.6437	-4.7063
H ₂ (g)	28.6105	1.0194	-0.1476	0.769
CH ₃ OH (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 [7 marks]
Hess's law.

Data:



- (b) In production of sulphur trioxide, 100 kmol of SO₂ and 100 kmol of O₂ are fed to a [7 marks]
reactor. If the percent conversion of SO₂ is 80, calculate the composition of the product
stream on mole basis.

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

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

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



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 [8 marks] parameters required for the computation of the above.