2019

Major

2nd Semester Examination

INDUSTRIAL CHEMISTRY

Paper—C3T

Material and Energy Balance

Full Marks : 60 Time : 3 Hours

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

Group–A

1. Answer any *ten* questions from the following : 10×2

   (a) Define the terms limiting reactant and excess reactant.

   (b) Define purge ratio and combined feed stream.

   (c) Explain Henry's law.

   (d) Define molarity and molality.

   (e) Distinguish between dry bulb temperature and wet bulb temperature.

(f) Explain the terms in Antoine's equation.

(g) Distinguish between vapor pressure and partial pressure

(h) Define standard heat of formation.

(i) Discuss the utility of by pass operation.

(j) Write down the material balance equation for a distillation process.

(k) What is an ideal gas ?

(l) An aqueous solution of NaCl is prepared by dissolving 30 g of NaCl in 100 g of water at 25°C. Find the molality of solution.

(m) Write down the general material balance equation for any unit operation or any unit process. Simplify it for steady state operation.

(n) Convert $R = 0.082 \frac{\text{lit atm}}{\text{gmole.K}}$ to $\frac{\text{Cal}}{\text{gmole.K}}$.

(o) Define heat capacity of a liquid.

Group–B

Answer any *four* questions : 4×5

2. Define the terms : percent saturation and relative saturation. Find out the relationship between these two. 5

3. (a) Write down clapeyron equation and explain each terms. 2

   (b) Calculate the weight of $1m^3$ of chlorine gas at a temperature of 25°C and a pressure of 745 mm Hg. 3

4. Calculate the total pressure and composition of the vapors in contact with a solution at 100°C containing 35% benzene, 40% toluene and 25% orthoxylene by weight

   Data : Vapor pressure at 100°C

   Benzene : 1340 mm Hg

   Toluene : 560 mm Hg

   O-xylene : 210 mm Hg 5

5. A natural gas has the following composition by volume :

   CH_4 : 82%, C_2H_6 : 12%, N_2 : 6%

   Calculate the density of the gas at 15°C and 760 mm Hg 5

6. At what rate in kCal/hr must heat be removed from a saturated methanol vapor to generate 100 kg/hr of methanol liquid at 30°C ? Given : Latent heat of condensation of methanol

$$= 263.4 \text{ kCal/kg}$$

specific heat of methanol = $0.6505 \frac{\text{kCal}}{\text{kg°C}}$

Boiling point of methanol = 64.7°C. 5

7. State and explain Hess's law. 5

Group–C

8. Answer any *two* from the following : 2×10=20

(a) Nitrogen is to be marketed in cylinder having volume of 80 litres each containing 3.5 kg of nitrogen. Calculate the pressure for which cylinders must be designed if they are subjected to a maximum temperature of 50°C. Assume that ideal gas law holds good. 5

(b) The gas acetylene is produced according to the following reactions :

$$CaC_2 + 2H_2O = C_2H_2 + Ca(OH)_2$$

Calculate the number of hours of service that can be derived from 1 kg of Calcium Carbide

in an acetylene lamp burning 100 litres of gas per hour at temperature of 25°C and pressure of 743 mm Hg. (atomic weight of Ca = 40)

9. (a) The waste acid from a nitrating process contains 30% H_2SO_4, 35% HNO_3 and 35% H_2O by weight. The acid is to be concentrated to contain 39% H_2SO_4 and 42% HNO_3 by addition of concentrated sulphuric acid containing 98% H_2SO_4 and concentrated nitric acid containing 72% HNO_3 (by weight). Calculate the quantities of three acids to be mixed to get 1000 kg of desired mixed acid. 6

(b) A ground nut seeds containing 45% oil and 45% solids are fed to expeller. The cake coming out of the expeller is found to contain 80% solids and 5% oil. Find the percentage recovery of oil. 4

10. (a) Calculate the standard heat of reaction of the following reaction :

$$2FeS_2(s) + \frac{11}{2} O_2(g) \rightarrow Fe_2O_3(s) + 4SO_2(g)$$

Data : Standard heat of formation :

ΔH°_f, $FeS_2(s) = -42520$ Cal

ΔH°_f, $Fe_2O_3(s) = -196500$ Cal

ΔH°_f, $SO_2(g) = -70960$ Cal 5

[Turn Over]

(b) Calculate the heat that must be removed in cooling 32 kg of oxygen from 215°C to 40°C. Using the following data :

C_p^0 in (kcal/Kmol.K) = a + bT + CT^2

a = 6.117, b × 10^3 = 3.167, C × 10^9 = – 1.005

5

11. The producer gas made from the coke has the following composition by volume :

CO = 28%, CO_2 = 3.5%, O_2 = 0.5%, N_2 = 68%

The gas is burned with such a quantity of air that oxygen from air is 20% in excess of the net oxygen required for complete combustion. If the combustion is 98% complete, calculate the weight of the gaseous product formed per 100 kg of gas burned. 10