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18BT41

Fourth Semester B.E. Degree Examination, Feb./Mar. 2022
Stoichiometry

Time: 3 hrs.

Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

- 1 a. How many moles of H_2SO_4 will contain 64kg of sulphur? (04 Marks)
b. 10g of caustic soda are dissolved in water to prepare 500ml of solution. Calculate the normality. (06 Marks)
c. A gas mixture is found to contain the following composition by volume. Ethylene 30.6%, benzene 24.5%, oxygen 1.3%, ethane 25%, nitrogen 3.1%, methane 15.5%. Calculate the
i) Composition in mole%
ii) Weight %
iii) Average molecular weight of gas sample
iv) Density of gas at NTP. (10 Marks)

OR

- 2 a. Calculate the equivalent moles of Na_2SO_4 in 1288g of $Na_2SO_4 \cdot 10H_2O$ crystals. (06 Marks)
b. Find the nitrogen content of 100kg urea sample containing 96.43% urea. (04 Marks)
c. Explain the generalized material balance equations for extraction and crystallization with diagram. (10 Marks)

Module-2

- 3 a. A gas mixture containing 15 mole % A and 85 mole % inerts is fed to one absorption tower where it is contacted with liquid solvent B which absorbs A. The mole ratio of solvent to gas entering tower is 2:1. The gas leaving the absorber contains 2.5% A, 1.5% B and rest inerts on mole basis. Calculate:
i) The percentage recovery of solute 'A'
ii) The fraction of solvent 'B' fed to column lost in gas leaving the tower
During the process, some solvent evaporates and gets added in gas leaving the tower. (10 Marks)
b. 2500kg of wet solids containing 70% solids by weight are fed to tray dryer where it is dried by hot air. The product finally obtained is found to contain 1% moisture by weight. Calculate:
i) Amount (in kg) of water removed from wet solids.
ii) Amount (in kg) of product obtained. (06 Marks)
c. It is required to make 100kg of 30% NaOH solution by mixing the following liquids: 20% NaOH solutions and 36% NaOH solution. Calculate the quantities of the two solutions to be mixed. (04 Marks)

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

OR

- 4 a. Calculate the Gross and Net calorific value of the natural gas at 298K considering the data given:

Component	Molar compositions %	GCV (kJ/mol)	NCV (kJ/mol)
CH ₄	89.4	890.65	802.62
C ₂ H ₆	5	1560.69	1428.62
C ₃ H ₈	1.9	2219.17	2043.11
C ₄ H ₁₀	1	2877.40	2657.32
CO ₂	0.7	-	
N ₂	2	-	

- Specific volume at 298K and 101.3kPa in 24.465m³/kmol. (10 Marks)
- b. The GCV of gaseous n-Butane is 2877.4kJ/mol at 298K. Calculate its NCV value (Net calorific value). (05 Marks)
- c. Crude oil is found to contain 87.1% carbon, 12.5% hydrogen and 0.4% sulphur by mass. Its GCV at 298.15K is 45071 kJ/kg oil. Calculate its NCV at 298.15K. (05 Marks)

Module-3

- 5 a. Ammonia is produced by the following reaction:
 $N_2 + 3H_2 \rightarrow 2NH_3$ calculate:
 i) The molal flow rate of hydrogen corresponding to nitrogen feed rate of 50kg mol/hr if they are fed in stoichiometric proportion.
 ii) The amount of ammonia produced per hour if percentage conversion is 30 and nitrogen feed rate is 50kg mol/hr. (10 Marks)
- b. Calcium oxide is formed by decomposing limestone pure CaCO₃. In kiln, the reaction goes to 70% completion.
 i) What is the composition of the solid product withdrawn from the Kiln?
 ii) What is the yield in kg of CO₂ produced per kg of limestone charged? (10 Marks)

OR

- 6 a. Fresh juice contains 14% solids and 86% water by weight and it is to be concentrated to contain 42% solids by weight. In a single evaporator system, it is found that the volatile constituents of juice escape with water leaving the concentrated juice 56%, with flat taste to overcome this problem part of the fresh juice bypass the evaporator. Calculate:
 i) The fraction of juice that bypass the evaporator.
 ii) The concentrated juice produced containing 42% solids by weight. (12 Marks)
- b. Metal phosphoric acid is obtained by dissolving phosphorous pentoxide in cold water. What is yield in kg of metal phosphoric acid produced from 50kg of P₂O₅ charged in reactor? (08 Marks)

Module-4

- 7 a. Calculate the heat of formation of benzoic acid crystals at 298.15K using following data:
 Standard heat of formation of CO₂ = -393.5kJ/mol
 Standard heat of formation of H₂O = -285.83kJ/mol
 Standard heat of formation of C₇H₆O₂ = -3226.95kJ/mol. (10 Marks)
- b. Calculate the enthalpy change between reactants and products is both are at 298.15K and the reactants of the process given below.
 $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$
- | Component | ΔH_f (kJ/mol) |
|--------------------------------|-----------------------|
| C ₄ H ₁₀ | -125.79 |
| CO ₂ | -393.51 |
| H ₂ O | -285.83 |

(04 Marks)

c. Define:

- i) Standard heat of reaction
- ii) Heat of formation
- iii) Standard heat of combustion.

(06 Marks)

OR

- 8 a. Methane gas is heated from 303K to 523K at atmospheric pressure. Calculate the heat added per mole methane using C_p data given

$$C_p^\circ = 19.2494 + 52.11 \times 10^{-3}T + 11.973 \times 10^{-6}T^2 - 11.3173 \times 10^{-9}T^3 \quad (08 \text{ Marks})$$

- b. Using the empirical expression relating the heat of reaction and the temperature of the reaction for the following reaction. Calculate the heat of reaction at 773K.



$$\Delta H_f^\circ \quad \text{kJ/mol}$$

$$\text{SO}_3 \quad -395720$$

$$\text{SO}_2 \quad -296810$$

$$C_p = a + bT + cT^2 + dT^3$$

Component	a	$b \times 10^{-3}$	$c \times 10^{-6}$	$d \times 10^{-9}$
SO ₃	22.036	121.624	-91.867	24.369
SO ₂	24.771	62.948	-44.258	11.122
O ₂	26.026	11.75	-2.343	-0.562

(12 Marks)

Module-5

- 9 a. Outline the Bioprocess engineering and history of development of bioprocess technology. (12 Marks)
- b. Explain the production of ethanol with a neat flow diagram. (08 Marks)

OR

- 10 a. Explain the production of Penicillin using flow diagram. (12 Marks)
- b. Explain the various unit operations involved in a bioprocess. (08 Marks)
