GUJARAT TECHNOLOGICAL UNIVERSITY
B. E. - SEMESTER – III • EXAMINATION – WINTER 2012

Subject code: 130504 **Date: 05-01-2013**
Subject Name: Process Calculation
Time: 10.30 am – 01.30 pm **Total Marks: 70**
Instructions:
1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1	**(a)**	Iron metal weighing 500 lb occupies a volume of 29.25L. Calculate the density of Fe in kg/dm^3.	**04**
	(b)	Two process feed streams are mixed to form a single stream. A soluble salt is added to one of the original stream at a steady rate. Samples taken of this stream show 4.76% salt by weight. Another feed stream does not contain any salt. Samples from the mixed stream show 0.62% salt by weight. What is the ratio of flows in the two feed streams?	**04**
	(c)	A solution of sodium chloride in water contains 30% NaCl (by mass) at 333K. The density of the solution is 1.2 kg/L. Find the molarity, normality and molality of the solution. Atomic mass: Na = 23, Cl = 35.5.	**06**

Q.2	**(a)**	(i) Explain recycle, bypass and purge streams with suitable diagram.	**05**
		(ii) Define: standard heat of reaction and standard heat of formation.	**02**
	(b)	Spent acid from fertilizer unit has the following composition by mass: H_2SO_4 = 20%, NH_4HSO_4 = 45%, H_2O = 30% and rest organic compound 5%. Calculate the total acid content of the spent acid in terms of H_2SO_4 after adding the acid content chemically bound in ammonium hydrogen sulfate. Atomic mass: H = 1, O = 16, S = 32, N = 14.	**07**

OR

	(b)	A gas mixture has the following composition by mole: CO = 22.8%, CO_2 = 15%, N_2 = 29.5%, O_2 = 4.5%, CH_4 = 28.2%. Calculate: i) Average molecular weight of the mixture. ii) Composition of gas on weight basis. iii) Density of mixture at STP conditions. Atomic mass: C = 12, H = 1, O = 16, N = 14	**07**

Q.3	**(a)**	Define: i) law of conservation of energy, ii) equivalent weight, iii) molality.	**03**
	(b)	Discuss the importance of flowsheet.	**04**
	(c)	In the Deacon process for manufacture of Chlorine, hydrochloric gas is oxidized with air. The reaction taking place is: 4 HCl + O_2 ➔ 2 Cl_2 + 2 H_2O. The air used is in excess of 30% of that theoretically required and the oxidation is 80% complete. Calculate the composition by volume of dry gases leaving the reaction chamber.	**07**

OR

Q.3	**(a)**	Explain: (i) Watson equation and (ii) Riedel equation.	**04**
	(b)	Slabs of building boards contain 16% moisture. They are dried to a water content of 0.5% by circulating hot air over them. The outgoing air contains 0.09 kg water vapor per kg dry air. Calculate the quantity of fresh air required per 1000 kg/h net dry board, if fresh air is supplied at 301K and 101.325 kPa	**10**

containing 0.2 kg/kg dry air humidity.

Q.4 **(a)** Pure FeS_2 is burnt with 60% excess air as per the following reaction: **07**
$$4\ FeS_2 + 11\ O_2 \rightarrow 2\ Fe_2O_3 + 8\ SO_2$$
Calculate the composition of exhaust gases in mole percent.

(b) (i) Define GCV and NCV. **03**
(ii) A heat exchanger for cooling a hot hydrocarbon liquid uses 10000 kg/h of **04**
cooling water, which enters the exchanger at 294K. The hot oil at the rate of
5000 kg/h enters at 423K and leaves at 338K and has an average heat capacity
of 2.51kJ/kgK. Calculate the outlet temperature of water.

OR

Q.4 **(a)** Discuss how stoichiometry is applied in various unit operations with suitable **07**
example and diagram.

(b) Pure methane is heated from 303K to 523K at atmospheric pressure. Calculate **07**
the heat added per kmole methane using C_p data.
$C_p = a + bT + cT^2 + dT^3$. Data for methane:
$a = 19.2494,\ b \times 10^3 = 52.1135,\ c \times 10^6 = 11.973,\ d \times 10^9 = -11.3173$.

Q.5 **(a)** Explain proximate and ultimate analysis of coal. **06**
(b) A sample of fuel has the following composition by mass: C = 84%, H_2 = **08**
15.2% and rest non-combustibles. The fuel was completely burnt with excess
air in an internal combustion engine. The dry exhaust gas has 8.6% CO_2 by
volume. Estimate:
    i)   exhaust gas composition
    ii) amount of excess air supplied.
    iii) percentage of excess air.

OR

Q.5 **(a)** (i) Define: (a) yield and (b) selectivity. **02**
(ii) 1000kg of sodium carbonate solution containing 25% Na_2CO_3 is subjected **05**
to evaporative cooling during which process 15% of water present in the
solution is evaporated. From the concentrated solution $Na_2CO_3.10H_2O$
crystallizes out. Calculate how much crystals will be produced if the solubility
of Na_2CO_3 is 21.5 gm per 100gm water.

(b) A multiple contact counter-current extractor is employed to extract oil from **07**
halibut livers with the help of ethyl ether. The fresh livers are charged to the
extractor at the rate of 1000 kg/h and contain 25.7% oil. Pure ether enters the
bottom of the extractor. The overflow from the extractor contains 70% oil.
The underflow rate is 0.23 kg solution/kg of oil-free solids and is known to
contain 12.8% oil. Based on these operating conditions, make the complete
material balance and find the flow rate of ether to the extractor. Also compute
the percentage recovery of oil. All percentage are by mass.

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