BENGAL ENGINEERING AND SCIENCE UNIVERSITY, SHIBPUR
M.E. (Civil) 1st SEMESTER EXAMINATIONS, 2012
Environmental Engineering Chemistry (CE 913)

Full Marks: 70 **Time: 3 hrs**

PART – I

Answer any 3 (THREE) questions.

1. Define the terms 'molecular weight', 'ionic bond' and 'valency'. Calculate the molarity of a 97% H_2SO_4 solution whose specific gravity is 1.86. Define 'half reaction' with a suitable example. Balance the chemical reaction when Oxalic Acid ($H_2C_2O_4$) gets oxidized by $KMnO_4$ under strong H_2SO_4 medium.

(3+3+3+5 = 14)

2. How does the 'ionic strength' influence on the activity of an ionic species in a solution. Calculate the activity co-efficients and activities of each ion in a solution containing 0.2 N Na_2CO_3, 0.08 M Na_2SO_4 and 0.8 N $FeSO_4$.
Illustrate the concept of 'chemical equilibria' for an electrolyte having atoms with multiple numbers. Write the considerations for solving an 'equilibrium problem' in finding out the species concentration.

(2+5+3+4=14)

3. If 0.6 gms of Benzoic acid (C_6H_5COOH) and 0.2 gms Formic acid (HCOOH) are added to enough distilled water to make 1 liter of solution, what will be the percent ionization of each species and pH of the solution?
K_a of Benzoic acid = 6.6×10^{-5} and K_a of Formic acid = 1.7×10^{-4}
Define a Tri-protic weak acid and briefly discuss the method to find out the percent ionization for each relevant species at a given pH.
Evaluate the percent ionization of the relevant species in a H_3PO_4 solution at the pH level 7. [Ionization constant for H_3PO_4, $H_2PO_4^{-1}$ and HPO_4^{-2} is 7.5×10^{-3}, 6.2×10^{-8} and 4.7×10^{-13} at 25°C respectively]

(5+5+4=14)

4. How many moles of KIO_3 requires to be added per litre of solution containing 0.15 M Ba^{+2} to bring about 99.8% precipitate as $Ba(IO_3)_2$? K_{sp} of $Ba(IO_3)_2$ may be taken as 1.5×10^{-9}.
Write the utility of 'Fractional precipitation' in reference to solubility of a metal. Why the solubility of a 'solute' is increased in presence of diverse ions?

(5+4+5=14)

5. How would you determine the 'saturation pH' of a water sample of given relevant characteristics. Define the term 'saturation index'. Determine the 'saturation index' of a water sample with following composition.

pH	7.90
Calcium Hardness	240
Total Hardness	370
Total Alkalinity	275

Note : All the parameters are expressed in mg/L as $CaCO_3$ except pH.
The pK_s and pk_2 values are 8.15 and 10.49 respectively at a temperature 10°.

(6+2+6=14)

P.T.O.

PART – II

Answer any 2 (TWO) questions

6. What is the significance of 'order' to describe a reaction? How would you determine 'kinetic constant' in case of a 'half order' reaction? Write the relevance of a 'Pseudo-first order reaction'.

NO_3^--N concentration of the effluent sample, collected from a biological reactor after 2 hrs from start-up is measured to be 15 mg/L as N. The NO_3^--N concentration of the influent wastewater is already estimated as 25 mg/L as N. Find out the rate of NO_3^--N conversion assuming Half-order kinetics. Also determine the total time required to lower the NO_3^--N concentration to 10 mg/L as N.

(2+3+3+6=14)

7. Write the kinetic relationships for a two-stage 'consecutive reaction'. Explain how the DO depletion on account of disposal of organic matter can be measured from the concept of consecutive reaction.

A wastewater sample containing NH_4^+-N, NO_2^--N and NO_3^--N concentration of 75 mg/L (as N), 14 mg/L (as N) and 6 mg/L (as N) respectively is subjected to nitrification. If the rate of NH_4^+-N conversion to NO_2^--N and NO_3^- production are 0.11/hr and 0.15/hr respectively, then determine the time required for 99% conversion of NH_4^+-N and the respective concentrations of nitrogenous species.

(3+6+5=14)

8. How does the 'Energy Substrate reaction' originate? Draw a typical profile of specific rate of such a reaction and comment on its different sections.

The rate of COD removal is observed as 0.12/day and 0.16/day at a temperature of 20°C and 24°C respectively. What would be the expected rate of COD removal at a temperature of 32°C?

Develop the kinetic expression to predict the effluent substrate concentration for a CFSTR of volume V and operating with a reaction period of T. The influent substrate concentration and the rate of reaction can be considered as C_o and k respectively.

(3+4+4+3=14)

9. Comment on the analogy between a 'plug-flow' and a 'completely mixed' reactor.

A Batch reactor for COD removal is operated with a wastewater flow rate of 1.5 m^3/hr and volume of 9 m^3. The removal rate constant is estimated to be 0.11 hr^{-1}. Find out the COD removal efficiency of this reactor. What will be the change in the COD removal efficiency if the flow rate is adjusted to 2.0 m^3/hr?

Establish that the efficiency of a completely mixed reactor would be enhanced, if it is divided into two compartments.

A completely mixed reactor of volume 12 m^3 is operated with a hydraulic retention period of 8 hrs and is fed with influent BOD concentration of 300 mg/L. The removal rate constant is already measured as 0.12 /day at steady state condition. If the reactor were divided into 3 numbers of cell of volume fraction 0.3, 0.35 and 0.35 then what would be the improvement in the overall efficiency?

(3+5+3+3=14)