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CEEGR 342 – Midterm 2 (100 points)

Multiple Choice (2 points each)

1. A batch reactor is used to determine reaction order. If a plot of LN(C/C0) vs. t is the most linear, what order is this?

a) 0^{th} b) 1^{st}

c) 2^{nd} d) 3^{rd}

2. What does CSTR stand for?

a) Continuously Stirred Tank Reactor b) Continuous Species Treatment Reactor

c) Continuously Stable Tank Reactor d) Continuously Steady Tracer Reaction

3. A batch reactor by definition _____.

a) Is at steady-state b) Has a first order reaction

c) Has no inflow or outflow d) Operates faster than a PFR

4. Given a maximum specific growth rate = 5/d and saturation coefficient (concentration at half-maximum growth rate) = 60 mg substrate/L, estimate the observed growth rate at a concentration of 20 mg substrate/L.

a) 1.3/d b) 1.5/d

c) 3.8/d d) 4/d

Short Answer

5. For a positive order reaction (non-zero), the volume requirement of a PFR is (less than/greater than) the volume requirement of a CSTR to achieve the same extent of reaction? (1 point)

6. Photosynthesis raises pH in aquatic systems because the organisms use dissolved CO_2 (or H_2CO_3) as their carbon source. Why does this raise the pH? In other words, what happens to the aqueous H^+ and why? (2 points)

7. Write the correct solubility product equilibrium expression (K_{sp} = …) for Hg_2Br_2 (s). The $K_{sp} = 6.4x10^{-23}$, you should include the magnitude of this constant in your answer. (3 points)

8. Identify <u>two</u> 'natural sources' of carbonates in water. (2 points)

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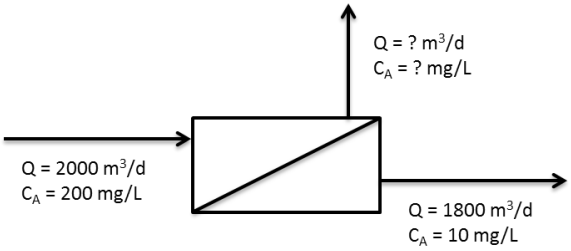
9. Biodegradation of PAH in a catch basin is observed to follow 0^{th} order kinetics. The catch basin operates as a 'batch reactor' in-between clean-outs. During one analysis, the PAH's were initially at 15 mg PAH/kg solids but were reduced to 8 mg/kg after 1.5 months. During a second analysis they were reduced from 9 mg/kg to 1 mg/kg after 2 months. Estimate how long it would take to reduce PAHs from 20 mg/kg to 5 mg/kg. (6 points)

10. The following diagram describes a membrane system. There is no reaction. Calculate the unknown quantities. (4 points)



11. The equilibrium constant for dissociation of hypochlorous acid at 25°C = $3.2x10^{-8}$. Its enthalpy change due to reaction = -89 kJ/mol rxn, its Gibbs free energy change due to reaction = +43 kJ/mol rxn. The reaction is shown below. Estimate the equilibrium constant at 10°C. (6 points)

$$HOCl = OCl^- + H^+$$

12. Calculate the mass of FeF_2 (93.8 g/mol) that can be added to 10-L of water before it begins to precipitate. (7)

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Long Answer

13. A 20-L carboy of lake water is initially at pH = 6.4, and has HCO_3^- concentration = 15 mM. Strong base (NaOH) is added to raise the pH to 11. What is the alkalinity <u>after</u> the pH is raised (i.e. at pH =11)? Show all steps and units. (12 points)

14. An aqueous system is at pH=5.5, with HCO_3^- = 1.3 mM, H_2CO_3 = 2.7 mM, and CO_3^{2-} = 0 mM. Determine if the system is at equilibrium using Gibbs free energy, not by comparing Q/K. If it is out of equilibrium, determine if the reaction will move in the direction written (L→R), or opposite to the direction written. <u>Show all steps and units</u>. (10 points)

$$H_2CO_3\ (aq) = HCO_3^-\ (aq) + H^+\ (aq)$$

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15. A tank holds 250 m^3 of wastewater contaminated with 100 mmol/L Ag^+. The wastewater also has 10 mmol/L SO_4^{2-}. We will precipitate the silver (Ag^+) down to 25 mmol/L by adding additional sulfate (SO_4^{2-}). Calculate the <u>total</u> mass of iron sulfate ($Fe_2(SO_4)_3$; 400 g/mol) required. (15 points)

16. Natural gas is primarily methane (CH_4). Calculate the mass of natural gas required to raise the temperature of a 1-kg iron griddle to 300°C assuming no heat is lost to the surroundings. The initial temperature of the griddle is 20°C. (12 points)

$$CH_4(g) + O_2(g) = CO_2(g) + H_2O(g)$$

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17. A PFR and CSTR are used in series as shown below. The same 1st order reaction occurs in each reactor, with k = 0.4/hr. Calculate the concentration of reactant 'A' out of the CSTR. Show all work and steps. (12 points)