THE OPEN UNIVERSITY OF SRI LANKA

B.Sc. DEGREE PROGRAMME 2012/13

ENVIRONMENTAL CHEMISTRY – CMU 3129

CONTINUOUS ASSESSMENT TEST II (No Book Test)

Date: 27th August 2013   Time: 4.00 pm – 5.30 pm

Registration No: ....   Invigilator's signature: ....

Question Number	Marks
1	
2	
3	
Total	
%	

Answer all the questions.

1.a.   (i) What is meant by the term productivity of a water body? How it is related to water quality?

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(ii) Explain briefly the phenomenon' thermal stratification.

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b.   Lakes are generally classified into three types. They are oligotrophic, eutrophic and dystrophic lakes. In thermally stratified lakes dissolved oxygen (DO) exhibiting characteristic vertical profiles which can vary with the season.

   (i) Draw a clearly labeled diagram to show dissolved oxygen profile in an oligotrophic lake.

   (ii)   Explain briefly the reasons for the change of DO concentration in oligotrophic lakes from top to bottom.

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(25 marks)

c.   (i)   Define the term Chemical Oxygen Demand (COD).

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d.   A polluted water sample is suspected of being contaminated with one of the following: Soap, Alkyl Benzene Sulphonate (ABS) or Linear Alkyl Sulphonate (LAS) surfactant. The sample has very low BOD relative to its COD.

(ii)   Which is contaminant?

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(iii)   Explain your answer.

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(15 marks)

d. (i)   State the Henry's law.

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(ii)   Dry air is 0.0314% CO_2 by volume. What is the solubility (in ppm) of CO_2 in water saturated with air at 1.00 atm at 25° C? What would be the pH of unpolluted rain water? At 25° C, the partial pressure of water vapour is 0.031 atm; Henry's law constant for CO_2 in water is 3.38×10^{-2} mol dm^{-3} atm^{-1}; the relative atomic mass for C= 12; O = 16.

Ka for $CO_2 + H_2O \leftrightarrow H^+ + HCO_3^-$ is 4.45×10^{-7} mol dm^{-3}. Comment on your answer.

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....(30 marks)

2.a. (i) What do you understand by the term total alkalinity of a water sample?

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(ii) Give three major species that can contribute to alkalinity in natural water bodies.

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(ii) Calculate the alkalinity of water sample if 8.65 ml of 4.60×10^{-2} M HCl is needed to titrate a 500.0 ml water sample to pH 4.3. Comment on your answer.

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(30 marks)

b. (i) What causes hardness in water?

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(ii) Differentiate between temporary and permanent hardness of water.

	Temporary hardness	Permanent hardness
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2		
3		

(iii) Hardness is an undesirable characteristic of water. Why is it considered undesirable?

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(20 marks)

c. E^o value for the redox reaction of SO_4^{2-} as H_2S is $+0.310$ V.

(i)   Write down the above mentioned redox reaction in terms of one electron mole.

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(ii)   Calculate pE^o for this redox reaction.

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(iii)   Deduce relationship of pE to pE^o for above mentioned redox reaction.

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(iv)   Using the above relationship, calculate pE value for water sample containing $[SO_4^{2-}] = 1 \times 10^{-3}$ mol dm^{-3} and smelling of H_2S at pH $= 6$. The partial pressure of H_2S is 1×10^{-2} atm.

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(50 marks)

3.a. (i)   What are pesticides?

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(ii) Give one example for each of the following.

1. Organo chlorine pesticide ....

2. Organo phosphate pesticide...

(iii) Why Organo phosphate pesticides are better than organo chlorine pesticides?

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(20 marks)

b.   (i)   What is meant by acid rain?

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(ii) Briefly describe the effects of acid rain on aquatic systems.

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c.   (i)   What are detergents?

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         (ii)   What is the primary role of the phosphate builders in detergents?

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(20 marks)

d.   (i)   What is meant by primary treatment in water treatment process?

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         (ii)   Explain briefly the important steps that are involved in primary water treatment process.

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(40 marks)

1.a. i.   Refer page 10

ii. As air temperatures rise in late spring, heat from the sun begins to warm the lake. As the amount of solar radiation absorbed decreases with depth, the lake heats from the surface down. The warm water is less dense than the colder water below resulting in a layer of warm water that floats over the cold water. The layer of warm water at the surface of the lake is called the epilimnion. The cold layer below the epilimnion is called the hypolimnion. These two layers are separated by a layer of water which rapidly changes temperature with depth. This is called the thermocline (or metalimnion). The three distinct layers of water, each with a different temperature or range of temperatures, is an excellent example of thermal stratification within a lake system.

b. i.   Refer page no. 20 for the sketch.

ii.   Oligtrophic lakes are deep, generally clear, and deficient in nutrients and without much biological activity. So low productivity, the amount of detritus will be substantially lower and little DO will be depleted from hypolimnion. So water will be saturated with oxygen from top to bottom.

c. i.   COD is a measure of the oxygen equivalent of the organic matter in a sample that is susceptible to oxidation by a strong oxidizing agent.

ii.   Contaminant – ABS
Soap is biodegradable. LAS is more biodegradable than ABS.ABS compared to soap and LAS undergoes very slowly or does not undergo biodegradation. So BOD is less relative to its COD.

d. i.   Refer page no 16

ii.   Calculate P_{CO_2} ; $P_{CO_2} = (P^0 - P_{H_2O})X_{CO_2}$
$$= 0.03 \text{ atm}$$
Calculate $[CO_2]_{aq}$ using Henry's equation.
$[CO_2]_{aq} = 0.1014 \times 10^{-2} \text{ mol dm}^{-3}$

Write expression for Ka, substitute for $[CO_2]_{aq}$. Find the concentration of H^+. Then find pH value using H^+ concentration.

2. a. i.   Total alkalinity is the total concentration of bases in water. OR
Total alkalinity is measured by measuring the amount of acid needed to bring the sample to a pH of 4.2 (at this pH all the alkaline species in the sample are used up)

ii. CO_3^{2-}, HCO_3^-, and OH^-
iii. 7.96×10^{-4} mol/litre. It is total alkalinity of that water.

b. i.   Hardness caused by divalent metallic cations.
The principle hardness causing cations are $Ca^{2+}, Mg^{2+}, Sr^{2+}$ and Mn^{2+}
ii.   Refer page no 40
iii.   Require considerable amounts of soap to produce lather.
Produce scale in industrial boilers, heaters and hot water pipes.

c. i. $8e + SO_4^{2-} + 10H^+ \leftrightarrow H_2S + 4H_2O$

$e + \frac{1}{8}SO_4^{2-} + \frac{5}{4}H^+ \leftrightarrow \frac{1}{8}H_2S + \frac{1}{2}H_2O$

ii. $pE_0 = \dfrac{{\sim}o}{0.0591}$

Substitute Eo value in the above equation and find pEo.

iii. $K_{eq} = \dfrac{P_{H_2S}^{\frac{1}{8}}}{[SO_4^{2-}]^{\frac{1}{8}} \cdot [H^+]^{\frac{5}{4}} \cdot a_{e-}}$

$a_{e-} = \dfrac{1}{K_{eq}} \cdot \dfrac{P_{H_2S}^{\frac{1}{8}}}{[SO_4^{2-}]^{\frac{1}{8}} \cdot [H^+]^{\frac{5}{4}}}$

$\log a_{e-} = -\log K_{eq} + \dfrac{1}{8}\log P_{H_2S} - \dfrac{1}{8}\log[SO_4^{2-}] - \dfrac{5}{4}\log[H^+]$

$-\log a_{e-} = +\log K_{eq} - \dfrac{1}{8}\log P_{H_2S} + \dfrac{1}{8}\log[SO_4^{2-}] + \dfrac{5}{4}\log[H^+]$

$pE = p_{E0} - \dfrac{1}{8}\log P_{H_2S} + \dfrac{1}{8}\log[SO_4^{2-}] - \dfrac{5}{4}pH$

iv. Substitute values for pEo, pH, concentration of SO_4^{2-} and partial pressure of H_2S and find value for pE.

3. a.   i.   Pesticides: Substances used for destroying insects or other organisms harmful to cultivated plants or to animals.

ii.   Organocholine – DDT
Organophophates – Parathion, Malathion

iii.   Organochlorine – long persistent insecticides and Organophosphates –   Non persistent insecticides. Organophosphates generally hydrolyze and do not bioaccumulate.

b.   i.   Acid rain- the rain (or snow) having the pH values less than 5.6.
ii.   Effect of acid rain on aquatic systems
   • pH of water bodies drops to lower value.
   • Acidification of water can dramatically reduce the fish population.
   • The phytoplanktons are destroyed.
   • The biodegrading organisms die in acidic water and consequently the litter accumulation in the water bodies. It pollutes the water and BOD increases.
   • Acidic water destroys the protective shell of different aquatic organisms such organisms will die in acidic water.
   • Acidification of a water body is generally accompanied by dissolution of metal ion from the underlying bedrock. These may include toxic metal ions such as Cd^{2+}, Pb^{2+} and Hg^{2+}.
   • Aluminum which is a highly toxic to fish is released upon acidification.

c.   i.   Detergents are cleaning agents.
ii.   To sequester Ca and Mg ions.
   To provide optimum medium for the function of surfactant.

d.   i.   Primary treatment process –
   It is a physical process. It consists of removal of gross solids such as large floating and suspended solid matters , grit, grease and scum from water.
ii.   Refer page no 109 - 110