THE OPEN UNIVERSITY OF SRI LANKA
B.Sc/ B.Ed DEGREE PROGRAMME- 2008/2009
Level 5- CHU 3122/ CHE 5122

ENVIRONMENTAL CHEMISTRY

ASSIGNMENT TEST II

Date: 8th October 2008 Time: 3.30 p.m. - 5.00 p.m.

Answer all the questions.

1. (a)(i) Draw the hydrologic cycle.
(ii)Write three unique properties of water and briefly explain their effects on life. (35 marks)

(b)(i) Write down the mathematical expression for the Henry's Law and identify the terms in it.
(ii) It has been suggested that the atmospheric carbon dioxide may reach 600 ppmv (0.060% by volume) with in a century. What would be the pH of rainwater in equilibrium with 600 ppmv of $CO_2(g)$?
(Henry's Law constant for CO_2 in water is 3.38×10^{-2} mol $dm^{-3} atm^{-1}$; the vapour pressure of water at 25^0C is 0.0313 atm.; equilibrium constant K_1 for:
$CO_2 + H_2O \rightleftharpoons H^+ + HCO_3^-$ is 4.45×10^{-7} mol dm^{-3}) (35 marks)

(c)(i) What do you mean by BOD (Biochemical Oxygen Demand) of a water body?
(ii) Show that 1.0 dm^3 of water saturated with oxygen at 25 °C is capable of oxidizing 8.2 mg of organic matter. (Assume organic matter to be polymeric carbohydrate, $\{CH_2O\}$).
Partial pressure of O_2 in dry air = 0.21 atm;
Henry's Law constant for O_2 at 25 °C, $K_H = 1.3 \times 10^{-3}$ mol dm^{-3} atm^{-1}.
(30 marks)

2.(a)(i) What do you mean by the term 'productivity' of a water body? Briefly explain how it is related to water quality. (20 marks)

(b)(i) What do you understand by the term 'alkalinity' of a water sample?
(ii) Give three major species that are responsible for the alkalinity in water.
(iii) Calculate the alkalinity of a water sample if 7.65 cm^3 of 5.20×10^{-3} mol dm^{-3} HCl is required to titrate a 250.0 cm^3 sample to a methyl orange end point.
(30 marks)

Environmental Chemistry CHU 3122 (2008 / 09)

Answer Guide to Assignment test II

)a i) page no 02

ii) page no 03

Henry's Law

$_{(aq)} = K \times P_G$

= Henry's Law constant
$_G$ – Partial pressure of the gas
$_{(aq)}$ = The Solubility of a gas in water

)

$$CO_2 + H_2O \overset{K_1}{\rightleftharpoons} H^+ + HCO_3^-$$

$_1 = 4.45 \times 10^{-7}$ mol dm^{-3}
lenry's Law constant for $CO_2 = 3.38 \times 10^{-2}$ moldm^{-3}atm^{-1}
he Vapour pressure of water at 25 ^{0}C = 0.0313 atm

$_{CO_2} = (1.0000 - 0.0313)$atm $\times 6 \times 10^{-4}$
$= 5.81 \times 10^{-4}$ atm

$[CO_2]_{aq}$ can calculated from Henry's Law

$[CO_2]_{aq} = K_H \times P_{CO_2}$
$= 3.38 \times 10^{-2}$(moldm^{-3}atm^{-1}) $\times 5.81 \times 10^{-4}$ atm
$= 1.96 \times 10^{-5}$ moldm^{-3}

$$CO_2 + H_2O \underset{}{\overset{K_1}{\rightleftharpoons}} H^+ + HCO_3^-$$

$[H^+] = [HCO_3^-]$

$$K_1 = \frac{[H^+] \times [HCO_3^-]}{[CO_2]}$$

$$K_1 = \frac{[H^+]^2}{[CO_2]}$$

$[H^+]^2 = K_1 [CO_2]$

$= 4.45 \times 10^{-7} \times 1.96 \times 10^{-5}$

$= 8.72 \times 10^{-12}$

$[H^+] = 2.95 \times 10^{-6}$

$pH = -\log [H^+]$

$= 5.53$

C)i)

BOD- It refers to the amount of oxygen utilized when organic matter in a given volume of water is degraded biologically.

ii) $[O_2]_{aq} = K_H + P_{O2}$

$= 1.3 \times 10^{-3}$ moldm^{-3}atm^{-1} x 0.21 atm

$= 2.73 \times 10^{-4}$ moldm^{-3}

Converting to mg dm^{-3}

$= 2.73 \times 10^{-4}$ moldm^{-3} x 32 gmol^{-1} x (1000mg/g)

$= 8.7$ mg dm^{-3} or 8.7 ppm

$(CH_2O) + O_2 \longrightarrow CO_2 + H_2O$

i.e. 30/32 x 8.7 = 8.156 mg of (CH_2O)

02)

a i) Productivity- The ability of a body of water to produce living material is known as its productivity.

ii) A good quality water should be low productivity. With excessive productivity, there can be choking by weeds and odour problems. Also in very productive waters, the growth of algae can be quite high; the concurrent deposition of dead algae reduces the oxygen levels in the water to very low values.

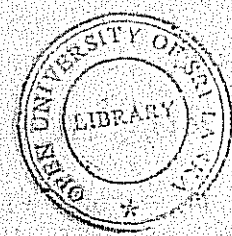
ii) The alkalinity of a water sample is a measure of the concentration of bases it contains. It is also the capacity to accept protons.

ii)

HCO_3^-

CO_3^-

OH^-



iii)

$$\frac{5.2 \times 10^{-3} \times 7.65}{1000} = \frac{x \times 250.00}{1000}$$

$$x = 1.59 \times 10^{-4} \text{ moldm}^{-3}$$

C) i) Acidity applied to natural water systems, is the capacity of the water to neutralize OH^-.

i) Acidity generally results from the presence of weak acids such as $H_2PO_4^-$, CO_2, H_2S, protein, fatty acids and acidic metal ions(particularly Fe^{3+})

d) i) Sources-

Cd-

enters water from industrial discharges and mining water

Pb –

Lead arises from a number of industrial and mining sources.

Lead from leaded gasoline is a major source of atmospheric and terrestrial lead. Much of this lead eventually enter natural water systems. Lead-containing limestone and Galena(PbS) may also contribute lead to natural waters.

Effects:

These metals have strong affinity for sulphur: they attack sulphur bonds in enzymes, and thus immobilize the enzyme. These metal attack carboxylic acid ($-CO_2H$) and amino($-NH_2$) groups of protein. Cd and Pb ions bind to cell membrane, hindering transport processes through the cell wall.

03)i)

$pE = -\log(a_{e^-})$

ii) Thermal Stratification-

Because of the unique temperature-density of water there are distinct layers within nonflowing bodies of water. During a sunny spell (In the summer),solar radiation heats up or surface layer(epilimnion);because of its lower density, it floats upon the bottom layer(hypolimnion). This phenomenon is called Thermal Stratification.

In a stratified lake, the is exposed to atmosphere i.e. contains relatively higher levels of dissolved oxygen-aerobic, we can expect pE value around +13.

In the hypolimnion, there is bacterial action on biodegradable organic material; this may cause the water to become anaerobic. In highly anaerobic water pE is low. Therefore as the depth increases pE decreases.

iii) α

$$\tfrac{1}{4} O_{2(g)} + H^+ + e^- \rightleftharpoons \tfrac{1}{2} H_2O \qquad pE_0 = 20.75$$

$$pE = pE_0 + \log(P_{O2}^{1/4} H^+)$$
$$= 20.75 + \tfrac{1}{4}\log P_{O2} - pH$$
$$= 13.75 + \tfrac{1}{4}\log(6 \times 10^{-4})$$
$$pE = 13.97$$

β

$$1/8\ SO_4^{2-} + 5/4\ H^+ + e^- \rightleftharpoons 1/8\ H_2S + \tfrac{1}{2} H_2O \quad pE^0 = 5.25$$

$$pE = pE^0 + \log \frac{[H^+]^{5/4}[SO_4^{2-}]^{1/8}}{[P_{H2S}]^{1/8}}$$

$$= 5.25 + \log \frac{[1 \times 10^{-6}]^{5/4}[10^{-3}]^{1/8}}{[10^{-2}]^{1/8}}$$

$$= 5.25 + 5/4 \log[1 \times 10^{-6}] + 1/8 \log[10^{-3}] - 1/8 \log[10^{-2}]$$
$$= 5.25 + (-7.500) + (-0.375) - (-0.25)$$
$$= 5.25 - (8.125)$$
$$= -2.885$$

C) Sources of radionuclides

* Fission products of heavy nuclei such as uranium or plutonium
* as waste products in nuclear power generations

Effects- Health effects of radionuclides depends on type and energy of radiation, $t_{1/2}$ of radionuclides. Among the with intermediate half-lives are the most dangerous. Radiation can damage living organism by iniating harmful chemical reactions in tissues. e.g. bonds can be broken in the micro molecules which carry out life process. In extreme cases of acute radiation poisoning, bone narrow is destroyed; bone narrow produces red blood cells and therefore the concentration of red blood cells is diminished.

b)ii) as Detergent builders

iv) Phosphate detergents are considered as major source of phosphate in water. Phosphate is essential nutrient for algal bloom which we must limit in natural waters. (Eutrophication)