The Open University of Sri Lanka
B.Sc. Degree Programme 2009/2010
Environmental Chemistry CHU 3122 /CHE 5122
Assignment II Test
Duration 1 1/2 hours

Date: 21.10. 2009 **Time: 4.00 pm – 5.30pm**

Answer all the questions

1 a. (i) Lakes are generally classified into three types. What are they?
(ii) What do you understand by "Thermal stratification"?
(iii) Draw a labeled diagram to illustrate stratification of a lake.
(iv) Show the stable forms of carbon, sulphur, nitrogen and iron in a stratified lake.

(40 marks)

b. (i) Name and state the law that describes the distribution of X in gaseous and aqueous phase as in $X_{(g)} \rightleftharpoons X_{(aq)}$ equilibrium.
(ii) Write the mathematical expression for the above mentioned law.
(iii) Write the importance of dissolved oxygen
(iv) Show that one liter of water saturated with oxygen at 25^0C is capable of oxidizing 8.2 milligrams of polymeric CH_2O.
Partial pressure of O_2 in dry air = 0.21 atm;
K_H at 25^0C is 1.3×10^{-3} mol l^{-1} atm^{-1}
H =I; C=12; O=16

(40 marks)

c. What is meant by the terms "Ground water" and "surface water"?

(20 marks)

2 a (i) Distinguish between autotrophic and heterotrophic organisms giving one example of each
(ii) Write down three main physical properties of a water body that affect aquatic life.
(iii) Briefly explain how they affect aquatic life.

(30 marks)

b. (i) What do you mean by
(α) Bio Chemical Oxygen Demand (BOD)
(β) Chemical Oxygen Demand (COD)
(ii) Write the balanced equation for the half reaction used in the COD titration, which converts dichromate ion to Cr^{3+}.

(iii) A 25 ml sample of river water was titrated with 0.001M $Na_2Cr_2O_7$ and required 8.30 ml to reach the end point. What is the chemical oxygen demand, in milligrams of O_2 per liter, of the sample?

(40 marks)

c. (i) What is Hard water?

(ii) Briefly describe the chemical difference between permanent hardness and temporary hardness in water.

(iii) Calculate the total alkalinity for a sample of river water for which phenolphthalein alkalinity is known to be 3.0×10^{-5} M, pH is 10.0 and bicarbonate ion concentration is 1.0×10^{-4} M.

(30 marks)

3.a (i) Define the term pE

(ii) What are the uses of a pE – pH diagram?

(iii) At pH 6.00 and pE 2.58, what is the concentration of Fe^{2+} in equilibrium with $Fe(OH)_3$?

pE_0 for the equilibrium $Fe^{3+} + e \rightleftharpoons Fe^{2+}$ is 13.2

and the equilibrium constant for $Fe(OH)_3(s) + 3H^+ \rightleftharpoons Fe^{3+} + 3H_2O$ is 9.1×10^3

(40 marks)

b.(i) Briefly describe the sources and environmental effects of the following trace metals in an aquatic system:

Hg, Cd, Pb and As

(40 marks)

c. Briefly explain how chelation can affect corrosion

(20 marks)

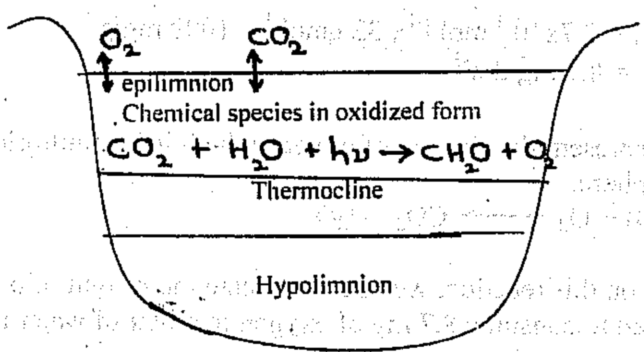
CHU 3122
Environmental chemistry
Assignment Test II –Answer guide (2009 / 10)

1) a)

i) Oligotropic
Eutropic
Dystropic

ii)
Thermal stratification
During a sunny spell (in the summer), solar radiation heats up a surface layer (epilimnion): because of its lower density, it floats upon the bottom layer (hypolimnion). We call this phenomenon as Thermal stratification

iii)



iii) Epilimnion- aerobic conditions

iv)

v) C- CO_2, H_2CO_3, HCO_3^-
S- SO_4^{2-}
N- HNO_3
Fe- $Fe(OH)_3$

} exist in there most oxidized forms

Hypolimnion- anaerobic condition

} Exist in there most reduced forms

C- CH_4
S- H_2S
N- NH_3, NH_4^+
Fe- $Fe^{2+}_{(aq)}$

b. (i) $X(g) \rightleftharpoons X(aq)$

Henry's law its state that the solubility of a gas in a liquid is proportional to the partial pressure of that gas in contact with the liquid.

(ii) Mathematical expression $G\ (aq) = K \times P_G$

- K – Henry's law constant
  PG - partial pressure of gas
  G(aq) – the solubility of a gas, G in water.

(iii) Importance of the dissolve oxygen

It provide oxygen for respiration of aquatic plants and animals.
helps to the degrade organic matter

(iv) The atmosphere contents 0.21 atm of oxygen
K_H at 25°C = 1.3×10^{-3} mol l^{-1} atm^{-1}
so the solubility of oxygen in water

$O_2(aq) = K_H\, P(O_2)$
$= 1.3 \times 10^{-3}$ mol l^{-1} atm^{-1} x 0.21 atm
$= 2.7 \times 10^{-4}$ mol l^{-1}

we convert 2.7×10^{-4} mol l^{-1} into mg dm^{-3}

O_2 (aq) = 2.7×10^{-4} mol l^{-1} x 32 gmol^{-1} x 1000 mg/g
= 8.7 mg dm^{-3}

- This represent the amount of oxygen which is in equilibrium with the atmosphere.
  $(CH_2O) + O_2 \longrightarrow CO_2 + H_2O$

Based on this reaction, we can't calculate the weight of organic matter required to consume 8.7 mg of oxygen in a liter of water in equilibrium with the atmosphere at 25°C.

$\frac{30}{32} \times 8.7 = 8.156$ mg of (CH_2O)

= 8.2 mg

C. Ground water

Ground water may dissolve minerals from the formations through which it passes. Occasionally the content of undesirable salts can become excessively high. However, most microorganisms originally present in ground water are gradually filtered out as it seeps through the ground.

Surface water,

- In surface water, many substances either dissolve or become suspended in it on its way to the ocean. in a lake or reservoir that contents mineral nutrients essential for algae growth. the surface water supports a heavy

- growth of algae. also surface water with a high level or biodegradable organic material used as food by bacteria. normally contains a large population of bacteria.

2) i) Autotrophic- Algae

Autotrophic organisms utilize solar or chemical energy to fix elements from sample, non living inorganic materials into complex life molecules that compose living organisms.

Heterotrophic – Bacteria and fungi

Heterotrophic organisms utilize the substances produced by organisms as energy sources and as the raw materials for the synthesis of their own biomass.

ii) Physical properties of a water body

Temperature
Transparency
Turbulence

iii)

- When the temperature of water is very low, biological processes become very low. Very high temperature are fatal to most organisms

Transparency of water is important for the growth of algae. therefore ,turbid water may not be very productive of biomass, even though it has the nutrients, optimum temperature and other conditions needed.

Turbulence of water is largely responsible for the transport of nutrients to living organisms and of waste products away from them. it plays a role in the transport of O_2. CO_2 and other gases through a body of water. it also plays a part in the exchange of there gases at the water- atmosphere interface.

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

COD- is defined as the quantity of a specified oxidant reacts with a sample under controlled conditions; the quantity of oxidant consumed is expressed in terms of its oxygen equivalence. COD is expressed in mg/L O_2.

- ii) $Cr_2O_7^{2-} + 14\,H^+ + 6e \longrightarrow 2Cr^{3+} + 7\,H_2O$

iii) Sample volume 25 ml

The number of moles of $Na_2Cr_2O_7$ required $= \frac{0.001 mol}{1000} x 8.3 ml$

$= 8.3 \times 10^{-6}$ mol

$Cr_2O_7^{2-} + 14 H^+ + 6e \longrightarrow 2 Cr3+ + 7 H_2O$

$O_2 + 4 H^+ + 4e \longrightarrow 2 H_2O$

$16 H^+ + 2 Cr_2O_7^{2-} \longrightarrow 4 Cr^{3+} + 3 O_2 + 8 H_2O$

1 mol $Cr_2O_7^{2-}$: 1.5 mol O_2

Therefore 8.3×10^{-6} mol of $Cr_2O_7^{2-} = 1.5 \times 8.3 \times 10^{-6}$ mol of O_2

$= 12.45 \times 10^{-6}$ moles of O_2

$= 12.45 \times 10^{-6} \times 32$ mg of O_2

$= 398.4 \times 10^{-3}$ mg of O_2

Concentration of **O_2** $= \frac{0.398 x 10^3}{25}$ mg/L

COD $= 15.92$ mg/L

c) i) Hard water is water that has high mineral content (mainly Ca and Mg ions) and sometimes other dissolved compounds such as bicarbonates and sulphates.

ii) Hardness due to bicarbonates of Ca^{2+} and Mg^{2+} ions, which can be removed simply by boiling the water is called temporary Hardness. Bicarbonate ions are decomposed on heating, liberating CO_2 and H_2O and forming precipitate of $CaCO_3$ or Mg CO_3.

Hardness which is not removed by boiling the water is called Permanent Hardness. It the metals are present in salts such as sulphate . or anything else other than bicarbonates, boiling will have no effect.

Addition of Na_2CO_3 will, however remove all hardness.

$CaSO_{4(aq)} + Na_2CO_{3(aq)} \longrightarrow CaCO_{3(s)} + Na_2SO_{4(aq)}$

and $Ca(HCO_3)_{2(aq)} + Na_2CO_{3(aq)} \longrightarrow CaCO_{3(s)} + 2 NaHCO_3$

iii) Total alkalinity $= [OH^-] + 2[CO_3^{2-}] + [HCO_3^-]$

$p^H + p^{OH} = 14$

$p^{OH} = - \log [OH^-]$

$[OH^-] = 1 \times 10^{-4}$ M

Phenophaline alkalinity $= 2 \times 3.0 \times 10^{-5} = 6.0 \times 10^{-5}$ M

Total alkalinity $= [OH^-] + 2[CO_3^{2-}] + [HCO_3^-]$

$= 1 \times 10^{-4}$ M $+ 6.0 \times 10^{-5}$ M $+ 1 \times 10^{-4}$ M

$= 2.6 \times 10^{-4}$ M

3)a)

i) $p^E = -\log (a_e)$

P^E is defined as the negative base 10 logarithm of the activity of electron

ii) uses of $P^E - p^H$ diagram

the diagram shows the region of stability and the boundary line for various species in water.

iii) $p^H = 6.00$ $[H^+] = 1 \times 10^{-6}$ M

$P^E = 2.58$

$Fe(OH)_{3(s)} + 3H^+_{(aq)} \rightleftharpoons Fe^{3+}_{(aq)} + 3H_2O_{(l)}$

$$K = \frac{[Fe^{3+}]}{[H^+]^3}$$

$$9.1 \times 10^3 = \frac{[Fe^{3+}]}{[H^+]^3}$$

$$Fe^{3+} = 9.1 \times 10^3 [H^+]^3$$

$$p^E = p^{E_o} + \log \frac{[Fe^{3+}]}{[Fe^{2+}]}$$

$$p^E = p^{E_o} + \log \frac{[9.1 \times 10^3 [H^+]^3]}{Fe^{2+}}$$

$$2.58 = 13.2 + \log \frac{[9.1 \times 10^3 [H^+]^3]}{Fe^{2+}}$$

$$-10.62 = \log \frac{[9.1 \times 10^3 (1 \times 10^{-6})^3]}{Fe^{2+}}$$

$$\log [Fe^{2+}] = \frac{-14.04}{-10.62} = 1.32$$

$$[Fe^{2+}] = \underline{\underline{20.89}} \text{ moldm}^{-3}$$

b) i) Hg- Mercury ores(cinnabar)
Fossil fuels,
pesticides and fungicides
Laboratory chemicals
Coal, paper mills

Environmental effect- neurological damage, irritability, paralysis, blindness or insanity, chromosome breakage and birth defects, depression

Cd- Industrial discharges, mining wastes, metal painting (electrolysis)

High blood pressure, kidney damage and destruction of testicular tissue and red blood cells
Cd poisoning causes bone fracture

Pb- leaded gasoline
Industrial wastages, mining sources
Limestone and galena

-severe destruction in kidney , reproductive system ,liver and the brain and central nervous system, sickness, death ,anemia

As- combustion of fossil fuels, coal , pesticides, mine tailing
produce as a by product of Cu .Au, and Pd refining

Carcinogenic
Acute poisonings
chronic poisoning

iii) corrosion $M - n e \rightleftharpoons M^{n+}$
When there are chelating agents in the water that will form complex with M^{n+}.Therefore the forward reaction will facilitate. So corrosion will be increased.