BIO 365 Environmental Contaminants

Review material for test I – Water, Soil and Atmospheric chemistry

This test will cover the basics of water, soil and atmospheric chemistry.

My suggestions for the test:

1) You should be comfortable with the review problems that we went over on the first day of class.

2) Make sure you understand what is covered in the notes (problems we worked through in class, concepts, etc.)

3) Be able to work through the problems that I listed in the chapters (9-1; 9-22; etc.). They are given below.

4) You should be able to convert values readily (ppm - molarity - mg/L)

I will post the answers for the chapter questions and the following questions.

Water chemistry

Baird Problems 9-1, 4, 8, 10a, 11, 22 Review 2, 3, 4, 5, 7, 8, 11, 12, 20

What is the oxidation state of C, N or S in the following compounds?

CO_2, CH_4, $C_6H_{12}O_6$, CO

NH_4^+, NH_3, NO_2^-, N_2O, NO, NO_3^-

SO_4^{2-}, H_2S, H_2SO_4, H_2SO_3, SO_2

Write half reactions for the following balanced equations and be able to determine the oxidation states of the atoms involved.

$2Na + Cl_2 \rightarrow 2Na^+ + 2Cl^-$

$2Na \rightarrow 2Na^+ + 2e^-$

$Cl_2 + 2e^- \rightarrow 2Cl^-$

$CH_2O + O_2 \rightarrow CO_2 + H_2O$

$H_2O + CH_2O \rightarrow CO_2 + 4e^- + 4H^+$

$O_2 + 4e^- + 4H^+ \rightarrow 2H_2O$

Determine the pH of the following solutions

0.02 M HCl (strong acid)

$pH = -\log[H^+] = -\log[0.02] = 1.7$

0.02 M H_2SO_4 (H_2SO_4 is a strong acid, however HSO_4^- is a weak acid and its dissociation is insignificant)

$pH = -\log(H^+) = -\log[0.02] = 1.7$

0.02 M NaOH (strong base)

$p[OH^-] = -\log[0.02] = 1.7 \qquad pH = 14 - 1.7 = 12.3$

0.5 M solution of HNO_3 (a weak acid whose K_a is 4.5×10^{-4})

$4.5 \times 10^{-4} = \frac{[H^+][NO_3^-]}{[HNO_3]} \qquad [0.5] \cdot 4.5 \times 10^{-4} = [H^+]^2 \qquad [H^+]^2 = 2.25 \times 10^{-4}$

$pH = 1.82$

0.05 M solution of N_2H_4 (a weak base whose K_b is 9.8×10^{-7})

$9.8 \times 10^{-7} = \frac{[N_2H_5^+][OH^-]}{[N_2H_4]} \qquad [0.05] \cdot 9.8 \times 10^{-7} = [OH^-]^2$

$p[OH^-] = 3.65 \qquad pH = 10.35$

Make sure you understand the pE concept and what a high or low pE represents.

Be familiar with the concept of carbonate equilibrium.

What is alkalinity and what does it represent?

For the reaction: $BaSO_4 \rightarrow Ba^{2+} + SO_4^{2-}$

$K_{sp} = 1.23 \times 10^{-10} = [Ba^{2+}][SO_4^{2-}] \qquad$ So... $[Ba^{2+}] = [SO_4^{2-}]$

What is the concentration of sulfate in a solution saturated with $BaSO_4$ in M? in g / L?

$1.23 \times 10^{-10} = [SO_4^{2-}]^2$

$1.11 \times 10^{-5} = [SO_4^{2-}]$

$\frac{1.11 \times 10^{-5}\ mol}{L} \times \frac{96\ g\ SO_4^{2-}}{mol} = 1.07 \times 10^{-3}\ g/L$

Why does Al solubility increase by 3 orders of magnitude with a single unit pH decrease?

$Al(OH)_3 \leftrightarrow Al^{3+} + 3OH^-$

$K_{sp} = [Al^{3+}][OH^-][OH^-][OH^-] = 10^{-33}$

Soil Chemistry

Baird Problems 12-3 Review 13, 14, 15,

How do increases/decreases in soil pH influence AEC and CEC?

Expect to have a problem similar to the septic tank example that I worked through in class.

In what ways can soil organic matter influence the movement of polar and non-polar contaminants?

Atmospheric chemistry

Baird problems 1-8, 9, 12 Review 10, 11, 12, 14,
Baird problems 2-11 Review 8

CO_2 is present in the atmosphere at concentrations over 200x that of CH_4 and over 1100x that of N_2O. Why are we concerned with the rise in the levels of the others?

What is the pH of CO_2 saturated rain water?

Henry's Law: $[H_2CO_3] = K_H \times P_{CO2}$

$K_H = 3.4 \times 10^{-2}$ mol L^{-1} atm^{-1}

$P_{CO2} = 0.00036$ atm

$K_a = [H^+][HCO_3^-] / [H_2CO_3] = 4.5 \times 10^{-7}$ mol L^{-1}

$[H_2CO_3] = 3.4 \times 10^{-2} \frac{mol}{L \cdot atm} \times 0.00036\ atm$

$= 1.2 \times 10^{-5} \frac{mol}{L}$

$4.5 \times 10^{-7} \frac{mol}{L} = \frac{[H^+]^2}{1.2 \times 10^{-5}}$

$4.5 \times 10^{-7} \frac{mol}{L} \cdot 1.2 \times 10^{-5} = [H^+]^2$ $pH = 5.63$

What would the pH be if the atmospheric $[CO_2]$ quadruples?

Plug in 0.00144 for 0.00036 atm ... pH = 5.33

If H_2SO_4 and HNO_3 influence the acidity of rain, why is there concern over atmospheric levels of SO_2 and NO_x (both of which are not very soluble in water)?

If the first step in the destruction of ozone is: $NO^{\bullet} + O_3 \rightarrow NO_2^{\bullet} + O_2$

And the overall reaction is: $O_3 + O \rightarrow 2\,O_2$

What is the second step (what happens to the $NO_2^{\bullet}$ produced in the first step)?

$NO_2^{\bullet} + O \rightarrow O_2 + NO^{\bullet}$

How does a single $Cl^{\bullet}$ destroy so much ozone?

Where is ozone formed and why? How is it destroyed?

9-1

$$\frac{0.00027 \text{ moles } O_2}{\text{L water}} \times \frac{32 \text{ g } O_2}{\text{mole } O_2} = 0.00878 \text{ g/L} = 8.7 \text{ mg/L}$$

9-4

$$NH_3 + O_2 \longrightarrow NO_3^- + H_2O$$

$$NH_3 + 2O_2 + OH^- \longrightarrow NO_3^- + H_2O$$

less alkaline since OH^- is consumed.

9-8

$$pE = 13.2 + \log\left(\left[Fe^{3+}\right]/\left[Fe^{2+}\right]\right)$$

$$= 13.2 + \log(100) = 15.2$$

9-10a

$$SO_4^{2-} \rightarrow H_2S$$

$$SO_4^{2-} + 10H^+ + 8e^- \rightarrow H_2S + 4H_2O$$

9-11

Skip

9-22

$pH = 5.5 \sim pOH = 8.5$

$[OH^-] = 3.2 \times 10^{-9} M$

$[Al^{3+}][OH^-]^3 = 10^{-33}$

$[Al^{3+}] = \frac{10^{-33}}{(3.2 \times 10^{-9})^3} = 3 \times 10^{-8} M$

$3 \times 10^{-8} \frac{mol}{L} \times \frac{26.98\ g}{mol} = 8.2 \times 10^{-7} \frac{g}{L}$

12.3

$50.7\ g\ C \times \frac{1\ mol\ C}{12\ g\ C} = 4.225\ mol$

$45.1\ g\ O \times \frac{1\ mol\ O}{16\ g\ O} = 2.819\ mol$

$4.27\ g\ H \times \frac{1\ mol\ H}{1\ g\ H} = 4.228\ mol$

$4.225 : 2.819 : 4.228$ or $1.499 : 1.5 : 1\ (\times 2)$

$3 : 3 : 2 \sim C_3H_3O_2$

1-8

$$OH^{\cdot} + O_3 \rightarrow HOO^{\cdot} + O_2$$

$$HOO^{\cdot} + O \rightarrow OH^{\cdot} + O_2$$

$$O_3 + O \rightarrow 2O_2$$

1-9

$$O^* + H_2O \rightarrow 2OH$$

1-12

$$O_3 + Cl^{\cdot} \rightarrow ClO^{\cdot} + O_2$$

$$O_3 + Br^{\cdot} \rightarrow BrO^{\cdot} + O_2$$

$$ClO^{\cdot} + BrO^{\cdot} \rightarrow Cl^{\cdot} + Br^{\cdot} + O_2$$

$$2O_3 \rightarrow 3O_2$$

2-11

$$NO_3^- \longrightarrow NH_4^+$$

$$NO_3^- + 10H^+ + 8e^- \longrightarrow NH_4^+ + 3H_2O$$