

## 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

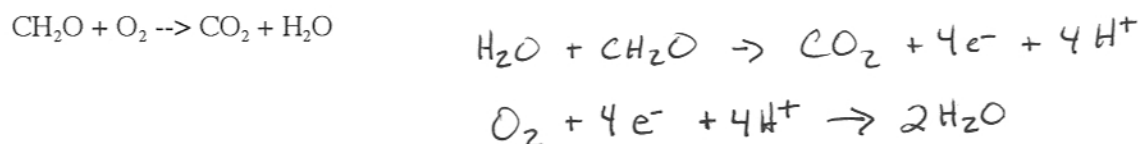
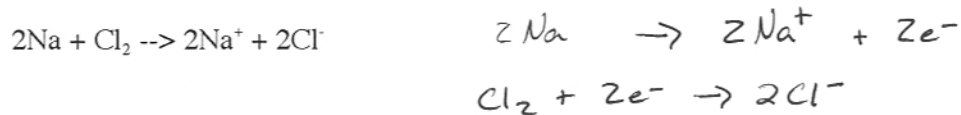
What is the oxidation state of C, N or S in the following compounds?

CO<sub>2</sub>, CH<sub>4</sub>, C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>, CO

NH<sub>4</sub><sup>+</sup>, NH<sub>3</sub>, NO<sub>2</sub><sup>-</sup>, N<sub>2</sub>O, NO, NO<sub>3</sub><sup>-</sup>

SO<sub>4</sub><sup>2-</sup>, H<sub>2</sub>S, H<sub>2</sub>SO<sub>4</sub>, H<sub>2</sub>SO<sub>3</sub>, SO<sub>2</sub>

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



Determine the pH of the following solutions

0.02 M HCl (strong acid)

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

0.02 M H<sub>2</sub>SO<sub>4</sub> (H<sub>2</sub>SO<sub>4</sub> is a strong acid, however HSO<sub>4</sub><sup>-</sup> is a weak acid and its dissociation is insignificant)

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

0.02 M NaOH (strong base)

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

0.5 M solution of HNO<sub>3</sub> (a weak acid whose K<sub>a</sub> is 4.5 x 10<sup>-4</sup>)

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

$$pH = 1.82$$

0.05 M solution of N<sub>2</sub>H<sub>4</sub> (a weak base whose K<sub>b</sub> is 9.8 x 10<sup>-7</sup>)

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

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

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<sub>4</sub> → Ba<sup>2+</sup> + SO<sub>4</sub><sup>2-</sup>

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

$$\text{So... } [Ba^{2+}] = [SO_4^{2-}]$$

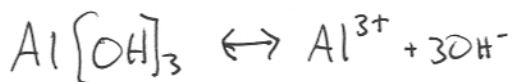
What is the concentration of sulfate in a solution saturated with BaSO<sub>4</sub> in M? in g/L?

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

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

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

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



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

## 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<sub>2</sub> is present in the atmosphere at concentrations over 200x that of CH<sub>4</sub> and over 1100x that of N<sub>2</sub>O. Why are we concerned with the rise in the levels of the others?

What is the pH of CO<sub>2</sub> saturated rain water?

Henry's Law:  $[H_2CO_3] = K_H \times P_{CO_2}$

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

$P_{CO_2} = 0.00036 \text{ atm}$

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

$$[H_2CO_3] = \frac{3.4 \times 10^{-2} \text{ mol}}{\text{L} \cdot \text{atm}} \times 0.00036 \text{ atm} \\ = 1.2 \times 10^{-5} \frac{\text{mol}}{\text{L}}$$

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

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

What would the pH be if the atmospheric [CO<sub>2</sub>] quadruples?

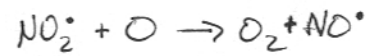
Plug in 0.00144 for 0.00036 atm ... pH = 5.33

If H<sub>2</sub>SO<sub>4</sub> and HNO<sub>3</sub> influence the acidity of rain, why is there concern over atmospheric levels of SO<sub>2</sub> and NO<sub>x</sub> (both of which are not very soluble in water)?

If the first step in the destruction of ozone is:  $\text{NO}^\bullet + \text{O}_3 \rightarrow \text{NO}_2^\bullet + \text{O}_2$

And the overall reaction is:  $\text{O}_3 + \text{O} \rightarrow 2 \text{O}_2$

What is the second step (what happens to the  $\text{NO}_2^\bullet$  produced in the first step)?



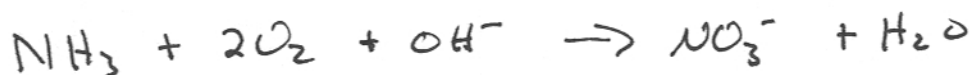
How does a single  $\text{Cl}^\bullet$  destroy so much ozone?

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

9-1

$$\frac{0.00027 \text{ moles } O_2}{L \text{ water}} \times \frac{32 \text{ g } O_2}{\text{mole } O_2} = 0.0087 \text{ g/L} = 8.7 \text{ mg/L}$$

9-4



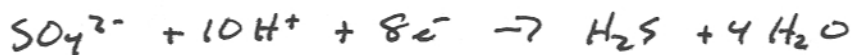
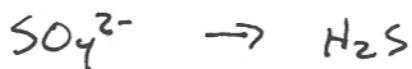
less alkaline since  $OH^-$  is consumed.

9-8

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

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

9-10a



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

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

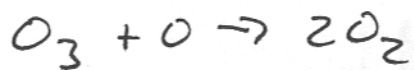
$$45.1 g O \times \frac{1 mol O}{16 g O} = 2.819 mol$$

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

$$4.225 : 2.819 : 4.228 \quad \text{or} \quad 1.499 : 1.5 : 1 \quad (x 2)$$

$$3 : 3 : 2 \sim C_3H_3O_2$$

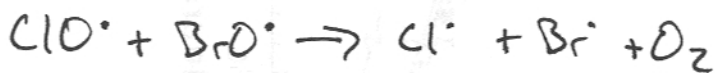
1-8



1-9



1-12



2-11

