Week 2

Chapter 2

1-6, 9-13, 17, 26

Problem 1

Using atomic weights given in Table 1, calculate the molecular and equivalent weights of (a) alum ($Al_2(SO_4)_3 \cdot 14.3H_2O$), (b) lime, (c) ferrous sulfate ($FeSO_4{\cdot}7H_2O$), (d) fluorosilicic acid, and (e) soda ash.

(a)

$$\text{Atomic Weight} = 2 \times 27 + 3 \times 96 + 14.3 \times (2 + 16) = \boxed{600 \text{ amu}}$$

$$\text{Total Valence: } 3 \times 2 = 6$$

$$\text{Equivalent Weight} = \frac{600}{6} = \boxed{100 \text{ amu}}$$

(b)

$$\text{Atomic Weight} = \boxed{56.1 \text{ amu}}$$

$$\text{Equivalent Weight} = \boxed{28 \text{ amu}}$$

(c)

$$\text{Atomic Weight} = \boxed{278 \text{ amu}}$$

$$\text{Equivalent Weight} = \boxed{139 \text{ amu}}$$

(d)

$$\text{Atomic Weight} = \boxed{144 \text{ amu}}$$

$$\text{Equivalent Weight} = \boxed{\text{N/A}}$$

(e)

$$\text{Atomic Weight} = \boxed{106 \text{ amu}}$$

$$\text{Equivalent Weight} = \boxed{53 \text{ amu}}$$

Problem 2

What ions are formed when the following compounds dissolve in water: (a) sodium nitrate, (b) sulfuric acid, (c) calcium hypochlorite, and (d) sodium carbonate.

(a)

$$\boxed{Na^+ \text{ and } NO_3^-}$$

(b)

$$\boxed{2H^+ \text{ and } HSO_4^-}$$

(c)

$$\boxed{Ca^{++} \text{ and } 2OCl^-}$$

(d)

$$\boxed{2Na^+ \text{ and } CO_3^=}$$

Problem 3

All of the fluoridation chemicals listed in Table 2-3 yield F^- ions in solution. If 1.0 mg of fluorosilicic acid is added to water, what is the increase in concentration?

$$\text{Ratio of Fluorine in Fluorosilicic Acid} = \frac{6 \times 19 \text{ amu}}{144 \text{ amu}} = 0.79$$

$$\text{Concentration} = 1 \text{ mg} \times 0.79 = \boxed{0.79 \text{ mg/L}}$$

Problem 4

If a water contains 29 mg/L of Ca^{++} and 16.4 mg/L of Mg^{++}, what is the hardness expressed in milligrams per liter as $CaCO_3$?

$$\text{Hardness of Ca}^{++} \text{ and Mg}^{++} = 29 \text{ mg/L} \frac{\text{EW CaCO}_3 \text{ amu}}{\text{EW Ca amu}} + 16.4 \text{ mg/L} \frac{\text{EW CaCO}_3 \text{ amu}}{\text{EW Mg amu}}$$

$$\text{Hardness of Ca}^{++} \text{ and Mg}^{++} = 29 \text{ mg/L} \frac{50 \text{ amu}}{20 \text{ amu}} + 16.4 \text{ mg/L} \frac{50 \text{ amu}}{12.2 \text{ amu}} = \boxed{140 \text{ mg/L}}$$

Problem 5

If a water contains 175 mg/L of calcium hardness and 40 mg/L of magnesium hardness, what are the concentrations of Ca^{++} and Mg^{++} ions?

$$\text{Ca}^{++} = \text{EW Ca amu} \frac{\text{Ca Hardness mg/L}}{\text{EW CaCO}_3 \text{ amu}} = 20 \text{ amu} \frac{175 \text{ mg/L}}{50 \text{ amu}} = \boxed{70 \text{ mg/L}}$$

$$\text{Mg}^{++} = \text{EW Mg amu} \frac{\text{Mg Hardness mg/L}}{\text{EW CaCO}_3 \text{ amu}} = 12.2 \text{ amu} \frac{40 \text{ mg/L}}{50 \text{ amu}} = \boxed{9.8 \text{ mg/L}}$$

Problem 6

The alkalinity of a water consists of 12 mg/L of CO_3^- and 100 mg/L of HCO_3^-. Calculate the alkalinity in milligrams per liter as $CaCO_3$.

$$\text{Alkalinity } = \text{mg/L CO}_3 \frac{\text{EW CaCO}_3 \text{ amu}}{\text{EW CO}_3 \text{ amu}} + \text{mg/L HCO}_3 \frac{\text{EW CaCO}_3 \text{ amu}}{\text{EW HCO}_3 \text{ amu}}$$

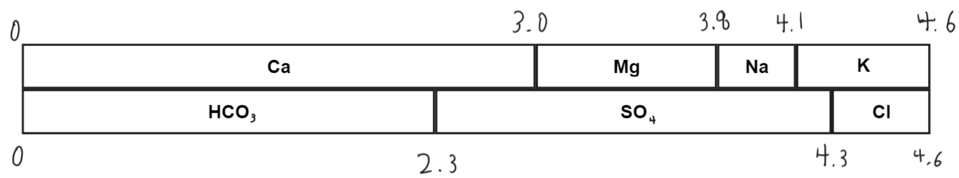
$$\text{Alkalinity } = 12 \text{ mg/L} \frac{50 \text{ amu}}{30 \text{ amu}} + 100 \text{ mg/L} \frac{50 \text{ amu}}{61 \text{ amu}} = \boxed{102 \text{ mg/L}}$$

Problem 9

Draw a milliequivalents-per-liter bar graph for the following water analysis:

Ca^{++} = 60 mg/L $\quad HCO_3^-$ = 115 mg/L as $CaCO_3$
Mg^{++} = 10 mg/L $\quad SO_4^=$ = 96 mg/L
Na^+ = 7 mg/L $\quad Cl^-$ = 11 mg/L
K^+ = 20 mg/L

Molecule	mg/L	EW	meq/L
Ca	60	20	3
Mg	10	12.2	0.8
Na	7	23	0.3
K	20	39.1	0.5
HCO_3	115	50	2.3
SO_4	96	48	2
Cl	11	35.5	0.3



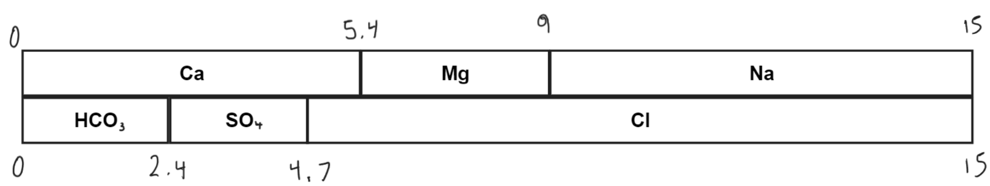
Problem 10

A brackish groundwater in an arid region has the following chemical characteristics:

Ca^{++} = 108 mg/L $\quad HCO_3^-$ = 146 mg/L
Mg^{++} = 44 mg/L $\quad SO_4^{-2}$ = 110 mg/L
Na^+ = 138 mg/L $\quad Cl^-$ = 366 mg/L

Draw the milliequivalents-per-liter bar graph. Calculate the carbonate hardness (associated with the bicarbonate ion), noncarbonated hardness, total hardness, sodium ion concentration, and alkalinity.

Molecule	mg/L	EW	meq/L
Ca	108	20	5.4
Mg	44	12.2	3.6
Na	138	23	6
HCO_3	146	61	2.4
SO_4	110	48	2.3
Cl	366	35.5	10.3



$$\text{Carbonate Hardness } = 2.4\text{ meq/L} \times 50\text{ amu} = \boxed{120\text{ mg/L}}$$

$$\text{Noncarbonate Hardness } = (5.4\text{ meq/L} - 2.4\text{ meq/L}) \times 50\text{ amu} = \boxed{150\text{ mg/L}}$$

$$\text{Total Hardness } = 9\text{ meq/L} \times 50\text{ amu} = \boxed{450\text{ mg/L}}$$

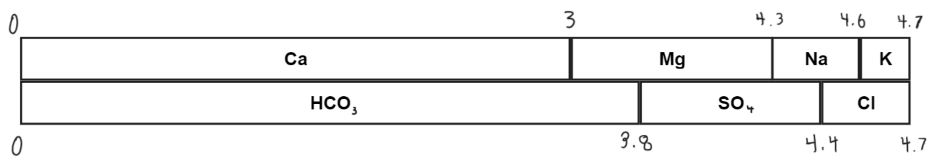
$$\text{Alkalinity } = 2.4\text{ meq/L} \times 50\text{ amu} = \boxed{120\text{ mg/L}}$$

Problem 11

Draw a milliequivalents-per-liter graph and list the hypothetical combinations of chemicals in solution for the following:

Calcium hardness	=	150 mg/L
Magnesium hardness	=	65 mg/L
Sodium ion	=	8 mg/L
Potassium ion	=	4 mg/L
Alkalinity	=	190 mg/L
Sulfate ion	=	29 mg/L
Chloride ion	=	10 mg/L
pH	=	7.7

Molecule	mg/L	EW	meq/L
Ca	150	50	3
Mg	65	50	1.3
Na	8	23	0.3
K	4	39.1	0.1
HCO_3	190	50	3.8
SO_4	29	48	0.6
Cl	10	35.5	0.3



Combinations (in meq/L): $\boxed{3\ Ca(HCO_3)_2,\ 0.8\ Mg(HCO_3)_2,\ 0.5\ MgSO_4,\ 0.1\ Na_2SO_4,\ 0.2\ NaCl,\ 0.1\ KCl}$

Problem 12

A sulfuric acid solution is added to scale-forming water to convert calcium carbonate to calcium bicarbonate. Write the chemical equation for this reaction, and calculate the amount of sulfuric acid in milligrams per liter to neutralize 20 mg/L of calcium carbonate.

$$\text{Balanced Reaction: } \boxed{H_2SO_4 + 2CaCO_3 \rightarrow Ca(HCO_3)_2 + CaSO_4}$$

$$\text{Molecular Weight } CaCO_3 = 100 \times 2 = 200 \text{ amu}$$

$$\text{Molecular Weight } H_2SO_4 = 98.1 \times 1 = 98.1 \text{ amu}$$

$$\frac{\text{mg/L } CaCO_3}{\text{Molecular Weight } CaCO_3} = \frac{\text{mg/L } H_2SO_4}{\text{Molecular Weight } H_2SO_4}$$

$$\frac{20 \text{ mg/L}}{200 \text{ amu}} = \frac{x \text{ mg/L } H_2SO_4}{98.1 \text{ amu}}$$

$$x = \boxed{9.81 \text{ mg/L}}$$

Problem 13

Calculate the pH of a solution containing 10 mg/L of sulfuric acid.

$$\text{Molecular Weight } H_2SO_4 = 98.1 \text{ amu}$$

$$H^+ = \frac{1 \text{ g}}{10 \text{ mg}} \div 98.1 \text{ amu} = 1.01 \times 10^{-4} \text{ g/L}$$

$$\text{pH} = -\log(H^+) = -\log(1.01 \times 10^{-4}) = \boxed{4}$$

Problem 17

In softening of water, lime slurry $Ca(OH)_2$ is added to precipitate the calcium ion, associated with the bicarbonate radical, as $CaCO_3$. Write a balanced equation for this reaction. Calculate the amount of lime as calcium oxide necessary to react with 100 mg/L of calcium hardness.

$$\text{Balanced Reaction: } \boxed{Ca(OH)_2 + Ca(HCO_3)_2 \rightarrow 2CaCO_3 + 2H_2O}$$

$$\frac{\text{EW CaO amu}}{\text{EW CaCO}_3\text{ amu}} = \frac{x \text{ mg/L CaO}}{\text{mg/L CaCO}_3}$$

$$\frac{28 \text{ amu}}{50 \text{ amu}} = \frac{x \text{ mg/L CaO}}{100 \text{ mg/L}}$$

$$x = \boxed{56 \text{ mg/L}}$$

Problem 26

In Eq. 29, why is the value of the constant 50,000 to calculate alkalinity as $CaCO_3$?

$$\text{Alkalinity} = \frac{\text{mL Titrant} \times \text{Normality of Acid} \times x}{\text{mL Sample}}$$

Where, according to the textbook, the volume of the titrant is 1 mL, the volume of the sample is 100 mL, the alkalinity is 10 mg/L, and the normality of the acid is 0.02 N.

$$10 \text{ mg/L} = \frac{1 \text{ mL} \times 0.02 \text{ N} \times x}{100 \text{ mL}}$$

$$x = \frac{10 \text{ mg/L} \times 100 \text{ mL}}{1 \text{ mL} \times 0.02 \text{ N}} = \boxed{50000}$$

Week 3

Chapter 3

15-17, 20-23, 26

Problem 15

Compare the latency, persistence, and infective dose of *Ascaris* and *Salmonella*.

Problem 16

Historically in the United States, the prevalent infectious diseases were typhoid, cholera, and dysentery. How have these diseases been virtually eliminated? Currently, the prevalent infectious diseases are giardiasis and cryptosporidiosis, causing diarrhea that can be life-threatening for persons with immunodeficiency syndrome. What actions are being taken to reduce the probability of waterborne transmission of these diseases? (Refer to Section 5.)

Problem 17

Discuss the significance of human carriers in transmission of enteric diseases. What major waterborne diseases in the United States are spread by carriers? How is the spread of two of these diseases amplified by animals?

Problem 20

In one statement, what is the general process in testing for *Giardia* cysts and *Cryptosporidium* oocysts? In method 1622, the water sample is only 10 L for testing natural stream water for *Cryptosporidium* oocysts. Using this method to test stream samples at a variety of locations, why was the accuracy for detection and enumeration of oocysts low?

Problem 21

Why must laboratories conducting tests for *Cryptosporidium* oocysts be audited and approved for quality assurance?

Problem 22

Why are coliform bacteria used as indicators of quality of drinking water? Under what circumstances is the reliability of coliform bacteria to indicate the presence of pathogens questioned?

Problem 23

Coliform bacteria in surface waters can originate from feces of humans, wastes of farm animals, or soil erosion. Can the coliforms from these three different sources be distinguished from one another?

Problem 26

Why is lactose (milk sugar), an ingredient in all culture media, used to test for the coliform group?