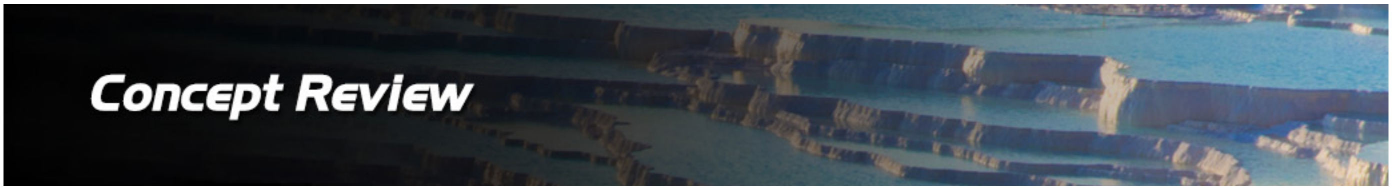

Chapter 7

Summary of Terms

Concentration A quantitative measure of the amount of solute in a solution.

Dissolving The process of mixing a solute in a solvent to produce a homogeneous mixture.

Electrolyte Any dissolved ion that allows for the flow of an electric current through the solution.

Hard water Water containing large amounts of calcium and magnesium ions.

Hydrogen bond An unusually strong dipole-dipole attraction occurring between molecules that have a hydrogen atom covalently bonded to a small highly electronegative atom, usually nitrogen, oxygen, chlorine, or fluorine.

Induced dipole A temporarily uneven distribution of electrons in an otherwise nonpolar atom or molecule.

Insoluble Not capable of dissolving to any appreciable extent in a given solvent.

Molarity A common unit of concentration equal to the number of moles of a solute per liter of solution.

Mole A very large number equal to 6.02×10^{23} and usually used in reference to the number of atoms, ions, or molecules within a macroscopic amount of a material.

Osmosis The net flow (diffusion) of water across a semipermeable membrane from a region of low solute concentration to a region of high solute concentration.

Precipitate A solute that has come out of solution.

Reverse osmosis A technique for purifying water by forcing it through a semipermeable membrane into a region of lower solute concentration.

Saturated solution A solution containing the maximum amount of solute that will dissolve in its solvent.

Semipermeable membrane A membrane containing submicroscopic pores that allow passage of water molecules but not of larger solute ions or solute molecules.

Solubility The ability of a solute to dissolve in a given solvent.

Soluble Capable of dissolving to an appreciable extent in a given solvent.

Solute Any component in a solution that is not the solvent.

Solvent The component in a solution that is present in the largest amount.

Supersaturated Solution A solution in which more solvent is dissolved than is normal at a particular temperature.

Unsaturated solution A solution that is capable of dissolving additional solute.

Review Questions

7.1 Dipole Attractions

1. What is the primary difference between a chemical bond and an attraction between two molecules?

2. Which is stronger, the ion–dipole attraction or the induced dipole–induced dipole attraction?

3. What is a hydrogen bond?

4. Are induced dipoles permanent?

7.2 Solutions

5. What happens to the volume of a sugar solution as more sugar is dissolved in it?

6. Why is a ruby considered to be a solution?

7. Distinguish between a solute and a solvent.

7.3 Concentration and the Mole

8. What does it mean to say that a solution is concentrated?

9. Is 1 mole of particles a very large number of particles or a very small number?

10. Is concentration typically given with the volume of solvent or the volume of solution?

7.4 Solubility

11. Why does the solubility of a gas solute in a liquid solvent decrease with increasing temperature?

12. Why do sugar crystals dissolve faster when crushed?

13. Is sugar a polar or nonpolar substance?

14. Use the solubility rules to predict whether any of the products formed from these reactions will precipitate as a solid:

$$HCl\ (aq) + NaOH\ (aq) \rightarrow NaCl + H_2O$$

15. Use the solubility rules to predict whether any of the products formed from these reactions will precipitate as a solid:

$$Na_2SO_4\ (aq) + BaCl_2\ (aq) \rightarrow 2\ NaCl + BaSO_4$$

7.5 How Soap Works

16. Which portion of a soap molecule is nonpolar?

17. Water and soap are attracted to each other by what type of molecular attraction?

18. What is the difference between a soap and a detergent?

7.6 Softening Hard Water

19. What component of hard water makes it hard?

20. Why are soap molecules so attracted to calcium and magnesium ions?

21. Calcium and magnesium ions are more attracted to sodium carbonate than to soap. Why?

7.7 Purifying Drinking Water

22. Why is treated water sprayed into the air prior to being piped to users?

23. What are two ways in which people disinfect water in areas where municipal treatment facilities are not available?

24. What naturally occurring element has been contaminating the water supply of Bangladesh?

Quantitative Questions

25. Assume the total number of molecules in a solution is about 3 million trillion. One million trillion of these are molecules of some poison, while two million trillion of these are water molecules. What percentage of all the molecules in the glass are water?

26. Assume the total number of molecules in a solution is about 1,000,000 million trillion. One million trillion of these are molecules of some poison, while 999,999 million trillion of these are water molecules. What percentage of all the molecules in the glass are water?

27. You drink a small glass of water that is 99.9999% pure water and 0.0001% some poison. Assume the glass contains about a 1,000,000 million trillion molecules, which is about 30 mL. How many poison molecules did you just drink. Should you be concerned?

28. How much sodium chloride, in grams, is needed to make 15 L of a solution that has a concentration of 3.0 grams of sodium chloride per liter of solution?

29. If water is added to 1 mole of sodium chloride in a flask until the volume of the solution is 1 liter, what is the molarity of the solution? What is the molarity when water is added to 2 moles of sodium chloride to make 0.5 liter of solution?

30. A student is told to use 20.0 grams of sodium chloride to make an aqueous solution that has a concentration of 10.0 g/L (grams of sodium chloride per liter of solution). Assuming that 20.0 grams of sodium chloride has a volume of 7.50 milliliters, show that she will need about

1.99 liters of water to make this solution. In making this solution, should she add the solute to the solvent or the solvent to the solute?

31. Rank the following solutions in order of increasing concentration. Solution A: 0.5 moles of sucrose in 2.0 liters of solution. Solution B: 1.0 moles of sucrose in 3.0 liters of solution. Solution C: 1.5 moles of sucrose in 4.0 liters of solution.

32. List the following compounds in order of increasing boiling point: CI_4, CBr_4, CCl_4, CF_4.

33. Rank the following compounds in order of increasing solubility in water:

CH_3CH_2-OH
Ethanol

$CH_3CH_2CH_2CH_2$-OH
n-Butanol

$CH_3CH_2CH_2CH_2CH_2CH_2$-OH
n-Hexanol

34. Rank in order of increasing number of solute molecules:

a. 7.0 L of 1.0 M sugar water

b. 5.0 L of 2.0 M sugar water

c. 2.0 L of 4.0 M sugar water

Solutions (Odd-Numbered)

1. A chemical bond is many times stronger than an attraction between molecules.

3. A hydrogen bond is a very strong dipole-dipole attraction involving a hydrogen atom bonded to a highly electronegative atom, such as oxygen.

5. The volume of a sugar solution gradually increases as more sugar is dissolved in it.

7. A solute is the component of lesser quantity in a solution (e.g., a pinch of salt in a glass of water). A solvent is the component of greater quantity in a solution (e.g., the water in a salt water solution).

9. A mole is a very large number: 6.02×10^{23}. For example, a mole of marbles would be enough to cover the entire land area of the United States to a depth greater than four meters.

11. The solubility of a gas decreases with increasing temperatures because the gas molecules will have more kinetic energy and be more likely to escape from solution. The greater kinetic energy of the solvent molecules also helps the gas molecules to escape.

13. Sugar is very polar as evidenced by its great solubility in water.

15. The barium sulfate, $BaSO_4$, should precipitate.

17. Water and soap are attracted to each other by ion-dipole attractions between each water molecule and the polar head of each soap molecule.

19. Large amounts of calcium and magnesium ions are found in hard water.

21. Sodium carbonate (Na_2CO_3) has a 2- charge in the carbonate ion $(CO_3)^{2-}$ to which calcium and magnesium are more attracted than to the 1- charge found in a molecule of soap. The hard water ions, calcium and magnesium, bind to the carbonate ions, which “softens” the water.

23. People disinfect their water by boiling it or adding disinfecting iodide tablets.

25. Divide the number of water molecules by the total number of molecules and multiply by 100 to get the percentage:

2 million trillion/3 million trillion $\times$ 100 = 67%

27. Study the previous question and you’ll find that you just ingested one million trillion poison molecules, along with 999,999 million trillion water molecules. Should you be concerned? Consider that the ratio of poison molecules to water molecules is about one to a million. This would be a concentration of 1 part per million (1 ppm). Whether this concentration is dangerous or not depends not only upon the poison, but also upon whether you drank this dose on a daily basis. Drinking this much arsenic daily would be very dangerous—arsenic poisoning becomes evident when the concentration is as little as 0.05 ppm! So think twice if you’re ever tempted to buy water solely because it is touted to be 99.9999% pure. Water will always contain impurities. For water to be safe, these impurities need to be below or well-below toxic concentrations. Water containing 0.0000000001% arsenic, for example, is considered safe. Interestingly, however, an 8

oz glass of such water, in most places, contains about 7 trillion arsenic atoms, which is a very, very tiny number compared to the 7×10^{24} water molecules.

29. a) 1 mole1 Liter = 1 Molar (1 M) b) 2 moles 0.5 Liters = 4 Molar (4 M)

31. Solution A = 0.25 M < Solution B = 0.33 M < Solution C = 0.375 M

33. The carbon-hydrogen structures are nonpolar. The structure for hexanol, therefore, is the most nonpolar of these three molecules, hence, it has the lowest solubility in water. Another way to look at this is as follows: the OH bond is a polar bond and this is what is needed to allow for good solubility in water. Only a small percentage of the *n*-hexanol molecule is made up of the OH bond. A greater percentage of the ethanol molecule (about a 33%) is made up of the OH bond. Water, therefore, has an easier time being attracted to an ethanol molecule than to a *n*-hexanol molecule. From left to right in order of increasing solubility in water:

$CH_3CH_2CH_2CH_2CH_2CH_2\text{-}OH$
n-Hexanol

$CH_3CH_2CH_2CH_2\text{-}OH$
n-Butanol

$CH_3CH_2\text{-}OH$
Ethanol

Solutions to Chapter 7
Calculation Corner
Concentrating on Solutions

1. Multiply the solution concentration by the final volume of the solution. This provides the amount of solute required: (380 g/L)(3 L) = 1140 g.
2. Divide the amount of solute by the solution concentration to obtain the amount of solution prepared: 20g/10 g/L = 2 L.

Concentrating on Dilutions

1. $(6.00\ M\ \text{NaOH})(x\ \text{mL}) = (2.00\ M\ \text{NaOH})(465\ \text{mL})$

   $x = 155$ mL

2. Units of volume cancel out within the math. Thus, so long as you have the same units of volume for before and after the solution, then the calculations will work.
3. $(3.00\ M\ \text{KBr})(55.0\ \text{mL}) = (1.00\ M)(x\ \text{mL})$

   $x = 165$ mL