Solutions - Answers

1. In what ways does a solution differ from a compound?

   A solution is a mixture of two or more substances, which can be separated by physical means, while a compound has two or more elements chemically bonded, and can only be separated by chemical means.

2. Why isn't a mixture of sand in water considered a solution?

   Sand and water is a heterogeneous mixture. The sand does not dissolve in the water.

3. Describe the concept of dynamic equilibrium as it applies to a saturated solution.

   In a saturated solution, the rate of solvation (dissolving) is equal to the rate of recrystalization so that no net change is observed.

4. There is much public concern about oil spills. Why doesn't most of the oil just dissolve in the ocean?

   Oil is a nonpolar substance, while water is polar. A nonpolar solute will not dissolve in a polar solvent.

5. Why does a nonpolar solvent not dissolve in a polar solvent?

   In order for the solute to dissolve, the solvent molecules have to separate from one another. Because the polar solvent molecules are attracted to one another more than to the nonpolar solute molecules, there is little tendency for them to separate and make room for the solute particles.

6. Why does an ionic substance not dissolve in a nonpolar solvent?

   An ionic solid is held together by the electrostatic attraction between unlike charges. Because these positive and negative ions have little attraction for the nonpolar solvent molecules, there is little reason for them to separate from the crystal and go into solution.

7. Solid naphthalene will dissolve in nonpolar octane. What can we conclude about the nature of naphthalene?

   If naphthalene will dissolve in a nonpolar solvent, then naphthalene must be nonpolar.

8. A compound, X, dissolves readily in water. Can we conclude that X is an electrolyte? Explain.

   Water is a polar solvent, which can dissolve polar and ionic solutes. In order for X to be an electrolyte it must produce ions in solution. X could be a polar solute, a polar solute would dissolve in water but it would not produce ions, therefore we cannot conclude that it is an electrolyte.

9. Is it possible for a solution to be both saturated and dilute? Explain.

   Yes. A solute may be only slightly soluble. A saturated solution occurs when the maximum amount of solute is dissolved. If the maximum amount that can dissolve is a small amount, then the solutions could be saturated and dilute.

10. What test could you perform to determine whether a solution is unsaturated, saturated, or supersaturated?

    Add a small crystal of the solute to the solution. If it dissolves, the solution was unsaturated. If it does not dissolve and falls to the bottom of the container, the solution was saturated. If it causes rescrystallization, the solution was supersaturated.

11. Originally Arrhenius believed that there must be the same number of positive and negative ions in a solution. However, the modern theory of electrolytes states that the total positive ionic charge must equal the total negative ionic charge. Is there a difference between these two statements? If so, why did Arrhenius' original theory have to be modified?

    Yes, there is a difference between the two statements. The Arrhenius theory would have been correct if all politive ions and negative ions had equal but opposite charges. However, different positive ions can have charges of 1+, 2+, 3+, or 4+, and different negative ions can have charges of 1-, 2-, 3-, or 4-. Thus, in the case of a solution of a salt like calcium chloride ($CaCl_2$), there are twice as many chloride ions (Cl^-) as calcium ions (Ca^{2+}); however, the total positive ionic charge does equal the total negative ionic charge.

12. Will we ever find a chemical that will dissolve all substance? (a universal solvent)? Give reasons for your answer.

    It is unlikely that any substance which is able to dissolve nonpolar solutes will also be polar enough to dissolve very polar or ionic solutes.

13. What volume of 0.140 mol/L hydrochloric acid would contain 5.00 g of the acid?

$$mol = \frac{5.00\ g}{36.46094\ g/mol} = 0.137\ mol$$

$$C = \frac{n}{V} \quad \therefore \quad V = \frac{n}{C} = \frac{0.137\ mol}{0.140\ mol/L} = 0.980\ L$$

14. Calculate the volume of concentrated phosphoric acid (14.6 mol/L) that must be diluted to prepare 500.0 mL of a 1.25 mol/L solution.

$$C_1V_1 = C_2V_2 \quad \therefore \quad V_1 = \frac{C_2V_2}{C_1} = \frac{(1.25\ mol/L)(0.5000\ L)}{14.6\ mol/L} = 0.0428\ L$$