Solutions: An Introduction

Aim

- To explain why substances dissolve

Notes

Definition: Solution = homogeneous mixture

- Nature of mixtures
  - consists of two or more kinds of matter
  - each substance in a mixture retains its own properties
    - sugar and water - sweet and wet
    - brine (salt water) - salty liquid
  - the composition is variable (not constant)
  - can be separated by physical means
- Distinguishing solutions from mechanical mixtures
  - properties of solutions
    - homogeneous mixtures – composed of two or more substances and have variable composition *BUT* the particles are distributed evenly throughout each other *SO* the composition is uniform
      - the solution appears to be one substance
    - consist of a ***solute*** dissolved in a ***solvent***
  - solute - substance that *IS* dissolved by another
  - solvent
    - substance that dissolves another
    - continuous phase - salt dissolved in water appears to be a liquid

Solubility - ability to dissolve in water

- Factors that affect solubility
  - Degree of solubility (how much dissolves)
    - nature of solute and solvent
      - in order for a solvent to dissolve a solute, it must exert forces of attraction on the solute
        - polar solvents such as water dissolve polar and ionic solutes because they exert mutual attractions that cause their particles to intermingle
        - nonpolar solvents such as benzene do NOT dissolve polar and ionic substances because they exert no forces of attraction that would cause the particles to separate so they can intermingle
          - oil and water do NOT mix
        - nonpolar substances such as fat dissolve in nonpolar solvents such as benzene because the forces of attraction are too weak to prevent the particles from freely intermingling
      - like dissolves like (See Table F - Table of Solubilities in Water)
    - Temperature (See Table G - Solubility Curves)
      - solubility of solid solutes generally increases as temperature increases
      - solubility of gaseous solutes generally decreases as temperature increases
    - Pressure
      - solids and liquids - no effect
      - gases: Henry's Law - mass of a dissolved gas in a liquid is directly proportional to the pressure of the gas
  - Rate of solution

Factor	Affect on Solid Solute	Affect on Gaseous Solute
Particle Size	reducing particle size by crushing increases the rate by increasing surface area	not applicable
Stirring	increases the rate by exposing fresh solvent to solute and increasing kinetic energy	decreases the rate by increasing kinetic energy, thereby reducing solubility
Amount of dissolved solute	as the amount of dissolved solute increases, the rate decreases	as the amount of dissolved solute increases, the rate decreases
Temperature	as the temperature increases, the rate increases	as the temperature increases, the rate decreases

- Saturation (see Table G)
  - Saturated solution - solution that cannot dissolve any more solute at a given temperature
    - added solute will NOT dissolve
  - Unsaturated solution - solution that can dissolve more solute at a given temperature
    - added solute will dissolve
      - Supersaturated solution - solution that holds more solute than it can dissolve at a given temperature
    - produced by dissolving solute at a high temperature and allowing it to cool slowly
      - addition of solute causes precipitation of the excess
- Concentration - the amount of solute compared to solvent
  - Qualitative descriptions
    - concentrated - large amount of solute compared to the amount of solvent
      - example - concentrated orange juice
    - dilute - small amount of solute compared to the amount of solvent
      - example - weak coffee

Answer the questions below by circling the number of the correct response

1. A reason why many salts dissociate in water is that water 1. consists of polar molecules, 2. contains ionic bonds, 3. has a linear structure, 4. does not ionize

2. Ammonia gas and hydrogen chloride gas are very soluble in water, which answer best explains the reason for this? 1. water is a good solvent for gases. 2. NH_3, HCl, and H_2O molecules are polar. 3. NH_3, and HCl molecules are very compact. 4. NH_3, HCl, and H_2O molecules are electrically symmetrical.

3. The attraction of water molecules to ions of a solute is 1. hydration, 2. dispersion, 3. ionization, 4. crystallization

4. When an ionic solid dissolves in water, which of the following occurs? 1. ionization of molecules 2. hydration of molecules 3. dissociation of ions 4. formation of ionic bonds with water

5. A reason why many ionic salts dissociate in water is that water
   1. consists of polar molecules
   2. has a linear structure
   3. contains ionic bonds
   4. does not ionize

6. A solution which contains less solute than should normally dissolve is 1. concentrated, 2. unsaturated, 3. saturated, 4. supersaturated

7. To a solution of NH_4Cl, a crystal of NH_4Cl is added. The crystal falls to the bottom and more solid comes out of the solution. This indicates the original solution was 1. unsaturated, 2. supersaturated, 3. saturated, 4. concentrated

8. A solution in which no more solute can still be added and dissolve is
   1. supersaturated
   2. saturated
   3. unsaturated
   4. concentrated

9. To a solution of NaCl, a crystal of NaCl is added and the crystal dissolves. The solution must have been 1. supersaturated, 2. saturated, 3. concentrated, 4. unsaturated

10. A solution which contains a maximum amount of solute that can be dissolved under the existing conditions is 1. saturated, 2. unsaturated, 3. dilute, 4. supersaturated

11. Crystals of NaCl, when added to a solution of this salt that is in equilibrium with excess sodium chloride, will 1. dissolve in the solution, 2. cause additional sodium chloride crystals to separate from the solution, 3. form a supersaturated solution, 4. cause no change in the concentration of the solution

12. A saturated solution of which salt would be the most concentrated at 30°C? (see solubility chart) 1. NaCl, 2. $NaClO_3$, 3. KCl, 4. $KClO_3$

13. Which saturated solution would be most dilute at 0°C?
   1. KI
   2. $NaNO_3$
   3. $NaClO_3$
   4. $KClO_3$

14. Which compound is most soluble in water?(see solubility chart)
   1. silver acetate
   2. silver chloride
   3. lead nitrate
   4. silver sulfate

15. As the temperature increases from 30°C to 40°C, the solubility of potassium nitrate in 100 g of water increases by approximately (see solubility chart)
   1. 5 grams
   2. 10 grams
   3. 15 grams
   4. 20 grams

16. Which compound is least soluble in 100 grams of water at 10°C?(see solubility chart)
   1. KNO_3
   2. KI
   3. NaCl
   4. $KClO_3$

17. A small crystal of the slightly soluble salt calcium sulfate dissolves in a solution of calcium sulfate. The original solution must have been 1. dilute and saturated, 2. concentrated and saturated, 3. dilute and unsaturated, 4. concentrated and unsaturated

18. As the temperature increases and the pressure remains constant, the solubility of a gas in a solution 1. decreases, 2. remains the same, 3. increases, 4. varies directly

19. As the pressure on a gas increases, temperature remaining constant its solubility in water 1. decreases, 2. remains the same, 3. increases, 4. varies inversely

20. Which silver compound is most soluble in water? (see solubility chart) 1. AgCl, 2. AgI, 3. Ag_2SO_4, 4. $AgNO_3$

21. How many grams of KCl are required to saturate 1000 grams of H_2O at 80°C?(see solubility chart) 1. 390, 2. 500, 2. 800, 4. 1000