Unit 8: Solutions

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Honors Chemistry

Unit Learning Objectives: By the end of the unit students will be able to…

(1) Define a solution and give examples.
(2) Define solute and solvent and determine the solute and solvent for a given solution
(3) Define molarity using a mathematical equation and give the appropriate units.
(4) Perform calculations involving molarity/solution concentration.
(5) Perform calculations involving solution dilution.
(6) Define dissociation and describe the interactions between water and ionic compounds that lead to dissociation.
(7) Write dissociation equations for ionic compounds and represent dissociation equations using a diagram showing ions and water molecules.
(8) Calculate the concentration of ions in a solution from the concentration of an ionic compound.
(9) Calculate the concentration of ions resulting from mixing two solutions by applying solution dilution and dissociation equations.
(10) Compare unsaturated and saturated solutions.
(11) Determine if a compound is soluble or insoluble in water using a solubility table.
(12) Define precipitate in terms of solubility.
(13) Describe the effect of temperature on solubility. Determine the solubility of a compound at a given temperature from a solubility curve.
(14) Write the formula equation, complete ionic equation, and net ionic equation for a precipitation reaction, giving the appropriate state for each substance.
(15) Develop a procedure to selectively precipitate an ion from solution on the basis of solubility rules.
(16) Perform stoichiometric calculations involving molarity of solutions.

Monday	Tuesday	Wednesday	Thursday	Friday
Feb. 1 Solutions Activity	**2** Solution Dilution	**3** Solvation/ Dissociation	**4** Solvation/ Dissociation	**5** Lab: Spectroscopy
8 Solubility	**9** Solubility	**10** Solubility	**11** Lab: Solubility	**12** Quiz: Solubility
15 **No School**	**16** Solution Stoich	**17** Solution Stoich	**18** **Unit 8 Review For Test**	**19** **Unit 8 Test** **HW packet Due**

A **solution** is a homogeneous mixture.

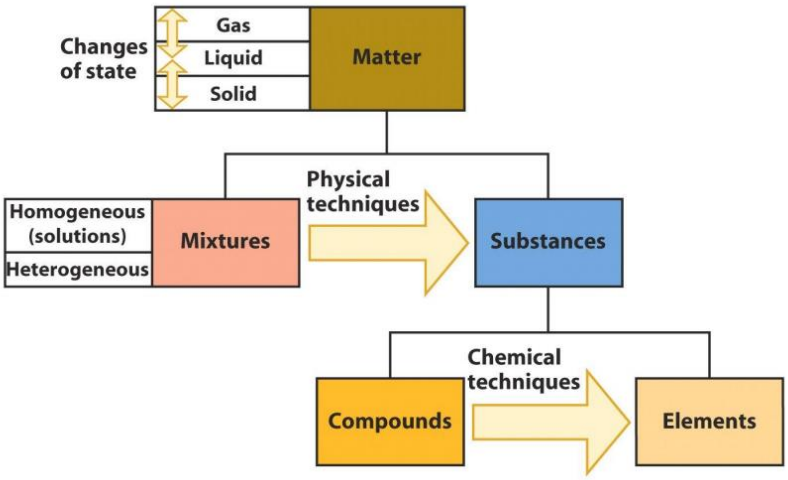
- Solute: _____

  _____

- Solvent: _____

  _____

Review: What is the concentration of a 2.0 L solution that contains 0.026 mol of NaCl?



Standard Solutions:_____

Solutions of a certain concentration are often prepared by diluting solutions of a higher concentration.

Dilution: _____

Dilution Calculations:

The moles of solute before dilution must equal the moles of solute following dilution (*this is because no solute is added; only solvent is added!*)

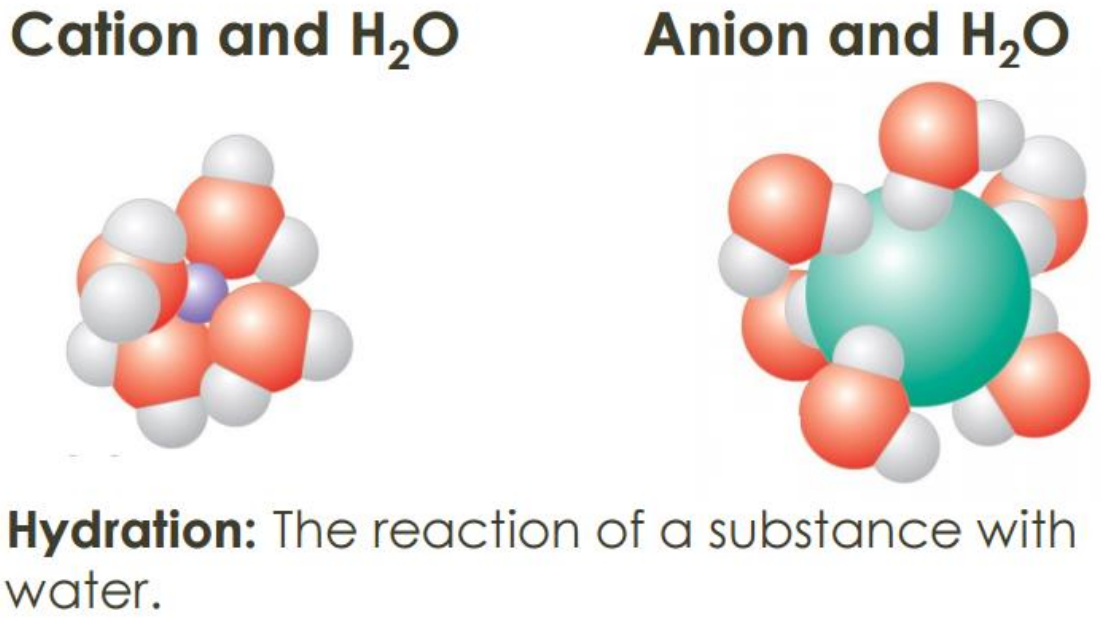
Ex. 2.0 L of 0.24 M solution of KBr is diluted to a final volume of 4.8 L. Calculate the final concentration. Calculate the mass of KBr present in the solution.

450 mL of solution contains 100 g of NaCl. What is the final concentration if 200 mL of water are added to the solution?

Solvation of Ionic Compounds:

Solvation: _____

Dissociation: _____



Review: Write the dissociation equation for each of the following:

1. $BaBr_2$

2. $ZnSO_4$

3. Cobalt (III) Chloride

4. Scandium Chlorate

Determining the Concentration of each Ion in a Dissociation Equation:

Steps to determine ion concentration

1. _____
2. _____
3. _____

Ex. Calculate the concentration of each ion in a 0.26 M solution of aluminum nitrate

Ex. Calculate the concentration of each ion in a 0.20 M solution of $SrCl_2$

Ex. Calculate the concentration of each ion in a 0.0540 M solution of iron (III) sulfate.

Dissociation and Mixing:

When two solutions are mixed, the concentration of each ion is diluted as a result of the added volume. The initial concentration of each ion is first calculated from the dissociation equation. The final concentration of each ion can then be calculated using the solution dilution equation. The final volume is the total added volume of both solutions. The final concentration of each ion is listed.

Ex. Calculate the concentration of each ion resulting from mixing 40 mL of 0.12 M potassium iodide with 60 mL of 0.15 M magnesium chloride, given that no reaction occurs.

Ex. Calculate the concentration of each ion resulting from mixing 2.5 L of 0.72 M ammonium chloride with 1.5 L of 0.80 M ammonium sulfate, given that no reaction occurs.

- If an ion is present in both of the original solutions, the final concentration is equal to the final concentration from each of the solutions added together

Solubility

Solubility: _____

Saturated: _____

Unsaturated: _____

Soluble: _____

Insoluble: _____

Precipitate: _____

Ex: Classify the following compounds as soluble (S) or insoluble (IN) in water.

a. PbI_2
b. MgS
c. $Al(OH)_3$
d. Li_2CO_3
e. $CuCl_2$

Solubility Table
Soluble >0.1 M at 25 °C
Insoluble <0.1 M at 25 °C

Anion	Cation	Solubility of Compounds
All	Alkali ions: Li^+, Na^+, K^+, Rb^+, Cs^+, Fr^+	Soluble
All	Hydrogen ion: H^+	Soluble
All	Ammonium ion: NH_4^+	Soluble
Nitrate, NO_3^- or Chlorate, ClO_3^- or Hypochlorite, ClO^- or Perchlorate, ClO_4^- or Acetate, $C_2H_3O_2^-$	All	Soluble
Chloride, Cl^- or Bromide, Br^- or Iodide, I^-	All others	Soluble
	Ag^+, Pb^{2+}, Cu^+	Insoluble
Fluoride, F^-	All others	Soluble
	Mg^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}	Insoluble
Sulphide, S^{2-}	Alkali ions, H^+, NH_4^+, Be^{2+}, Mg^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}	Soluble
	All others	Insoluble
Hydroxide, OH^-	Alkali ions, H^+, NH_4^+, Ba^{2+}, Sr^{2+}	Soluble
	All others	Insoluble
Sulphate, SO_4^{2-}	All others	Soluble
	Ag^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}	Insoluble
Oxalate, $C_2O_4^{2-}$ or Phosphate or PO_4^{3-} Carbonate, CO_3^{2-}, or Sulphite SO_3^{2-}	Alkali ions, H^+, NH_4^+	Soluble
	All others	Insoluble

Solubility and Reactions

Solutions of ionic compounds can react to form a precipitate.
This reaction can be written in three forms:

1. The **formula equation**- a balanced double replacement reaction labelling soluble compounds as aqueous (aq.) and insoluble compounds as solid (s)
2. The **complete ionic equation**- all aqueous compounds are dissociated, solid compounds remain undissociated
3. The **net ionic equation**- identical species are cancelled. The ions which do not participate in the reaction are called **spectator ions.**

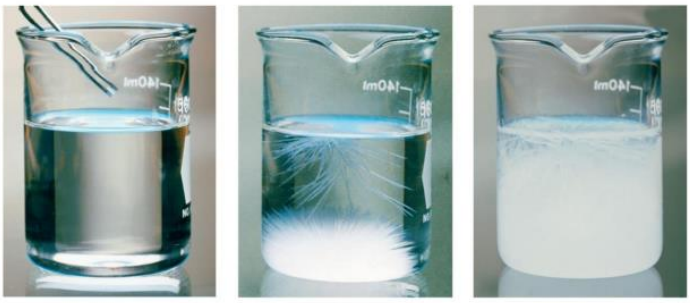
Ex. Write the formula equation, complete ionic equation, and the net ionic equation for the reaction between $Pb(NO_3)_2$

Ex. Write the formula equation, complete ionic equation, and net ionic equation for the reaction between $MgSO_4$ and Na_3PO_4. List Spectator Ions

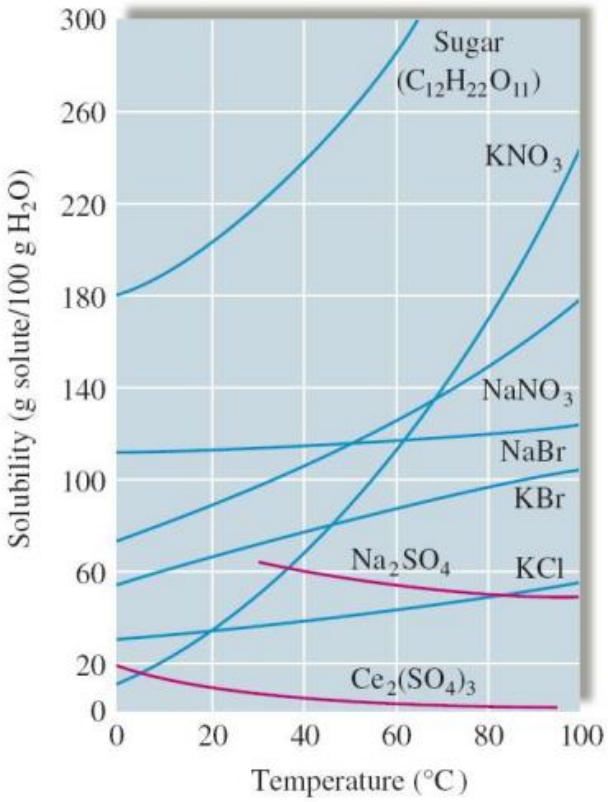
Ex. Write the formula equation, complete ionic equation, and net ionic equation for the reaction between $CaBr_2$ and $AgNO_3$. List the spectator ions.

Factors Affecting Solubility:

- **Saturated Solution:** A solution that holds the maximum amount of solute.
- **Unsaturated Solution:** A solution that holds less than the maximum amount of solute.
- **Supersaturated Solution:** A solution that holds more than the maximum amount of solute.



- If a solutions is supersaturated any small disturbance can cause the solute to recrystallize



- The graph shows the saturation level of different solutions at a given temperature. If a solution has a solubility that results in a point above the line, then the solution is considered to be supersaturated. However, if a solution has a solubility that results in a point under the line, then the solution is considered unsaturated.

Selective Precipitation

Selective precipitation is a procedure in which ions are separated from one another in solution based on their differing solubility. An ion must be found that forms a precipitate with only ONE of the ions present in the solution and not with any other. In order to add the ion to the solution, it must be added with an "escort" ion. An escort ion can be chosen if it is soluble with the ion being added. Good positive escort ions include the alkali ions, hydrogen, and ammonium since they are soluble with all anions; good negative escort ions include nitrate, chlorate, hypochlorite, perchlorate, and acetate as they are soluble with all cations. Once the precipitate is formed, it can be filtered from the solution and the next ion(s) can be precipitated. There are many possible variations to a selective precipitation procedure.

ex. A solution contains Ca^{2+} and Cu^{+} ions. Describe a procedure to separate each of the ions from solution.

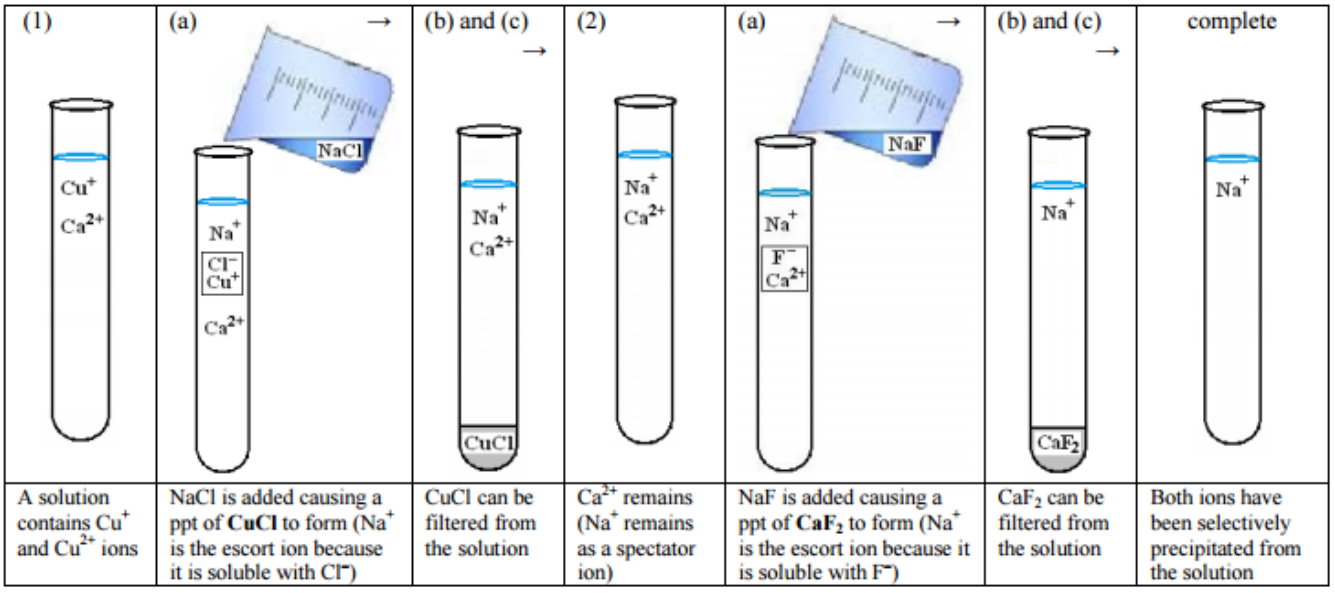
	Ca^{2+}	Cu^{+}
Cl^-	no ppt	ppt
F^-	ppt	X

(once Cu^{+} is precipitated, it no longer needs to be considered)

(1) (a) Add NaCl (b) ppt CuCl (c) filter

(2) (a) Add NaF (b) ppt CaF_2 (c) filter

Selective Precipitation Procedure



A solution contains Cu^{+} and Cu^{2+} ions	NaCl is added causing a ppt of **CuCl** to form (Na^{+} is the escort ion because it is soluble with Cl^-)	CuCl can be filtered from the solution	Ca^{2+} remains (Na^{+} remains as a spectator ion)	NaF is added causing a ppt of **CaF_2** to form (Na^{+} is the escort ion because it is soluble with F^-)	CaF_2 can be filtered from the solution	Both ions have been selectively precipitated from the solution

Ex. A solution contains Ba^{2+}, Pb^{2+}. Describe a procedure to separate each of the ions from solution.

Ex. A solution contains Br^-, F^-, and S^{2-}. Describe a procedure to separate each of the ions from solution.

Solution Stoichiometry

Ex. 100 mL of 0.300 M barium chloride reacts with 200 mL of sodium sulfate.

a. What concentration of sodium sulfate solution is required?
b. What would be the mass of each of the products?

Ex. 150 mL of 0.150 M lead (II) nitrate reacts with 205 mL of 0.250 mL of 0.250 M potassium iodide solution.

a. What reactant is limiting and which is in excess?
b. What would be the mass of each of the products?
c. Write the net ionic equation for the formation of the precipitate.