4.1 - 4.5 Solutions, Solubility

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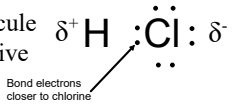
Polar Covalent Bonds

When two elements share electrons unequally, the result is a dipole: a molecule with charged ends.

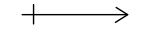
Partial charges are present on a molecule due to lopsided electron distribution.

The charged ends of the molecule are labeled with δ^+ if it's positive or δ^- if it's negative (delta).

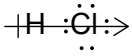


A dipole is denoted with an arrow pointing towards the negatively charged end.

Symbol:



Positive Negative



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Properties of Covalent Compounds

A. Polar compounds dissolve in polar solvents (acetone, water, ammonia - etc).

B. Non-polar compounds dissolve in non-polar solvents. (vegetable oil, gasoline, turpentine, mineral oil, etc.)

C. Dissimilar compounds tend not to dissolve in each other (oil and water, lava lamp).

Mix This!!

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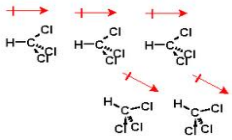
Properties of Covalent Compounds

D. Covalent compounds have lower melting and boiling temperatures than ionic compounds.

E. Exhibit different intermolecular forces:

I. Dipole–dipole: attraction between positive and negative ends of molecules.



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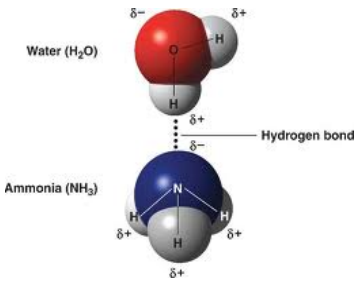
Properties of Covalent Compounds

II. Hydrogen bond A dipole-dipole force where the positive end is a hydrogen atom; the negative end is either fluorine, oxygen, or nitrogen



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Solution Terms

Solutions: substances composed of two or more components having uniform composition.

Solvent: Substance that dissolves something.

Solute: Substance that is dissolved.

Concentration: amount of solute dissolved in solvent.

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Solutions & Electrical Conductivity

Electrolyte – substance that when dissolved in water produces a solution that can conduct electricity.

Strong Electrolytes – conduct current very efficiently (bulb shines brightly). Completely ionized in water.

Weak Electrolytes – conduct only a small current (bulb glows dimly). A small degree of ionization in water.

Nonelectrolytes – no current flows (bulb remains unlit). Dissolves but does not produce any ions.

Care for a spot of tea?

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Molarity (M)

Moles of solute dissolved per liter of solution:

Molarity units are mol/L.

$$M = \frac{moles\ solute}{liters\ of\ solution}$$

1. What's the molarity if 1.8 moles NaCl are dissolved in water, making 2.5 liters of solution?

$$M = \frac{moles\ dissolved}{liters\ of\ solution} = \frac{1.8\,mol}{2.5\,L} = 0.72\,M\ NaCl$$

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2. Another Molarity Example

How many g NaCl are needed to make 1.8 L of a 0.35 M solution? (molar mass NaCl = 58.44 g/mol)

First, calculate moles NaCl:

$$M = \frac{moles\ solute}{liters\ solution}$$

$$moles\ solute = M \bullet L = 0.35\frac{mol}{L} \bullet 1.8\,L = 0.63\,moles\ NaCl$$

Last: moles to mass conversion

$$0.63\,mol\ NaCl \bullet \frac{58.44\,g\ NaCl}{1.0\,mol\ NaCl} = 36.8\,g\ NaCl$$

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Factors Speeding Dissolution of Solids

Agitation – stirring or shaking

Larger surface area – pulverize solute

Heating – solids dissolve faster in warm solvent

Gases do not dissolve in warm solvent, however, but do in cold solvent.

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Guided Practice: Making Solutions

To make 1.0 L of a 1.0 M aqueous solution of NaCl:

A. Mass out one mole of NaCl (58.44 g).

B. Dissolve in 500 mL of water in Volumetric Flask

C. Add water to the 1000 mL mark.

3. If you added NaCl to 1000 mL water, how would that affect concentration?

You'd have a volume larger than 1 L: the solution would be less than 1 M.

Volumetric Flask

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Diluting Molar Solutions

Stock solution: a concentrated solution.

Dilute solution: solution made from a stock solution.

$$M_1 \bullet V_1 = M_2 \bullet V_2$$

M = molarity
V = volume

Note: volume can be any unit, as long as they are the same.

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4. Dilution Example

What would the resulting concentration be, if 250 mL of 3.8 M NaCl were diluted to 1.0 L?

First, realize V_2 = 1000 mL

$$M_1V_1 = M_2V_2$$

$$M_2 = \frac{M_1V_1}{V_2}$$

$$= \frac{3.8\,M \bullet 250\,mL}{1000\,mL} = 0.95\,M\ NaCl$$

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Solubility

How well a chemical dissolves in water (or other solvent).

In **double replacement** reactions, there might be a solid product (called a precipitate).

Solubility Resource (Resource Page 10) determines which product is soluble and which is not.

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General Solubility Rules

Cations: NH_4^+ ion; all Group 1 elements are soluble.

Anions: nitrate is always soluble.

Chloride, bromide, and iodide salts are soluble, except for silver, lead (II), and mercury (II).

Sulfate salts are soluble (except $BaSO_4$, $PbSO_4$, Hg_2SO_4, $CaSO_4$).

Most OH^- are only slightly soluble (NaOH, KOH are soluble, $Ba(OH)_2$, $Ca(OH)_2$ are marginally soluble).

Most S^{2-}, CO_3^{2-}, CrO_4^{2-}, PO_4^{3-} salts are only slightly soluble, except for those containing Group 1 cations.

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5. Solubility Check!

A. Would nickel carbonate dissolve, or form a solid in water?

B. Will KCl dissolve, or remain solid in water?

C. Will CuS be aqueous or solid in water?

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6. Solubility Demo.

Calcium chloride and sulfuric acid solutions react in a double replacement reaction, forming a precipitate. Write and balance the reaction, THEN determine which product is the precipitate using your table.

$$\_\_CaCl_{2(aq)} + \_\_H_2SO_{4(aq)} \longrightarrow \_\_\_HCl + \_\_CaSO_4$$

$$CaCl_2 + H_2SO_4 \longrightarrow 2\ HCl + CaSO_4$$

From your table, calcium sulfate is insoluble:

$$CaCl_{2(aq)} + H_2SO_{4(aq)} \longrightarrow 2\ HCl_{(aq)} + CaSO_{4(s)}$$

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Homework

Read 4.5 - 4.7

Problems in your Booklet
Due: Next Class.

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