Chemical Reactions and Equations

Plan

- States of Matter + solubility
- Chemical Equations
- Balancing equations
- Types of reactions

Program of Studies

2 f) predict whether an ionic compound is relatively soluble in water, using a solubility chart.

3) Identify and classify chemical changes, and write word and balanced chemical equations for significant chemical reactions, as applications of Lavoisier's law of conservation of mass

3 c) c) describe evidence for chemical changes; i.e., energy change, formation of a gas or precipitate, colour or odour change, change in temperature

States of Matter

- Going forward, we will need to specify states of matter when we write formulas
- We looked at 4 main types (s, l, g, aq)

- When we write out reactions, we will need to determine the components.

States of Matter

- Most compounds we will see are solid or aqueous. We will learn some ways to tell if things are liquids or gases

- Our main job is to tell if something is aqueous or solid (whether it dissolves in water)

Solubility of Some Common Ionic Compounds in Water at 298.15 K

Ion	Group 1 ions NH_4^+ NO_3^- ClO_3^- ClO_4^- CH_3COO^-	F^-	Cl^- Br^- I^-	SO_4^{2-}	CO_3^{2-} PO_4^{3-} SO_3^{2-}	IO_3^- $OOCCOO^{2-}$	OH^-
Solubility greater than or equal to 0.1 mol/L (aq) **(very soluble)**	most	most	most	most	Group 1 ions NH_4^+	Group 1 ions NH_4^+ $Co(IO_3)_2$ $Fe_2(OOCCOO)_3$	Group 1 ions NH_4^+ Sr^{2+}
Solubility less than 0.1 mol/L **(slightly soluble)** (s)	$RbClO_4$ $CsClO_4$ $AgCH_3COO$ $Hg_2(CH_3COO)_2$	Li^+ Mg^{2+} Ca^{2+} Sr^{2+} Ba^{2+} Fe^{2+} Hg_2^{2+} Pb^{2+}	Cu^+ Ag^+ Hg_2^{2+} Pb^{2+} Tl^+	Ca^{2+} Sr^{2+} Ba^{2+} Ag^+ Hg_2^{2+} Pb^{2+} Ra^{2+}	most	most	most

Note: This solubility table is only a guideline that is established using the K_{sp} values. A concentration of 0.1 mol/L corresponds to approximately 10 g/L to 30 g/L depending on molar mass. Hg_2^{2+} is a polyatomic ion of mercury.

States of Matter

- A solubility table is on the 5th page of your data booklet

- We can use it to tell whether something is soluble or not!

Using a Solubility Table

- NaCl

1) Find the non-metal in top row
2) Move down the chart and find the metal
3) Move left to see the solubility

- HgCl

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Find the solubility of the following:

NH_4F

KNO_3

$Ca(OH)_2$

MgS

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Hints for determining state

- Large molecular compounds are usually solid (like sucrose, $C_{12}H_{22}O_{11(s)}$), medium are liquid (ethanol, $C_2H_5OH_{(l)}$), small ones are gases (methane, CH_4)

- Some compounds you've seen in daily life, and you know the state at room temperature. Think sugar, salt, hydrogen peroxide, oils, etc.
- Try and practice! The more you do it, the more you'll remember!

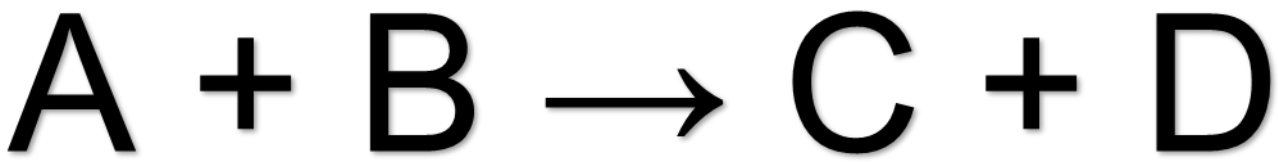
Chemical Equations

- One of the main things we will study in chemistry is chemical reactions
- We use chemical equations to show our reactions

$$C + O_2 \rightarrow CO_2$$

Chemical Equations

- There are three things needed in a chemical equation



Reactants

"Forms" arrow

Products

Conservation of Mass

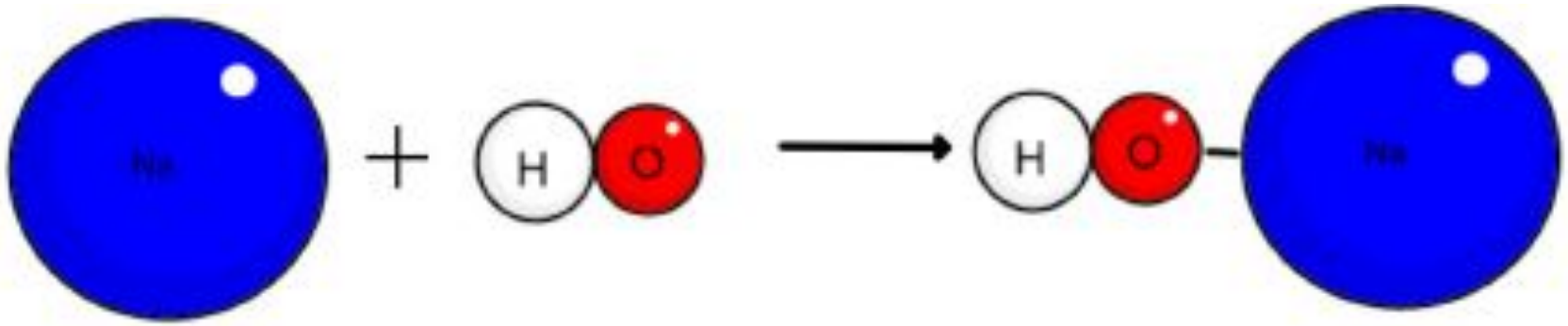
- Properly written chemical equations obey **Lavoisier's Law of Conservation of Mass:**
- **"During a chemical change, matter is neither created nor destroyed"**

- In other words, **the amount of reactants must equal the amount of products in a chemical reaction**

Conservation of Mass

- Let's look at an example, with sodium hydroxide

$$Na^+ + OH^- \rightarrow NaOH$$



- We have three atoms on each side of the equation. Our number of atoms is conserved, the same before and after the reaction

Conservation of Mass

- Second example, magnesium nitrite

$$Mg + NO_2 \rightarrow Mg(NO_2)_2$$

Our reactants have fewer atoms than our products

We need to “balance” our equation

Conservation of Mass

- Let's balance our equation

$$\_\_\_Mg + \_\_\_NO_2 \rightarrow \_\_\_\_Mg(NO_2)_2$$

What about another?

$$\_\_H_2 + \_\_\_\_O_2 \rightarrow \_\_\_\_H_2O$$

Conservation of Mass

- One tricky example

$$\_\_\_Fe + \_\_\_\_O_2 \rightarrow \_\_\_\_Fe_2O_3$$

This one is more difficult because there are 2 O on the left and 3 on the right. We need to use common multiples

Conservation of Mass

- One tricky example

$$\_\_\_Fe + \_\_\_\_O_2 \rightarrow \_\_\_\_Fe_2O_3$$

This one is more difficult because there are 2 O on the left and 3 on the right. We need to use common multiples

Balancing

- When we correctly balance an equation, there will be the same number of atoms on each side of the arrow

We can follow some simple steps!

- $\_\_\_CuCl_2 + \_\_\_Fe \rightarrow \_\_\_Cu + \_\_\_FeCl_3$

Step 1: Make a list of all atoms present

Step 2: Start to place numbers (**coefficients**) in front of products and reactants. Go one atom at a time

Write in pencil. Trial and Error is okay!

- $\_\_\_CuCl_2 + \_\_\_Fe \rightarrow \_\_\_Cu + \_\_\_FeCl_3$

$\_\_\_CuCl_2 + \_\_\_Fe \rightarrow \_\_\_Cu + \_\_\_FeCl_3$

Be Careful when counting atoms in compounds. This is where our brackets are important

$Mg(OH)_2$

How many oxygens and hydrogens?

$Ca(NO_3)_2$

How many nitrogens and oxygens?

Chemical Reactions

- How do we know when a chemical reaction has occurred?

- From Science 9, we learned ways to tell whether something has changed chemically, or if it just changed physically

Chemical Changes

- In a chemical change, the compounds we started with have changed into new compounds
  - Heat or light can be given off
  - Gas can be produced (bubbles)
  - Precipitate can form (solid that separates from a solution)
  - Colour can change
  - Odour can change

Physical Changes

- Some processes can occur that don't result in a chemical change
- The compounds we started with are the same, they just might be in a different form. We can usually go back to the original form
  - Phase Changes (change of state e.g. melting, evaporating)
  - Dissolving
  - Change in texture, size, volume, mass, weight, or density

Energy Changes

- When different processes occur, energy can be absorbed or released

- This energy can take the form of heat, light, sound, or in some cases electricity.

Exothermic Changes

- **Exothermic reactions** release energy in the form of heat, light, sound or electricity

  - **Combustion**
  - **Diluting Acids**
  - **Cellular respiration (how cells make energy)**

Endothermic Changes

- **Endothermic reactions** absorb energy, usually in the form of heat, or light

  - **Chemical Cold packs (dissolving)**
  - **Neutralizing acids/bases**
  - **Photosynthesis (how plants make sugar)**

Types of Reactions

In Science 10, we will learn 5 types of reactions:

1. **Simple Composition (SC) or Formation (F).** Two elements combine to form a compound

$$2Na_{(s)} + Cl_{2(aq)} \rightarrow 2NaCl_{(aq)}$$

Types of Reactions

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Types of Reactions

2. Simple Decomposition (SD): A compound decomposes into its two elements

$$2HgO_{(s)} \rightarrow 2Hg_{(l)} + O_{2(g)}$$

Replacement Reactions

3. Single Replacement (SR): An element and compound react to form a different element and compound

$$Zn_{(s)} + Cu(NO_3)_{2(aq)} \rightarrow Zn(NO_3)_{2(aq)} + Cu_{(s)}$$

Replacement Reactions

4. Double Replacement (DR): Two compounds form two new compounds

$$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + HOH_{(l)}$$

Combustion Reactions

5. Hydrocarbon Combustion (HC): A hydrocarbon reacts with oxygen gas to form carbon dioxide gas and water vapor

$$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$$

- Note: any other reaction can be classified with “O” for “other”

Reactions

Practice: Balance the following, ignore states of matter (for now). Indicate the type (SC, SD, SR, DR, HC, O) of reaction

1) $\_\_C_3H_8 + \_\_ O_2 \rightarrow \_\_ CO_2 + \_\_ H_2O$

2) $\_\_Al + \_\_ Fe_3N_2 \rightarrow \_\_ AlN + \_\_ Fe$

3) $\_\_ Na + \_\_ Cl_2 \rightarrow \_\_ NaCl$

Reactions

1. $\_\_H_2O_2 \rightarrow \_\_H_2O + \_\_O_2$

2. $\_\_C_6H_{12}O_6 + \_\_O_2 \rightarrow \_\_H_2O + \_\_CO_2$

3. $\_\_CO_2 + \_\_H_2O \rightarrow \_\_C_6H_{12}O_6 + \_\_O_2$

4. $\_\_NaClO_3 \rightarrow \_\_NaCl + \_\_O_2$

Equations with only one side

Now that we know the five types of reactions, we can predict unknown products!

$$Mg_{(s)} + O_{2(g)} \rightarrow \_\_\_\_\_$$

We have 4 steps: