Auburn Mountainview

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Chemical Equations

By end of this lesson, I can…

MS1: write a balanced chemical equation.

MS2: write a balanced net ionic equation.

MS3: identify the reaction type of a chemical equation.

MS4: predict whether a replacement reaction will take place.

MS5: identify and predict reaction states: Solid, Liquid, Gas, Aqueous.

AB1: I can identify and describe the differences of acids and bases.

AB2: I can identify the reactions of acids and bases by the various acid/base definitions.

AB3: I can calculate a compounds acidity/basicity using the pH scale.

What equations show

- **Chemical Reaction**: Process in which one or more substances are converted into new substance(s) with different physical and chemical properties.
  - **Reactant**(s): the chemical(s) being introduced in the reaction.
  - **Product**(s): the chemical(s) being produced by the reaction.

What equations show

- As in the last unit Chemical Compounds can not be altered.
  - Ex: H_2SO_4: ~~H_4SO_4~~, ~~$H_22(SO_4)$~~, $2H_2SO_4$ ✓
- Chemical reactions must be balanced. (conservation of matter)
  - All individual elements on the reactant side must be present on the product side in the same quantities.
  - Ex: $2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$

Review: Balancing

$$2KCl \rightarrow 2K + Cl_2$$

2 ~~1~~ K ~~1~~ 2

2 ~~1~~ Cl 2

$$2Ba(NO_3)_2 + K_4PO_4 \rightarrow 4KNO_3 + Ba_2PO_4$$

2 ~~1~~ Ba 2

4 ~~2~~ NO_3 ~~1~~ 4

4 K ~~1~~ 4

1 PO_4 1

Signs and terms

Yields: 

Heat is added: 

Reaction is reversible:  or 

States of Matter:

$X_{(g)}$: Gas $X_{(l)}$: Liquid $X_{(s)}$: Solid

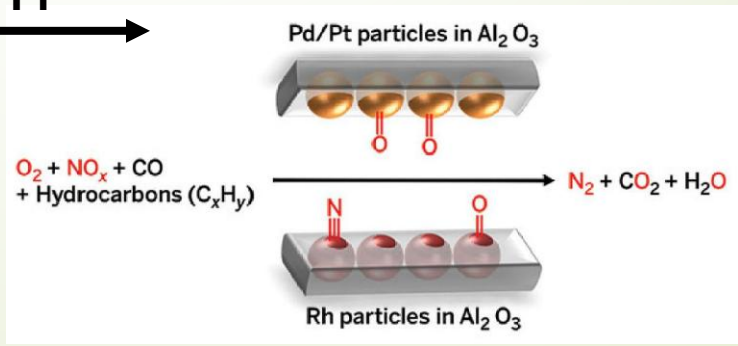
$X_{(aq)}$: Aqueous (dissolved in water)

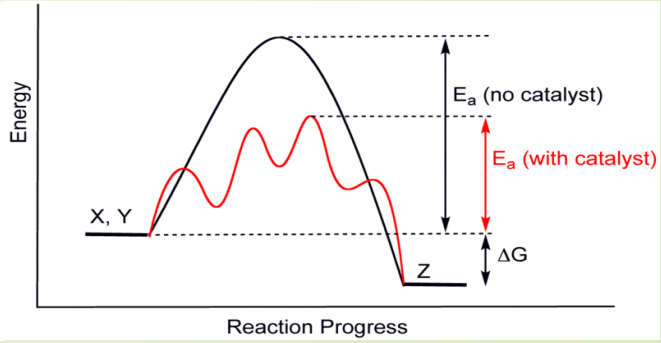
Diatomic Element: Molecule comprised of only one type of element: Back of Ion Chart

(H_2, O_2, N_2, F_2, Cl_2, I_2, Br_2, At_2, P_4, S_8)

Signs and terms

- •: Is used to show the presence of two chemicals without caring about the bonds.
  - Hydrates: While forming a solid some salts incorporate water in them. Boiling the water off (anhydrous) does not change the chemical properties.
- Catalyst: Things that increase the rate of a reaction without being consumed by it.
  - Ex for Platinum: $\xrightarrow{Pt}$





Types of Reactions (I)

- Synthesis (Direct Combination)

$$A + B \rightarrow C$$

  - Two or more reactants that combine to form a more complex product.

Ex: $Pb_{(s)} + O_{2(g)} \rightarrow PbO_{2(s)}$

Lead reacts with Diatomic Oxygen to form Lead (IV) Oxide. (Basic oxidation reaction.)

Types of Reactions (II)

- **Decomposition:**

$$A \rightarrow B + C$$

  - A reactant that breaks down to form two or more products.

$$\text{Ex: } KClO_{3(s)} \xrightarrow{\Delta} KClO_{(s)} + O_{2(g)}$$

When heated Potassium Chlorate decomposes into Potassium Hypochlorite and Oxygen Gas. (Thermolytic)

Types of Reactions (III)

- (Single) Replacement:

$$A + BX \rightarrow AX + B$$

  - The more active element/compound takes the place of another element/compound.

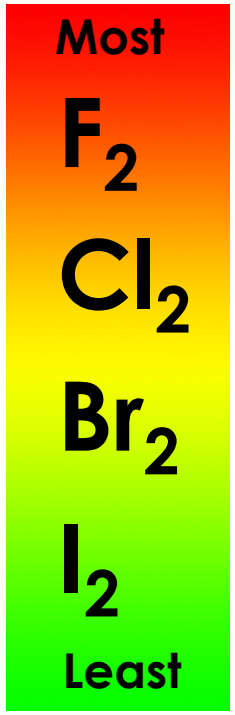
Ex: $Fe_{(s)} + CuSO_{4(aq)} \rightarrow FeSO_{4(aq)} + Cu_{(s)}$

Iron and Copper (II) Sulfate will form Iron (II) Sulfate and Copper Dendrites. (Basic replacement reaction.)

Metal Reactivity :SR

- A metal will replace a metal in an ionic compound if it is more reactive.
  - A list of metals can be found on the ion chart.
    - Back, Top Left.
- Ex: Na + $HgNO_3$ → Will it React?
  - Na is higher on the series so yes it will.
  - Answer: Na + $HgNO_3$ → Hg + $NaNO_3$
- Ex: Ni + CaO → Will it React?
  - Ni is lower on the series so no reaction.
  - Answer: Won't React (or )

Halogen Reactivity Series



Ex: $2NaI + Cl_2 \longrightarrow 2NaCl + I_2$

$NaF + Br_2 \longrightarrow$ will not react

Reduction Oxidation

- Redox: Looking at a typical SR reaction an ionic metal became pure or an ionic metal became pure.
  - Reduction: any atom, molecule, ion that gains e^-.
  - Oxidation: any atom, molecule, ion that loses e^-.

$$2K_{(s)} + Na_2SO_{4(aq)} \rightarrow 2Na_{(s)} + K_2SO_{4(aq)}$$

- Broken down:

$$2K \rightarrow 2K^+ + 2e^- \text{ (Potassium was oxidized)}$$

$$2Na^+ + 2e^- \rightarrow 2Na \text{ (Sodium was reduced)}$$

$$2K + 2Na^+ \rightarrow 2Na + 2K^+$$

- To Remember : Leo to Lion says Ger.
  - Loses Electron: Oxidation, Gains Electron: Reduction
  - Oil Rig is another mnemonic.

Types of Reactions (IV)

- (Ionic) Double-Replacement:

$$AX + BY \rightarrow AY + BX$$

  - When two compounds interact in an aqueous solution to form a precipitate, gas, or water/non-ionized substance.

Ex: $NaCl_{(aq)} + AgNO_{3(aq)} \rightarrow NaNO_{3(aq)} + AgCl_{(s)}$.

(**Precipitate** is formed)

Ex: $2HCl_{(aq)} + FeS_{(aq)} \rightarrow FeCl_{2(aq)} + H_2S_{(g)}$

(Gas is formed)

Ex: $HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

(Liquid is formed)

Solubility Rules

- Ionic Bonds not in the presence of water are solid.
- Ionic Solutions are mixed to see if a reaction happens
- Many Double Replacement reactions form a precipitate.
- Rules may be found on the back of the Ion Chart.
  - This is only for Ionic bonds in a DR or SR reaction.
  - All rules must be processed in order.
  - Soluble = (aq), Insoluble = (s)
- If both products are (aq) then the reaction does not happen.

Net Equations/Spectator Ions

- Spectator ions are ions that don't participate in the reaction (they stay aqueous).
  - Look at this reaction:

    $NaCl_{(aq)} + AgNO_{3(aq)} \rightarrow NaNO_{3(aq)} + AgCl_{(s)}$
  - Notice the Na^+ and NO_3^- parts are always aqueous.
  - They just go along for the ride… (Spectators).
- You can rewrite the equation in Net Ionic Form.

  $Cl^-_{(aq)} + Ag^+_{(aq)} \rightarrow AgCl_{(s)}$

Spectator Ions/Net Equations

- What is the Net Equation for the following?

  $Mg(ClO_3)_2 + K_2O \rightarrow KClO_3 + MgO$

- First Balance and then add Phase States

  $Mg(ClO_3)_{2(aq)} + K_2O_{(aq)} \rightarrow 2KClO_{3(aq)} + MgO_{(s)}$

- Highlight the non (aq) and its reactant parts.

  $Mg(ClO_3)_{2(aq)} + K_2O_{(aq)} \rightarrow 2KClO_{3(aq)} + MgO_{(s)}$

- Rewrite: If the ion is separated add the correct charge back.

$$Mg^{2+}_{(aq)} + O^{2-}_{(aq)} \rightarrow MgO_{(s)}$$

Spectator Ions/Net Equations

- **What is the Net Equation for the following?**

$$SnI_4 + Pb(NO_3)_2 \rightarrow Sn(NO_3)_4 + PbI_2$$

$$SnI_{4(aq)} + 2Pb(NO_3)_{2\,(aq)} \rightarrow Sn(NO_3)_{4\,(aq)} + 2PbI_{2(s)}$$

$$SnI_{4(aq)} + 2Pb(NO_3)_{2\,(aq)} \rightarrow Sn(NO_3)_{4\,(aq)} + 2PbI_{2(s)}$$

$$4I^{1+}_{(aq)} + 2Pb^{2-}_{(aq)} \rightarrow 2PbI_{2(s)}$$

Two Special Cases

- Combustion
  - Hydrocarbons ($C_xH_{y\ or\ (2x+2)}$) reaction to O_2 (burning) will produce CO_2 and water vapor.

$$C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(g)}$$

- Neutralization (A special DR)
  - Acids and Bases form a salt and water.

$$HF_{(aq)} + KOH_{(aq)} \rightarrow KF_{(aq)} + H_2O_{(l)}$$

- General Thought : Anytime H_2O is produced pay special attention.

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Defining Acids/Bases: Arrhenius

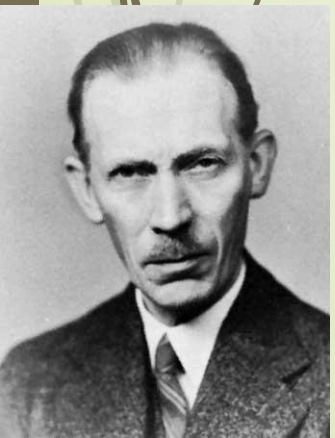
- In 1884 Swedish chemist Svante Arrhenius came up with a definition for acids/bases.
  - An acid is a substance that dissociates in water to produce Hydrogen ions (increases H^+).
  - Bases are substances that dissociates in water to produce ions (increases OH^-).
  - Mixing together results in neutralization.

$$\text{Acid} + \text{Base} \rightarrow \text{Salt} + \text{Water}$$

- Problems with the Arrhenius Definition
  - This only explains water reactions.
  - Certain bases do have an OH^- anion.
    - This is a simplification (does not explain NH_3).

Defining Acids/Bases: Brønsted-Lowry

- Brønsted-Lowry (1923) explains reactions that occur in non-water solutions and in other phases.
  - An acid is any substance that can donate H^+ ions.
  - A base is any substance that can accept H^+ ions.
- This expands the last definition in two ways
  - Defines acids and bases independently from water.
  - It focuses only on the H^+ ions (not the OH^- ions).



Defining: Strong and Weak

- Strong acid/bases are compounds that completely break up in water. For example, mixing a 1-mol/L of:
  - HCl will cause nearly all of the H^+ ions to disassociate.

$$HCl_{(g)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$$

  - HF would only disassociate about 8.1%.

$$CF_{(l)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + F^-_{(aq)}$$

- $H_3O^+_{(aq)}$ is called a Hydronium ion.
- While HF is a weak acid it very reactive. (can not be stored in glass)

Common Strong Acids	
Chloric Acid	$HClO_3$
Hydrobromic Acid	HBr
Hydrochloric Acid	HCl
Hydroiodic Acid	HI
Nitric Acid	HNO_3
Perchloric Acid	$HClO_4$
Sulfuric Acid	H_2SO_4

Common Strong Bases	
Lithium Hydroxide	LiOH
Sodium Hydroxide	NaOH
Potassium Hydroxide	KOH
Cesium Hydroxide	CsOH
Calcium Hydroxide	$Ca(OH)_2$
Strontium Hydroxide	$Sr(OH)_2$
Barium Hydroxide	$Ba(OH)_2$