TYPES OF CHEMICAL REACTIONS

http://www.youtube.com/watch?v=tE4668aarck&feature=related

The Five Major Class of Chemical Reaction

http://www.youtube.com/watch?v=i-HHvx1VC_8

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Six Types of Reaction

1) $E + E \rightarrow$ Compound — Formation

2) $C \rightarrow E + E$ ...etc — Decomposition

3) $E + C \rightarrow E + C$ — Single Replacement

4) $C + C \rightarrow C + C$ — Double Replacement

$A + B \rightarrow$ water + salt — Neutralization

5) $C_xH_y + O_2 \rightarrow CO_2 + H_2O$ — Combustion

6) $C_xH_y + O_2 \rightarrow C + CO + CO_2 + H_2O$ — Incomplete combustion

TYPES OF CHEMICAL REACTIONS

Reactions can be classified according to different types.

1. **Synthesis (*Formation, Composition)***

- 2 elements (or 2 compounds) react to produce a single compound
- states of reactants and products: usually all pure substances except acids (aq)
- can usually predict product

Element + element → compound
A + B → AB
Where A and B are atoms and /or molecules and AB is a larger molecule.

Reactants → products

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Examples:

a) magnesium reacts with oxygen from the air

$Mg_{(s)} + O_{2(g)} \rightarrow Mg^{2+} O^{2-}$

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

Formation

b) hydrogen and oxygen react to produce water

$2\,H_{2(g)} + O_{2(g)} \rightarrow 2\,H_2O_{(\ell)}$

Formation

c) Aluminum reacts with nitrogen to produce compound. Ionic

$Al_{(s)} + N_{2(g)} \longrightarrow Al^{3+} N^{3-}$

$2Al_{(s)} + N_{2(g)} \rightarrow 2AlN_{(s)}$

Formation

2. Decomposition

- A single compound is broken down (decomposed) into 2 or more products (elements &/or compounds)
- states of reactants and products: usually all pure substances except acids (aq)
- can usually predict products
- most require energy as heat, light or electricity

Compound → two or more elements or compounds

AB → A + B

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Examples:

a) mercury(II)oxide decomposes

$Hg^{2+}\ O^{2-}$

$2\,HgO_{(s)} \longrightarrow 2Hg_{(\ell)} + O_{2(g)}$

decomp

b) water is broken down into its elements

$2\,H_2O_{(\ell)} \rightarrow 2H_{2(g)} + O_{2(g)}$

Decomposition.

Single Displacement (*Single Replacement)*

- An element and a compound react to produce a new element and new compound
- Metal elements replace the cation: metal ions in ionic compounds or H^+ ions in acids or water
- Nonmetal elements replace the anion: nonmetal ions in ionic compounds

States of reactants and products

-Metal elements: all pure substances (solid except for mercury, $Hg_{(l)}$).

- Nonmetal elements: all pure substances (solid, liquid or gas).

- Compound reactants: usually aqueous solution (aq) or water, **$HOH_{(l)}$**

-Compound products: if **ionic**, use solubility chart on back of periodic table

a) If compound is high solubility = aqueous (aq)

b) If compound is low solubility = solid (s)

products

products

C + E → C + E

Generally single displacement reactions follow the pattern,
element + compound → compound + element
Z + AB → ZB + A Where Z is a metal.

Or
element + compound → compound + element
Y + AB → AY + B Where Y is a nonmetal

Ex1: potassium + calcium iodide → calcium + potassium iodide
Z + AB → A + ZB
Ex2: Bromine + calcium iodide → iodine + calcium bromide
Y + AB → B + AY

How do we decide which element is displaced? Generally, metals replace metals and nonmetals replace nonmetals. In the example above, iodine replaced bromine (both nonmetals).

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Examples:

a) mercury and silver nitrate solution react → a compound dissolve in water.

$Hg_{(s)} + Ag^{+}NO_3^{-}{}_{(aq)} \rightarrow Ag_{(s)} + Hg^{2+}NO_3^{-}{}_{(aq)}$

$Hg_{(s)} + 2AgNO_{3(aq)} \rightarrow 2Ag_{(s)} + Hg(NO_3)_{2(aq)}$

S.R

b) zinc reacts with sulfuric acid

SO_4^{2-}

$Zn_{(s)} + H^{+}SO_4^{2-}{}_{(aq)} \rightarrow H_{2(g)} + Zn^{2+}SO_4^{2-}{}_{(aq)}$

$Zn_{(s)} + H_2SO_4{}_{(aq)} \rightarrow H_{2(g)} + ZnSO_{4(aq)}$

SR

S.R

c) calcium reacts with water

$Ca_{(s)} + H^{+1}OH^{-}_{(l)} \rightarrow H_{2(g)} + Ca^{2+}OH^{-}$

$Ca_{(s)} + 2HOH_{(l)} \rightarrow H_{2(g)} + Ca(OH)_{2(s)}$

S.R

d) chlorine reacts with sodium bromide solution

$Cl_{2(g)} + Na^{+}Br^{-}_{(aq)} \rightarrow Br_{2(l)} + Na^{+}Cl^{-}_{(aq)}$

$Cl_{2(g)} + 2NaBr_{(aq)} \rightarrow Br_{2(l)} + 2NaCl_{(aq)}$

S.R

e) nitrogen reacts with magnesium bromide solution

$N_{2(g)} + Mg^{2+}Br^{-}_{(aq)} \rightarrow Br_{2(l)} + Mg^{2+}N^{3-}_{(s)}$

$N_{2(g)} + 3MgBr_{2(aq)} \rightarrow 3Br_{2(l)} + Mg_3N_{2(s)}$

S.R

Double Displacement (*Double Replacement)*

- Usually 2 ionic compounds in aqueous solution are reacting
- Products may be one or more of:

-Low solubility, therefore forms a precipitate (solid)- use solubility table
- A gas (that bubbles out of the mixture)
- A molecular compound such as water ($HOH_{(l)}$)

compound +compound →compound + compound

AB + XY → AY + XB

Where A and X are metals and B and Y are nonmetals

Example: Write the balanced chemical equation for the word equation given:

Potassium sulfate + copper(II)bromide →copper (II) sulfate + potassium bromide

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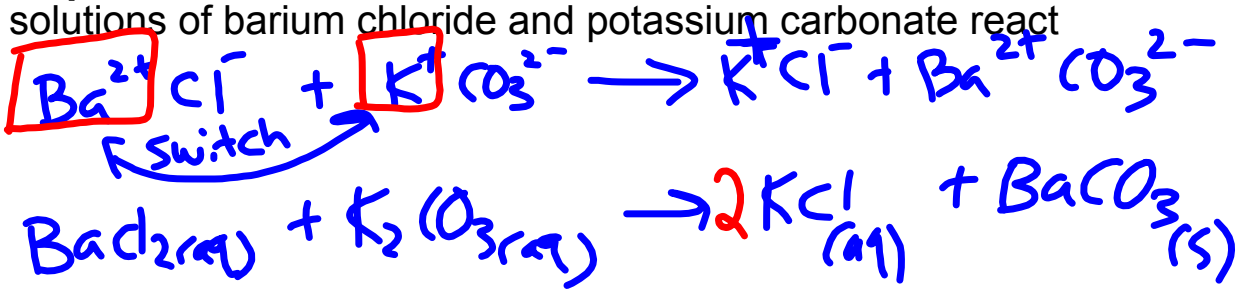
Examples:

a) solutions of barium chloride and potassium carbonate react



$BaCl_{2(aq)} + K_2CO_{3(aq)} \rightarrow 2KCl_{(aq)} + BaCO_{3(s)}$

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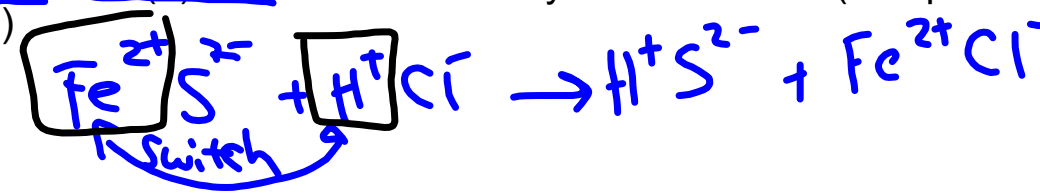
b) solid iron(II)sulfide reacts with hydrochloric acid (one product is a gas)



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

D.R

5. **Neutralization** (Double Replacement)

A neutralization reaction occurs between an acid and a base. The products of such a reaction are a salt and water. *

Salt: Ionic compound that is produced by the reaction of an acid with a base.

Acid + Base → Salt + Water

An an acid is added to a basic solution, the base is gradually consumed.

When all the base has reacted, the result is a neutral solution of a salt and water. The solution is neither acidic or basic. Any additional acid will make the solution acidic.

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Examples: Write the chemical equation for the following:

a) the reaction between hydrochloric acid and sodium hydroxide.

$H^+Cl^- + Na^+OH^- \rightarrow Na^+Cl^- + H^+OH^-$ (switch)

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

b) The reaction between sulfuric acid and sodium hydroxide.

$H^+SO_4^{2-} + Na^+OH^- \rightarrow Na^+SO_4^{2-} + H^+OH^-$ (switch)

$H_2SO_{4(aq)} + 2NaOH_{(aq)} \rightarrow Na_2SO_{4(aq)} + 2HOH_{(l)}$

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Examples of neutralization reactions:

- Oven cleaner
- Baking (baking soda + acids → CO_2 bubbles which get trapped in batter causing it to rise)
- Antacids (neutralize stomach acid)
- Swimming pools
- Soda-acid fire extinguishers

($H_2SO_{4(aq)} + 2NaHCO_{3(s)} \rightarrow Na_2SO_{4(aq)} + 2CO_{2(g)} + 2H_2O_{(l)}$

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6. Combustion

What is complete combustion?

It is the rapid reaction of a substance with oxygen to produce compounds called oxides. More commonly referred to as burning.

Generally,

Hydrocarbon + oxygen → carbon dioxide + water vapor + energy

$C_xH_y + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(g)} + E$

(exothermic reaction)

-Energy produced is in the form of heat or light.

-Fuels used in our society are mainly hydrocarbons (gas, kerosene, candles, etc.)

propane

-Because of the high heat involved water is produced as a gas. Also, CO_2 is produced in such large amounts it is a contributor to the greenhouse effect.

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Note: In balancing hydrocarbon combustion reactions, it is easiest to balance the C and H atoms first and the oxygen last.

Examples

a) Combustion of propane, $C_3H_{8(g)}$.

burning

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

combustion

6-0 4-0

10 - 0

b) Butane, $C_4H_{10(g)}$ is burned as fuel in a lighter

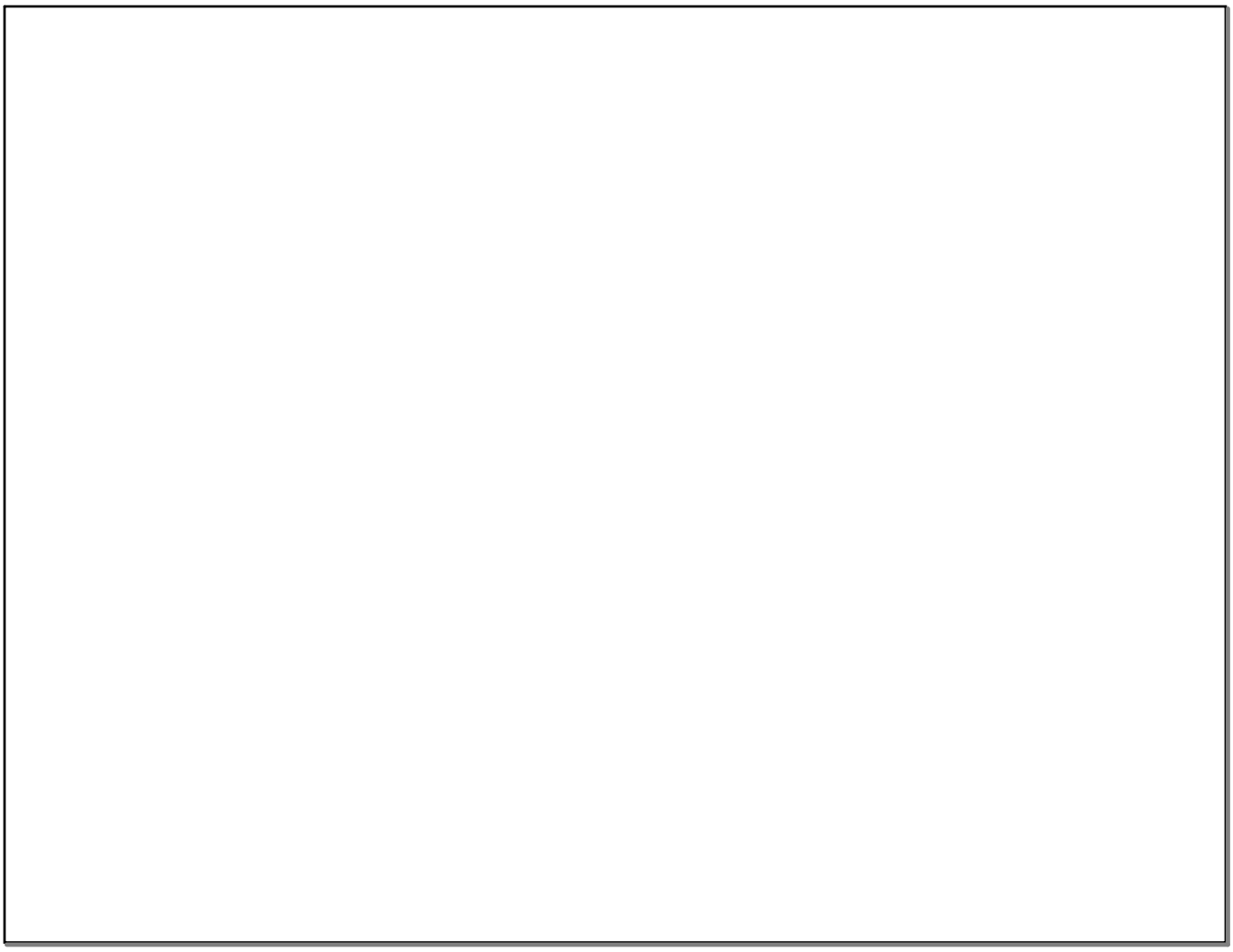
$2C_4H_{10(g)} + 13O_{2(g)} \rightarrow 8CO_{2(g)} + 10H_2O_{(g)}$

16-0 10-0

c) A candle, assume $C_{25}H_{52(s)}$, combusts in the presence of oxygen

$C_{25}H_{52(s)} + 38O_{2(g)} \rightarrow 25CO_{2(g)} + 26H_2O_{(g)}$

50 26



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Incomplete combustion

This occurs when not enough oxygen is available. In this case the products are carbon monoxide (CO - an extremely poisonous gas), carbon (C), carbon dioxide (CO_2), and water (H_2O). Incomplete combustion does not generate as much heat energy as complete combustion.

Example: Incomplete combustion of $C_3H_{8(g)}$

$$1\,C_3H_{8(g)} + \frac{7}{2}\,O_{2(g)} \rightarrow 1\,CO_{(g)} + 1\,C_{(s)} + 1\,CO_{2(s)} + 4\,H_2O_{(g)}$$

$$2\,C_3H_{8(s)} + 7\,O_{2(g)} \rightarrow 2\,CO_{(g)} + 2\,C_{(s)} + 2\,CO_{2(g)} + 8\,H_2O_{(g)}$$

Incomplete combustion of $C4H8_{(g)}$

$$1\,C_4H_{8(g)} + 4\,O_{2(g)} \rightarrow 2\,CO_{(g)} + 1\,C_{(s)} + 1\,CO_{2(g)} + 4\,H_2O_{(g)}$$

Fire Water Balloon - Cool Science Experiment

http://www.youtube.com/watch?v=qeDZQ9-gsjY&feature=channel

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REACTION TYPES - GENERALIZATIONS

REACTION TYPE	GENERALIZATION	STATES
Formation (Synthesis)	2 elements (or 2 cpds) → single cpd	all pure substances
Decomposition	single cpd → 2 or more products	all pure substances (elements &/or cpds)
Single Displacement	element + cpd → element + cpd	pure elements, $HOH_{(l)}$ or aqueous reactants, *s or aq products
Double Displacement	2 cpds → 2 new cpds	aq reactants, $HOH_{(l)}$ *s or aq products
Complete Hydrocarbon Combustion	$C_xH_y + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(g)}$	

***Use the solubility chart to predict the state (aqueous or solid) of ionic** products of displacement reactions.

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NOTE:

1. Write water as **HOH** in displacement reactions and as **H_2O** in other types.

2. All metallic elements are **monatomic**. Eg. $Na_{(s)}$ $Pb_{(s)}$ & all are **solid**, except $Hg_{(l)}$.

3. Some nonmetallic elements are **diatomic** ie. The "HONorable Halogens"

$H_{2(g)}$ $O_{2(g)}$ $N_{2(g)}$ $F_{2(g)}$ $Cl_{2(g)}$ $Br_{2(l)}$ $I_{2(s)}$

P_4 S_8

4. All pure ionic compounds are **solids.**

5. Some pure molecular compounds are **gases**. Eg. NH_3 H_2S HCl and Nonmetal oxides of C, N, and S ie. CO_2 CO SO_2 SO_3 NO NO_2 N_2O

6. In Single Displacement Reactions:
- metal elements replace metal ions in ionic compounds or H in acids or water
- nonmetal elements replace nonmetal ions in ionic compounds

7. In ionic compounds always write the cation (metal or ammonium ion) **first** in the chemical formula.

8. Some molecular elements: phosphorus = $P_{4(s)}$ sulfur = $S_{8(s)}$

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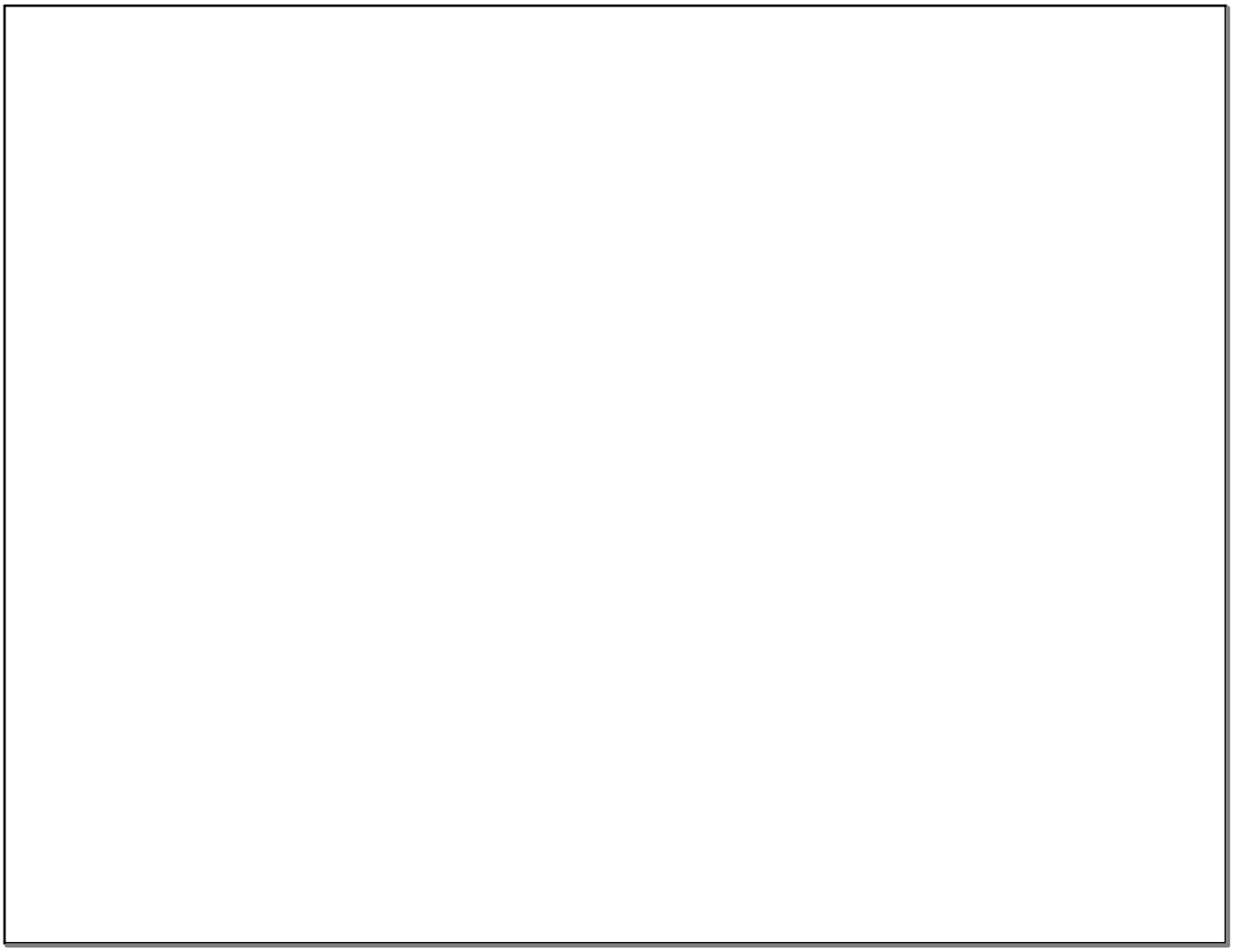

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