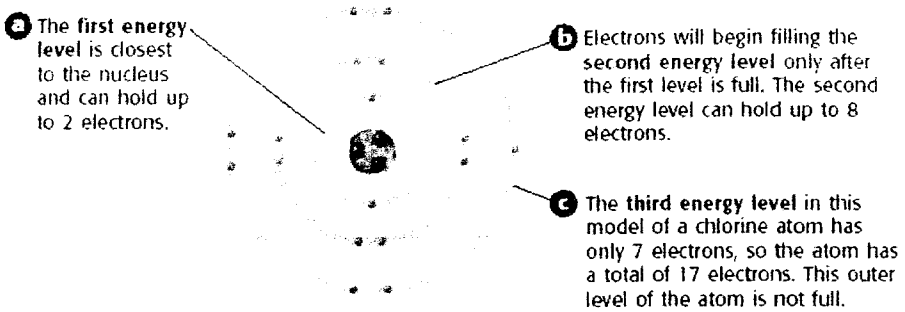
# I ELECTRONS AND CHEMICAL BONDING:

## A. Combining Atoms Through Chemical Bonding:

1. Chemical bonding is the joining of atom to form new substances.
2. The properties of the new substances are different.
3. An interaction that holds 2 atoms together is called a chemical bond.

## B. Electron Number and Organization:

1. Remember,,,atoms have no charge, so the atomic number also is the number of electron.
2. Only electrons in the outer energy level make chemical reactions.
3. Electrons in the outer energy level are called valence electrons.




## C. To Bond or Not to Bond:

1. The number of electrons in the outer level determine whether the atom bonds.

2. Atoms that have 8 valence electrons do NOT bond!
3. Atoms bond by gaining, losing, or sharing electrons to have a full outer energy level.

## II IONIC BONDS:

### A. Forming Ionic Bonds:

1. An ionic bond forms when electrons are transferred from one atom to another.
2. During IONIC bonding, 1 or more valence electrons are transferred.
3. When an atom gains or loses an electron it is no longer neutral, instead it is charged.
4. An atom that has a charge is called an ion.

### B. Forming Positive Ions:

1. An atom that loses an electron becomes positive because now it has fewer electrons than protons.
2. Metals have few valence electrons, so they lose them easily.

### B. Forming Negative Ions:

1. An atom that gains an electron becomes negative because now it has more electrons than protons.
2. Nonmetals have an almost full outer energy level, so they tend to gain electrons to get a full outer shel'

C. Gain or Lose?:

use p. table

| Element | Metal (M) Nonmetal (N) | Electrons in outer shell | Lose or Gain Electrons? |
|---|---|---|---|
| OXYGEN | N | 6 | gain |
| GOLD | M | 1 | lose |
| BROMINE | N | 7 | gain |
| IRON | M | 2 | lose |
| PHOSPHORUS | N | 5 | gain |

D. Ionic Charge Practice:

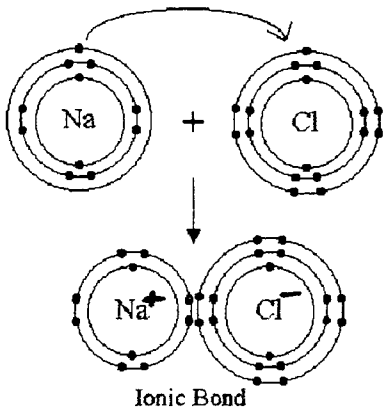
| Element | Metal or Nonmetal | # of e's in last shell | Gain or Lose? | Ion Charge |
|---|---|---|---|---|
| Nickel | M | 2 | lose | + |
| Iodine | N | 7 | gain | − |
| Sulfur | N | 6 | gain | − |
| Cesium | M | 1 | lose | + |

E. Ionic Compounds:

1. When ionic bonds form, the # of electrons lost by the metal atoms equals the number gained by the nonmetal atoms.

2. The compound is now formed because the charges of the ions cancel each other.

   a. The ions stay together because opposites attract !!



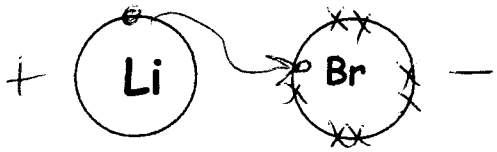
Ionic Bond

b. Ionic compounds form in a pattern called crystal lattice

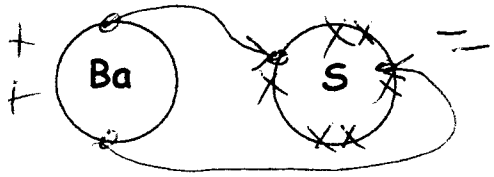
NaCl crystals → 

F. Ionic Bond Practice:

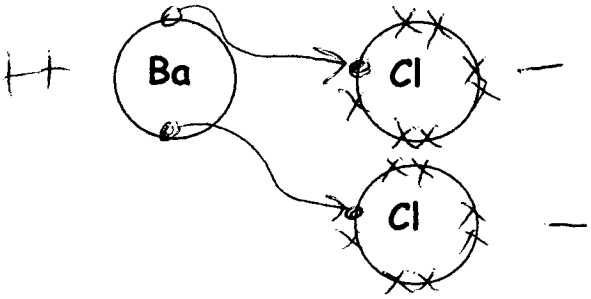
1. LiBr



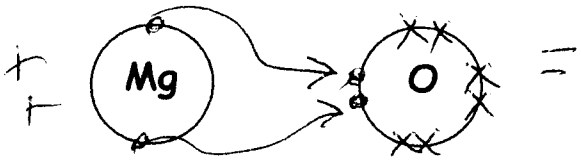

2. BaS



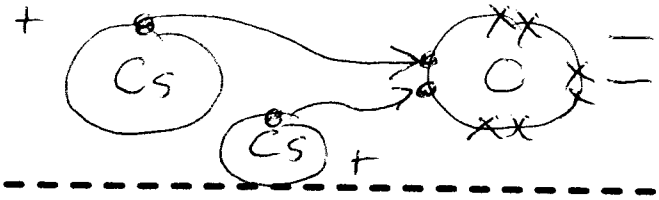

3. $BaCl_2$



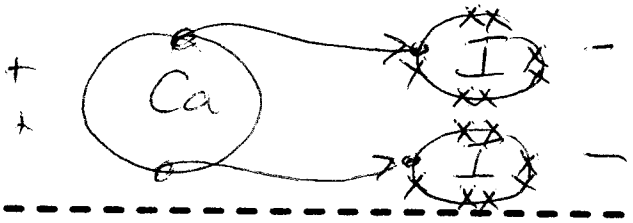

4. MgO



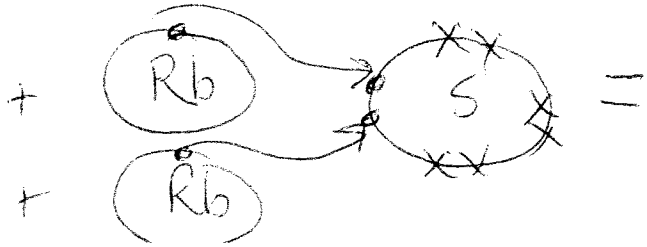

5. $Cs_2O$




6. $CaI_2$



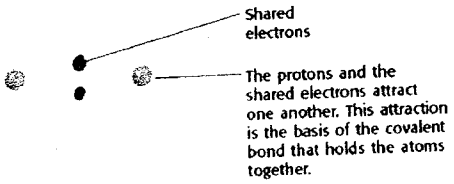

7. $Rb_2S$



## III Covalent and Metallic Bonds:

### A. Covalent Bonds:

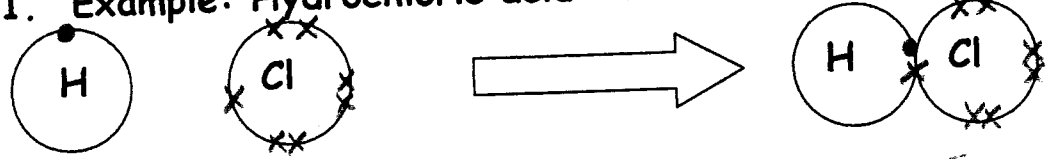
1. A covalent bond forms when atoms share one or more pairs of electrons.
2. This type of bond happens usually with nonmetals.
3. Below is a picture of two hydrogen atoms in a covalent bond.




4. Each hydrogen shares its one electron with the other.
5. Substances made with covalent bonds are made up of molecules.
6. A molecule consists of 2 or more atoms joined in a definite ratio.
7. The hydrogen molecule shown above is a very simple molecule.
8. Molecules made up of 2 atoms of the same element are called diatomic molecules.
9. Elements found in nature as diatomic molecules are called diatomic elements. Examples:

$H_2$ $N_2$ $O_2$ $F_2$ $Cl_2$ $I_2$ $Br_2$

10. A drawing of a covalent bond only shows the outer shell.
11. Example: Hydrochloric acid HCl

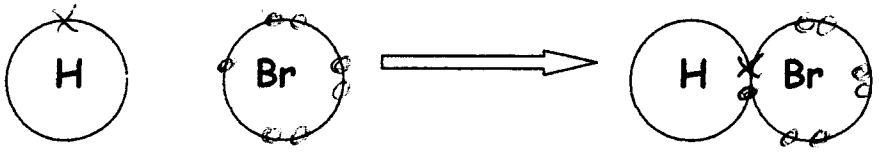



By sharing, H now has 2 electrons & Cl has 8 electrons.

## B. Practice Time:

Use an X for the electrons of one element and a ● for the electrons of a different element. That makes it less confusing !

1. H + Br ⟹ HBr

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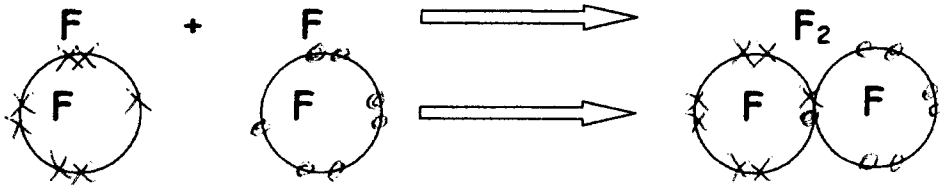
2. F + F ⟹ $F_2$

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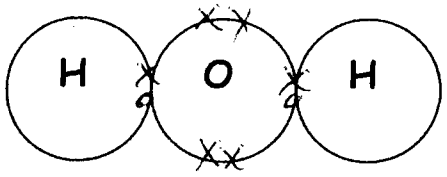
3. $H_2O$

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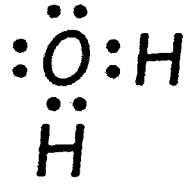
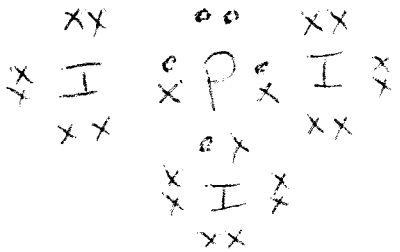
4. You can also use an electron-dot diagram that shows the valence electrons but not the energy level. Instead of different colors, still show X's and ●'s



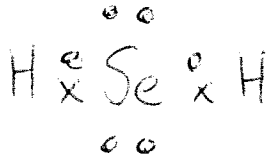

This electron-dot diagram for water shows only the outermost level of electrons for each atom. But you still see how the atoms share electrons.

5. Your turn !!!

a) $PI_3$




b) $H_2Se$

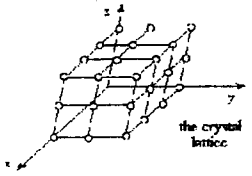


## IV IONIC AND COVALENT COMPOUNDS:

### A. Ionic Compounds and Their Properties:

1. Compounds made with ionic bonds are ionic compounds.

2. *Brittleness:*




a) Ionic compounds are made in a crystal lattice.

b) When hit, the pattern shifts which causes it to breake

3. *High Melting Points:*

a) Ionic bonds are strong so melting points are high

b) Most ionic compounds are solid are room temperature.

4. *Solubility and Electrical Conductivity:*

a) They dissolve easily in water.

b) The solution that forms when an ionic compound dissolves in water can conduct electricity.

### B. Covalent Compounds and Their Properties:

1. Most compounds are covalent compounds.

2. Covalent bonds are weaker than ionic bonds.

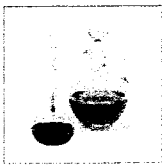
BUT malleable - (metallic bonds)

3. Remember, covalent bonds form molecules.

4. *Low Solubility:*

a) Many covalent compounds do NOT dissolve well in water.

b) Examples: * Carbon dioxide in soda * Oil in vinegar

5. ***Low Melting Points***:

a) Since covalent bonds are weaker they melt easily.

6. ***Electrical Conductivity***:

a) Some dissolve in water, but most don't.

b) If they do dissolve, the solution has uncharged molecules, so they don't conduct electricity.

C. Comparison Table:

| IONIC BONDS | COVALENT BONDS |
|---|---|
| STRONGER | WEAKER |
| crystalline | not |
| high melting pt | low melting pt |
| can conduct elec | can't conduct el |
| brittle | malleable |
| transfers electron | shares electrons |

## V FORMING NEW SUBSTANCES:

color → STATE

A. Chemical Reaction Signs:

1. give off heat
2. change in
3. give off light
4. smoke, bubbles
5. Most important: a new substance is formed

B. Bonds: Holding Molecules Together:

1. How do new substance form in a chemical reaction?
   a) First: bonds break in starting substance
   b) Then: atoms rearrange themselves
   c) Then : new Bonds Form

## VI CHEMICAL FORMULAS ….:

A. What is a chemical formula?

1. A shorthand way to use chemical symbols and numbers to represent a substance.

B. Rules for writing formulas:

1. Write the positive ion first.
2. Write the negative ion second.
3. The negative ion ends in ide.
4. The sum of the ion charges must be zero.
5. Some elements ( transition metals) can have more than one ion charge.

C. Example:

1. Lithium is in Group IA and will lose its one electron.
2. If it loses its one electron, its charge will be $1^+$.

D. Formula Example:

1. Lithium ion: 1+ Chlorine ion: 1−

$Li^{1+}$ $Cl^{1-}$

$LiCl$

Name of compound: lithium chloride

2. Potassium ion: 1+ Oxygen ion: 2−

$K^{1+}$ $K^{1+}$ $O^{2-}$

$K_2O$

Name of compound: potassium oxide

E. Formula Table:

| Ions | $Cl^{1-}$ | $O^{2-}$ | $S^{2-}$ | $N^{3-}$ |
|---|---|---|---|---|
| $Li^{1+}$ | $LiCl$ | $Li_2O$ | $Li_2S$ | $Li_3N$ |
| $Cu^{1+}$ | $CuCl$ | $Cu_2O$ | $Cu_2S$ | $Cu_3N$ |
| $K^{1+}$ | $KCl$ | $K_2O$ | $K_2S$ | $K_3N$ |
| $Ba^{2+}$ | $BaCl_2$ | $BaO$ | $BaS$ | $Ba_3N_2$ |
| $Zn^{2+}$ | $ZnCl_2$ | $ZnO$ | $ZnS$ | $Zn_3N_2$ |

F. Polyatomic Ions:

1. A group of ATOMS that act as one ion.
2. When writing the formula, put a ( ) around the polyatomic ion and then write the subscript outside of it.
3. Example: $Ca^{2+}$ $NO_3^{1-}$ $NO_3^{1-}$

$Ca(NO_3)_2$

CALCIUM nitrate

Compound Name*:

(endings don't change)

G. Oxidation Table: The table below is used as a reference.
BUT !! You can still figure out ion charges with the periodic table!

* 1. The OXIDATION number of an atom is the NUMBER of electrons an atom GAINS or LOSES in forming compounds
2. Oxidation numbers are used to write correct formulas

*Table 12–1.*
Common Oxidation Numbers

| 1+ | 2+ | 3+ |
|---|---|---|
| Hydrogen, $H^+$ | Barium, $Ba^{2+}$ | Aluminum, $Al^{3+}$ |
| Lithium, $Li^+$ | Calcium, $Ca^{2+}$ | Chromium(III), $Cr^{3+}$ |
| Potassium, $K^+$ | Cobalt(II), $Co^{2+}$ | Iron(III), $Fe^{3+}$ |
| Silver, $Ag^+$ | Copper(II), $Cu^{2+}$ | |
| Sodium, $Na^+$ | Iron(II), $Fe^{2+}$ | |
| Ammonium, $NH_4^+$ | Magnesium, $Mg^{2+}$ | |
| Copper(I), $Cu^+$ | Zinc, $Zn^{2+}$ | |
| **1–** | **2–** | **3–** |
| Bromide, $Br^-$ | Oxide, $O^{2-}$ | Nitride, $N^{3-}$ |
| Chloride, $Cl^-$ | Sulfide, $S^{2-}$ | Phosphate, $PO_4^{3-}$ |
| Iodide, $I^-$ | Carbonate, $CO_3^{2-}$ | |
| Acetate, $C_2H_3O_2^-$ | Sulfate, $SO_4^{2-}$ | |
| Hydroxide, $OH^-$ | | |
| Nitrate, $NO_3^-$ | | |

H. More Practice !!!

1. Potassium and Iodine:

$K^{1+}$ $I^{1-}$

Formula? $KI$

Name? potassium iodide

2. Zinc and Bromine:

$Zn^{2+}$ $Br^{1-}$ $Br^{1-}$

Formula? $ZnBr_2$

Name? zinc bromide

3. Aluminum and Sulfate:

$Al^{3+}$ $SO_4^{2-}$

$Al^{3+}$ $SO_4^{2-}$

$SO_4^{2-}$

Formula? $Al_2(SO_4)_3$

Name? aluminum sulfate

4. Magnesium and Phosphate:

$Mg^{2+}$ $PO_4^{3-}$

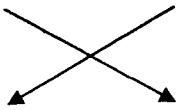
$Mg^{2+}$ $PO_4^{3-}$

$Mg^{2+}$

Formula? $Mg_3(PO_4)_2$

Name? magnesium phosphate

I The Easier Method: (Criss Cross)



1. $Ba^{2+}$ $Cl^{1-}$ → 1, 2 → $BaCl_2$

2. $Na^{1+}$ $O^{2-}$ → 2, 1 → $Na_2O$

3. $Ca^{2+}$ $PO_4^{3-}$ → 3, 2 → $Ca_3(PO_4)_2$

4. $Al^{3+}$ $S^{2-}$ → 2, 3 → $Al_2S_3$

## VII CHEMICAL EQUATIONS:

### A. TERMS:

1. A CHEMICAL EQUATION: uses chemical symbols and formulas as a shortcut to describe a chemical reaction.
2. REACTANTS: The starting materials in a chemical reaction. They are found on the left (of the arrow).
3. PRODUCTS: The substances formed from a reaction. They are found on the right of the arrow.

The formulas of the **reactants** are written before the arrow.

The formulas of the **products** are written after the arrow.

$$C + O_2 \xrightarrow{\text{yields}} CO_2$$

A **plus sign** separates the formulas of two or more reactants or products from one another.

The **arrow**, also called the *yields sign*, separates the formulas of the reactants from the formulas of the products.

### B. Equations Must be Balanced:

1. Atoms are in a reaction are NEVER lost or gained.
2. Every atom in the reactants becomes part of the product.
3. When writing a chemical equation, make sure….

   ** the number of atoms of each element in the reactants equals the number of atoms in the products

4. Lavoisier's (in the 1700's) work led to the .....

LAW of CONSERVATION of MASS

5. It states that MASS is neither CREATED

or DESTROYED.

C. How to Balance an Equation:

1. To balance an equation, you must use COEFFICIENTS

2. Coefficients are used in FRONT of symbols & formulas.

3. A coefficient tells the....

* number of ATOMS * number of MOLECULES

**4 $H_2O$**

4 water MOLECULE

8 hydrogen HYDROGEN ATOMS

4 oxygen O ATOMS

4. When balancing an equation:

* ONLY CHANGE THE COEFFICIENT

* NEVER CHANGE THE SUBSCRIPTS

5. EXAMPLES:

a) Sodium plus chlorine yields sodium chloride

2 Na + _____ $Cl_2$ ⟶ 2 NaCl

b) Potassium plus Bromine yields potassium bromide

2 K + _____ $Br_2$ ⟶ 2 KBr

c) Carbon plus chlorine yields carbon tetrachloride.

_____ C + 2 $Cl_2$ ⟶ _____ $CCl_4$

6. Using R|P charts:

a). ___C + 2 $Cl_2$ → ___$CCl_4$

| R | P |
|---|---|
| 1 C | C 1 |
| 4 Cl | Cl 4 |

b) ~~___CaO + ___$SO_2$ → ___$O_2$ + ___$CaSO_4$~~

| R | P |
|---|---|
| 1 Al | Al 2 |
| 6 Cl | Cl 6 |

c) 2 Al + 3 $Cl_2$ → 2 $AlCl_3$

| R | P |
|---|---|
| 2 H | H 2 |
| 2 Cl | Cl 2 |
| 1 Zn | Zn 1 |

d) 2 HCl + ___Zn → ___$ZnCl_2$ + ___$H_2$

| R | P |
|---|---|
| 2 N | N 2 |
| 6 H | H 6 |

e) ___$N_2$ + 3 $H_2$ → 2 $NH_3$

| R | P |
|---|---|
| 2 S | S 2 |
| 6 O | O 6 |

f) 2 $SO_2$ + ___$O_2$ → 2 $SO_3$

| R | P |
|---|---|
| 4 H | H 4 |
| 2 S | S 2 |
| 2 O | O 2 |

g) 2 $H_2S$ + ___$O_2$ → 2 $H_2O$ + 2 S

| R | P |
|---|---|
| 6 H | H 6 |
| 3 S | S 3 |
| 3 O | O 3 |

h) 3 $H_2S$ + ___$SO_3$ → 3 $H_2O$ + 3 S

## 7. More Practice!!!

a) $2CaO + 2SO_2 + O_2 \rightarrow 2CaSO_4$

b) $C_6H_{12}O_6 \rightarrow 6C + 6H_2O$

c) $4Cr + 3O_2 \rightarrow 2Cr_2O_3$

d) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

e) $2H_2 + O_2 \rightarrow 2H_2O$

f) $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

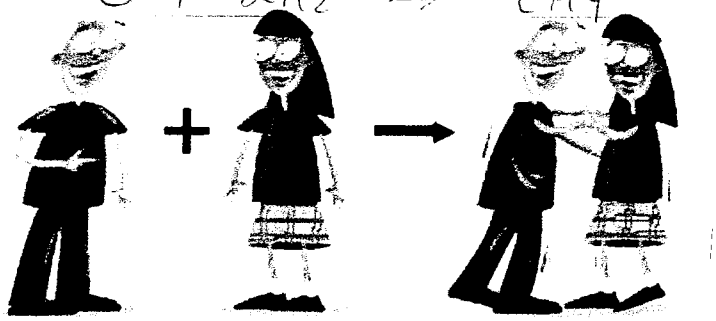
g) $2KClO_3 \rightarrow 2KCl + 3O_2$

h) $2AgNO_3 + H_2SO_4 \rightarrow Ag_2SO_4 + 2HNO_3$

## VIII TYPES OF CHEMICAL REACTIONS:

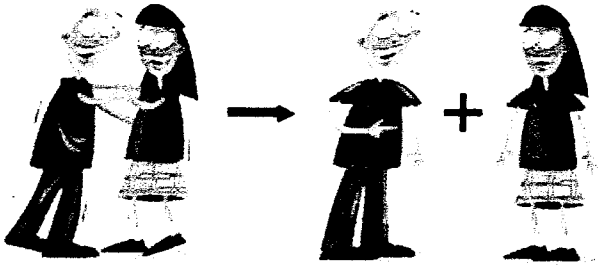
### A. Synthesis Reactions:

1. A reaction in which 2 or more substances combine to form one new compound.
2. A + B ⟹ AB
3. Examples:
   a) $4Ag + O_2 \rightarrow 2Ag_2O$
   b) $H_2 + Cl_2 \rightarrow 2HCl$
   c) $C + 2H_2 \rightarrow CH_4$



### B. Decomposition Reactions:

1. A reaction in which a single compound breaks down to form 2 or more simpler substances.
2. AB ⟹ A + B
3. Examples:
   a) $2H_2O \rightarrow 2H_2\uparrow + O_2\uparrow$
   b) $2NaCl \rightarrow 2Na + Cl_2\uparrow$



C. **Single-Displacement Reactions**: (replacement

1. An element replaces another element that is part of a compound.

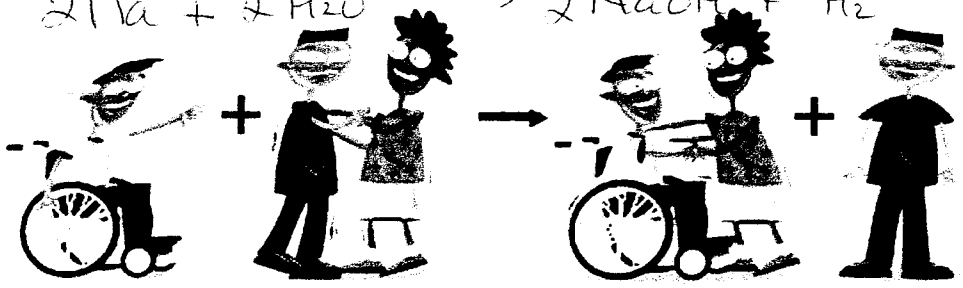
2. A + BC ⟹ AC + B

3. Examples:

a) $Zn + 2HCl \rightarrow ZnCl_2 + H_2\uparrow$

b) $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$

c) $2Na + 2H_2O \rightarrow 2NaOH + H_2$



D. **Double-Displacement Reactions**:

1. A reaction in which ions from 2 compounds exchange places.

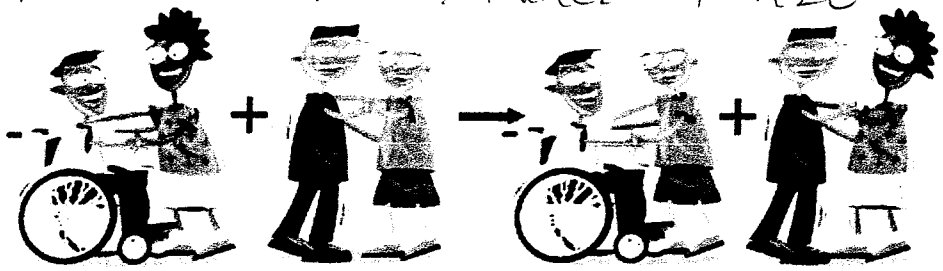
2. AB + CD ⟹ AD + CB

3. Examples:

a) $KI + PbNO_3 \rightarrow PbI\downarrow + KNO_3$

b) $NaCl + AgNO_3 \rightarrow NaNO_3 + AgCl\downarrow$

c) $HCl + NaOH \rightarrow NaCl + H_2O$



d) $3NaOH + FeCl_3 \rightarrow 3NaCl + Fe(OH)_3$

## IX ENERGY AND RATES OF CHEMICAL REACTIONS:

### A. Reactions and Energy:

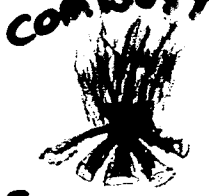
1. Chemical ENERGY is part of ALL chemical reactions.
2. Energy is needed to break bonds in the reactants.
3. As new bonds form in the products, energy is released
4. By comparing both above, you can decide if energy is absorbed or released in the overall reaction.

### B. Exothermic Reaction: EXIT

1. A chemical reaction in which energy is released.
2. The energy released is often written as a product.

$$2\ Na + Cl_2 \Longrightarrow 2\ NaCl + \text{energy}$$

3. The temperature goes up.



EXOTHERMIC

### C. Endothermic Reaction:

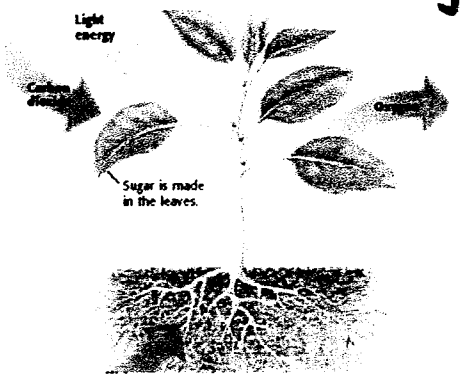
1. A chemical reaction in which energy is absorbed.
2. The energy that is taken in is often written as a reactant.

$$2\ H_2O + \text{energy (electricity)} \Longrightarrow 2H_2 + O_2$$

3. The temperature goes down.
4. Photosynthesis is an endothermic reaction.

$$6\ CO_2 + 6\ H_2O + \text{energy (sunlight)} \Longrightarrow C_6H_{12}O_6 + 6\ O_2$$

glucose oxygen

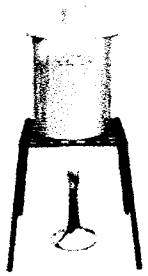


D. Rate of Reaction.

1. The speed at which new particles form is called the Rate of Reaction.

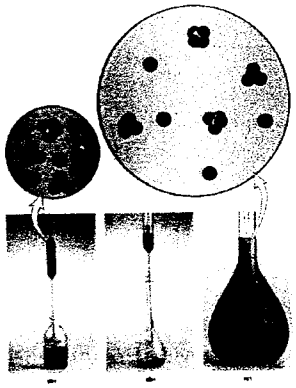
E. Factors That Increase the Rate of Reaction:

1. High Temperature



a) At high temperatures, particles of reactants move quickly and collide often.

2. High Concentration



a) When there is a high concentration, there is a smaller distance between reactant particles, and they hit into each other more often.

3. More Surface Area

a) Greater surface area exposes more reactant particles to other reactant particles.

4. Catalyst

a) A substance that speeds up a reaction without being permanently changed.

b) An inhibiter is the opposite. It slows down or stops a chemical reaction.

* An example: Food preservatives slow down the decomposition of food

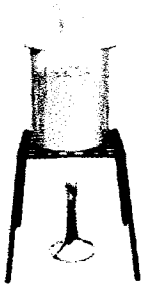
D. Rate of Reaction.

1. The speed at which new particles form is called the Rate of Reaction.

E. Factors That Increase the Rate of Reaction:

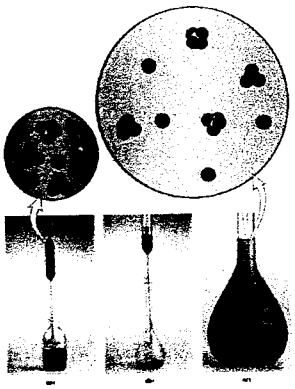
1. High Temperature

a) At high temperatures, particles of reactants move quickly and collide often.



2. High Concentration

a) When there is a high concentration, there is a smaller distance between reactant particles, and they bump into each other more often.



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