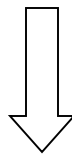


Chemical Reactions

Chemical Reactions

Chemical change = Chemical reaction

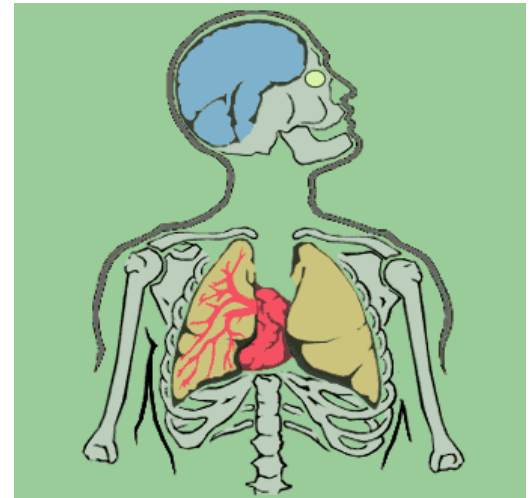
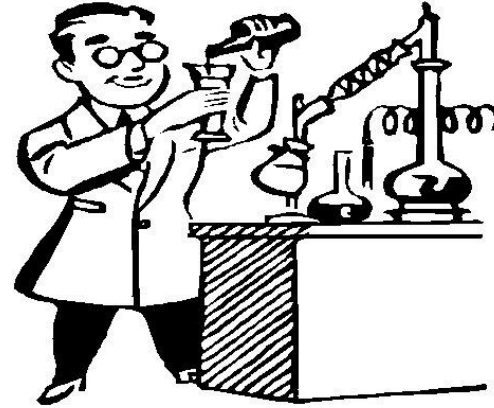
Substance(s) is used up (disappear)



New substance(s) is formed.

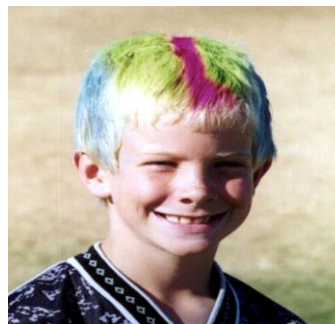
Different physical and chemical properties.

Chemical Reactions

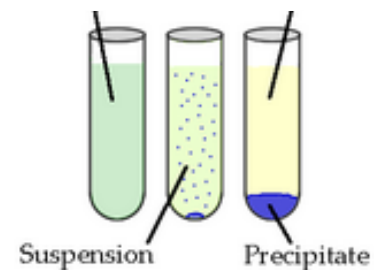


Evidence for chemical reactions

1. Color changes



2. A solid is formed (precipitation)

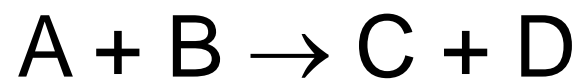


3. Bubbles form (gas)

4. Heat (and/or flame) is produced, or heat is absorbed



Chemical Reactions

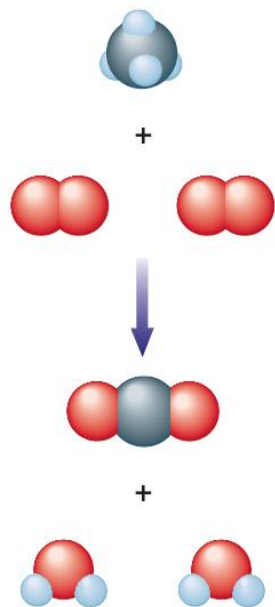
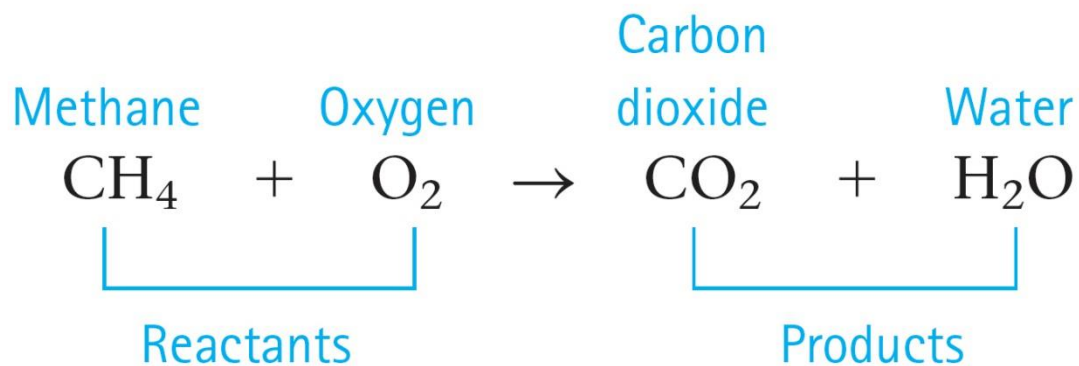


Reactants

Products

Chemical Equation

Chemical Reactions



Products contain the same atoms as reactants.

Rearrangement of atoms



Chemical Equation

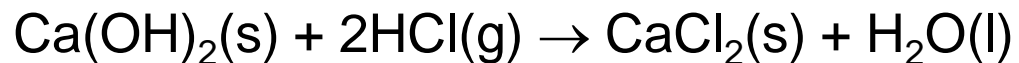
Physical States (forms)

Solid (s)

Liquid (l)

Gas (g)

Aqueous (aq)



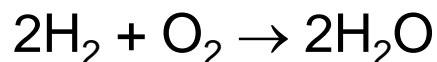
Chemical Equation

Chemical equation gives us some information:

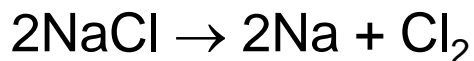
1. Identities of the reactants and products.
2. Relative amounts of the reactants and products.
3. Physical states of the reactants and products.
4. Stoichiometry

Type of chemical reactions

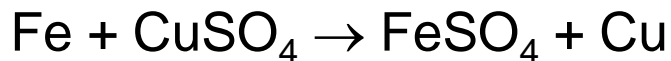
1. $A + B \rightarrow AB$ **Synthesis reaction (combination)**



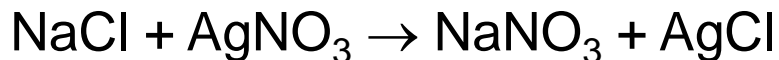
2. $AB \rightarrow A + B$ **Decomposition (analysis)**



3. $A + BC \rightarrow AC + B$ **Single replacement reaction**



4. $AB + CD \rightarrow AD + CB$ **Double replacement reaction**



Type of chemical reactions

5. $AB + xO_2 \rightarrow yCO_2 + zH_2O + \text{Heat (Energy)}$ **Combustion**



Balance a chemical equation

All chemical equations should be balanced.

Why balancing?

Balance a chemical equation

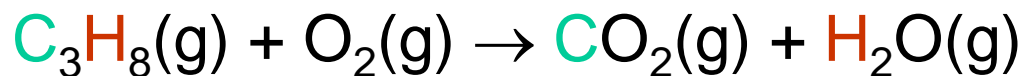
Law of conservation of mass

Atoms are neither destroyed nor created.

They shift from one substance to another.

Balance a chemical equation

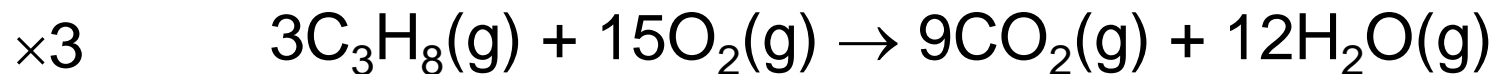
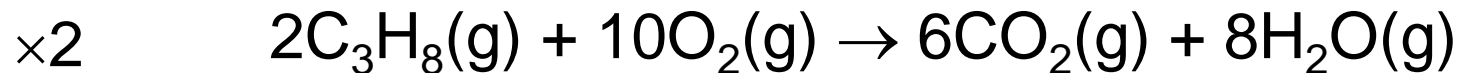
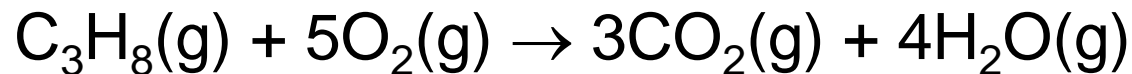
1. Begin with atoms that appear in only one compound on the left and right.
2. If an atom occurs as a free element, balance it last.
3. Change only **coefficients** (not formulas).



last

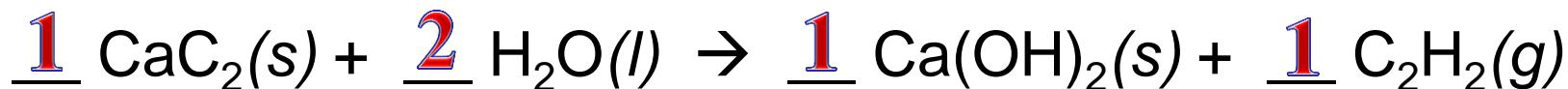
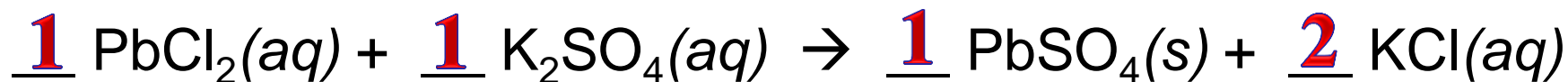
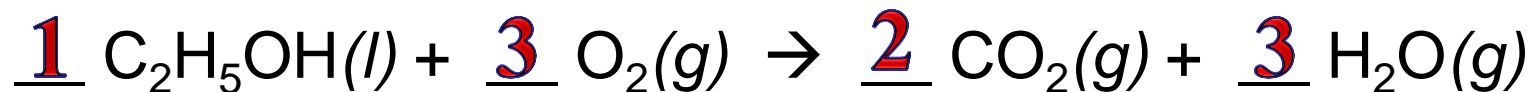
Always double check!

Balance a chemical equation

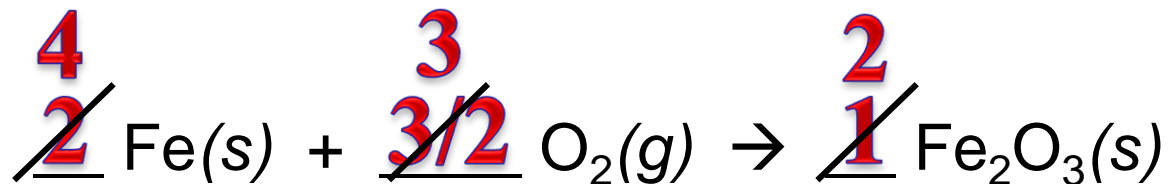
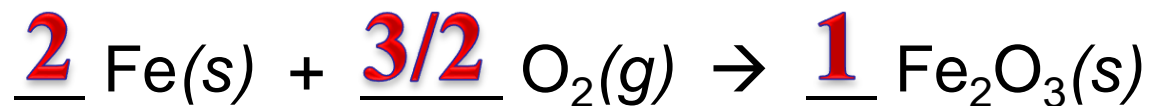


Lowest set of numbers

Examples for Balancing



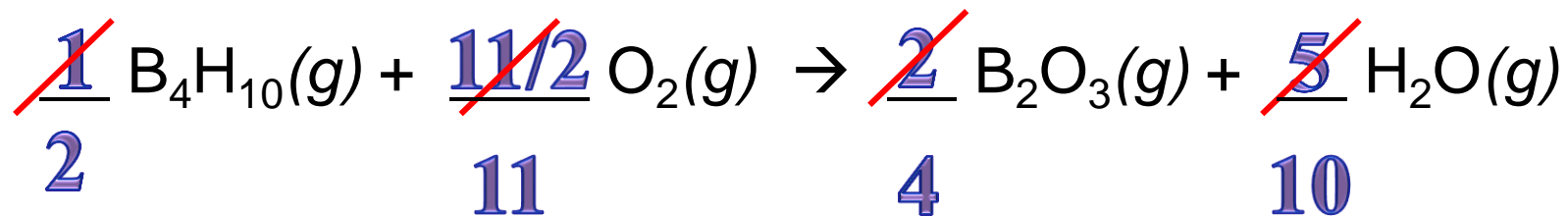
Examples for Balancing



Notes: Always use the lowest possible integer numbers.

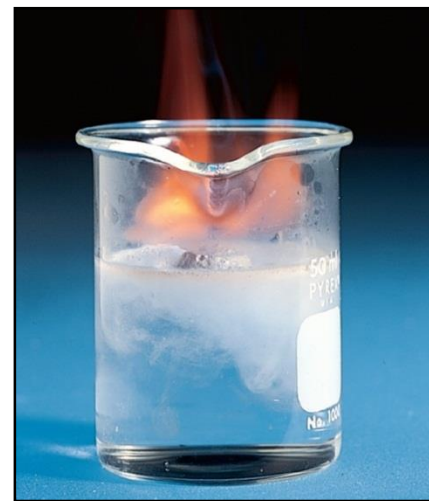
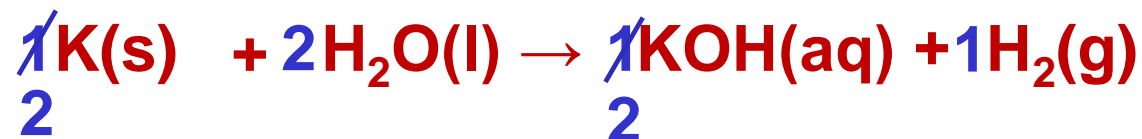
If you get a fraction, multiply it out.

Examples for Balancing



Examples for Balancing

- “Solid potassium reacts with water to form hydrogen gas and potassium hydroxide dissolved in solution.”
- Write and balance the chemical equation for this reaction.



Why does a chemical reaction occur?

Several driving forces:

1. Formation of a solid
2. Formation of water
3. Transfer of electrons
4. Formation of a gas

Why does a chemical reaction occur?

Several driving forces:

1. Formation of a solid
2. Formation of water
3. Transfer of electrons
4. Formation of a gas

Reactions in Aqueous Solutions

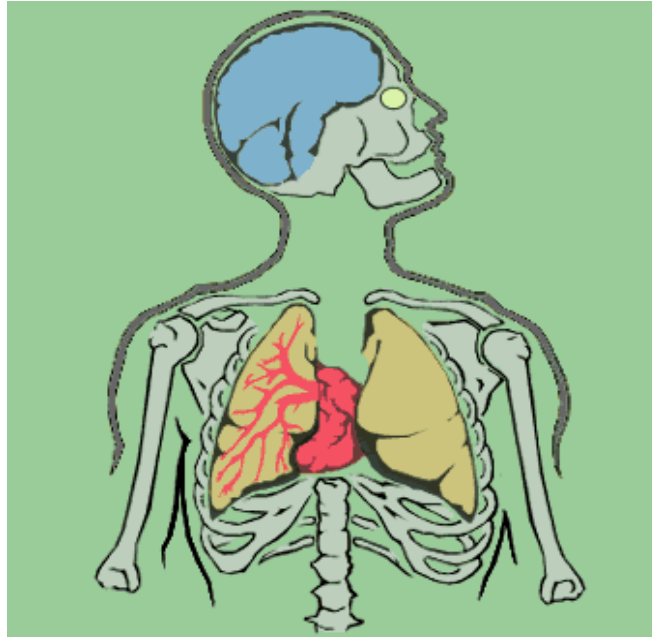
Ionic compounds (Salt)

Aqueous solution: solvent is water

Reactions in Aqueous Solutions

Chemical reactions that occur in water.

60% of our body is water.



In our body reactions occur in the aqueous solution.

Formation of a solid

Precipitation reactions

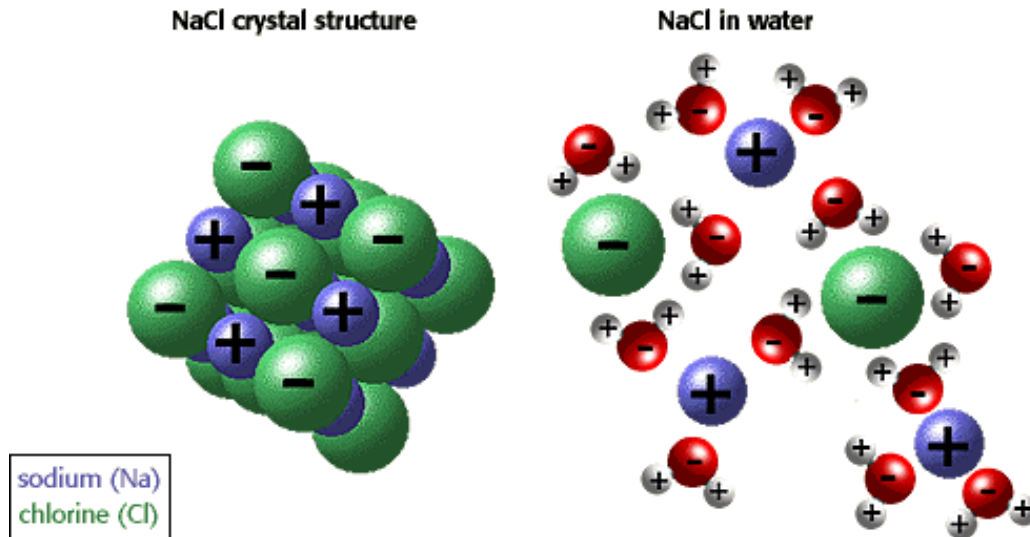


Precipitate



Ionic Compounds

When an ionic compound dissolves in water, ions are produced.



Each ion is surrounded by water molecules.

Ions Hydrated by H₂O

Hydration

Ionic Compounds

1. **Soluble ionic compound:** it completely dissociates in water.
(ions are formed)
2. **Slightly soluble ionic compound:** it partially dissociates in water.
3. **Insoluble ionic compound:** it does not dissociate in water (almost).

- **Note:** the terms ***insoluble*** and ***slightly soluble*** mean such a miniscule amount dissolves that you can't see any decrease in the amount of solid present.



Solubility Rules

Table 7.1 General Rules for Solubility of Ionic Compounds (Salts) in Water at 25 °C

1. Most nitrate (NO_3^-) salts are soluble.
2. Most salts of Na^+ , K^+ , and NH_4^+ are soluble.
3. Most chloride salts are soluble. Notable exceptions are AgCl , PbCl_2 , and Hg_2Cl_2 .
4. Most sulfate salts are soluble. Notable exceptions are BaSO_4 , PbSO_4 , and CaSO_4 .

5. Most hydroxide compounds are only slightly soluble.* The important exceptions are NaOH and KOH . $\text{Ba}(\text{OH})_2$ and $\text{Ca}(\text{OH})_2$ are only moderately soluble.
6. Most sulfide (S^{2-}), carbonate (CO_3^{2-}), and phosphate (PO_4^{3-}) salts are only slightly soluble.*

Soluble

Insoluble

Preceding rules trump following rules.

Solubility Rules

- Another way of showing the same rules.

Soluble		Insoluble	
NO_3^- salts		S^{2-} , CO_3^{2-} , PO_4^{3-} salts	
Na^+ , K^+ , NH_4^+ salts		OH^- salts	Except for those containing Na^+ , K^+ , Ca^{2+} , Ba^{2+}
Cl^- , Br^- , I^- salts	Except for those containing Ag^+ , Hg_2^{2+} , Pb^{2+}		
SO_4^{2-} salts	Except for those containing Ba^{2+} , Pb^{2+} , Ca^{2+}		

Formation of a solid

Precipitation reactions

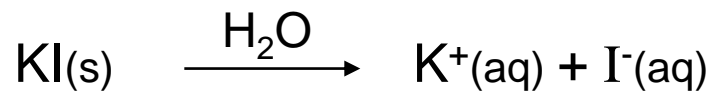


Precipitate

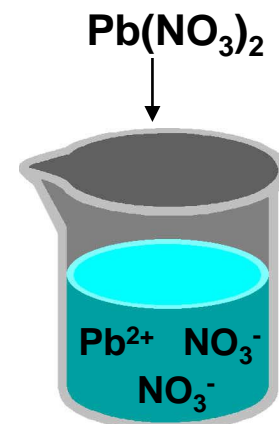
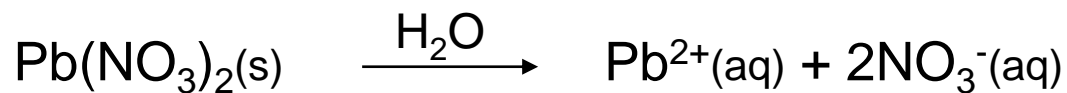
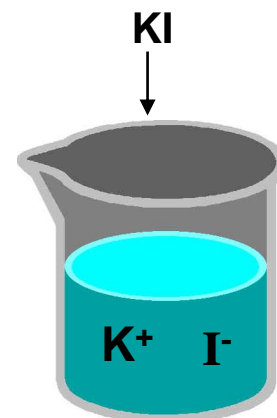


Aqueous Solution (ionic compounds)

aqueous solution: solvent is water



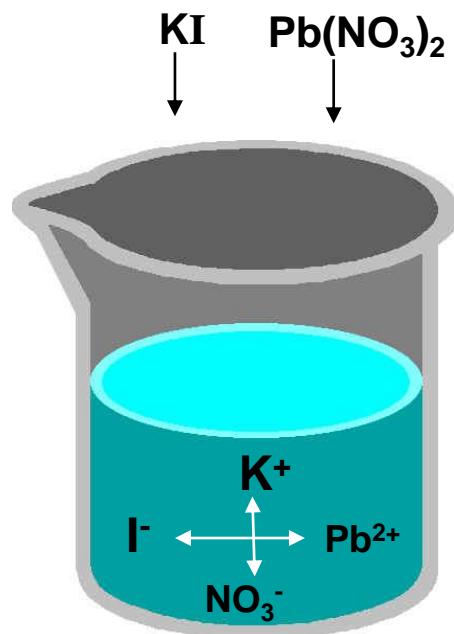
Dissociation
(Ionization)



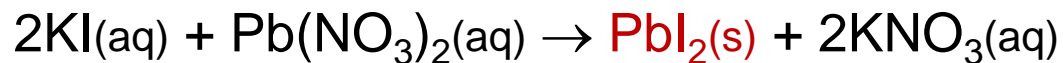
Aqueous Solution (ionic compounds)

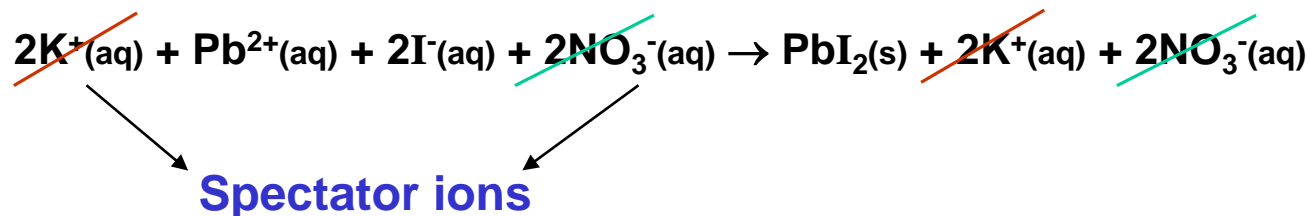
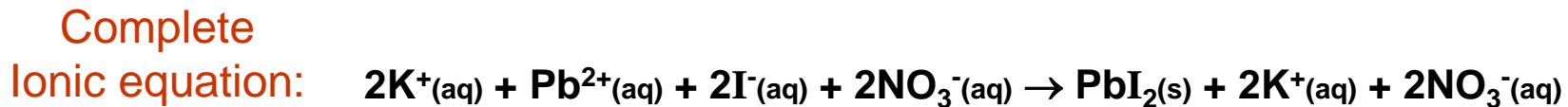
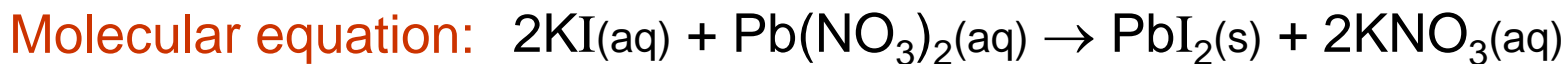
Sometimes the ions react with each other.

Positive ions will interact with negative ions.



Sometimes ions stick together to form a **solid (precipitate)**.



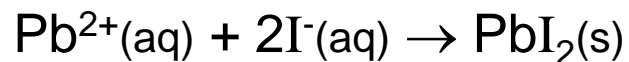


- The ions that ***do not react*** are called spectator ions.

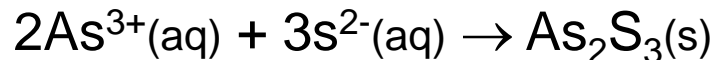


Ionic Equations

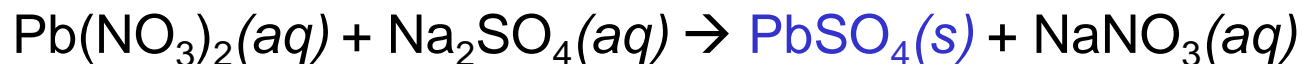
Net ionic equation:



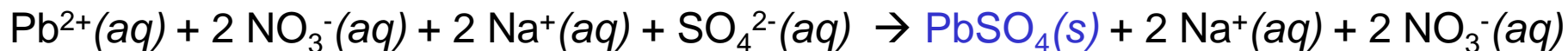
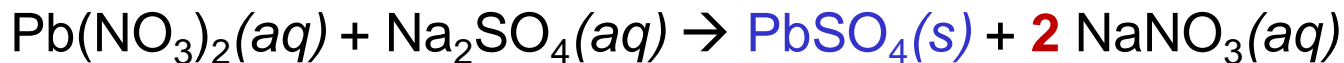
Total charge on left side = Total charge on right side
balanced equation



Example

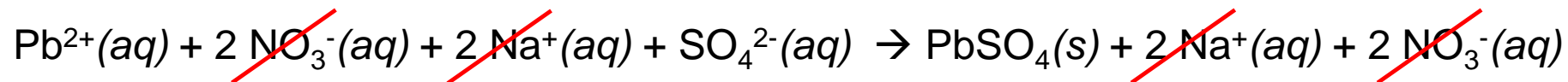


Balance it:



Complete ionic equation

Example



Spectator ions



Practice

1. Molecular equation



2. Balancing

3. Complete ionic equation

4. Net ionic equation

Why does a chemical reaction occur?

Several driving forces:

1. Formation of a solid
2. Formation of water
3. Transfer of electrons
4. Formation of a gas

Acids and Bases

Acids: sour



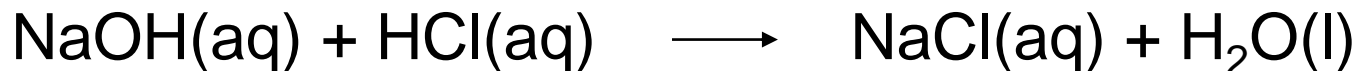
Bases: bitter or salty



Acid-Base Reactions

Neutralization

Strong acid + Strong base → Salt + H₂O



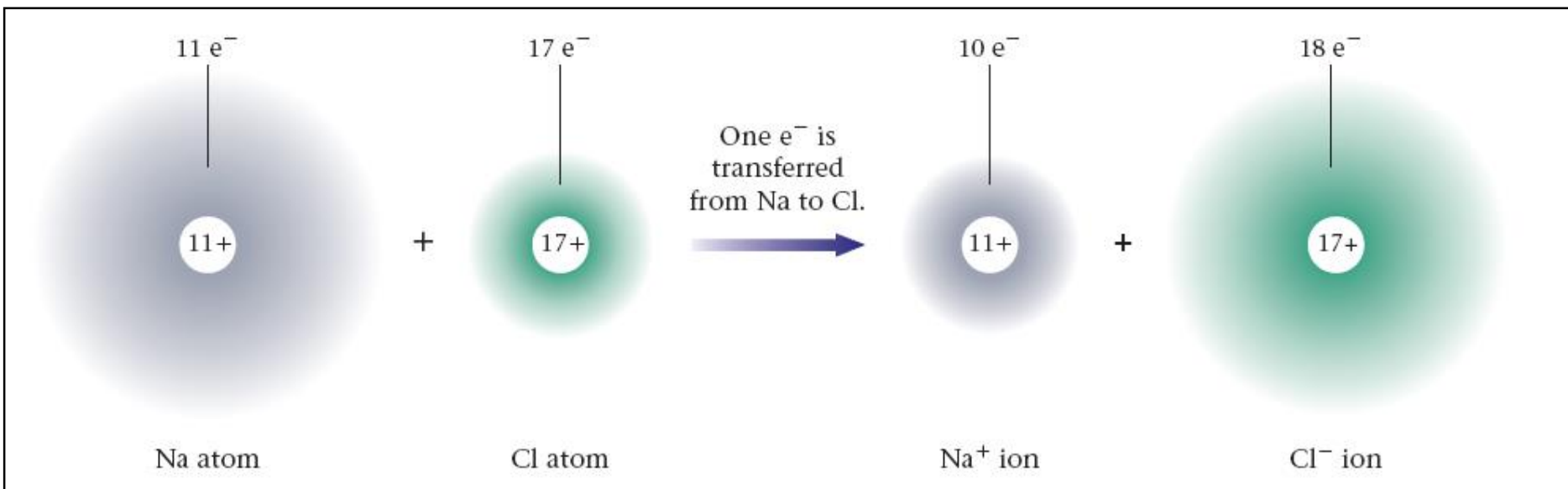
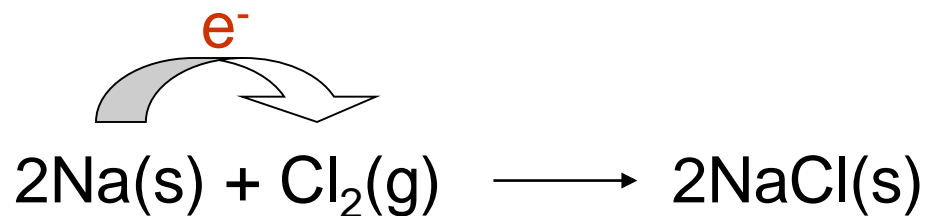
The only chemical change is the formation of water.

Why does a chemical reaction occur?

Several driving forces:

1. Formation of a solid
2. Formation of water
3. Transfer of electrons
4. Formation of a gas

Oxidation and Reduction reactions (redox)



Oxidation and Reduction reactions (redox)

oxidation: it is the loss of electrons.



reduction: it is the gain of electrons.



Remember – **LEO** says **GER**.
Loss of Electrons is Oxidation
Gain of Electrons is Reduction.



Oxidation and Reduction reactions (redox)

Metal + Nonmetal : Transfer of electrons

Oxidation and Reduction reactions (redox)

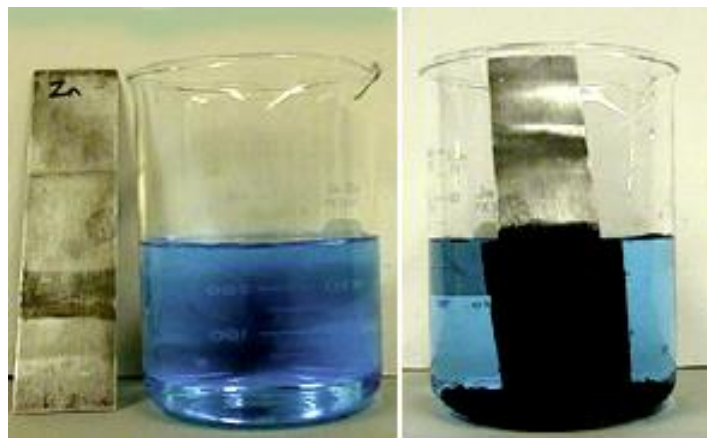
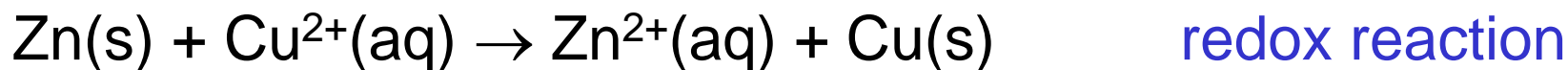
Oxidation and reduction always occur together.

(The lost e^- must go somewhere!)

Oxidation and Reduction reactions (redox)

oxidation: it is the loss of electrons.

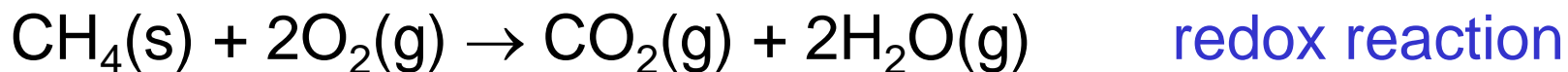
reduction: it is the gain of electrons.



Oxidation and Reduction reactions (redox)

oxidation: is the gain of oxygen / loss of hydrogen.

reduction: is the loss of oxygen / gain of hydrogen.



↓
C gains O and loses H
is oxidized
(reducing agent)

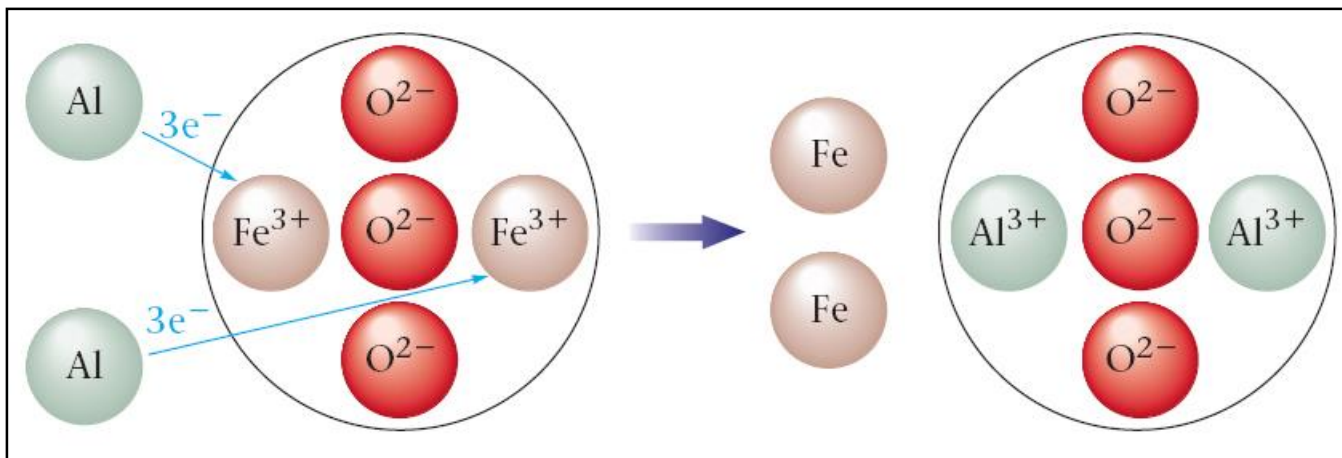
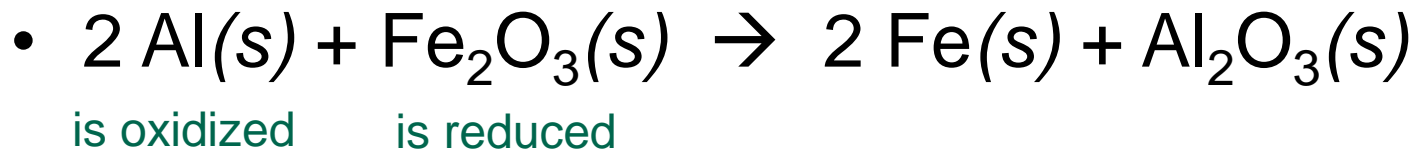
↘
O gains H
is reduced
(oxidizing agent)

single replacement reaction and combustion reactions → redox reactions

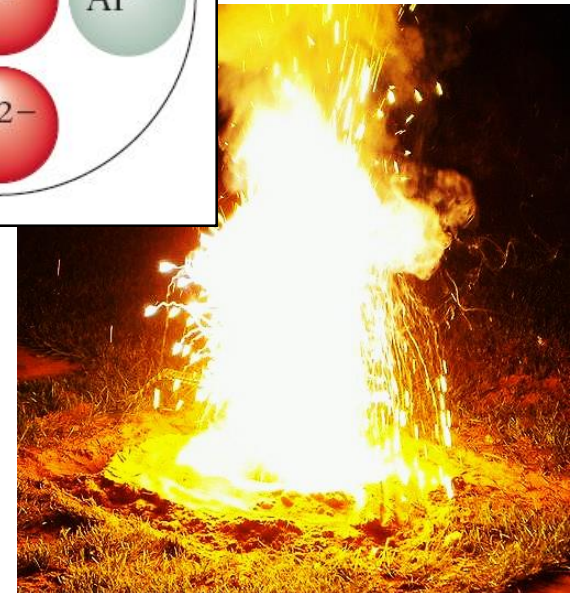
double replacement reactions → non redox

Oxidation and Reduction reactions (redox)

Example 2:



- Called the *Thermite reaction*.
- Let's just say it's vigorous!



Oxidation and Reduction reactions (redox)

Example 3:

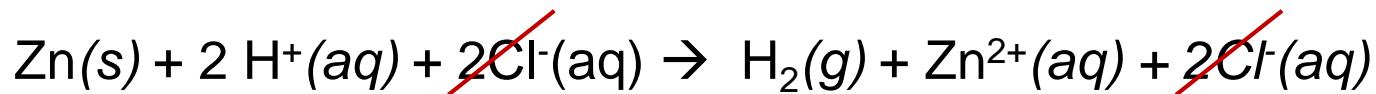


is oxidized

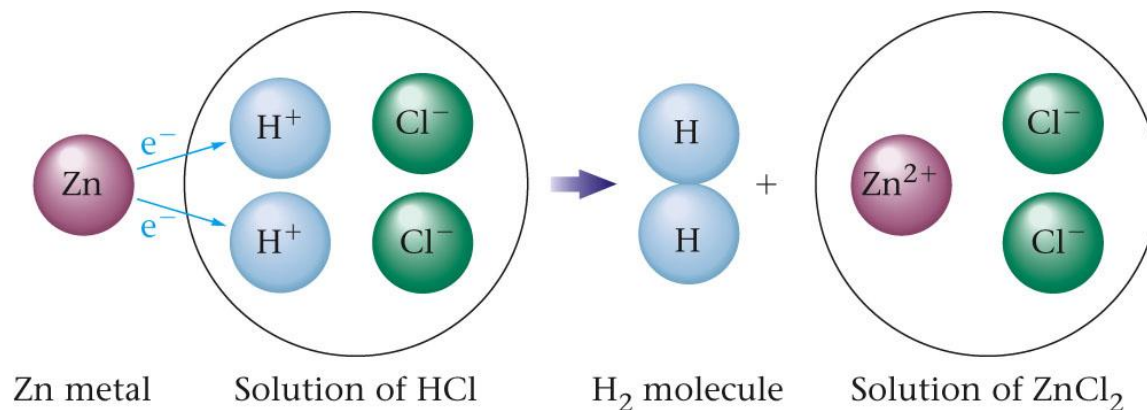
is reduced

Oxidation and Reduction reactions (redox)

Example 4:



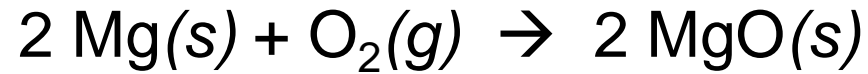
is oxidized is reduced



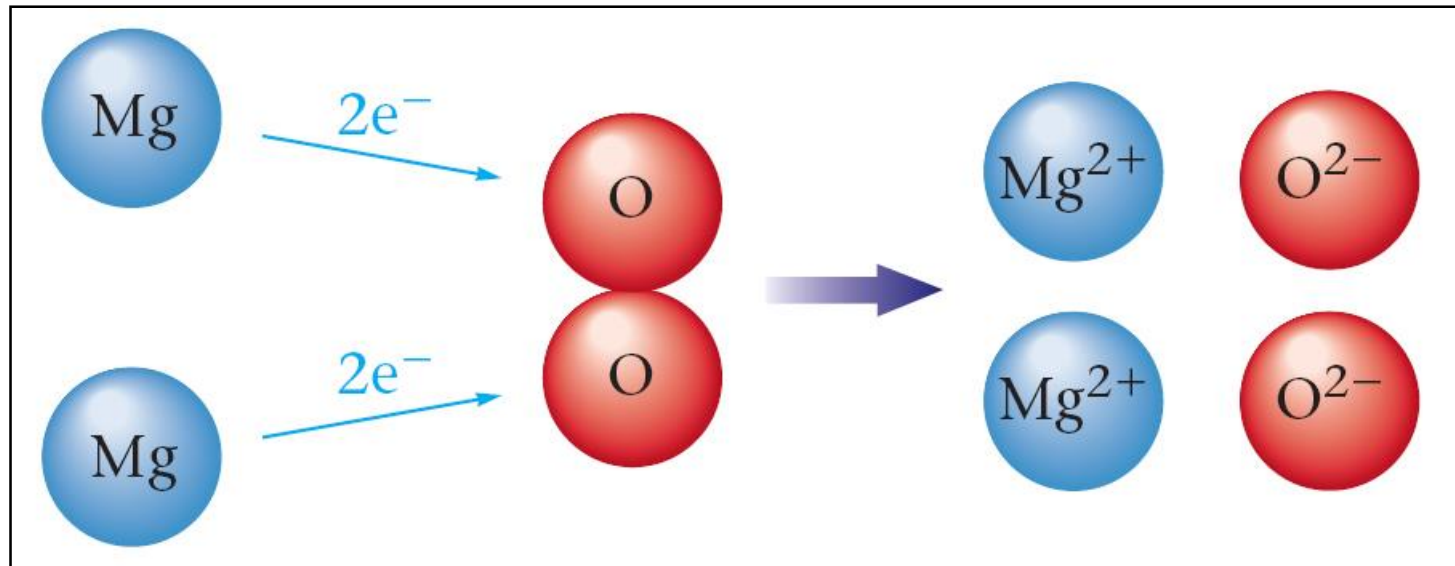
Note: this reaction also shows the fourth driving force of a reaction, namely, *the formation of a gas*.

Oxidation and Reduction reactions (redox)

Example 5:



is oxidized is reduced



Classification of chemical reactions

