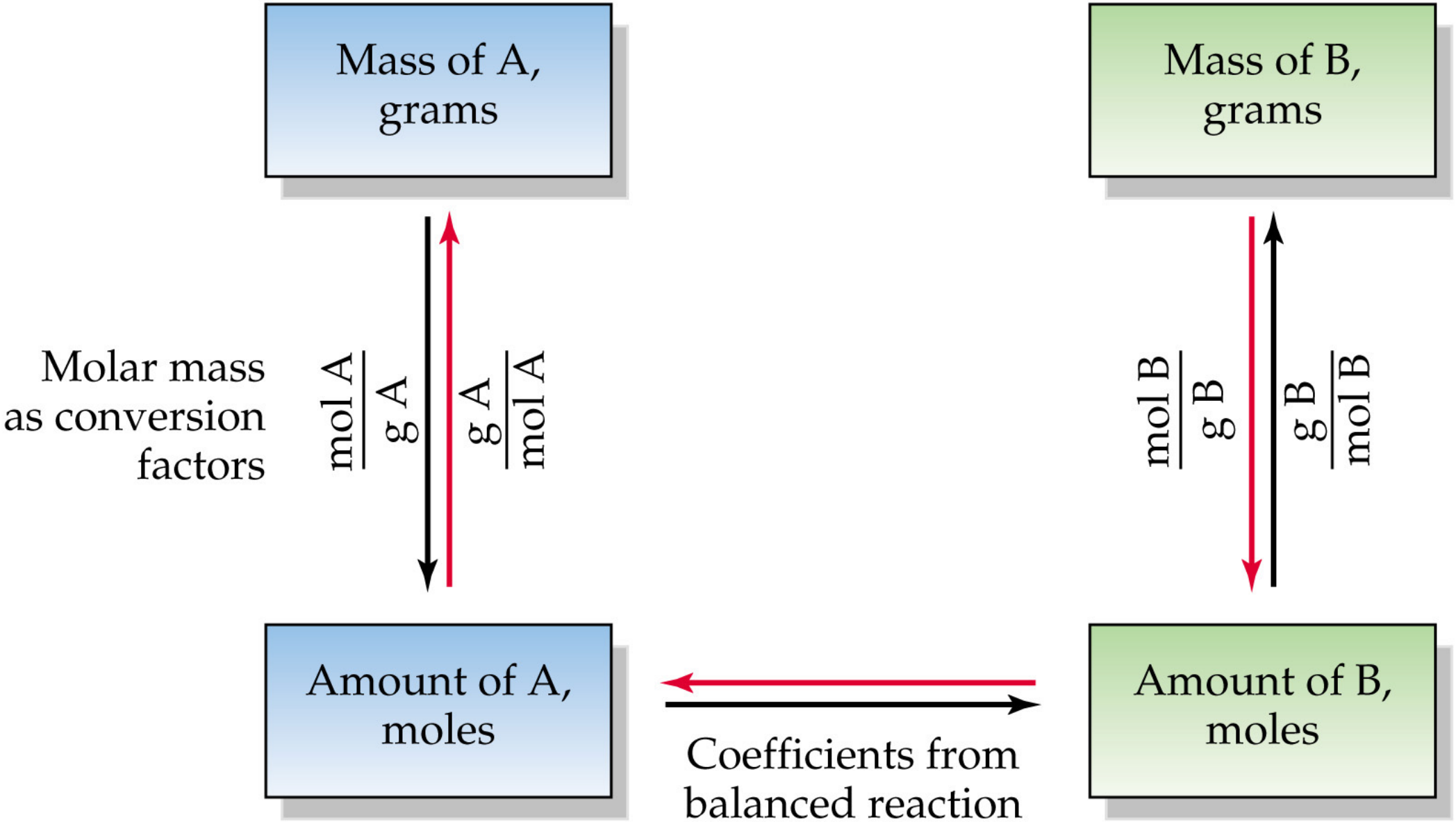
Reactions—continued

And chemical review!!

Steps to find grams in chemical reaction

- Balance the equation to get molar ratios
- Find molar mass of the substances in question
- Find moles of the one given in grams
- Set up a proportion to compare molar ratio to the moles of known and unknown
- If the unknown is on top, it is easier to solve, so set it up that way!!



Proportions

- Mathematical device to compare ratios
- Cross-multiply to solve
- Correctly organized
- Be sure you keep same:same in columns and rows

Proportions to find moles

- Correctly organized

Example

$$\frac{\text{moles of a}}{\text{moles of b}} = \frac{\text{coefficient of a}}{\text{coefficient of b}}$$

or

$$\frac{\text{moles of a}}{\text{coefficient of a}} = \frac{\text{moles of b}}{\text{coefficient of b}}$$

- cross-multiply to solve
- The convert moles back to grams

Proportions

- Correctly organized
- It doesn’t matter how you write the first ratio, as long as you label the numbers
- Try to put unknown on the top—easier to solve
- The second ratio needs to match the first

Problem $NO + O_2 \rightarrow NO_2$

- 64 grams O_2
- How many grams NO_2 produced?

First: Balance Equation

$$2NO + O_2 \rightarrow 2NO_2$$

Problem $2NO + O_2 \rightarrow 2NO_2$

- 64 grams O_2
- How many grams NO_2 produced?

Balance Equation

Determine molar ratios of them 1:2

Find molar mass of each component

NO_2 = 46 g, O_2 = 32 g, (NO = 30 g)

Problem $2NO + O_2 \rightarrow 2NO_2$

- 64 grams O_2
- How many grams NO_2 produced?

Molar mass of each: O_2 = 32 g, NO_2 = 46 g

How many moles is 64 grams O_2?
2 moles

Problem $2NO + O_2 \rightarrow 2NO_2$

- 64 grams O_2
- How many grams NO_2 produced?
- Molar mass of each O_2 = 32 g, NO_2 = 46 g

Molar ratios O_2:NO_2 is 1:2
Two moles of O_2—do you need proportion to find moles of NO_2?
So four moles of NO_2 is produced
How many grams is that?
4 mol x 46 g/mol = 184 grams

Problem

$$H_2S + O_2 \rightarrow SO_2 + H_2O$$

- 32 grams SO_2
- How many grams O_2 used?

Problem

- 32 grams SO_2
- How many grams O_2 used?

$$H_2S + O_2 \rightarrow SO_2 + H_2O$$

- Balance first

$$2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$$

- Then determine molar ratios
- 2 SO_2 to 3 O_2

Problem

- 32 grams SO_2
- How many grams O_2 used?

$$2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$$

- Find molar masses
  - SO_2 = 32 + 32 = 64 g/mol SO_2
  - O_2 = (2x1) +16 = 32 g/mol O_2
  - H_2O= (2x1) +16 = 18 g/mol H_2O
  - H_2S = (2x1) +32 = 34 g/mol H_2S

Problem

- 32 grams SO_2
- How many grams O_2 used?

$$2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$$

- 32 g SO_2 needs how many grams O_2?
- How many moles is 32 g SO_2?

$$32\,\mathrm{g\,SO_2} \cdot \frac{1\,mole}{64\,\mathrm{g}} = 0.5\,moles\,\mathrm{SO_2}$$

Problem

- 32 grams SO_2
- How many grams O_2 used?

$$2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$$

- How many moles O_2 is needed?
- 0.5 moles SO_2 in 2:3 ratio with O_2
- 0.75 moles O_2

$$32\,\mathrm{g\,SO_2} \cdot \frac{1\,mole}{64\,\mathrm{g}} = 0.5\,moles\,\mathrm{SO_2}$$

Set up proportion

- 32 grams SO_2
- How many grams O_2 used?

with the unknown on top (the O_2)

$$\frac{?\ \text{moles}\ O_2}{[\qquad\qquad]} = \frac{[\qquad\qquad]}{[\qquad\qquad]}$$

Problem 6

$$C + O_2 \rightarrow CO_2$$

Is it balanced?

Molar ratio 1:1:1

4 grams oxygen

- Grams carbon consumed?
- Grams carbon dioxide produced?

Problem 6

$$C + O_2 \rightarrow CO_2$$

Molar ratio 1:1:1
4 grams oxygen

- 1 mole O_2 = 32 g

$$4g\ O_2 \cdot \frac{1\,mole}{32g} = 0.125\,moles\,O_2$$

Problem 6

$$C + O_2 \rightarrow CO_2$$

Molar ratio 1:1:1

0.125 moles O_2 in 1:1 ratio

0.125 moles C
0.125 moles CO_2

Problem 6

$$C + O_2 \rightarrow CO_2$$

0.125 moles C

Grams carbon consumed?

$$0.125 moles\ C \cdot \frac{12g}{1\,mole} = 1.5g\ C$$

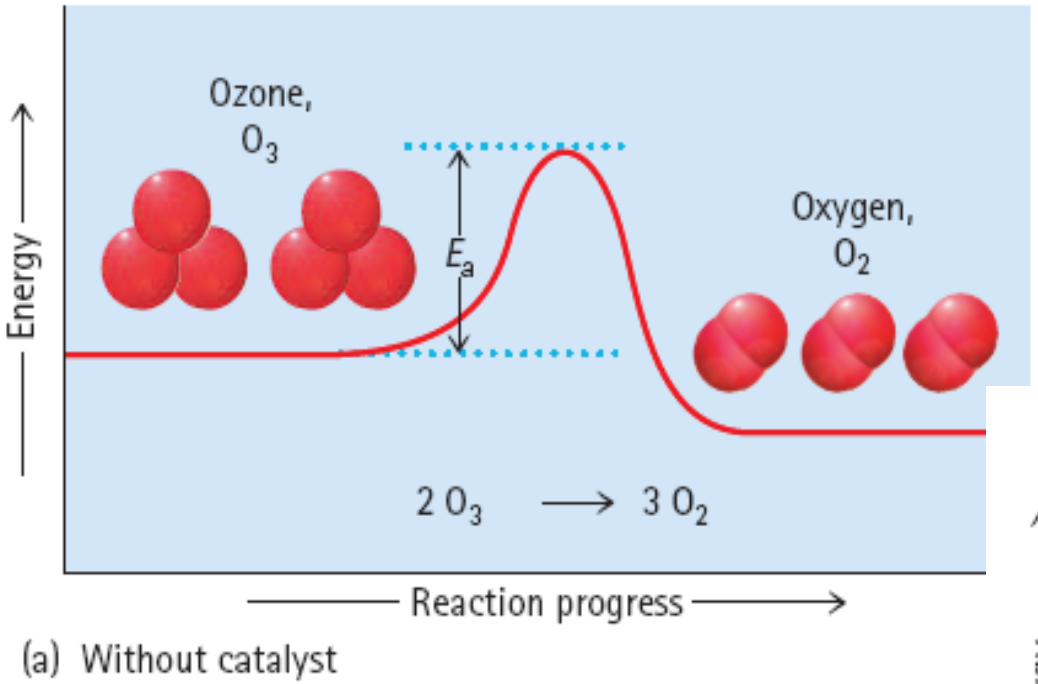
$$0.125\ \text{mole}\ CO_2 \cdot \frac{44g}{1\,mole} = 5.5g\ CO_2$$

Reaction Speed

Collision of molecules required for it to occur

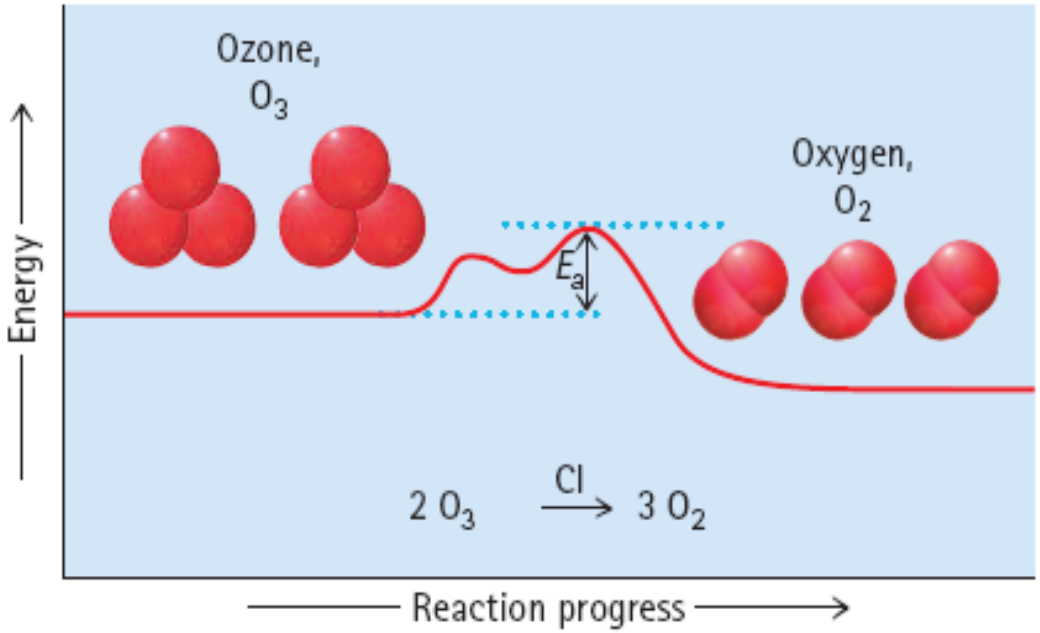
- Increase concentration
- Increase temperature
- Catalyst can facilitate reaction

Reaction of ozone to oxygen



(a) Without catalyst

- Chlorine catalyst



(b) With chlorine catalyst

Energy of reactions

- Release heat energy from chemical bonds
- EXOTHERMIC
- Methane combustion

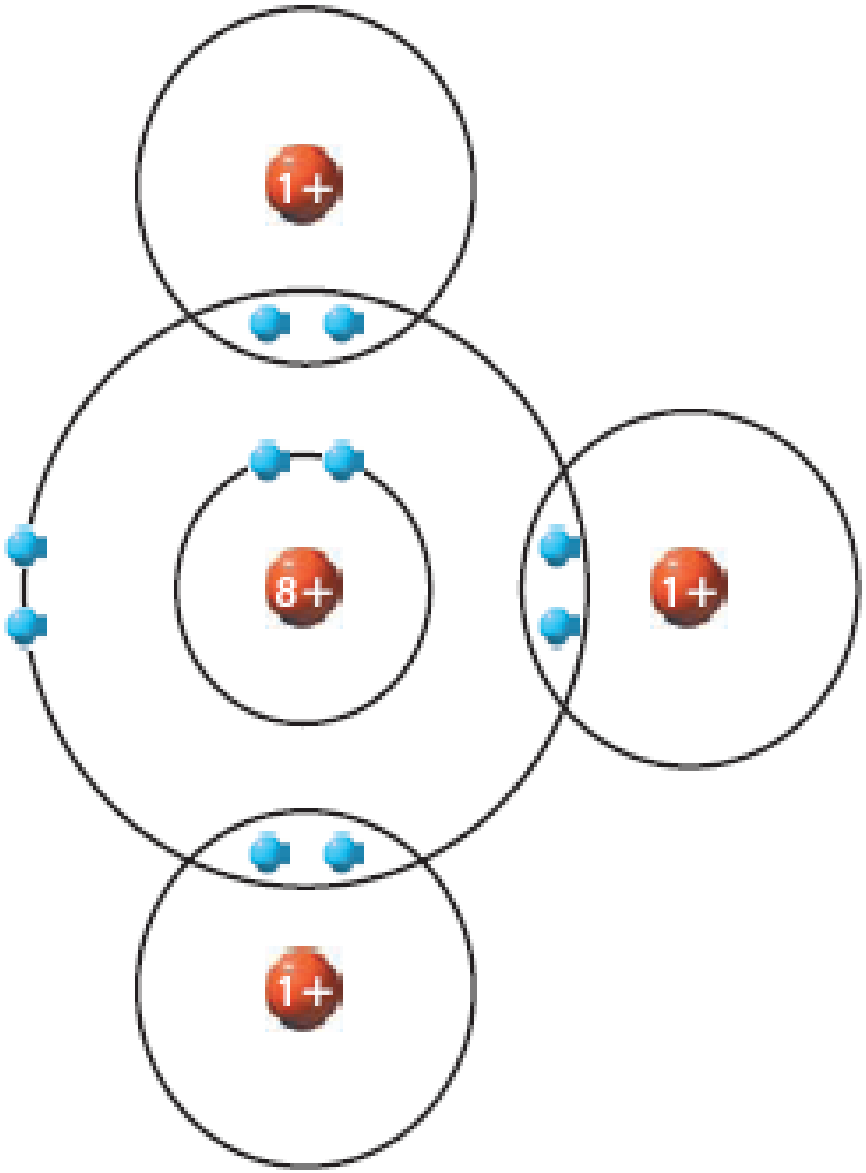
- Take heat energy into chemical bonds
- ENDOTHERMIC
- Formation of water

Two Types of Reactions

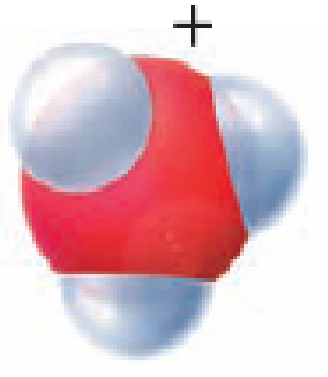
- Acid-Base reactions
- Oxidation-Reduction reactions

Acid-Base Reactions

- Transfer of hydrogen ions—protons
- Makes water into H_3O^+ and OH^-
- Hydronium and Hydroxide



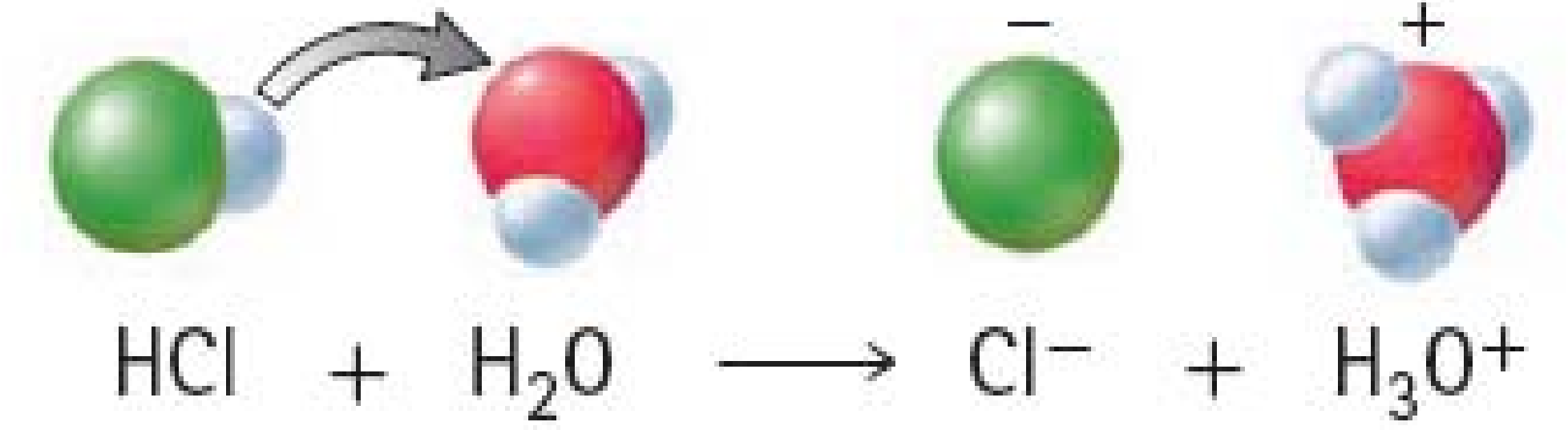
Electron dot structure
of hydronium ion



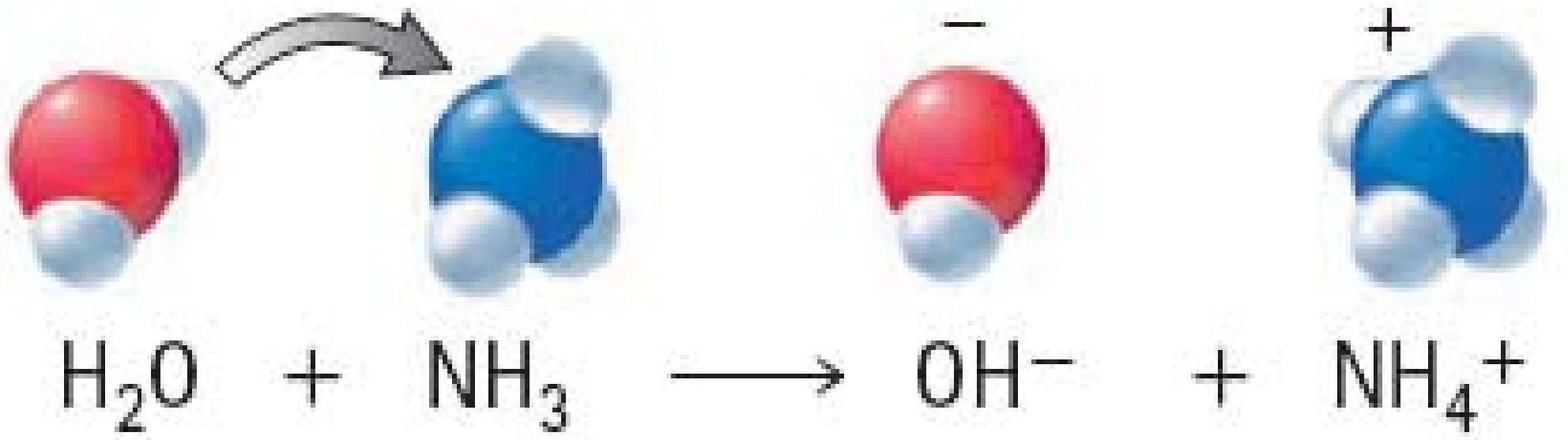
H_3O^+

Space-filling model
of hydronium ion

Dissolving HCl makes acid

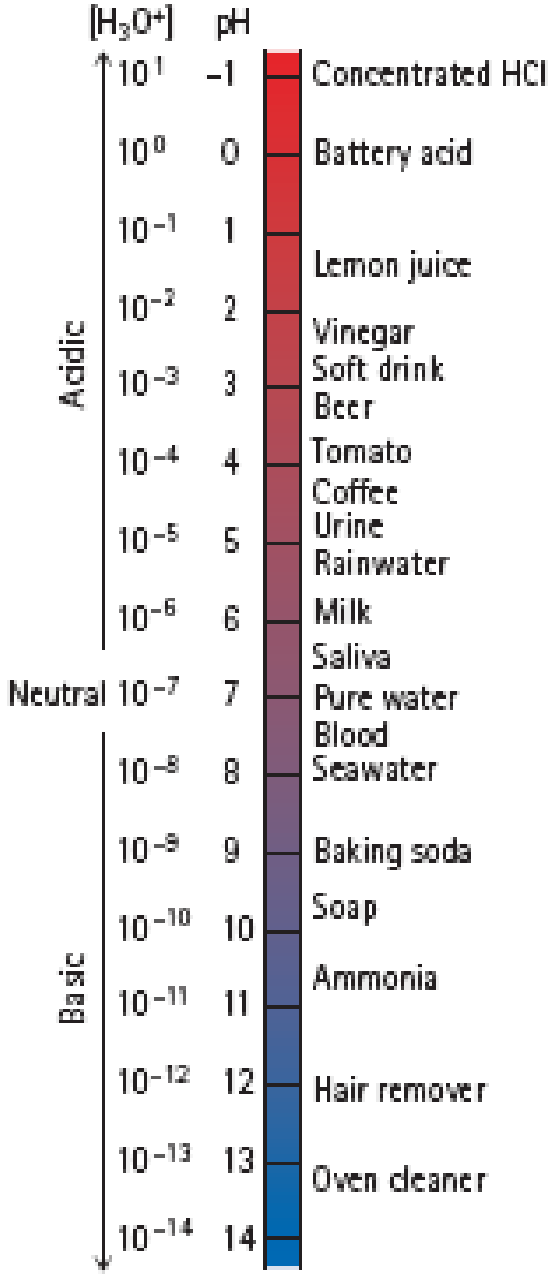


Dissolving NH_3 makes base



Measuring Acid Strength

- Measure of acidity is pH
  - Concentration of H_3O^+ in powers of 10
  - Negative of that power is the pH
  - pH of pure water is 7
  - Acids 0 to 7, bases 7 to 14
- Use electric current to determine pH



Acid Base Reactions

- Neutralize one another
- Acid + Base → Water + Salt
- Generic term ***salt*** is the ionic product of an acid-base reaction

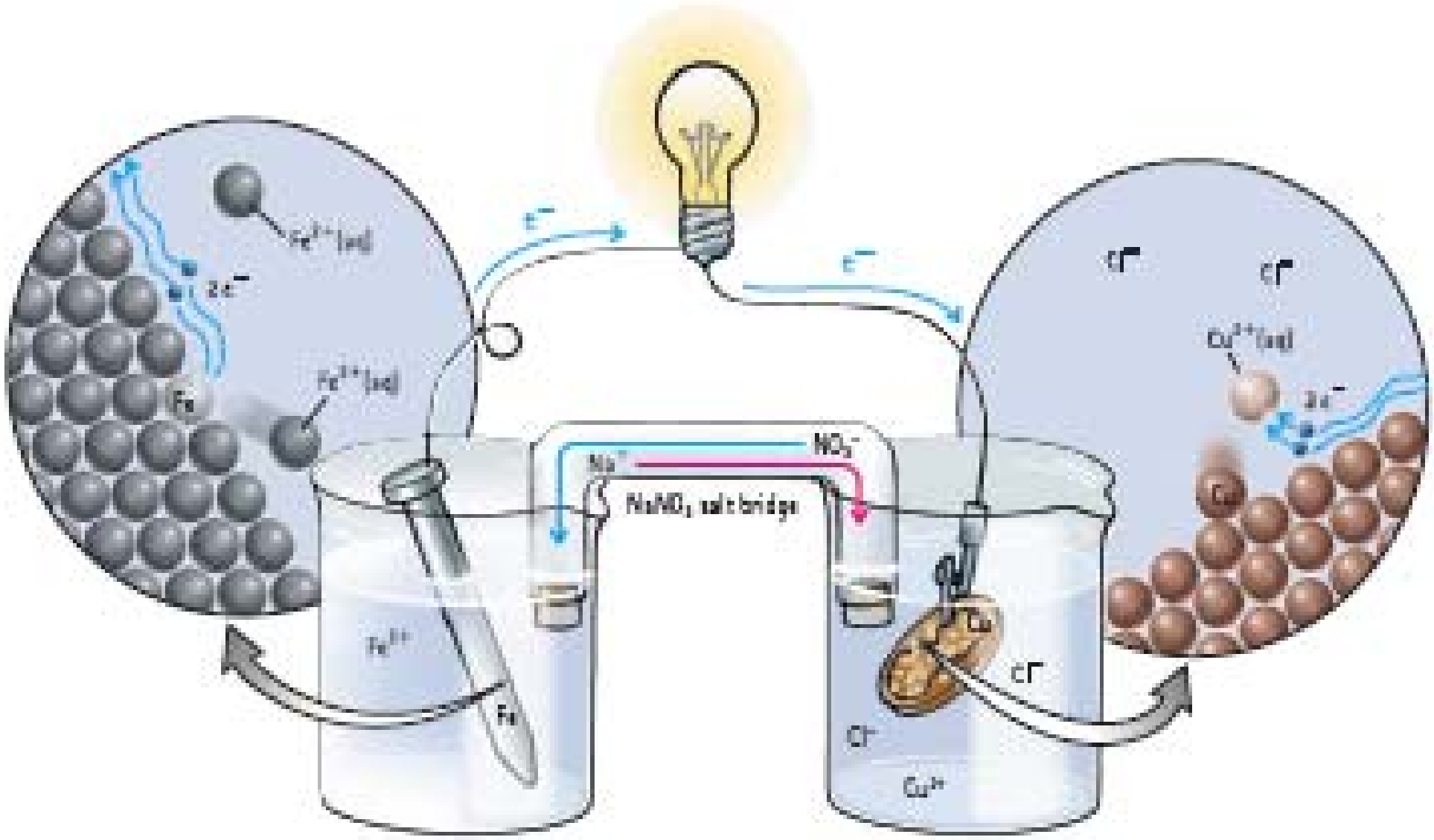
$$CaCO_3 + 2HCl \rightarrow CO_2 + H_2O + CaCl_2$$

Oxidation-Reduction Reactions

- Transfer of electrons
- Often bonding with oxygen
- Identifying the components of reaction—look for the transfer of electrons
  - Loss of Electrons—Oxidation (LEO)
  - Gain of Electrons—Reduction (GER)
  - (LEO the lion goes GER) =)

Batteries

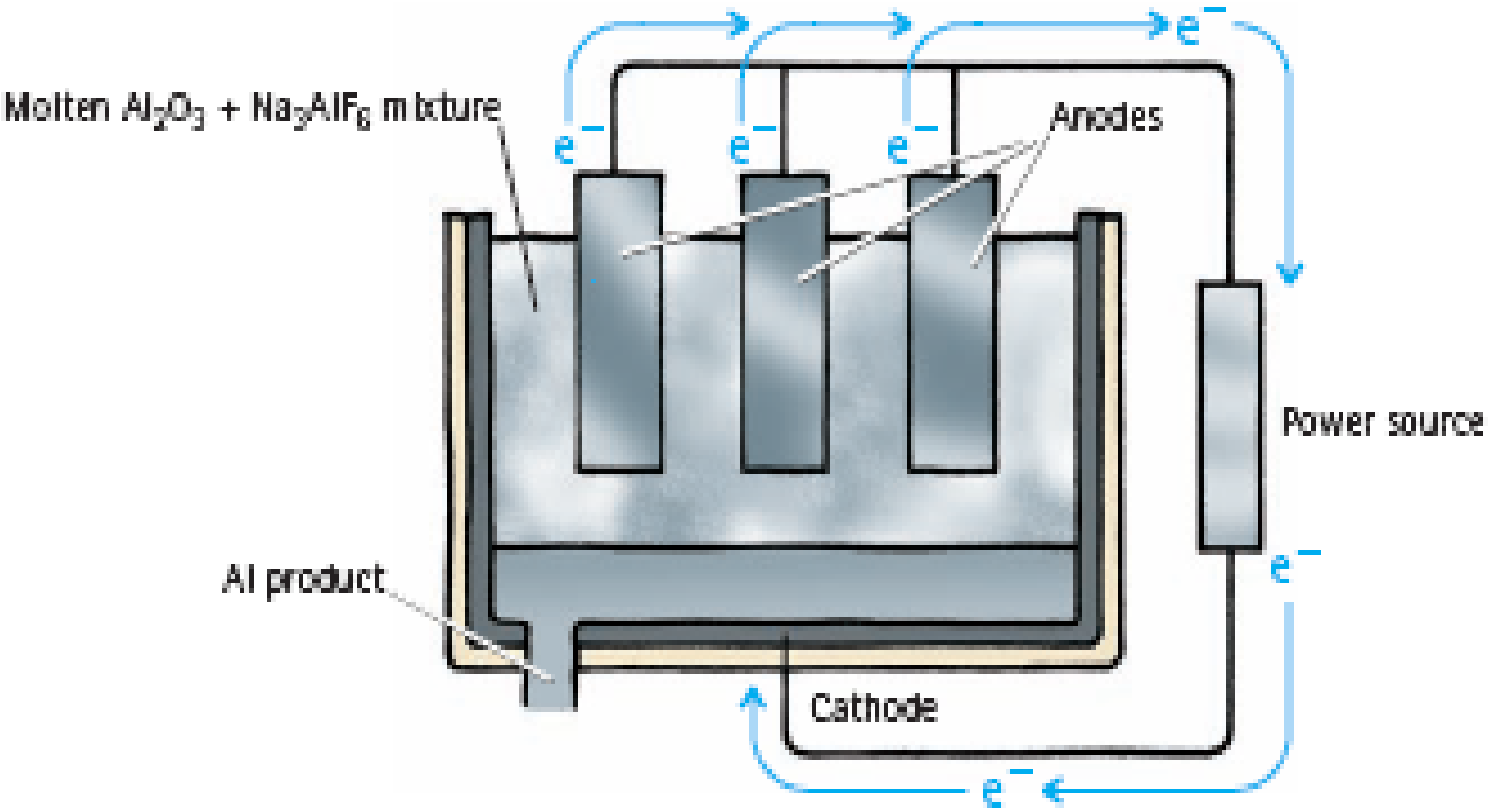
- Batteries function because of an oxidation-reduction reaction
  - Anode—source of electrons
  - Cathode—destination of electrons
- Need to have a way for electrons to get back to their source
  - Complete the circuit
  - Salt bridge or other device


e⁻
e⁻
Fe
Fe²⁺(aq)
2e⁻
Fe²⁺(aq)
Fe²⁺
Fe
NO₃⁻
Na⁺
NaNO₃ salt bridge
Cl⁻
Cl⁻
Cu²⁺(aq)
2e⁻
Cu
Cu
Cl⁻
Cl⁻
Cu²⁺
Oxidation Fe ⟶ Fe²⁺ + 2 e⁻
Reduction Cu²⁺ + 2 e⁻ ⟶ Cu

Electrolysis

- Electroplating is a useful Oxidation-Reduction Reaction
  - Ancient weak-acid electric circuits probably were utilized for this
- Electrolysis breaks covalent bonds
  - Aluminum oxide ore
  - Water can be source of hydrogen and oxygen,
    - For use in a fuel cell
    - Combining the two becomes source of electricity

Oxidation $2\,AlOF_3^{2-} + 6\,F^- + C \longrightarrow 2\,AlF_6^{3-} + CO_2 + 4\,e^-$



Reduction $AlF_6^{3-} + 3\,e^- \longrightarrow Al + 6\,F^-$

Corrosion

- An oxidation-reduction reaction
- Metals combine with oxygen
  - the oxide product has different properties
    - Weaker
    - Greater volume

Corrosion

- An oxidation-reduction reaction
- Metals combine with oxygen
  - Some metals coated or connected by electric circuit with others as a ‘sacrifice’ metal to protect strength of another
    - Zinc oxidizes more readily than iron
    - Attached to steel ship keels and rudders
    - Zinc galvanized nails

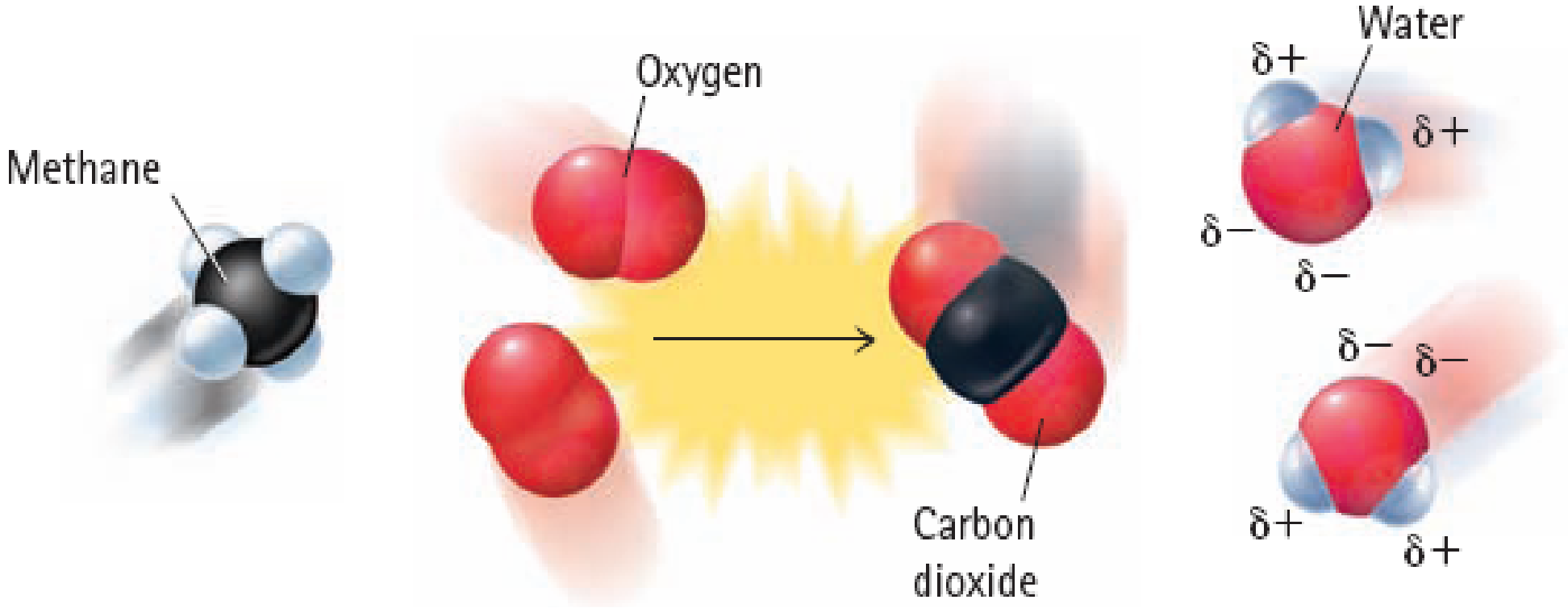
Combustion Reactions

- Combustion is an oxidation-reduction reaction

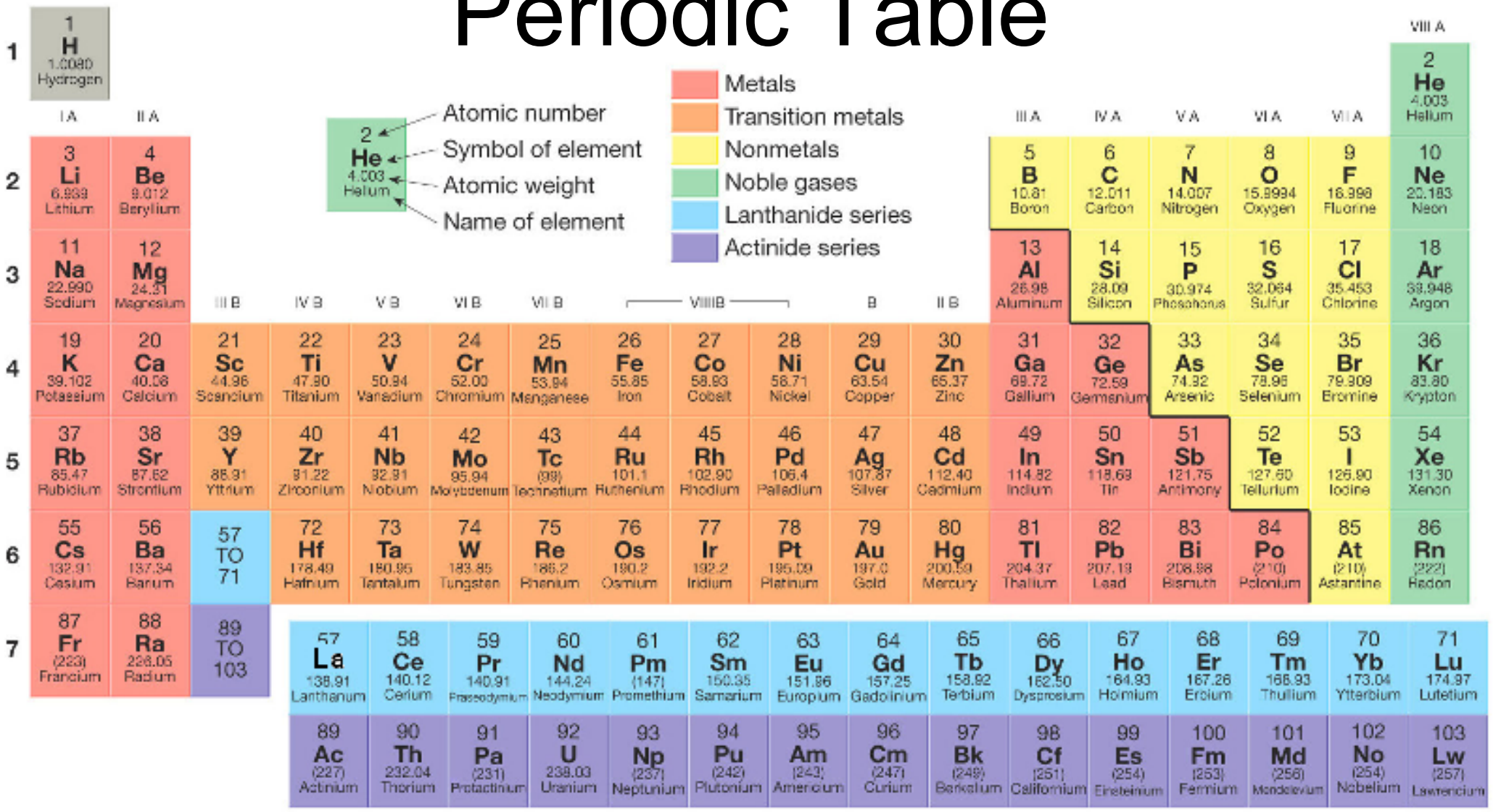
$$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$$

  - Methane: C and H are oxidized
  - Oxygen is reduced

Methane Combustion



Periodic Table



Groups or Families

- Alkali Metals
- Alkaline Earth Metals
- Transition Metals
- Oxygen Group (chalcogens)
- Halogens
- Noble Gases

Ions of Element Groups

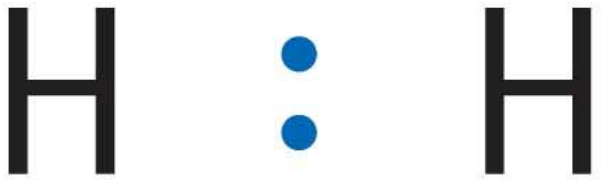
- Alkali Metals + 1
- Alkaline Earth Metals + 2
- Transition Metals +, number variable
- Oxygen Group - 2
- Halogens - 1
- Noble Gases no ions formed (usually)

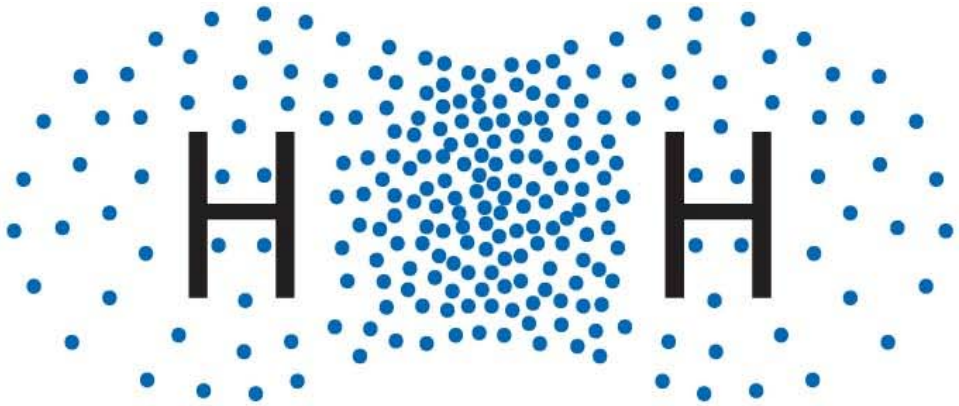
Ionic bonds form ionic compounds

Need even ratio of charges in the compounds

Covalent Bonds

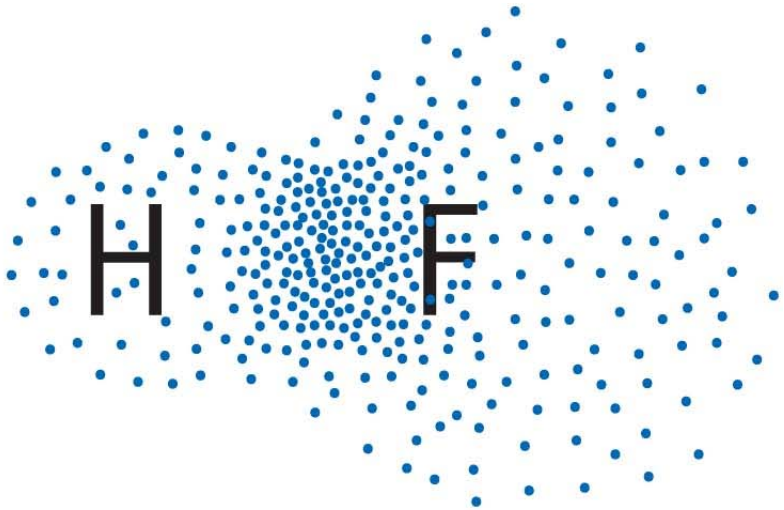
- When the two atoms are the same, electrons within covalent bond shared evenly.
- Nonpolar





Polar Covalent Bonds

- They may be shared *unevenly*, however, when the bonded atoms are different.
- Forms a dipole—has uneven charge



Compounds

- More than one type of atom in the molecule
- Has a **Chemical Formula**
- Sodium Chloride $NaCl$
- Ammonia NH_3
- Subscript tells how many of each
- (Subscript 1 is omitted)

Chemical Equations

- $C+O_2 \rightarrow CO_2$
- $C_{(s)} + O_{2\,(g)} \rightarrow CO_{2\,(g)}$

- Reactants on left, products on right
- Each are balanced because same number of atoms of reactants as products
- Letter subscript refers to the phase of the substance

Formula Mass/Molar Mass

- Mole: A super-large number, 6.02×10^{23}, used to measure numbers of atoms or molecules, a.k.a. Avogadro's number.

The formula mass of a substance expressed in grams contains one mole.

Substance	Formula Mass
Carbon, C	12
Oxygen, O_2	32
Carbon dioxide, CO_2	44
Sucrose, $C_{12}H_{22}O_{11}$	342

Molar mass of propane C_3H_8

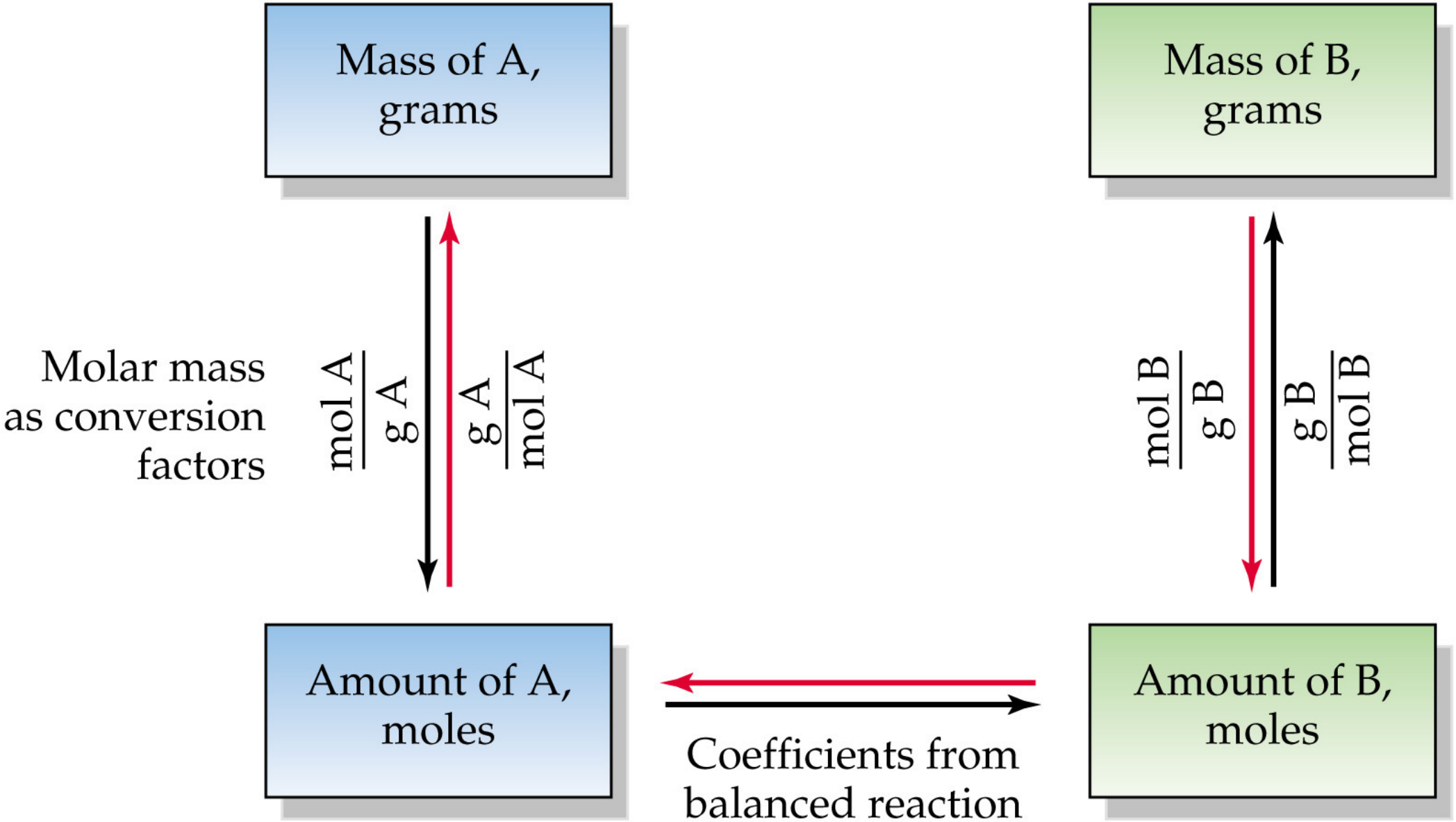
- assume molar mass of C = 12 g/mole
  - 3 C x 12 g/mole = 36 g/mole
- assume molar mass of H = 1 g/mole
  - 8 H x 1 g/mole = 8 g/mole
- 8 g/mole + 36 g/mole = 44 g/mole ***C_3H_8***

Grams calculated from Moles

- Can find the mass of substance from knowing molar mass and moles

  Na=23 g/mole ¼ mole

- Multiply molar mass times moles
- 23 g/mole x 0.250 moles = 5.75 g



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Proportions to find moles

- Correctly organized

Example

$$\frac{\text{moles of a}}{\text{moles of b}} = \frac{\text{coefficient of a}}{\text{coefficient of b}}$$

or

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- cross-multiply to solve
- The convert moles back to grams