Example:

How many milliliters of 6.00M hydrochloric acid is needed to completely react with 25.0 g of sodium carbonate?

$$2HCl(aq) + Na_2CO_3(s) \longrightarrow H_2O(l) + CO_2(g) + 2NaCl(aq)$$

1 - Convert 25.0 g sodium carbonate to moles. Use formula weight.
2 - Convert moles sodium carbonate to moles HCl. Use chemical equation.
3 - Convert moles HCl to volume. Use concentration (6.00 moles/L)

(1) Na_2CO_3: Na: 2 x 22.99
C: 1 x 12.01
O: 3 x 16.00

105.99 g Na_2CO_3 = mol Na_2CO_3

$$25.0\text{ g }Na_2CO_3 \times \frac{\text{mol }Na_2CO_3}{105.99\text{ g }Na_2CO_3} = 0.235871308\text{ mol }Na_2CO_3$$

(2) 2 mol HCl = mol Na_2CO_3

$$0.2358713086\text{ mol }Na_2CO_3 \times \frac{2\text{ mol HCl}}{\text{mol }Na_2CO_3} = 0.4717426172\text{ mol HCl}$$

Example:

How many milliliters of 6.00M hydrochloric acid is needed to completely react with 25.0 g of sodium carbonate?

$$2HCl(aq) + Na_2CO_3(s) \longrightarrow H_2O(l) + CO_2(g) + 2NaCl(aq)$$

1 - Convert 25.0 g sodium carbonate to moles. Use formula weight.
2 - Convert moles sodium carbonate to moles HCl. Use chemical equation.
3 - Convert moles HCl to volume. Use concentration (6.00 moles/L)

(3) 6.00 mol HCl = L   mL = 10^{-3} L

$$0.4717426172 \text{ mol HCl} \times \frac{L}{6.00 \text{ mol HCl}} \times \frac{mL}{10^{-3} L} = 78.6 \text{ mL of } 6.00 \text{ M HCl}$$

You CAN solve this problem on one line (plus writing down the factors!)

105.99 g Na_2CO_3 = mol Na_2CO_3 | 2 mol HCl = mol Na_2CO_3

6.00 mol HCl = L | mL = 10^{-3} L

$$25.0 \text{ g } Na_2CO_3 \times \frac{\text{mol } Na_2CO_3}{105.99 \text{ g } Na_2CO_3} \times \frac{2 \text{ mol HCl}}{\text{mol } Na_2CO_3} \times \frac{L}{6.00 \text{ mol HCl}} \times \frac{mL}{10^{-3} L} = 78.6 \text{ mL}$$

(1) (2) (3)

EXAMPLE PROBLEM:

$$2\,Na(s) + Cl_2(g) \rightarrow 2\,NaCl(s)$$

How many grams of sodium metal is required to completely react with 2545 grams of chlorine gas?

1 - Convert 2545 g chlorine gas to moles using formula weight
2 - Convert moles chlorine gas to moles Na using chemical equation
3 - Convert moles Na to g using formula weight.

Cl_2: 2x35.45 | 70.90 g Cl_2 = mol Cl_2 (1)

2 mol Na = mol Cl_2 (2)

Na: 22.99 g Na = mol Na (3)

$$2545\,g\,Cl_2 \times \frac{mol\,Cl_2}{70.90\,g\,Cl_2} \times \frac{2\,mol\,Na}{mol\,Cl_2} \times \frac{22.99\,g\,Na}{mol\,Na} =$$

$$= \boxed{1650.\,g\,Na}$$

EXAMPLE PROBLEM:

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

How many mL of 0.250 M sodium hydroxide is required to completely react with 15.0 mL of 2.00 M sulfuric acid?

1 - Convert 15.0 mL of sulfuric acid to moles using concentration (2.00 mol/L)
2 - Convert moles sulfuric acid to moles NaOH using chemical equation.
3 - Convert moles NaOH to volume using concentration (0.250 mol/L)

(1) 2.00 mol H_2SO_4 = L   mL = 10^{-3} L

(2) mol H_2SO_4 = 2 mol NaOH

(3) 0.250 mol NaOH = L   mL = 10^{-3} L

$$15.0\text{ mL} \times \frac{10^{-3}\text{ L}}{\text{mL}} \times \frac{2.00\text{ mol } H_2SO_4}{\text{L}} \times \frac{2\text{ mol NaOH}}{\text{mol } H_2SO_4} \times \frac{\text{L}}{0.250\text{ mol NaOH}} \times \frac{\text{mL}}{10^{-3}\text{ L}} =$$

= **240. mL of 0.250 M NaOH**

Shortcut: Use MILLIMOLES for solutions!

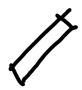
$$15.0\text{ mL} \times \frac{2.00\text{ mol } H_2SO_4}{\text{L}} \times \frac{2\text{ mol NaOH}}{\text{mol } H_2SO_4} \times \frac{\text{L}}{0.250\text{ mol NaOH}} = 240.\text{ mL}$$

(milli- didn't cancel out, so it appears in the asnwer!)

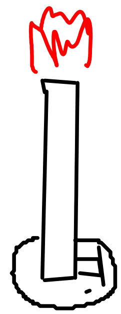
CONCEPT OF LIMITING REACTANT

- When does a chemical reaction STOP?

$$2Mg(s) + O_2(g) \xrightarrow{\Delta} 2MgO(s)$$



Magnesium strip



Flame, oxygen from air

Magnesium oxide powder

- When does this reaction stop? When burned in open air, this reaction stops when all the MAGNESIUM STRIP is gone. We say that the magnesium is LIMITING.

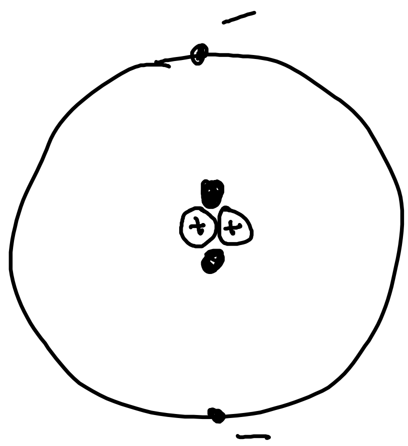
- This reaction is controlled by the amount of available magnesium

- At the end of a chemical reaction, the LIMITING REACTANT will be completely consumed, but there may be some amount of OTHER reactants remaining. We do chemical calculations in part to minimize these "leftovers".

- Reactants that are left at the end of a chemical reaction (in other words, they are NOT the limiting reactant) are often called "excess". So reacting magnesium with "excess oxygen" means that magnesium is limiting.

END OF CHAPTER 9 MATERIAL

STRUCTURE OF THE ELECTRON CLOUD



The nuclear model describes atoms as consisting of a NUCLEUS containing protons and neutrons and an ELECTRON CLOUD containing electrons.

The ELECTRON CLOUD is described as being a diffuse (lots of empty space) region of the atom. Nothing else about it is part of the nuclear model.

... but the nuclear model is not useful to explain several things:

- Does not explain why atoms react differently from one another
- Does not explain how atoms emit and absorb light (atomic line spectra)

ELECTROMAGNETIC SPECTRUM

(see p324-326)

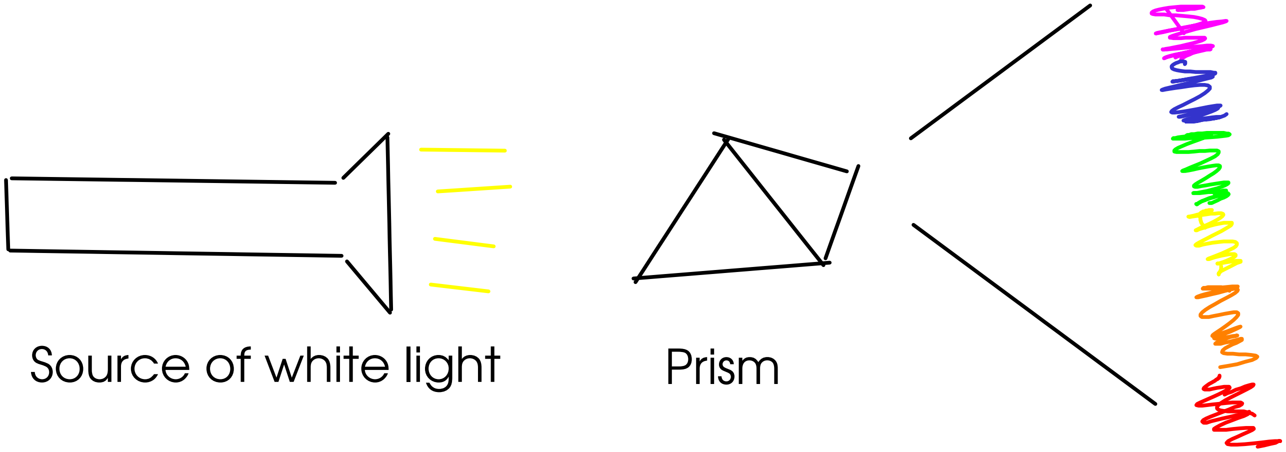
- Different kinds of "light" have different energy contents

GAMMA RAYS	X RAYS	ULTRA-VIOLET	VISIBLE LIGHT	INFRARED LIGHT	MICROWAVES

Higher energy / Higher Frequency / Shorter Wavelength ⟷ Lower energy / Lower Frequency / Longer Wavelength

VIOLET INDIGO BLUE GREEN YELLOW ORANGE RED

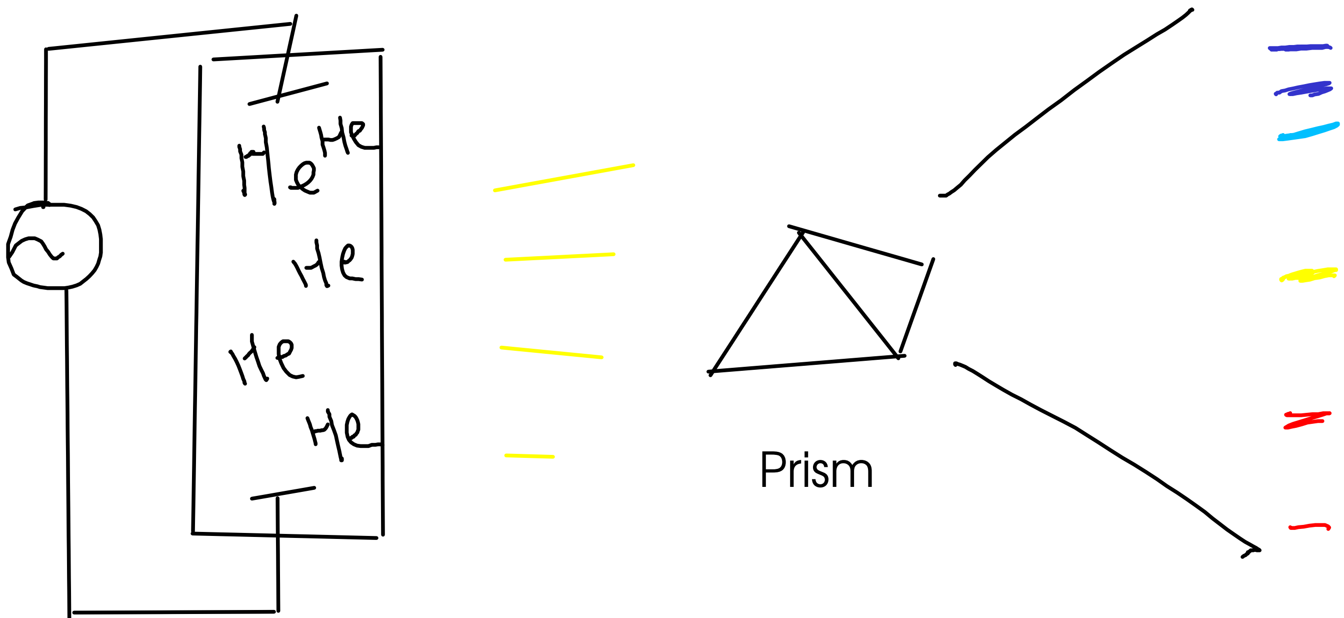
- Different colors of visible light correspond to different amounts of energy



Source of white light

Prism

Rainbow (all colors represented)



Prism

Gaseous Helium excited
by electricity

LINE SPECTRUM - only
a few specific colors appear!
(see p329 for example)