SINGLE-REPLACEMENT REACTIONS

$$A + BC \rightarrow AC + B$$

One element, usually a metal, replaces another element in a compound. This forms a new compound and leaves behind a new free element!

example: $Cu(s) + 2\,AgNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2\,Ag(s)$

0   +1   +2   0

Copper loses electrons, goes from 0 charge to +2 charge!

Silver gains electrons, goes from +1 charge to 0 charge!

... but just because you combine an element and a compound doesn't mean that a reaction will occur. Some combinations react, some don't!

- Whether a reaction occurs depends on how easiily the replacing and replaced elements lose electrons. An atom that loses electrons more easily will end up in IONIC form (in other words, in the compound). An atom that loses electrons less easily will end up as a free element.

- We say that an atom that loses elecrons more easily that another is MORE ACTIVE than the other element. But how would you get information about ACTIVITY?

ACTIVITY SERIES

- comes from experiental data. It's a list of elements in order of their ACTIVITY - more active elements are higher in the series!

A sample activity series

↑ Activity

Sodium	Na^{+}	Very active metals will replace hydrogen in acids AND in water!
Magnesium	Mg^{2+}	
Aluminum	Al^{3+}	Metals more active than hydrogen will replace hydrogen in acids!
Zinc	Zn^{2+}	
Iron	Fe^{2+}	
Lead	Pb^{2+}	
Hydrogen	H^{+}	
Copper	Cu^{2+}	These metals are unreactive to most acids!
Silver	Ag^{+}	

PREDICTING SINGLE REPLACEMENT REACTIONS

$Ag(s) + H_2SO_4(aq) \rightarrow$ NO REACTION!

Silver is LESS active than hydrogen.
Silver does NOT replace hydrogen ,and no reaction occurs!

$Mg(s) + ZnSO_4(aq) \rightarrow MgSO_4(aq) + Zn(s)$

Magnesium is MORE active than zinc.
Magnesium replaces zinc in this reaction!

$Pb(s) + 2HCl(aq) \rightarrow PbCl_2(s) + H_2(g)$

Lead is MORE active than hydrogen.
Lead replaces hydrogen in this reaction!

Pure hydrogen exists as a diatomic molecule. Remember experiment 3!

$Zn(s) + Pb(NO_3)_2(aq) \rightarrow Zn(NO_3)_2(aq) + Pb(s)$

Zinc is MORE active than lead.
Zinc replaces lead in this reaction!

CHEMICAL CALCULATIONS - RELATING MASS AND ATOMS

$$\_\ Na_2CO_3 + \_2HCl \rightarrow \_\ H_2O + \_\ CO_2 + \_2NaCl$$

Chemical equations are written and balanced in terms of ATOMS and MOLECULES

- While chemical equations are written in terms of ATOMS and MOLECULES, that's NOT how we often measure substances in lab!

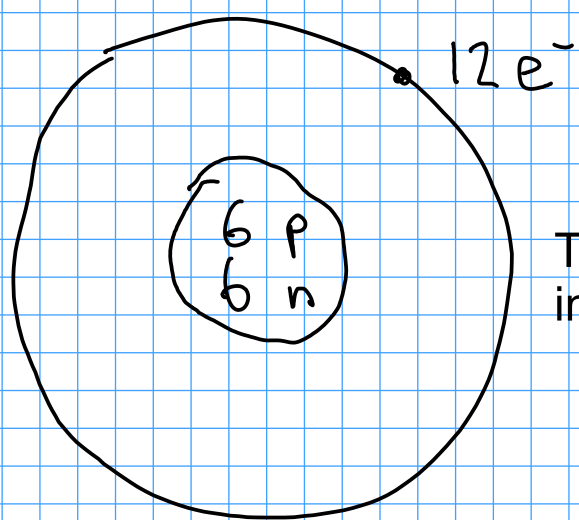
- measurements are usually MASS (and sometimes VOLUME), NOT number of atoms or molecules!

THE MOLE CONCEPT

- A "mole" of atoms is 6.022×10^{23} atoms

Why so big? Because atoms are so small!

- Why - in the metric dominated world of science - do we use such a strange number for quantity of atoms?



carbon-12

The mole is also defined as the number of carbon-12 atoms in exactly 12 g of carbon-12

THE MOLE CONCEPT

- Why define the mole based on an experimentally-measured number?

- The atomic weight of an element (if you put the number in front of the unit GRAMS) is equal to the mass of ONE MOLE of atoms of that element!

Carbon (C): Atomic mass 12.01 ~~amu~~ → 12.01 g

↓

the mass of ONE MOLE of naturally-occurring carbon atoms

Magnesium (Mg): 24.31 g = the mass of ONE MOLE OF MAGNESIUM ATOMS

- So, using the MOLE, we can directly relate a mass and a certain number of atoms!

RELATING MASS AND MOLES

- Use DIMENSIONAL ANALYSIS (a.k.a "drag and drop")

- Need CONVERSION FACTORS - where do they come from?

- We use ATOMIC WEIGHT as a conversion factor.

Mg : 24.31 | 24.31 g Mg = 1 mol Mg

"mol" is the abbreviation for "mole"

Example: How many moles of atoms are there in 250. g of magnesium metal?

24.31 g Mg = 1 mol Mg

$$250.\ \text{g Mg} \times \frac{1\ \text{mol Mg}}{24.31\ \text{g Mg}} = 10.3\ \text{mol Mg}$$

Example: You need 1.75 moles of iron. What mass of iron do you need to weigh out on the balance?

$55.85\ g\ Fe = 1\ mol\ Fe$

$$1.75\ mol\ Fe \times \frac{55.85\ g\ Fe}{1\ mol\ Fe} = 97.7\ g\ Fe$$

WHAT ABOUT COMPOUNDS? FORMULA WEIGHT

Example: 25.0 g of WATER contain how many MOLES of water molecules?

H_2O

H: 2 x 1.008 = 2.016

O: 1 x 16.00 = 16.00

18.016 ← formula weight of water!

Formula weight = mass of one mole of an element OR compound

$18.016\ g\ H_2O = 1\ mol\ H_2O$

$25.0\ g\ H_2O \times \frac{1\ mol\ H_2O}{18.016\ g\ H_2O} = 1.39\ mol\ H_2O$

Formula weight goes by several names:

- For atoms, it's the same thing as ATOMIC WEIGHT
- For molecules, it;s called MOLECULAR WEIGHT
- Also called "MOLAR MASS"