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^{+}
Magnesium Mg^{2+}

Very active metals will replace hydrogen in acids AND in water!

Aluminum Al^{3+}
Zinc Zn^{2+}
Iron Fe^{2+}
Lead Pb^{2+}

Metals more active than hydrogen will replace hydrogen in acids!

Hydrogen H^{+}

Copper Cu^{2+}
Silver Ag^{+}
Gold Au^{3+}

These metals are unreactive to most acids!

PREDICTING SINGLE REPLACEMENT REACTIONS

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

Lead is MORE ACTIVE than hydrogen,so we would expect lead to replace hydrogen in hydrochloric acid.

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

Since zinc is MORE ACTIVE than lead, we expect it to replace lead in lead(II) nitrate.

$$Ag(s) + H_2SO_4(aq) \rightarrow \text{NO REACTION}$$

Silver is LESS ACTIVE than hydrogen, so we do not expect it to replace hydrogen in sulfuric acid.

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

Magnesium is more active than zinc, so we expect it to replace zinc in zinc(II) sulfate.

Activity ↑

Sodium	Na^+
Magnesium	Mg^{2+}
Aluminum	Al^{3+}
Zinc	Zn^{2+}
Iron	Fe^{2+}
Lead	Pb^{2+}
Hydrogen	H^+
Copper	Cu^{2+}
Silver	Ag^+
Gold	Au^{3+}

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!

MASS ↑ Na_2CO_3 solid; VOLUME ↑ HCl solution

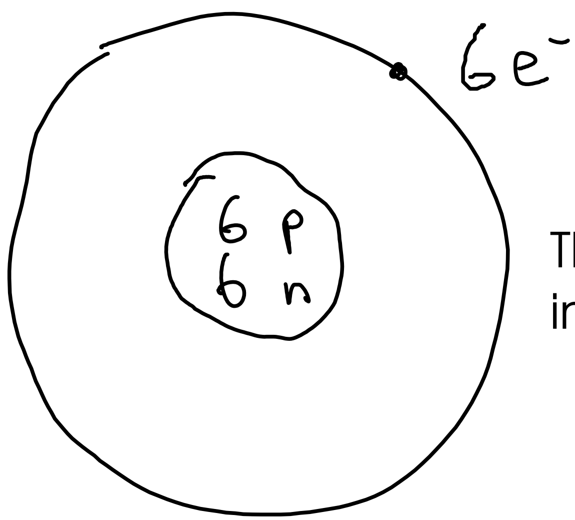
... so how do we relate atoms and molecules with things we routinely measure in lab - like grams and milliliters?

THE MOLE CONCEPT

- A "mole" of atoms is 6.022 $\times 10^{23}$ atoms

Why so big? Because atoms are so small!

- Why - in the metric dominated world of science - do we use such a strange number fo 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

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.

$Mg : 24.31 \quad | \quad 24.31\ g\ Mg = 1\ \underline{mol}\ Mg$

"mol" is the abbreviation for "mole"

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

$24.31\ g\ Mg = mol\ Mg$

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

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

Fe: 55.85 amu

55.85 g Fe = mol Fe

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

WHAT ABOUT COMPOUNDS? FORMULA WEIGHT

Example: 25.0 g of WATER contain how many MOLES of water molecules?
(H_2O)

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 either an element OR a compound!

$18.016\ g\ H_2O = mol\ H_2O$

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

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"

Example: How many grams of ammonium carbonate do we need to weigh out to get 3.65 moles of ammonium carbonate?

First, we have to find the FORMULA of ammonium carbonate!

NH_4^+ CO_3^{2-}

NH_4^+

$(NH_4)_2CO_3$

N : 2 x 14.01

H : 8 x 1.008

C : 1 x 12.01

O : 3 x 16.00

96.094 Formula weight of ammonium carbonate

$96.094 \text{ g } (NH_4)_2CO_3 = \text{mol } (NH_4)_2CO_3$

$$3.65 \text{ mol } (NH_4)_2CO_3 \times \frac{96.094 \text{ g } (NH_4)_2CO_3}{\text{mol } (NH_4)_2CO_3} = 351 \text{ g } (NH_4)_2CO_3$$