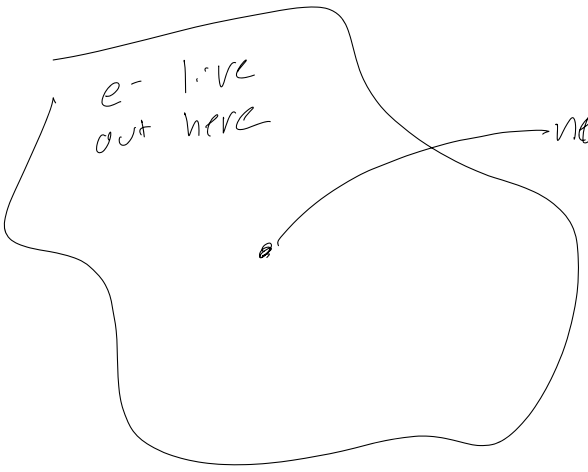
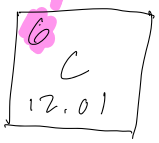
Atoms - made of protons, neutrons, electrons

protons: heavy, + charge
neutrons: heavy, neutral
electrons: light, - charged



Atomic # (Z) = # of protons in nucleus
tells you type of atom



Mass # (A) = # protons + # neutrons

$^{12}_{6}C$ → carbon atom with 6p, 6n
"carbon-12"

$^{13}_{6}C$ → carbon atom with 6p, 7n
"carbon-13"

$^{13}_{6}C$ and $^{12}_{6}C$ are isotopes of carbon
same # p
diff # n

Atomic mass - given in "atomic mass units" (amu)
such that 1 atom of $^{12}_{6}C$ has a mass of exactly 12 amu

$^{16}_{8}O$ 15.9948 amu

Cl has 2 major isotopes

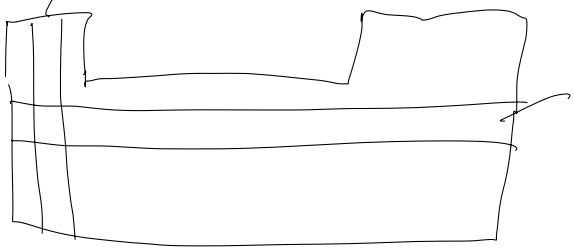
$^{35}_{17}Cl$ 34.969 amu is 75.8% of Cl atoms

$^{37}_{17}Cl$ 36.966 amu is 24.2% of Cl atoms

1000 Cl atoms → 758 Cl-35
242 Cl-37

$(758\ Cl\text{-}35 \times 34.969\ amu) + (242\ Cl\text{-}37 \times 36.966\ amu) = 35450\ amu$

↓ for 1000 Cl atoms



atoms in same group have similar properties

Molecules — how to represent

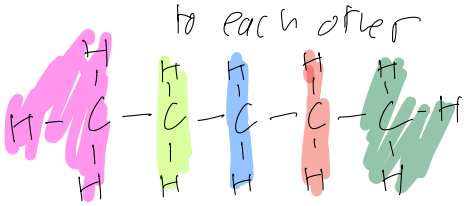
molecular formula — which atoms and how many

C_5H_{12} mississippi

condensed formula — shows relations/connections between groups of atoms

$CH_3CH_2CH_2CH_2CH_3$

structural formula — diagram showing how all atoms are connected to each other



Many compounds are made of molecules

Many compounds are not made of molecules but are made of ions → "Ionic compounds"

Ion: atom or group of atoms with a charge

anion – neg charge – got extra electrons
cation – pos charge – lost electrons

NaCl is our exemplar of an ionic compound
not made of Na atoms, Cl atoms
yes made of Na^+ cations and Cl^- anions
↓ Na atom that "lost" 1 e^-
↓ Cl atom that "gained" 1 e^-

Na^+ and Cl^- attract and come together to make NaCl

H, Li, Na, K, etc → +1 ions
Be, Mg, Ca, etc → +2 ions
F, Cl, Br, etc → −1 ions
O, S, Se, etc → −2 ions

* pos and neg charges must cancel

Mg ions = Mg^{2+}
Cl ions

1 Mg^{2+} = +2
2 Cl^- gives −2
→ $MgCl_2$

Polyatomic ions – groups of atoms with net charge
– need to know name, formula, charge

NH_4^+	ammonium	CH_3COO^-	acetate
NO_3^-	nitrate	$C_2O_4^{-2}$	oxalate
MnO_4^-	permanganate	ClO_4^-	perchlorate
PO_4^{-3}	phosphate	SO_4^{-2}	sulfate
CO_3^{-2}	carbonate	OH^-	hydroxide

SO_4^{2-}

compound with Mg ions (Mg^{2+}) and nitrate ions

$Mg(NO_3)_2$ ~~MgN_2O_6~~ NO_3^-

Na^+ and NO_3^- → $NaNO_3$ ~~$Na(NO_3)$~~

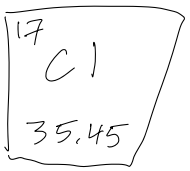
Keeping track of atoms + molecules

use counting unit called the "mole"

1 mole is the number of atoms of $^{12}_{6}C$ in exactly 12 grams of $^{12}_{6}C$

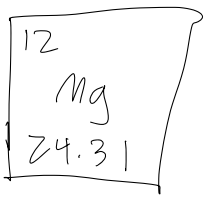
1 mole = 6.02×10^{23}

The mass in grams of 1 mole of an atom is equal to atomic weight from periodic table



1 mole of Cl atoms weighs 35.45 grams

Ex: We have 11.2 g Mg



$$11.2 \text{ g Mg} \times \frac{1 \text{ mole Mg}}{24.31 \text{ grams Mg}} = 0.461 \text{ moles Mg}$$

$$0.461 \text{ moles Mg} \times \frac{6.02 \times 10^{23} \text{ atoms of Mg}}{1 \text{ mole of Mg}} = 2.77 \times 10^{23} \text{ atoms of Mg}$$

Ex: How much does 4.97×10^{24} atoms of Mg weigh?

$$4.97 \times 10^{24} \text{ atoms Mg} \times \frac{1 \text{ mole Mg}}{6.02 \times 10^{23} \text{ atoms Mg}} = 8.26 \text{ moles Mg}$$

$$8.26 \text{ moles Mg} \times \frac{24.31 \text{ grams Mg}}{1 \text{ mole Mg}} = 200.7 \text{ g Mg}$$

Counting molecules

1 mole of water molecules (H_2O) contains 2 moles H atoms
1 mole of O atoms

$$2 \text{ moles H atoms} \times \frac{1.01 \text{ grams H atoms}}{1 \text{ mole H atoms}} = 2.02 \text{ g H atoms}$$

$$1 \text{ mole O atoms} \times \frac{16.0 \text{ g O atoms}}{1 \text{ mol O atoms}} = 16.0 \text{ g O atoms}$$

18.02 g is molar mass of water

How many H_2O molecules in 35.6 g of H_2O

$$35.6 \text{ g } H_2O \times \frac{1 \text{ mole } H_2O}{18.02 \text{ g } H_2O} \times \frac{6.02 \times 10^{23} \text{ molecules } H_2O}{1 \text{ mole } H_2O} = 1.19 \times 10^{24} \text{ molecules of water}$$

1.19×10^{24} O atoms

2.38×10^{24} H atoms

Mass percentage in molecules

CH_4 → get molar mass (1 mole C: $12.01 \text{ g} \times 1$) + (4 mole H: $1.01 \text{ g} \times 4$)

1 mole CH_4 weighs 16.05 g

$$\text{Mass \% C} \rightarrow \frac{12.01 \text{ g}}{16.05 \text{ g}} \times 100 = 75\%$$

$$\text{Mass \% H} \rightarrow \frac{4.04 \text{ g}}{16.05 \text{ g}} \times 100 = 25\%$$

Mass % can be measured and then it can be used to figure out formula of unknown material

Ex: Unknown is 85.6% C by mass
14.4% H by mass

If you had 100g then 85.6g C, 14.4g H

$$85.6\text{g C} \times \frac{1\text{mol C}}{12.01\text{g C}} = 7.12 \text{ moles C}$$

$$14.4\text{g H} \times \frac{1\text{mol H}}{1.01\text{g}} = 14.28 \text{ moles H}$$

Ratio of C:H is 7.12:14.28 → really 1:2

empirical formula is CH_2 but can't an actual molecular formula - just a ratio

C_2H_4, C_3H_6, C_4H_8, C_5H_{10} } all have CH_2 as empirical formula

Need more info to figure out which is molecular formula → need molar mass

If molar mass is found to be 42 grams/mole
then C_3H_6 is the formula