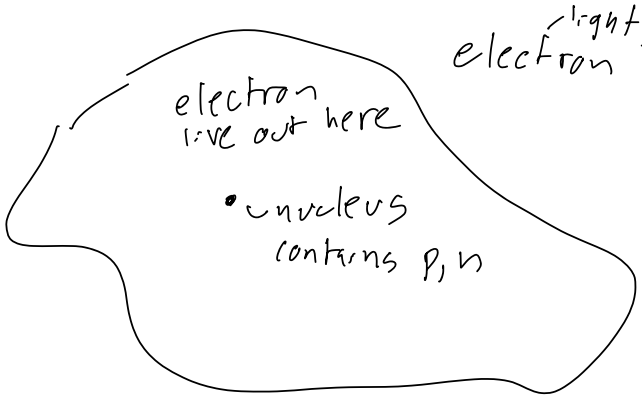
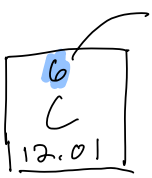
Atoms + Molecules

atoms are made of protons (heavy, +1), neutrons (heavy, 0 charge), electron (light, -1)



Atomic # (Z) = # of protons → tells you what type of atom something is



Mass # (A) = # protons + # neutrons

$^{12}_{6}C$ (A = 12, Z = 6) has 6p, 6n or carbon-12

$^{13}_{6}C$ has 6p, 7n or carbon-13

isotopes — have same # p but diff # n

Atomic mass - relative scale such that 1 atom of $^{12}_{6}C$ has mass of exactly 12 amu (atomic mass units)

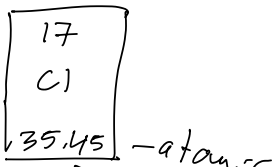
1 atom of $^{16}_{8}O$ 15.9948 amu

$1\ amu = 1.661 \times 10^{-24}\ g$

Isotopes of Cl

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

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



– atomic weight

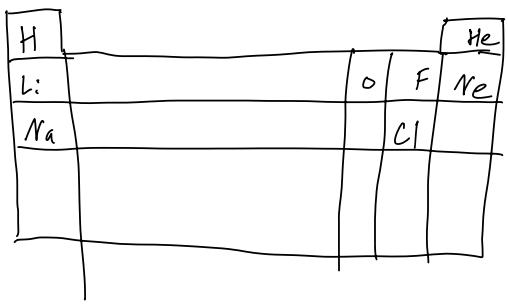
$(34.969\ amu \times 0.758) + (36.966 \times 0.242) = 35.45\ amu$

$^{12}_{6}C$ 98.9%

$^{13}_{6}C$ 1.099%

$^{14}_{6}C$ 0.0000001%

$^{14}_{7}N$ and $^{16}_{7}N$ Not isotopes



column = group → similar properties

rows = periods

across a row L → R Z increases

Molecules – how to represent

Molecular formula – how many of each type of atom

C_5H_{12} assess S_4ae

condensed formula – shows connectivity/relations between groups of atoms

$CH_3CH_2CH_2CH_2CH_3$

structural formula - diagram showing how all atoms are connected to one another

* Note that molecule is actually 3D

compounds come in 2 types

- Molecular → made of molecules C_5H_{12}, $C_6H_{12}O_6$
- Ionic compounds are made of ions

  ion = atom or group of atoms w/ a charge

  anion → neg charged, got extra electron(s) somehow

  cation → pos charged, lost electron(s)

NaCl - not made of Na atoms and Cl atoms

- made of Na^{+1} cations and Cl^{-1} anions
  - Na^{+1} ↓ Na atom that lost e^-
  - Cl^{-1} ↓ Cl atom that stole an e^-
- Na^+ and Cl^- attract to make NaCl

H, Li, Na, K → form +1 ions
Be, Mg, Ca → form +2 ions
F, Cl, Br, I → form -1 ions
O, S, Se → form -2 ions

* # pos charges and neg charges must balance

Mg and Cl → $MgCl_2$ has net zero charge

Mg ↓ likes to be Mg^{2+}

Cl ↓ likes to be Cl^-

Polyatomic ions — groups of atoms w/ non zero charge

* need to know name, formula, charge

NH_4^+ ammonium	CO_3^{2-} carbonate	MnO_4^- permanganate
NO_3^- nitrate	PO_4^{3-} phosphate	CH_3COO^- acetate
$C_2O_4^{-2}$ oxalate	OH^- hydroxide	
ClO_4^{-1} perchlorate	SO_4^{2-} sulfate	

Mg^{2+} and NO_3^- → $Mg(NO_3)_2$ not MgN_2O_6

Keeping track of all ~~atoms~~ atoms + molecules

counting unit called "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}

1 mole of water molecules ≈ 1 tablespoon of water

** The mass in grams of 1 mole of atoms of an element is ~~equal~~ equal to the atomic weight from periodic table

12
Mg
24.31

on avg 1 Mg atom weighs 24.31 amu

1 mole Mg atoms weighs 24.31 g

Imagine 11.2 g of Mg

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

$$0.461\text{ moles Mg} \times \frac{6.02\times10^{23}\text{ atoms Mg}}{1\text{ moles Mg}} = 2.77\times10^{23}\text{ atoms of Mg}$$

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

$$4.97\times10^{24}\text{ atoms Mg} \times \frac{1\text{ mole Mg}}{6.02\times10^{23}\text{ atoms Mg}} = 8.26\text{ moles Mg}$$

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

What about molecules?

1 mole of H_2O contains 1 mole of O atoms
2 moles of H atoms

$$1\text{ mole O atoms} \times \frac{16\text{ g}}{1\text{ mole}} = 16\text{ g}$$
$$2\text{ mole H atoms} \times \frac{1.01\text{ g}}{1\text{ mole}} = 2.02\text{ g}$$

} 18.02 g is mass of 1 mole of water

"molar mass" of water is 18.02 g

$$35.6\text{ g } H_2O \times \frac{1\text{ mole } H_2O}{18.02\text{ g } H_2O} = 1.98\text{ moles } H_2O \rightarrow 1.19\times10^{24}\text{ molecules of } H_2O$$

1.98 moles O atoms → 1.19×10^{24} O atoms

3.96 moles H atoms → 2.38×10^{24} H atoms

Mass % or % composition

CH_4 molar mass $= (1 \times 12.01\,g) + (4 \times 1.01\,g)$ (mass of 1 mole C; mass of 1 mole H)

$= 16.05\,g$

mass % C $= \frac{12.01\,g}{16.05\,g} = 75\%$

mass % H $= \frac{4.04\,g}{16.05\,g} = 25\%$

Can get formula of unknown material from % mass

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

If you had 100g it would contain

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

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

} gives mole ratio

C:H is $7.12 : 14.28 \approx 1 : 2$

empirical formula CH_2 is just ratio

C_2H_4, C_3H_6, C_4H_8 } all have CH_2 as empirical formula

Then do analysis to figure out molar mass

If we find molar mass 42 g/mol → C_3H_6 is molecular formula