05: Atoms and Molecules

Key Chemistry Terms

- **Atom:** Smallest piece of matter that retains the chemical properties of the element.
- **Nucleus:** Center of the atom—contains the protons and neutrons.
- **amu:** Atomic Mass Unit (1.66×10^{-27} kg)
- **Ion:** Atom with a charge, resulting from the loss or gain of electrons.
- **Anion:** Atom with a negative charge.
- **Cation:** Atom with a positive charge.
- **Periodic Table:** Organizes the elements.
- **Isotopes:** Atoms of the same element with a different number of neutrons.
- **Mass Number:** # of protons + # of neutrons.
- **Average Atomic Mass:** Weighted average of the masses of all isotopes of that element.
- **Molecules:** Atoms of different elements combined in a definite ratio to form a new "unit".

What is an Atom?

Atom is composed of sub-atomic particles

Particle	Location	Mass	Charge
Proton	Nucleus	1 amu = 1.67×10^{-27} kg	+1
Neutron	Nucleus	1 amu = 1.67×10^{-27} kg	0
Electron	Outside the nucleus	0.00055 amu = 9.10×10^{-31} kg	-1

Nucleus:
- Overall positive charge.
- Most of the mass of the atom in a small space (dense).
- Outside the nucleus:
  - Overall negative charge
  - Very little mass in a large space (low density)
  - Atom overall:
  - Charge depends on ratio of protons to electrons
  - Mass depends on number of protons & neutrons

Protons:
- # of determine the identity of the element—each element has a different number of protons.
- The atomic number (on periodic table) = # of protons.
- Cannot be lost or gained without changing the identity of the element (nuclear reaction).

Electrons:
- # of and configuration determine the "chemistry" of the element.
- Determined by the charge and the # of protons.
- Can be lost or gained to form charged atoms (ions).

Ions

- Atoms can gain or lose electrons to form ions (atoms with a charge.
- The charge depends on the ratio of protons to electrons.

Before	Change	After	Charge
Oxygen atom 8 protons 8 electrons	Gain 2 electrons	Oxygen anion 8 protons 10 electrons	O^{2-}
Sodium atom 11 protons 11 neutrons	Lost one electron	Sodium cation 11 protons 10 electrons	Na^{+}

Chemistry Symbology

- Element symbols (one or two letters, always beginning with a capital letter) are found on the periodic table.
- Elements are organized by atomic number.
- Element symbols can be written to include many pieces of information:

$${}^{A}_{Z}X^{C}_{\#}$$ Where

A = mass number
Z = atomic number
C = charge
# = number of atoms

Atomic number = # of protons
Mass # = # of protons + # of neutrons
Charge = # of protons - # of electrons

Isotopes

Atoms of the same element can contain a different number of neutrons.

- Neutrons do not affect charge.
- Neutrons do affect mass (neutron mass = 1 amu).
- Isotopes of the same element will have different masses.

- Masses are shown in the upper right corner of the symbol or after the elements name:
  e.g.: ^{13}C or Carbon-13

Mass Number	Average Atomic Mass
# of protons + # of neutrons	Weighted average of actual mass of all isotopes
Always a whole number	Not a whole number
Talks about one specific isotope	Takes into account all isotopes
Is not found on the periodic table	Is found on the periodic table.

Calculating average atomic mass:
Atomic mass = Σ(fractional abundance)(mass of that isotope)

Atoms, Elements & Molecules

Atoms	→	Elements	→	Molecules
Composed of protons, neutrons & electrons		Pure substance		Pure substance
Smallest piece of matter displaying chemical properties of element		Every atom is contains same # of protons		Atoms of more than one element bonded together
"Building block of matter"		Found on the periodic table		Displays properties different from the individual elements

- Molecules are written with element symbols to show which type of atoms are present & subscripts to show how many atoms are present.
- The most metallic element (closest to Group 1A) is written first (except in organic molecules).
  eg: NaCl or $CaCl_2$

How to Use This Cheat Sheet: These are the keys related this topic. Try to read through it carefully twice then recite it out on a blank sheet of paper. Review it again before the exams.