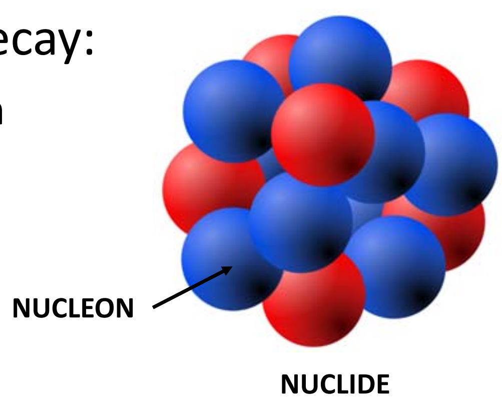
Grade 11 Chemistry

Matter, Trends, and Chemical Bonding

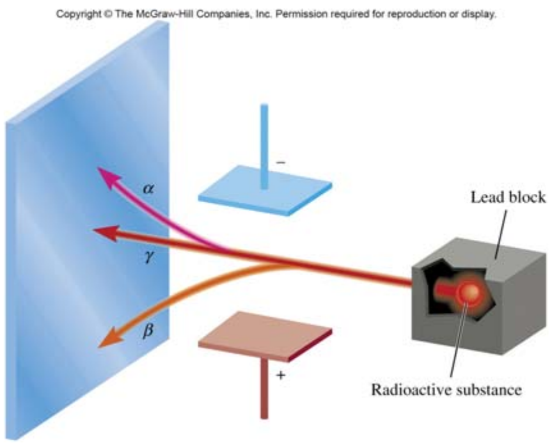
Class 2

Nuclear Reactions

- Nucleons – general term for protons and neutrons
- Nuclide – nucleus of an isotope
- Types of radioactive decay:
  - Alpha particle emission
  - Beta particle emission
  - Gamma radiation
  - Positron emission
  - Electron capture



- Three types of rays are produced by the decay of radioactive substances such as uranium:



1. **Alpha Rays** – consists of positively charged particles called alpha particles
2. **Beta Rays** – electrons that are deflected by the negatively charged plate called beta particles
3. **Gamma Rays** – high energy rays with no charge and are not affected by the external field

Balancing Nuclear Equations

- The sum of the mass numbers (written as superscripts) on each side of the equation must balance
- The sum of the atomic numbers (written as subscripts) on each side of the equation must balance)

$$^{222}_{88}\text{Ra} \longrightarrow \, ^{4}_{2}\text{He} + \, ^{218}_{86}\text{Rn}$$

Alpha Particle Emission

- Loss of an alpha (α) particle
- A α-particle is a helium nucleus (two protons, two neutrons and no electrons; 2+ charge)

$$^{226}_{88}\mathrm{Ra} \rightarrow \, ^{222}_{86}\mathrm{Rn} + \, ^{4}_{2}\mathrm{He}$$

Checkpoint

Find X, a and b:

$$^{a}_{b}\mathrm{X} \rightarrow \, ^{248}_{97}\mathrm{Bk} + \, ^{4}_{2}\mathrm{He}$$

Checkpoint

Find X, a and b:

$$^{212}_{84}\mathrm{Po} \rightarrow \ ^{a}_{b}X + \ ^{4}_{2}\mathrm{He}$$

Beta Decay Emission

- Occurs when a nucleus spontaneously decays into a proton and a beta (β) particle
- β-particle represented as $_{-1}^{0}\mathrm{e}$ or β^{-}

$$^{3}_{1}\mathrm{H} \rightarrow \ ^{3}_{2}\mathrm{He} + \ ^{0}_{-1}\mathrm{e}$$

Checkpoint

Find X, a and b:

$$^{90}_{38}\mathrm{Sr} \rightarrow \, ^{a}_{b}\mathrm{X} + \, ^{0}_{-1}\mathrm{e}$$

Checkpoint

Find X, a and b:

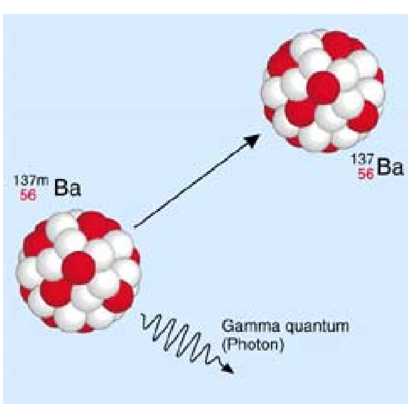
$$^{a}_{b}\mathrm{X} \rightarrow \, ^{137}_{56}\mathrm{Ba} + \, ^{0}_{-1}\mathrm{e}$$

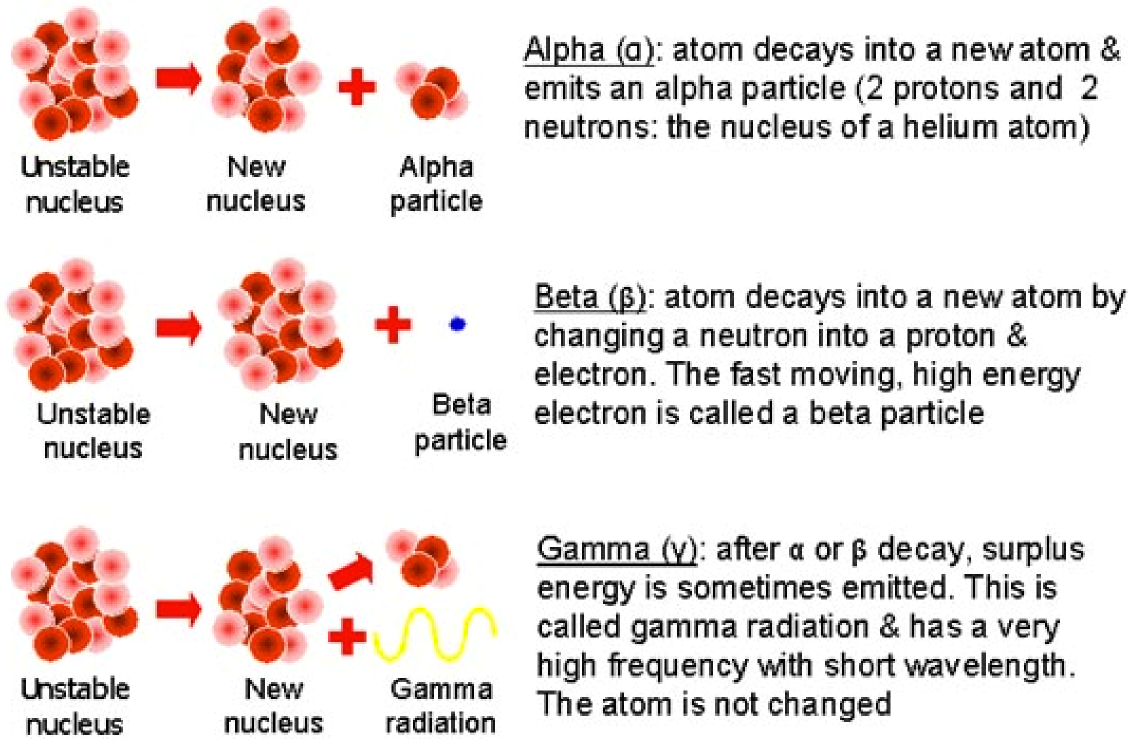
Gamma Radiation

- Gamma radiation is high energy radiation
- Often accompanies alpha or beta particle emission but is not always shown in the equation
- Represented by $^{0}_{0}\gamma$

$$^{137}_{55}\mathrm{Cs} \rightarrow \ ^{137}_{56}\mathrm{Ba} + \ ^{0}_{-1}\mathrm{e} + \ ^{0}_{0}\gamma$$

- When a radioactive nucleus emits an alpha or beta particle, the nucleus is often left in a unstable, high-energy state.
- The relaxation of the nucleus to a more stable state emits gamma radiation





Positron Emission

- Conversion of a proton in the nucleus into a neutron and an ejected positron
- Positron is a "positive electron" – same mass as an electron but positive charge
- Positron represented as ${}^{0}_{1}e$ or β^{+}

$$ {}^{40}_{19}\mathrm{K} \rightarrow {}^{40}_{18}\mathrm{Ar} + {}^{0}_{1}\mathrm{e} $$

Electron Capture

- Nucleus captures an inner-shell electron and converts a proton into a neutron

$$^{197}_{80}\mathrm{Hg} + {}^{0}_{-1}\mathrm{e} \rightarrow {}^{197}_{79}\mathrm{Au}$$

Nuclear Fission and Fusion

- Nuclear Fission: Occurs when a highly unstable isotope splits into smaller particles
  – Requires a particle accelerator
  – Atom absorbs a stream of high-energy particles such as neutrons
- Nuclear Fusion: Occurs when a target nucleus absorbs an accelerated particle
  – Requires very high temperatures to proceed
  – Produces large amounts of energy

Checkpoint

a) Find X, a and b:

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{87}_{35}\mathrm{Br} + {}^{a}_{b}\mathrm{X} + 3\,{}^{1}_{0}\mathrm{n}$$

b) Al-27 when it collides with a certain nucleus, transforms into P-30 along with a neutron. Write a balanced nuclear equation for this reaction

Name	Symbol(s)	Representation	Description
Alpha particle	${}^{4}_{2}\mathrm{He}$ or ${}^{4}_{2}\alpha$		(High-energy) helium nuclei consisting of two protons and two neutrons
Beta particle	${}^{0}_{-1}\mathrm{e}$ or ${}^{0}_{-1}\beta$		(High-energy) electrons
Positron	${}^{0}_{+1}\mathrm{e}$ or ${}^{0}_{+1}\beta$		Particles with the same mass as an electron but with 1 unit of positive charge
Proton	${}^{1}_{1}\mathrm{H}$ or ${}^{1}_{1}\mathrm{p}$		Nuclei of hydrogen atoms
Neutron	${}^{1}_{0}\mathrm{n}$		Particles with a mass approximately equal to that of a proton but with no charge
Gamma ray	γ	 γ	Very high-energy electromagnetic radiation

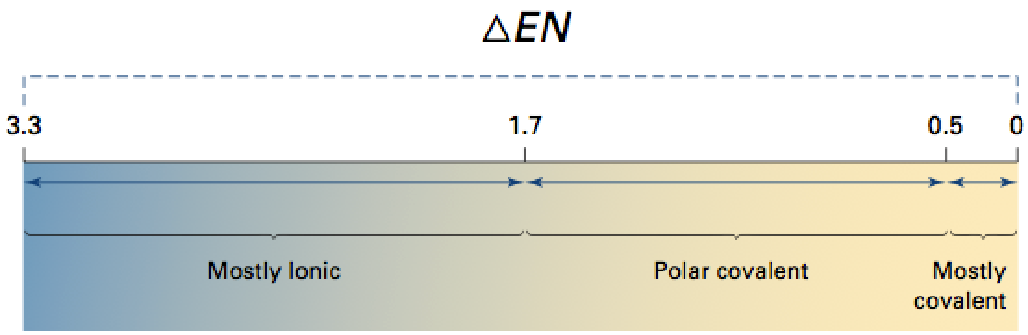
Chemical Bonding

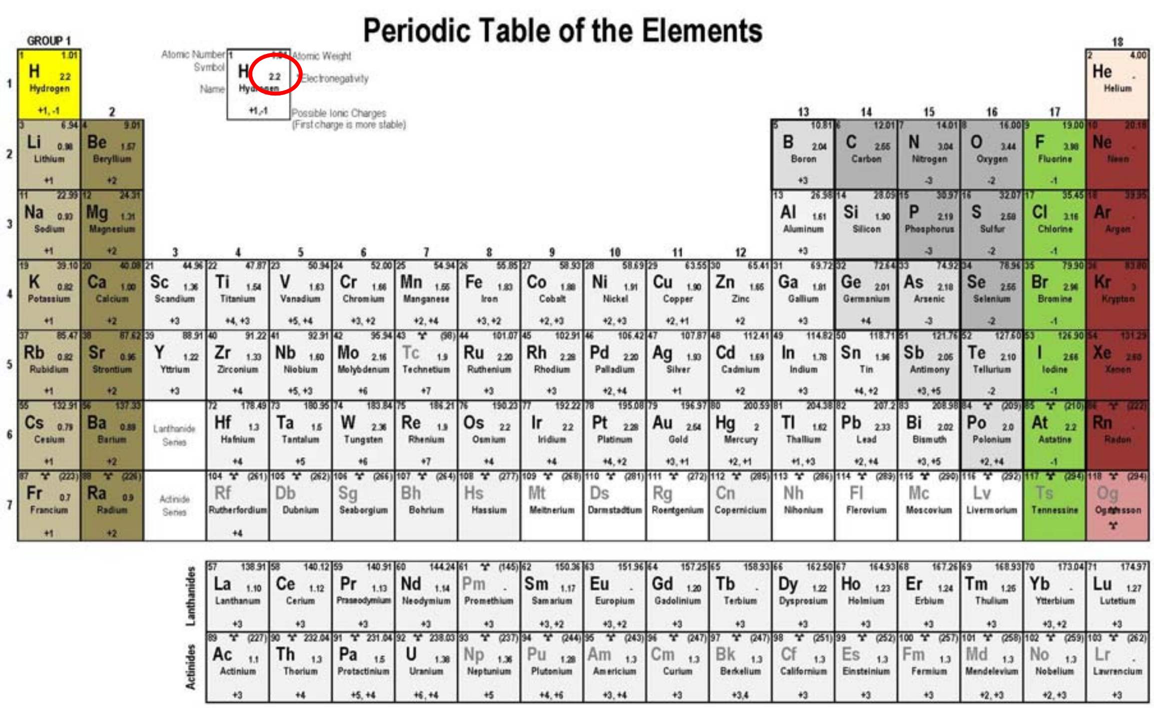
- Chemical Bonds – the interaction between the valence electrons of atoms
  - Formation of a bond creates a compound that is more stable than individual atoms on their own

- **Ionic Bond** – interaction of electrostatic charges; exchange of electrons
  - Between cations and anions
- **Covalent Bond** – when atoms share electrons

Property	Ionic compound	Covalent compound
state at room temperature	crystalline solid	liquid, gas, solid
melting point	high	low
electrical conductivity as a liquid	yes	no
solubility in water	most have high solubility	most have low solubility
conducts electricity when dissolved in water	yes	not usually

- How do you figure out if a compound is ionic or covalent? – Look at electronegativity differences ΔEN





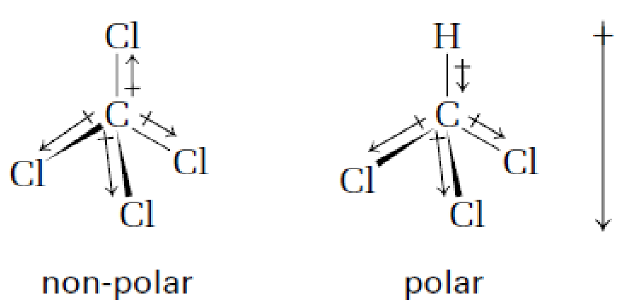
Checkpoint

Determine the ΔEN for each compound and indicate whether each bond is ionic, polar covalent or covalent; show partial charges

a) O-H
b) C-H
c) Mg-Cl
d) Na-F

Molecular Shape and Polarity

- Polarity can be determined by looking at electronegativity



- Different molecular shapes can be non-polar or polar depending on the distribution of the atoms

Checkpoint

Which of the following molecules are polar?

a) CO_2

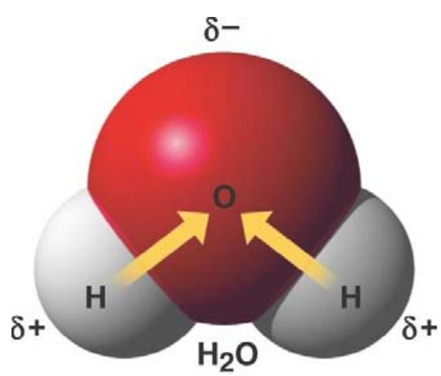
b) CF_4

c) H_2O

d) NH_3

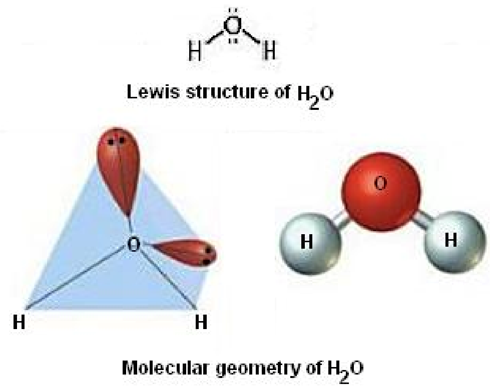
Polar Covalent Bonds

- When two bonding atoms have a ΔEN between 0.5 and 1.7
- Ex: Water is a polar covalent molecule

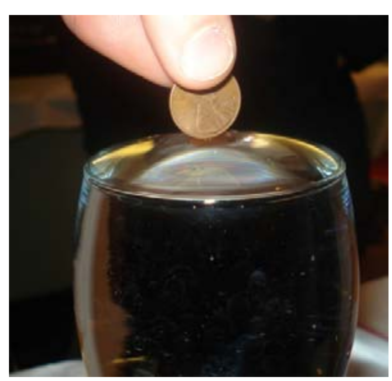


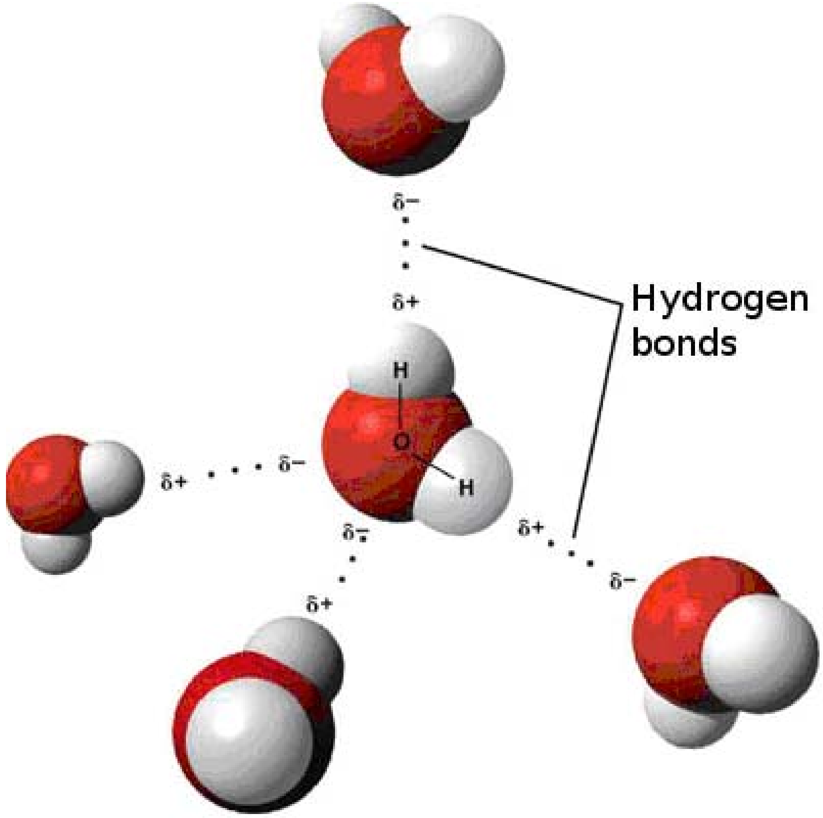
- ΔEN of the O-H is 1.24 so the O has a slightly negative charge and the H has a slightly positive charge
- Water is a polar molecule

- Why is water bent rather than linear?
  - The oxygen in water has two lone pairs which is not shown in the models
  - The lone pairs and the two hydrogens form a tetrahedral shape
  - Shape is determined by VSEPR theory (Grade 12 Chemistry)

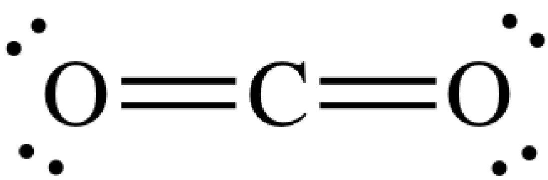
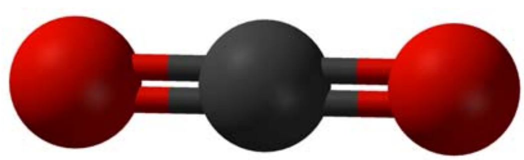


- The oxygen with the negative charge would attract hydrogens with a positive charge and vice versa
- Water's polarity explains why water skaters can walk on water and why you can pour liquid above the rim of a cup





- What about Carbon Dioxide?
  - ΔEN of C-O is 0.89 therefore it is supposedly polar covalent
  - But CO_2 is a linear molecule

  - Oxygen atoms have a partial negative charge and the carbon atom has a partial positive charge
  - Due to the linear shape, the effects of the polar bonds cancel out
  - CO_2 is non-polar

Checkpoint

Determine if each of the following molecules are polar or non-polar.

a) HF
b) CH_4
c) CH_3OH
d) Cl_2
e) BF_3
f) CH_3Br