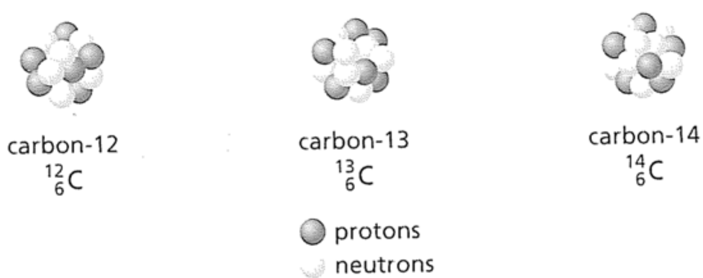
Science 10 - Physics Notes

Part 1

1.) **Atoms and isotopes**

- Atoms have a nucleus and some empty space. The nucleus is the dense centre of an atom that contains most of the mass of the atom.
- The nucleus contains the protons and neutrons. Electrons are the last particle of the atom and are found "zipping" around the nucleus.
- Protons and neutrons are particles that are about 1800 times heavier than an electron. Protons are positively charged and neutrons are neutral. Electrons have a negative charge.
- The **number of protons** decide what the type of atom is. 6 protons are always carbon. 92 protons are always uranium. **So . . . the number of protons can't change without changing the element!!!**
- Neutrons however can change. Carbon always has 6 protons. BUT it doesn't always have 6 neutrons. Sometimes it has 7 or even 8 neutrons. All of these different carbon atoms are still carbon. We call the different types of carbon isotopes. We distinguish between these different isotopes in its name.

Carbon-12 is carbon with 6 protons and 6 neutrons (hence 12). $^{12}_{6}C$
Carbon–13 is carbon with 6 protons and 7 neutrons. $^{13}_{6}C$
Carbon–14 is carbon with 6 protons and 8 neutrons (Radioactive). $\mathbf{^{14}_{6}C}$



- All isotopes are written the same except **hydrogen**. Hydrogen has different names for each isotope.
- Hydrogen is hydrogen with 0 neutrons, deuterium with 1 neutron, and tritium with 2 neutrons.

2.) **Radioactive decay notes**

- Certain elements are radioactive. Radioactive means that these atoms spontaneously emit radiation (energy). Examples of radioactive elements are polonium, radium, astatine, radon, francium and uranium.
- A nucleus of an atom that emits this radiation is undergoing radioactive decay. This means as the nucleus releases energy the nucleus (atom) is actually changing!
- How the nucleus changes, depends on the **type** of energy emitted. There are three main types of energy emitted during nuclear decay.

a.) Alpha decay – **symbol** = α (alpha). Alpha has a +2 charge and is a helium nucleus that is shot out of the nucleus. → $^{4}_{2}He$

b.) Beta decay – **symbol** = β (beta). Beta has a charge of –1 and is an electron that is shot out of the nucleus. → $^{0}_{-1}\beta$

c.) Gamma decay – **symbol** = γ (gamma). Gamma has no charge and is energetic "light" that is shot out of the nucleus. → $^{0}_{0}\gamma$

- Once the energy is emitted the nucleus is changed. This is called transmutation. Transmutation changes a parent nucleus into a daughter nucleus.

3.) **Three types of decay notes**.

- Alpha decay occurs when two protons and two neutrons (alpha particle) are emitted together from the nucleus.
  - Ex. – **polonium–210** undergoes alpha decay to form **lead–206**.

$$^{210}_{84}Po \rightarrow {}^{206}_{82}Pb + {}^{4}_{2}He$$

*** this is known as a nuclear reaction equation***

- Beta decay occurs when one electron (beta particle) is emitted from the nucleus.
  - Ex. – **carbon–14** undergoes beta decay to form **nitrogen–14**.

$$^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$$

  - This equation is possible because one neutron breaks apart into a proton, electron and neutrino.

- Gamma decay occurs when high energy, no particle, (alpha particle) is emitted from the nucleus. This emission of gamma rays will occur after some alpha or beta particles have been emitted. Emitting gamma rays WILL NOT change the identity of the atom, as gamma rays are only energy.
  - Ex. – **americium–241** undergoes alpha decay to form **neptunium–237**.

Note the asterisk to show the excited state!!

$$^{241}_{95}Am \rightarrow {}^{237}_{93}Np^{*} + {}^{4}_{2}He$$

$$^{237}_{93}Np^{*} \rightarrow {}^{237}_{93}Np + {}^{0}_{0}\gamma$$

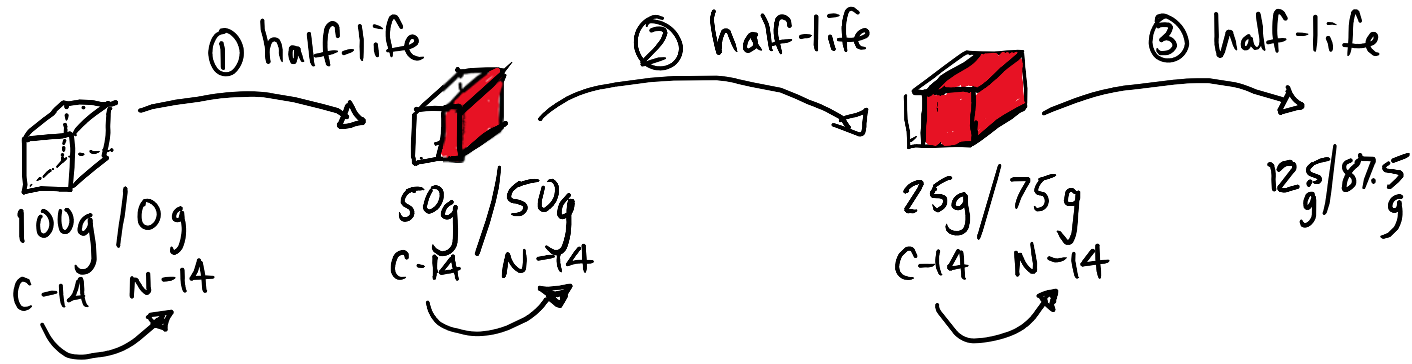
- Radioactivity can be detected using a device called a Geiger counter.

4.) **Half-life notes**

- Half-life is the time it takes for half of your radioactive sample nuclei to decay.

Over time radioactive nuclei decay to become a new element. As more time passes this new nucleus will often decay again and again until the nucleus reaches a stable form. This "chain" of decaying nuclei is called a decay series. Ex. – $Uranium - 238$ changes to $lead - 206$ in a decay series of 14 steps.

- Half-life is a measure of **time**. Half-lives can be seconds, hours, days weeks months years, hundreds, millions and even billions of years.



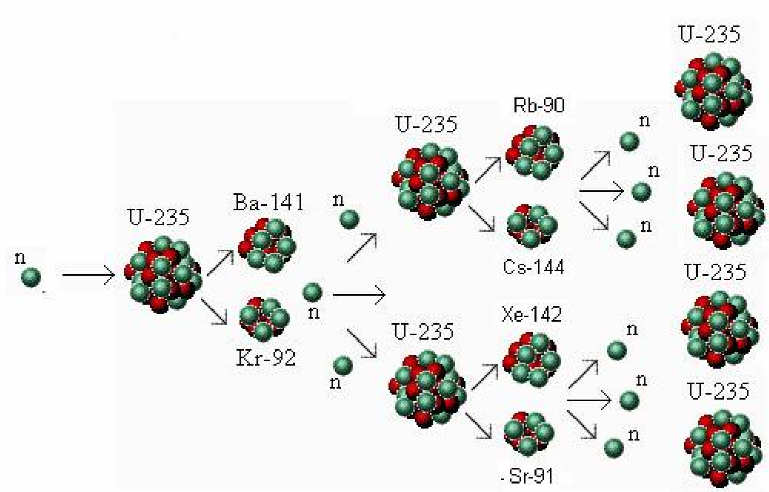
Part 2

1.) **Fission**

- Nuclear fission is the process of splitting an atom into two smaller atoms.
- Fission occurs by adding a neutron into the nucleus of an atom. The new nucleus becomes unstable and splits into two smaller atoms. The number of total protons and total neutrons remains the same, however, the total masses of the two new atoms add up to slightly less than the total should have. This is because a small amount of mass was converted into energy. This is where the big "boom" of a nuclear bomb comes from.
- We can write nuclear fission equations to show fission reactions.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow \ ^{141}_{56}Ba + \ ^{92}_{36}Kr + \ 3\ ^{1}_{0}n$$

- Notice how the protons and mass number are conserved!!!
- Because 3 neutrons are released in each fission, these neutrons can go on to split three more atoms to produce 9 neutrons, which can go on to split and produce 27 more neutrons etc.
- This production of more neutrons that was started with allows a nuclear fission to be self-sustaining. This chain of constant splitting of atoms is called a chain reaction.



5.) **Fusion**

- Fusion is the reverse of fission. Fusion is fusing (joining) two smaller nuclei into one larger nucleus.
- This reaction conserves the protons and neutrons but converts a small amount of mass into energy.
- The sun is powered by the fusion of two hydrogen atoms to form a helium atom (and a lot of energy)!
- To have two nuclei fuse they must collide at very high speeds that only occur at high temperatures (like in stars).
- We can write nuclear fusion equations to show fusion reactions.

$$ {}_{1}^{3}H + {}_{1}^{2}H \rightarrow {}_{2}^{4}He + {}_{0}^{1}n $$

- Notice how the neutrons and mass number are conserved!!!