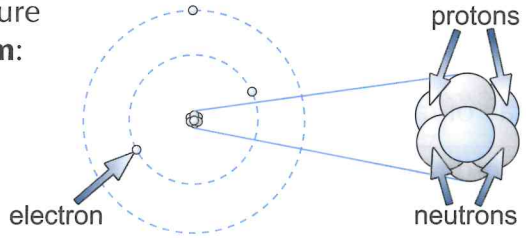
Atomic Structure

Atoms are Made Up of Three Types of Particle

1) According to the **nuclear model**, the atom is made up of electrons, protons and neutrons.
2) The **nucleus** is at the **centre** of the atom. It contains **protons** (which have a **positive** charge) and **neutrons** (which have **no charge**), giving the nucleus an **overall positive charge**. Protons and neutrons are both known as **nucleons**.
3) The nucleus is **tiny** but it makes up **most** of the **mass** of the atom. The rest of the atom is mostly **empty space**, containing only the negative **electrons** which orbit **around** the nucleus.

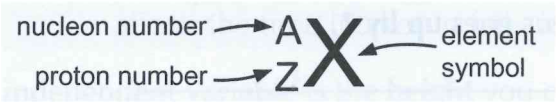
Here's the structure of a **lithium atom**:



	relative mass	relative charge
proton	1	+1
neutron	1	0
electron	0.0005	–1

Atomic Structure can be Represented Using Nuclide Notation

1) The **proton number** (or atomic number), **Z**, is the number of **protons** in an atom.
2) The **nucleon number** (or mass number), **A**, is the total number of **protons** and **neutrons**.
3) An element can be **described** by its **proton** and **nucleon numbers**:

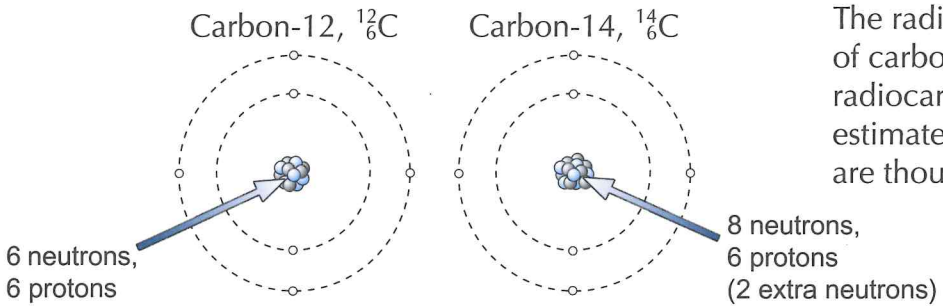


For example, lithium has 4 neutrons and 3 protons, so its symbol is $^{7}_{3}Li$.

Isotopes are Different Forms of the Same Element

1) Isotopes are atoms with the **same number** of **protons** but a **different number** of **neutrons**.
2) This means they have the **same proton number**, but **different nucleon numbers**.
3) Many isotopes are **unstable** and give off **radiation** (see next page).

EXAMPLE: Carbon-12 and carbon-14 are two isotopes of carbon.



The radioactive decay of carbon-14 is used in radiocarbon dating to estimate the age of things that are thousands of years old.

Radiocarbon dating — what physicists do on Valentine's Day...

1) How many protons and neutrons are there in each of the following nuclei?
   a) $^{241}_{95}Am$ b) $^{239}_{94}Pu$ c) $^{90}_{38}Sr$ d) $^{60}_{27}Co$ e) $^{226}_{88}Ra$
2) What is an isotope of an element?

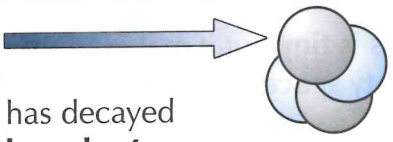
Nuclear Radiation

If an atom is **unstable**, it can undergo **radioactive decay** and give off **nuclear radiation**. By decaying, a nucleus emits **particles** or **energy**, making it **more stable**.

There are **three** kinds of nuclear radiation you need to know about:

In *Alpha Decay* (Symbol α), an Alpha Particle is Emitted

1) An **alpha particle** is emitted from the **nucleus**. It is made up of **two protons** and **two neutrons**.
2) As a result, the **proton number** of the atom that has decayed goes **down by 2** and the **nucleon number** goes **down by 4**.



EXAMPLE: The alpha decay of radium-226.

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

Proton and nucleon numbers are both conserved during all forms of radioactive decay:

Nucleon number: 226 = 222 + 4 Proton number: 88 = 86 + 2

In *Beta Decay* (Symbol β), an *Electron* is Emitted

1) A **neutron** in the nucleus turns into a **proton** and an **electron**. The electron is **emitted** from the nucleus and is called a **beta particle**.
2) As a result the **proton number** of the nucleus goes **up by 1**, but the **nucleon number doesn't change**.

EXAMPLE: The beta decay of radium-228.

$^{228}_{88}Ra \rightarrow {}^{228}_{89}Ac + {}^{0}_{-1}\beta$

Nucleon number: 228 = 228 + 0
Proton number: 88 = 89 – 1

Gamma Decay (Symbol γ) Emits *Electromagnetic* Radiation

1) High-energy **electromagnetic radiation**, called **gamma radiation** is **emitted** from the nucleus.
2) The **number** of **protons** and **neutrons** in the nucleus **stays the same**.

EXAMPLE: The gamma decay of iodine-131.

$^{131}_{53}I \rightarrow {}^{131}_{53}I + {}^{0}_{0}\gamma$ Proton and nucleon numbers don't change.

You beta learn this radiation stuff — I promise it's not alpha nothing...

1) What is an alpha particle made up of?
2) Describe what happens during the emission of beta and gamma radiation.
3) Complete the following decay equations by filling in any missing radiation symbols, proton numbers or nucleon numbers:
   a) $^{242}_{94}Pu \rightarrow {}^{\_}_{\_}U + {}^{4}_{2}\alpha$ b) $^{\_}_{\_}K \rightarrow {}^{40}_{20}Ca + {}^{0}_{-1}\beta$ c) $^{222}_{86}Rn \rightarrow {}^{218}_{84}Po + {}^{\_}_{\_}\_$ d) $^{14}_{6}C \rightarrow {}^{\_}_{\_}N + {}^{0}_{-1}\beta$