Ötzi the Iceman, a Copper Age man, was discovered by German tourists in the Italian Alps in 1991 when a glacier melted enough to expose his remains. Analysis of his corpse has exposed his last meal, illnesses he suffered, and places he lived. Radioactivity was used to determine that he lived in about 3300 BC. Ötzi can be seen today in the Südtiroler Archäologiemus um (South Tyrol Museum of Archaeology) in Bolzano, Italy.

Physics 052
L10

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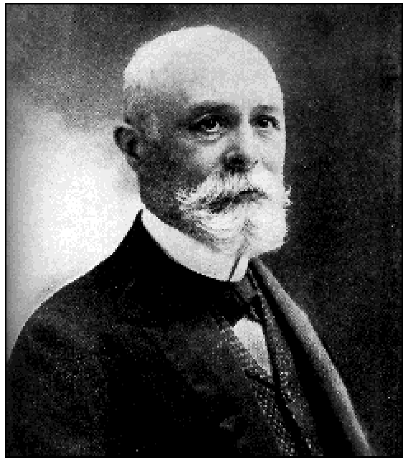
CH 30 & 31 Nuclear Physics and Ionizing Radiation

What are we going to talk about today?

CH 30 & 31 Nuclear Physics & Ionizing Radiation

- 30.0 The Atomic Nucleus.
- 30.1 Radioactivity.
- 30.2 Half –Life.
- 31.2 Radiation Units.
- 31.3 Harmful Effect of radiation

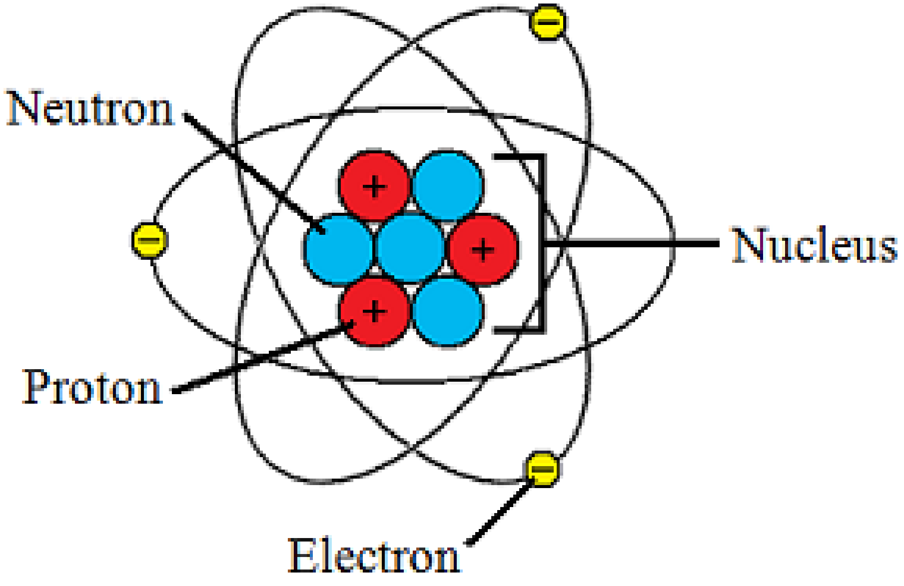


Henri Antoine Becquerel
French Professor of Applied Physics Nobel Prize in Physics 1903 (1852 – 1908)

Marie Curie: Polish Scientist (1867–1934). In 1903, Marie Curie shared the Nobel Prize in Physics with her husband, Pierre, and with Becquerel for their studies of radioactive substances. In 1911, she was awarded a Nobel Prize in Chemistry for the discovery of radium and polonium.

30.0 The Atomic Nucleus

The atom, considered the basic unit of matter, is composed of a nucleus and one or more electrons. The structure of an atom may be comprised of three particles: the negatively charged electron, the positively charged proton, and the uncharged neutron.



Nuclear Notation:

A = mass number (sum of protons + neutrons)

X = element symbol

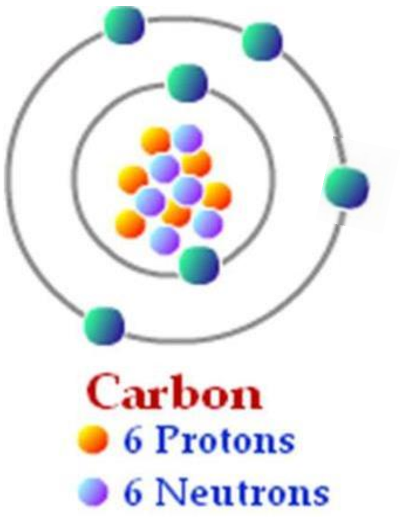
Z = atomic number (number of protons or charge)

We can represent the element as $^{A}_{Z}X$

Where the mass number **A** is shown in the left superscript position and the atomic number **Z** may be indicated in the left subscript position, For example: $^{4}_{2}He$

30.0 The Atomic Nucleus

Isotopes are atoms that have identical atomic numbers but different mass numbers as the result of differing numbers of neutrons. For example :

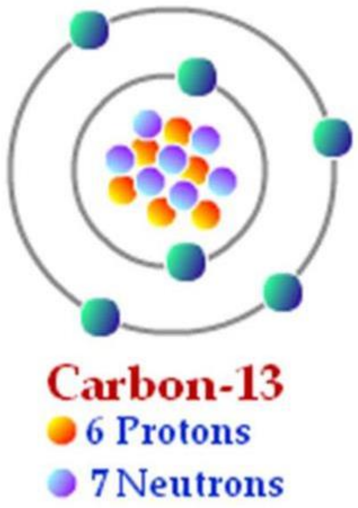


carbon-12

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

carbon-13

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



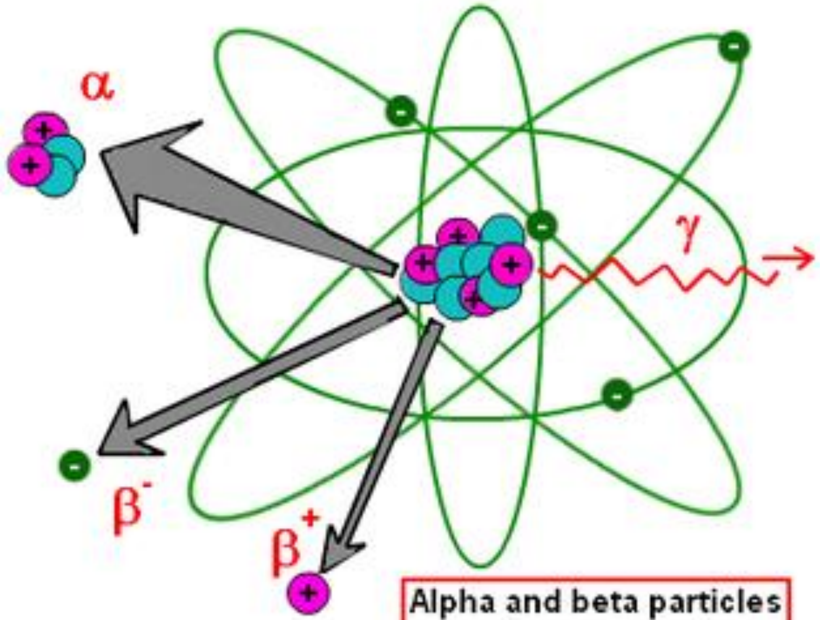
For each carbon isotope, how many electrons? protons? neutrons?

	electrons	protons	neutrons
Carbon 12			
Carbon 13			

30.1 Radioactivity

Radioactivity is the spontaneous disintegration of atomic nuclei. The nucleus emits α(alpha) particles, β(beta) particles, or electromagnetic rays (Gamma Rays γ) during this process.

After decaying radioactive atoms "change" into other atoms.



Alpha and beta particles and gamma photon

Why does the atom do this?!

The nucleus attempts to become more stable

1. Can create a new element
2. A new form of the original element (isotope) appears.

This process is referred to as the decay of atoms.

The rate of Radioactive decay is described in half–lives

The three types of radiation

Alpha α

Beta β

Gamma γ

$^{4}_{2}He$

- A helium nucleus, consisting of two protons and two neutrons.
- A relative charge of +2.
- A high mass compared with beta particles.
- Speed up to 0.1 x speed of light
- Strong ionizing effect
- Not very penetrating (stopped by paper, or skin, or a few centimetres of air
- Deflected by magnetic and electric fields

For example $^{238}_{92}U \longrightarrow {}^{4}_{2}He + {}^{234}_{90}Th$

30.1 Radioactivity

Alpha α

Beta β

Gamma γ

$^{0}_{-1}e$

- Each beta particle is an electron.
- A relative charge of –1.
- A low mass compared with alpha particles.
- Speed up to 0.9 x speed of light
- Weak ionizing effect.
- Penetrating, but stopped by a few millimetres of aluminium or other metal.
- Deflected by magnetic and electric fields

For example $^{32}_{15}P \longrightarrow ^{32}_{16}S + ^{0}_{-1}e$

30.1 Radioactivity

Alpha α

Beta β

Gamma γ

$^{0}_{0}\gamma$

- Not particles, but electromagnetic waves and part of the electromagnetic spectrum.
- No charge.
- No mass
- Travel at the speed of light
- Very weak ionising effect.
- Very strongly penetrating – intensity reduced by lead and thick concrete, but never completely stopped.
- Not deflected by magnetic or electric fields

For example $^{238}_{92}U \rightarrow ^{234}_{90}Th + ^{4}_{2}He + 2\,^{0}_{0}\gamma$

Checkpoint 1:

Identify the missing substance in each of the following nuclear reactions.

$$^{214}_{82}Pb \rightarrow {}^{214}_{83}Bi + ...$$

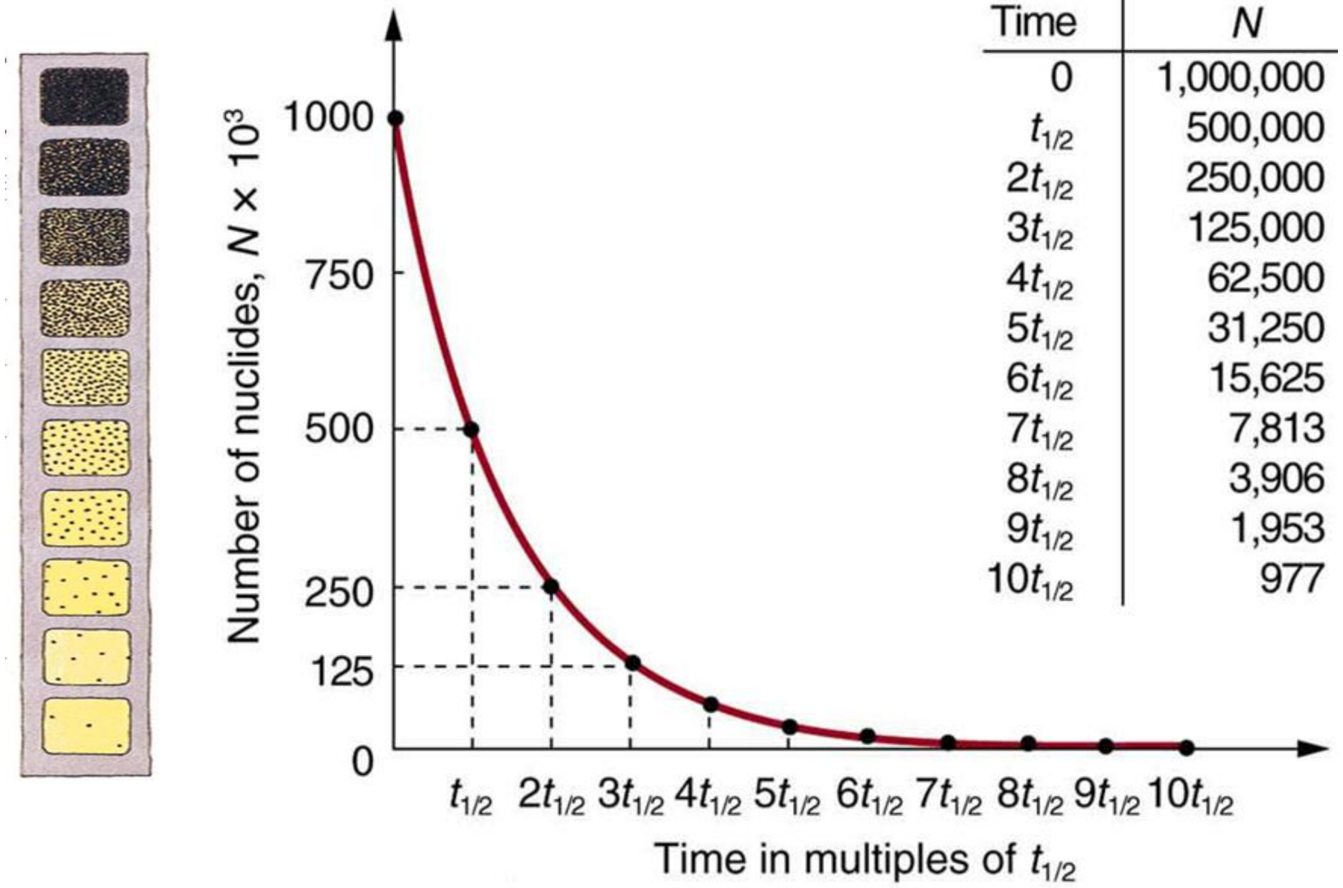
$$^{214}_{83}Bi \rightarrow {}^{214}_{84}Po + ...$$

$$^{214}_{84}Po \rightarrow {}^{210}_{82}Pb + ...$$

30.2 Half -Life.

Half–life is the time required for half of the atoms of a radioactive material to decay to another nuclear form.

Mean life is average of all half lives



Time	N
0	1,000,000
$t_{1/2}$	500,000
$2t_{1/2}$	250,000
$3t_{1/2}$	125,000
$4t_{1/2}$	62,500
$5t_{1/2}$	31,250
$6t_{1/2}$	15,625
$7t_{1/2}$	7,813
$8t_{1/2}$	3,906
$9t_{1/2}$	1,953
$10t_{1/2}$	977

31.2 Radiation Units.

- The Becquerel (Bq): Disintegration per second, dps
- The curie (Ci)

  where 1 Ci = 37,000,000,000 Bq
- rem: Rem is the term used to describe equivalent or effective radiation dose.

- In the SI Units, the Sievert (Sv) describes equivalent or effective radiation dose. One Sievert is equal to 100 rem.
- 1Sv= 100 rem

Harmful Effect of radiation: https://www.youtube.com/watch?v=tMJarZ-aw2g