AlAYEN IRAQI UNIVERSITY
Health and Medical Technologies
Anesthesia Department

Radio activity and radioactive isotopes

General Chemistry

Lec 4

Review of Atomic Terms

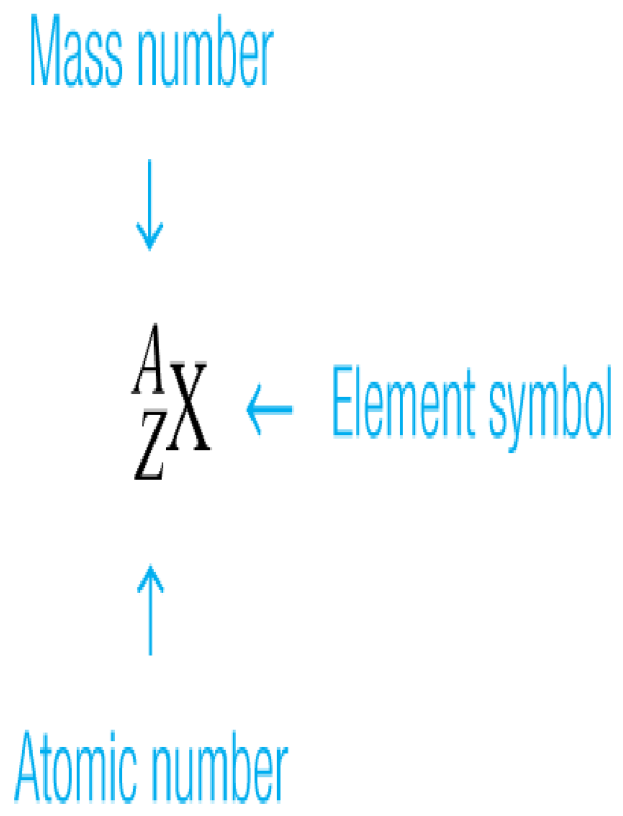
- **Nucleons** – particles found in the nucleus of an atom
neutrons and protons

•**Atomic Number (Z)** – number of protons in the nucleus

•**Mass Number (A)** – sum of the number of protons and neutrons

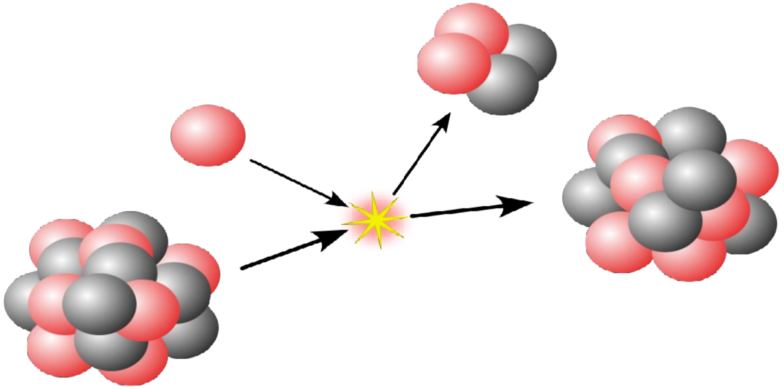
•**Isotopes** – atoms with identical atomic numbers but different mass numbers

•**Nuclide** – each unique atom

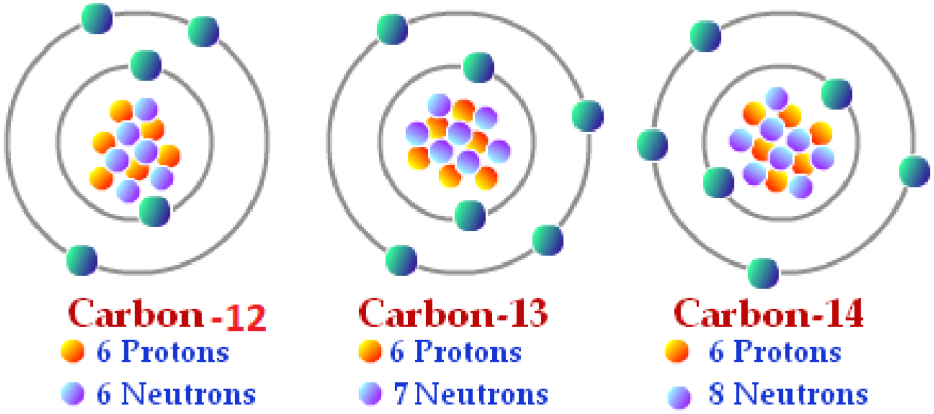


RADIOACTIVITY, A NATURAL PROPERTY OF CERTAIN ATOMS

In nature, the nuclei of most atoms are stable. However, certain atoms have unstable nuclei due to an excess of either protons or neutrons, or an excess of both. They are described as radioactive, and are known as radioisotopes or radionuclides. The nuclei of radioactive atoms change spontaneously into other atomic nuclei, which may or may not be radioactive. For instance, uranium-238 changes into a succession of different radioactive nuclei until it reaches a stable form, lead-206.

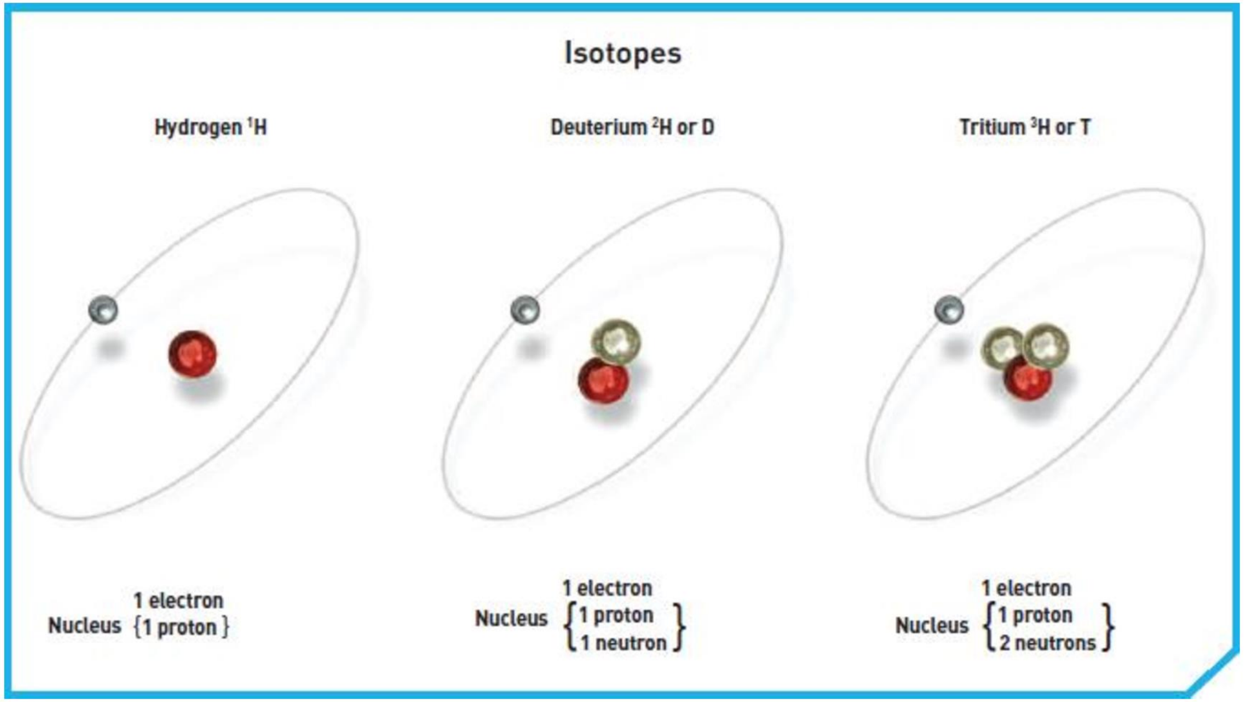


This irreversible transformation of a radioactive atom into a different type of atom is known as disintegration. It is accompanied by the emission of different types of radiation. A chemical element can therefore have both radioactive isotopes and non-radioactive isotopes. For example, carbon-12 is not radioactive, but carbon-14 is. Because radio - activity only affects the nucleus and not the electrons, the chemical properties of radioactive isotopes are the same as those of stable isotopes



Isotopes of Carbon

Isotopes:- Atoms with the same number of protons and different numbers of neutrons. They belong to the same chemical element. Ex:- Hydrogen-1 (1 proton), Deuterium (1 proton+1 neutron), and Tritiuam (1 proton+2 neutron) are three hydrogen isotopes.



*** The chemical properties of an atom are determined by the number of electrons**

- Most of the isotopes which occur naturally are stable.
- A few naturally occurring isotopes and all of the man-made isotopes are unstable.
- Unstable isotopes can become stable by releasing different types of particles.
- This process is called radioactive decay and the elements which undergo this process are called radioisotopes/radionuclides.

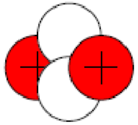
➢ Radioactive Decay

Radioactive decay results in the emission of either:

alpha particle (α), a beta ray (β), or a gamma ray(γ).

❖ Alpha (α) Decay

An alpha particle is identical to that of a helium nucleus. It contains two protons and two neutrons



$$^{A}_{Z}X \longrightarrow \, ^{A-4}_{Z-2}Y + \, ^{4}_{2}He$$

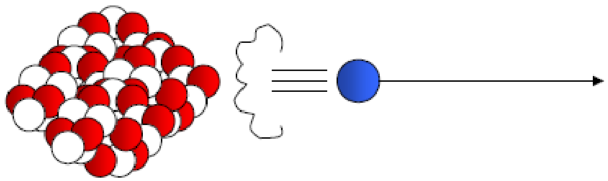
EX:- $^{222}_{88}Ra \rightarrow \, ^{4}_{2}He + \, ^{218}_{86}Rn$

$$^{230}_{90}Th \rightarrow \, ^{4}_{2}He + \, ^{226}_{88}Ra$$

Net effect is loss of 4 in mass number and loss of 2 in atomic number.

❖ Beta (β) Decay

As a result of beta decay, the nucleus has one less neutron, but one extra proton. The atomic number, Z, increases by 1 and the mass number, A, stays the same.



$$ {}^{A}_{Z}X \longrightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}\beta $$

EX:-

$$ {}^{234}_{90}Th \rightarrow {}^{234}_{91}Pa + {}^{0}_{-1}e $$

$$ {}^{131}_{53}I \rightarrow {}^{0}_{-1}e + {}^{131}_{54}Xe $$

Net effect is to change a neutron to a proton.

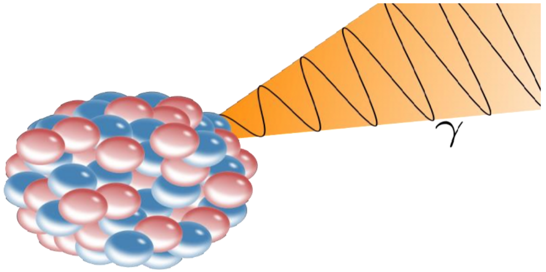
❖ **Gamma (γ) Decay**

• Gamma rays are not charged particles like a and b particles.

• Gamma rays are electromagnetic radiation with high frequency.

• When atoms decay by emitting a or b particles to form a new atom, the nuclei of the new atom formed may still have too much energy to be completely stable.

• This excess energy is emitted as gamma rays (gamma ray photons have energies of ~ **1** x **10^{-12} J**).



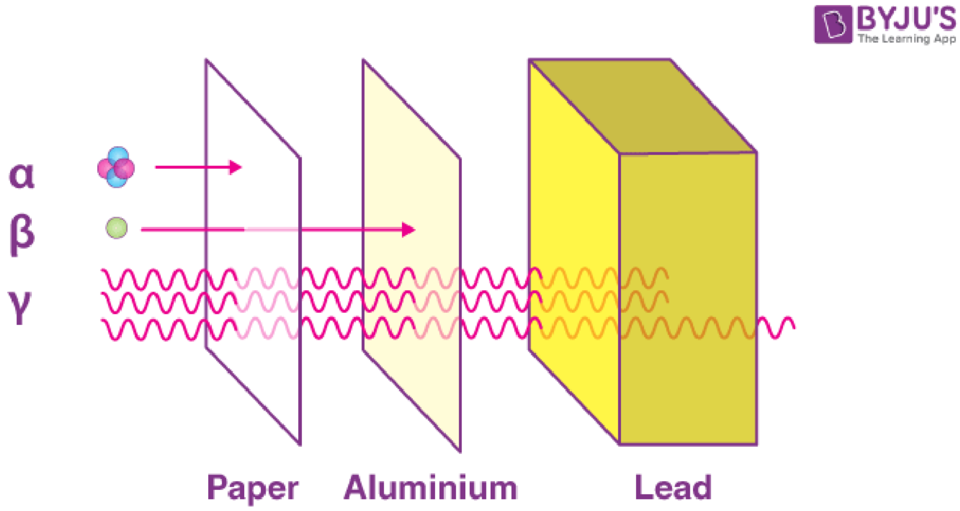
Gamma ray release

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

Net effect is no change in mass number or atomic number.

➢ Absorption of Radiation

- Alpha (α) – absorbed by 2-3 cm air and thin paper
- Beta (β) – can penetrate paper absorbed by a few mm of metal
- Gamma (γ) – very penetrating absorbed by many cm of lead and metres of concrete



➢ Radioactive Half-Life

- Radioactive decay depends on chance.
- It is possible to predict the average behavior of lots of atoms, but impossible to predict when any one atom will decay.
- One very useful prediction we can make is the **half-life**.
- **The half-life** is the time it takes for half of the original sample of radioactive material to decay to half its original

- Most radioactive materials decay in a series of reactions.
- Radon gas comes from the decay of uranium in the soil.
- Uranium (U-238) decays to radon-222 (Ra-222).

$$U^{238} \xrightarrow[\text{4.5 billion years}]{\alpha \text{ decay}} Th^{234}$$

$$Th^{234} \xrightarrow[\text{24 days}]{\beta \text{ decay}} Pa^{234}$$

$$Pa^{234} \xrightarrow[\text{6.7 hours}]{\beta \text{ decay}} U^{234}$$

$$U^{234} \xrightarrow[\text{245,500 years}]{\alpha \text{ decay}} Th^{230}$$

$$Th^{230} \xrightarrow[\text{75,000 years}]{\alpha \text{ decay}} Ra^{226}$$

$$Ra^{226} \xrightarrow[\text{1,600 years}]{\alpha \text{ decay}} Rn^{222}$$

- **Application of Isotopes**

  1- Food and Agriculture

  a- Fertilisers

  b- Increasing genetic variability

  c- Food irradiation and preservation

  2- Medicine Sterilization

  a- Treatment of cancer

  b- Diagnosis - Tracers and imaging

  3- Carbon dating

  4-Smoke detectors

THANK YOU!

؟؟ ANY QUESTIONS

PLEASE ASK