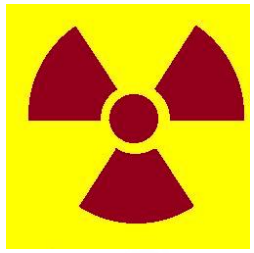
Chapter 6: Modern Physics

Radiation Physics

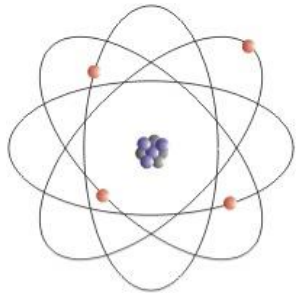
Radiation



- Radiation is a form energy (wave or particles) emitted by an atom.
- Classified as ionizing and non-ionizing
- Ionizing radiation classified as
  - Directly ionizing (cause by charged particles)
  - Indirectly ionizing (cause by uncharged particles)
- Non-ionizing radiation:
  - Changes occur in bound electronic states
  - Changes spin state

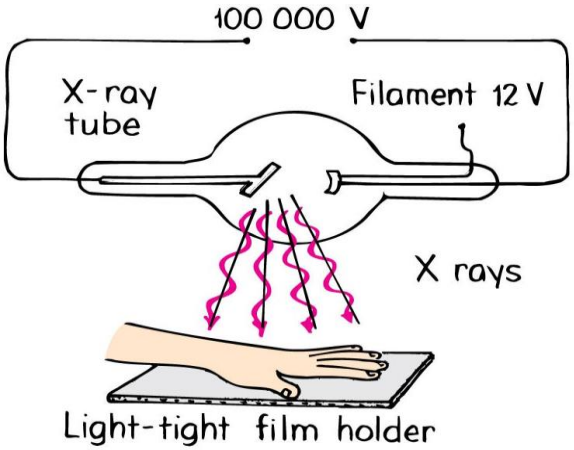
Bohr Model of the Atom

- Planetary model of the atom.
- Electrons occupy "stationary" states, electrons make "quantum jumps" from one energy state to another.
- Energy levels, **$E=hf$**
- Useful to understand light emission.



X-Rays and Radioactivity

- Roentgen discovered X-rays produced by a beam of electrons striking the glass surface of a gas-discharge tube.
- He found that X-rays could pass through solid materials, could ionize the air, showed no refraction in glass, and were undeflected by magnetic fields.



أشعة إكس: عباره عن موجات كهرومغناطيسية ذات تردد أعلى من الأشعه فوق البنفسجية، وهى تنبعث من خلال عمليات إنتقال الإلكترون إلى أقل حالات الطاقه فى الذرات.

X-Rays and Radioactivity

- X-rays are high-frequency electromagnetic waves, usually emitted by the de-excitation of the innermost orbital electrons of atoms.
- An energetic beam of electrons striking a solid surface excites the innermost electrons and produces higher-frequency photons of X-radiation.

X-Rays and Radioactivity

- X-ray photons have high energy and can penetrate many layers of atoms before being absorbed or scattered.
- X-rays do this when they pass through your soft tissue to produce an image of the bones inside your body.

X-Rays and Radioactivity

Radioactivity

- Radioactivity is the process of nuclear decay (radioactive decay).
- Nothing new in the environment; it's been going on since time zero.
- It warms Earth's interior, is in the air we breathe, and is present in all rocks (some in trace amounts).
-

النشاط الإشعاعى: هو عملية تحول نواة الذره وهذا ما يؤدى إلى إنبعاث جسيمات نشطه.

Example 1

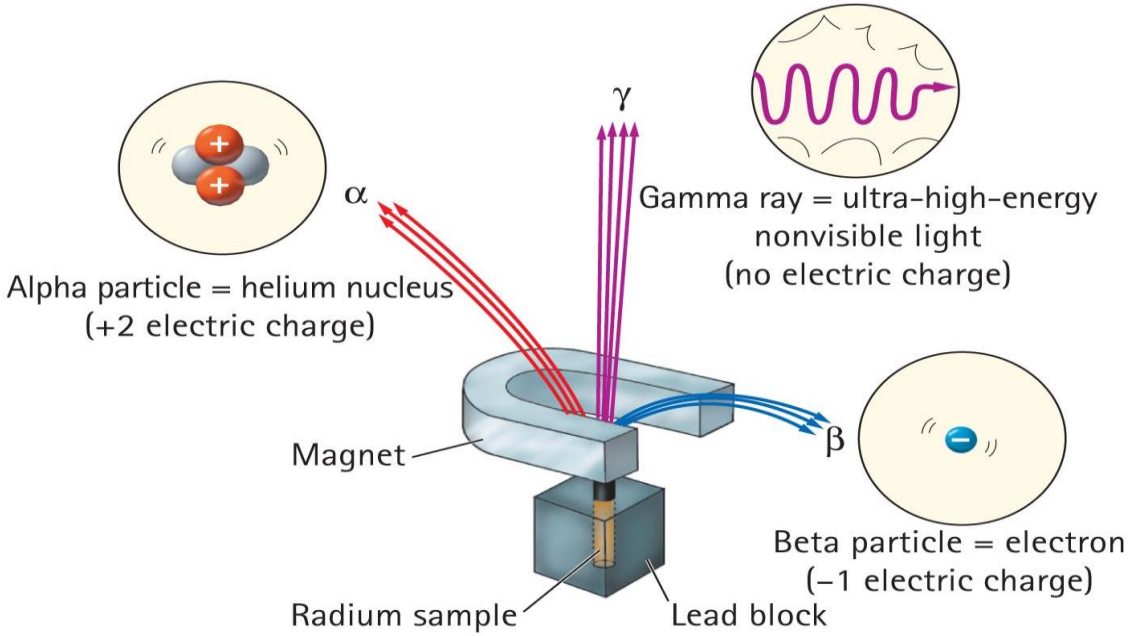
The radioactive decay of nature's elements occurs in the

A. soil we walk on.
B. air we breathe.
C. interior of Earth.
D. All of the above.

Alpha, Beta, and Gamma Rays

Radioactive elements emit three distinct types of radiation:

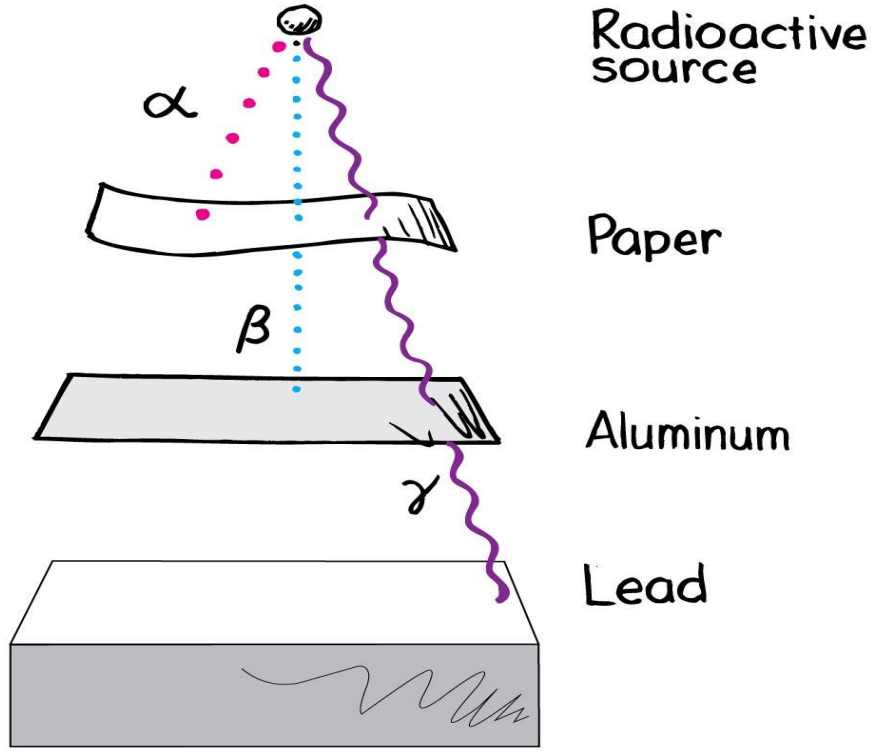
- α —alpha: positively charged (helium nuclei)
- β — beta: negatively charged (electrons)
- γ —gamma (electromagnetic radiation)



Alpha, Beta, and Gamma Rays

Relative penetrations

أشعة ألفا: عباره عن تدفق لجسيمات ألفا (نواة هليوم) تطردها عناصر معينه.
أشعة بيتا: عباره عن تدفق من الإلكترونات (او بوزيترون) ينطلق أثناء النشاط الإشعاعى لنواة معينه.
أشعة غاما: عباره عن موجه كهرومغناطيسية عالية التردد تنبعث من خلال نواة ذرات مشعه.



Example 2

The origins of radioactivity go back to

A. military activities in the mid-20th century.

B. the Industrial Revolution two centuries ago.

C. the beginning of human error.

D. before humans emerged on Earth.

Example 3

Any atom that emits an alpha particle or beta particle

A. becomes an atom of a different element, always.
B. may become an atom of a different element.
C. becomes a different isotope of the same element.
D. increases its mass.

Alpha, Beta, and Gamma Rays

Food irradiation kills microbes.

- Doesn’t make the food radioactive.

Example 4

Which of these is the nucleus of the helium atom?

A. Alpha
B. Beta
C. Gamma
D. All are different forms of helium.

Example 5

Which of these is actually a high-speed electron?

A. Alpha

B. Beta

C. Gamma

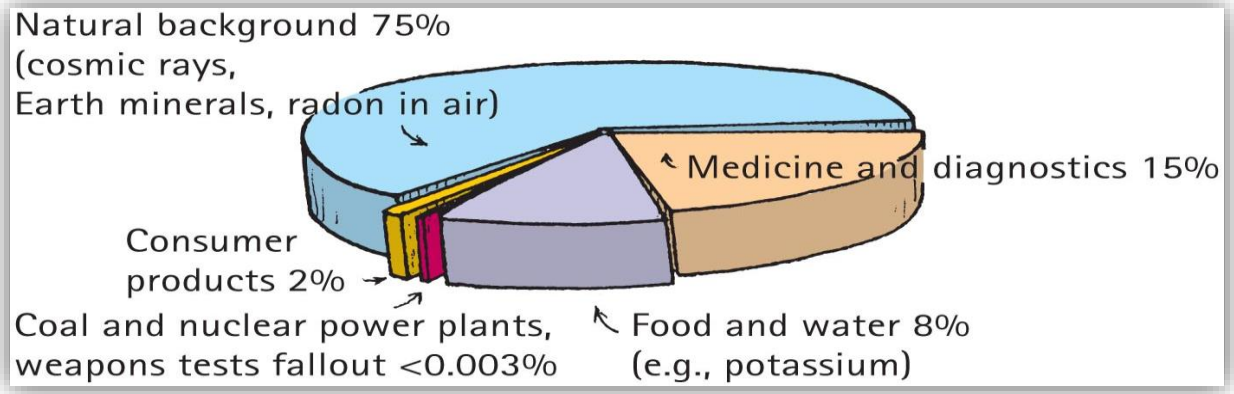
D. All are high speed.

Explanation:

Choice D may be true, but doesn't directly answer the question.

Environmental Radiation

Radon, a common environmental hazard



- Most radiation from natural background
- About one-sixth (1/6) from non-natural sources
- **Radon is the biggest contributor (> 50%)**

Environmental Radiation

Units of radiation

Particle	Radiation Dosage		Factor		Health effect
alpha	1 rad	×	10	=	10 rems
beta	10 rad	×	1	=	10 rems

- Doses of radiation
  - Lethal doses of radiation begin at 500 rems.

SI unit of radiation dose is Gray (Gy

For health effect the unit is Sievrt (Sv).

راد: هو مختصر (جرعة الإشعاع المؤينه للجسم) لوحدة الطاقه الممتصه. يساوى واحد "راد" 0.01 J من الطاقه الممتصه لكل كيلوجرام من أنسجة الجسم.

رم: هو مختصر (مكافئ رونتجن للشخص) للوحدة المستحدمه لقياس تأثير الإشعاع المؤين على البشر.

Units

SI units	Other units
Gray (Gy) = J/kg - the SI unit of measurement of *dose* - one joule of energy is absorbed per kilogram of matter being irradiated 1 kGy = 1000 Gy	**rad** - dose unit 1 rad = 100 erg/g 100 rad = 1Gy
Sievert (Sv) The SI unit of dose for radiation safety purposes 100 rem = 1 Sv; 100 mrem = 1 mSv	**Rem** - Dose unit used for radiation safety purposes.

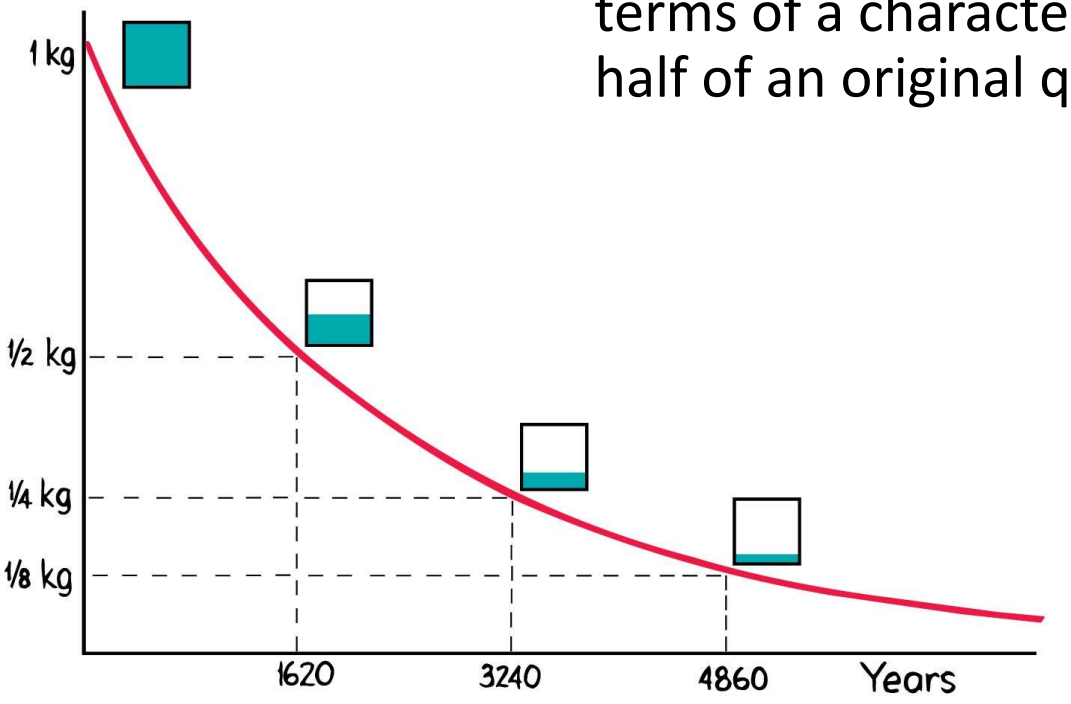
Environmental Radiation

Source received annually	Typical dose (mrem)
Natural origin	
Cosmic radiation	26
Ground	33
Air (Radon-222)	198
Human tissues (K-40; Ra-226)	35

Environmental Radiation

Doses of radiation	Typical dose (mrem)
Human origin	
Medical procedures	
Diagnostic X-rays	40
Nuclear diagnostics	15
TV tubes, other consumer products	11
Weapons-test fallout	1
Commercial fossil-fuel power plants	<1
Commercial nuclear power plants	<<1

Radioactive Half-Life

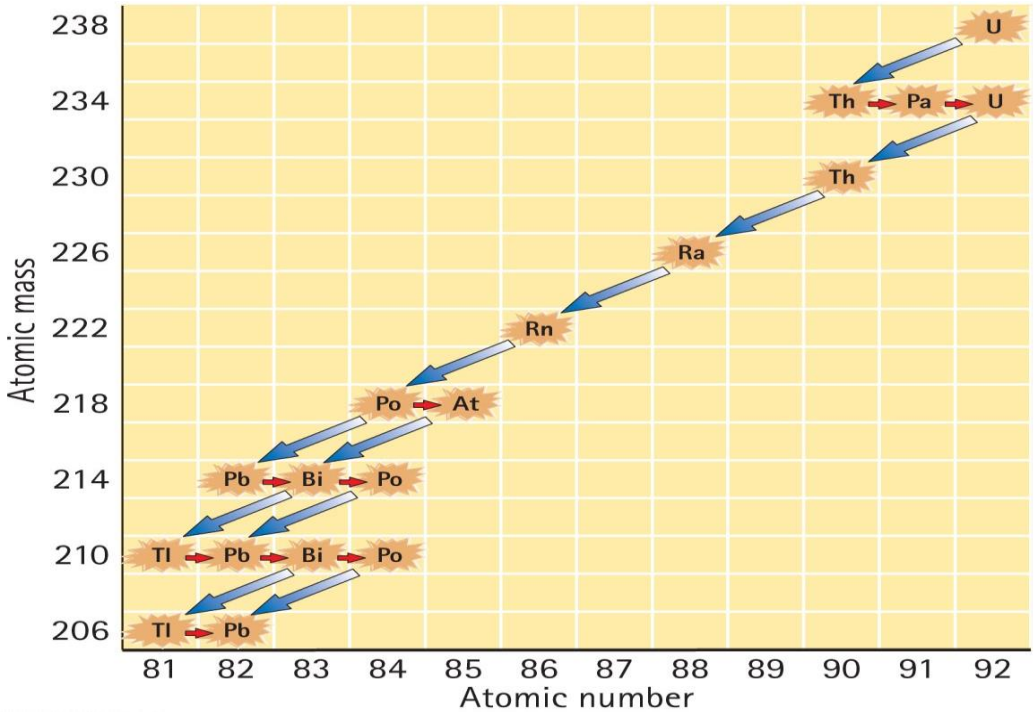


The rate of decay for a radioactive isotope is measured in terms of a characteristic time, the half-life, the time for half of an original quantity of an element to decay.

عمر النصف: هو الوقت اللازم لإنشطار نصف الذرات فى عينة نظير مشع حتى يبلى.

Radioactive Half-Life

Uranium-238 to lead-206 through a series of alpha and beta decays. In 4.5 billion years, half the uranium presently in Earth will be lead.



Example 6

A certain isotope has a half-life of 10 years. This means the amount of that isotope remaining at the end of 10 years will be

A. zero.
B. one-quarter.
C. half.
D. the same.

Radiation Detectors الكواشف الإشعاعية

- Geiger counter detects incoming radiation by a short pulse of current triggered when radiation ionizes a gas in the tube.
- Scintillation counter indicates incoming radiation by flashes of light produced when charged particles or gamma rays pass through the counter.

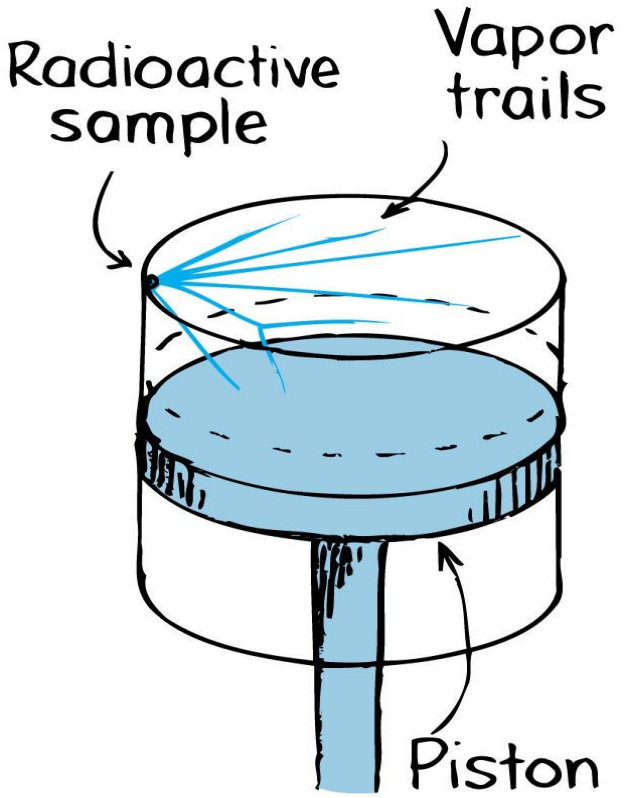
(a)

(b)

Radiation Detectors

Cloud chamber:

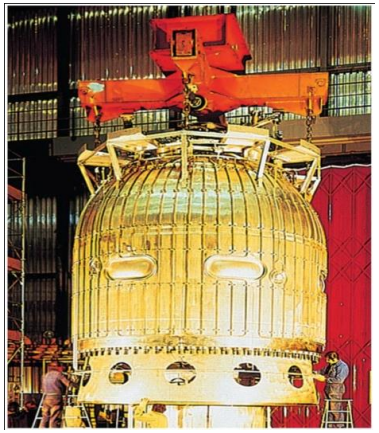
- Charged particles moving through supersaturated vapor leave trails.
- When the chamber is in a strong electric or magnetic field, bending of the tracks provides information about the charge, mass, and momentum of the particles.



Radiation Detectors

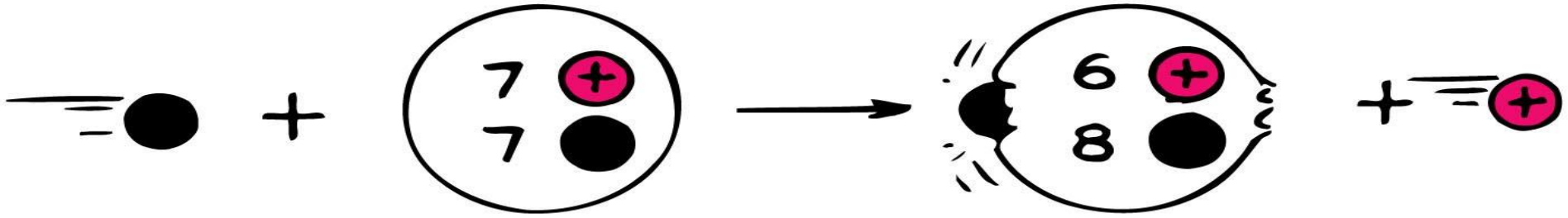
Bubble chamber :

- Liquid hydrogen is heated under pressure in a glass and stainless steel chamber to a point just short of boiling.
- If the pressure in the chamber is suddenly released at the moment an ion-producing particle enters, a thin trail of bubbles is left along the particle's path.



Radiometric Dating

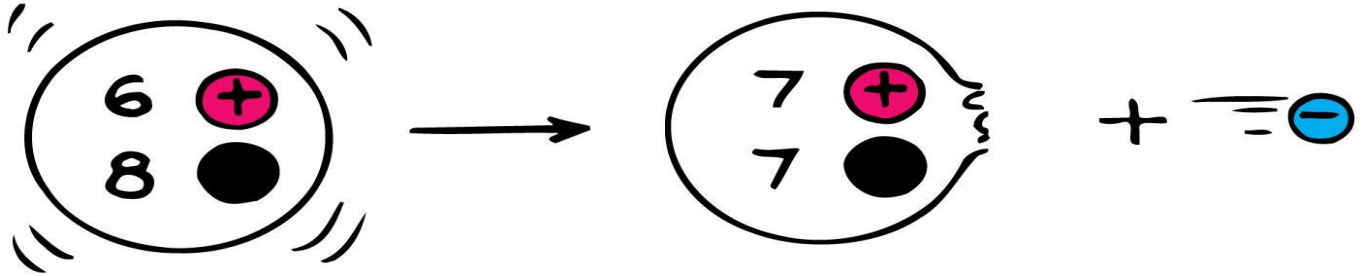
- Earth's atmosphere is continuously bombarded by cosmic rays, which causes many atoms in the upper atmosphere to transmute. These transmutations result in many protons.
- A nitrogen that captures a neutron and becomes an isotope of carbon by emitting a proton:



$$^{14}_{7}\mathrm{N} + {}^{1}_{0}n \rightarrow {}^{14}_{6}\mathrm{C} + {}^{1}_{1}\mathrm{H}$$

Radiometric Dating

- Carbon-14 is a beta emitter and decays back to nitrogen.

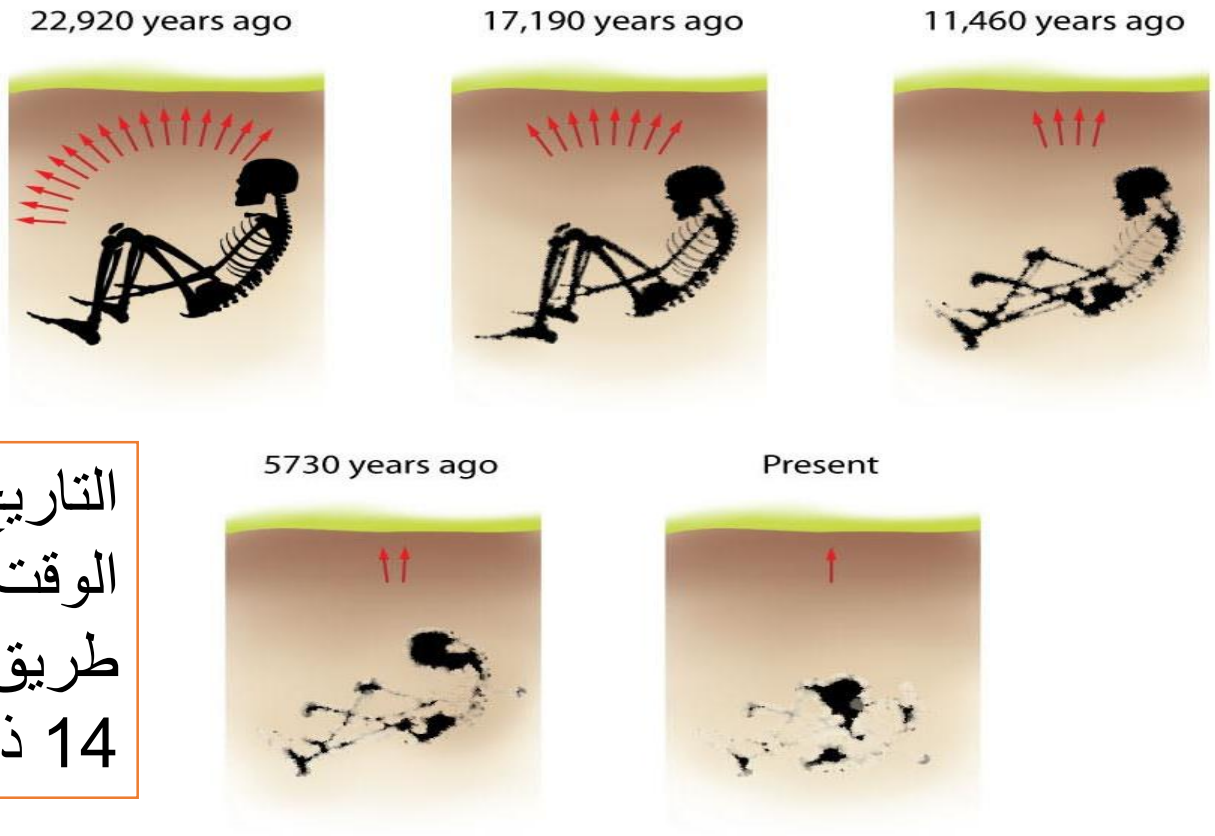


$$^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$$

- Because living plants take in carbon dioxide, any C-14 lost by decay is immediately replenished with fresh C-14 from the atmosphere.
- Dead plants continue emitting C-14 without replenishment.

Radiometric Dating

Relative amounts of C-12 to C-14 enable dating of organic materials.



التاريخ الكربونى: هى عملية تحديد الوقت المنقضى منذ الوفاة وذلك عن طريق قياس النشاط الإشعاعى لعدد 14 ذرة كربون المتبقية.