Radioactivity

Contents

A: INTRODUCTION / CAUSES OF RADIOCTIVITY

Radioactivity is the spontaneous disintegration/decay of an unstable nuclide.
A nuclide is an atom with defined mass number (number of protons and neutrons), atomic number and definite energy.
Radioactivity takes place in the nucleus of an atom unlike chemical reactions that take place in the energy levels involving electrons.
A nuclide is said to be stable if its neutron: proton ratio is equal to one (n/p = 1)
All nuclide therefore try to **attain n/p = 1** by undergoing radioactivity.
Examples
(i)Oxygen nuclide with $^{16}_{8}O$ has **8** neutrons and **8** protons in the nucleus therefore an **n/p = 1** thus **stable** and do **not** decay/disintegrate.
(ii)Chlorine nuclide with $^{35}_{17}Cl$ has **18** neutrons and **17** protons in the nucleus therefore an n/p = 1.0588 thus **unstable** and **decays**/disintegrates to try to attain n/p = 1.

(ii)Uranium nuclide with ${}^{237}_{92}U$ has 206 neutrons and 92 protons in the nucleus therefore an n/p = 2.2391 thus more unstable than ${}^{235}_{92}U$ and thus more readily decays / disintegrates to try to attain n/p = 1.
(iii) Chlorine nuclide with ${}^{37}_{17}Cl$ has **20** neutrons and **17** protons in the nucleus therefore an n/p = 1.1765 thus **more unstable** than ${}^{35}_{17}Cl$ and thus more **readily** decays / disintegrates to try to attain n/p = 1.
(iv)Uranium nuclide with ${}^{235}_{92}U$ has **143** neutrons and **92** protons in the nucleus therefore an n/p = 1.5543 thus more **stable** than ${}^{237}_{92}U$ but also **readily** decays / disintegrates to try to attain n/p = 1.
All **unstable** nuclides naturally try to attain nuclear **stability** with the production of:

(i)alpha(α) particle decay

The alpha (α) particle has the following main characteristic:
i)is **positive**ly charged(like protons)
ii) has mass number **4** and atomic number **2** therefore equal to a charged Helium atom (${}^{4}_{2}He^{2+}$)
iii) have very **low** penetrating power and thus can be stopped /blocked/shielded by a thin sheet of **paper.**
iv) have **high** ionizing power thus cause a lot of **damage** to living cells.
v) a nuclide undergoing α-decay has its mass number **reduced** by **4** and its atomic number **reduced** by **2**

<u>Examples of alpha decay</u>

${}^{210}_{84}Pb$	->	${}^{x}_{82}Pb$	+	${}^{4}_{2}He^{2+}$
${}^{210}_{84}Pb$	**->**	**${}^{206}_{82}Pb$**	**+**	**${}^{4}_{2}He^{2+}$**
${}^{226}_{88}Ra$	->	${}^{222}_{y}Rn$	+	${}^{4}_{2}He^{2+}$
${}^{226}_{88}Ra$	**->**	**${}^{222}_{86}Rn$**	**+**	**${}^{4}_{2}He^{2+}$**
${}^{x}_{y}U$	->	${}^{234}_{90}Th$	+	${}^{4}_{2}He^{2+}$
${}^{238}_{92}U$	**->**	**${}^{234}_{90}Th$**	**+**	**${}^{4}_{2}He^{2+}$**
${}^{x}_{y}U$	->	${}^{230}_{88}Ra$	+	$2\ {}^{4}_{2}He^{2+}$
${}^{238}_{92}U$	**->**	**${}^{230}_{88}Ra$**	**+**	**$2\ {}^{4}_{2}He^{2+}$**
${}^{210}_{84}U$	->	${}^{x}_{y}W$	+	10 α

$^{210}_{84}U$ -> $^{170}_{64}W$ + 10α

$^{210}_{92}U$ -> $^{x}_{y}W$ + 6α

$^{210}_{92}U$ -> $^{186}_{80}W$ + 6α

(ii)Beta (β) particle decay

The Beta (β) particle has the following main characteristic:

i)is negatively charged(like electrons)

ii)has no mass number and atomic number negative one(-1) therefore equal to a fast moving electron (**$^{0}_{-1}e$**)

iii) have medium penetrating power and thus can be stopped /blocked/shielded by a thin sheet of aluminium foil.

iv) have medium ionizing power thus cause less damage to living cells than the α particle.

v) a nuclide undergoing β -decay has its mass number **remain** the same and its atomic number **increase** by **1**

<u>Examples of beta (β) decay</u>

1. $^{23}_{x}Na$ -> $^{23}_{12}Mg$ + $^{0}_{-1}e$

$^{23}_{11}Na$ -> $^{23}_{12}Mg$ + $^{0}_{-1}e$

2. $^{234}_{x}Th$ -> $^{y}_{91}Pa$ + $^{0}_{-1}e$

$^{234}_{90}Th$ -> $^{y}_{91}Pa$ + $^{0}_{-1}e$

3. $^{207}_{70}Y$ -> $^{x}_{y}Pb$ + $3\,^{0}_{-1}e$

$^{207}_{70}Y$ -> $^{207}_{73}Pb$ + $3\,^{0}_{-1}e$

4. $^{x}_{y}C$ -> $^{14}_{7}N$ + $^{0}_{-1}e$

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

5. $^{1}_{x}n$ -> $^{y}_{1}H$ + $^{0}_{-1}e$

$^{1}_{0}n$ -> $^{1}_{1}H$ + $^{0}_{-1}e$

6. $^{4}_{2}He$ -> $4\,^{1}_{1}H$ + $x\,^{0}_{-1}e$

$^{4}_{2}He$ -> $4\,^{1}_{1}H$ + $2\,^{0}_{-1}e$

7. $^{228}_{88}Ra \rightarrow\ ^{228}_{90}Th + x\,\beta$

$\mathbf{^{228}_{88}Ra \rightarrow\ ^{228}_{92}Th + 4\,\beta}$

8. $^{232}_{90}Th \rightarrow\ ^{212}_{82}Pb + 2\,\beta + x\,\alpha$

$\mathbf{^{232}_{90}Th \rightarrow\ ^{212}_{82}Pb + 2\,\beta + 5\,\alpha}$

9. $^{238}_{92}U \rightarrow\ ^{226}_{88}Ra + x\,\beta + 3\,\alpha$

$\mathbf{^{238}_{92}U \rightarrow\ ^{226}_{88}Ra + 2\,\beta + 3\,\alpha}$

10. $^{218}_{84}Po \rightarrow\ ^{206}_{82}Pb + x\,\beta + 3\,\alpha$

$\mathbf{^{218}_{84}Po \rightarrow\ ^{206}_{82}Pb + 4\beta + 3\,\alpha}$

(iii)Gamma (y) particle decay

The gamma (y) particle has the following main characteristic:

i)is **neither** negatively charged(like electrons/beta) nor positively charged(like protons/alpha) therefore **neutral**.

ii)has **no** mass number and atomic number therefore equal to **electromagnetic waves**.

iii) have very **high** penetrating power and thus can be stopped /blocked/shielded by a thick block of lead..

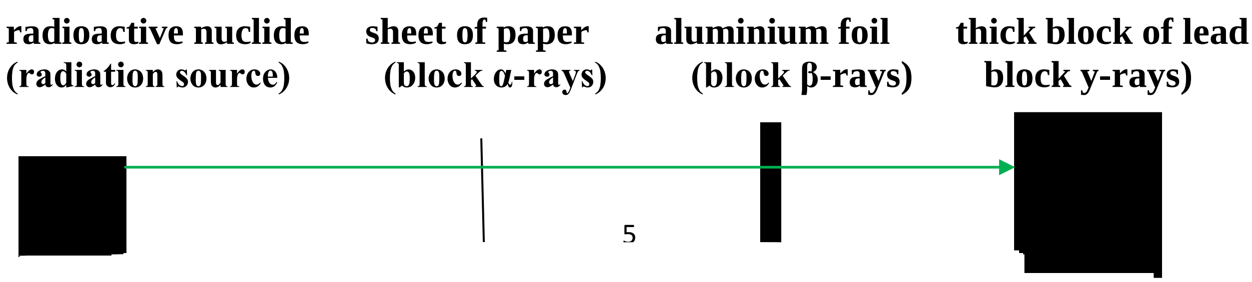
iv) have very **low** ionizing power thus cause less damage to living cells unless on prolonged exposure..

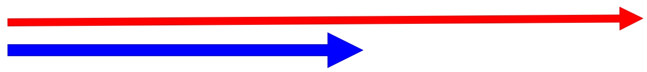
v) a nuclide undergoing y -decay has its mass number and its atomic number **remain** the **same**.

<u>Examples of gamma (y) decay</u>

- $^{37}_{17}Cl \rightarrow\ ^{37}_{17}Cl + y$
- $^{14}_{6}C \rightarrow\ ^{14}_{6}C + y$

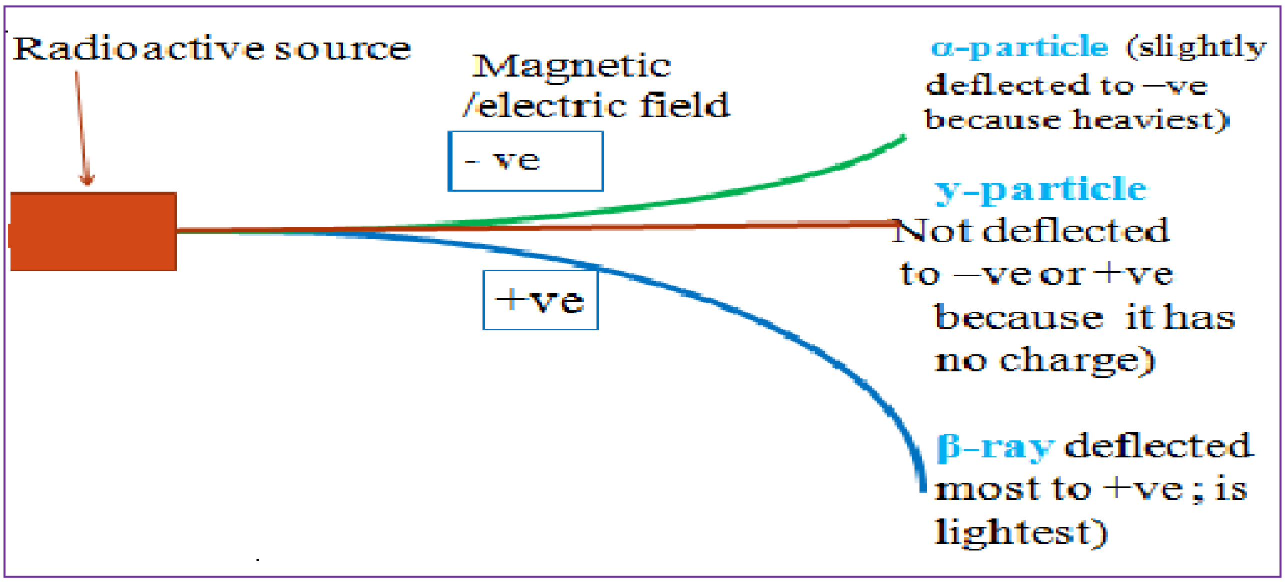
The sketch diagram below shows the **penetrating power** of the radiations from a radioactive nuclide.



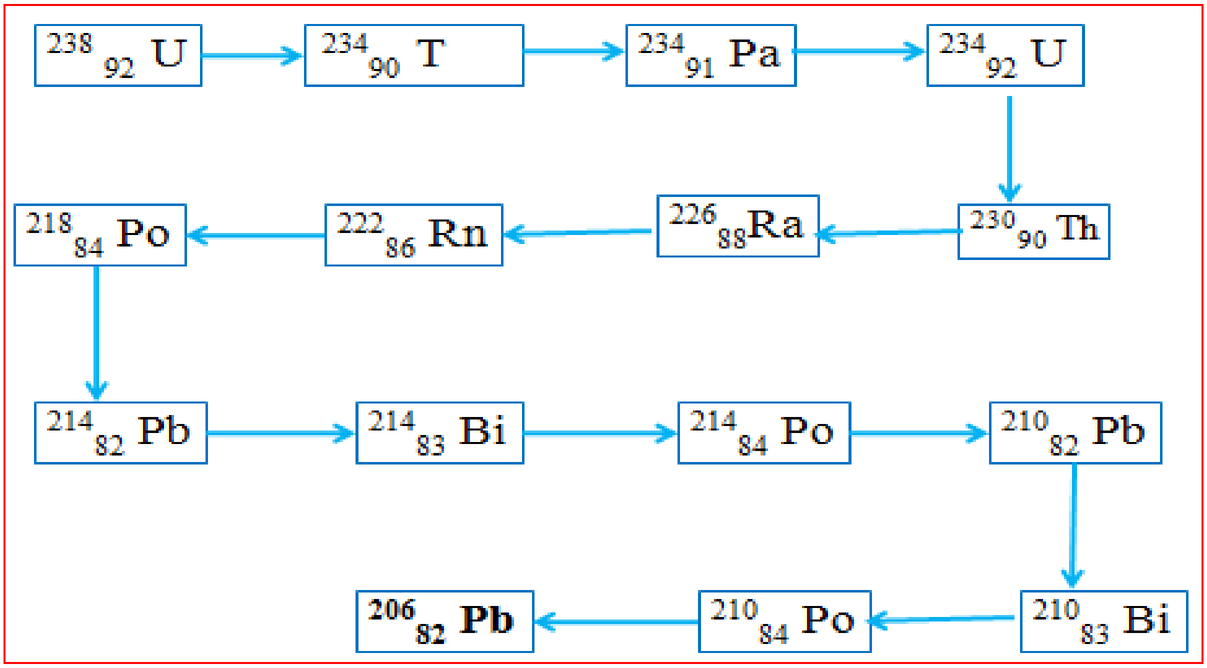


α-rays **β-rays** **y-rays**

The sketch diagram below illustrates the effect of **electric /magnetic field** on the three radiations from a radioactive nuclide



Radioactive disintegration/decay **naturally** produces the stable $^{206}_{82}Pb$ nuclide /isotope of lead.Below is the $^{238}_{92}U$ natural decay series. Identify the particle emitted in each case



Write the nuclear equation for the disintegration from :

(i) $^{238}_{92}U$ to $^{234}_{90}T$

$$^{238}_{92}\mathbf{U} \quad -> \quad ^{234}_{90}\mathbf{T} \quad + \quad ^{4}_{2}\mathbf{He}^{2+}$$

$$^{238}_{92}\mathbf{U} \quad -> \quad ^{234}_{90}\mathbf{T} \quad + \quad \alpha$$

(ii) $^{238}_{92}U$ to $^{222}_{84}Rn$

$$^{238}_{92}\mathbf{U} \quad -> \quad ^{222}_{84}\mathbf{Rn} \quad + \quad 4\ ^{4}_{2}\mathbf{He}^{2+}$$

$$^{238}_{92}\mathbf{U} \quad -> \quad ^{222}_{84}\mathbf{Rn} \quad + \quad 4\alpha$$

$^{230}_{90}Th$ undergoes alpha decay to $^{222}_{86}Rn$. Find the number of α particles emitted. Write the nuclear equation for the disintegration.

<u>Working</u>

$$^{230}_{90}\mathbf{Th} \quad -> \quad ^{222}_{86}Rn \quad + \quad \mathbf{x}\ ^{4}_{2}\mathbf{He}$$

<u>Method 1</u>

Using mass numbers

230 = 222 + 4 x => 4 x = 230 - 222 = <u>8</u>

x = 8 / 4 = <u>2 α</u>

Using atomic numbers

90 = 86 + 2 x => 2 x = 90 - 86 = <u>4</u>

x = 4 / 2 = <u>2 α</u>

Nuclear equation

$^{230}_{90}\mathbf{Th}$ **->** $^{222}_{86}\mathbf{Rn}$ **+** **2** $^{4}_{2}\mathbf{He}$

$^{214}_{82}$Pb undergoes beta decay to $^{214}_{84}$Rn. Find the number of β particles emitted. Write the nuclear equation for the disintegration.

Working

$^{214}_{82}$Pb -> $^{214}_{84}$Rn + **x** $^{0}_{-1}\mathbf{e}$

Using atomic numbers only

82 = 84 - x => -x = 82 - 84 = -2

x = 2 β

Nuclear equation

$^{214}_{82}$Pb -> $^{214}_{84}$Rn + **2** $^{0}_{-1}\mathbf{e}$

$^{238}_{92}$U undergoes beta and alpha decay to $^{206}_{82}$Pb. Find the number of β and α particles emitted. Write the nuclear equation for the disintegration.

Working

$^{238}_{92}$U -> $^{206}_{82}$Pb + **x** $^{0}_{-1}\mathbf{e}$ **+** **y** $^{4}_{2}\mathbf{He}$

Using Mass numbers only

238 = 206 + 4y => 4y = 238 - 206 = 32

$$y = \frac{32}{4} = 8\,\alpha$$

Using atomic numbers only and substituting the 8 α(above)

$^{238}_{92}$U -> $^{206}_{82}$Pb + 8 $^{4}_{2}$He + x $^{0}_{-1}$e

92 = 82 + 16 + - x

=> 92 – (82 + 16) = - x

x = 6 β

Nuclear equation

$^{238}_{92}$U -> $^{206}_{82}$Pb + **6** $^{0}_{-1}\mathbf{e}$ **+** **8** $^{4}_{2}\mathbf{He}$

$^{298}_{92}$U undergoes alpha and beta decay to $^{214}_{83}$Bi. Find the number of α and β particles emitted. Write the nuclear equation for the disintegration.

Working

$^{298}_{92}$U -> $^{210}_{83}$Bi + **x** $^{4}_{2}\mathbf{He}$ **+** **y** $^{0}_{-1}\mathbf{e}$

Using Mass numbers only

298 = 214 + 4x => 4x = 298 - 214 = 84

y = 84 = 21 α

4

Using atomic numbers only and substituting the 21 α (above)

$^{238}_{92}U \rightarrow ^{214}_{83}Bi + 21\,^{4}_{2}He + y\,^{0}_{-1}e$

$92 = 83 + 42 + -y$

$\Rightarrow 92 - (83 + 42) = -x$

x = 33 β

Nuclear equation

$^{298}_{92}U \rightarrow ^{210}_{83}Bi + 21\,^{4}_{2}He + 33\,^{0}_{-1}e$

B:NUCLEAR FISSION AND NUCLEAR FUSION

Radioactive disintegration/decay can be initiated in an industrial laboratory through two chemical methods:

a) nuclear **fission**

b) nuclear **fusion.**

a)Nuclear fission

Nuclear fission is the process which a fast moving neutron bombards /hits /knocks a heavy **unstable** nuclide releasing l**ighter** nuclide, **three** daughter neutrons and a large quantity of **energy.**

Nuclear fission is the basic chemistry behind **nuclear bombs** made in the nuclear reactors.

The three daughter neutrons becomes again fast moving neutron bombarding / hitting /knocking a heavy unstable nuclide releasing lighter nuclides, three more daughter neutrons each and a larger quantity of energy setting of a **chain reaction**

Examples of nuclear equations showing nuclear fission

$^{1}_{0}n + ^{235}_{b}U \rightarrow ^{90}_{38}Sr + ^{c}_{54}Xe + 3\,^{1}_{0}n + a$

$^{1}_{0}n + ^{27}_{13}Al \rightarrow ^{28}_{13}Al + y + a$

$^{1}_{0}n + ^{28}_{a}Al \rightarrow ^{b}_{11}Na + ^{4}_{2}He$

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

$^{1}_{0}n + ^{1}_{1}H \rightarrow ^{2}_{1}H + a$

$^{1}_{0}n + ^{235}_{92}U \rightarrow ^{95}_{42}Mo + ^{139}_{57}La + 2\,^{1}_{0}n + 7a$

b) Nuclear fusion

Nuclear fusion is the process which **smaller** nuclides join together to form **larger** / heavier nuclides and releasing a large quantity of **energy**.
Very high temperatures and pressure is required to overcome the repulsion between the atoms.
Nuclear fusion is the basic chemistry behind solar/sun radiation.
Two daughter atoms/nuclides of Hydrogen fuse/join to form Helium atom/nuclide on the surface of the sun releasing large quantity of energy in form of heat and light.

$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{a}_{b}He + ^{1}_{0}n$

$^{2}_{1}H + a \rightarrow ^{3}_{2}He$

$^{2}_{1}H + ^{2}_{1}H \rightarrow a + ^{1}_{1}H$

$4\ ^{1}_{1}H \rightarrow ^{4}_{2}He + a$

$^{14}_{7}H + a \rightarrow ^{17}_{8}O + ^{1}_{1}H$

C: HALF LIFE PERIOD ($t^{1}/_{2}$)

The half-life period is the **time** taken for a radioactive nuclide to spontaneously decay/ disintegrate to **half** its **original** mass/ amount.
It is usually denoted **$t\ ^{1}/_{2}$**.
The rate of radioactive nuclide disintegration/decay is **constant** for each nuclide.

The table below shows the half-life period of some elements.

Element/Nuclide	**Half-life period($t\ ^{1}/_{2}$)**
$^{238}_{92}U$	4.5×10^{9} years
$^{14}_{6}C$	5600 years
$^{229}_{88}Ra$	1620 years
$^{35}_{15}P$	14 days

$^{210}_{84}Po$	0.0002 seconds

The **less** the half life the **more** **unstable** the nuclide /element.
The half-life period is determined by using a Geiger-Muller counter (**GM tube**) .A GM tube is connected to ratemeter that records the **count-rates per unit time**.
This is the rate of decay/ disintegration of the nuclide.
If the count-rates per unit time **fall** by **half**, then the **time** taken for this **fall** is the half-life period.

Examples

a)A radioactive substance gave a count of 240 counts per minute but after 6 hours the count rate were 30 counts per minute. Calculate the half-life period of the substance.

If $t^1/_2 = x$
then 240 --x-->120 –x-->60 –x--->30
From 240 to 30 =3x =6 hours
=>x = $t^1/_2$ = (6 / 3)
= **2 hours**

b) The count rate of a nuclide fell from 200 counts per second to 12.5 counts per second in 120 minutes.
Calculate the half-life period of the nuclide.

If $t^1/_2 = x$
then
200 --x-->100 –x-->50 –x--->25 –x--->12.5
From 200 to 12.5 =4x =120 minutes
=>x = $t^1/_2$ = (120 / 4)
= **30 minutes**

c) After 6 hours the count rate of a nuclide fell from 240 counts per second to 15 counts per second on the GM tube. Calculate the half-life period of the nuclide.

If $t^1/_2 = x$
then 240 --x-->120 –x-->60 –x--->30 –x--->15
From 240 to 15 =4x =6 hours
=>x = $t^1/_2$ = (6 / 4)= **1.5 hours**

d) Calculate the mass of nitrogen-13 that remain from 2 grams after 6 half-lifes if the half-life period of nitrogen-13 is 10 minutes.

If $t^1/_2 = x$ then:

2 **--x-->**1 –**2x-->**0.5 –**3x--->**0.25 –**4x-->**0.125–**5x--->**0.0625–**6x--->**0.03125
After the 6th half life **0.03125 g** of nitrogen-13 remain.

e) What fraction of a gas remains after 1hour if its half-life period is 20 minutes?

If $t\ ^1/_2 = x$ then:
then 60 /20 = 3x
1 --x--> $^1/_2$ –2x--> $^1/_4$ –3x---> $^1/_8$
After the 3rd half-life **$^1/_8$** of the gas remain

f) 348 grams of a nuclide A was reduced to 43.5 grams after 270days.Determine the half-life period of the nuclide.

If $t\ ^1/_2 = x$ then:
348 --x-->174 –2x-->87 –3x--->43.5
From 348 to 43.5=3x =270days
=>x = $t\ ^1/_2$ = (270 / 3)
= **90 days**

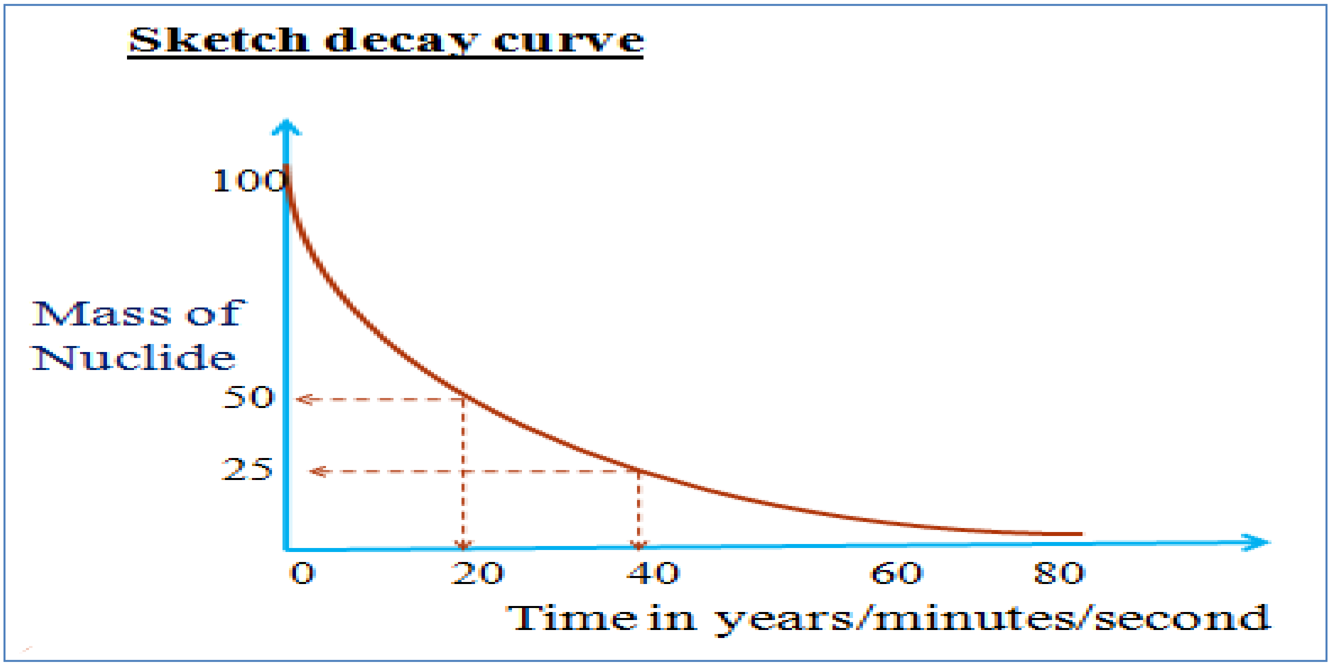
g) How old is an Egyptian Pharaoh in a tomb with 2grams of ^{14}C if the normal ^{14}C in a present tomb is 16grams.The half-life period of ^{14}C is 5600years.

If $t\ ^1/_2$ = x = 5600 years then:
16 --x-->8 –2x-->4 –3x--->2
3x = (3 x 5600)
= 16800years

h) 100 grams of a radioactive isotope was reduced 12.5 grams after 81days.Determine the half-life period of the isotope.

If $t\ ^1/_2 = x$ then:
100 --x-->50 –2x-->25 –3x--->12.5
From 100 to 12.5=3x =81days
=>x = $t\ ^1/_2$
= (81 / 3)
= **27 days**

A graph of activity against time is called **decay curve.**
A decay curve can be used to determine the half-life period of an isotope since activity decrease at equal time interval to half the original



(i)From the graph show and determine the half-life period of the isotope.

From the graph t $^{1}/_{2}$ changes in activity from:

(100 – 50) => (20 – 0) = **20** minutes

(50 – 25) => (40 – 20) = **20** minutes

Thus t ^{½} = **<u>20 minutes</u>**

(ii)Why does the graph tend to 'O'?

Smaller particle/s will disintegrate /decay to half its original.

There can <u>never</u> be 'O'/zero particles

<u>D: CHEMICAL vs NUCLEAR REACTIONS</u>

Nuclear and chemical reaction has the following **similarities**:

(i)-both involve the **subatomic** particles; electrons, protons and neutrons in an atom

(ii)-both involve the subatomic particles trying to make the atom more **stable**.

(iii)-Some for of **energy** transfer/release/absorb from/to the environment take place.

Nuclear and chemical reaction has the following **differences**:

(i) Nuclear reactions mainly involve **protons** and **neutrons** in the **nucleus** of an atom.

Chemical reactions mainly involve outer **electrons** in the **energy levels** an atom.

(ii) Nuclear reactions form a **new element**.

Chemical reactions **do not** form new elements

(iii) Nuclear reactions mainly involve evolution/production of **large** quantity of **heat/energy**.

Chemical reactions produce or absorb **small** quantity of heat/energy.

(iv)Nuclear reactions are accompanied by a **loss** in **mass**/mass defect.Do not obey the **law of conservation of matter**.

Chemical reactions are not accompanied by a loss in mass/ mass defect hence obey the law of conservation of matter.

(v)The **rate** of decay/ disintegration of the nuclide is **independent** of **physical** conditions (temperature/pressure /purityp/article size)

The rate of a chemical reaction is **dependent** on physical **conditions** (temperature/pressure/purity/particle size/ surface area)

E: APPLICATION AND USES OF RADIOCTIVITY.

The following are some of the fields that apply and use radioisotopes;

a)**Medicine: -**Treatment of cancer to **kill** malignant tumors through **radiotherapy.**

-Sterilizing hospital /surgical instruments /equipments by exposing them to gamma radiation.

b) Agriculture:

If a plant or animal is fed with radioisotope, the metabolic processes of the plant/animal is better understood by **tracing** the route of the radioisotope.

c) Food preservation:

X-rays are used to kill bacteria in **tinned** food to last for a long time.

d) Chemistry:

To study **mechanisms** of a chemical reaction, one reactant is **replaced** in its structure by a radioisotope e.g.

During esterification the **'O'** joining the ester was discovered comes from the **alkanol** and not alkanoic acid.

During photosynthesis the **'O'** released was discovered comes from **water**.

e) Dating rocks/fossils:

The quantity of ^{14}**C** in living things (plants/animals) is **constant.**

When they die the fixed mass of ^{14}C is t**rapped** in the cells and **continues** to decay/disintegrate.

The half-life period of ^{14}C is 5600 years .

Comparing the mass of ^{14}C in l**iving** and **dead** cells, the age of the dead can be determined.

F: DANGERS OF RADIOCTIVITY.

All rays emitted by radioactive isotopes have **ionizing effect** of changing the **genetic** make up of living cells.

Exposure to theses radiations causes **chromosomal** and /or **genetic** mutation in living cells.

Living things should therefore **not** be exposed for a long time to radioactive substances.

One of the main uses of radioactive isotopes is in generation of large cheap **electricity** in nuclear reactors.

Those who work in these reactors must wear protective devises made of **thick** glass or l**ead** sheet.

Accidental leakages of radiations usually occur

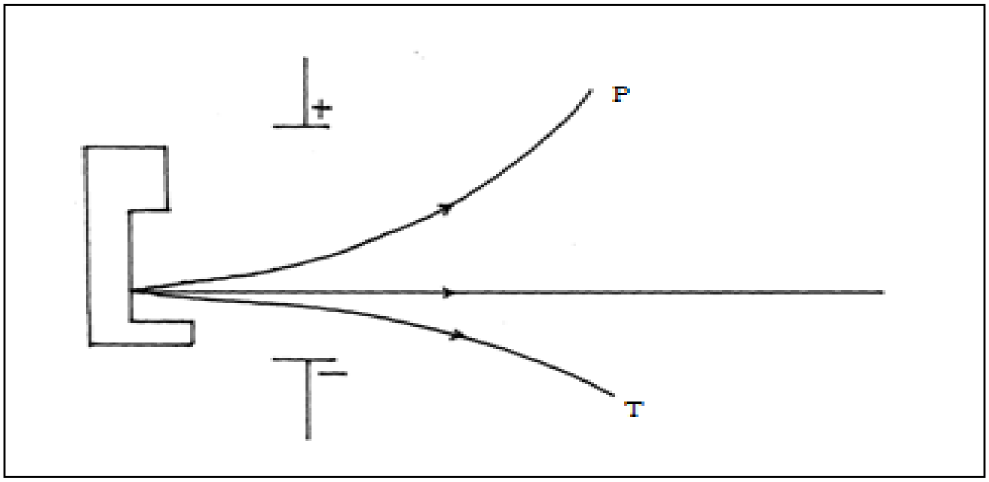
In 1986 the Nuclear reactor at **Chernobyl** in Russia had a major explosion that emitted poisonous nuclear material that caused immediate environmental disaster

In 2011, an **earthquake** in Japan caused a nuclear reactor to leak and release poisonous radioactive waste into the Indian Ocean.

The immediate and long term effects of exposure to these **poisonous** radioactive waste on human being is of major concern to all environmentalists.

G: SAMPLE REVISION QUESTIONS

The figure below shows the behaviour of emissions by a radioactive isotope x. Use it to answer the question follow



(a) Explain why isotope **X** emits radiations. (1mk)

-is unstable //has n/p ratio greater/less than one

(b) Name the radiation labeled **T** (1mk)

alpha particle

(c) Arrange the radiations labeled **P** and **T** in the increasing order of ability to be deflected by an electric filed. (1mk)

T -> P

a) Calculate the mass and atomic numbers of element B formed after $^{212}_{80}X$ has emitted three beta particles, one gamma ray and two alpha particles.

Mass number

= 212 – (0 beta+ o gamma + (2 x 4) alpha = <u>204</u>

Atomic number

= 80 – (-1 x3) beta + 0 gamma + (2 x 2)) alpha =<u>79</u>

b)Write a balanced nuclear equations for the decay of $^{212}_{80}X$ to B using the information in (a) above.

$$\mathbf{^{212}_{80}X \rightarrow {}^{204}_{79}B + 2\,^{4}_{2}He + 3\,^{0}_{-1}e + y}$$

Identify the type of radiation emitted from the following nuclear equations.

(i) $^{14}_{6}C$ -> $^{14}_{7}N$ + ………

β - Beta

(ii) $^{1}_{1}H$ + $^{1}_{0}n$ -> $^{2}_{1}H$ + ……

y -gamma

(iii) $^{235}_{92}U$ -> $^{95}_{42}Mo$ + $^{139}_{57}La$ + $^{1}_{0}n$ +……

7 β – seven beta particles

(iv) $^{238}_{92}U$ -> $^{234}_{90}Th$ + … …

α-alpha

(v) $^{14}_{6}C$ + $^{1}_{1}H$ -> $^{15}_{7}N$ + ……

y-gamma

X grams of a radioactive isotope takes 100 days to disintegrate to 20 grams. If the half-life period isotope is 25 days, calculate the initial mass X of the radio isotope.

Number of half-lifes = (100 / 25) = 4
20g -----> 40g ----> 80g-----> 160g -----> 320g
Original mass X = 320g

Radium has a half-life of 1620 years.
(i)What is half-life?
The half-life period is the time taken for a radioactive nuclide to spontaneously decay/ disintegrate to half its original mass/ amount

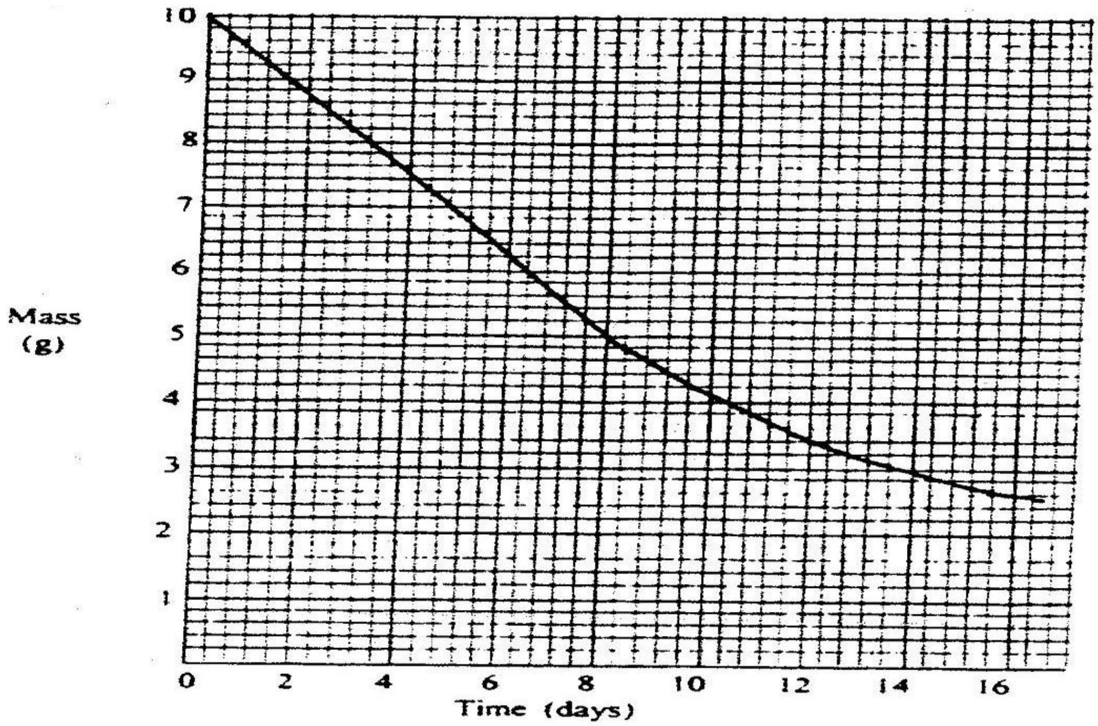
b)If one milligram of radium contains 2.68 x 10 18 atoms ,how many atoms disintegrate during 3240 years.

Number of half-lifes = (3240 / 1620) = 2
1 mg ---1620---> 0.5mg ---1620----> 0.25mg
If 1mg -> 2.68×10^{18} atoms

Then 0.25 mg -> ($0.25 \times 2.68 \times 10^{18}$) = 6.7×10^{17}
Number of atoms remaining = 6.7×10^{17}

-**Number of atoms disintegrated =**
($2.68 \times 10^{18} - 6.7 \times 10^{17}$)
= 2.01×10^{18}

The graph below shows the mass of a radioactive isotope plotted against time



Using the graph, determine the half – life of the isotope

From graph 10 g to 5 g takes 8 days

From graph 5 g to 2.5 g takes 16 – 8 = 8 days

Calculate the mass of the isotope dacayed after 32 days

Number of half lifes= 32/8 = 4

Original mass = 10g

10g—1^{st} -->5g—2^{nd}-->2.5—3^{rd} –>1.25—4^{th} -->0.625 g

Mass remaining = 0.625 g

Mass decayed after 32 days = 10g - 0.625 g = 9.375g

A radioactive isotope X_2 decays by emitting two alpha (a) particles and one beta (β) to form $^{214}{}_{83}Bi$

(a)Write the nuclear equation for the radioactive decay

$^{212}_{86}X \;\; -> \;\; ^{214}_{83}Bi \;+\; 2\,^{4}_{2}He \;+\; ^{0}_{-1}e$

(b)What is the atomic number of X_2?

86

(c) After 112 days, 1/16 of the mass of X_2 remained. Determine the half life of X_2

1—x-> $^1/_2$ –x-> $^1/_4$ –x-> $^1/_8$–x-> $^1/_{16}$
Number of $t^1/_2$ in 112 days = 4
$t^1/_2 = \frac{112}{4} =$ 28 days

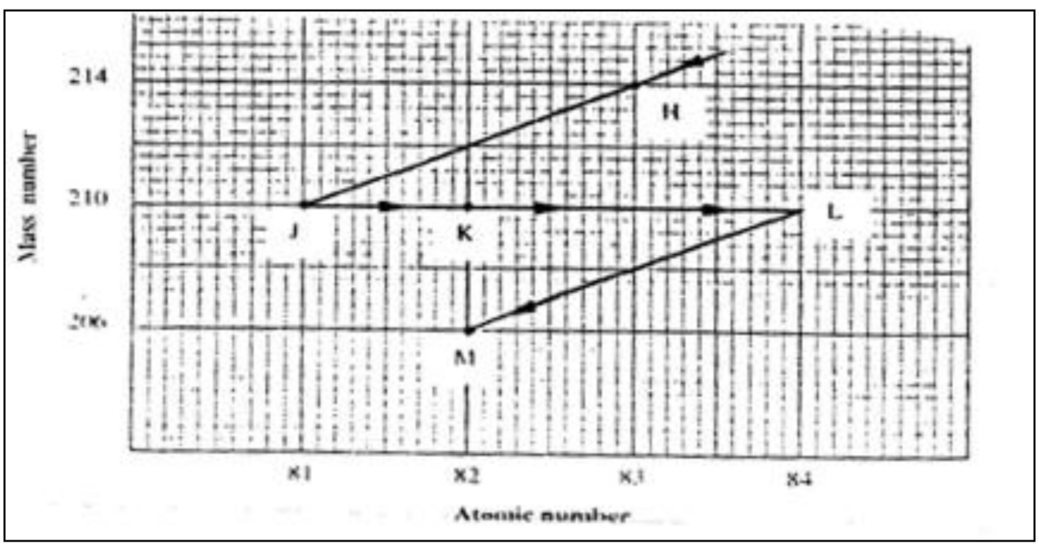
1.Study the nuclear reaction given below and answer the questions that follow.

$^{12}_{6}C$ --step 1-->$^{12}_{7}N$ --step 2--> $^{12}_{11}Na$

(a)$^{12}_{6}C$ and $^{14}_{6}C$ are isotopes. What does the term isotope mean?
Atoms of the same element with different mass number /number of neutrons.

(b)Write an equation for the nuclear reaction in step II
$^{12}_{7}N \rightarrow {}^{12}_{11}Na + {}^{0}_{-1}e$
(c)Give one use of $^{14}_{6}C$
Dating rocks/fossils:
Study of metabolic pathways/mechanisms on plants/animals

Study the graph of a radioactive decay series for isotope H below.



(a) Name the type of radiation emitted when isotope
(i) H changes to isotope J.
Alpha-Mass number decrease by 4 from 214 to 210(y-axis)

atomic number decrease by 2 from 83 to 81(x-axis)

(ii) J changes to isotope K

Beta-Mass number remains 210(y-axis)

atomic number increase by 1 from 81 to 82(x-axis).

(b) Write an equation for the nuclear reaction that occur when isotope

(i)J changes to isotope L

$^{210}_{81}\mathbf{J} \;\; \rightarrow \;\; ^{210}_{84}\mathbf{L} \;\; + \;\; 3\,^{0}_{-1}\mathbf{e}$

(i)H changes to isotope M

$^{214}_{83}\mathbf{H} \;\; \rightarrow \;\; ^{206}_{82}\mathbf{M} \;\; + \;\; 3\,^{0}_{-1}\mathbf{e} \; + \;\; 2\,^{4}_{2}\mathbf{He}$

Identify a pair of isotope of an element in the decay series

K and M

Have same atomic number 82 but different mass number K-210 and M-206

a)A radioactive substance emits three different particles.

Identify the particle:

(i)with the highest mass.

Alpha/ α

(ii) almost equal to an electron

Beta/ β

1.a)State two differences between chemical and nuclear reactions(2mks)

(i) Nuclear reactions mainly involve **protons** and **neutrons** in the **nucleus** of an atom.Chemical reactions mainly involve outer **electrons** in the **energy levels** an atom.

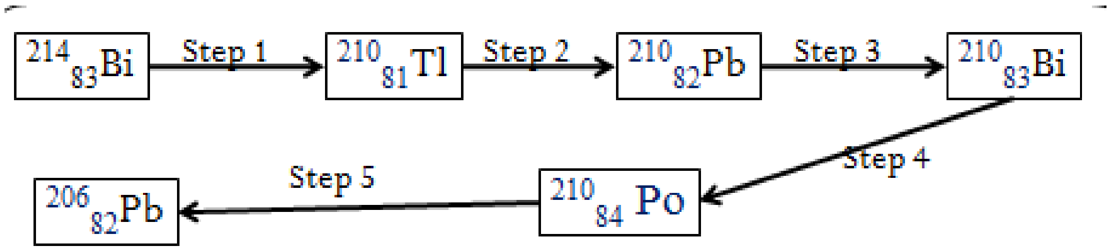
(ii) Nuclear reactions form a **new element**. Chemical reactions **do not** form new elements

(iii) Nuclear reactions mainly involve evolution/production of **large** quantity of **heat/energy.**Chemical reactions produce or absorb **smaller** quantity of heat/energy.

(iv)Nuclear reactions are accompanied by a **loss** in **mass** /mass defect. Chemical reactions are not accompanied by a loss in mass.

(v)R**ate** of decay/ disintegration of nuclide is **independent** of **physical** conditionsThe rate of a chemical reaction is **dependent** on physical **conditions** of temperature/pressure/purity/particle size/ surface area

b)Below is a radioactive decay series starting from $^{214}_{83}$Bi and ending at $^{206}_{82}$Pb. Study it and answer the question that follows.



Identify the particles emitted in steps I and III (2mks)

I - **α-particle**

III - **β-ray**

ii)Write the nuclear equation for the reaction which takes place in (a) step I

$$^{214}_{83}Bi \rightarrow {}^{210}_{81}Bi + {}^{4}_{2}He$$

(b) step 1 to 3

$$^{214}_{83}Bi \rightarrow {}^{210}_{81}Bi + {}^{4}_{2}He + 2\,{}^{0}_{-1}e$$

(c) step 3 to 5

$$^{210}_{82}Pb \rightarrow {}^{206}_{82}Pb + {}^{4}_{2}He + 2\,{}^{0}_{-1}e$$

(c) step 1 to 5

$$^{214}_{83}Bi \rightarrow {}^{206}_{82}Pb + 2\,{}^{4}_{2}He + 3\,{}^{0}_{-1}e$$

The table below give the percentages of a radioactive isotope of Bismuth that remains after decaying at different times.

Time (min)	0	6	12	22	38	62	100
Percentage of Bismuth	100	81	65	46	29	12	3

i)On the grid below , plot a graph of the percentage of Bismuth remaining(Vertical axis) against time.

ii)Using the graph, determine the:

I. Half – life of the Bismuth isotope

II. Original mass of the Bismuth isotope given that the mass that remained after 70 minutes was 0.16g (2mks)

d) Give one use of radioactive isotopes in medicine (1mk)

14.a)Distinguish between nuclear fission and nuclear fusion. (2mks)

Describe how solid wastes containing radioactive substances should be disposed of. (1mk)

b)(i)Find the values of Z_1 and Z_2 in the nuclear equation below

$$^{Z1}_{92}U + ^{1}_{0}n \rightarrow ^{94}_{38}Sr + ^{140}_{Z2}Xe + 2\,^{1}_{0}n$$

iii)What type of nuclear reaction is represented in b (i) above?

A radioactive cobalt $^{61}_{28}Co$ undergoes decay by emitting a beta particle and forming Nickel atom,

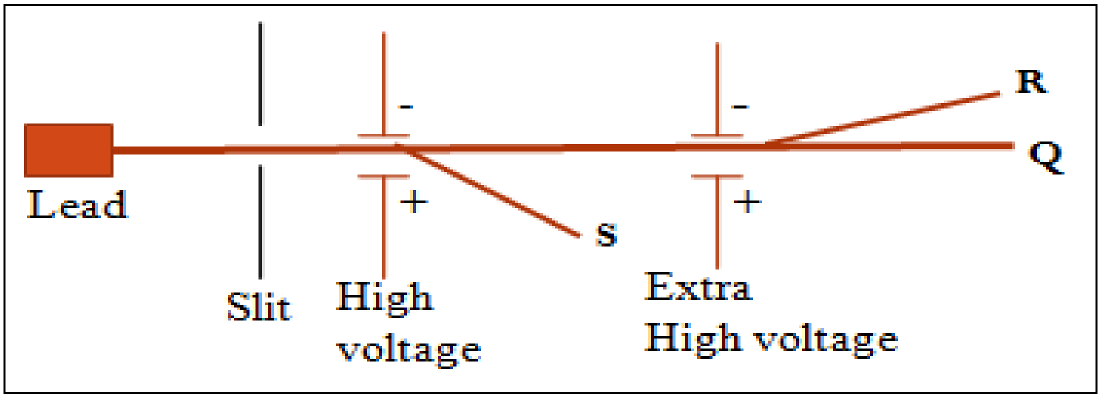
Write a balanced decay equation for the above change

1 mark

If a sample of the cobalt has an activity of 1000 counts per minute, determine the time it would take for its activity to decrease to 62.50 if the half-life of the element is 30years 2 marks

Define the term half-life.

The diagram below shows the rays emitted by a radioactive sample

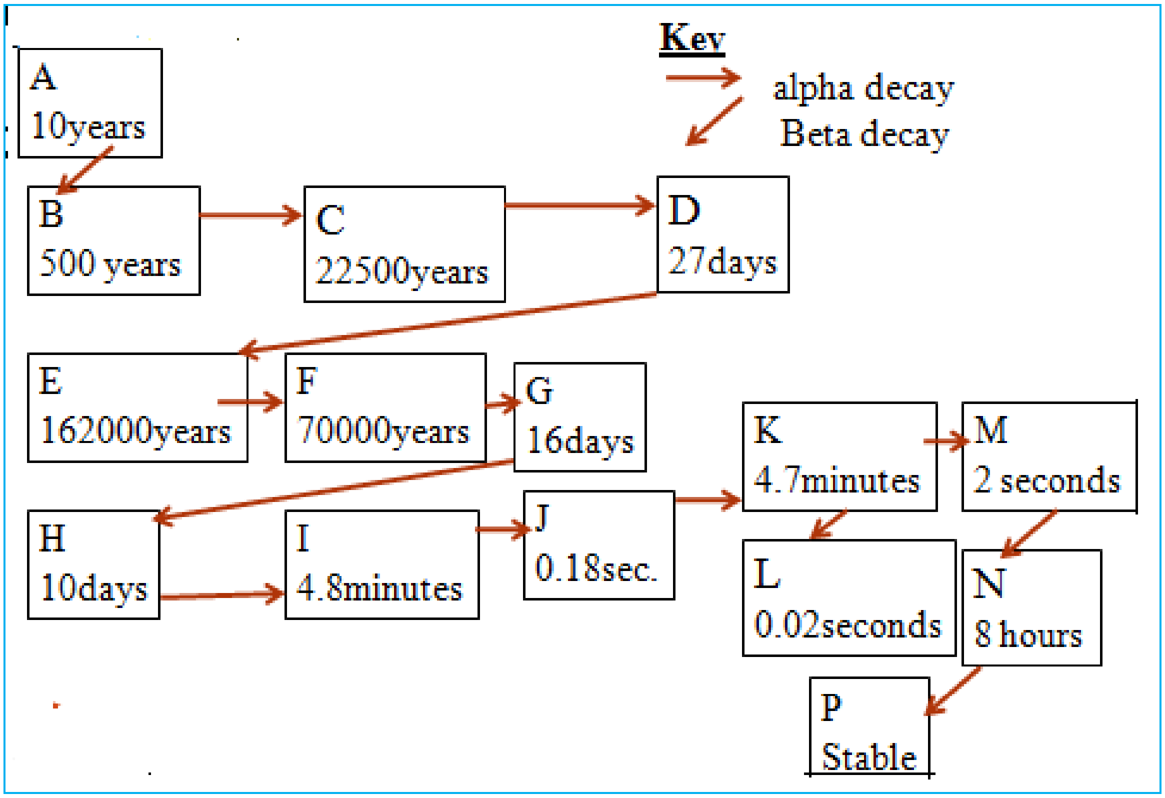


a) Identify the rays S,R and Q
   S- Beta (**β)particle/ray**
   R- Alpha (**α)particle/ray**
   Q- Gamma (**y)particle/ray**

b) State what would happen if an aluminium plate is placed in the path of ray R,S and Q:

R-is blocked/stopped/do not pass through
Q-is not blocked/pass through
S-is blocked/stopped/do not pass through

(c) The diagram bellow is the radioactive decay series of nuclide A which is $^{241}_{94}Pu$.Use it to answer the questions that follow. The letters are not the actual symbols of the elements.



(a)Which letter represent the : Explain.

(i)shortest lived nuclide

L-has the shortest half life

(ii)longest lived nuclide

P-Is stable

(iii) nuclide with highest n/p ratio

L-has the shortest half life thus most unstable thus easily/quickly decay/disintegrate

(iv) nuclide with lowest n/p ratio

P-is stable thus do not decay/disintegrate

(b)How long would it take for the following:

(i)Nuclide A to change to B

10 years (half life of A)

(ii) Nuclide D to change to H

27days +162000years+70000years+16days

232000 years and 43 days

(iii) Nuclide A to change to P

27days +162000years+70000years+16days

232000 years and 43 days

Study

❖❖❖❖❖❖❖❖❖❖❖❖❖❖❖❖❖❖❖❖**END**❖❖❖❖❖❖❖❖❖❖❖❖❖❖❖❖❖❖❖❖❖