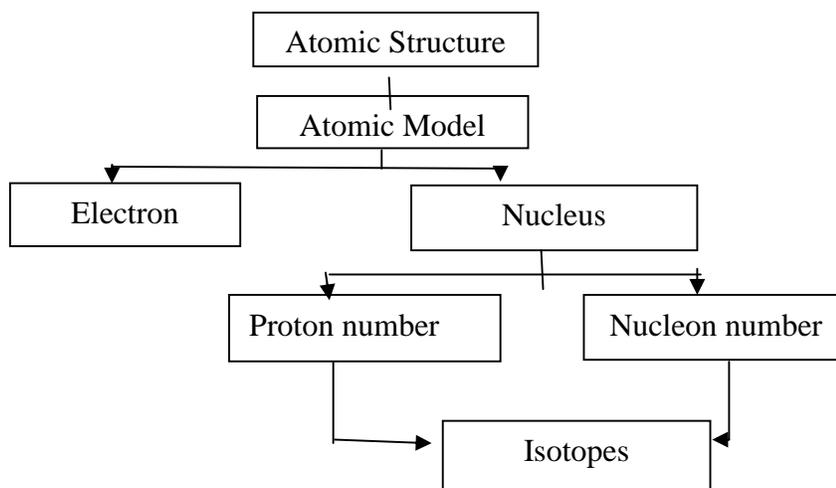


## CHAPTER 10: RADIOACTIVE



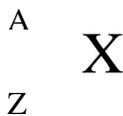
### 10.1 THE NUCLEUS OF AN ATOM

#### 10.1.1 The composition of the nucleus

1. Atomic Model has a *nucleus* which consists of *proton* and *neutron* with *electron* revolving around the nucleus like the planet revolving around the Sun.
2. A proton has a *positive* charge whereas an *electron* has a charge.

#### 10.1.2 Nuclide

1. A nuclide is an atom of a particle structure



2. An atom of an element is represented by its symbol as above.

A is for *nucleon number* Z is for *proton number* and X is for *element*

3.  ${}_{13}^{27}\text{Al}$

The proton number of aluminium is *13*,

The nucleon number of aluminium is *27*

The number of neutron in this nucleus is *14*

4. Carbon – 12, each nucleus contains 6 protons and 6 neutrons. Hence  $A = 12$  and  $Z = 6$ .

Write the symbol for this nuclide

.....  ${}_{6}^{12}\text{C}$  .....

### 10.1.3 Isotopes

1. What it meant by the isotopes ?

...*Isotopes are atoms of the same element with the same number of protons but different number of neutron*

2. Write symbolically isotopes:

carbon -12 .....  ${}_{6}^{12}\text{C}$  .....

carbon -14 .....  ${}_{6}^{14}\text{C}$  .....

deuterium .....  ${}_{1}^{2}\text{H}$  .....

tritium .....  ${}_{1}^{3}\text{H}$  .....

oxygen – 16 .....  ${}_{8}^{16}\text{O}$  .....

oxygen – 17.....  ${}_{8}^{17}\text{O}$  .....

helium – 3.....  ${}_{2}^{3}\text{He}$  .....

helium – 4 .....  ${}_{2}^{4}\text{He}$  .....

### Exercise 10.1

1. A nucleus contains protons and neutrons. Which of these particles experiences an electrostatic force ?

.....*protons*.....

2. Gold (Au) has 79 protons and 118 neutrons. Write the symbol for this nuclide

..... $^{118}_{79}\text{Au}$ .....

3. An isotope of nitrogen can be represented by ( $^{15}_7\text{N}$ ). How many of the following particles does it have ?

a) protons .....*7*.....

b) neutrons.....*8*.....

c) electrons .....*7*.....

4. An atom of element Y has a proton number 5 and a nucleon number 11. Identify the element

.....*boron*..... $^{11}_5\text{B}$ .....

## **10.2 RADIOACTIVE DECAY**

### **10.2.1 Radioactivity**

1. What is meant by the radioactivity ?

...*Radioactivity is the spontaneous and random emission of radioactive rays from unstable radioactive materials after which they become more stable*.....

2. The process is said to be spontaneous because ...

*It is not influenced by any physical factors such as temperature, pressure, time , etc.....*

3. The emission of radioactive rays is random means that :

- a) *emission occurs at irregular intervals.....*
- b) *emission does not occur at the same rate .....*

**Exercise 10.2.1**

a) Describe what happens to an atom when it undergoes radioactive decay.

*.....When a radioactive nucleus decays, its nucleus breaks up, emits an alpha particle or beta particle and energy, and form a new atoms of a different element.....*

(b) A scientist measures the count rate from a radioactive substance over a period of 20 minutes. The table shows the results of his measurements.

time/minutes	0	5	10	15	20
$\frac{\text{count rate}}{\text{counts/s}}$	800	400	205	105	50

(i) From the table, estimate the half-life of the substance.

half-life = *..5.....* minutes

(ii) How many half-lives elapsed during the 20 minute experiment?

number of half-lives = *..4 half - life.....*

(iii) If the scientist had taken readings for 25 minutes, what might the count rate have been at the end of his experiment?

count rate after 25 minutes = *.....25.....* counts/s

**10.2.2 Characteristics of the three types of Radioactive Emissions**

Radioactive emissions	Alpha particles	Beta particles	Gamma rays
Symbol	${}^4_2\alpha$	${}^0_{-1}\beta$	$\gamma$
Nature	<i>Positive charged , helium nucleus He</i>	Electron	<i>Neutral electromagnet ray</i>
Charge	+2 electric charges	<i>-1 electric charge</i>	0
Speed	<i>(1/20 ) x the speed of light, cc</i>	<i>3 % - 99 % of the speed of light , c</i>	Speed of light
Energy	<i>For a particular source, all <math>\alpha</math> particle are emitted with the same Ke</i>	<i>For a particular source <math>\beta</math>- particle emitted have various KE</i>	Nil
In an electric field	<i>Bends to negative plate</i>	Bends to positive plate	<i>Does not bend , showing that it is neutral</i>
In magnetic field	<i>Bends a little showing that it has a big mass. Direction of the bend indicates that it is positively charges</i>	<i>Bend a lot showing that it has a small mass. Direction of the bend indicates that it is positively charged</i>	<i>Does not bend showing that it is neutral.</i>
Ionising power	<i>Strongest</i>	<i>Intermediate</i>	Weakest
Penetrating power	<i>Low</i>	Intermediate	<i>Hight</i>
Stopped by	A thin sheet of paper	<i>A few millimeters of aluminium</i>	<i>A few centimeters of lead or concrete</i>
Range in air	<i>A few centimetres</i>	<i>A few metres</i>	A few hundred metres

Complete the table .

**Exercise 10.2.2**

1. Uranium -238 (  ${}_{92}^{238}\text{U}$  ) emits an alpha particle and disintegrates into a thorium atom.

State the nucleon number and proton number of the thorium isotope formed.

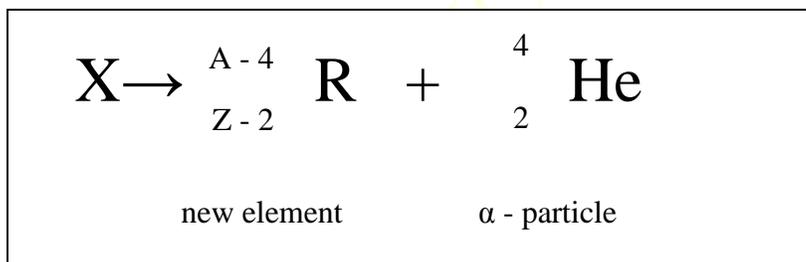


2. Strontium - 90 (  ${}_{38}^{90}\text{Sr}$  ) decays to yttrium-90



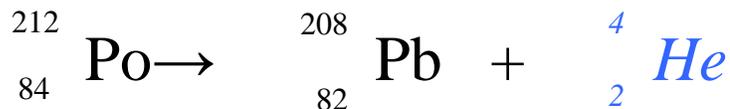
**10.2.3 Changes in the proton number and nucleon number in Radioactive Decay**

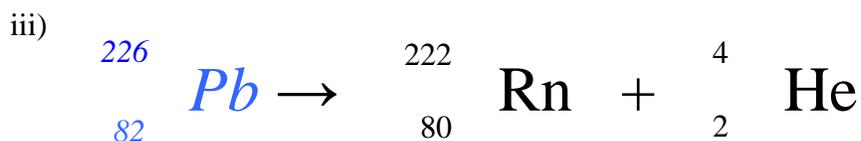
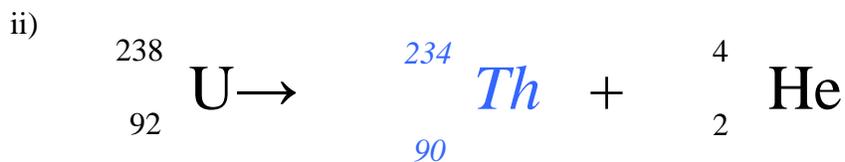
1.



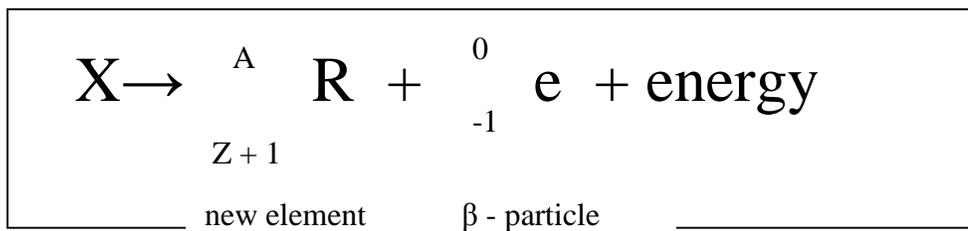
a) Complete the equation to show the emission of alpha particle

i)

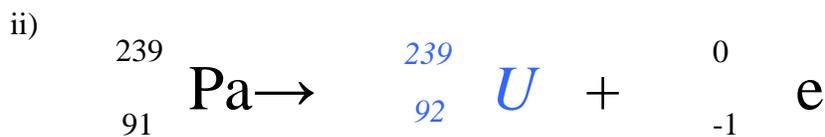




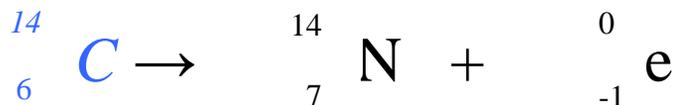
2.



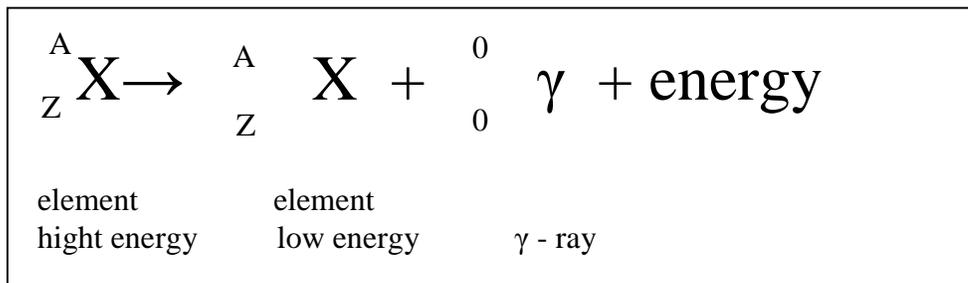
Complete the equation to show the emission of beta particle



iii)

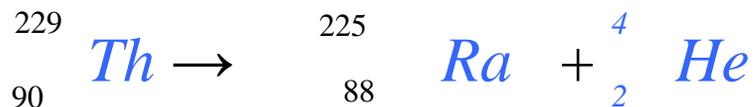


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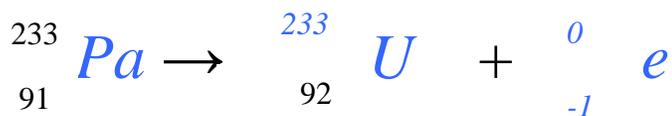


Complete the equation to show the combination emission of gamma ray, beta particle and alpha particle. Identify the element (emission) A, B, C, D and E in the symbolically form.

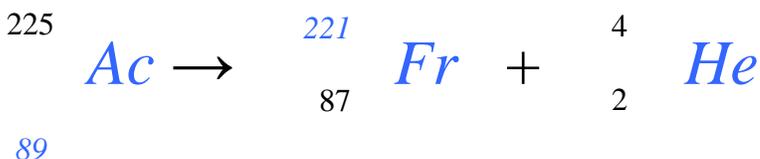
i)



ii)



iii)



**Exercise 10.2.3**

1) Complete the following table about the particle in an atom. The first row has been filled in as an example

particle	mass	charge	location
Proton	1 unit	+ 1 unit	In the nucleus
Neutron	<i>1 unit</i>	<i>0</i>	<i>In the nucleus</i>
electron	<i>1/1833</i>	<i>- 1 unit</i>	<i>Moves around the nucleus</i>

(i) Which of the particles in the table make up an  $\beta$ -particle?

.....*electron*.....

(ii) On the same scale as indicated by the table, state

1. the mass of an  $\alpha$ -particle, .. *4 unit*.....

2. the charge of an  $\alpha$ -particle. ....*+ 2 unit charges*.....

**10.2.4 Radioactive Detectors**

Complete the table below

No	Radiative emission	Dectector	Reason
1.	Beta and gamma.	Photographic Films	<i>Cannot penetrare through the metal</i>
2.	<i>Alpha and beta</i>	Gold Leaf Electroscopes	Strong ionising power

3.	Alpha, beta and gamma	Cloud Chambers	<p><i>Tracks of alpha thicks and straight.</i></p> <p><i>Beta – thin and twist</i></p> <p><i>Gamma – thinner than beta.</i></p>
4.	<i>Alpha, beta and gamma</i>	Geiger – Muller Tube ( G.M Tube )	Alpha is positive charge , unlike charge are attracted in a strong electric field between the two electrodes.
5.	Alpha, beta and gamma	Geiger – Muller Tube ( G.M Tube )	<p><i>The explosure of radiation over one week - AGM tube connected to the scaler.</i></p> <p><i>Minimum intensity of a radiation.-AGM tube connected to a ratemeter</i></p>

### **10.2.5 Half – Life**

The half - life of radioactive source is the time taken for half number of the nuclei in a sample of radioactive atoms to decay.

#### **Example :**

Pa takes 20.8 hours to shrinks from 80 g to 5 g.

a) How many half –lives are there

80 g  $\rightarrow$  40 g  $\rightarrow$  20 g  $\rightarrow$  10 g  $\rightarrow$  5 g

$T_{1/2}$        $T_{1/2}$        $T_{1/2}$        $T_{1/2}$

( This decay process has taken the time of 4 half – lives )

20.8 hours = 4  $T_{1/2}$  ,     $T_{1/2} = 20.8 / 4 = 5.2$  hours.

#### **Exercise 10.2. 5**

1. A radioactive of gamma rays has a half – life of 4 days . A Geiger counter placed 3 m from the source initially has a count – rate of 21600 per minute . After 8 days, the counter is moved back to a distance of 6 m from the source and its rate , in counts per minute is then. ...

*5400 per minute*

*( 21600 @ 10800 @ 5400 )*

2. The number of radioactive nuclides in two different samples P and Q are initially 4 N and N respectively. If the half – life of P is t and that of Q is 3 t, the number of radioactive nuclides in P will be the same as the number of radioactive nuclides in Q after a time of ...

*3 t*

3. The activity of a sample of radioactive isotope decrease to  $\frac{1}{4}$  of its initial value in 32 s. How much more time would be required for the activity to decrease to  $\frac{1}{64}$  Of its initial value ?

*4 x 16 = 64 s*

4. A detector is used for monitoring an  $\alpha$  – source and a reading of 240 units is observed. After a time equal to twice the half – life of the  $\alpha$  – source, the reading has fallen to 66 units. If a 5 mm thick lead sheet is inserted between the  $\alpha$  – source and the detector, the reading would probably be ...

*6 unit ,back ground reading*

5. A counter is placed near a very weak radioactive source which has a half – life of 2 hours. The counter registers 95 count/ min at noon and 55 count / min at 2 p.m . The expected count – rate, in count / min , at 6 p. m m on the same day is ...

*12 count / min*

### **10.3 RADIOISOTOPES**

#### **10.3.1 The application of radioisotope in industries**

1. Radioisotopes are isotopes with radioactive properties.

Radioisotope source	Use in	Mechanism
Americium -241	Smoke detector	Alpha particle emitted from the source ionise air molecules. The ionized air molecules conduct electricity and a small current flow to the detector. Smoke absorb alpha particles, the current flow decrease and

		trigger the alarm.
<i>Beta - ray</i>	Thickness control	<i>A radioisotope sends radiation through the sheet material as it comes off the production line. <math>\alpha</math> and <math>\beta</math> radiation are used for thin sheets. A radiation detector on the other side of the sheet measures the intensity of the radiation passing through the sheet. The detector inform the machinery to adjust the thickness of the sheet automatically.</i>

### **Exercise10.3.1**

1. A factory produces aluminium sheets of thickness 1 mm each. The thickness of the sheets is monitored by a gauge . A source is used in the gauge

- a) Explain why  $\alpha$  and  $\gamma$  sources are not used in gauge

*$\alpha$  cannot be penetrate*

- b) The count rate recorder should be around 90 count per second when the thickness of the aluminium sheets is 1 mm. On a certain day when the gauge is operating properly, the following data are recorded:

Times	0	10	20	30	40	50	60	70	80	90	100
Count recorder rate/ counts per second	90	89	91	90	90	88	66	64	90	89	89

Describe and explain the variation in the reading in the above table

### **10.3.2 The applications of radioisotopes in medical field**

1. In Medical field radioisotopes are use in

- a) *Sterilising*
- b) *Radioactive tracer*
- c) *Cancer treatment*

#### **Exercise 10.3.2**

1. Iodine – 131 is a radioisotopes which decays by emitting  $\beta$  – particle and  $\gamma$  – rays. It is used in hospitals to test the kidneys of patients. During the test, an iodine – 131 solution is injected into the bloodstream of a patient. As the blood passes through the kidney , iodine -131 will be absorbed by the kidney and eventually excreted out of the body with the urine. If the kidney is not functioning properly, both the absorption and excretion rates of iodine-131 will decrease. A  $\gamma$  – detector is placed near the kidneys of the patient to detect the activity of the radiation coming from the kidney

- a) Using X to denote the daughter nucleus, write down an equation for the decay of an iodine – 131 nucleus



- b) Explain why the  $\beta$  – particles emitted by iodine – 131 fail to reach the detector

*The beta particle can be absorbed easily by the human body*

- c) The half – life of iodine – 131 is 8 days  
i) State the meaning of half – life

*Half-life is the time taken for the activity to drop from its original value. It is a constant value for the specific radioactive source*

- ii) For safety purpose, the activity of iodine – 131 solution in the test should not exceed  $1.5 \times 10^8$  disintegrations per second. .When an iodine -131 solution is prepared its activity is  $6 \times 10^8$  disintegrations per second. How many days preparation would the solution be suitable for the test ?

$$6 \times 10^8 \times \left(\frac{1}{2}\right)^t = 1.5 \times 10^8$$

$$\left(\frac{1}{2}\right)^t = \frac{1}{4}, t = 2$$

$$2 T_{\frac{1}{2}} = 2 \times 8 \text{ days} = 16 \text{ days}$$

- iii) Besides iodine -131 , technetium -99 m is another radioisotopes which is also used in the kidney test. Technetium -99 m emits  $\gamma$  – radiation only and its half- life is 6 hours. Which if these two sources do you think is more preferable for use in the kidney test ? Explain your answer

*Technetium – 99 m is preferable. It has a much shorter half- life and is relatively convenient to prepare, better in sense of less total radiation absorption*

### 10.3.2 The application of radioisotopes in archaeology and in the field of agriculture

1. In Archaeology and in the field of agriculture

a) *Radioactive dating*

b) *Controlling pest*

### 10.4 NUCLEAR ENERGY

#### 10.4.1 Atomic Mass Unit (a. m. u )

1 Atoms are too *small* to be measured in kilogram or gram

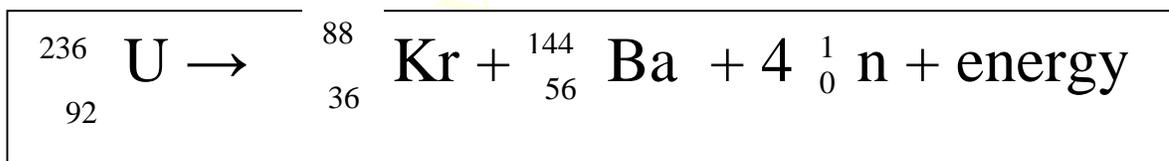
2. The mass of an atom, nucleus and proton are measured in *atomic mass unit ( a.m.u )*

3. 1 a.m.u =  $\frac{1}{12}$  *mass of C – 12 atom*

4. 1 a.m.u =  $1.66 \times 10^{-27}$  kg

#### Exercise 10.4.1

1. Determine the energy in unit eV for reaction shown below



Where U = 236.04556 a.m.u

Kr = 87.91445 a.m.u

Ba = 143.92284 a.m.u

n = 1.00867 a.m.u

c =  $3.00 \times 10^8$  m s<sup>-1</sup>

1 MeV =  $1.00 \times 10^{-13}$  J

$$\begin{aligned} \text{Energy} &= 2.59 \times 10^{-11} \text{ J} \\ &= 259 \text{ MeV} \end{aligned}$$

## 10.4.2 Nuclear Energy

### Nuclear Fission

1. Nuclear fission is triggered by other particles. For instance, when uranium – 235 is bombed with...*slow neutron*, the nucleus of uranium – 235 may split into *two pieces*.....and emit more...*neutron*



### Exercise

1. In a nuclear reaction U- 235 is bombarded by a neutron giving Cs – 141, Rb – 93 and 2 neutrons and energy is released . From table below , determine the energy released when one U – 235 atom undergoes such a nuclear reaction.

Radioactive element	Atomic mass unit, u
U- 235	235.0492
Rb – 93	93.92157
Cs – 141	140.91963
Neutron	1.00867

$$1a.m.u = 1.66 \times 10^{-27} \text{ kg}$$

$$c = 3.00 \times 10^8 \text{ m s}^{-1}$$



Total mass of product  $m_1$

$$= 93.92157 + 140.91963 + 1.00867 \times 2$$

$$= 236.85854 \text{ a.m.u}$$

Total mass of reactant ,  $m_2$

$$= 235.0492 + 1.00867$$

$$= 236.11359 \text{ a.m.u}$$

$$\text{Mass defect} = m_1 - m_2$$

$$= 236.85854 - 236.11359$$

$$= 0.74495 \text{ a.m.u}$$

$$= 0.74495 \times 1.66 \times 10^{-27} \text{ kg} = 1.236617 \times 10^{-27}$$

$$E = m c^2$$

$$= 1.236617 \times 10^{-27} \times (3.00 \times 10^8)^2$$

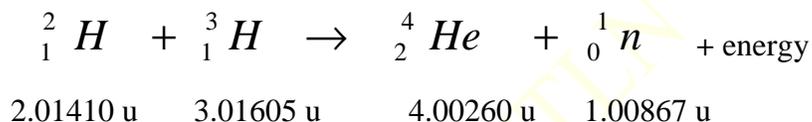
$$= 1.1129533 \times 10^{-10} \text{ J}$$

$$= 1112.9553 \text{ MeV}$$

### **Nuclear Fusion**

1. Nuclear fusion is .....*the combination of small atoms into a larger atom and with the release of heat.*

2. The following equation shown a fusion reaction



$$[ 1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}, c = 3.00 \times 10^8 \text{ m s}^{-1} ]$$

What is the energy produced ?

$$E = mc^2 = 2.820672 \times 10^{-12} \text{ J}$$

### **Exercise**

1. Hydrogen nuclei fuse together in the Sun. The nucleus of one isotope of hydrogen contains one proton and has the nuclide notation  ${}^1_1\text{H}$ . Other isotopes of hydrogen have the nuclide notations  ${}^2_1\text{H}$  and  ${}^3_1\text{H}$ .

(a) State the number of protons and the number of neutrons in a nucleus of each of the two other isotopes of hydrogen.

${}^2_1\text{H}$  .....*number of proton 1 and number of neutrons 1*.....

${}^3_1\text{H}$  ..... *number of proton 1 and number of neutrons 2*.....

(b) Nuclei may fuse when they come together.

(i) Explain why nuclei do not easily come together.

.....*small atoms must collide at a high speed with another, temperature of gas must high to give high average kinetic energy* .....

ii) Explain why nuclei are able to come together in the centre of the Sun.

.....*Sun has very high temperature to give high kinetic energy*  
.....

### **Chain Reactions**

1. A chain reaction is ...*a self – sustaining reaction in which the products of a reaction can initiate another similar reaction*.....

2. In a chain reaction *uranium bombarbed by a neutron.three free neutros barium and krypton and agreat amout of energy are produced.*

3. The *three neutron* will bombard another *three uranium atoms.*

### **Nuclear Reactor**

1. The most common type of nuclear reactor in a nuclear plant is called the pressurized water reactor ( PWR ).

2. *Uranium -235* is used as *nuclear fuel*.

3. *A lot of heat* will be produced

4. *Nuclear fission* can be controlled *by moderators graphite*

5. *Nuclear reaction* can be controlled by the *Boron and Cadmium* as control rod, to absorb secondary neutron

6. Carbon dioxide or water is used *as a cooling agent , remove the heat of reaction to make steam for turbine generator*

7. The lead and concrete *keep the radiation inside the reactor*

### **Exercise**

1. Uranium – 235 is used as ... *nuclear fuel*.....
2. In the nuclear fission a lot of .....*heat*..... will be produced
3. The energy released from nuclear fission can be used to generate ...*electricity*

## **10.5 IMPORTANT OF PROPER MANAGEMENT OF RADIOACTIVE SUBSTANCE**

### **10.5.1 Negative Effects of Radioactive Substances**

1. *Radioactive* wastes are considered *dangerous* waste
2. The negative effects of radioactive waste depend on..
  - a) *quantity of waste*
  - b) *the type of waste*
  - c) *the half- life of waste*
  - d) *the type of radioactive rays emitted*
- 3 Long half – lives *threaten our health*
4. Radioactive waste must be kept in a *special thick barrel made of lead or concrete*
5. The barrel containing the radioactive waste then *buried in unused mines or non residential areas.*

### **10.5.2 Safety Precautions**

1. *Lead* is used to block radioactive rays
2. *Use distance controller or tongs* to move radioactive materials
3. The *uniform* worn by workers in a nuclear plant must be *kept in special bags*
4. Worker in radioactive energy station must wear *badges* to which the worker have been *exposed to radioactive rays can be determined.*
5. *Nuclear reactor* should be build on islands or areas *far away from residents*

6. Barrels containing radioactive materials must be labeled “ *Radioactive materials* “ and must carry the radioactive symbol.

### **Exercise**

1. In a research laboratory using radioactive materials, safety precautions have to be observed. Some of the safety precautions adopted by the laboratory are listed below.

On the lines after each precaution, state reasons why it is a wise precaution

(a) Radioactive materials should only be picked up using long-handled tools.

REASON 1 .....*Radioactive materials considered dangerous*.....

REASON 2 .....*Avoid contact with radioactive substances*.....

(b) Food must not be taken where radioactive materials are being used.

REASON .....*Radioactive will threaten our health*.....

(c) The researchers must wash their hands after the source has been put away safely.

REASON .....*To ensure the radioactive is not on their hand or body*.....

(d) Radioactive materials must be stored in a locked drawer or cabinet.

REASON .....*To minimise the exposure to radioactive materials*.....

### **Reinforcement Chapter 10**

#### **Part a : Objective question.**

1. A positively charged ion (+1) has an atomic number of Z. Find its number of electrons and , number of neutrons

	Number of electrons	Number of neutrons
A	Z	Z
B.	Z - 1	Z
C	Z + 1	Z
D.	Z - 1	<i>Not enough information</i>

2. Which of the following is deduced from the Rutherford's scattering experiment ?

- A. There are neutrons inside a nucleus.
- B. The sign of the charge of the nuclei is the same as the sign of alpha particles*
- C. Electrons are embedded in a nucleus.
- D. Electrons are light in mass compared with the nucleus.
- E. Electrons has the opposite charge compared with the nucleus.

3. Isotopes have the same ...

- I. number of protons
- II. number of neutrons
- III. half – life

- A. I only*
- B. III only
- C. I and II only
- D. II and III only

4. Which of the following best represents the magnitude of the radius of an atom ?

- A.  $10^{-2}$  m
- B.  $10^{-6}$  m
- C.  $10^{-10}$  m*
- D.  $10^{-14}$  m

5. Which of the following conclusions could be deduced from Rutherford's scattering experiment ?

- I. The positive charge in an atom is confined to a very small region.
- II. The volume of an atom mainly consists of empty space
- III. Electrons in an atoms are orbiting in different orbits

- A. I only
- B. III only*
- C. I and II only
- D. II and III only

6. The proton number of an atom is the number of ...

- A. neutrons in the nucleus.
- B. protons in the nucleus*
- C. neutrons and electrons in the nucleus
- D. protons and neutrons in the nucleus

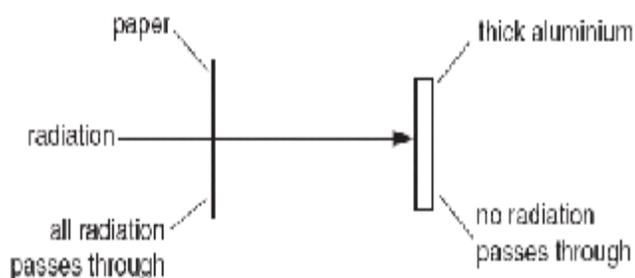
7 A small amount of a radioactive isotope contains 72 billion unstable nuclei. The half-life of the isotope is 4 hours. How many unstable nuclei would remain after 12 hours?

- A 6 billion  
C 18 billion  
B 9 billion  
D 24 billion

8. How many nucleons are in a nucleus of  ${}_{19}^{30}\text{K}$  ?

- A 19  
C 30  
B 20  
D 58

9 .A radioactive source emits radiation that can pass through a sheet of paper but not through thick aluminium.



What does this show about the radiation?

- A It is alpha-particles.  
C It is gamma-rays.  
B It is beta-particles.  
D It is a mixture of alpha-particles and gamma-rays.

10 A sample of a radioactive isotope is decaying. Which atoms will decay first?

- A impossible to know, because radioactive decay is random  
B impossible to know, unless the age of the material is known  
C atoms near the centre, because they are surrounded by more atoms  
D atoms near the surface, because the radiation can escape more easily

**Part B : Structure question**

1. Some pond water becomes contaminated by the release of radioactive waste.

The radioactivity of a sample of the contaminated water is tested every week for 5 weeks.

The results are shown in the table below.

time / weeks	0	1	2	3	4	5
activity count	800	440	240	130	70	40

(a) Plot these values on graph

(b) Draw the best curve through your points.

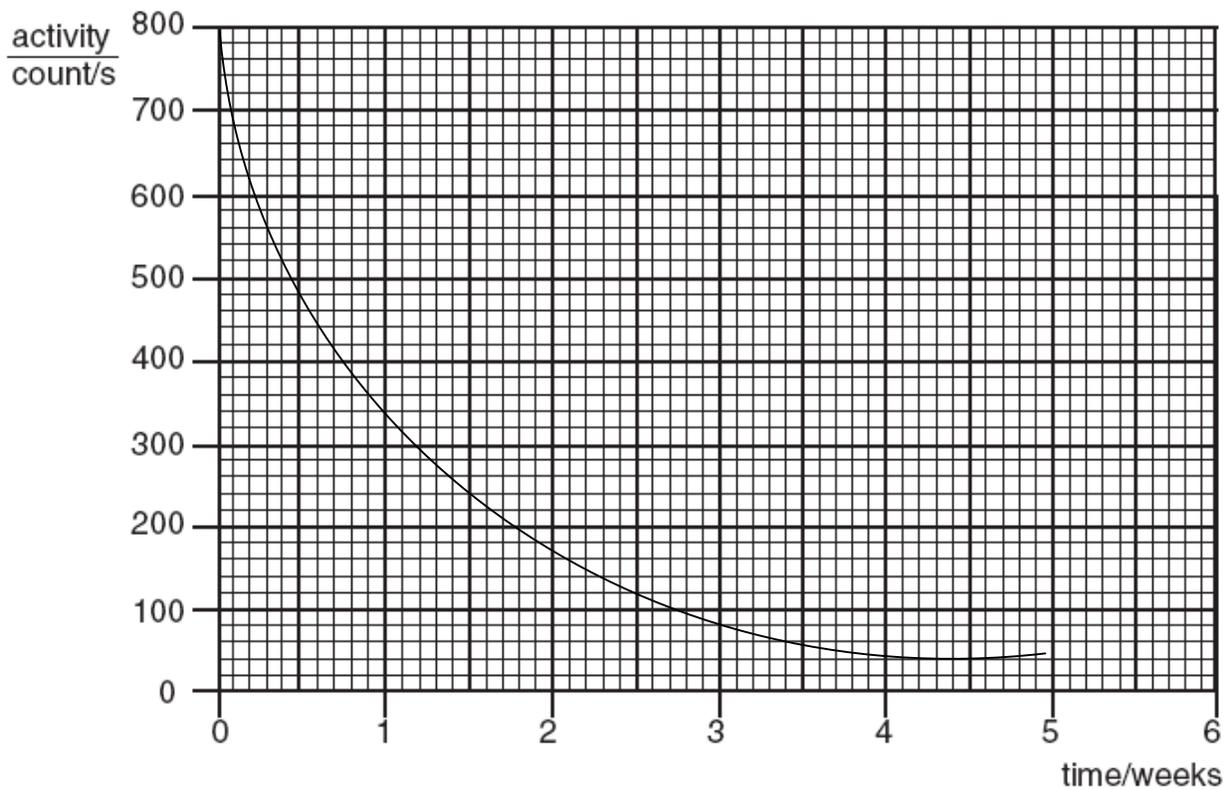
(c) Use your graph to find the half-life of the radioactive material in the sample. Show clearly on the graph how you obtained your answer.

half-life of radioactive material = ..... 0.75..... weeks

(d) Suggest two major sources of background radiation.

(i) *Cosmic rays from the sun and other star* .....

(ii) *radioactive minerals on the earth* .....



**2 (a)** When a nucleus decays by emitting an  $\alpha$ -particle, what happens to

**(i)** the number of neutrons in the nucleus,

.....*the number of the neutron is decrease by two*.....

**(ii)** the number of protons in the nucleus,

.....*the number of the protons is decrease by two*.....

**(iii)** the charge on the nucleus?

.....*the charge of the nucleus decrease by + 2*.....

**(b)** On 1st January 1900, a sample of a particular radioactive nuclide had an activity of 3200 count / min. The nuclide has a half-life of 22 years. Calculate the activity of the nuclide remaining in the sample on 1st January 1966

activity = .....*400*..... count / min

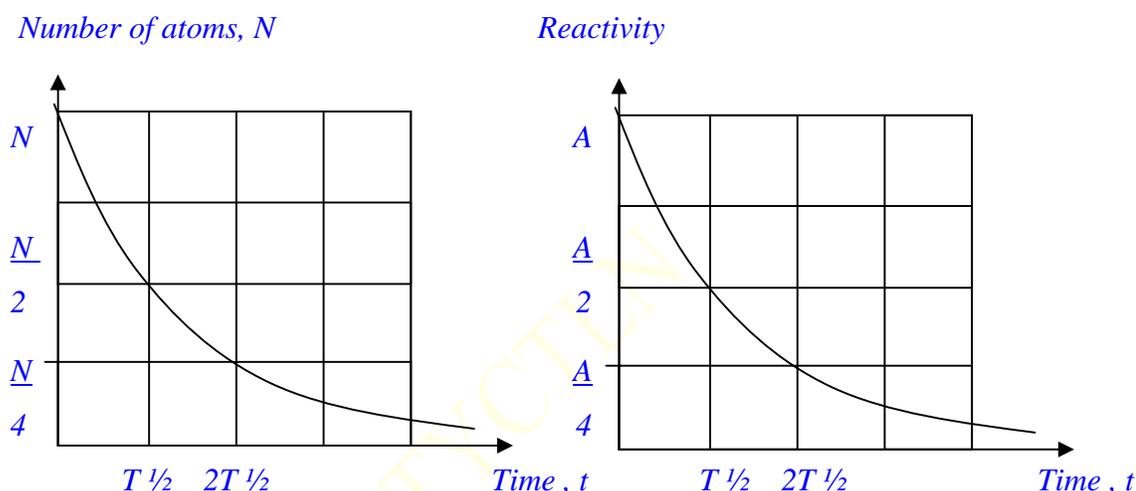
**Part C : Essay questions**

1. As a researcher , you are to study the characteristics of radioactive substance that have different half-life to be used for the treatment of cell tumours in a patient

a) What is meant by half – life ? [ 1 mark ]

*The half – life of a radioactive substance is the time taken for the substance to decay to half its original amount.*

b) With the help of a graph , explain from the aspect of the remaining atoms the activity of a radioactive substance during the decay process [ 4 marks]



*The number of atoms decrease to half its original number in the time of half- life.*

*The activity decrease to half its original value in the time of its half – life*

c) The following table shows the properties of five radioisotopes substances U, V , W, X and Y

Properties Radioactive	Half - life	Rays / Radiation	Nucleon number	Radioactivity
U	432 years	Alpha	95	20
V	1620 years	Alpha, beta gamma	226	10
W	6 hours	Gamma	99	50
X	5.27 years	Gamma	60	25
Y	15 days	Beta	32	30

Based on the above table

i) explain the suitability of the properties of the radioactive substances that can be used to kill tumour cells of a cancer patient

- *Half – life is short*

- *So that the radioactive effects do not remain for a long time in the body of the patient*

- *Rays or selected gamma radiation*

- *This is because gamma radiation has a strong penetration power. Hence it is able to kill the tumour cells in cancer patients*

- *The nucleon number does not play an important role in the choice of the radioactive substance for the treatment of cancer.*

- *The nucleon number only shows the total number of protons and neutrons in the radioactive nucleus (or it shows roughly the mass )*

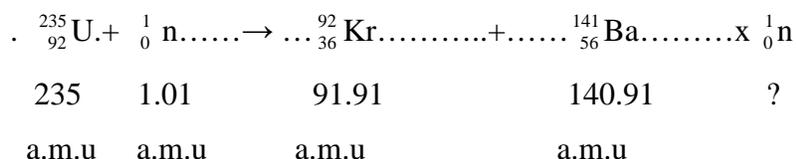
- *Average activity*

- *This produces the necessary dose for killing the cell tumour*

ii ) determine which radioactive substance is the most suitable for killing tumour cells in a cancer patient , giving reasons

*Radioactive substance W is chosen. This is because its half- life is short and it produces gamma radiation and has high activity.*

d) The following equation shows the decay of a radioactive substance



i) What is the value of x ? [ 1 mark ]

$x = 3$

ii) What is the type of reaction shows in the equation ? [ 1 mark ]

*Nuclear fission*

iii) What is the mass defect in kg for the radioactive decay ?

*Mass defect*

$$= (235.04 + 1.01) - [(140.91 + 91.91 + 3(1.01))]$$

$$= 0.20 \text{ a.m.u}$$

$$= 0.20 \times 1.66 \times 10^{-27} \text{ kg}$$

$$= 3.32 \times 10^{-28} \text{ kg}$$

iv) Determine the energy produced in MeV

[ 1 mark ]

$$[ 1.66 \times 10^{-27} \text{ kg}, c = 3.00 \times 10^8, 1 \text{ eV} = 1.6 \times 10^{-19} \text{ J} ]$$

*Energy produced,  $E = mc^2$*

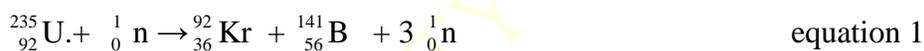
$$= 3.32 \times 10^{-28} \times (3 \times 10^8)^2$$

$$= 2.988 \times 10^{-11} \text{ J}$$

$$= \frac{2.988 \times 10^{-11}}{1.66 \times 10^{-19}}$$

$$= 186.75 \text{ MeV}$$

2.



Two equation above show two processes which generate radioactive energy. The processes occur randomly

a) i. Why are the processes said to be occurring randomly

*The processes is random because the probability of a nucleus decaying at a given instant is the same for all nuclei in the sample*

.ii) Based on the equation 1 and equation 2 state the similarities and link these properties to a named physical concept [ 4 marks ]

- *In both processes , the nuclear mass changes*
- *Both processes release a lot heat*
- *The energy released depends on the mass defect*
- *The relationship between the mass defect and the energy released is given by Einstein's equation  $E = m c^2$*

b) Radioactive waste is kept in a container and immersed in water. Explain the properties of the material which is used to make the container , then explain why the container must be immersed in water [ 5 marks ]

- *The box must be made of lead*
- *The density of lead is high and lead can block any emission of radioactive rays from escaping*
- *Because water can cool radioactive material*
- *This is due to the large quantity of heat released during the decay of radioactive waste*

c) Describe the changes made in order that nuclear energy can be safe and beneficial [9 marks]

- *Draw nuclear reactor.*
- *The energy sources are arranged in long rods surrounded by a graphite stand*
- *The control rod made of cadmium and boron absorbs additional neutrons*
- *This rod is moved in and out from the reactor , in order to control the of reaction which influences the quantity of heat released from the reactor*
- *Fast moving neutrons released by spontaneous nuclear fission reactions are slowed down after passing through the graphite.*
- *Slow moving neutrons will be absorbed by the uranium rod next to it and produces a reaction. Such arrangement ensures continuous reaction*
- *The heat generated during nuclear fission is transferred out by using carbon dioxide gas or heavy water (  $D_2 O$  )*
- *The heat in gas or water is used for boiling water to convert it to steam in the heat exchange unit.*
- *The steam is then used to turn the electric generating turbines.*