

# Radioactivity



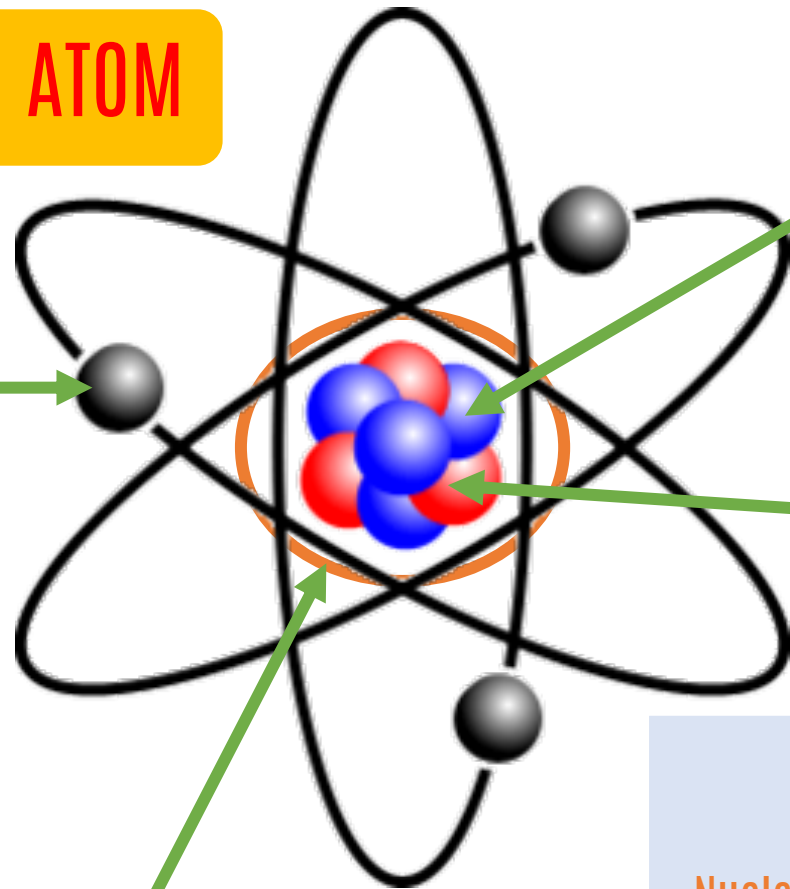
WITHOUT FEAR

THERE CANNOT  
BE COURAGE

be amazing with Teacher  
*alinainmanarif*

DREAM BIG AIM HIGH NEVER GIVE UP

# THE NUCLEUS OF AN ATOM



**proton**

- Positively charge particles

**electron**

- Negatively charge particles
- Very small
- Move around in electron shells

**neutron**

- Neutral particles

**nucleus**

- Contains most of the mass of an atom

Nucleon number  
(mass number)

A X

Proton number

Z



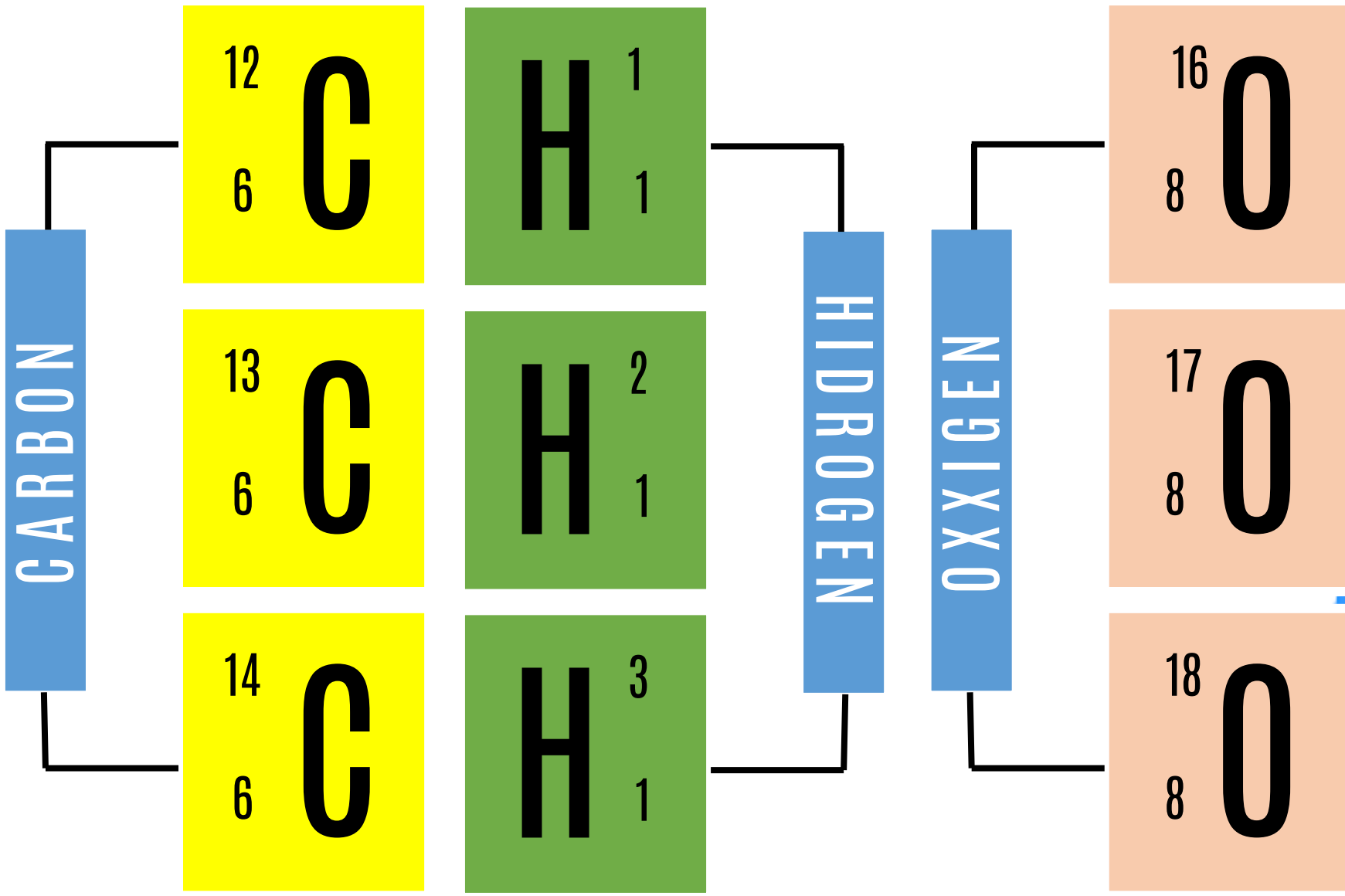
12

C

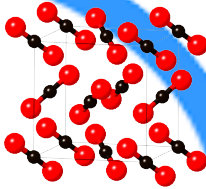
6


Neutron number  
= A - Z  
= 16 - 6  
= 6





**ISOtopes** are atoms of the same element with the  
 = proton number  
 ≠ neutron number

≠ physical properties 

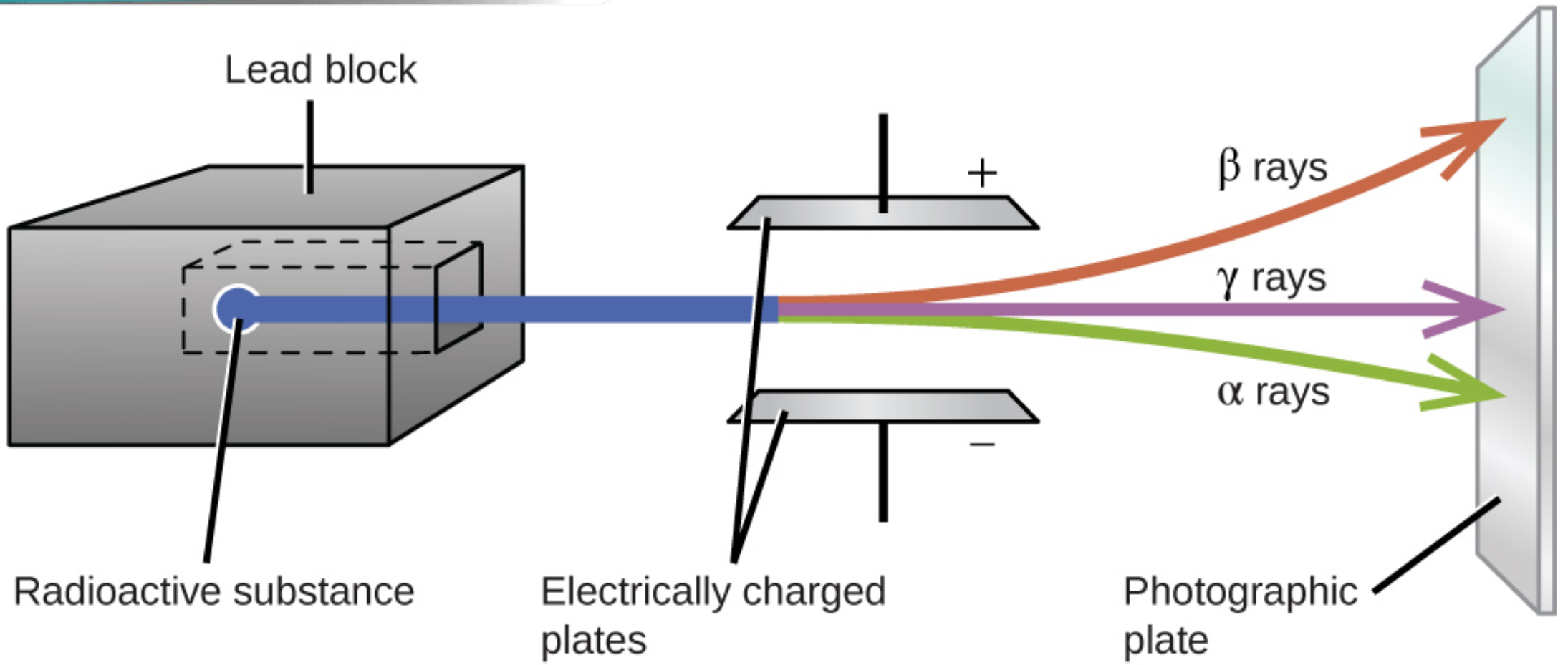
= chemical properties 

# 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	<b>Positive</b> charged, helium nucleus (He)	<b>Electron</b>	<b>Neutral</b> electromagnet ray
Charge	+2 electric charges	-1 electric charge	0
Speed	(1/20) x the speed of light, cc	3% - 99% of the speed of light, c	Speed of light
In an electric field	Bends to <b>negative</b> plate	Bends to <b>positive</b> plate	<b>Does not</b> bend (neutral)
In magnetic field	Bends a little showing that it has a <b>big mass</b> .	Bend a lot showing that it has a <b>small mass</b> .	<b>Does not</b> bend (neutral)
<b>Ionising</b> power	<b>Strongest</b>	<b>Intermediate</b>	<b>Weakest</b>
<b>Penetrating</b> power	<b>Low</b>	<b>Intermediate</b>	<b>High</b>
Stopped by	A thin sheet of paper	A few millimeters of aluminium	A few centimeters of lead or concrete
Range in air	A few centimeters	A few meters	A few hundred meters

# CHARACTERISTICS OF THE Three TYPES OF Radioactive emissions

In an **electric** field



# CHARACTERISTICS OF THE **Three** TYPES OF **Radioactive emissions**

In **magnetic** field

Bend a lot (**small mass**)

$\beta^+$  particles  
(positrons)

$\alpha$  particles

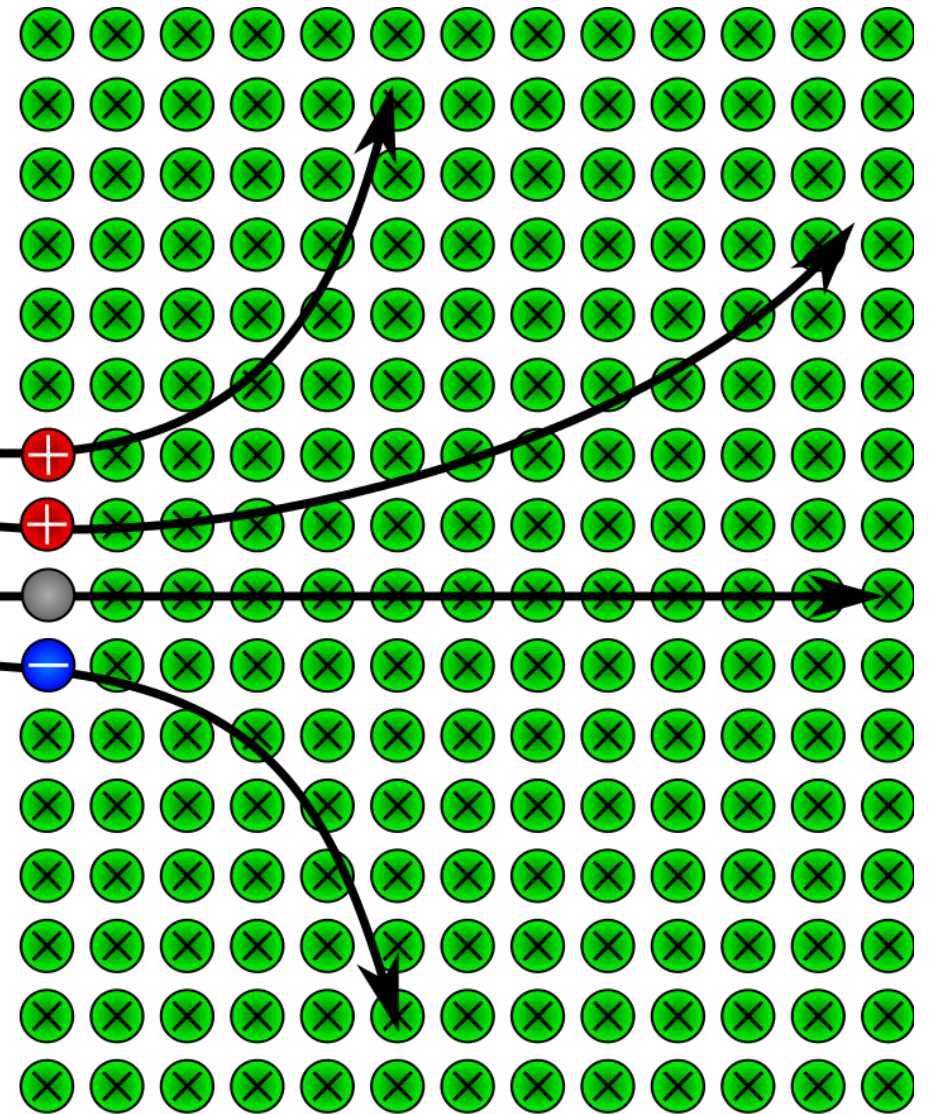
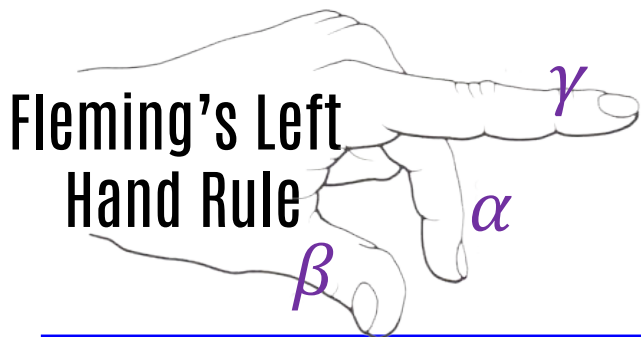
Bends a little (**big mass**)

**Does not** bend (**neu+ral**)

neutrons  
 $\gamma$  rays

$\beta^-$  particles  
(electrons)

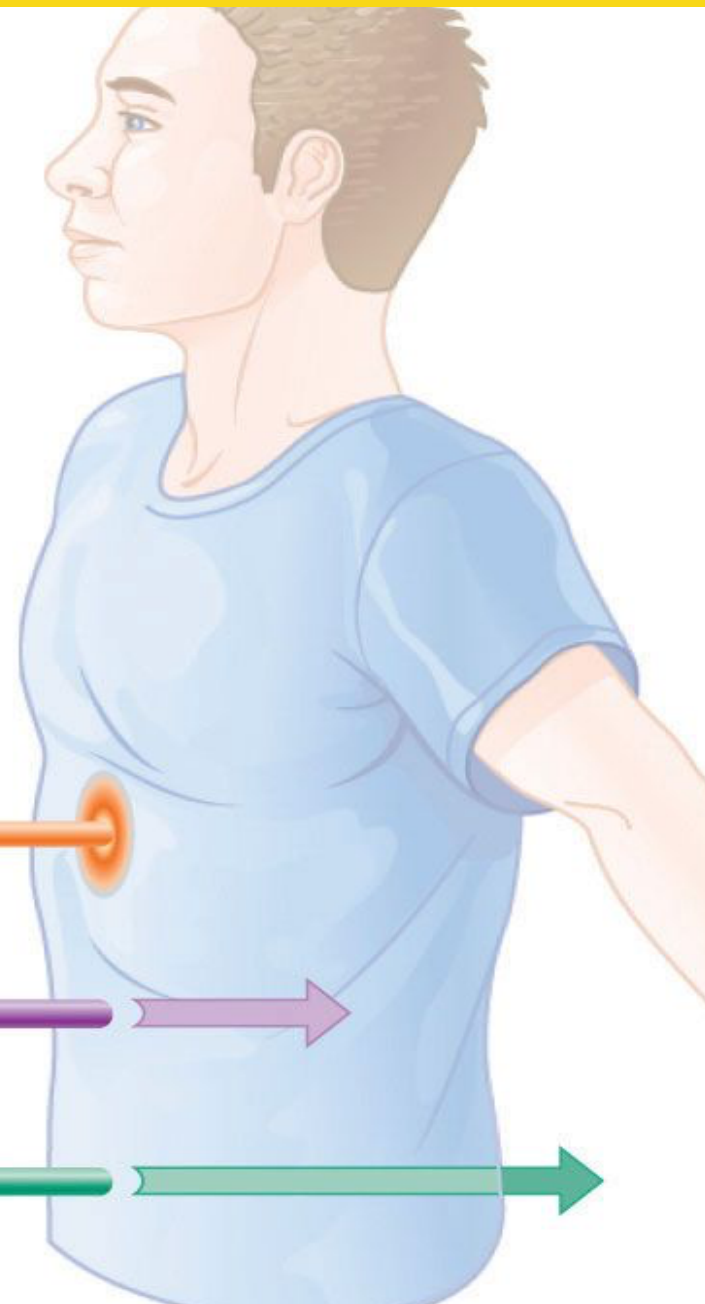
Bend a lot (**small mass**)



To determine the charged particles in a magnetic field

**penetrating** power

## Radiation Effects On Humans



**Low**

$\alpha$  particle

**Intermediate**

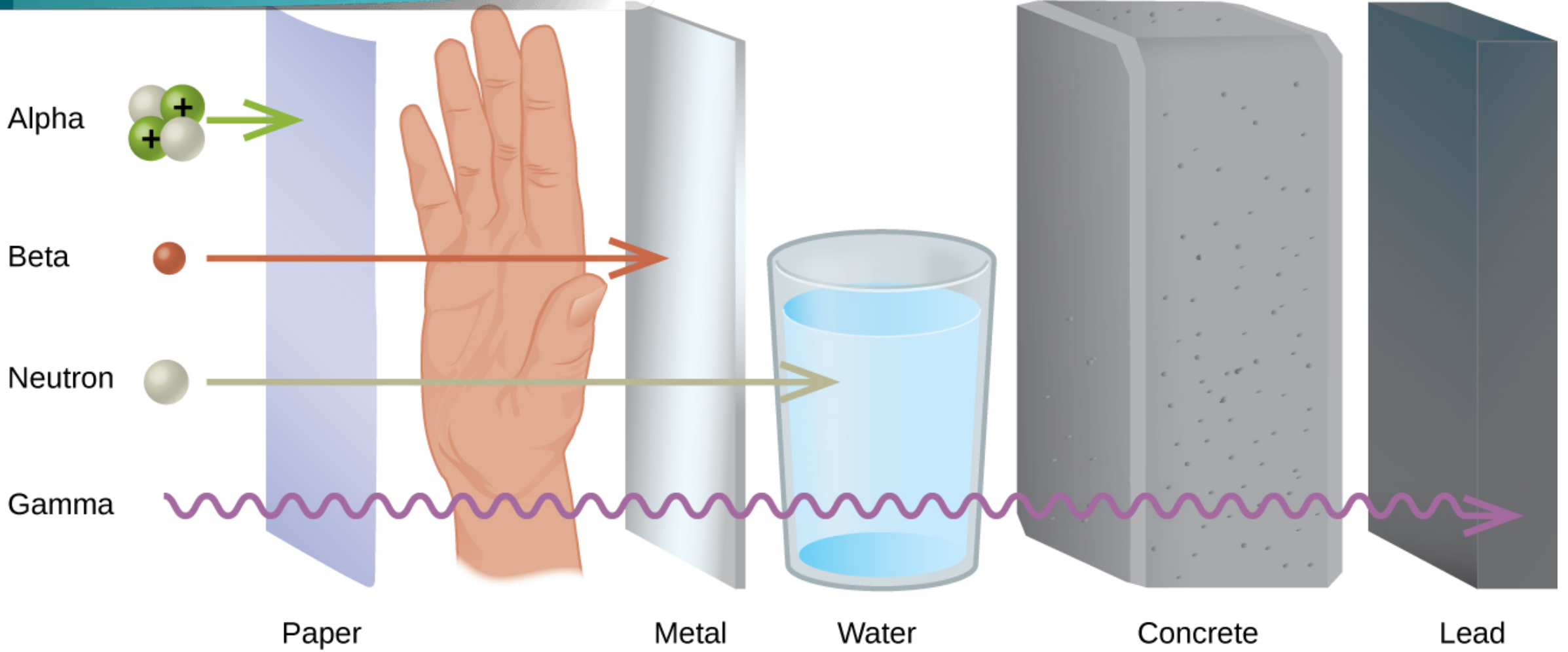
$\beta$  particle

**High**

$\gamma$  ray

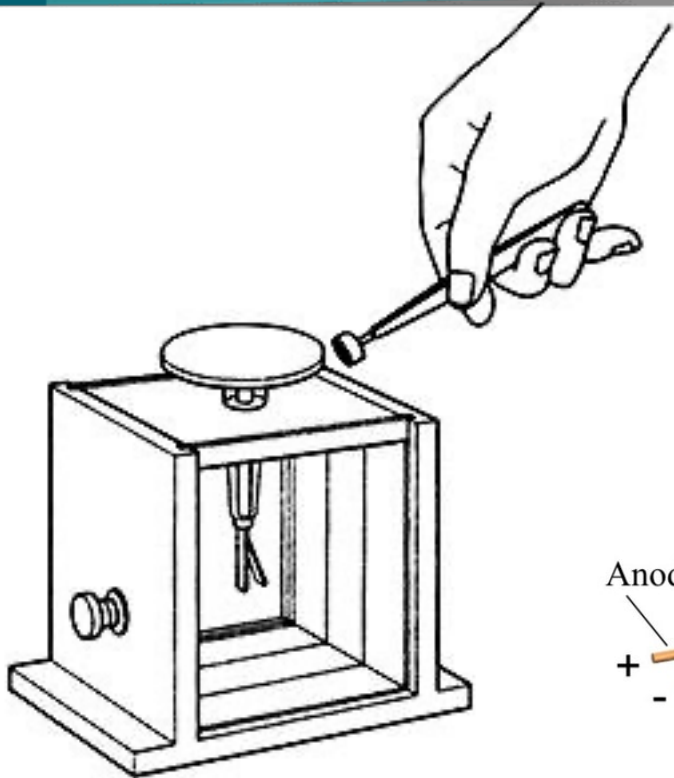
# CHARACTERISTICS OF THE Three TYPES OF Radioactive emissions

penetrating power

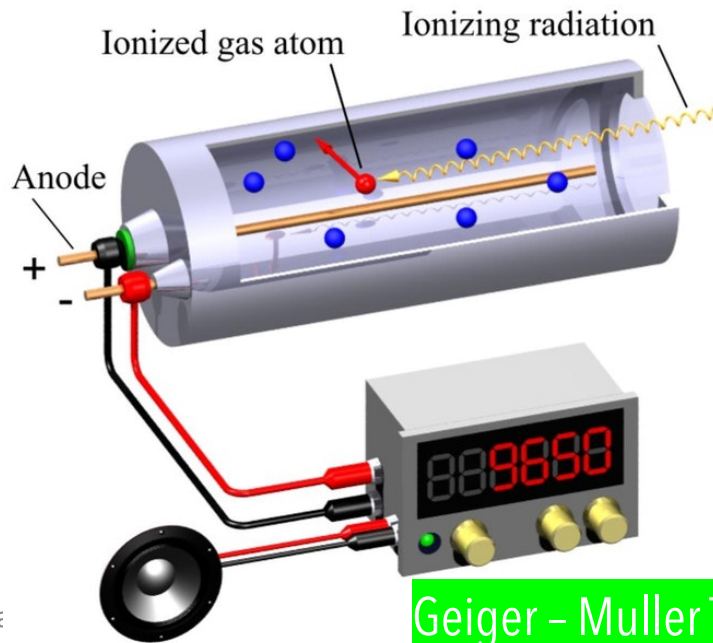


# CHARACTERISTICS OF THE Three TYPES OF Radioactive emissions

## radioactive detectors



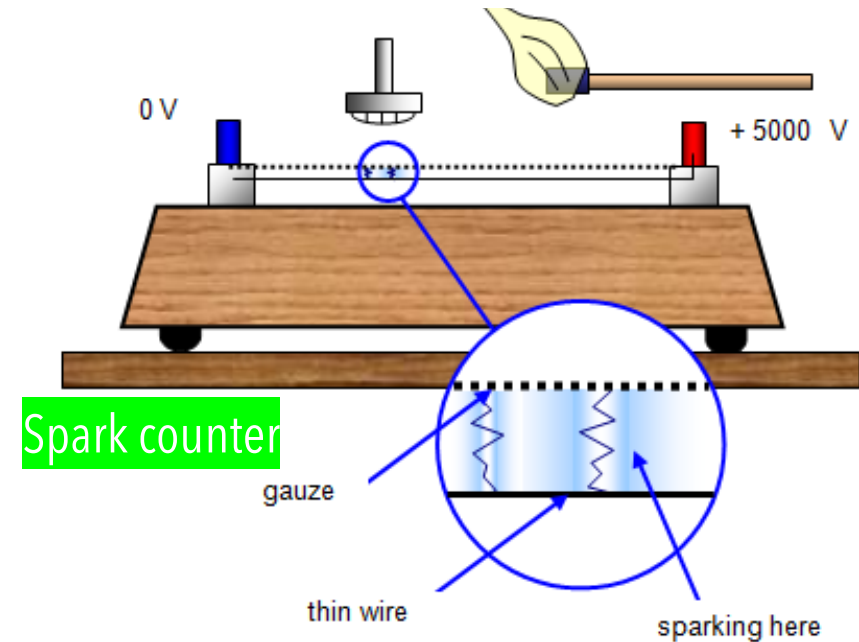
Gold Leaf Electroscopes



Geiger - Muller Tube

### RADIOACTIVE EMISSION

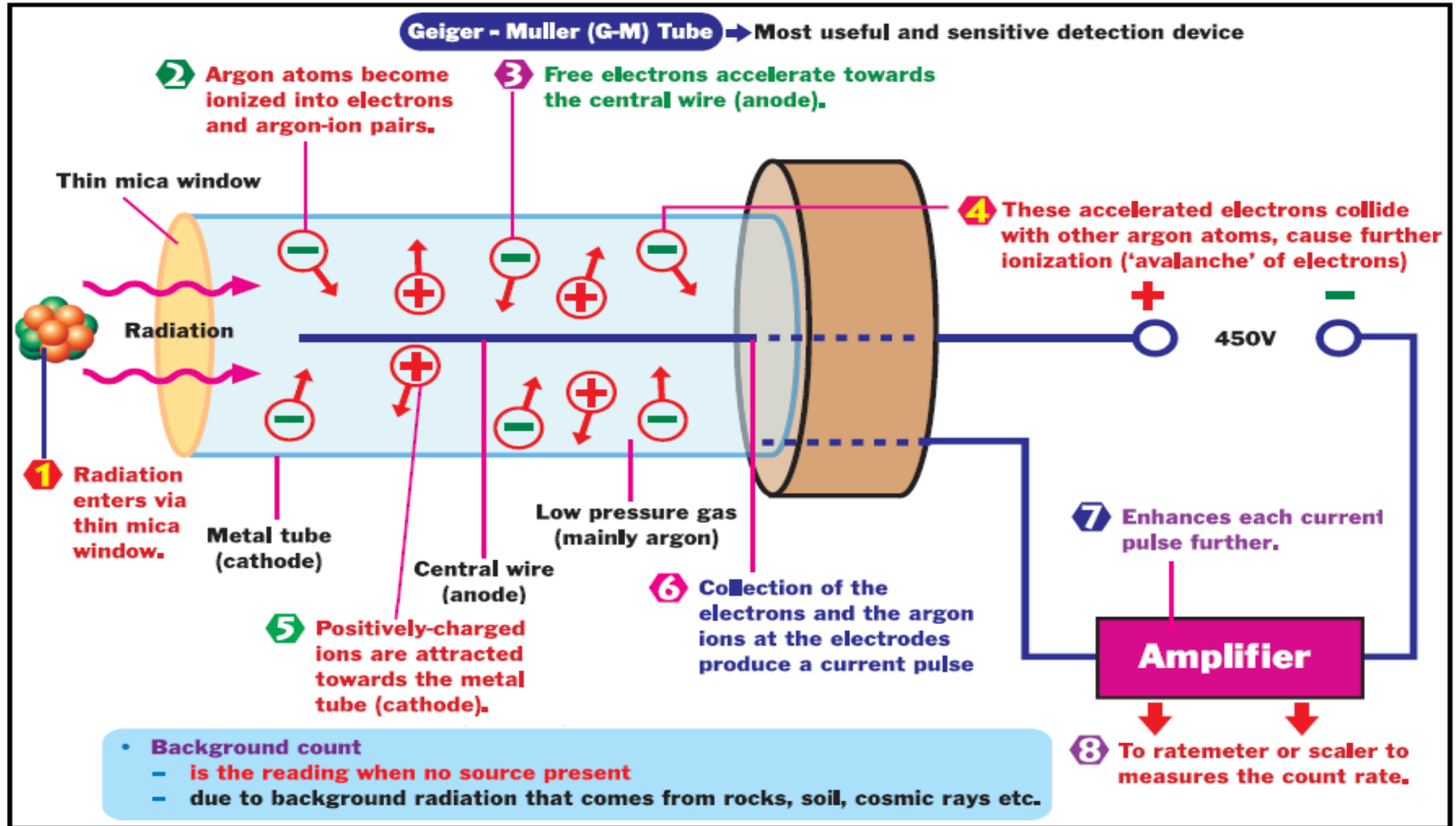
DETECTOR	RADIOACTIVE EMISSION		
	Alpha particles	Beta particles	Gamma rays
Photographic Films		✓	✓
Gold Leaf Electroscopes	✓	✓	
Cloud Chambers	✓	✓	✓
Spark counter	✓		
Geiger - Muller Tube (G.M Tube)	✓	✓	✓



Spark counter

# CHARACTERISTICS OF THE **Three** TYPES OF **Radioactive emissions**

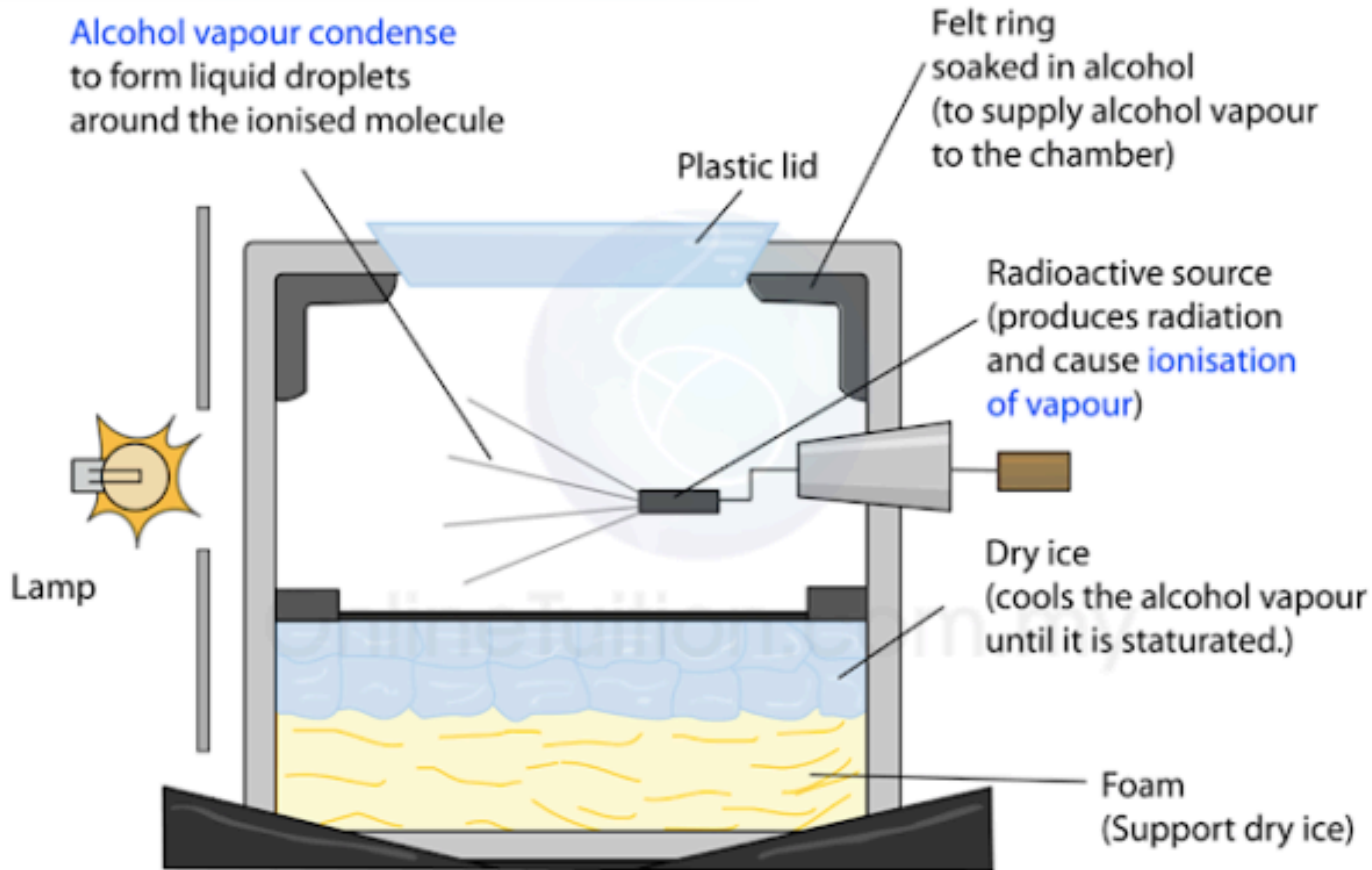
## Geiger - Muller Tube



# CHARACTERISTICS OF THE **Three** TYPES OF **Radioactive emissions**

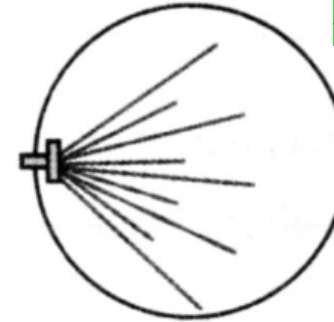
## radioactive **detectors**

Alcohol vapour condense to form liquid droplets around the ionised molecule



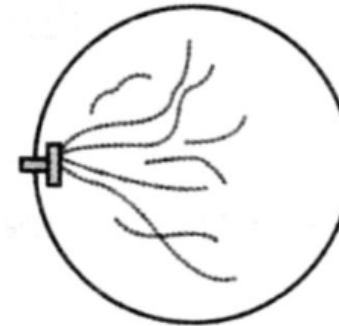
<http://spmphysics.onlinetuition.com.my/>

### ALPHA PARTICLES



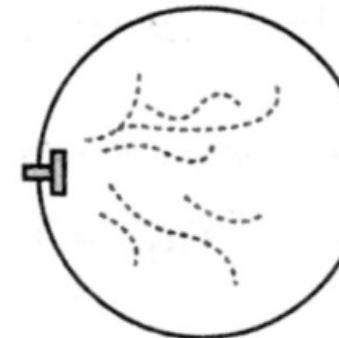
- **Dense** - strong ionization power
- **Straight** tracks - the alpha particle has a **large mass** and momentum so it is **not** easily **deflected**

### BETA PARTICLES



- **Thin, straight** tracks - very **fast** beta particles.
- short, thick tracks which curve in **random direction** - slower beta particles.

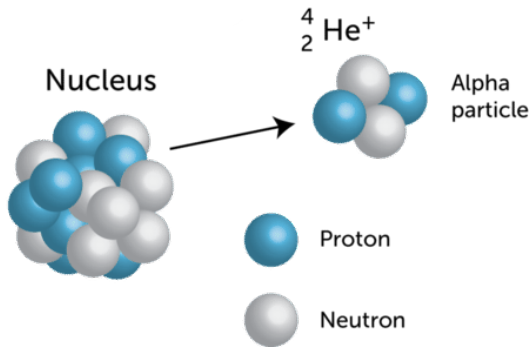
### GAMMA RAYS



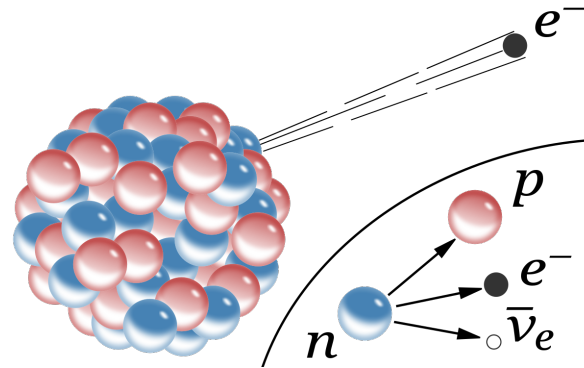
- Tracks **not clear** or continuous - **low ionizing** power

# RADIOACTIVE DECAY

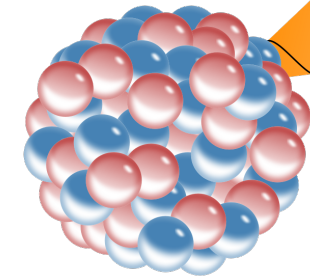
Radioactivity is the spontaneous and random emission of radioactive rays from unstable radioactive materials after which they become more stable.



$\alpha$ -decay



$\beta$ -decay

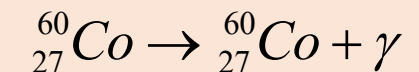
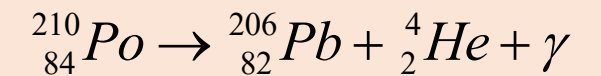
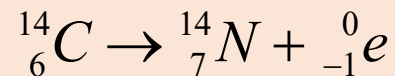
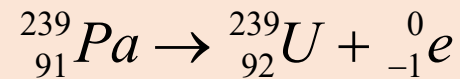
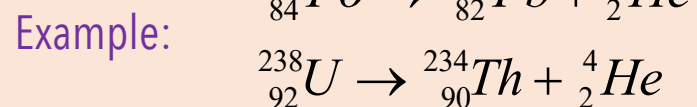


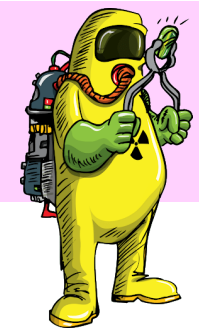
$\gamma$ -decay

Equation: 
$${}^A_Z X \rightarrow {}^{A-4}_{Z-2} Y + {}^4_2 He$$

Equation: 
$${}^A_Z X \rightarrow {}^A_{Z+1} Y + {}^0_{-1} e$$

Equation: 
$${}^A_Z X \rightarrow {}^A_Z X + \gamma$$





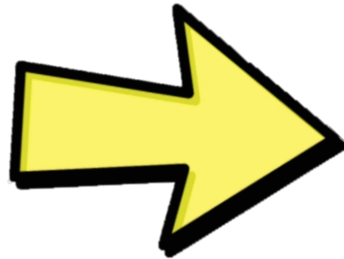
# RADIOACTIVE DECAY

EXAMPLE

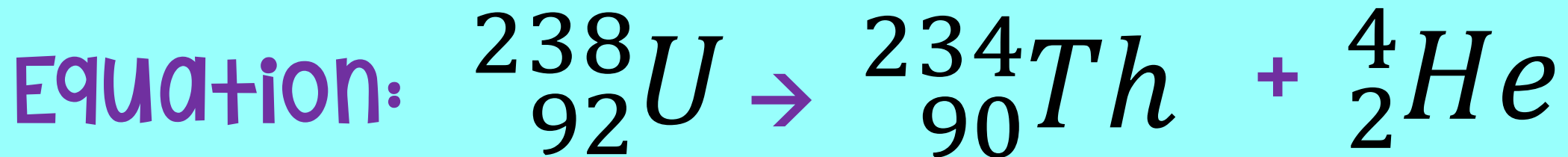
1

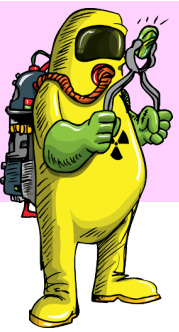
Uranium-238 emits an **alpha particle** and decays into a thorium atom. State the nucleon number and proton number of the thorium, the isotope formed. Write an equation for this decay.

Uranium-238



Nucleon number (mass number)  $238$   
Proton number  $92$   
 $U$





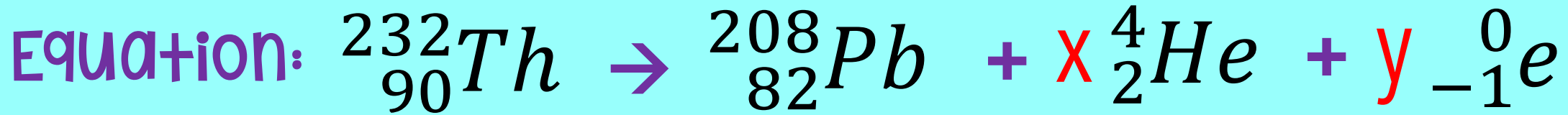
# RADIOACTIVE DECAY

EXAMPLE

2

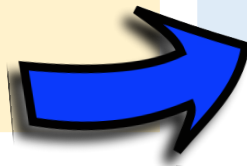
Thorium-232 decays to Plumbum-208, by emitting **alpha** particles and **beta+** particles. Determine the number of alpha particles and beta particles being emitted?

Thorium-232  Plumbum-208



$$\begin{aligned} 232 &= 208 + 4x + 0 \\ 4x &= 24 \\ x &= 6 \end{aligned}$$

$$\begin{aligned} 90 &= 82 + 2x - y \\ 8 &= 12 - y \\ y &= 12 - 8 \\ y &= 4 \end{aligned}$$



# RADIOACTIVE DECAY

Diagram 1 shows the decay series of Radon-222.

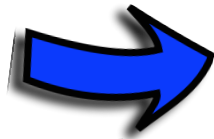
Write an equation to show the decay of Rn-222 to Po-218.



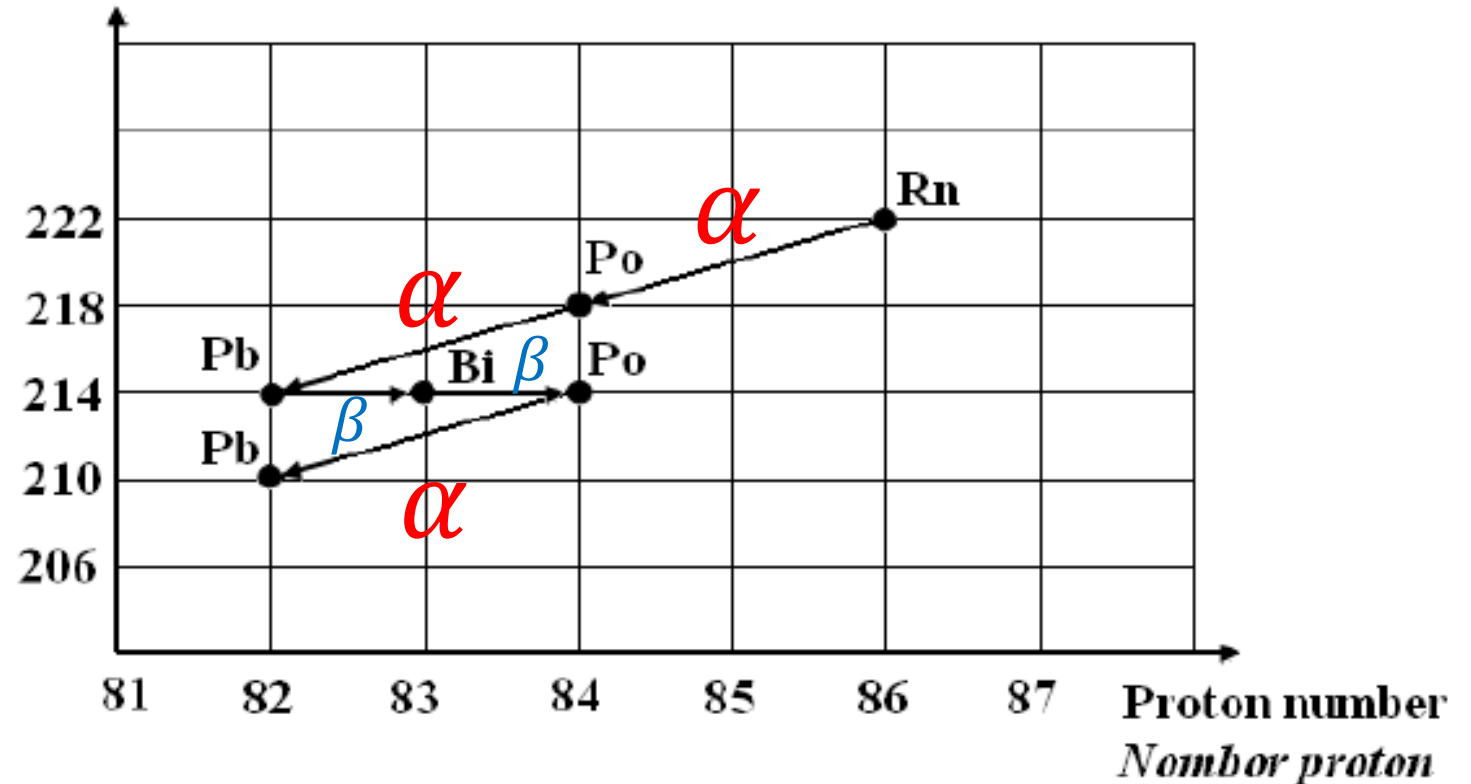
Determine the number of alpha particles and beta particles produced in the decay.

$$\alpha = 3$$

$$\beta = 2$$



Nucleon number  
*Nombor nukleon*

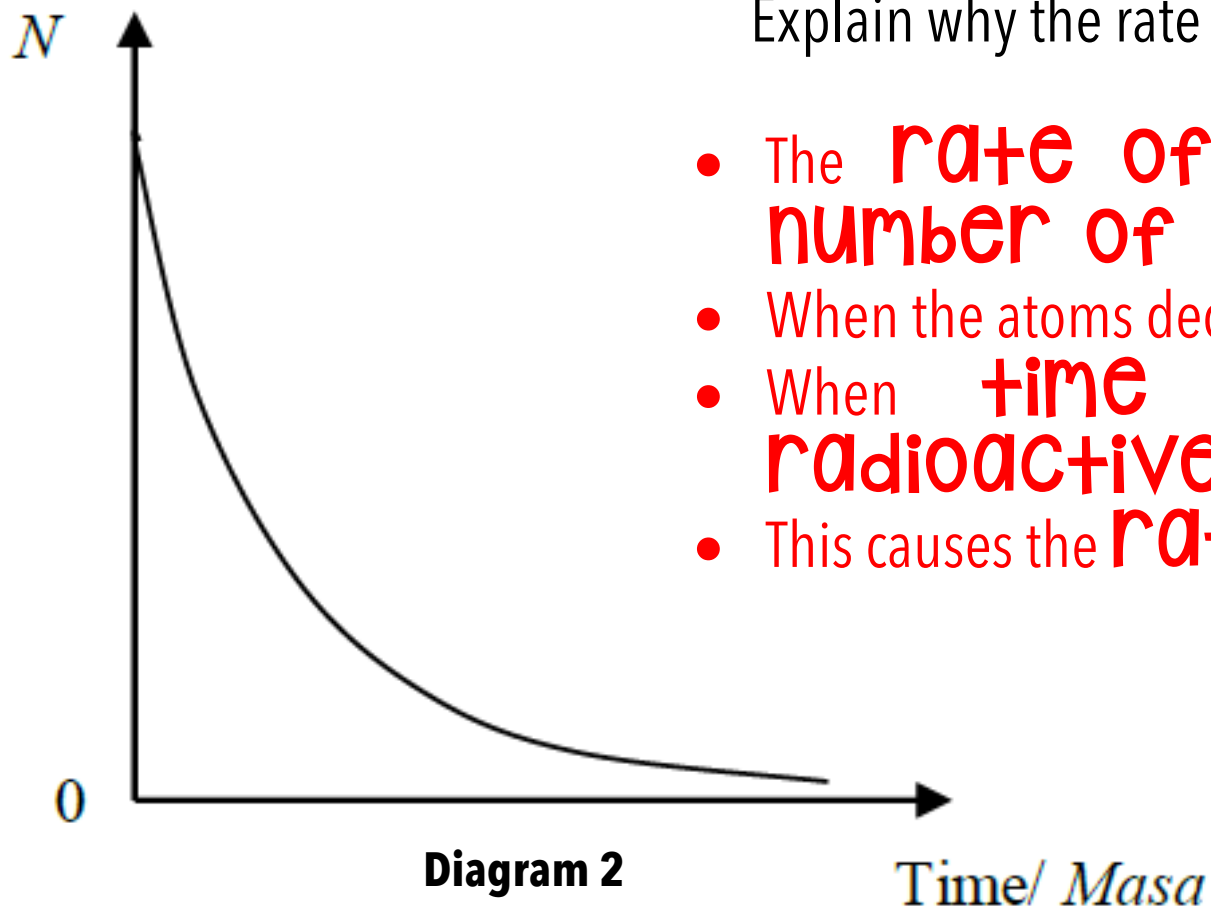




# RADIOACTIVE DECAY

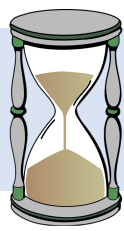
Diagram 2 is a graph that shows how the number of radioactive atoms,  $N$ , of radioactive isotope in a specimen changes with time,  $t$ .

Explain why the rate of decay decreases with time.



- The **rate of decay** is directly proportional to the **number of radioactive atoms**
- When the atoms decay they **become stable** atoms
- When **time increases** the **number of radioactive atoms decreases**
- This causes the **rate of decay to decrease**

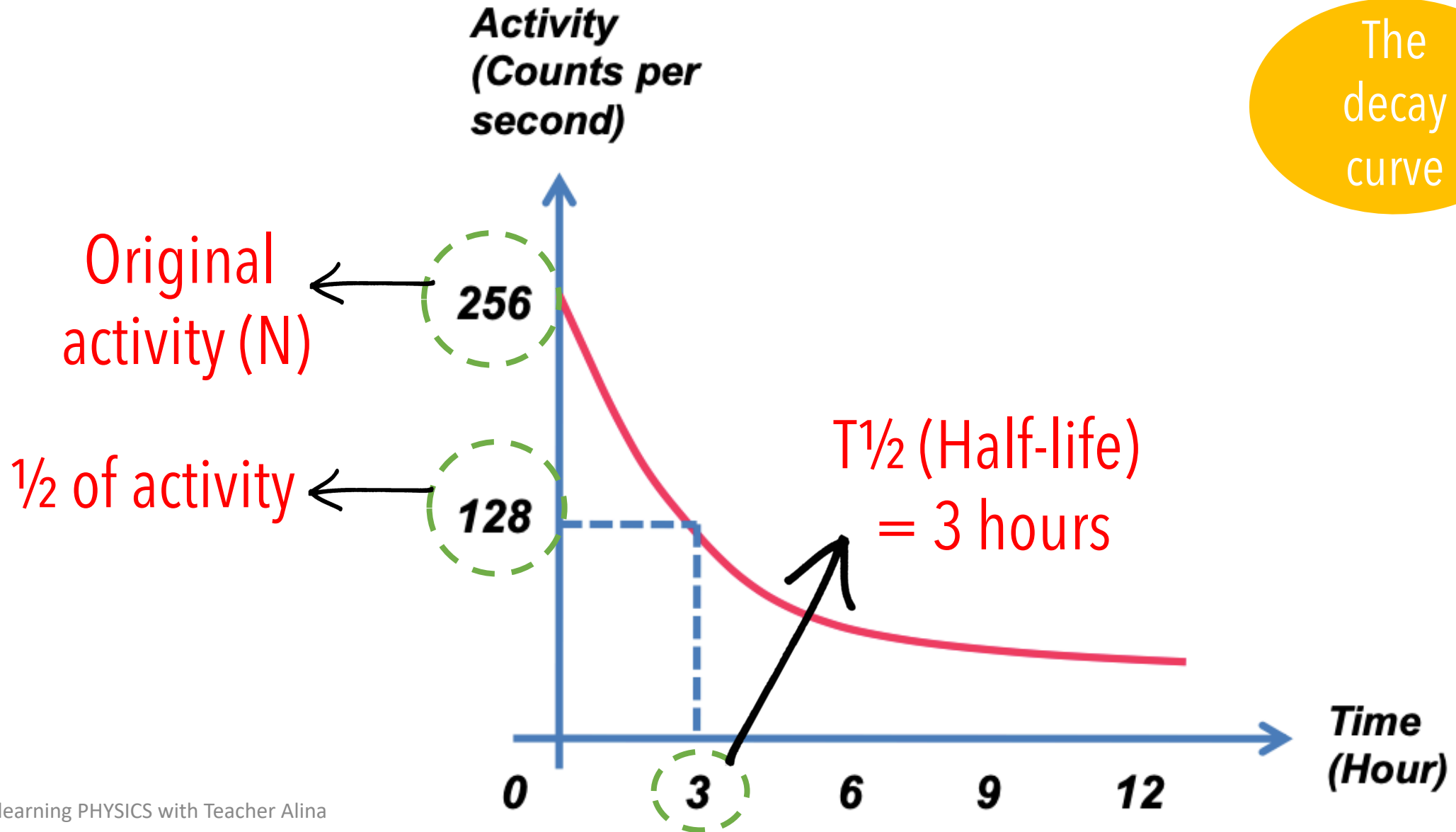
# HALF LIFE



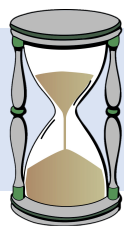
The **time** taken for the number of the **undecayed** nuclei in the sample to be **reduced** to **half** of its **original number**



The decay curve



# HALF LIFE



The **time** taken for the number of the **undecayed** nuclei in the sample to be **reduced** to **half** of its **original number**

$$N = \left(\frac{1}{2}\right)^n N_o$$

$N$  = Amount of radioisotope particles after  $n$ -th half-life

$N_o$  = Initial amount of radioisotope particles

$n$  = number of half-life

$$\left(\frac{1}{2}\right)^n N = \left(\frac{1}{8}\right) N$$

$$\left(\frac{1}{2}\right)^n = \left(\frac{1}{2^3}\right)$$

$$\left(\frac{1}{2}\right)^n = \left(\frac{1}{2}\right)^3$$

$$n = 3$$

$$\therefore 3 \times T_{\frac{1}{2}} = 30 \text{ days}$$

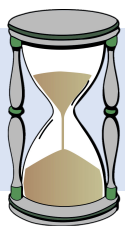
$$T_{\frac{1}{2}} = 10 \text{ days}$$

## EXAMPLE

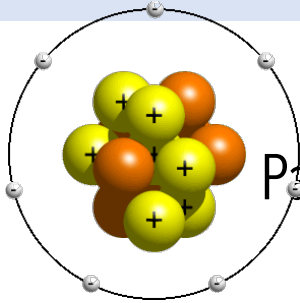
1

In 30 days, the activity of a sample of radioisotope decrease to one-eighth of its original activity. Calculate its half-life.

# HALF LIFE



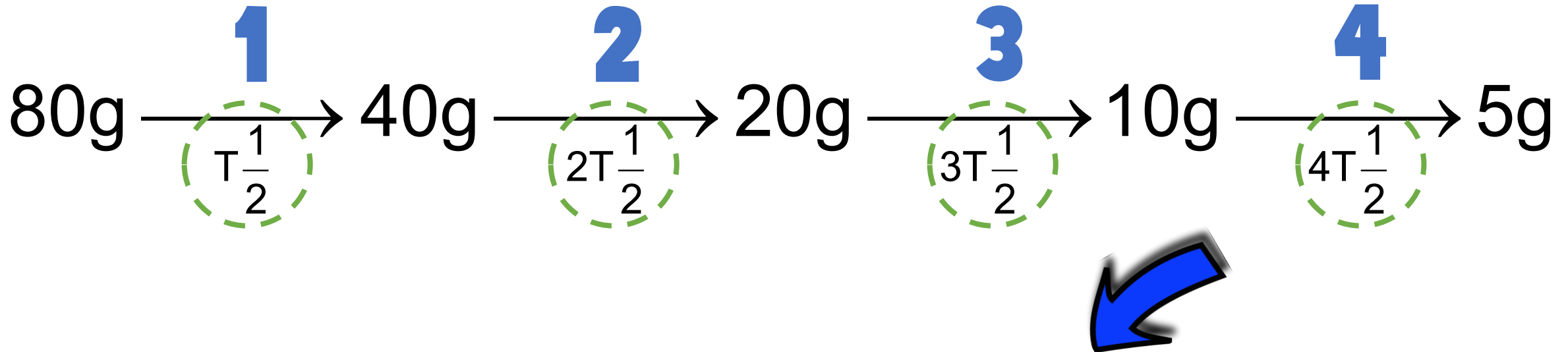
The **time** taken for the number of the **undecayed** nuclei in the sample to be **reduced** to **half** of its **original number**



Pa takes 20.8 hours to shrinks from 80 g to 5 g. How many half -lives are there?

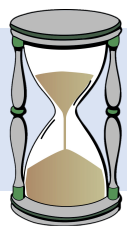
EXAMPLE

2



This decay process has taken the time of 4 half - lives

# HALF LIFE



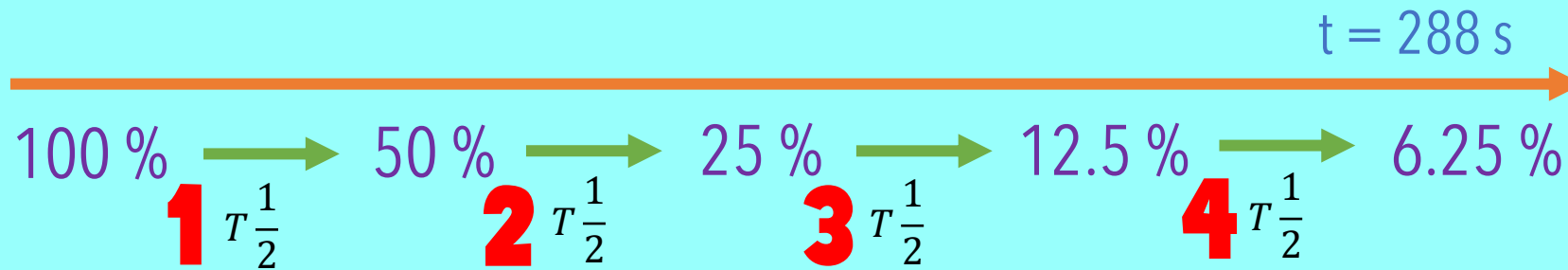
The **time** taken for the number of the **undecayed** nuclei in the sample to be **reduced** to **half** of its **original number**

**EXAMPLE**

**3**

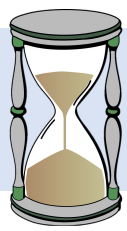
The radioactive atoms in a substance decay to become stable atoms. It was found that after 288 s, 6.25% of the atoms have not decayed. What is the half-life of the substance?

Original activity (N) = 100% **REDUCED** → 6.25 %



$$4 T_{\frac{1}{2}} = 288$$
$$T_{\frac{1}{2}} = 72 \text{ s}$$

# HALF LIFE



The **time** taken for the number of the **undecayed** nuclei in the sample to be **reduced** to **half** of its **original number**

## EXAMPLE

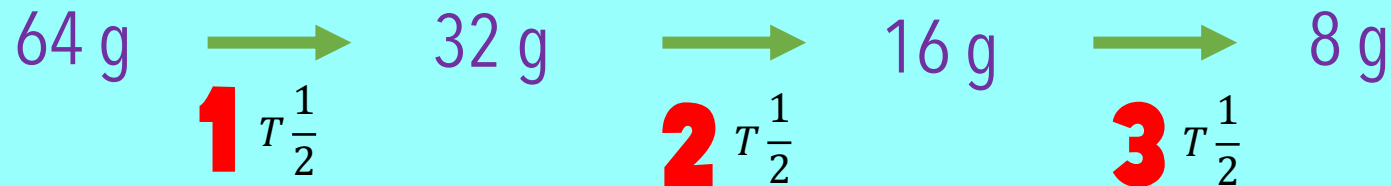
4

The half-life of iodine-131 is 8 days. A radioactive sample contains 64 g of iodine-131. Determine the mass of iodine that **has decayed** and has **not** decayed after 24 days.

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

After 24 days  $\rightarrow 3 T_{\frac{1}{2}}$

$(\frac{24}{8} = 3)$



mass of iodine has **not** decayed = 8 g

mass of iodine that has **decayed** =  $(64 - 8) = 56$  g

# HALF LIFE



The **time** taken for the number of the **undecayed** nuclei in the sample to be **reduced** to **half** of its **original number**

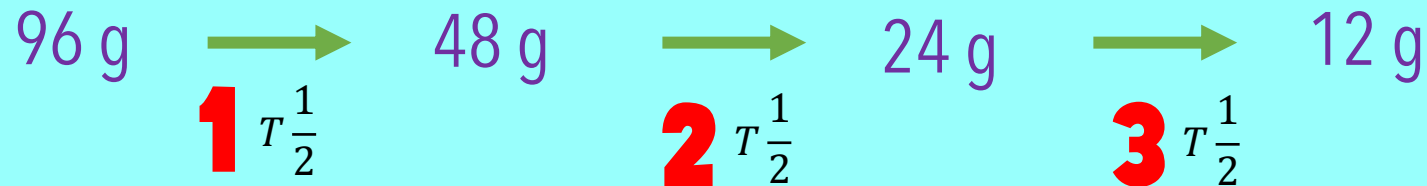
EXAMPLE

5

A sample of lead-211 of mass 96 g has a half-life of 36.1 minutes.

- (a) What fraction of the sample has not decayed after 108.3 minutes?  
(b) What is the mass of the decayed products after this period of time?

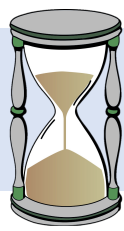
$$T_{\frac{1}{2}} = 36.1 \text{ minutes} \quad \text{After 108.3 minutes} \rightarrow 3 T_{\frac{1}{2}} \rightarrow \left( \frac{108.3}{36.1} = 3 \right)$$



mass of iodine has **not** decayed = 12 g =  $\frac{1}{8}$

mass of iodine that has **decayed** =  $(96 - 12) = 84$  g

# HALF LIFE

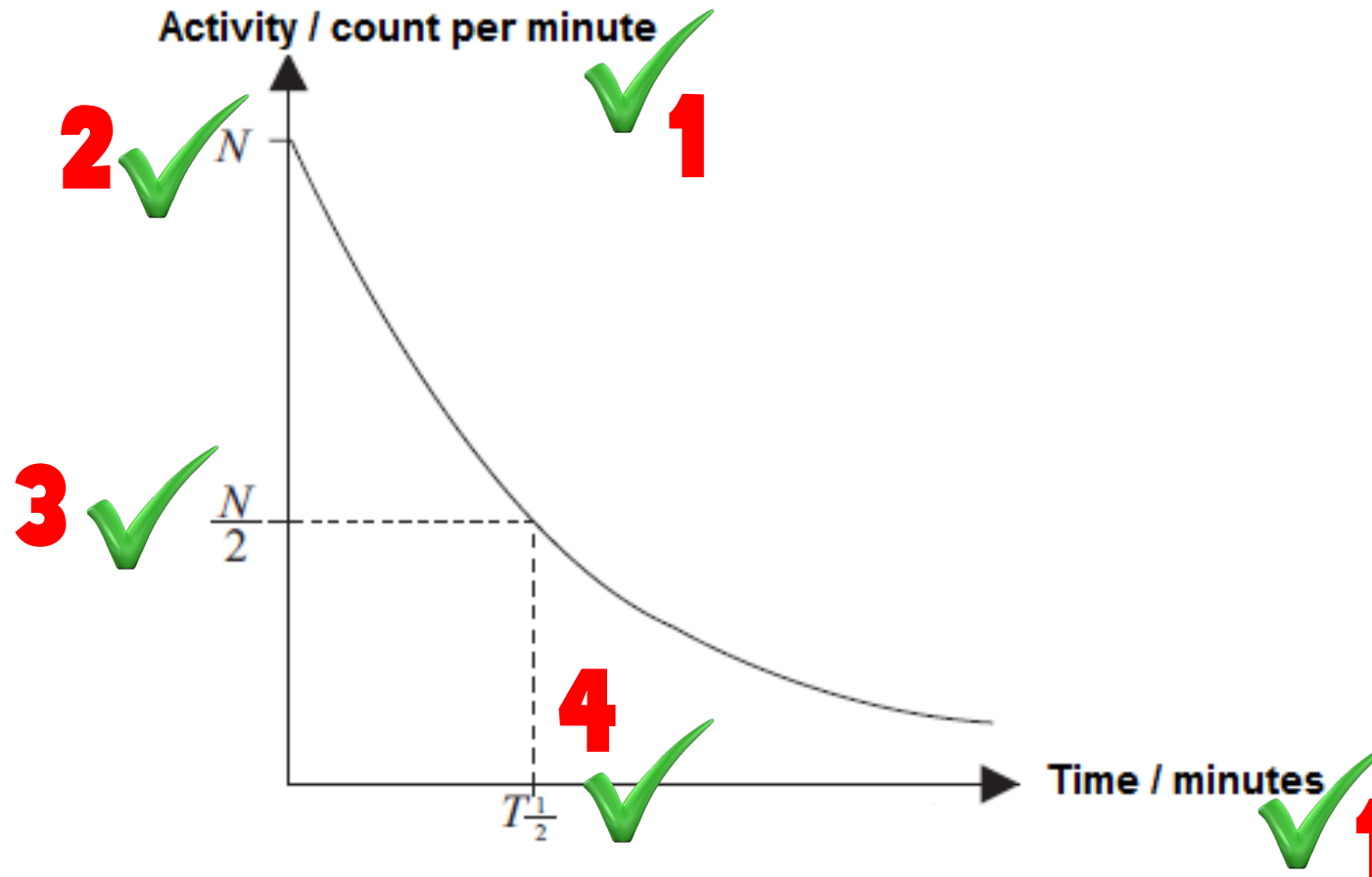


The **time** taken for the number of the **undecayed** nuclei in the sample to be **reduced** to **half** of its **original number**

EXAMPLE

6

Sketch activity against time graph to show the decay of a radioactive substance. Explain how the half-life is determined.



# THE USES OF RADIOISOTOPE

Unstable isotope which decay and give out radioactive emissions



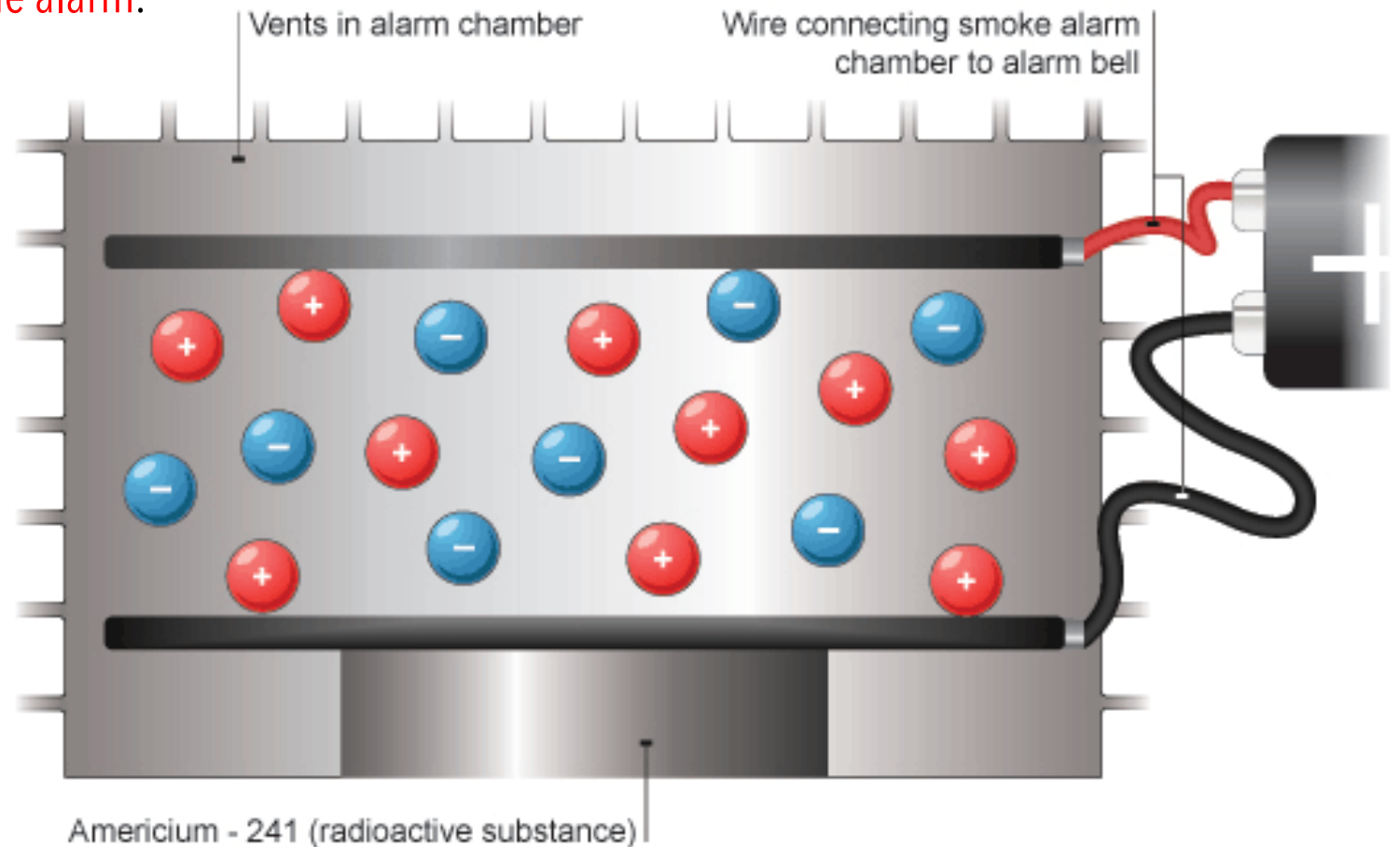
Use In	Radioisotope Source	Uses
Medicine	<ol style="list-style-type: none"> <li>1. Sodium iodide</li> <li>2. Sodium-24</li> <li>3. Phosphorus</li> <li>4. Cobalt-60</li> </ol>	<ul style="list-style-type: none"> <li>• to treat an overactive thyroid gland and thyroid cancer</li> <li>• to detect the position of blood clot</li> <li>• to detect and treat brain tumour</li> <li>• to destroy cancer cell</li> <li>• to sterilize medical equipment</li> </ul>
Industries	<ol style="list-style-type: none"> <li>1. Sodium-24</li> <li>2. Polonium-210</li> </ol>	<ul style="list-style-type: none"> <li>• to detect leakage of underground pipes</li> <li>• neutralize static charge in photographic plates and other material</li> </ul>
Agriculture	Nitrogen-15 & Phosphorus-32	<ul style="list-style-type: none"> <li>• as tracer in the study of the effectiveness of fertilizers</li> </ul>
Archaeology	Carbon-14	<ul style="list-style-type: none"> <li>• to determine the age of artefacts (carbon dating)</li> </ul>

# THE USES OF RADIOISOTOPE

Unstable isotope which decay and give out radioactive emissions

## SMOKE DETECTOR

1. Alpha particles emitted from the source and ionized air molecules.
2. The ionized air molecules conduct electricity and a small current flows in the smoke detector.
3. When smoke enters the detector, the soot particles in the smoke absorb some of the alpha particles.
4. This causes a decrease in the current that flows in the smoke detector and trigger the alarm.

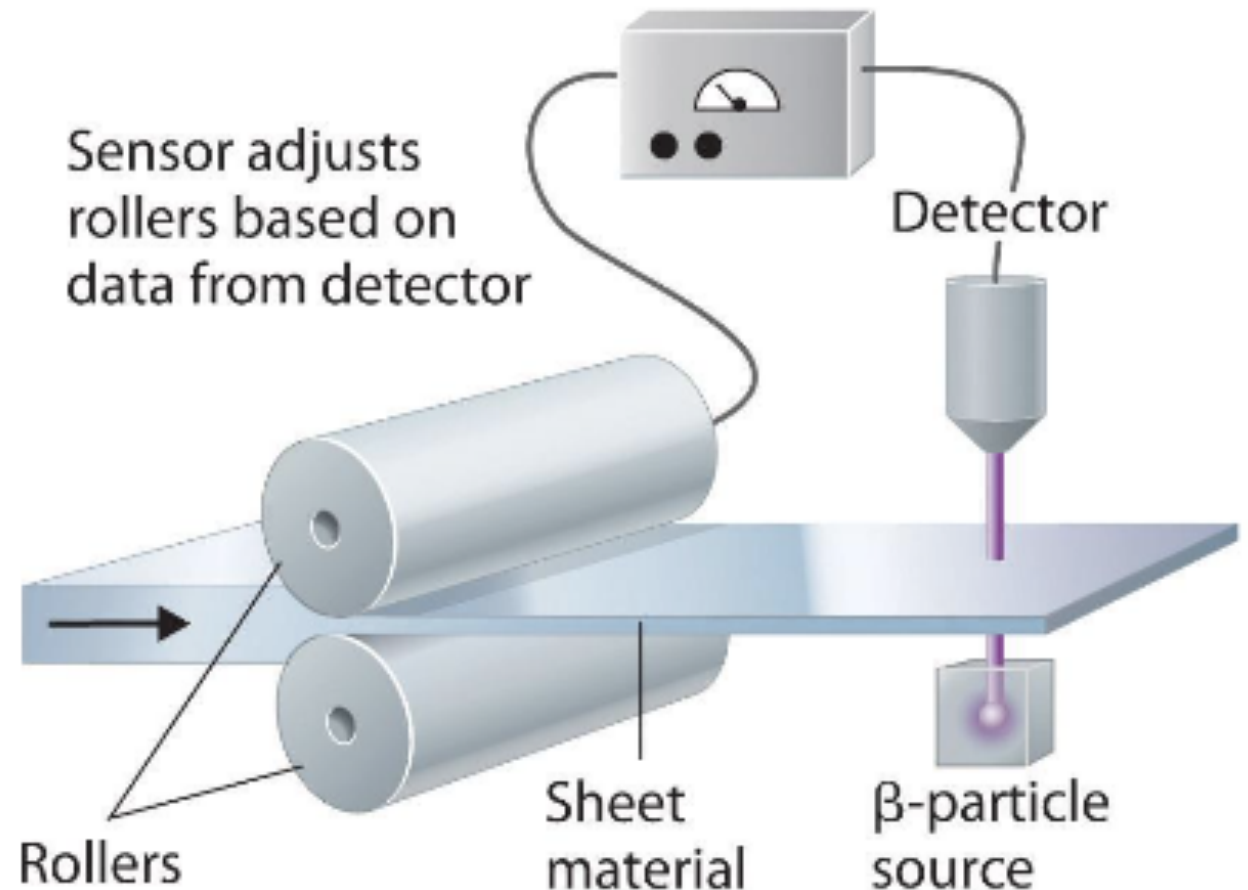


# THE USES OF RADIOISOTOPE

Unstable isotope which decay and give out radioactive emissions

## THICKNESS CONTROL

1. Put the radioactive source **opposite** the detector
2. Detector is connected to the thickness indicator
3. Detector detect the reading of the changes in counts
4. Thickness is measured with the thickness indicator
5. If the **reading** of the detector is **less** than the specified value, the thickness of the paper is too **tick** / vice versa

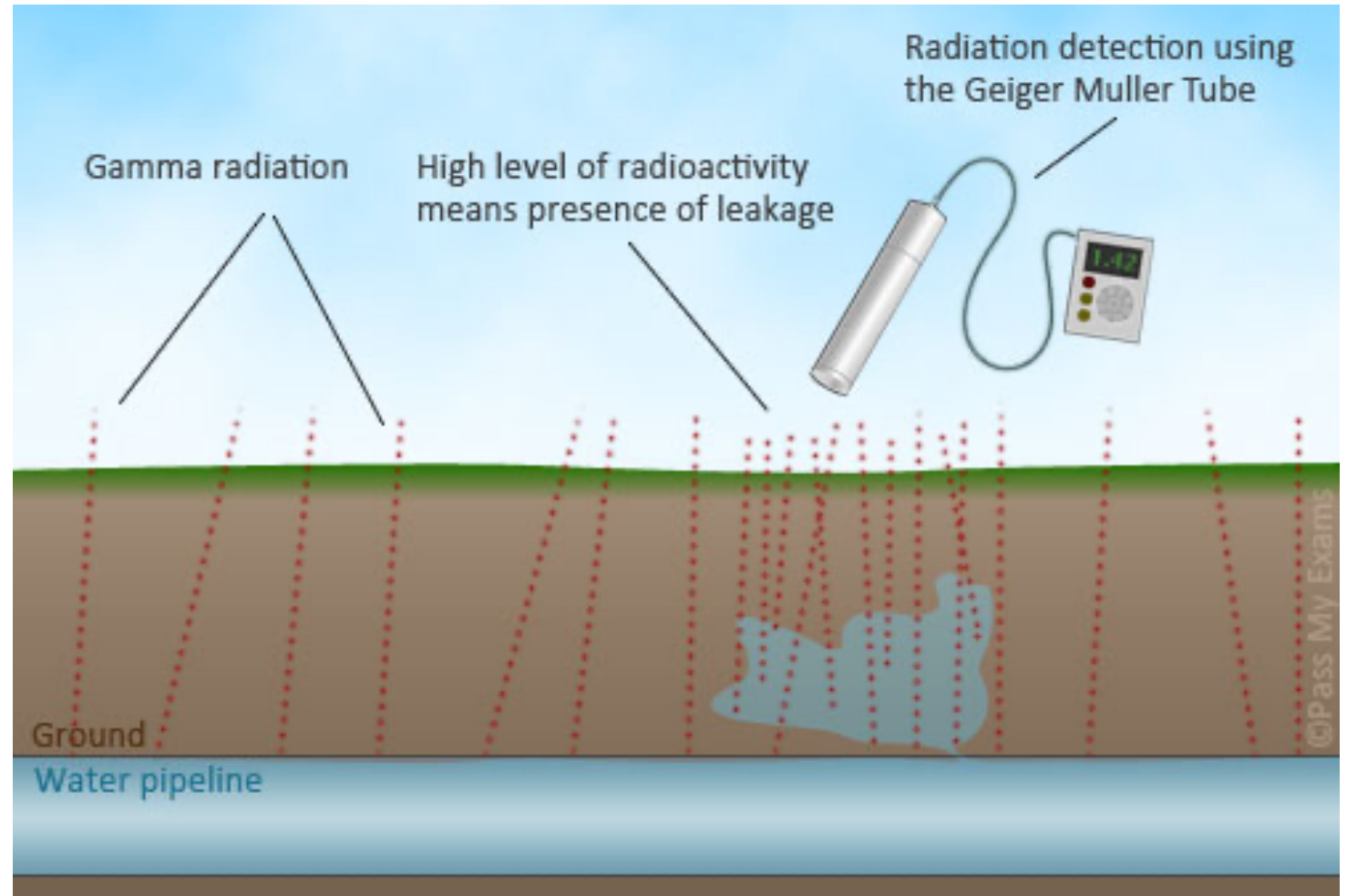


# THE USES OF RADIOISOTOPE

Unstable isotope which decay and give out radioactive emissions

## DETECTING LEAKS IN UNDERGROUND WATER PIPES

1. A radioactive substance which emits beta particles is added to a fluid in a pipeline to measure the flow rate in the pipeline and to find leaks.
2. The radiation produced by the radioactive substance can be detected with a GM tube counter placed above ground.
3. A larger increase in the count rate will indicate that there is leak in that area.



# THE USES OF RADIOISOTOPE

Unstable isotope which decay and give out radioactive emissions

Radiotherapy



Chemotherapy



Sterilizing



In medical treatment, radioactive substances is **dangerous** and cause cancer if in the body for too long.

That's why a **Short half-life** is used for medical purpose.

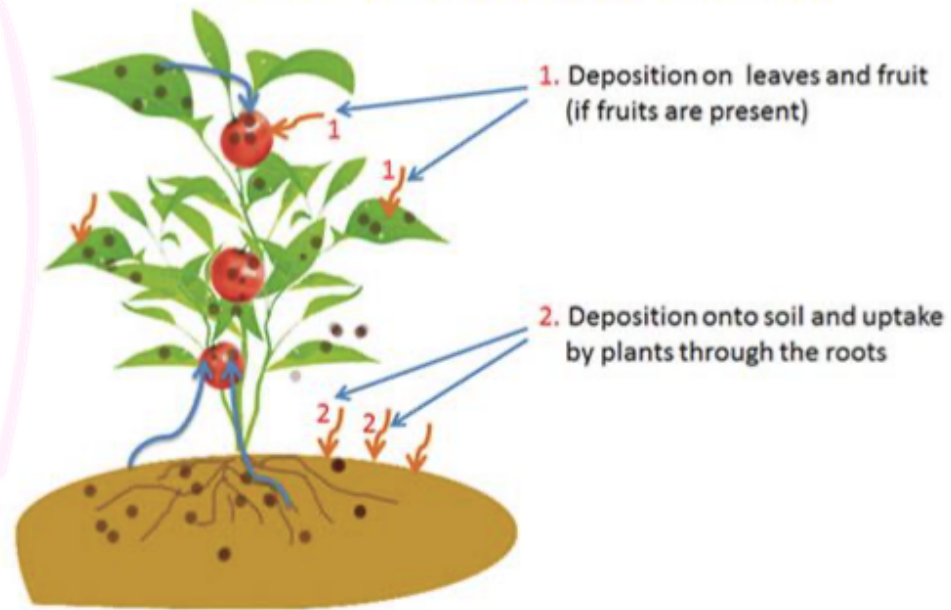


## MEDICAL

# THE USES OF RADIOISOTOPE

Unstable isotope which decays and give out radioactive emissions

The transfer of radionuclides to plants



## AGRICULTURE

to kill pests and parasites and to control the ripening of fruits.

## ARCHEOLOGY



1. Carbon-14 is a radioisotope with a half-life of 5730 years and decays by emitting beta particles.
2. Living animals and plants have a known proportion of carbon-14 in their tissues which remains constant.
3. When living things die, the amount of carbon-14 in their body decreases at a known rate.
4. The amount of carbon-14 left in a decayed plant or animal can be used to tell its age.

## EXAMPLE 1:

Why is an isotope that emits alpha particles not suitable for use as a tracer in medicine?

- Alpha particles have the **weakest penetration power** and has a range of a few cm in /air
- They **cannot pass through the body tissues** of the patient,
- therefore **cannot be detected outside the body**
- The power of **ionisation** of alpha particles is very **high** and may **destroy human cells**

## EXAMPLE 2:

Diagram 1 shows a water detection system designed by a student to detect the level of water in a storage tank so that an outlet valve can be opened automatically when the water level is too high .

The radioactive source and detector are used to detect the level of water in the tank.

The radioactive source contains a radioisotope.

Explain how the outlet valve opens when the water level is too high.

- When the **water level** is **high**, **radioactive** rays **pass through** the **water**
- Water **absorbs part of the radiation**
- Detector shows reading **decreases**
- Detector **activates** the outlet valve controller to **open** the outlet valve

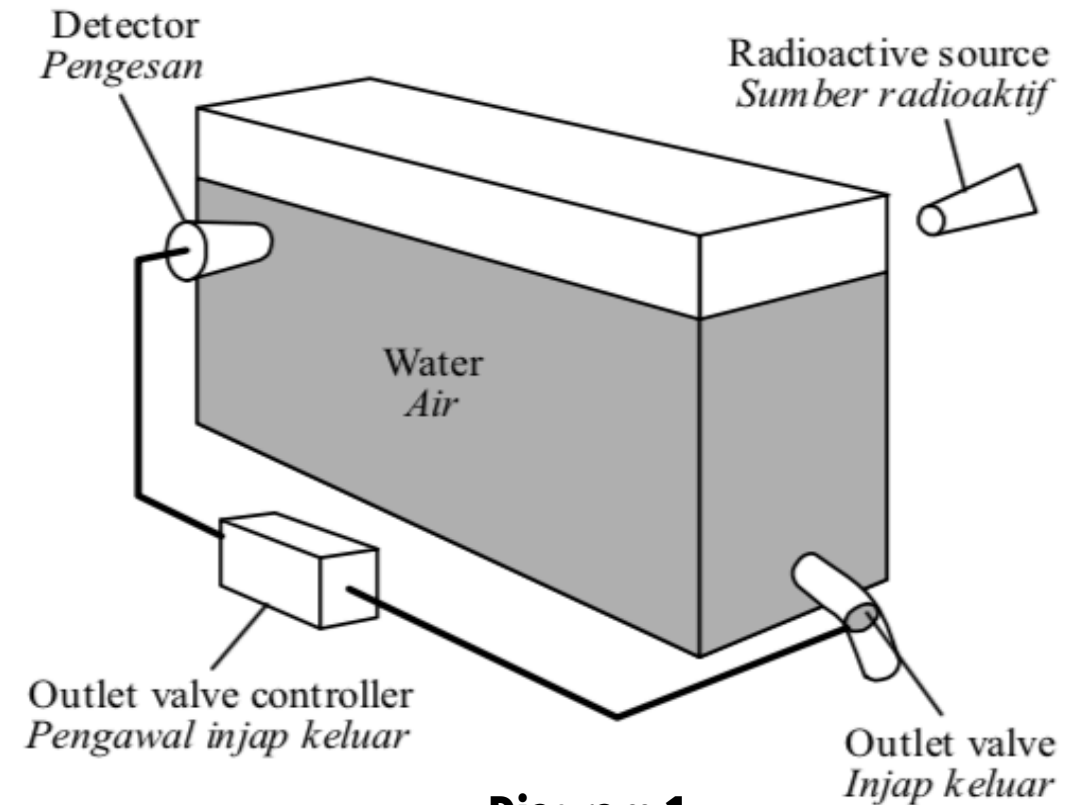


Diagram 1

Diagram 2 shows a technician detecting the leakage of an underground water pipe using a radioisotope and a detector.

Suggest the **type of radioisotope** and **safety precautions** that must be taken by the technician during this operation.

**Shorter Half-life**

Allow time for the radioisotopes to reach the leakage site // Minimize the contamination of the environment

**Emit  $\beta$  radiations**

The radiations can penetrate the soil but not the pipe

**Easily soluble in water**

Easy to dissolve the radioisotopes in water

**Wear a radiation badge // film badge**

To monitor the exposure to radiations

## EXAMPLE 3:

**Wear protective clothing / shoes**


To minimize the technician from the exposure to the radiations

Radiation detector  
*Pengesan sinaran*



Leakage site  
*Kawasan kebocoran*

**Diagram 2**



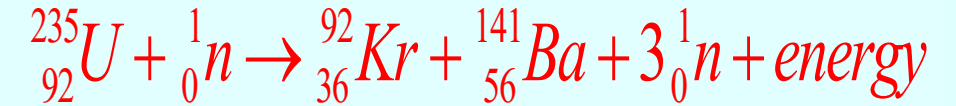
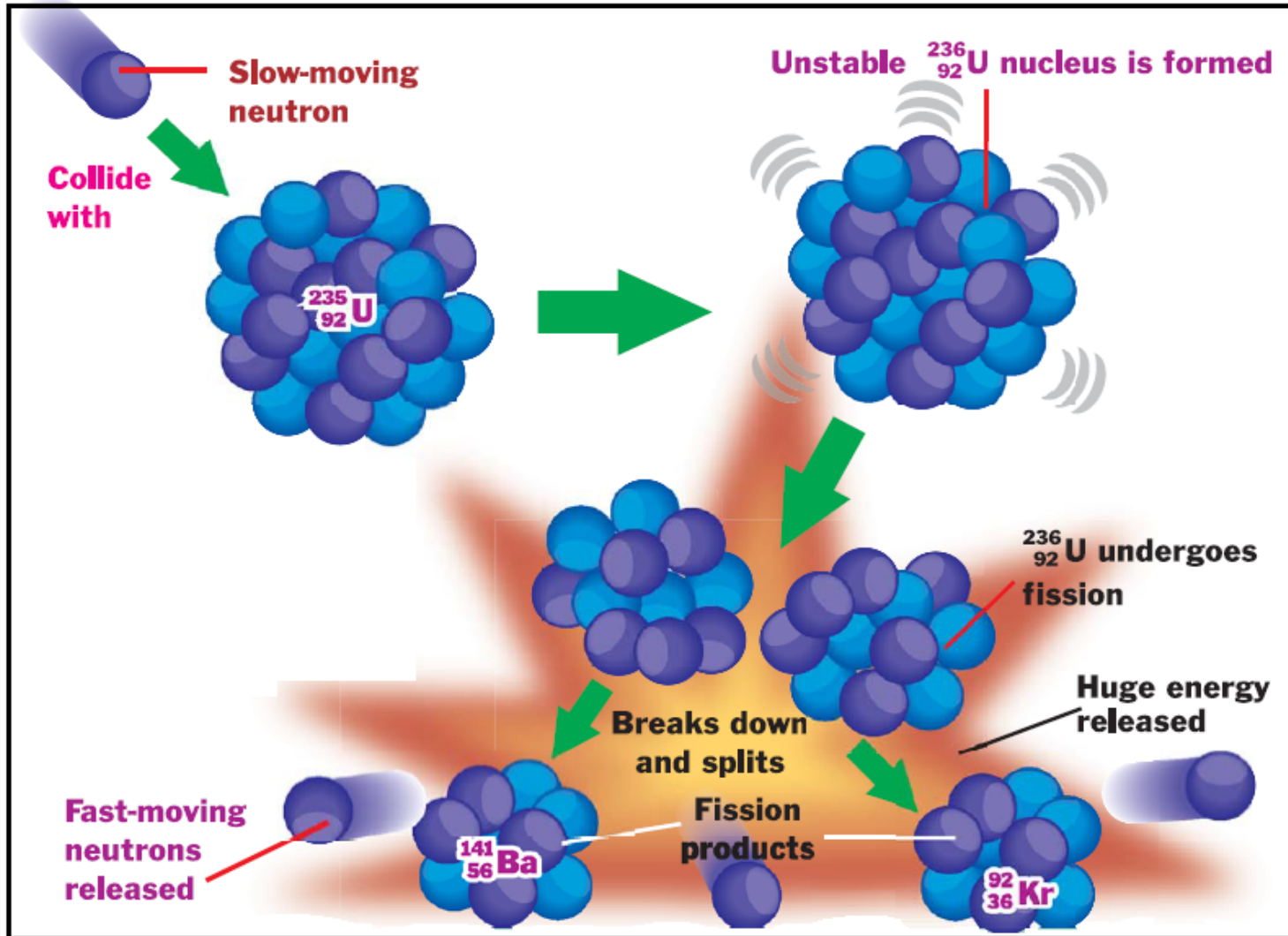
# NUCLEAR FISSION

## NUCLEAR ENERGY

A process of splitting a heavier nucleus into two lighter nuclei and emitting several neutrons and energy.

### NOTES:

- ❑ Atoms are too small to be measured in kilogram or gram
- ❑ The mass of an atom, nucleus and proton are measured in atomic mass unit (a.m.u)
- ❑ 1 a.m.u =  $\frac{1}{12}$  x mass of C - 12 atom
- ❑ 1 a.m.u =  $1.66 \times 10^{-27}$  kg



### Difference between nuclear fission and radioactive decay:

- ❖ The nucleus is divided into two large fragments of roughly equal mass
- ❖ There is a significant mass defect
- ❖ Other neutrons are emitted in the process

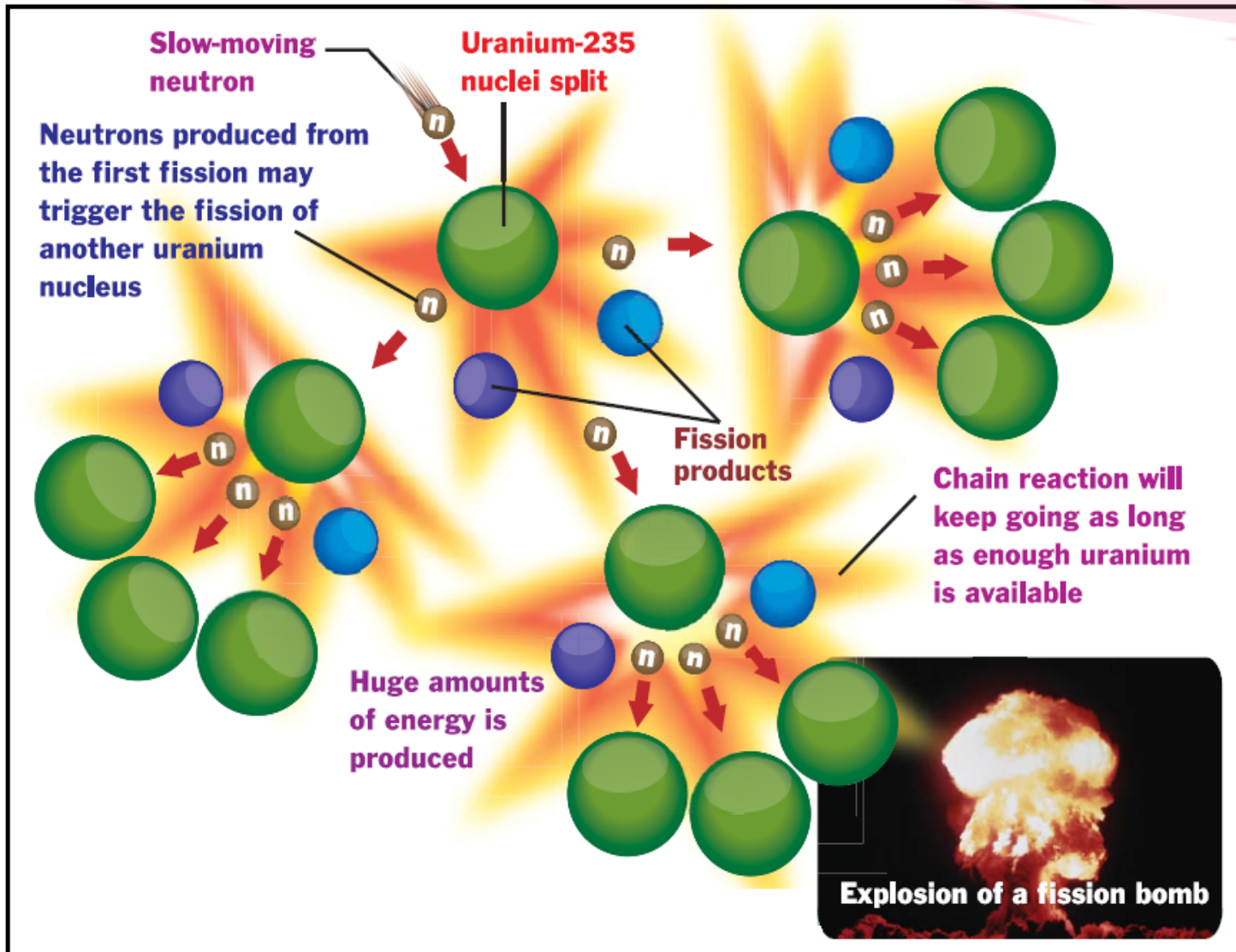





# CHAIN REACTION

## NUCLEAR ENERGY

Is a self-sustaining reaction in which the products of a reaction can initiate another similar reaction.



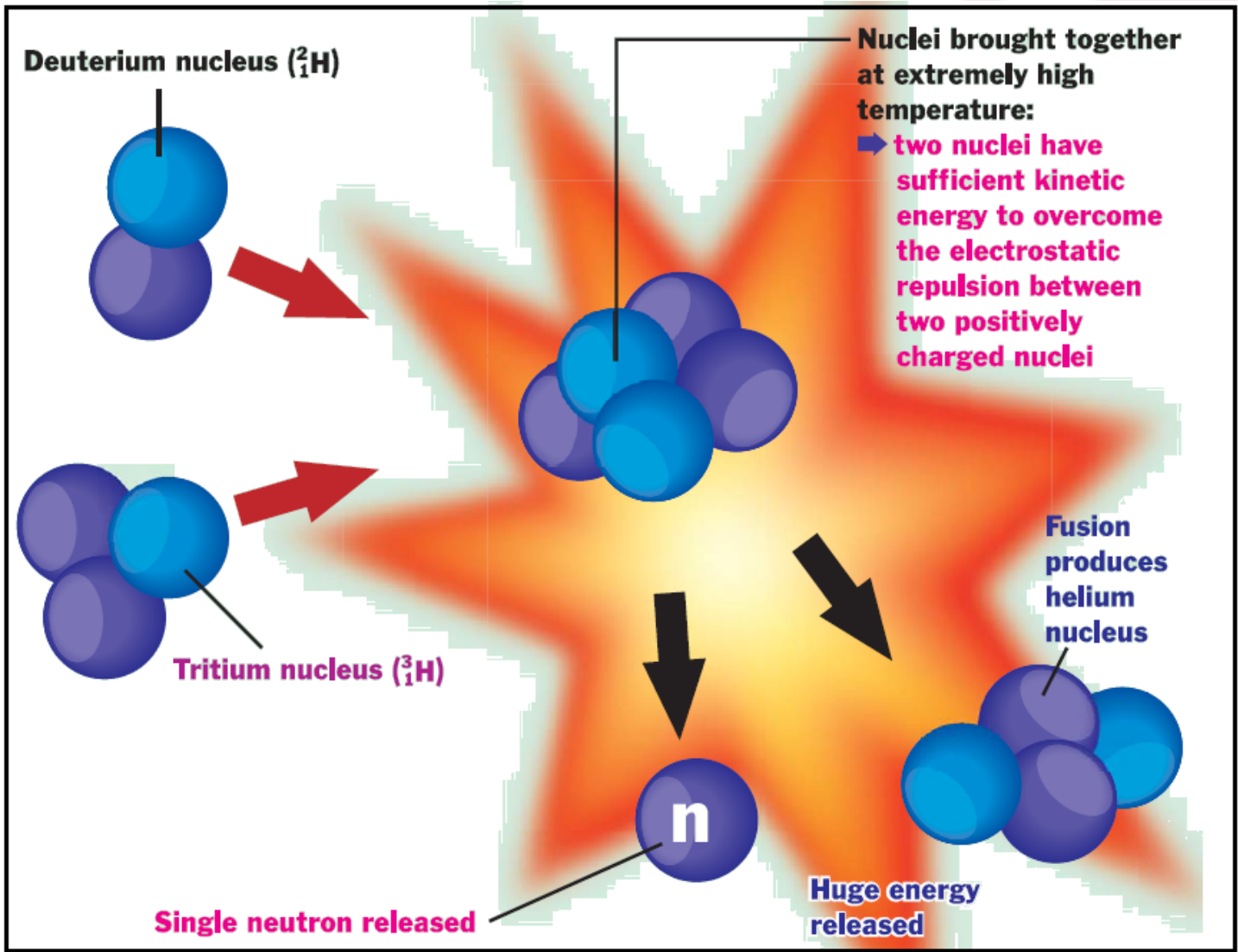
1. In order for a chain reaction to occur, the sample of uranium must have a certain minimum mass known as **critical mass**.
2. The neutrons produced in a fission reaction are very fast neutrons. Slower neutrons are more easily captured by the uranium nuclei.
3. **Graphite** can act as **moderators** to **slow down the chain reaction** to occur at a smaller critical mass.



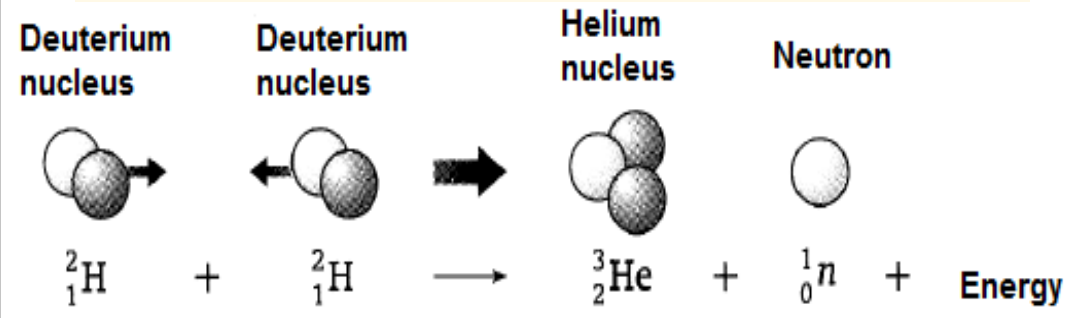
# NUCLEAR FUSION

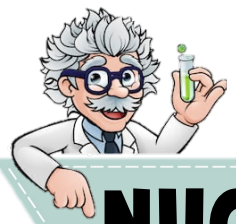
## NUCLEAR ENERGY

A process of combining of two lighter nuclei to form a heavier nucleus, releasing a vast amount of energy during the process



Huge amount of energy that **Sun** produces comes from nuclear fusion reactions. Sun has very **high temperature** to give **high kinetic energy**.





# NOTES:

## NUCLEAR ENERGY

- Both nuclear fission and fusion **release** a large amount of **energy**.  
The source of this energy is from the loss of mass in nuclear reactions.
- The sum of the masses of the particles before the reaction is more than the sum of the masses of the particles after the reaction.
- Mass defect is [sum of the masses before reaction – sum of the masses after reaction]
- Mass and energy can be exchanged one for the other.
- A **LOSS OF MASS** in a nuclear reaction means that **the mass had changed to energy**.
- The relationship between the mass and the energy:

$$E = mc^2$$

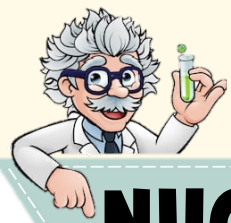
Where

E = energy released, in joules, J

m = loss of mass or mass defect, in kg

c = speed of light =  $3.0 \times 10^8$  m/s



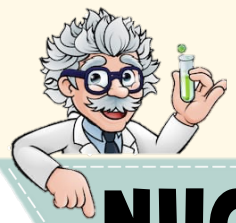


# Differences BETWEEN NUCLEAR FUSION AND NUCLEAR FISSION

## NUCLEAR ENERGY

	NUCLEAR FUSION	NUCLEAR FISSION
<b>DEFINITION</b>	A process the combining of two lighter nuclei to form a heavier nucleus, releasing a vast amount of energy during the process.	A process of splitting a heavier nucleus into two lighter nuclei and emitting several neutron and energy.
<b>WHERE DID THE ENERGY COME FROM?</b>	The reduction in mass when two light nuclide fuse together, is converted into energy	The reduction in the total mass of fragments compared to the mass of the original nuclide is converted into energy
<b>PROCESS THAT TAKES PLACE</b>	Light nuclei at high speeds and very high temperature overcome the repulsion force and fuse to form a single nucleus	Moving particles, e.g. neutrons, hit and break up heavy nucleus and produce enough neutrons to break up other nuclei (chain reaction)
<b>CAN THE RATE OF REACTION BE CONTROLLED?</b>	<b>Difficult</b> to control	<b>can</b> be control
<b>EXAMPLES</b>	Fusion is the process that powers the <b>sun</b>	Fission is the process in a <b>nuclear reactor</b>

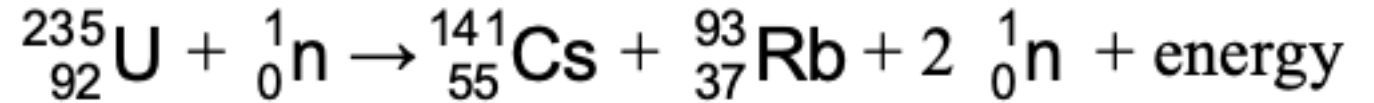




## EXAMPLE 1:

A nuclear reaction is represented by the following equation:

### NUCLEAR ENERGY

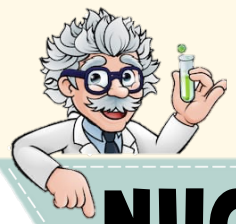


The mass defect produced in the reaction is 0.19585 u.  
[1 u =  $1.66 \times 10^{-27}$  kg, Speed of light,  $c = 3 \times 10^8 \text{ ms}^{-1}$ ]  
Calculate the energy released

$$\begin{aligned} m &= 0.1958 \times 1.66 \times 10^{-27} \\ &= 3.25028 \times 10^{-28} \text{ kg} \end{aligned}$$

$$\begin{aligned} E &= mc^2 \\ &= 3.25028 \times 10^{-28} \times (3 \times 10^8)^2 \\ &= 2.9253 \times 10^{-12} \text{ J} \end{aligned}$$





## EXAMPLE 2:

Diagram 1 shows a type of nuclear reaction.

# NUCLEAR ENERGY

Name this type of nuclear reaction:

## NUCLEAR FISSION

Explain how nuclear energy is produced from the nuclear reaction shown in Diagram 1.

- There is a mass defect during the reaction
- The mass defect changes to energy
- The total energy produced is given by  $E = mc^2$

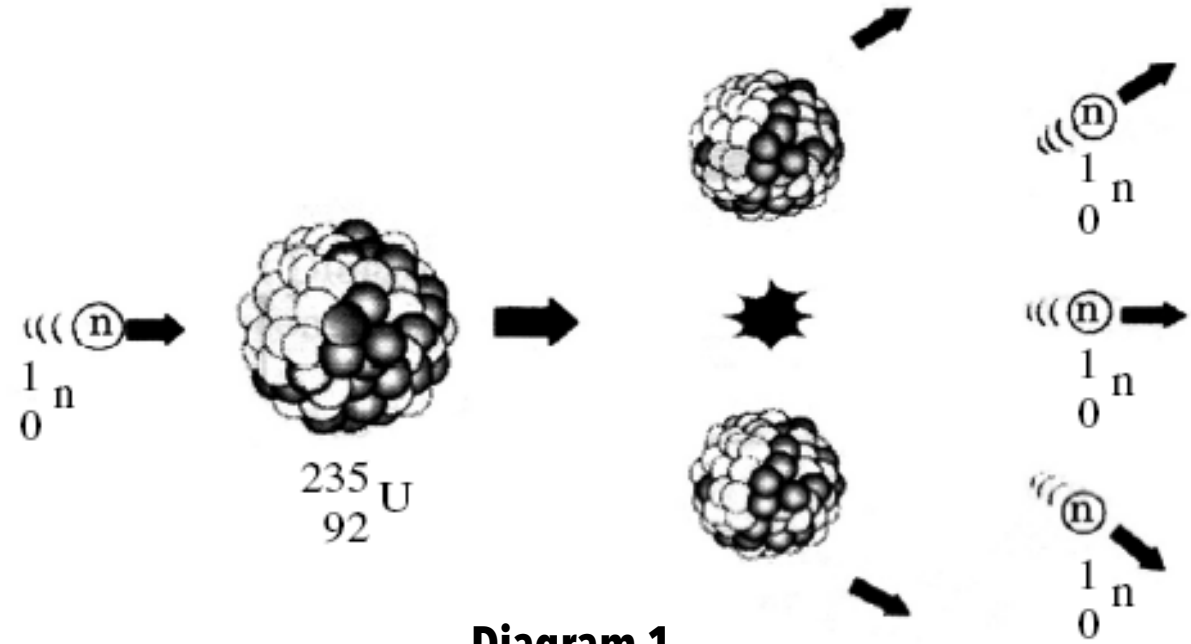
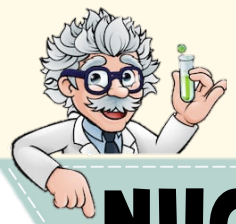


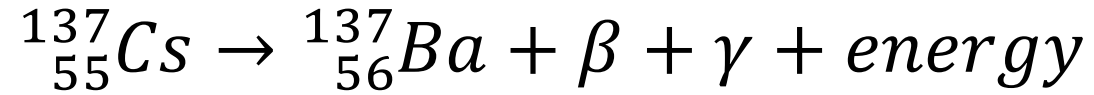
Diagram 1



# Example 3:

## NUCLEAR ENERGY

Radioisotope used in the food irradiation is Cesium-137.  
Cesium-137 decay is represented by the following equation:



Element		Atomic mass unit (u)
Cesium	${}^{137}_{55}\text{Cs}$	136.907089
Barium	${}^{137}_{56}\text{Ba}$	136.905827
Beta particle	$\beta$	0.000549

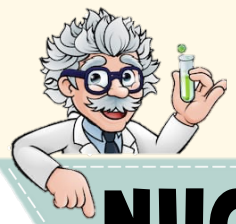
Additional information :  
 1 u =  $1.66 \times 10^{-27}$  kg  
 Speed of light,  $c = 3 \times 10^8$  ms<sup>-1</sup>

Determine the mass defect in kg.

$$\begin{aligned}
 \text{mass defect} &= 136.907089 - 136.905827 - 0.000549 \\
 &= 0.000713 \text{ u} \\
 &= 0.000713 \times 1.66 \times 10^{-27} \text{ kg} \\
 &= 1.1836 \times 10^{-30} \text{ kg}
 \end{aligned}$$

Calculate the energy released from the radioactive decay.

$$\begin{aligned}
 E &= 1.1836 \times 10^{-30} \times (3 \times 10^8)^2 \\
 &= 1.0652 \times 10^{-13} \text{ J}
 \end{aligned}$$

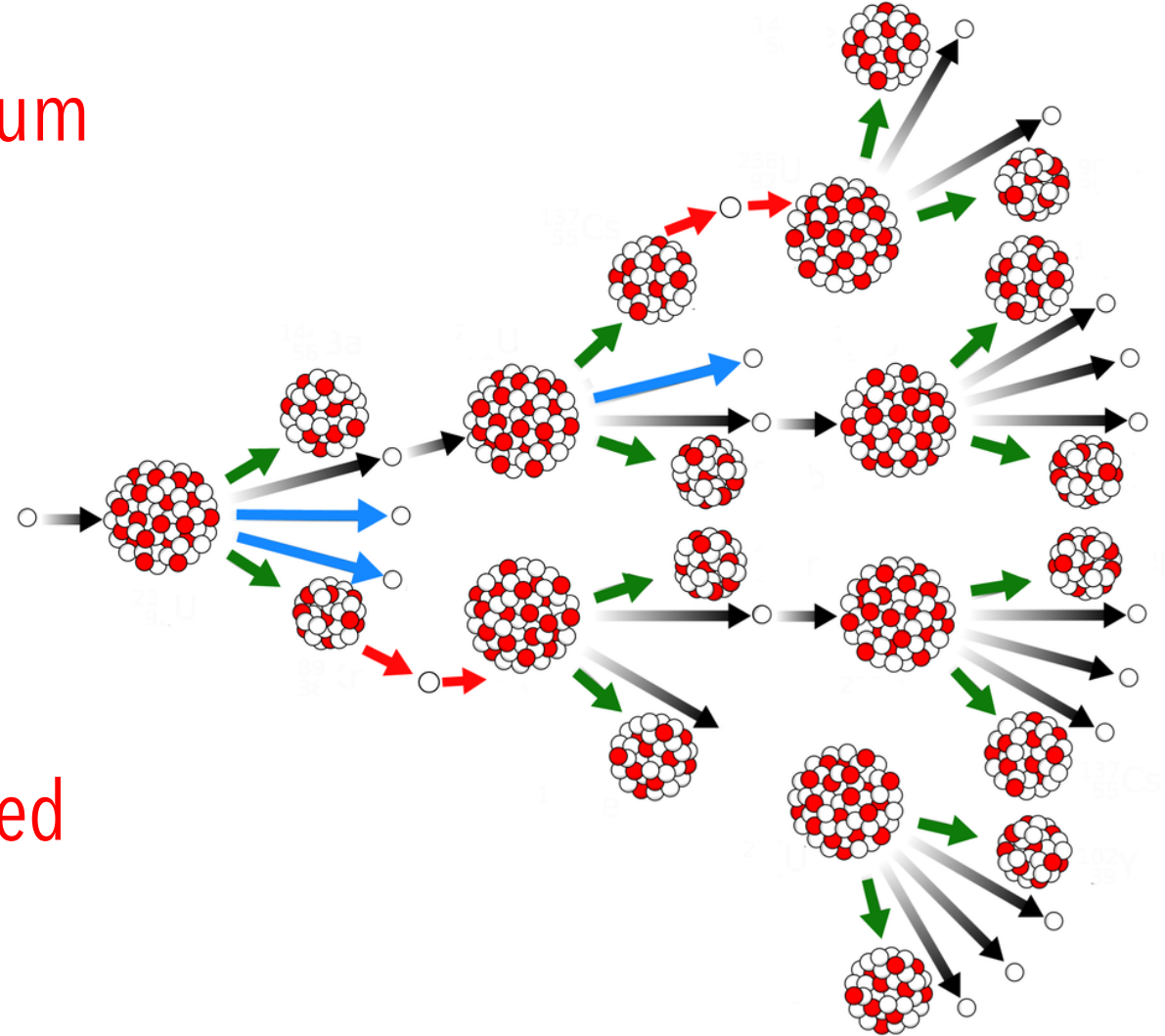


## EXAMPLE 4:

Nuclear fission produces a chain reaction. Describe how chain reaction occurs in nuclear fission of Uranium-235.

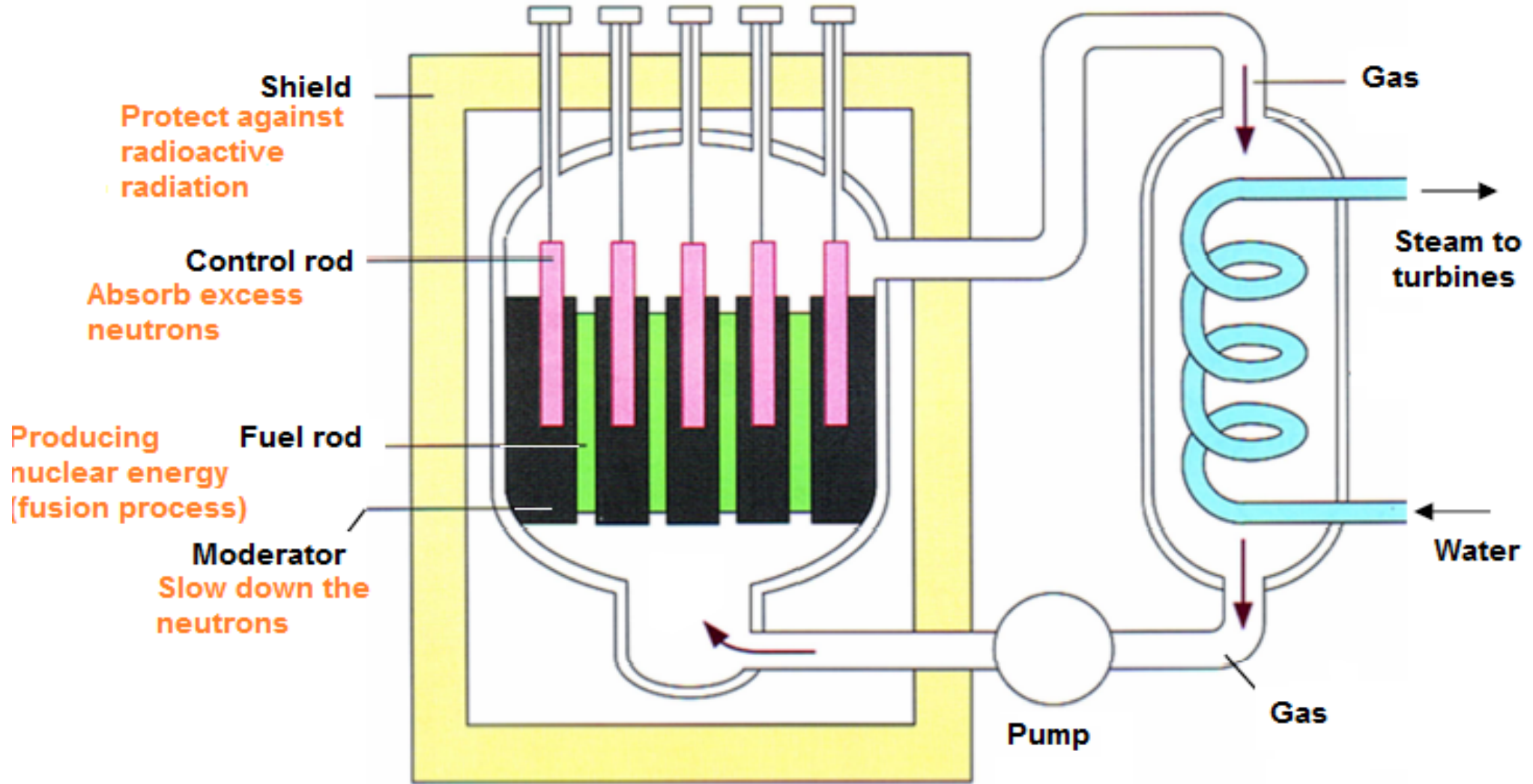
### NUCLEAR ENERGY

- **Neutron bombard** a uranium nucleus
- **Three neutrons are produced**
- These new neutrons bombard new uranium nucleus (**exceed critical mass**)
- For every reaction the neutrons produced will **generate a chain reaction**





# NUCLEAR REACTOR





# NUCLEAR REACTOR



ASPECT	ANSWER	REASON
Fuel used	Uranium	Produce fission reaction easily
Half life of the source	Long	Lasting // can be used for longer time // No need to be replaced often
State of matter	Solid	Easy to handle
Moderator	Graphite	Slow down the motion of neutrons
Control Rod	Boron / Cadmium	Absorb the neutron

# IMPORTANT OF PROPER MANAGEMENT OF RADIOACTIVE SUBSTANCE



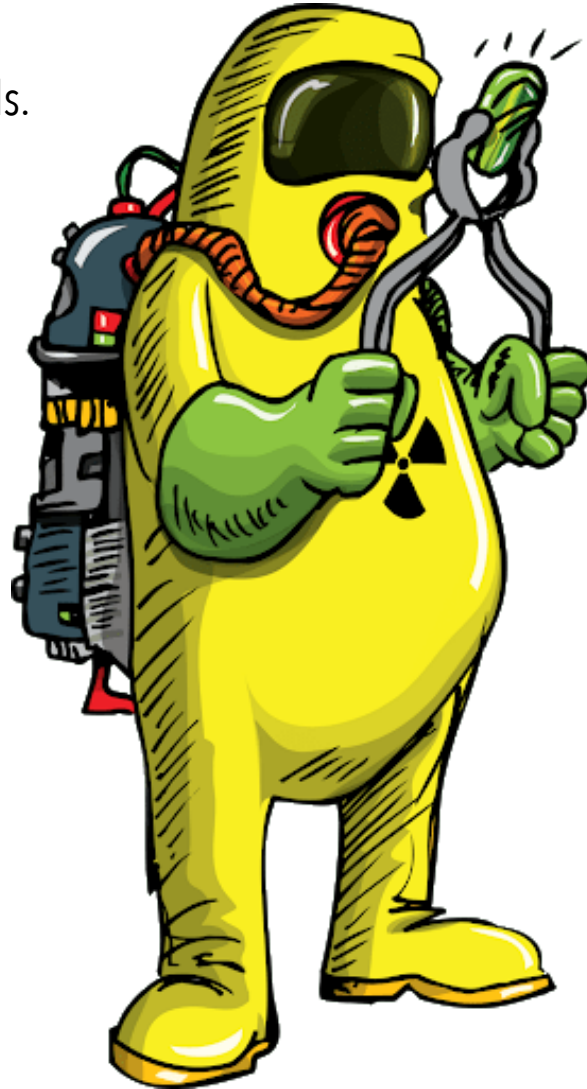
Read and follow the advice and instructions marked on radioactive sources, equipment and work manuals.



Eating, drinking, applying cosmetic or storing food is prohibited.



Store into the concrete lead box : to avoid the radioactive ray escape to the surrounding



Wear glove and goggle to avoid direct contact with the radioactive source

Laboratory coats, long pants, and closed-toe footwear should be worn.

Label the container with warning symbol



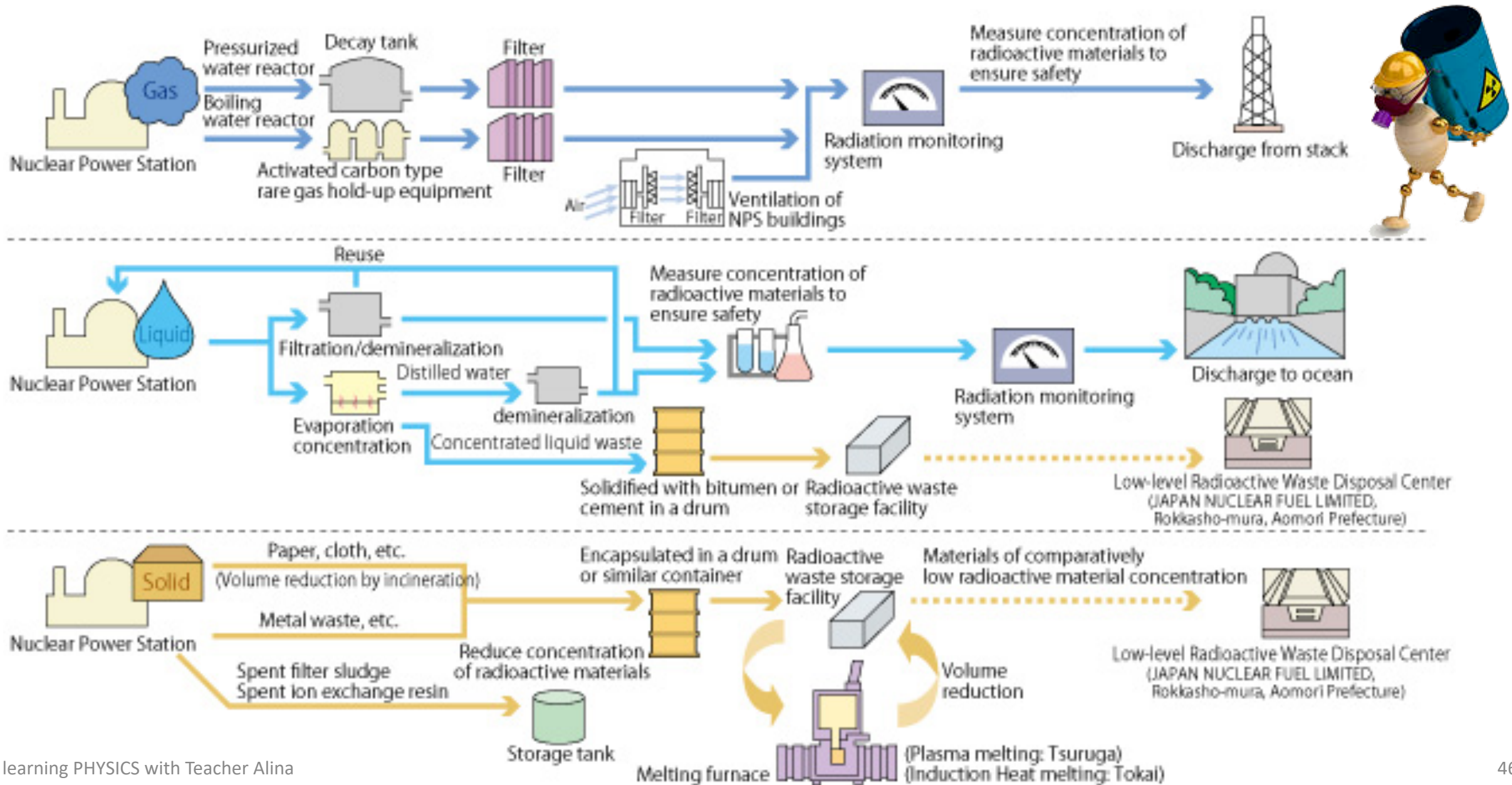
# EXAMPLE 1:

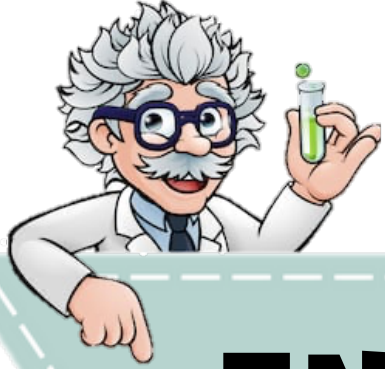
Diagram 1 shows a radioactive source is handled by a scientist. The method shown is not safe. Suggest and explain:



Modification	Explanation
<b>Use forceps // robot</b>	The distance between the source and the body is far.
<b>Wear a mask // goggles</b>	The radiation does not penetrate our eyes
<b>Use a lead box // container with thick concrete</b>	To prevent radiation leakage to surroundings
<b>Keep the exposure time as short as possible</b>	The body is not exposed to the radiation for a long time.
<b>Wear protective clothing // shoes // Wear coat lined with lead</b>	To minimize from the exposure to the radiations To protect the body from the radiation
<b>Wear a radiation badge // film badge</b>	To monitor the exposure to radiations
<b>Attach the detector to a longer rod</b>	To minimize the technician from the exposure to the radiations
<b>Put radiation symbol on the storage box</b>	To inform users of dangerous contents of the box.

# IMPORTANT OF PROPER MANAGEMENT OF RADIOACTIVE SUBSTANCE





# ENJOY LEARNING PHYSICS

With Teacher

*Alina*

YOUR **Mind**  
IS A **Powerful** THING.  
WHEN YOU FILL IT WITH **Positive** THOUGHTS,  
YOUR LIFE WILL START TO **Change**.