RATU NAVULA COLLEGE

Y12 PHYSICS HOME LEARNING KIT 9

LESSON 105
LO: use Lenz's law to determine the direction of induced current placed in a perpendicular magnetic field.

FARADAY'S LAW OF ELECTROMAGNETIC INDUCTION:

1st law: a changing magnetic field can produce an induced current.

-magnitude of induced emf can be obtained by Faraday's second law:

2nd Law: the magnitude of induced e.m.f generated in a coil is directly proportional to the rate of changes in magnetic flux.

Direction of induced emf can be found by Lez's Law:

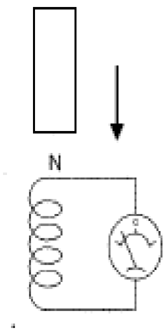
LENZ'S LAW

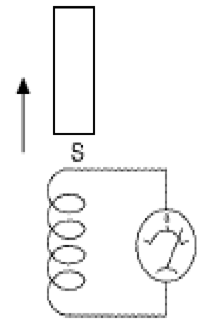
- States that *" the polarity of induced emf is such that it tends to produce a current which opposes the change in magnetic flux that produced it"*

  In simple terms:

- "the direction of an induced current is always such to oppose the change in the magnetic field that produces it." (emf will oppose the movement of magnet)

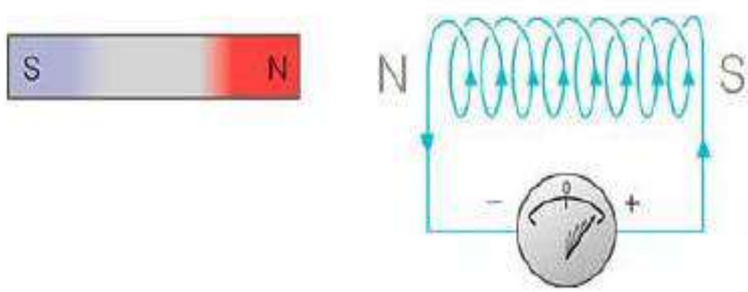
  0r
  - "if an induced current flow, its direction is always such that it will oppose the change which produced it."





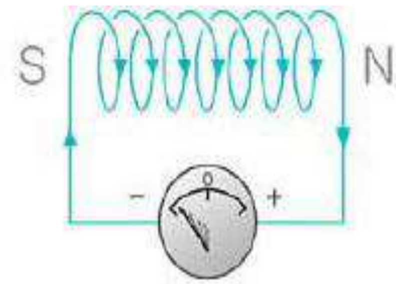
EXAMPLE 1 When a magnet is moving towards the coil.

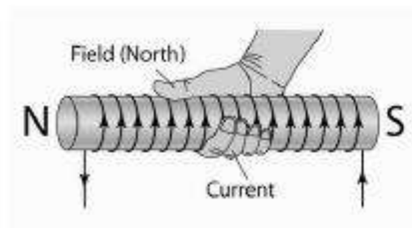
we can easily determine the direction of the induced current by applying right hand rule. In this case, the current flows in anticlockwise direction.



EXAMPLE 2 When a magnet is moving away from the coil

determine the direction of the induced current by applying right hand rule. In this case, the current flows in clockwise direction.





10

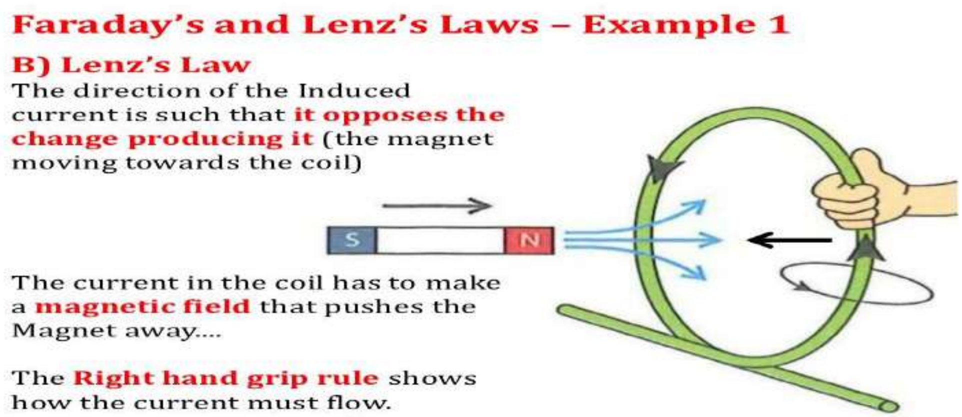
- Faraday's law of electromagnetic induction states that the magnitude of the induced e.m.f. is proportional to the rate of change of the magnetic flux linked with the circuit or rate at which the magnetic flux are cut.
- Faraday also found that the magnitude of the induced current increases when
  - The magnet is move at a faster speed in and out of the coil;
  - A stronger magnet is used;
  - The number of turns in the coil is increased.

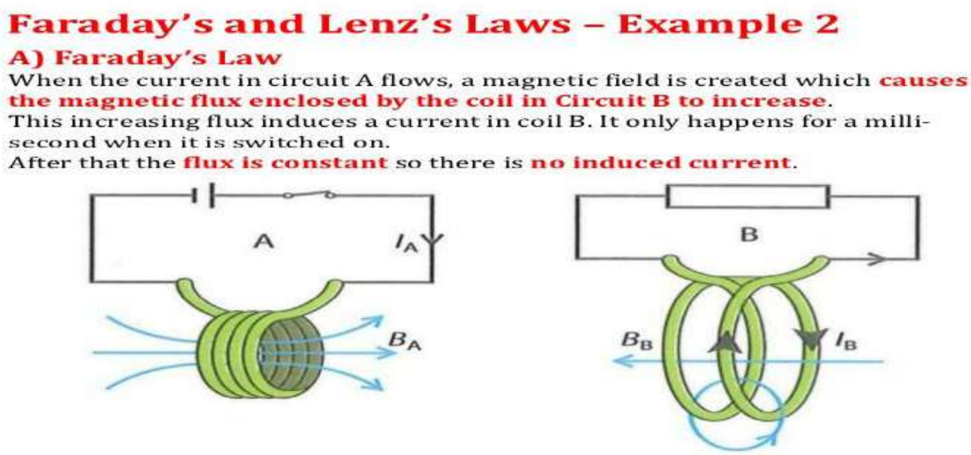
Electromagnetic Induction

Faraday's Law

Faraday's law

- States that the induced voltage in a coil is proportional to the number of loops, multiplied by the rate at which the magnetic field changes within those loops.
- Amount of current produced by electromagnetic induction is dependent on
  - resistance of the coil,
  - circuit that it connects,
  - induced voltage.





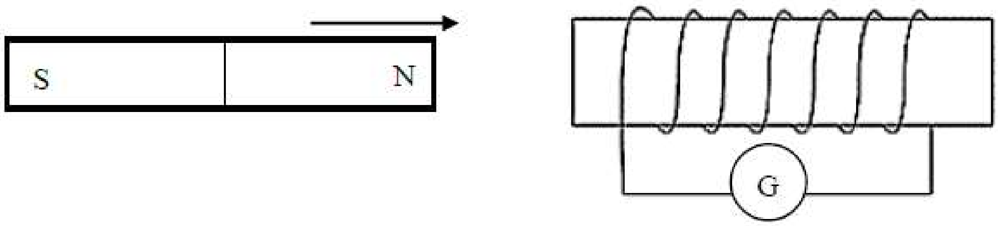
2019

Lenz devised a rule to find out the direction of

A. potential difference.
B. flow of power in fuse.
C. current induced in a circuit.
D. electromagnetic difference.

2018

The diagram given below shows a bar magnet approaching a solenoid.



(i) Draw how the current will flow in the solenoid on the diagram given in the **Answer Booklet.** **(1 mark)**

(ii) Label on the same diagram given in part (i) in the **Answer Booklet**, what poles will be induced on the ends of the solenoid. **(1 mark)**

2017

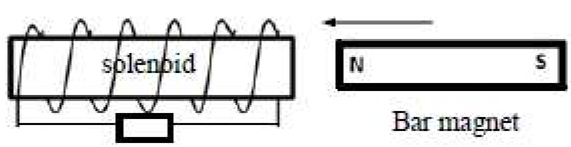
The __________ Law states that the direction of an induced current is always such as to oppose the change in the magnetic field that produces it.

A. Ohm's
B. Lenz's
C. Hooke's
D. Newton's

2015

The diagram below shows a bar of magnet being moved toward a solenoid. What pole will be induced on the side closest to the magnet?

A. East
B. South
C. North
D. West

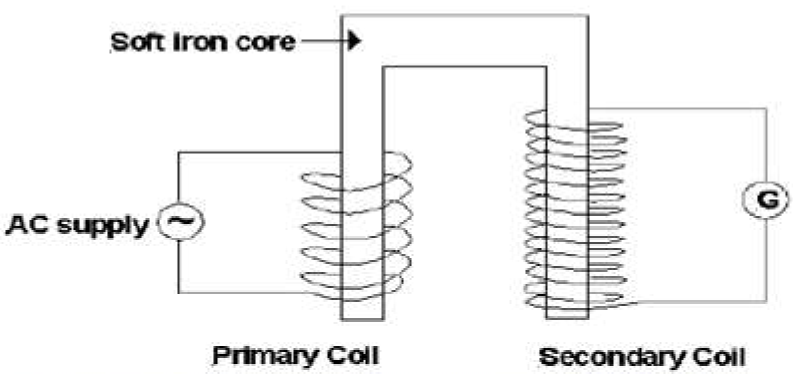


LESSON 106
LO: solve problems dealing with an ideal transformer.

TRANSFORMERS

$$\frac{V_P}{V_S} = \frac{N_P}{N_S} = \frac{I_S}{I_P}$$

- Is an electrical device that uses the principle of induction between the primary coil and the secondary to either 'step up' or 'step down' the voltage.
- Works only on AC.
- A **step up transformers** results in an increased voltage while a **step down transformer** results in a decreased voltage



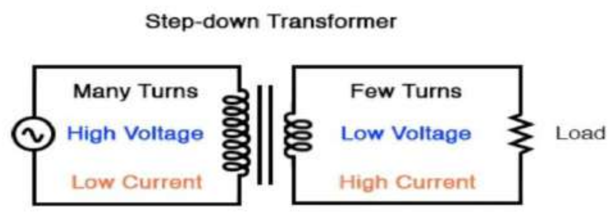
http://webs.mn.catholic.edu.au/physics/emery/hsc_motors.htm#work1

- a useful property of the transformer is the ability to transform voltage and current levels according to a simple ratio determined by the ratio of input and output coils of wire.

$$\frac{V_P}{V_S} = \frac{N_P}{N_S}$$

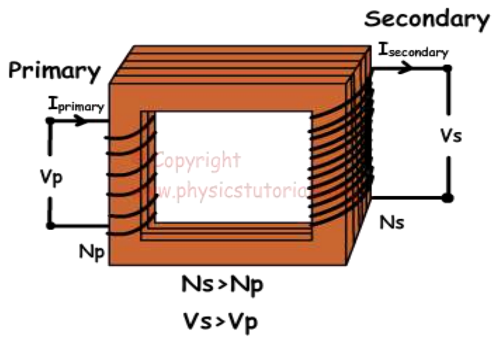
where V_P = primary voltage, V_S = secondary voltage, N_P = number of turns of wire in primary coil and N_S = number of turns of wire in secondary coil.

Step down	vs	Step UP
$V_p > V_s$		$V_p < V_s$



function: to decrease the voltage in the secondary coil

step up transformer



function: to increase the voltage in the secondary coil

-Ideal transformer: is 100 % efficient.

-Efficiency [of any machine]

Is the ratio of receiving-end power to the sending-end power

$$\frac{power\ output}{power\ input} x\ 100\%$$

Transformer

Input And Output Of A Transformer

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

V_p = *input (primary) potential difference* (V)
V_s = *output (secondary) potential difference* (V)
N_p = *number of turns in primary coil*
N_s = *number of turns in secondary coil*

Power In A Transformer

Ideal Transformer

$$V_p \times I_p = V_s \times I_s$$

V_p = *input (primary) potential difference* (V)
V_s = *output (secondary) potential difference* (V)
I_p = *input (primary) current* (A)
I_s = *output (secondary) current* (A)

Non-ideal transformer

$$Efficiency = \frac{V_s I_s}{V_p I_p} \times 100\%$$

Power Transmission

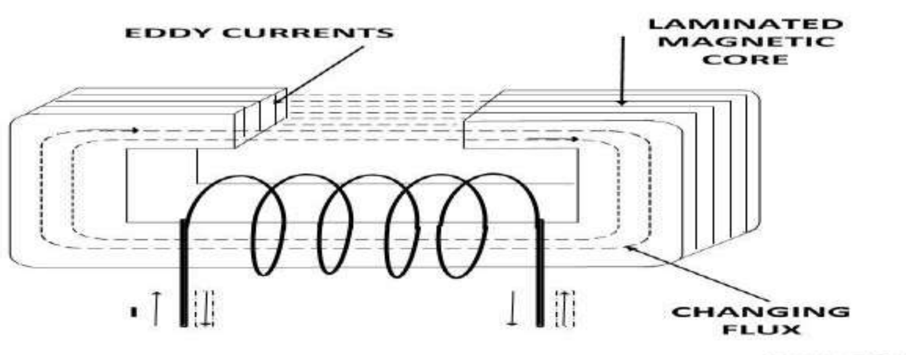
2Steps to find the energy/power loss in the cable

a. Find the current in the cable by the equation $P=IV$
b. Find the Power lost in the cable by the equation $P=I^2R$.

-however problems such as 'Eddy Current" occurs in Transformers.

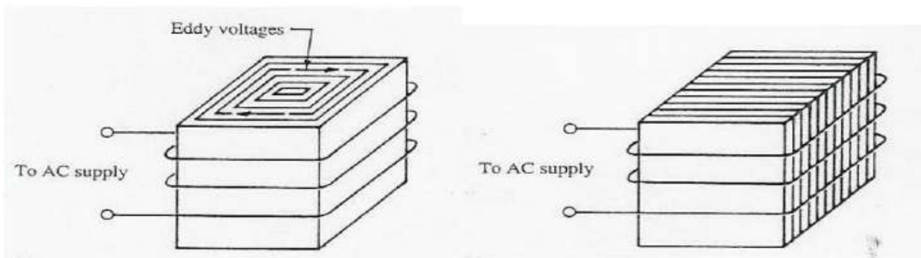
[Eddy current: currents that circulates within conductors. Major loss of electrical energy in the form of heat due to friction in the magnetic circuit esp where the core is saturated. There is magnetic flux leakage]

-Eddy Current can be reduced by using laminating sheets. This will prevent heat loss and increase efficiency.



Eddy Currents and Eddy Current Losses

- Solid Iron Core
- Laminated Core



ECE 441 1

2019

A step-up transformer will step up the level of

A. voltage.
B. current.
C. battery.
D. frequency.

2018

The transformer for a child monitor has 72 turns in the primary coil and operates from the mains supply of 240 V. It steps down the voltage in the secondary coil to 150 V. Assume the transformer is 100% efficient and produces a power output of 468 W.

(i) Calculate the current in the secondary coil. **(1 mark)**

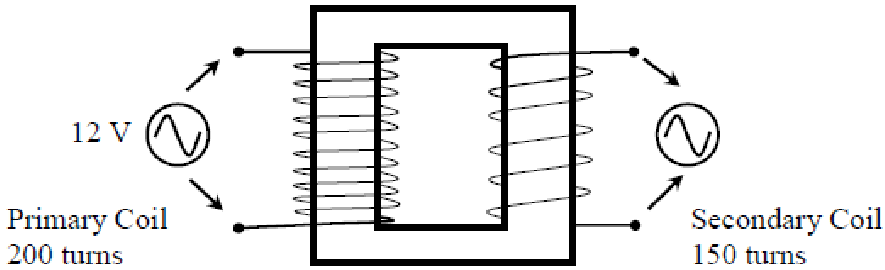
(ii) Calculate the current in the primary coil. **(1 mark)**

(iii) Explain how energy conservation operates in an ideal transformer. **(1 mark)**

(iv) Explain how the power output of the transformer will change if it is not 100% efficient. **(1 mark)**

2017

The diagram given below shows a transformer.



(i) State with a reason whether it is a **step-up** or **step-down** transformer. **(1 mark)**

(ii) Calculate the voltage induced in the secondary coil. **(1 mark)**

(iii) State the purpose of laminating the transformer. **(1 mark)**

L 107-108 Experiment 12: The direction of an induced current in a coil

STRAND 7 ATOMIC PHYSICS

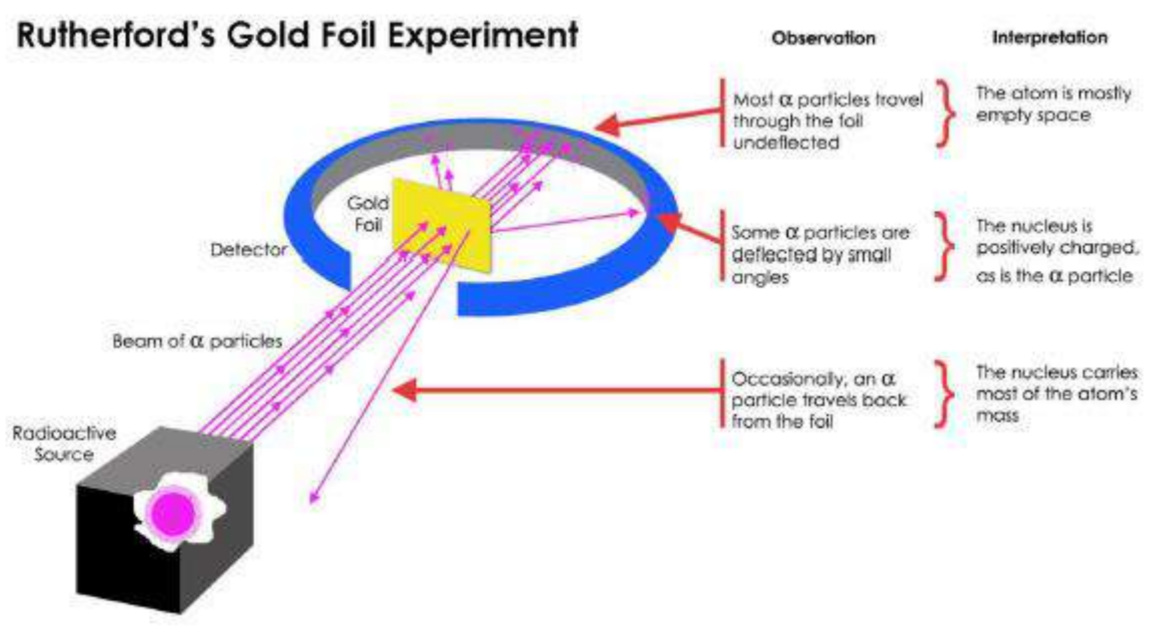
S/S: 7.1 RADIOACTIVITY

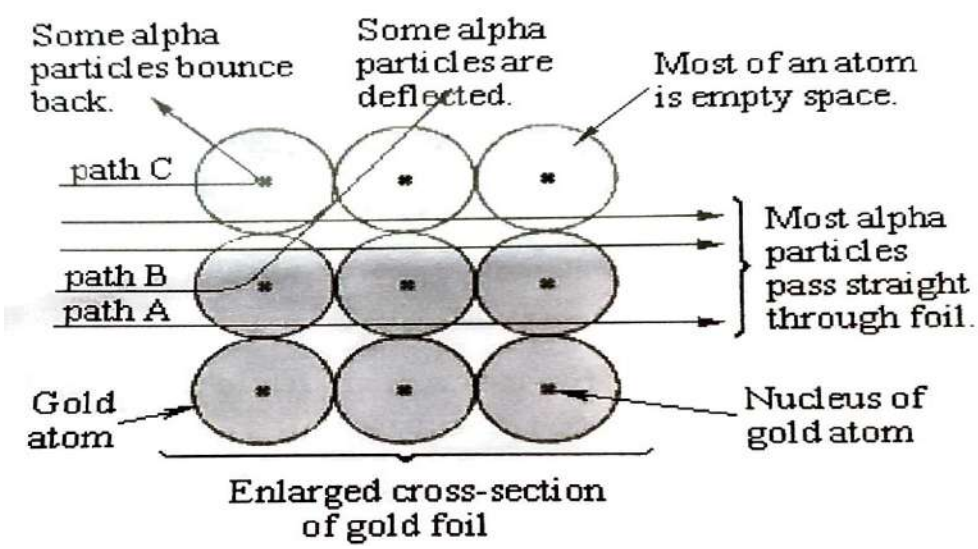
LESSON 109

LO: describe basic nuclear structure and penetrating power of radioactive decay and their effects on matter.

RUTHERFORDS MODEL OF THE ATOM

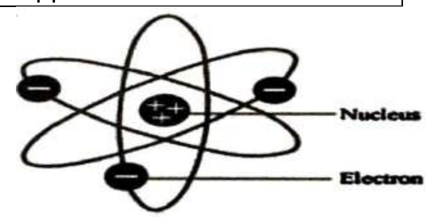
-Alpha particles or [Helium Nuclei] were bombarded into a thin gold foil.


Rutherford's Gold Foil Experiment
Observation
Interpretation
Most α particles travel through the foil undeflected
The atom is mostly empty space
Some α particles are deflected by small angles
The nucleus is positively charged, as is the α particle
Occasionally, an α particle travels back from the foil
The nucleus carries most of the atom's mass
Gold Foil
Detector
Beam of α particles
Radioactive Source

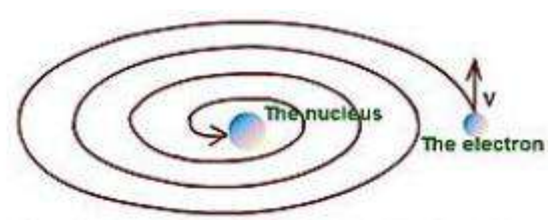

Some alpha particles bounce back.
Some alpha particles are deflected.
Most of an atom is empty space.
path C
path B
path A
Most alpha particles pass straight through foil.
Gold atom
Nucleus of gold atom
Enlarged cross-section of gold foil

RUTHERFORDS MODEL OF ATOM

OBSERVATION	CONCLUSION/POSTULATES	WEAKNESS/DEFECTS
-**most** of the alpha particles passed straight through the gold foil.	-the atom is mostly empty space.	-atom does not collapse.
-**some** alpha particles (which are big in size) were deflected by small angles.	-the nucleus is positively charged, as the alpha particle.	-cannot explain chemical properties of an atom because it does not account for the energy levels./does not say anything about the arrangement of electron in an atom.
-**very few** alpha particles were deflected backwards	-the nucleus carries most of the atom's mass. / volume occupied by the central region(nucleus) is very small.	-His model predicts that the atom will emit a continuous spectrum BUT this does not happen.



drawback of Rutherford's atomic model



In the planetary model of atom, the electron should emit energy and spirally fall on the nucleus.

(i) An electron revolving around the nucleus gets accelerated towards the nucleus. An accelerating charged particle must emit radiation and lose energy. Thus, the electron in an atom must continuously emit radiation and lose energy and would slow down and will not be able to withstand the attraction of the nucleus. As a result it should follow a spiral path and ultimately fall into nucleus.

- Electrons that are orbiting accelerate and radiate energy and fall back in the nucleus but this does not happen.

(ii) Rutherford model of atom does not say anything about the arrangement of electron in an atom.

- It does not explain why atoms emitted contain frequencies of light in the emission spectrum.

- His model predicts that the atom will emit a continuous spectrum but this does not occur.
- Can not explain chemical properties of an atom because it does not account for the energy levels
- Atom does not collaspe

1. **Why did Rutherford use a vacuum?**
   To avoid collision with air particles

2. **Why did he use gold foil?**
   Gold is ductile, malleable, has large nuclei

3. **Why would Beta particles not work as bullets?**
   Too light, too easily deflected

4. **Why would gamma rays not work as bullet?**
   No mass, too strong.

<u>Note:</u>

1. Rutherford used principles of conservation of momentum and energy to postulate his model of atom.

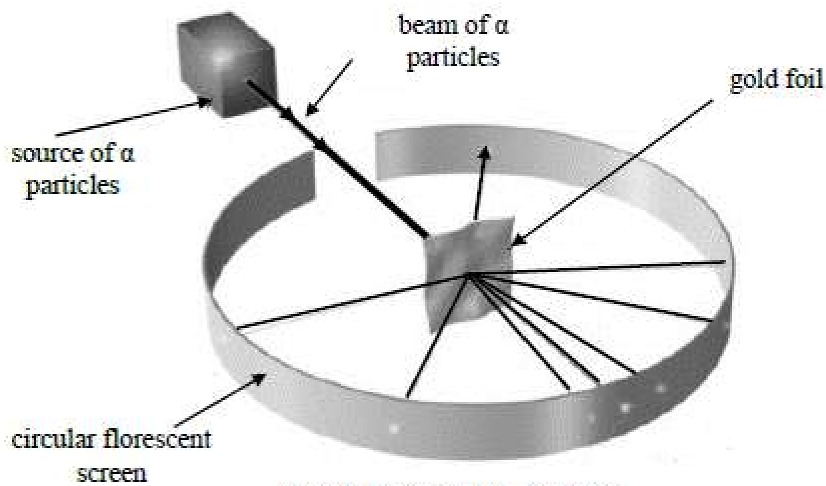
Using the above, he postulated that **The nucleus contains the mass of the atom.**

2. **Rutherfords assumption about the size and mass of nucleus versus the size and mass of atom.**

Mass of the nucleus is approximately the same as atom. (Size of the nucleus is very small compared to the size of the atom.

2019

Ernest Rutherford performed an experiment to determine the structure of an atom. The experiment involved firing a beam of alpha particles from a radioactive source towards a thin film of gold foil. The sketch below shows the three observed paths of the alpha particles.



Source: https://www.chegg.com

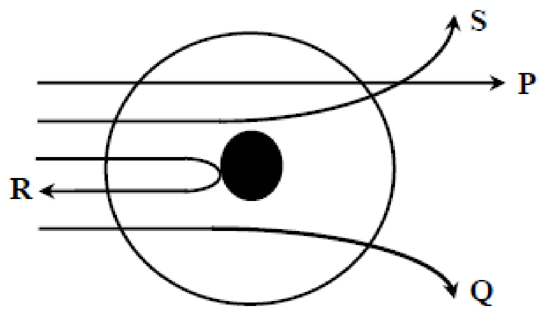
State one observation made in this experiment. **(1 mark)**

2018

State **one** drawback of Rutherford's atomic model.

2017

Refer to the diagram given below which shows the paths of alpha particles in Rutherford's gold foil experiment to answer **Question 19**.



Which one of the following labelled paths shows that an atom is mostly an empty space?

A. **P**
B. **Q**
C. **R**
D. **S**

LESSON 110 LO: explain nuclear decay process and interaction of radiation with matter.

<u>ATOMIC NUCLEUS</u>

1. Protons: are positively charged particles.
   Mass of proton = 1.67×10^{-27} kg

2. Neutrons: are neutral charged particles.Neutrons= mass #- atomic #

3. Electrons: are negatively charged particles.
   Electronic mass, $m = 9.1 \times 10^{-31}$ kg

4. Atomic number: Is the number of protons in the nucleus. In a neutral atom, the # of protons = # of electrons.

$$ {}^{A(mass\ \#)}_{z(Atomic\ \#)}X $$

5. Mass number: # of protons + # of neutrons.

6. Isotopes: elements with same atomic # but different mass #.

$^{12}_{6}C \quad ^{13}_{6}C$

$^{35.5}_{17}Cl \quad ^{37.5}_{17}C$

$^{226}_{88}Ra \quad ^{228}_{88}Ra$

EXAMPLE

How many protons, neutrons and electrons does an atom of $^{235}_{92}U$ have?

p: 92 e: 92 n: mass # - atomic # = 235 – 92 = 143.

RADIOACTIVE DECAY

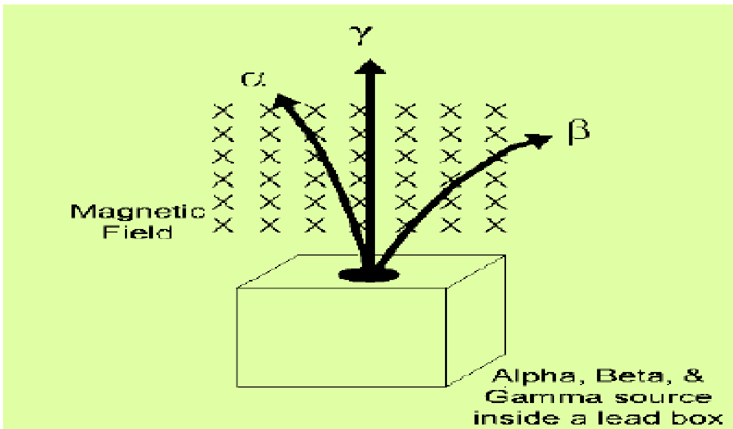
- Also known as **nuclear decay** or **radio activity**.
- Is the process by which a nucleus of an unstable atom loses energy by emitting ionizing radiation.
- **Geiger Counter:** instrument used for measurement and detection of radioactivity.

COMMON CHARACTERISTICS OF RADIO ACTIVE ELEMENTS ARE:

1. They ionise the air through which the radiations are travelling.
2. Radiation can affect the physiology of cells.
   E.g they can destroy the germinating power of seeds, kill bacteria and can be harmful to animals and humans.

RADIO ACTIVITY

There are **3** types of radiation:



Source :studyphysics.ca

1. ALPHA DECAY (α)

- During an alpha decay a nucleus is able to reach a more stable state by allowing 2 protons and 2 neutrons to leave the nucleus.

$$^{235}_{92}U \longrightarrow ^{231}_{90}Th + ^{4}_{2}He$$

- A helium nucleus,(the alpha particle,) of 2 protons and 2 neutrons is emitted at high speed/ kinetic energy from the nucleus.
- deflected as **positive** particles in a magnetic field.
- Cannot penetrate human skin however hazardous if ingested.
- Can only travel 1 inch through air.
- Penetrating power is not very good (10% of speed of light) hence can be stopped by a single of paper.

Example : The iridium-168 isotope is known to go through alpha decays. Write out a decay equation that shows this process.

Solution

$$^{168}_{77}Ir \rightarrow ^{4}_{2}\alpha + ^{164}_{75}Re$$

2. BETA DECAY (β)

- deflected as the **negative** particle in a magnetic field.
- Can pass through about 3mm of aluminium.
- It can be positive (positron) ${}^{0}_{1}e$
- It can be negative (electron) ${}^{0}_{-1}e$
- Travels with speed of 90% of the speed of light.
- The neutron becomes a proton (which stays in the nucleus) and an electron that goes out (the beta particle)

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

Example:

Potassium-40 is known to go through beta positive decays. Write out the decay equation for this decay.

$${}^{40}_{19}K \rightarrow {}^{0}_{1}\beta + {}^{40}_{18}Ar$$

3. GAMMA DECAY (γ)

- not deflected in a magnetic field.
- can pass through several cm of LEAD.
- Does not involve any change in the atomic (proton) number or mass number. [**no mass, no charge**]

Example:

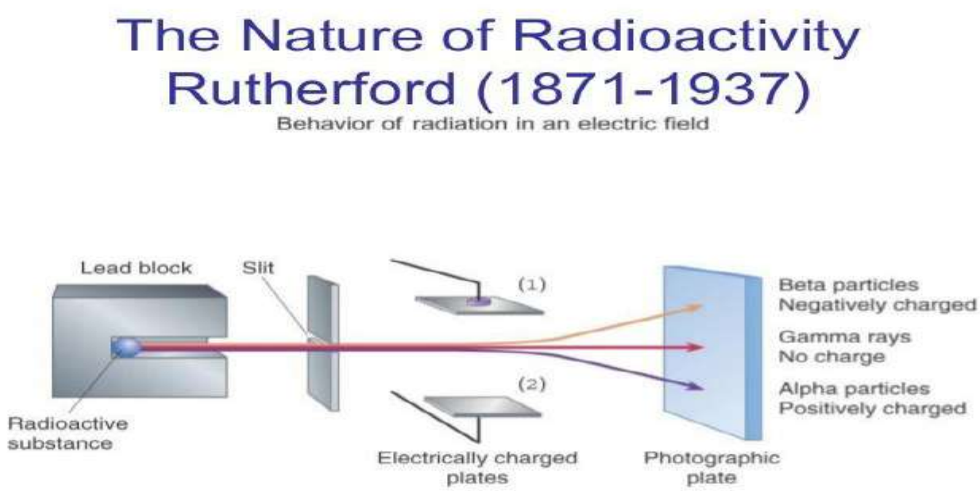
The argon-40 that was produced in Example 4 is in an excited state, so it releases a burst of gamma radiation. Write the equation for this.

Solution

$${}^{40}_{18}Ar \rightarrow \gamma + {}^{40}_{18}Ar$$

<u>Order of penetrating power</u>
γ (highest) > β > α (lowest)

<u>Order of ionizing power</u>
α (highest) > β > γ (lowest)



note:

1. Nuclear Reaction: changes in the nucleus of the atom. The energy released Is called nuclear energy.

2. Nuclear fusion: nuclei of two atoms fuse together to form a heavier nucleus.

3.Nuclear fission: the unstable atom splits into stable atom.

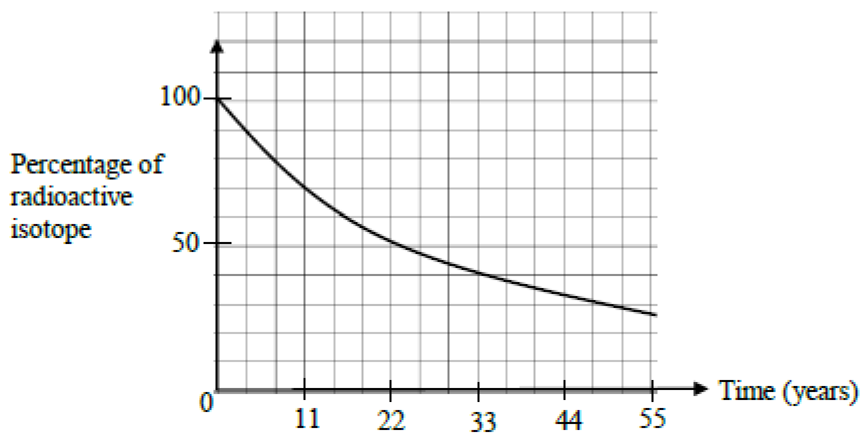
4. Binding energy: amount of energy which must be supplied to separate the nucleus into individual nucleons.

5. In nuclear reaction- these following quantities must remain constant.
   a. mass number
   b. atomic number
   c. momentum
   d. mass energy

LESSON 111 LO: solve problems involving radioactive decay.

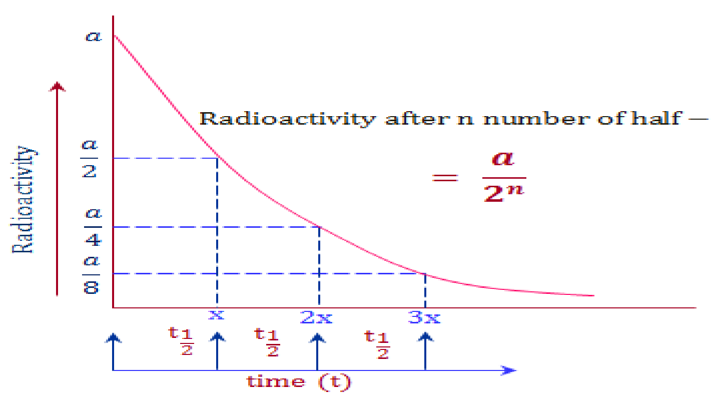
HALF LIFE

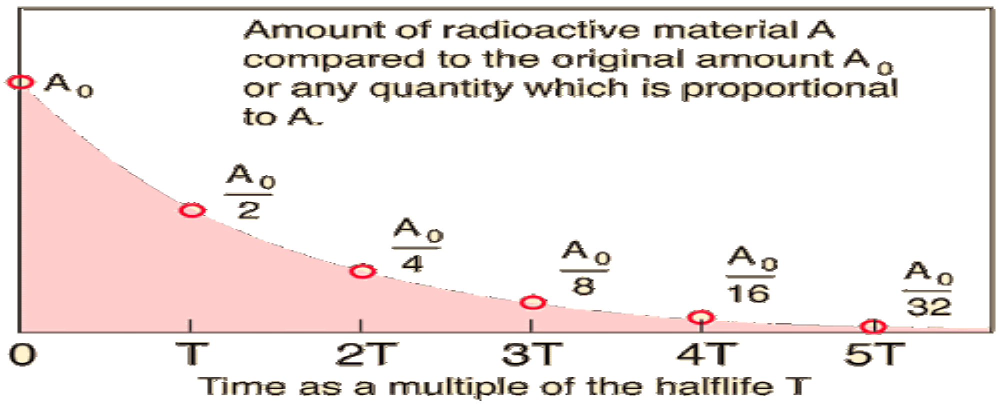
- Time taken for half of the radioactive element to decay. or
- Is the time it will take half of the parent atom to trans mutate into something else (through alpha or beta decay)



$$A = \frac{A_o}{2^n}$$

A_o: amount remaining
n: number of half life





Example

Let say you have 100 g of radioactive C-14. The half-life of C-14 is 5730 years.

(a) How many grams are left after one half-life?

50g

(b) How many grams are left after two half-lives?

$100gram \xrightarrow{\boxed{1}} 50gram \xrightarrow{\boxed{2}} 25gram$

Example

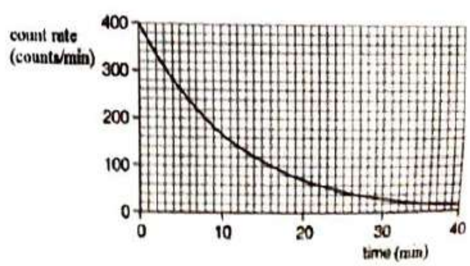
You have 160 g of an isotope with a half-life of 4 days. How much will be left after 16 days?

You can work this out by saying: $\frac{16days}{4days} = 4$ *Half lives*

160gram $\xrightarrow{1}$ 80gram $\xrightarrow{2}$ 40gram $\xrightarrow{3}$ $\xrightarrow{4}$ 10gram

Example

Given below is the decay curve for a radioactive isotope that emits only β-particles. Use the graph to find the value of the half-life of the isotope. *The count rate drops from 400 to 200 counts a minute in 8 minutes, so the half-life is 8 minutes.*



2019

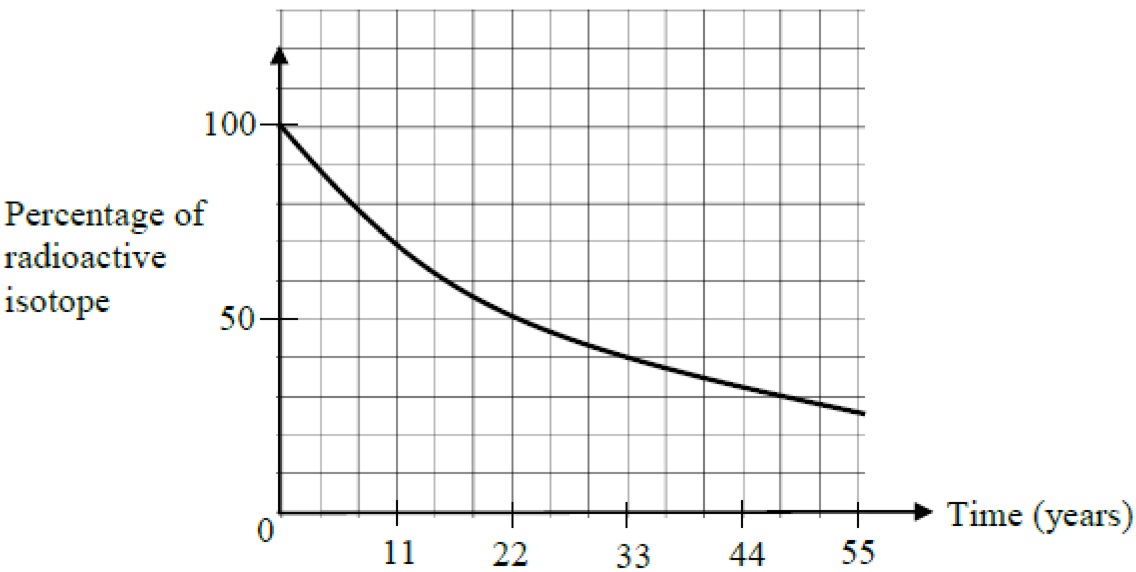
A radioactive source has half-life of 60 hours. How many hours will it take to decay to $\frac{1}{16}$ of its original amount? **(2 marks)**

2018

During beta decay, an electron is emitted from the nucleus as a β-particle. Which of the following can be used to stop beta particles from travelling in air?

A. Oil
B. Lead
C. Paper
D. Aluminium

The graph given below shows the decay curve for a radioactive isotope of lead, $^{210}_{82}Pb$, of initial mass 20 mg.



(i) Use the graph above to determine the half-life of lead isotope. **(1 mark)**

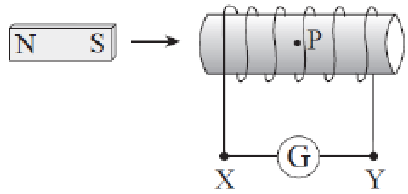
(ii) Calculate the fraction of lead that has **decayed** after 66 years. **(2 marks)**

(iii) Calculate the amount of lead left after 66 years. **(1 mark)**

WORKSHEET 9 QP

2010

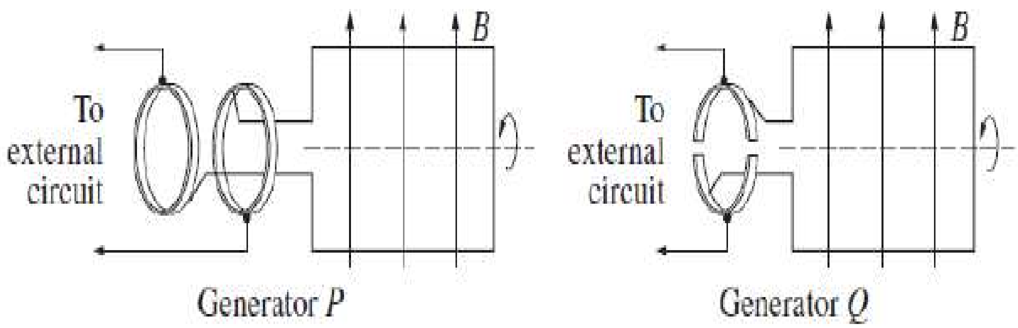
The diagram given below shows a bar magnet moving towards a solenoid.



Which of the pairs in the table below indicates the **direction of the current** through the galvanometer and the **direction of the magnetic field** produced by this current at location P inside the solenoid?

	Direction of the current through the Galvanometer	Direction of the magnetic field at P
A.	From X to Y	Right
B.	From X to Y	Left
C.	From Y to X	Right
D.	From Y to X	Left

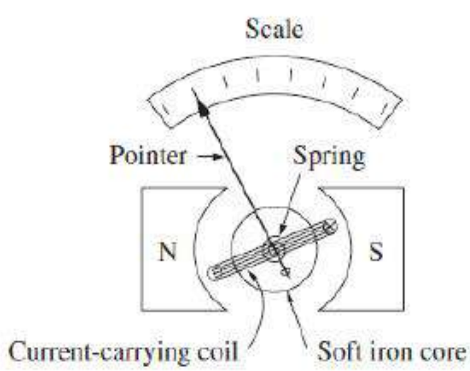
Two types of generators are shown in the diagram below.



(i) What is the function of the brush in a generator? **(1 mark)**

(ii) Which of these generators is an AC generator? **(1 mark)**

The diagram given below shows a simple electrical meter.



(i) State the purpose of the soft iron core. **(1 mark)**

(ii) State **one** way of increasing the sensitivity of the electric meter. **(1 mark)**