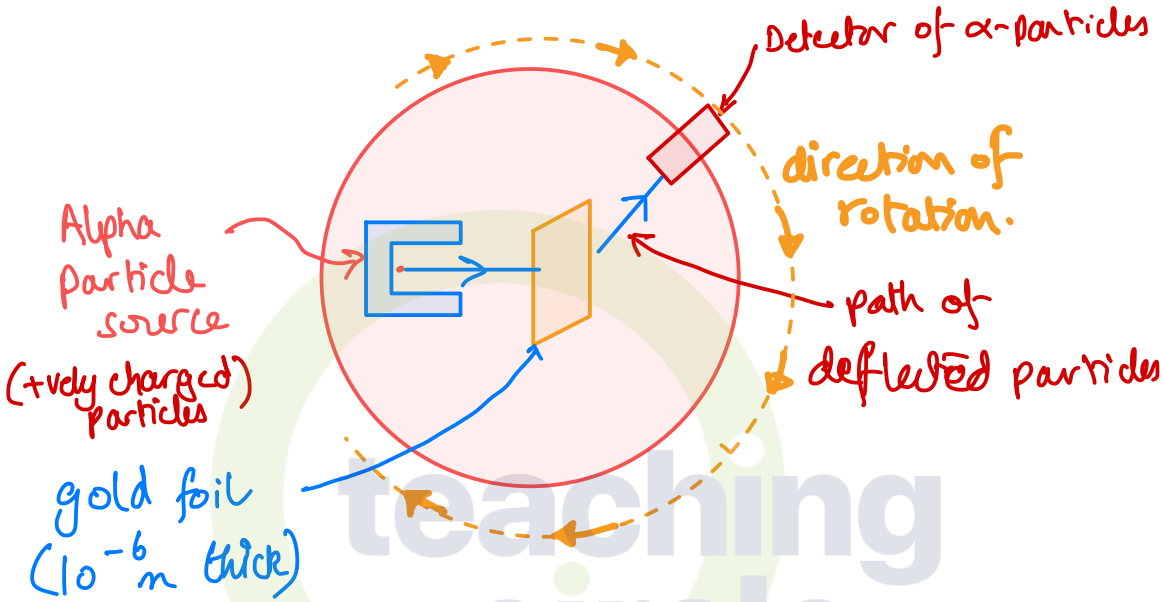
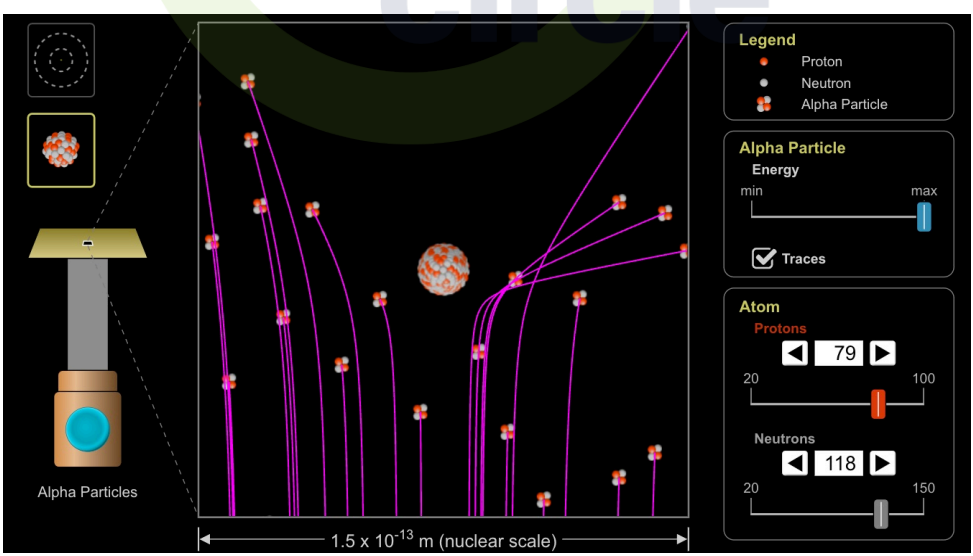
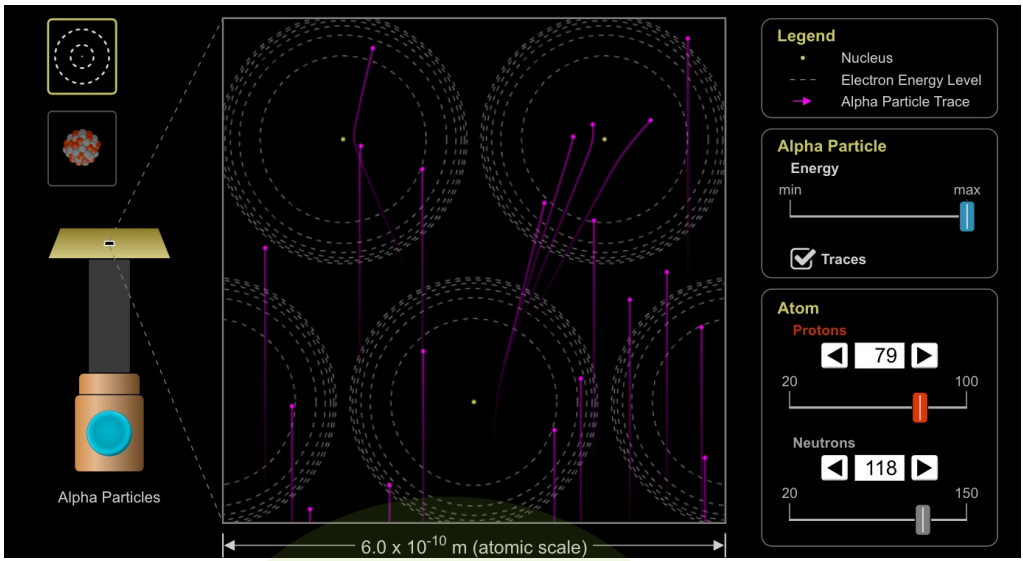
Particle Physics

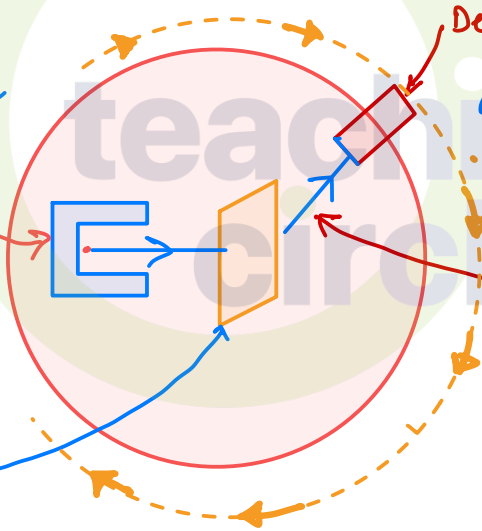






encased in a metal with a small gap for a fine beam

Alpha particle source



Detector of α-particles

detects scattered α-particles through different angles.

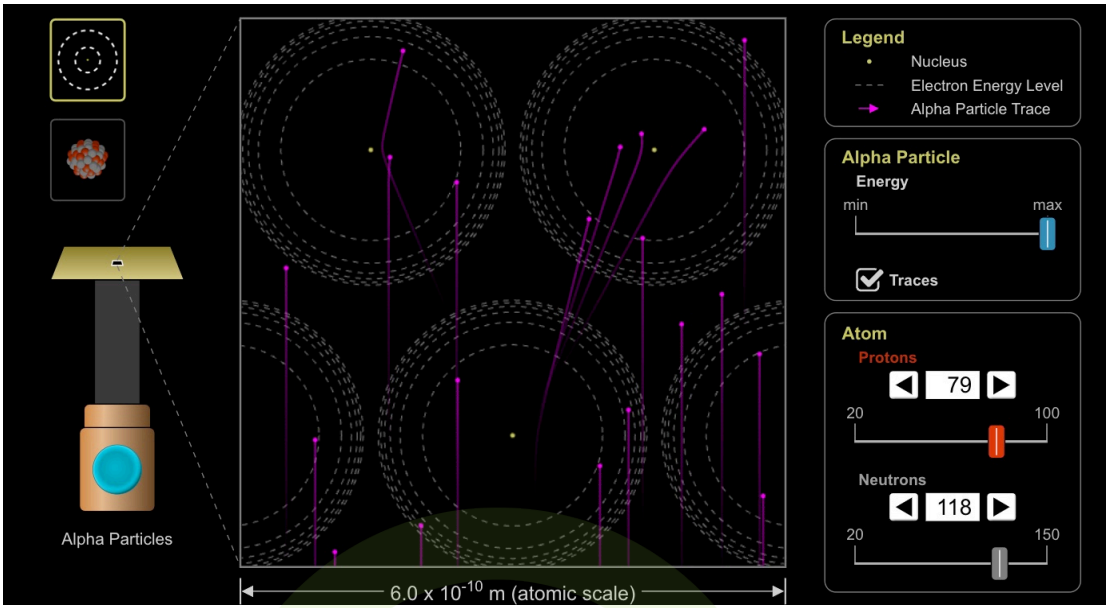
path of deflected particles

gold foil (10^{-6} m thick)

↓

gold is used because it is malleable, can be easily broken down into sheets.

Thin: to allow alpha particles to pass without being absorbed.



Observations:	Conclusions
Majority of alpha particles pass straight undeviated	Atom is majorly vacant.
Some alpha particles deflect through small angles. (<10°)	There is a positively charged nucleus which repels alpha particles.
Very few alpha particles deflect through large angles. (>90°)	Nucleus is charged and contains most of mass.
	Atoms consist of small dense truly charged nuclii.

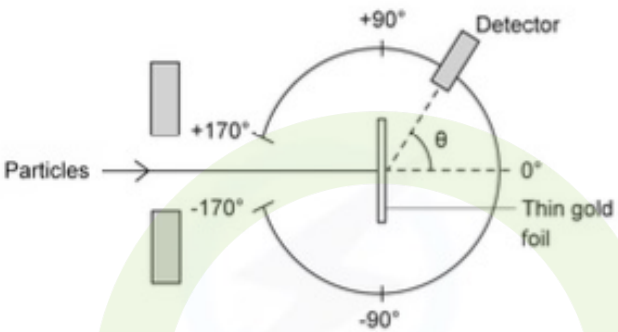
Diameter of atom $\sim 10^{-10}$ m

Diameter of nucleus $\sim 10^{-14} - 10^{-15}$ m

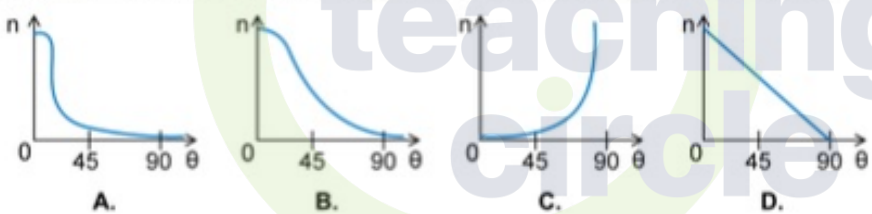
Note: e have negligible mass and they don't concentrate (they are spinning)

In an α-particle scattering experiment, a student set up the apparatus below to determine the number n of α-particle incident per unit time on a detector held at various angles θ.

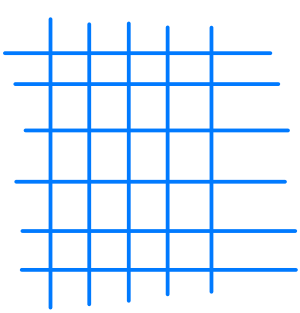
Max



Which of the following graphs best represents the variation of n with θ from 0 to 90°?



Note:



wire mesh & gold foil.

→ alpha particles

- Why Beta particle is not used? Light particle and would be repelled by orbiting e.
- Why gamma is not used? Gamma is neutral, it passes straight undeviated

Nuclide Notation

- $^{A}_{Z}X \longrightarrow$ nuclide

A: mass number / nucleon number

Z: proton number

- protons and neutrons collectively in nucleus are called nucleons.

Isotopes

Forms of the same element with different mass numbers (or different number of neutrons).

$^{1}_{1}H$, $^{2}_{1}H$, $^{3}_{1}H$

Identity of an element

A. Proton #

B. Nucleon #

Note:

* If an atom is neutral then which numbers will always be equal?

6 **(a)** One of the results of the α-particle scattering experiment is that a very small minority of the α-particles are scattered through angles greater than 90°.

State what may be inferred about the structure of the atom from this result.

.....

.....

.....

..... [2]

7 Which statement about the alpha-particle scattering experiment provides evidence for the existence of the nucleus?

A A tiny proportion of the alpha-particles are deflected through large angles.
B Slower alpha-particles are deflected through larger angles.
C The kinetic energies of the deflected alpha-particles are unchanged.
D The number of alpha-particles deflected depends on the thickness of the foil.

4 The table gives some data relating to four neutral (uncharged) atoms W, X, Y and Z.

	W	X	Y	Z
nucleon (mass) number	16	17	17	18
total number of particles (protons, neutrons and electrons) in the atom	24	26	25	28

Two of the atoms are isotopes of the same element.
What is the proton number of this element?

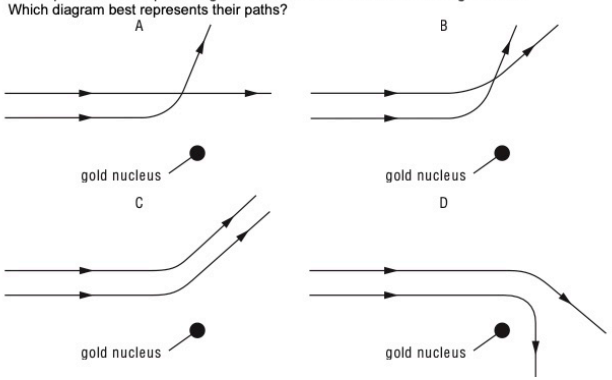
A 7 **B** 8 **C** 9 **D** 10

12 A nucleus Q has the notation ${}^{y}_{x}Q$.

Which of the following is an isotope of Q?

A ${}^{y-1}_{x}Q$ **B** ${}^{y}_{x-1}Q$ **C** ${}^{y}_{x+1}Q$ **D** ${}^{y-1}_{x+1}Q$

29 Two α-particles with equal energies are fired towards the nucleus of a gold atom.
Which diagram best represents their paths?



e.g $^{197}_{79}Au$ # of protons

# of neutrons.

Unified Mass Atomic Unit (u)

Mass of a proton or neutron

$1u = 1.66 \times 10^{-27} kg$

* The masses of nuclii are very small hence expressed in terms of u.

mass of proton = 1u

mass of neutron = 1u

mass of an atom of Au = 197u

Elementary Charge

$1e = 1.6 \times 10^{-19} C.$

Charge on Gold nucleus =

He^4_2

Mass of 1 atom of He = _____

Charge on He nucleus = _____

(c) A radioactive source produces a beam of α-particles in a vacuum. The average current produced by the beam is 6.9×10^{-9}A.

Calculate the average number of α-particles passing a fixed point in the beam in a time of 1.0 minute.

number = ... [3]

Nuclear Reactions have to obey conservation laws.

i) Nucleon Number
ii) Charge.
iii) Baryon Number
iv) Lepton Number.

46 A nickel nucleus $^{59}_{28}Ni$ can be transformed by a process termed K-capture. In this process the nucleus absorbs an orbital electron.
If no other process is involved, what is the resulting nucleus?

A $^{58}_{28}Ni$ **B** $^{58}_{27}Co$ **C** $^{59}_{27}Co$ **D** $^{59}_{29}Cu$

$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{96}_{37}Rb + {}^{137}_{55}Cs + N\,{}^{1}_{0}n$$

Type	Composition	Mass (kg)	Charge (C)	Relative Ionization	Relative Penetration
Alpha (α)	2 protons + 2 neutrons (Helium nucleus)	6.64×10^{-27}	$+3.20 \times 10^{-19}$	Very high ionization	Very low penetration (stopped by paper)
Beta minus (β^-)	Electron (e^-)	9.11×10^{-31}	-1.60×10^{-19}	Moderate ionization	Moderate penetration (stopped by aluminum)
Beta plus (β^+)	Positron (e^+)	9.11×10^{-31}	$+1.60 \times 10^{-19}$	Moderate ionization	Moderate penetration (stopped by aluminum)
Gamma (γ)	Photon (high-energy EM radiation)	0	0	Very low ionization	Very high penetration (stopped by thick lead or concrete)

Key Notes:

- **Alpha particle** (α) consists of 2 protons and 2 neutrons, making it a Helium nucleus. It has a relatively large mass compared to beta particles and a positive charge.
- **Beta minus** (β^-) is an electron emitted during beta decay.
- **Beta plus** (β^+) is a positron, the electron's antiparticle.
- **Gamma radiation** (γ) is high-energy electromagnetic radiation, with no mass or charge.
- **Ionization** refers to how easily the particle can ionize atoms it passes through. Alpha particles have very high ionization power, while gamma rays have very low ionization power.
- **Penetration** refers to how far the radiation can penetrate materials. Alpha particles are stopped by paper or skin, beta particles can be stopped by a few millimeters of aluminum, and gamma rays require thick lead or concrete to be stopped.

Matter and Antimatter

- Everything we know of is made up of matter. (protons, neutrons, electrons .. - -.)
- Every matter has its antimatter.

e.g $x = \sqrt{4}$

$x = \pm 2$

$+2$ Matter

-2 Antimatter

dash for anti particle

Antiparticle

- All properties for matter and antimatter are same except charge "sign."

Matter	charge	Antimatter	charge
electron	-1		
proton	$+1$		
neutron	0		
electron neutrino	0		

particle	antiparticle
u, d, c, s, t, b	