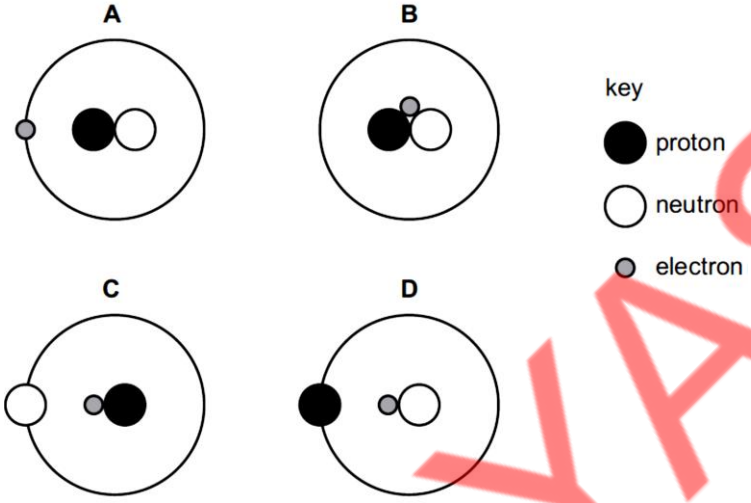
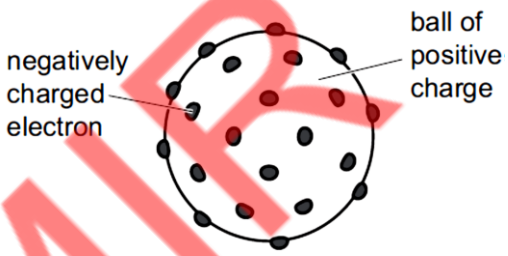
Chapter # 23
Nuclear Physics
Atom/Nucleus/Isotopes

Q-1: Which diagram shows a possible structure of a neutral atom?



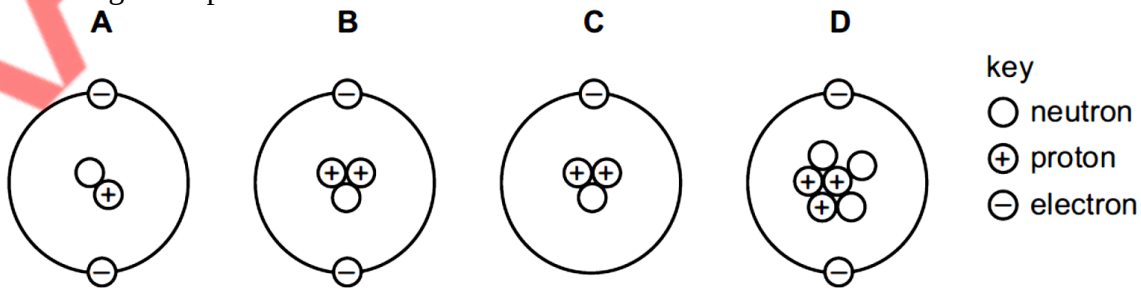
Q-2: The diagram shows an early model of the structure of an atom.



This early model is different from the atomic model accepted today.
Which statement about the early model is **not** included in the model accepted today?

A The atom is mainly filled with a ball of positive charge.
B The electrons are negatively charged.
C There are positive and negative charges.
D There are small particles called electrons.

Q-3: Which diagram represents the structure of a neutral atom?



Q-4: A simple model of the atom consists of small particles orbiting a central nucleus. Which row is correct?

	charge on nucleus	charge on orbiting particles
A	negative	negative
B	negative	positive
C	positive	negative
D	positive	positive

Q-5: What is the nucleon number of a nuclide?

A the number of neutrons in the nucleus
B the number of protons in the nucleus
C the number of protons minus the number of neutrons in the nucleus
D the number of protons plus the number of neutrons in the nucleus

Q-6: Which statement about the nuclei of all atoms is correct?

A They all contain electrons.
B They are all always stable.
C They all contain protons and electrons.
D They all have a positive charge.

Q-7: The nucleus of an atom X is represented by the notation shown.

$$^{P}_{Q}X$$

How many protons and how many neutrons are in this nucleus?

	number of protons	number of neutrons
A	P	Q
B	P	Q – P
C	Q	P
D	Q	P – Q

Q-8: The charge on a proton is *e*. What is the charge on an electron and what is the charge on a neutron?

	electron	neutron
A	*e*	*e*
B	*e*	0
C	$-e$	$-e$
D	$-e$	0

Q-9: Which statement is correct for the nucleus of **any** atom?

A The nucleus contains electrons, neutrons and protons.
B The nucleus contains the same number of protons as neutrons.
C The nucleus has a total charge of zero.
D The nucleus is very small compared with the size of the atom.

Q-10: The symbol represents a nucleus of zinc.

$^{68}_{30}Zn$

Which row gives the numbers of protons and neutrons in this nucleus?

	number of protons	number of neutrons
A	30	38
B	30	68
C	38	30
D	38	68

Q-11: A nuclide of cobalt contains 27 protons and 32 neutrons. Which symbol represents this nuclide?

A $^{27}_{59}Co$ **B** $^{32}_{27}Co$ **C** $^{32}_{59}Co$ **D** $^{59}_{27}Co$

Q-12: Four nuclides are represented below.

$^{6}_{3}E$ $^{7}_{3}G$ $^{6}_{4}L$ $^{7}_{5}M$

Which pair of nuclides are isotopes of the same element?

A E and G **B** E and L **C** G and L **D** G and M

Q-13: The nuclide notation for the isotope lithium-7 is $^{7}_{3}Li$ How many neutrons are there in an atom of lithium-7?

A 3 **B** 4 **C** 7 **D** 10

Q-14: Each nucleus of nuclide X contains 10 protons and a total of 22 nucleons. Which notation is correct for this nuclide?

A $^{22}_{10}X$ **B** $^{22}_{32}X$ **C** $^{12}_{10}X$ **D** $^{10}_{22}X$

Q-15: An iron nuclide is represented by the symbol shown.

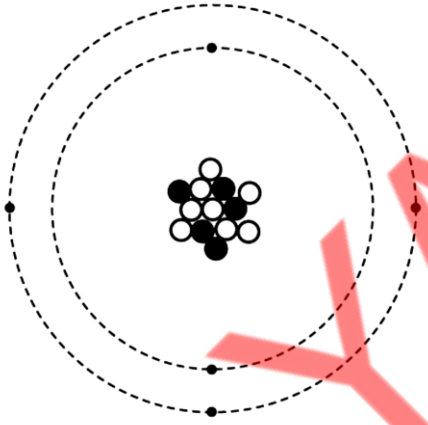
$^{56}_{26}Fe$

Which statements about a nucleus of this iron nuclide are correct?

1 The nucleus contains 56 neutrons.
2 The nucleon number is 30.
3 The proton number is 26.

A 1 and 2 only **B** 1 and 3 only **C** 2 and 3 only **D** 3 only

Q-16: Fig. represents a neutral atom of an isotope of element X.



a) State **one** similarity between this atom and a neutral atom of a different isotope of element X.

b) The isotope of element X is radioactive. It decays to form an isotope of element Y by emitting a β-particle.

i) Using Fig. deduce the nuclide notation for the isotope of Y produced by this decay.

nuclide notation: .....
..... Y

ii) β-particles ionise the air they pass through less strongly than the same number of α-particles. Suggest why this is so.

Q-17: Fig. 1 shows the nuclide notation for three isotopes of an element.

$$\begin{matrix} {}^{1}_{1}X & {}^{2}_{1}Y & {}^{3}_{1}Z \end{matrix}$$

a) **i)** Describe how the nuclide notation shows that each isotope is of the same element.

ii) Describe how the nuclide notation shows the differences between the isotopes.

b) Radioactive sources emit radiation when they decay. State the names of **three** types of radioactive emission.

c) Radioactive emissions have differing characteristics. One characteristic is their ionising effect. Complete the statement about ionisation, using words from the box. The words can be used once, more than once or not at all.

electrons	negatively	neutrons	positively	neutrally	protons

When atoms are ionised, ... may be removed, leaving ..... charged atoms (ions), or ..... may be gained, forming ..... charged atoms (ions).

d) Polonium-210 has a half-life of 140 days. A sample of polonium-210 has

8.0 × 1010 atoms. Calculate the number of polonium-210 atoms remaining in the sample after 280 days.

Alpha Particle scattering experiment

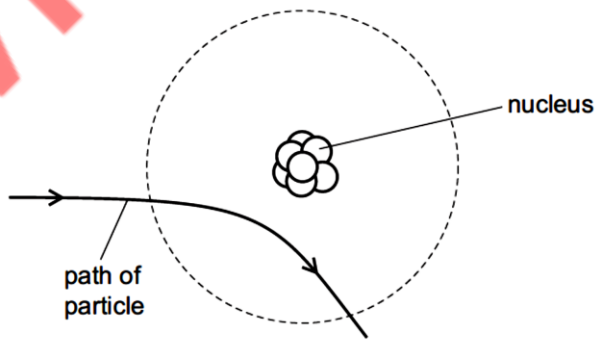
Q-18: In the Geiger Marsden experiment, a beam of alpha-particles is fired at a very thin sheet of gold foil, in a vacuum. What is deduced from this experiment?

A Alpha-particles are repelled by electrons.
B Atoms contain air.
C Electrons are found in atomic nuclei.
D Nuclei are much smaller than atoms.

Q-19: In the Geiger-Marsden experiment, a beam of alpha-particles is fired at a thin sheet of gold in a vacuum. The majority of the alpha-particles pass straight through the sheet without being deflected. What does this show?

A The alpha-particle is uncharged.
B The alpha-particle is very large.
C The nucleus is positively charged.
D The nucleus is very small.

Q-20: In the diagram, the circle represents an atom (not to scale) with the nucleus at its centre. A particle is emitted by a radioactive source and approaches the nucleus of the atom. The curved arrow shows the path of the particle.



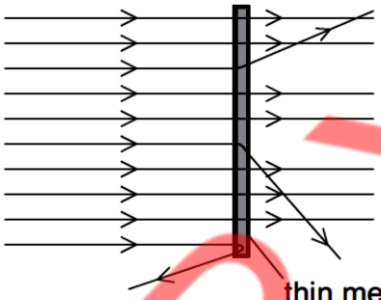
What is the nature and charge of the particle?

	nature of particle	charge of particle
A	α-particle	negative
B	α-particle	positive
C	β-particle	negative
D	β-particle	positive

Q-21: A very important experiment improved scientists' understanding of the structure of matter. The experiment involved α-particles being fired at a thin, gold foil.
What happened?

A All the α -particles were absorbed by the nuclei of the gold atoms.
B All the α -particles were unaffected by the gold atoms.
C Some of the α -particles were attracted by the neutrons in the nuclei of the gold atoms.
D Some of the α -particles were repelled by the protons in the nuclei of the gold atoms.

Q-22: The diagram shows α -particles incident on a thin metal foil.



How does the motion of these particles give evidence for the nuclear atom?

A Most particles passing through with minimal deflection shows that the atom is mostly Empty space.
B Most particles passing through with minimal deflection shows that the mass of the atom is uniformly distributed.
C Large deflections of some particles shows that the atom is mostly empty space.
D Large deflections of some particles shows that the charge in the atom is uniformly distributed.

Q-23: The scattering of particles by a thin gold foil provided scientists with evidence for the Nuclear atom. Which particles were scattered by the gold nuclei in the thin foil?

A α-particles **B** β-particles **C** neutrons **D** protons

Q-24: A thin metal foil is placed in a vacuum. α-particles are fired at the foil and most go Straight through. A very small proportion of the α-particles are deflected through large angles. What does this provide evidence for?

A α-particles are very small.
B There are negative electrons in each atom.
C There is a tiny nucleus in each atom.
D There are neutrons in each atom.

Q-25: α-particles are directed at a metal foil. Most of the particles pass through the foil with little

change in direction. A small proportion of the particles are scattered back through large angles. What does this evidence suggest about the structure of an atom?

A It consists of a charged centre much smaller than the size of the atom and with little of the mass of the atom.

B It consists of a negative charge the size of the atom containing small positive charges scattered through it.

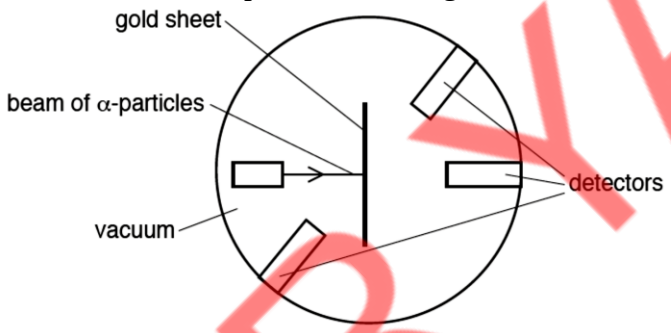
C It consists of a charged centre much smaller than the size of the atom but with most of The mass of the atom.

D It consists of a positive charge the size of the atom containing small negative charges scattered through it.

Q-26: The results of the alpha-particle scattering experiment gave evidence for which of the following?

A nuclear fusion **B** radioactive decay **C** the existence of isotopes **D** the nuclear atom

Q-27: a) Fig. shows a beam of α-particles moving towards a thin sheet of gold in a vacuum.



Detectors in the region surrounding the thin gold sheet detect the α-particles and determine the number of particles that travel in various directions. State and explain what can be deduced from the following observations.

i) The majority of the α-particles pass through the gold sheet undeflected and are detected on the far side.

deduction :

explanation :

ii) A small number of α-particles are deflected as they pass through the gold sheet.

deduction :

explanation :

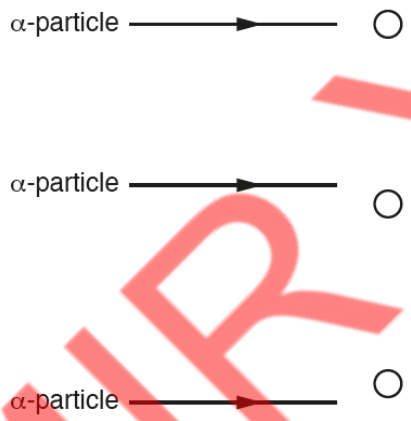
iii) A very small number of α-particles are deflected through very large angles or return back the way they came.

Deduction:

explanation :

b) A beam that consists of both α-particles and β-particles is passed through a region of space where there is a magnetic field perpendicular to the direction of the beam. State **two** ways in which the deflection of the α-particles differs from that of the β-particles.

Q-28: a) The circles shown in Fig. represent three gold nuclei. Three α-particles are approaching the gold nuclei.



On Fig., complete the path of each α-particle.

b) A detector of radioactivity in a laboratory indicates an average of 16 counts / min when no radioactive samples are present. A radioactive sample of half-life 1.5 days is placed close to the detector, which indicates a count rate of 208 counts / min. Calculate the count rate that is indicated 6 days later.

c) The waste from nuclear power stations includes the isotopes technetium-99, tin-126 and selenium-79. These isotopes are radioactive with half-lives of many thousands of years. State **three** economic and environmental consequences of producing this waste.

Q-29: a) A student makes a model of an atom. The model contains 24 electrons, 25 protons and 26 neutrons. Some of these particles are inside a nucleus at the centre of the model.

i) Determine the nucleon number (mass number) of the atom.

ii) Explain why the model represents a charged atom.

iii) The student makes a new model of a different isotope of the same element. Describe the nucleus of this new model.

b) Americium-241 is radioactive. Its nuclide notation is $^{241}Am_{94}$.

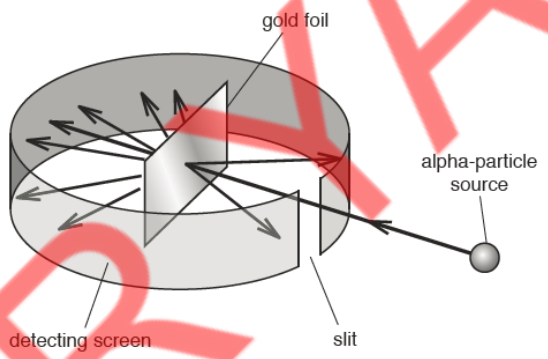
i) Determine the number of neutrons in a nucleus of americium-241.

ii) A nucleus of americium-241 emits an α-particle and decays to

uranium237. Complete the nuclear equation for the decay of americium-241.

$$^{241}_{94}Am \rightarrow \text{.....}^{\text{.....}}\alpha + {}^{237}_{\text{.....}}U$$

c) Geiger and Marsden studied the structure of gold atoms. Fig. 1 shows a version of their apparatus. Alpha-particles strike a thin gold foil.

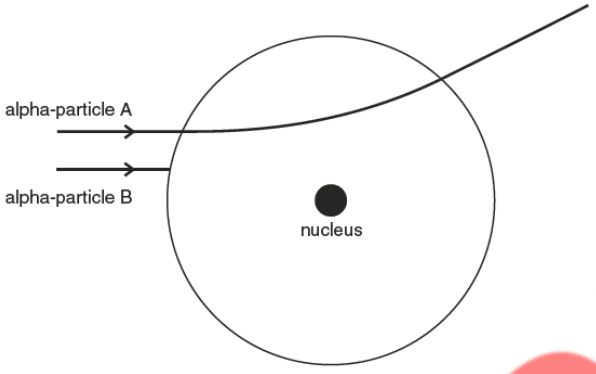


The apparatus shown is in a container from which all the air is removed.

i) Suggest why it is necessary to remove all the air from the container.

ii) The alpha-particles are emitted from the source at random. Explain why most of the alpha particles from the source do not reach the gold foil.

iii) Fig. 2 shows a model of an atom of the gold foil, with its nucleus at the centre.



The alpha-particle labelled A is deflected by the nucleus, as shown. On Fig. 2, complete the path of the alpha-particle labelled B.

iv) Explain how the alpha-particle scattering experiment provides evidence for the existence of a small nucleus inside the atom.

Answer

Q-1: A **Q-2: A** **Q-3: B** **Q-4: C** **Q-5: D** **Q-6: D** **Q-7: D**

Q-8: D **Q-9: D** **Q-10: A** **Q-11: D** **Q-12: A** **Q-13: B** **Q-14: A**

Q-15: D

Q-16: a) **equal number of electrons OR equal number of protons**

b) **i)** $^{13}X_5\ ^{0}\beta_{-1}\ ^{13}Y_6$

ii) **any three from:**
β-particles have charge of smaller size
β -particles have smaller mass
β -particles have less energy
β particles travel faster / less time near to air molecule
effect / force on electrons in air molecules less

Q-17: a) **i)** **same proton number OR same number of protons OR same atomic number OR same Z**

ii) **different nucleon number OR different number of neutrons OR different mass number OR different A**

b) **alpha, beta and gamma OR symbols**

c) **top line: electrons – positive (ly)**
bottom line: electrons – negative (ly)

d) **two half-lives indicated**
2.0 x10^{10} (atoms remain)

Q-18: D **Q-19: D** **Q-20: B** **Q-21: D** **Q-22: A** **Q-23: A** **Q-24: C**

Q-25: A **Q-26: D**

Q-27: a) i) nucleus is very small
very few α-particles hit or pass near to a nucleus
ii) nucleus is charged
(charged) α-particles experience a force
iii) centre / (small) part of atom OR nucleus includes most of the mass of the atom / is (very) dense
(α-particles move and) nucleus stays still
b) any two from:
opposite direction
(much) smaller deflection
undergo deflections of similar magnitude

Q-28: a) top: any path to the left within 45 degrees to the horizontal
middle: path to the right and deflected up (ending in a straight line)
bottom: path to the right and deflected down (ending in a straight line)
b) 192
use or clear indication of 4 half-lives
(192 / 16 =) 12
c) any 3 different valid points e.g.
• must be stored with shielding
• must be stored securely / safely
• must be transported with shielding
• must be transported securely
• expensive to store
• expensive to transport
• in case of accident / terrorism could escape to environment / danger to people
• site of storage uninhabitable for thousands of years

Q-29: a) i) 51
ii) more protons than electrons
or different number of protons and electrons
positive and negative do not cancel
iii) 25 protons
a different number of neutrons
b) i) 147
ii) α has mass number 4
α has proton number 2
correct proton number for U ecf their value for α
c) i) alpha particles only travel a short distance in air
or alpha particles stopped / scattered / deflected by air
or alpha particles ionise air
ii) particles come off in different directions

or not emitted in one line / as a ray
or not all the particles pass through the slit

\ **iii)** **B correct shape and deflected more than A**

iv) **particles close to / fired at the nucleus are deflected (back) / repelled some particles pass (straight) through**
a few particles come back / large deflection or most pass (straight) through (with little deviation)
and how this explains the nucleus is small