38 The diagram shows a sequence of radioactive decays involving three α-particles and a β^- particle.

$$^{237}_{93}\text{Np} \xrightarrow{\alpha} \text{Q} \xrightarrow{\beta^-} \text{R} \xrightarrow{\alpha} \text{S} \xrightarrow{\alpha} \text{T}$$

What is nuclide T?

A $^{225}_{88}$Ra **B** $^{231}_{88}$Ra **C** $^{225}_{90}$Th **D** $^{229}_{90}$Th

39 The number of electrons in a neutral atom of an isotope of plutonium, $^{239}_{94}$Pu, is changed to produce a charged atom (ion) W.

W has an overall charge of $+1.6 \times 10^{-19}$ C.

How many protons, neutrons and electrons are in W?

	protons	neutrons	electrons
A	94	145	93
B	94	145	95
C	238	94	239
D	239	94	238

39 A nucleus of magnesium-23 decays to form a nucleus of sodium-23, emitting a β^+ particle and particle X.

What is particle X?

A an antineutrino

B an electron

C a neutron

D a neutrino

40 A nucleus of $^{238}_{92}$U decays in stages by emitting α-particles and β^- particles, eventually forming a nucleus of $^{206}_{82}$Pb.

How many α-particles and how many β^- particles are emitted during the decay chain?

	α-particles	β^- particles
A	8	6
B	8	10
C	16	6
D	16	22

38 What is the correct equation for β^+ decay?

A neutron $\rightarrow$ proton + electron + electron antineutrino

B neutron $\rightarrow$ proton + electron + electron neutrino

C proton $\rightarrow$ neutron + positron + electron antineutrino

D proton $\rightarrow$ neutron + positron + electron neutrino

39 A nucleus of polonium, $^{214}_{84}$Po, decays by emitting an α-particle to become a nucleus of lead.

The nucleus of lead is also unstable and decays by emitting a β^- particle to form a nucleus of bismuth which then decays by emitting a β^- particle to produce a nucleus X.

What is the number of neutrons in nucleus X?

A 126 **B** 128 **C** 130 **D** 210

6 The nuclide $^{3}_{1}H$ is an isotope of hydrogen that is called tritium.

(a) **(i)** Determine the numbers of protons, neutrons and electrons in a neutral atom of tritium.

number of protons = ...

number of neutrons = ...

number of electrons = ...

[2]

(ii) Draw a labelled diagram to represent a simple model of the arrangement of the protons, neutrons and electrons in a tritium atom.

[2]

(b) Tritium is radioactive and undergoes β^- decay to form an isotope of helium (He). Gamma radiation is not emitted during this decay.

(i) Complete the equation to represent the radioactive decay of tritium.

$$^{3}_{1}H \rightarrow {}^{\ldots\ldots}_{\ldots\ldots}He + {}^{\ldots\ldots}_{\ldots\ldots}\beta + {}^{0}_{0}X$$

[2]

(ii) State the name of particle X.

..... [1]

(c) Determine the quark composition of a tritium nucleus.

.....

..... [2]

[Total: 9]

6 Fig. 6.1 shows four alpha particles W, X, Y and Z moving towards a gold nucleus that is in thin gold foil.

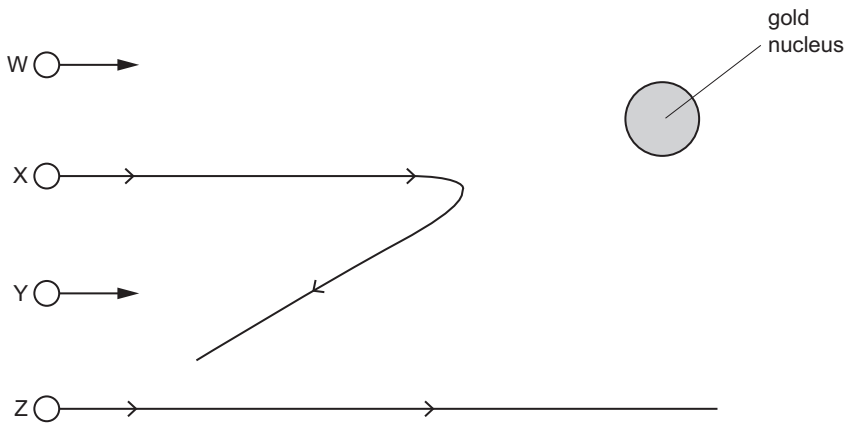

Fig. 6.1 (not to scale)

(a) **(i)** The paths of particles X and Z are shown.

Complete Fig. 6.1 to show possible paths for particles W and Y. [3]

(ii) Describe what may be inferred about the structure of an atom from the path of particle X.

.....

.....

..... [1]

(iii) When a beam containing many alpha particles is incident on thin gold foil, nearly all of the alpha particles follow paths that are similar to the path of particle Z.

Describe what may be inferred from this about the structure of an atom.

.....

.....

..... [1]

(b) State the mass and the charge, in terms of the atomic mass unit u and the elementary charge *e*, of an alpha particle.

mass = ... u

charge = ... *e*
[2]

(c) There are two types of hadron.
The hadrons that are in alpha particles are each composed of three quarks.

(i) State the name of this type of hadron.

..... [1]

(ii) Show, by reference to their constituent quarks, that the hadrons in an alpha particle have charges of either zero or +1*e*.

[2]

[Total: 10]

39 Which statement explains why alpha-particles have discrete energies, but beta-particles have a continuous range of energies?

A Beta-particles have a much smaller mass than alpha-particles which means beta-particles can be emitted with a larger range of velocities.

B Only alpha-particles experience repulsion from the nucleus which is dependent on the number of protons in the nucleus.

C Only beta-particles are emitted with another lepton and some energy is transferred to the other lepton.

D Only the energy of alpha-particles is discrete because the composition of alpha-particles is always the same.

38 Two neutral atoms are isotopes of the same element.

Which statement about the atoms is correct?

A They have a different number of neutrons and a different number of electrons.

B They have a different number of neutrons and the same number of protons.

C They have the same number of neutrons and a different number of electrons.

D They have the same number of neutrons and the same number of protons.

7 **(a)** Nitrogen-12 ($^{12}_{7}$N) is an unstable isotope of nitrogen that decays by the emission of radiation to carbon-12 ($^{12}_{6}$C).

Complete the full nuclear equation for the decay, including all the particles involved.

$^{12}_{7}\text{N} \rightarrow$

[3]

(b) Hydrogen-1 ($^{1}_{1}$H) is an isotope of hydrogen. An atom of hydrogen-1 comprises a proton with an orbiting electron.

An antiparticle equivalent of hydrogen-1 comprises an antiproton with an orbiting positron. The antiquarks in the antiproton are the antiparticles of the quarks in a proton.

(i) State the charge on the positron in terms of the elementary charge *e*.

charge = ... *e* [1]

(ii) State the group (class) of fundamental particle to which the positron belongs.

..... [1]

(iii) In Table 7.1, state the flavour and charge of the three antiquarks that comprise the antiproton.

Table 7.1

flavour	charge / *e*

[3]

[Total: 8]

5 **(a)** Potassium-40 ($^{40}_{19}K$) undergoes β^- decay to form a nuclide of element X. Particle Z is emitted during the decay. The equation for the decay is shown.

$$^{40}_{19}K \rightarrow {}^{P}_{Q}X + {}^{R}_{S}\beta^- + Z$$

(i) State the values of *P*, *Q*, *R* and *S*.

P = ... *R* = ...

Q = ... *S* = ...

[2]

(ii) State the name of particle Z.

..... [1]

(iii) State the name of the class of fundamental particle to which both the β^- particle and particle Z belong.

..... [1]

(b) Determine the quark composition of an alpha-particle.

quark composition ..... [3]

[Total: 7]