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

39 The number of electrons in a neutral atom of an isotope of plutonium, $^{239}_{94}\text{Pu}$, 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

40 Which particle is a lepton?

A meson

B positron

C proton

D quark

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.

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

[2]

(ii) State the name of particle X.

..... [1]

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

.....

..... [2]

[Total: 9]

40 The nucleus of a radioactive isotope of an element emits an α-particle. The daughter nucleus then emits a β^- particle and then the daughter nucleus of that reaction emits another β^- particle.

Which statement describes the final nuclide that is formed?

A It is a different isotope of the original element.

B It is a nuclide of a different element of higher proton number.

C It is a nuclide of the same element but with different proton number.

D It is identical to the original nuclide.

40 How many flavours (types) of antiquark are there?

A 3 **B** 4 **C** 5 **D** 6

8 **(a)** An antiparticle equivalent of the neutron is called the antineutron. The quarks in the antineutron are the antiparticles of the quarks in a neutron.

The elementary charge is *e*.

In Table 8.1, state the flavour and charge of the three antiquarks that comprise the antineutron.

Table 8.1

flavour	charge / *e*

[3]

(b) In β^- decay, a neutron decays to form a proton.

Theory predicts that an antineutron should decay to form an antiproton. A particle and an antiparticle should also be observed.

Suggest the names of the particle and the antiparticle.

particle: .....

antiparticle: .....

[2]

[Total: 5]

8 **(a)** State what is meant by the de Broglie wavelength.

.....

..... [1]

(b) Calculate the de Broglie wavelength of an electron moving at a speed of $4.9 \times 10^7\,\text{m s}^{-1}$.

wavelength = ... m [2]

(c) State **one** similarity and **one** difference between an electron and a positron.

similarity: .....

.....

difference: .....

.....
[2]

(d) An electron moving at a speed of $4.9 \times 10^7\,\text{m s}^{-1}$ collides with a positron that is travelling at the same speed in the opposite direction. As a result of the collision, two gamma-ray photons are produced.

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

..... [1]

(ii) State what happens to the electron and to the positron.

.....

.....

..... [2]

(iii) Explain why two gamma-ray photons are produced, rather than just one.

.....

..... [1]

(iv) Show that the kinetic energy of the electron before the collision is 1.1×10^{-15} J.

[1]

(v) Use the information in **(d)(iv)** to determine, to three significant figures, the wavelength associated with the gamma radiation emitted in the collision.

wavelength = ... m [3]

[Total: 13]