1. (a) Nuclei X and Y are different isotopes of the same element.

Nucleus X is unstable and emits a β^+ particle to form nucleus Z.

By comparing the number of protons in each nucleus, state and explain whether the charge of nucleus X is less than, the same as or greater than the charge of:

(i) nucleus Y

.....

..... [1]

(ii) nucleus Z.

.....

.....

..... [2]

(b) Hadrons can be divided into two groups (classes), P and Q. Group P is baryons.

(i) State the name of group Q.

..... [1]

(ii) Describe, in general terms, the quark structure of hadrons that belong to group Q.

.....

..... [1]

[Total: 5]

9702/22/O/N/22 Q7

2. (a) Describe the structure of an **atom** of uranium-238, $^{238}_{92}U$.

.....

.....

..... [2]

(b) The decay of uranium-238 is shown by the equation

$$^{238}_{92}U \longrightarrow {}^{234}_{90}Th + X.$$

For nucleus X, calculate the ratio, in $C\,kg^{-1}$, of

$$\frac{\text{charge}}{\text{mass}}.$$

ratio = ... $C\,kg^{-1}$ [3]

(c) Two particles P and Q each consist of three quarks. These quarks are up (u) or down (d) quarks.

Particle P has no overall charge.

Particle Q has an overall charge of +2*e*, where *e* is the elementary charge.

State the quark composition of:

(i) particle P

..... [1]

(ii) particle Q.

..... [1]

[Total: 7]

3. (a) A lepton is an example of a fundamental particle.

State what is meant by fundamental particle.

.....

..... [1]

(b) A lambda particle Λ^0 is a hadron that consists of an up (u) quark, a down (d) quark and a strange (s) quark.

Show that the charge on the Λ^0 particle is zero.

[2]

(c) The Λ^0 particle is unstable. It can decay into a neutron (n) and a pion (π^0) as shown by

$$\Lambda^0 \longrightarrow n + \pi^0.$$

The π^0 particle consists of an up quark and an up antiquark.

(i) Compare the properties of an up quark and an up antiquark.

.....

.....

..... [2]

(ii) Explain why the neutron is classed as a baryon and the π^0 particle is classed as a meson.

.....

.....

..... [2]

[Total: 7]

4. (a) Fluorine-18 ($^{18}_{9}F$) is an isotope that decays to an isotope of oxygen (O) by the emission of a β^+ particle.

(i) Complete the nuclear equation for the decay, including all the particles involved.

$$^{18}_{9}F \rightarrow$$

[3]

(ii) A quark in the fluorine-18 nucleus changes flavour during the decay. State this change of flavour.

..... quark to ..... quark. [1]

(b) A hadron has a charge of $-2e$, where e is the elementary charge.

(i) State and explain whether the hadron is a meson or a baryon.

.....

.....

..... [2]

(ii) State a possible quark composition for the hadron.

.....

..... [1]

[Total: 7]

9702/22/M/J/22 Q7

5.(a) A nucleus of caesium-137 ($^{137}_{55}Cs$) decays by emitting a β^- particle to produce a nucleus of an element X and an antineutrino. The decay is represented by

$$^{137}_{55}Cs \rightarrow {}^{Q}_{S}X + {}^{P}_{R}\beta^- + {}^{0}_{0}\overline{\nu}.$$

(i) State the number represented by each of the following letters.

P .....

Q .....

R .....

S .....

[2]

(ii) State the name of the class (group) of particles that includes the β^- particle and the antineutrino.

..... [1]

(b) A particle Y has a quark composition of ddd where d represents a down quark.

A particle Z has a quark composition of $\overline{u}$d where $\overline{u}$ represents an up antiquark.

(i) Show that the charges of particles Y and Z are equal.

[2]

(ii) State and explain which particle is a meson and which particle is a baryon.

meson: .....

.....

baryon: .....

.....

[2]

[Total: 7]

9702/21/M/J/22 Q7

6.(a) An unstable nucleus ${}^{A}_{Z}X$ decays by emitting a β^- particle.

(i) Determine quantitatively the changes, if any, in A and Z when X decays.

change in A = ...

change in Z = ...
[2]

(ii) In addition to the β^- particle, another lepton is emitted during the decay.

State the name of the other lepton that is emitted.

..... [1]

(b) A particle P is composed of an up quark (u) and a down antiquark ($\bar{d}$).

(i) Calculate the charge q of particle P in terms of e, where e is the elementary charge.

Show your working.

q = ... e [2]

(ii) Particle P belongs to **two** classes (groups) of particles.

State the names of these two classes.

1 .....

2 .....
[2]

[Total: 7]

9702/22/F/M/22 Q7

7. (a) A nucleus of sodium-22 ($^{22}_{11}Na$) decays by emitting a β^+ particle. A different nucleus is formed by the decay.

(i) State the name of another lepton that is produced by the decay.

..... [1]

(ii) Determine the nucleon number and the proton number of the nucleus that is formed by the decay.

nucleon number = ...

proton number = ...
[2]

(iii) The quark composition of a nucleon in the sodium-22 nucleus is changed during the decay.

Describe the change to the quark composition of the nucleon.

.....

..... [1]

(b) A baryon consists of quarks that are the same flavour (type). The charge of the baryon is $-2e$, where e is the elementary charge.

(i) Calculate, in terms of e, the charge of each quark.

charge = ... e [1]

(ii) State a possible flavour (type) of the quarks.

..... [1]

[Total: 6]

9702/22/O/N/21 Q7

8. A stationary nucleus P of mass 243 u decays by emitting an α-particle of mass 4 u to form a different nucleus Q, as illustrated in Fig. 7.1.

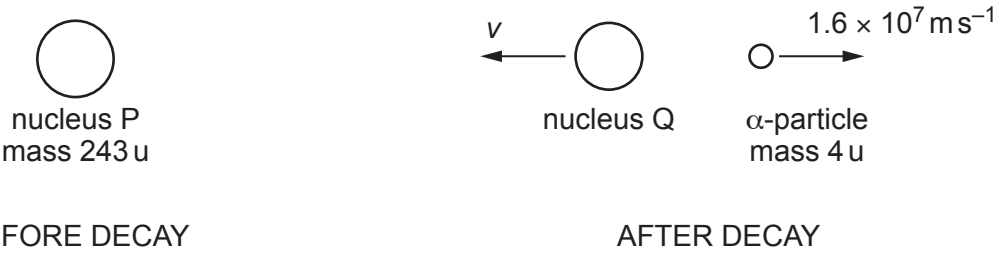

Fig. 7.1

The initial speed of the α-particle is $1.6 \times 10^7\,\text{m s}^{-1}$.

(a) Use the principle of conservation of momentum to explain why the initial velocities of nucleus Q and the α-particle must be in opposite directions.

.....

.....

.....

..... [2]

(b) Determine the initial speed v of nucleus Q.

v = ... m s^{-1} [2]

(c) Calculate the initial kinetic energy, in MeV, of the α-particle.

kinetic energy = ... MeV [3]

(d) A graph of number of neutrons N against proton number Z is shown in Fig. 7.2.

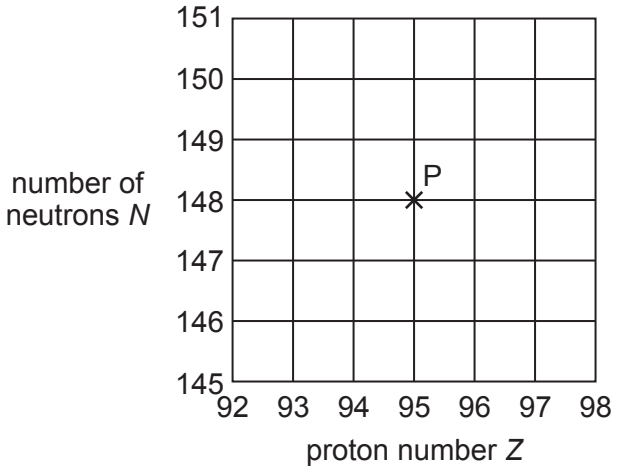

Fig. 7.2

The graph shows a cross that represents nucleus P.

A nucleus R has a nucleon number of 242 and is an isotope of nucleus P.

Nucleus R decays by emitting a β^- particle to form a different nucleus S.

(i) On Fig. 7.2, draw a cross to represent:

1. nucleus R (label this cross R)

2. nucleus S (label this cross S).

[2]

(ii) State the name of the other lepton, in addition to the β^- particle, that is emitted during the decay of nucleus R.

..... [1]

[Total: 10]

9. (a) Complete Table 6.1 to show the masses (in terms of the unified atomic mass unit u) and charges (in terms of the elementary charge *e*) of α, β^+ and β^- particles.

Table 6.1

	mass / u	charge / *e*
α-particle		
β^+ particle		
β^- particle		

[4]

(b) Carbon-14 is radioactive and decays by emission of β^- particles.

(i) Nuclei do not contain β^- particles.

Explain the origin of the β^- particle that is emitted from the nucleus during β^- decay.

.....

.....

..... [1]

(ii) State the change in the quark composition of a carbon-14 nucleus when it emits a β^- particle.

..... [1]

(iii) Suggest why the β^- particles are emitted with a range of different energies.

.....

.....

.....

..... [2]

[Total: 8]

10. **(a)** State the quark composition of:

(i) a proton

..... [1]

(ii) a neutron

..... [1]

(iii) an alpha-particle.

.....

..... [2]

(b) In the alpha-particle scattering experiment, alpha-particles were directed at a thin gold foil.

State what may be inferred from:

(i) the observation that most alpha-particles pass through the foil

..... [1]

(ii) the observation that some alpha-particles are scattered through angles greater than 90°.

.....

.....

..... [2]

(c) A proton and an alpha-particle are moving in the same uniform electric field.

Determine the ratio

$$\frac{\text{acceleration of proton due to the electric field}}{\text{acceleration of alpha-particle due to the electric field}}.$$

ratio = ... [2]

[Total: 9]

11. (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]

(b) An α-particle is made up of other particles. One of these particles is a proton.

State and explain whether a proton is a fundamental particle.

.....

..... [1]

(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]

(d) The α-particles in the vacuum in **(c)** enter a uniform electric field. The α-particles enter the field with their velocity in the same direction as the field.

State and explain whether the magnitude of the acceleration of an α-particle due to the field decreases, increases or stays constant as the α-particle moves through the field.

.....

.....

..... [2]

(e) A nucleus X is an isotope of a nucleus Y. The mass of nucleus X is greater than that of Y.

Both of the nuclei are in the same uniform electric field.

State and explain whether the magnitude of the electric force acting on nucleus X is greater than, less than or the same as that acting on nucleus Y.

.....

.....

..... [2]

[Total: 10]

12. **(a)** A proton in a nucleus decays to form a neutron and a β^+ particle.

(i) State the name of another lepton that is produced in the decay.

..... [1]

(ii) State the name of the interaction (force) that gives rise to this decay.

..... [1]

(iii) State which of the three particles (proton, neutron or β^+ particle) has the largest ratio of charge to mass.

..... [1]

(iv) Use the quark model to show that the charge on the proton is $+e$, where e is the elementary charge.

[2]

(v) The quark composition of the proton is changed during the decay.

Describe the change to the quark composition.

.....

..... [1]

13. (a) The results of the α-particle scattering experiment provide evidence for the structure of the atom.

Result 1: The vast majority of the α-particles pass straight through the metal foil or are deviated by small angles.

Result 2: A very small minority of α-particles is scattered through angles greater than 90°.

State what may be inferred (deduced) from:

(i) result 1

.....

..... [1]

(ii) result 2.

.....

.....

..... [2]

(b) A radioactive decay sequence contains four nuclei, P, Q, R and S, as shown.

$$^{218}_{84}\text{P} \rightarrow {}^{214}_{82}\text{Q} \rightarrow {}^{214}_{83}\text{R} \rightarrow \text{S}$$

Nucleus S is an isotope of nucleus P.

(i) Determine the proton number and the nucleon number of nucleus S.

proton number = ...

nucleon number = ...
[2]

(ii) The quark composition of a nucleon in Q changes as Q decays to form R.

Describe this change to the quark composition of the nucleon.

.....

..... [1]

[Total: 6]

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14. **(c)** The β^- particle is produced by the decay of a neutron.

(i) Complete the equation below to represent the decay of the neutron.

$$^{1}_{0}n \rightarrow {}^{0}_{-1}\beta^- + \begin{matrix}\cdots\cdots\\ \cdots\cdots\end{matrix}\cdots\cdots + \begin{matrix}\cdots\cdots\\ \cdots\cdots\end{matrix}\cdots\cdots$$

[2]

(ii) State the name of the group (class) of particles that includes:

1. neutrons

.....

2. β^- particles.

.....

[2]

15. **(a)** A nucleus of an element X decays by emitting a β^+ particle to produce a nucleus of potassium-39 ($^{39}_{19}K$) and a neutrino. The decay is represented by

$$^{Q}_{S}X \rightarrow {}^{39}_{19}K + {}^{P}_{R}\beta^+ + {}^{0}_{0}\nu.$$

(i) State the number represented by each of the following letters.

P .....

Q .....

R .....

S .....

[2]

(ii) State the name of the interaction (force) that gives rise to β^+ decay.

..... [1]

(b) A hadron is composed of three identical quarks and has a charge of +2*e*, where *e* is the elementary charge.

Determine a possible type (flavour) of the quarks.
Explain your working.

.....

..... [2]

[Total: 5]

16. **(a)** State and explain whether a neutron is a fundamental particle.

.....

..... [1]

(b) A proton in a stationary nucleus decays.

(i) State the **two** leptons that are produced by the decay.

.....

..... [2]

(ii) Part of the energy released by the decay is given to the two leptons.

State **two** possible forms of the remainder of the released energy.

.....

..... [2]

[Total: 5]

17. A nucleus of plutonium-238 ($^{238}_{94}$Pu) decays by emitting an α-particle to produce a new nucleus X and 5.6 MeV of energy. The decay is represented by

$$^{238}_{94}\text{Pu} \longrightarrow \text{X} + \alpha + 5.6\,\text{MeV}.$$

(a) Determine the number of protons and the number of neutrons in nucleus X.

number of protons = ...

number of neutrons = ...
[2]

(b) Calculate the number of plutonium-238 nuclei that must decay in a time of 1.0 s to produce a power of 0.15 W.

number = ... [2]

[Total: 4]

18. (a) The decay of a nucleus $^{35}_{18}Ar$ by β^+ emission is represented by

$$^{35}_{18}Ar \longrightarrow X + \beta^+ + Y.$$

A nucleus X and two particles, β^+ and Y, are produced by the decay.

State:

(i) the proton number and the nucleon number of nucleus X

proton number = ...

nucleon number = ...
[1]

(ii) the name of the particle represented by the symbol Y.

..... [1]

(b) A hadron consists of two down quarks and one strange quark.

Determine, in terms of the elementary charge *e*, the charge of this hadron.

charge = ... [2]

[Total: 4]

19. A sample of a radioactive substance may decay by the emission of either α-radiation or β-radiation and/or γ-radiation.

State the type of radiation, one in each case, that:

(a) consists of leptons

.....[1]

(b) contains quarks

.....[1]

(c) cannot be deflected by an electric field

.....[1]

(d) has a continuous range of energies, rather than discrete values of energy.

.....[1]

[Total: 4]

20. (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]

(b) A hadron has an overall charge of $+e$, where e is the elementary charge. The hadron contains three quarks. One of the quarks is a strange (s) quark.

(i) State the charge, in terms of e, of the strange (s) quark.

charge = ... [1]

(ii) The other two quarks in the hadron have the same charge as each other.

By considering charge, determine a possible type (flavour) of the other two quarks. Explain your working.

.....

.....[2]

[Total: 5]

21. (a) The names of four particles are listed below.

alpha beta-plus neutron proton

State the name(s) of the particle(s) in this list that:

(i) are not fundamental

.....[1]

(ii) do not experience an electric force when situated in an electric field

.....[1]

(iii) has the largest ratio of charge to mass.

.....[1]

(b) A hadron has a charge of $+e$ where e is the elementary charge. The hadron is composed of only two quarks. One of these quarks is an antidown ($\bar{d}$) quark. By considering charge, state and explain the name (flavour) of the other quark.

.....

.....[3]

[Total: 6]

22. **(a)** In the following list, underline all particles that are leptons.

antineutrino positron proton quark [1]

(b) A stationary nucleus of magnesium-27, $^{27}_{12}Mg$, decays by emitting a β^- particle and γ radiation. An incomplete equation to represent this decay is

$$^{27}_{12}Mg \longrightarrow X + \beta^- + \gamma.$$

(i) State the nucleon number and the proton number of nucleus X.

nucleon number = ...

proton number = ...
[2]

(ii) State the name of the interaction that gives rise to this decay.

.....[1]

(iii) State **two** possible reasons why the sum of the kinetic energy of the β^- particle and the energy of the γ radiation is less than the total energy released during the decay of the magnesium nucleus.

1. .....

.....

2. .....

.....
[2]

[Total: 6]

23. A graph of nucleon number A against proton number Z is shown in Fig. 7.1.

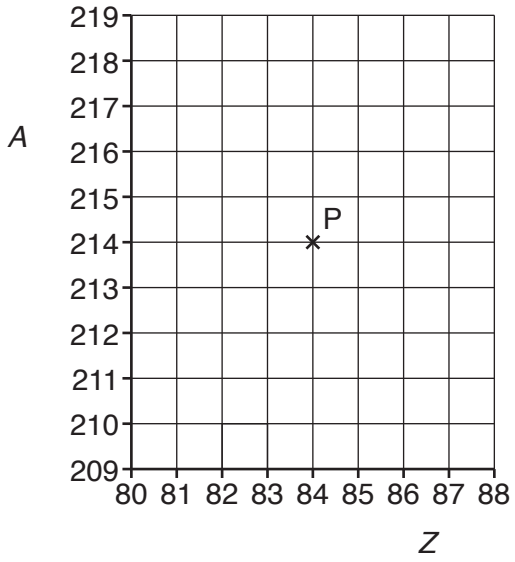

Fig. 7.1

The graph shows a cross (labelled P) that represents a nucleus P.

Nucleus P decays by emitting an α particle to form a nucleus Q.
Nucleus Q then decays by emitting a β^- particle to form a nucleus R.

(a) On Fig. 7.1, use a cross to represent

(i) nucleus Q (label this cross Q), [1]

(ii) nucleus R (label this cross R). [1]

(b) State the name of the class (group) of particles that includes the β^- particle.

.....[1]

(c) The quark composition of one nucleon in Q is changed during the emission of the β^- particle. Describe this change to the quark composition.

.....

.....[1]

[Total: 4]

24. A stationary nucleus X decays to form nucleus Y, as shown by the equation

$$X \longrightarrow Y + \beta^- + \bar{\nu}.$$

(a) In the above equation, draw a circle around all symbols that represent a lepton. [1]

(b) State the name of the particle represented by the symbol $\bar{\nu}$.

.....[1]

(c) Energy is released during the decay process. State the form of the energy that is gained by nucleus Y.

.....[1]

(d) By comparing the compositions of X and Y, state and explain whether they are isotopes.

.....

.....

.....[2]

(e) The quark composition of one nucleon in X is changed during the emission of a β^- particle. Describe this change to the quark composition.

.....

.....[1]

[Total: 6]

25. A sample of a radioactive isotope emits a beam of β^- radiation.

(a) State the change, if any, to the number of neutrons in a nucleus of the sample that emits a β^- particle.

.....[1]

(b) The number of β^- particles passing a fixed point in the beam in a time of 2.0 minutes is 9.8×10^{10}.

Calculate the current, in pA, produced by the beam of β^- particles.

current = ... pA [3]

(c) Suggest why the β^- particles are emitted with a range of kinetic energies.

.....

.....

.....

.....[2]

[Total: 6]

26. A stationary nucleus X decays by emitting a β^+ particle to form a nucleus of carbon-13 ($^{13}_{6}C$). An incomplete equation to represent this decay is

$$X \rightarrow {}^{13}_{6}C + \beta^+.$$

(a) State the name of the class (group) of particles that includes β^+.

.....[1]

(b) For nucleus X, state the number of

protons, ...

neutrons. ..... [1]

(c) The carbon-13 nucleus has a mass of 2.2×10^{-26} kg. Its kinetic energy as a result of the decay process is 0.80 MeV.

Calculate the speed of this nucleus.

speed = ... $m\,s^{-1}$ [3]

(d) Explain why the sum of the kinetic energies of the carbon-13 nucleus and the β^+ particle cannot be equal to the total energy released by the decay process.

.....

.....[1]

[Total: 6]

27. A neutron within a nucleus decays to produce a proton, a β^- particle and an (electron) antineutrino.

$$n \longrightarrow p + \beta^- + \bar{\nu}$$

(a) Use the quark composition of the neutron to show that the neutron has no charge.

[3]

(b) Complete Fig. 8.1 by giving appropriate values of the charge and the mass of the proton, the β^- particle and the (electron) antineutrino.

	proton	β^- particle	antineutrino
charge			
mass			

Fig. 8.1

[2]

[Total: 5]

28. (a) The following particles are used to describe the structure of an atom.

electron neutron proton quark

Underline the fundamental particles in the above list. [1]

(b) The following equation represents the decay of a nucleus of $^{60}_{27}Co$ to form nucleus Q by β^- emission.

$$^{60}_{27}Co \rightarrow {}^{A}_{B}Q + \beta^- + x$$

(i) Complete Fig. 7.1.

	value
A	
B	

Fig. 7.1

[1]

(ii) State the name of the particle x.

.....[1]

[Total: 3]

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29. (a) Describe **two** differences between the decay of a nucleus that emits a β^- particle and the decay of a nucleus that emits a β^+ particle.

1. .....

.....

2. .....

.....

[2]

(b) In a simple quark model there are three types of quark. State the composition of the proton and of the neutron in terms of these three quarks.

proton: .....

neutron: .....

[1]

[Total: 3]

30. (a) Use the quark model to show that

(i) the charge on a proton is $+e$,

.....[1]

(ii) the charge on a neutron is zero.

.....[1]

(b) A nucleus of $^{90}_{38}Sr$ decays by the emission of a β^- particle. A nucleus of $^{64}_{29}Cu$ decays by the emission of a β^+ particle.

(i) In Fig. 7.1, state the nucleon number and proton number for the nucleus produced in each of these decay processes.

	nucleus formed by β^- decay	nucleus formed by β^+ decay
nucleon number		
proton number		

Fig. 7.1 [1]

(ii) State the name of the force responsible for β decay.

.....[1]

(iii) State the names of the leptons produced in each of the decay processes.

β^- decay: .....

β^+ decay: .....
[1]

[Total: 5]

31. A nucleus of bismuth-212 ($^{212}_{83}$Bi) decays by the emission of an α-particle and γ-radiation.

(a) State the number of protons and the number of neutrons in the nucleus of bismuth-212.

number of protons = ...

number of neutrons = ...
[1]

(b) The γ-radiation emitted from the nucleus has a wavelength of 3.8 pm.

Calculate the frequency of this radiation.

frequency = ... Hz [3]

(c) Explain how a single beam of α-particles and γ-radiation may be separated into a beam of α-particles and a beam of γ-radiation.

.....

.....

.....

.....[2]

(d) The α-particle emitted from the bismuth nucleus has an initial kinetic energy of 9.3×10^{-13} J. As the α-particle moves through air it causes the removal of electrons from atoms. The α-particle loses energy and is stopped after removing 1.8×10^5 electrons as it moved through the air.

Determine the energy, in eV, needed to remove one electron.

energy = ... eV [2]

[Total: 8]

32. (a) State **one** difference between a hadron and a lepton.

.....

.....[1]

(b) A proton within a nucleus decays to form a neutron and two other particles. A partial equation to represent this decay is

$$^{1}_{1}p \rightarrow {}^{1}_{0}n + {}^{\cdots\cdots}_{\cdots\cdots} \cdots\cdots + {}^{\cdots\cdots}_{\cdots\cdots} \cdots\cdots$$

(i) Complete the equation. [2]

(ii) State the name of the interaction or force that gives rise to this decay.

.....[1]

(iii) State three quantities that are conserved in the decay.

1. .....

2. .....

3. .....

[3]

(c) Use the quark composition of a proton to show that it has a charge of $+e$, where e is the elementary charge.

Explain your working.

[3]

[Total: 10]

33. (a) State **one** difference between a hadron and a lepton.

.....

.....[1]

(b) (i) State the quark composition of a proton and of a neutron.

proton: .....

neutron: .....
[2]

(ii) Use your answer in **(i)** to determine the quark composition of an α-particle.

quark composition: .....[1]

(c) The results of the α-particle scattering experiment provide evidence for the structure of the atom.

result 1: The vast majority of α-particles pass straight through the metal foil or are deviated by small angles.

result 2: A very small minority of α-particles are scattered through angles greater than 90°.

State what may be inferred from

(i) result 1,

.....

.....[1]

(ii) result 2.

.....

.....

.....

.....[2]

[Total: 7]

34. (a) Distinguish between an α-particle and a β^+-particle.

.....

.....

.....

.....

.....[3]

(b) State the equation that shows the decay of a particle in a nucleus that results in β^+ emission. All particles in the equation should be shown in the notation that is usually used for the representation of nuclides.

[2]

(c) (i) State the quark composition of

1. a proton,

.....

2. a neutron.

.....
[2]

(ii) Use the quark model to explain the charge on a proton.

.....

.....

.....[1]

[Total: 8]

35. (a) State the name of the class (group) to which each of the following belongs:

electron .....

neutron .....

neutrino .....

proton .....

[2]

(b) A proton may decay into a neutron together with two other particles.

(i) Complete the following to give an equation that represents this proton decay.

$$^{1}_{1}p \rightarrow {}^{\cdots\cdots}_{\cdots\cdots}n + {}^{\cdots\cdots}_{\cdots\cdots}\cdots\cdots + {}^{\cdots\cdots}_{\cdots\cdots}\cdots\cdots$$

[2]

(ii) Write an equation for this decay in terms of quark composition.

[1]

(iii) State the name of the force responsible for this decay.

.....[1]

[Total: 6]

36. (a) Give one example of

a hadron: .....

a lepton: .....
[1]

(b) Describe, in terms of the simple quark model,

(i) a proton,

.....[1]

(ii) a neutron.

.....[1]

(c) Beta particles may be emitted during the decay of an unstable nucleus of an atom. The emission of a beta particle is due to the decay of a neutron.

(i) Complete the following word equation for the particles produced in this reaction.

neutron → ..... + ... + ... [1]

(ii) State the change in quark composition of the particles during this reaction.

.....[1]

[Total: 5]

37. A neutron decays by emitting a β^- particle.

(a) Complete the equation below for this decay.

$$^{1}_{0}\text{n} \rightarrow \overset{\cdots\cdots}{\underset{\cdots\cdots}{\cdots\cdots}} + \overset{\cdots\cdots}{\underset{\cdots\cdots}{\beta^-}} + \overset{\cdots\cdots}{\underset{\cdots\cdots}{\bar{\nu}}}$$

[2]

(b) State the name of the particle represented by the symbol $\bar{\nu}$.

..... [1]

(c) State the name of the class (group) of particles that includes β^- and $\bar{\nu}$.

..... [1]

(d) State

(i) the quark structure of the neutron,

..... [1]

(ii) the change to the quark structure when the neutron decays.

.....

..... [1]

[Total: 6]