Week 26

A-Level Physics

Homework bundle for this week

本周作业合集

exercises.lol

Contents 目录

A-Level Physics Name: ____________ Score: ______

1. Most α-particles passing straight through the gold foil showed that the atom is:
   - ☐ mostly empty space
   - ☐ a solid ball of charge
   - ☐ entirely negative
   - ☐ made only of nuclei
2. An α-particle is:
   - ☐ a helium nucleus (2 protons + 2 neutrons)
   - ☐ a fast electron
   - ☐ a high-energy photon
   - ☐ a single proton
3. What is the charge on an up quark?
   - ☐ $+\frac{2}{3}e$
   - ☐ $-\frac{1}{3}e$
   - ☐ $+1\,e$
   - ☐ 0
4. Almost all of an atom's mass is in its nucleus.

   ☐ True ☐ False
5. Of the three, α radiation is the most strongly ionising.

   ☐ True ☐ False
6. A proton is made of which quarks?
   - ☐ u u d
   - ☐ u d d
   - ☐ u u u
   - ☐ d d d
7. Protons and neutrons together are called ______.

   ____

8. The positron is the ______ of the electron.

____

9. A neutron is u d d. What is its total charge, in units of e?

____

10. How many neutrons are in ${}^{14}_{6}\mathrm{C}$?

____

A-Level Physics

1. **mostly empty space**

   If most go straight through, there is little in the way — the atom is mostly empty, with the mass and charge concentrated in a tiny nucleus.

2. **a helium nucleus (2 protons + 2 neutrons)**

   An α-particle is ${}^4_2\alpha$ — a helium-4 nucleus with charge $+2e$.

3. $+\frac{2}{3}e$

   Up-type quarks (up, charm, top) carry $+\frac{2}{3}e$; down-type (down, strange, bottom) carry $-\frac{1}{3}e$.

4. **True**

   Protons and neutrons are ~1 u each; electrons are ~1/1836 u, so the nucleus holds nearly all the mass.

5. **True**

   Yes — α is the strongest ioniser (and so the least penetrating); γ is the weakest ioniser (and most penetrating).

6. **u u d**

   Proton = u u d, giving charge $\frac{2}{3} + \frac{2}{3} - \frac{1}{3} = +1$.

7. **nucleons**

   The nucleon number A counts the protons plus neutrons in the nucleus.

8. **antiparticle**

   An antiparticle has the same mass but opposite charge — the positron is $+e$ to the electron's $-e$.

9. **0**

   $\frac{2}{3} - \frac{1}{3} - \frac{1}{3} = 0$ — the neutron is uncharged.

10. **8**

    $N = A - Z = 14 - 6 = 8$ neutrons.

11.1 Atoms, nuclei and radiation

Name: ____________ Class: ________ Date: __________ **Total: 18 marks**

KEY WORDS nucleus 原子核 • proton 质子 • isotope 同位素 • nuclide 核素 • neutron 中子

Objective

Build the skills to answer exam questions on **atoms, nuclei and radiation** — the nuclear model, nuclide notation, decay equations, and conservation.

You must be able to:

- describe the **nuclear atom** and the α-scattering evidence
- use ${}^{A}_{Z}\mathrm{X}$ notation; find protons, neutrons and electrons
- complete α and β **decay equations** (including the (anti)neutrino)
- apply **conservation** (charge, nucleon number, momentum) to a decay

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

The nuclear atom

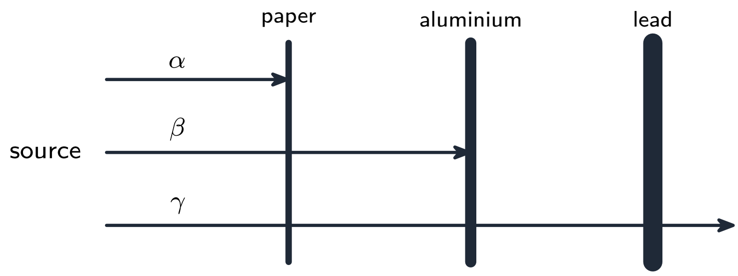
α-scattering showed the atom is **mostly empty space** (most pass straight through) with a **tiny, dense, positive nucleus** (rare large deflections). The atom has **protons** $(+e)$ and **neutrons** (0) in the nucleus, with **electrons** $(-e)$ around it.

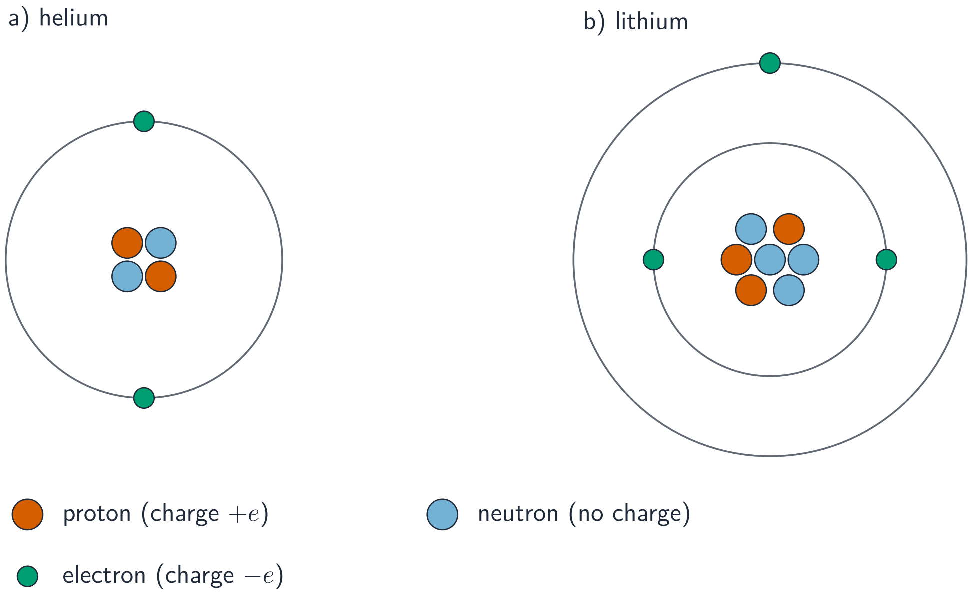
Notation and counting

${}^{A}_{Z}\mathrm{X}$: Z = **proton number** (fixes the element), A = **nucleon number** (protons + neutrons). For a nuclide: **protons** $= Z$, **neutrons** $= A - Z$, and a **neutral atom** has **electrons** $= Z$. **Isotopes** are the same element (Z) with different neutron numbers.

Worked example. Tritium ${}^{3}_{1}\mathrm{H}$: protons $= 1$, neutrons $= 3 - 1 = 2$, electrons (neutral) $= 1$.

Radiation





The nuclear model of the atom

	composition	charge	mass (u)
α	2 protons + 2 neutrons	$+2e$	4
β^-	an electron	$-e$	≈ 0
γ	EM photon	0	0

α has **discrete** energies; β has a **continuous** range (an (anti)neutrino shares the energy).

■ Decay equations

Balance the top numbers (A) and the bottom numbers (Z) on each side.

- α decay: ${}^{238}_{92}\mathrm{U} \rightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\alpha$.
- β^- decay (a neutron $\rightarrow$ proton): ${}^{3}_{1}\mathrm{H} \rightarrow {}^{3}_{2}\mathrm{He} + {}^{0}_{-1}\beta + {}^{0}_{0}\bar{\nu}$. The **antineutrino** $\bar{\nu}$ carries away 0 charge and 0 nucleon number, so it does not change the balance.

■ **Conservation and recoil**

In any decay, **charge** (proton number), **nucleon number**, **(linear) momentum** and **mass–energy** are all conserved. If a **stationary** nucleus decays, the two products fly apart with **equal and opposite momentum**:

Worked example. A stationary nucleus emits an α-particle (mass 4 u) at 1.5×10^7 m s^{-1}; the daughter nucleus has mass 234 u. Momentum: $m_\alpha v_\alpha = m_R v_R$, so $v_R = \dfrac{4 \times 1.5 \times 10^7}{234} = 2.6 \times 10^5$ m s^{-1}.

2 Practice

Now apply the methods above.

2.1 State **two** conclusions Rutherford drew from the α-scattering experiment. [2]

2.2 For ${}^{14}_{6}\mathrm{C}$, state the number of **protons**, **neutrons** and **electrons** (neutral atom). [2]

2.3 Define **isotopes**. [1]

2.4 Complete the β^- decay: ${}^{14}_{6}\mathrm{C} \rightarrow \quad \mathrm{N} + {}^{0}_{-1}\beta + \,?$ — give the missing nuclide numbers and name the last particle. [2]

3 Exam-style questions

3.1 Which radiation is stopped by a sheet of **paper**? [1]

- **A** α
- **B** β
- **C** γ
- **D** X-rays

3.2 A stationary nucleus decays into a nucleus R and an α-particle.

(a) State **three** quantities that are conserved during the decay. [2]

(b) The α-particle (mass 4 u) leaves at 1.6×10^7 m s^{-1}; nucleus R has mass 222 u. Calculate the **speed** of R. [3]

3.3 Explain why β-particles are emitted with a **continuous range** of energies. [2]

3.4 State the **charge** and the **mass** (in u) of α, β^- and γ radiation. [3]

Solutions

Each answer shows the steps, then the **result**.

2.1

- any two: the atom is **mostly empty space**; there is a **tiny, dense nucleus**; the nucleus is **positively charged**; most of the atom's **mass** is in the nucleus

2.2

- protons $= Z = 6$; electrons (neutral atom) $= Z = 6$
- neutrons $= A - Z = 14 - 6 = \mathbf{8}$

2.3

- atoms of the **same element** (same proton number) with **different numbers of neutrons**

2.4

- nucleon number A and proton number Z both balance

$$^{14}_{6}\mathrm{C} \rightarrow \ ^{14}_{7}\mathrm{N} + \ ^{0}_{-1}\beta + \ ^{0}_{0}\bar{\nu}$$

- the last particle is an (electron) **antineutrino**

3.1 A

- an α particle is a helium nucleus: massive and doubly charged, so it ionises heavily, loses energy fast and stops in a sheet of paper
- **B** β needs a few millimetres of aluminium; **C** γ and **D** X-rays need centimetres of lead. Heavier and more charged means *less* penetrating

3.2

(a) any three: **charge** (proton number), **nucleon number**, **(linear) momentum**, **mass–energy**

(b) the parent was stationary, so momentum is conserved: $m_\alpha v_\alpha = m_R v_R$

$$v_R = \frac{m_\alpha v_\alpha}{m_R} = \frac{(4\ \mathrm{u})(1.6 \times 10^7\ \mathrm{m\ s^{-1}})}{222\ \mathrm{u}} = \mathbf{2.9 \times 10^5}\ \mathrm{m\ s^{-1}}$$

3.3

- a β-decay also emits an (anti)**neutrino**
- the (anti)neutrino **shares** the released energy with the β-particle in varying proportions, so the β energy varies

3.4

- α: charge $+2e$, mass 4 u
- β^-: charge $-e$, mass ≈ 0 (1/1836 u)
- γ: charge 0, mass 0

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

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

A-Level Physics: **w25 14**

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.

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

[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.

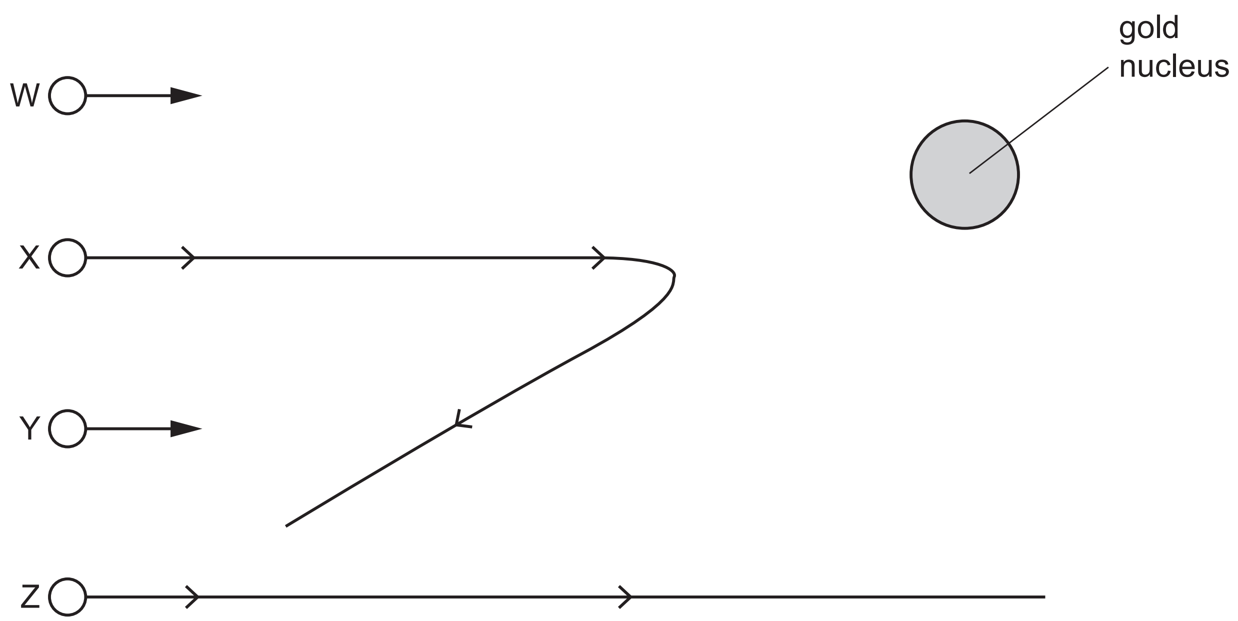


Fig. 6.1 (not to scale)

(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]

11.2 Fundamental particles

Name: ______________ Class: __________ Date: ____________ **Total: 27 marks**

KEY WORDS quark 夸克 • fundamental 基本粒子 • hadrons 强子 • baryons 重子 • mesons 介子

Objective

Build the skills to answer exam questions on **fundamental particles** — quarks, hadrons, antiparticles, and quark changes in β-decay.

You must be able to:

- recall the six **quark** flavours and their charges, and classify **hadrons** (baryons/mesons)
- give the **quark composition** of protons, neutrons and their **antiparticles**
- describe quark changes in β^- and β^+ decay; classify particles as **leptons**

1 Worked examples

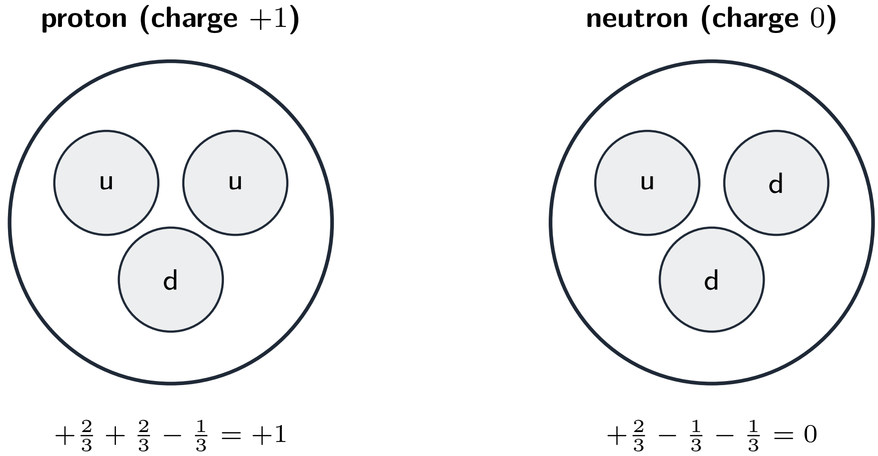
Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

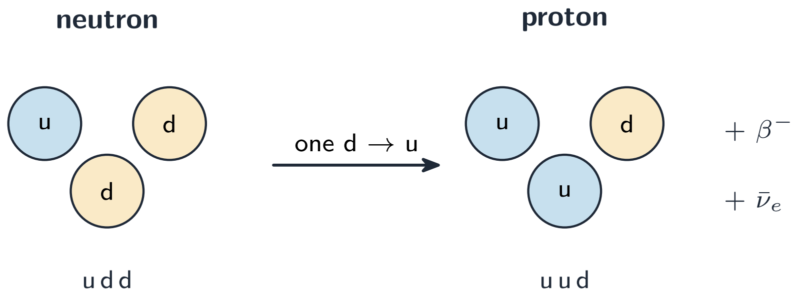
Quarks

A **quark** is a fundamental particle. Six flavours: **up, charm, top** (charge $+\frac{2}{3}e$) and **down, strange, bottom** (charge $-\frac{1}{3}e$). Each **antiquark** has the **opposite** charge ($\bar{\mathrm{u}} = -\frac{2}{3}e$, $\bar{\mathrm{d}} = +\frac{1}{3}e$).

Hadrons

Particles made of quarks are **hadrons**: a **baryon** = 3 quarks; a **meson** = 1 quark + 1 antiquark. Protons and neutrons are **baryons** (not fundamental):





Beta decay changes a quark and the nucleus

■ Antiparticles

Every particle has an **antiparticle** with the **same mass** but **opposite charge**. The **positron** is the antiparticle of the electron (charge $+e$, and like the electron it is a **lepton**). An **antiproton** is made of the **antiquarks** of a proton: $\bar{u}\bar{u}\bar{d}$, charge $-\frac{2}{3}-\frac{2}{3}+\frac{1}{3}=-1$ (i.e. $-e$).

■ β-decay in quarks and leptons

- β^- decay: a **down** quark $\rightarrow$ **up** quark, so a neutron becomes a proton: $\mathrm{d} \rightarrow \mathrm{u}+\beta^-+\bar{\nu}_e$.
- β^+ decay: an **up** quark $\rightarrow$ **down** quark, so a proton becomes a neutron: $\mathrm{u} \rightarrow \mathrm{d}+\beta^++\nu_e$. In nuclear form, e.g. ${}^{12}_{7}\mathrm{N} \rightarrow {}^{12}_{6}\mathrm{C} + {}^{0}_{+1}\beta + {}^{0}_{0}\nu$.

Electrons, positrons and neutrinos are fundamental particles called **leptons**.

2 Practice

Now apply the methods above.

2.1 State what a **quark** is, and name **two** flavours. [2]

2.2 State the charge of an **up** quark and a **down** quark. [2]

2.3 State the **quark composition** of a proton and of a neutron. [2]

2.4 State the charge of a **positron** and the class of fundamental particle it belongs to. [2]

3 Exam-style questions

3.1 A **baryon** consists of: [1]

- **A** two quarks
- **B** three quarks
- **C** one quark and one antiquark
- **D** one quark

3.2 Show that the quark composition **u u d** gives a total charge of +1. [2]

3.3 An **antiproton** is the antiparticle of a proton.

(a) State the **quark composition** of an antiproton. [1]

(b) Show that its total charge is $-e$. [2]

3.4 Describe the change in **quark composition** during β^- decay, and name the lepton emitted. [3]

3.5 A meson Q and a nucleus of radium-228 are studied in a particle laboratory. The unified atomic mass unit is 1.66×10^{-27} kg.

(a) **State** what is meant by a **fundamental particle**. [1]

(b) Q is a meson with a charge of zero. **Determine** one possible quark composition for Q, and explain why your answer gives zero charge. [2]

(c) Q has a mass of 0.67 u and a kinetic energy of 2.1×10^{-16} J. **Calculate** its speed. [3]

(d) **State** the number of electrons in a neutral atom of radium-228, $^{228}_{88}\mathrm{Ra}$. [1]

(e) A radium-228 nucleus decays in a series of steps to a nucleus X, emitting **5** α-particles and **4** β^{-} particles in total. **Determine** the number of protons and the number of neutrons in X. [3]

Solutions

Each answer shows the steps, then the **result**.

2.1

- a **fundamental particle** (with no smaller parts)
- any two flavours of: up, down, charm, strange, top, bottom

2.2

- up $= +\frac{2}{3}e$
- down $= -\frac{1}{3}e$

2.3

- proton = **u u d**
- neutron = **u d d**

2.4

- charge $= +e$
- it is a **lepton**

3.1 B

- a baryon is **three quarks** (a proton is uud, a neutron udd)
- **C** is a **meson** (quark + antiquark); **A** and **D** are not observed as free particles

3.2

- charges: up $= +\frac{2}{3}e$, down $= -\frac{1}{3}e$

$$+\frac{2}{3}e + \frac{2}{3}e - \frac{1}{3}e = \frac{4}{3}e - \frac{1}{3}e = +\mathbf{e}$$

3.3

(a) $\bar{\mathrm{u}}\,\bar{\mathrm{u}}\,\bar{\mathrm{d}}$ (the antiquarks of u u d)

(b) $\bar{\mathrm{u}} = -\frac{2}{3}e$ and $\bar{\mathrm{d}} = +\frac{1}{3}e$

$$-\frac{2}{3}e - \frac{2}{3}e + \frac{1}{3}e = -e$$

3.4

- a **down** quark changes into an **up** quark
- so u d d (neutron) becomes u u d (proton)
- an **electron** (the β^- particle), together with an antineutrino, is emitted

3.5

(a) a particle that **cannot be subdivided** into anything smaller

(b) a meson is a **quark and an antiquark**

- any pair such as $\mathrm{u}\bar{\mathrm{u}}$ ($+\frac{2}{3}e - \frac{2}{3}e = 0$) or $\mathrm{d}\bar{\mathrm{d}}$ ($-\frac{1}{3}e + \frac{1}{3}e = 0$) gives zero charge, because the antiquark carries the opposite charge to the quark

(c) $m = (0.67\ \mathrm{u})(1.66 \times 10^{-27}\ \mathrm{kg\ u^{-1}}) = 1.11 \times 10^{-27}\ \mathrm{kg}$

- $E_{\mathrm{K}} = \frac{1}{2}mv^2$, so $v = \sqrt{2E_{\mathrm{K}}/m}$

$$v = \sqrt{\frac{2 \times 2.1 \times 10^{-16}\ \mathrm{J}}{1.11 \times 10^{-27}\ \mathrm{kg}}} = \mathbf{6.1 \times 10^{5}}\ \mathrm{m\ s^{-1}}$$

(d) **88** — a neutral atom has as many electrons as protons

(e) each α removes 2 protons and 2 neutrons; each β^- turns a neutron into a proton (adds a proton, removes a neutron)

- protons: $88 - (5 \times 2) + 4 = \mathbf{82}$
- nucleons: $228 - (5 \times 4) = 208$, so neutrons $= 208 - 82 = \mathbf{126}$

A-Level Physics: **w25 11**

40 Which particle is a lepton?

A meson

B positron

C proton

D quark

A-Level Physics: **w25 12**

38 An up quark in a hadron changes to a down quark.

The elementary charge is *e*.

What is the magnitude of the change in the charge of the hadron?

A $\frac{1}{3}e$ **B** $\frac{2}{3}e$ **C** e **D** zero

A-Level Physics: **w25 14**

40 Which combination of three quarks has no overall charge?

A down, strange, strange

B up, charm, strange

C up, charm, top

D up, down, strange

6 **(a)** State what is meant by a fundamental particle.

....

.... [1]

(b) **(i)** Particle Q is a meson with a charge of 0.

Determine a possible quark composition for Q.

.... [2]

(ii) Particle Q has a mass of 0.67 u and a kinetic energy of 2.1×10^{-16} J.

Calculate the speed of particle Q.

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

(c) Radium-228 ($^{228}_{88}Ra$) is a radioactive nuclide.

(i) State the number of electrons in a neutral atom of radium-228.

number of electrons = ... [1]

(ii) A nucleus of radium-228 undergoes a series of decays to form nucleus X.
During the process, 5 α-particles and 4 β^- particles are emitted.

Determine the number of protons and the number of neutrons in nucleus X.

number of protons = ...

number of neutrons = ...
[2]

[Total: 9]

38 Which list contains only fundamental particles?

A antineutrinos, baryons, neutrons, electrons

B mesons, electrons, neutrinos, protons

C positrons, quarks, hadrons, protons

D quarks, positrons, neutrinos, leptons

40 A hadron consists of antiquarks that are all identical.

What is a possible value, in terms of the elementary charge e, for the charge on the hadron?

A $0e$ **B** $+1e$ **C** $+2e$ **D** $+3e$

A-Level Physics: **s25 12**

39 What is the composition of a meson?

A 1 quark and 1 antiquark

B 1 quark and 2 antiquarks

C 2 quarks and 1 antiquark

D 3 quarks

40 A nucleus of carbon-11 contains 6 protons and 5 neutrons.

The nucleus of carbon-11 decays by β^+ emission.

What is the total number of up and down quarks in the product of the decay of this nucleus?

	up quarks	down quarks
A	15	18
B	16	17
C	17	16
D	18	15

A-Level Physics: **s25 13**

33 What **cannot** be the charge on a charge carrier?

A -4.8×10^{-19} C

B -3.2×10^{-19} C

C -2.4×10^{-19} C

D $+3.2 \times 10^{-19}$ C

38 A nucleus decays by emitting a β^+ particle.

Which particle **must** also be emitted from the nucleus?

A antineutrino

B β^- particle

C α-particle

D neutrino

39 What are the charges on an antidown quark and on an antistrange quark?

	antidown quark	antistrange quark
A	$+\frac{1}{3}e$	$+\frac{1}{3}e$
B	$+\frac{1}{3}e$	$-\frac{1}{3}e$
C	$-\frac{1}{3}e$	$+\frac{1}{3}e$
D	$-\frac{1}{3}e$	$-\frac{1}{3}e$