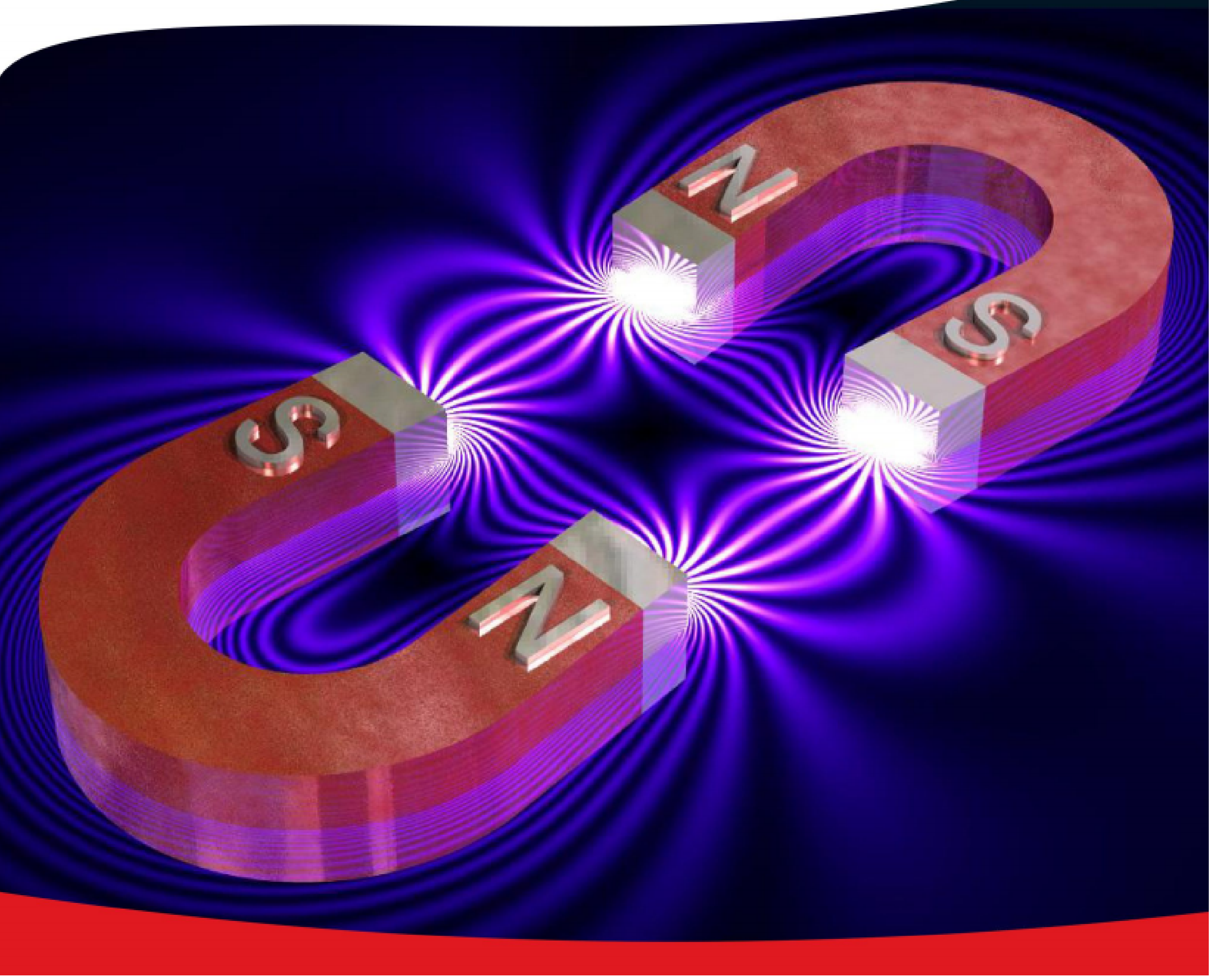
Cambridge International AS & A Level

PHYSICS (9702) P2

TOPIC WISE QUESTIONS + ANSWERS | COMPLETE SYLLABUS



PapaCambridge

Chapter 13

Particle and nuclear physics

13.1 Atoms, nuclei and radiation

250. 9702_s20_qp_21 Q: 6

(a) Two horizontal metal plates are separated by a distance of 2.0 cm in a vacuum, as shown in Fig. 6.1.

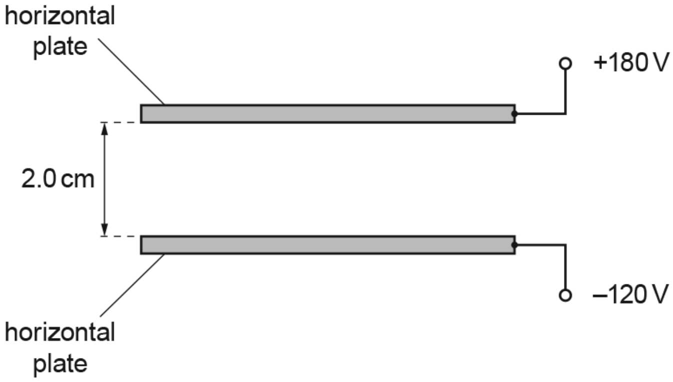


Fig. 6.1

The top plate has an electric potential of +180 V and the bottom plate has an electric potential of –120 V.

(i) Determine the magnitude of the electric field strength between the plates.

electric field strength = ... NC^{-1} [2]

(ii) State the direction of the electric field.

.... [1]

(b) An uncharged atom of uranium-238 ($^{238}_{92}U$) has a change made to its number of orbital electrons. This causes the atom to change into a new particle (ion) X that has an overall charge of +2*e*, where *e* is the elementary charge.

(i) Determine the number of protons, neutrons and electrons in the particle (ion) X.

number of protons = ...

number of neutrons = ...

number of electrons = ...
[3]

(ii) The particle (ion) X is in the electric field in **(a)** at a point midway between the plates.

Determine the magnitude of the electric force acting on X.

force = ... N [2]

(iii) The nucleus of uranium-238 ($^{238}_{92}U$) decays in stages, by emitting α-particles and β^- particles, to form a nucleus of thorium-230 ($^{230}_{90}Th$).

Calculate the total number of α-particles and the total number of β^- particles that are emitted during the decay of uranium-238 to thorium-230.

number of α-particles = ...

number of β^- particles = ...
[2]

[Total: 10]

251. 9702_w20_qp_23 Q: 7

Two vertical metal plates are separated by a distance *d* in a vacuum, as shown in Fig. 7.1.

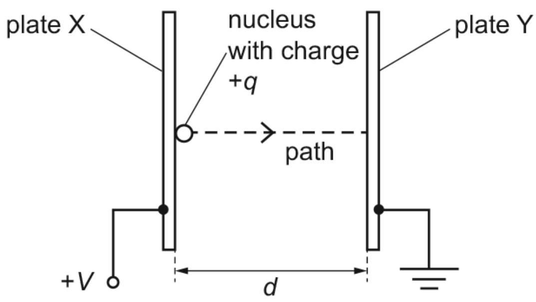


Fig. 7.1 (not to scale)

The potential difference (p.d.) between the plates is *V*. A nucleus with charge +*q* is initially at rest on plate X. The nucleus is accelerated by the uniform electric field from plate X along a horizontal path to plate Y.

(a) State expressions, in terms of some or all of *d*, *q* and *V*, for:

(i) the magnitude of the electric field strength

electric field strength = ... [1]

(ii) the magnitude of the electric force acting on the nucleus

force = ... [1]

(iii) the kinetic energy of the nucleus when it reaches plate Y.

kinetic energy = ... [1]

(b) State the change, if any, in the kinetic energy of the nucleus on reaching plate Y when the following separate changes are made.

(i) The distance *d* is halved, but the p.d. *V* remains the same.

.... [1]

(ii) The nucleus is replaced by a different nucleus that is an isotope of the original nucleus with fewer neutrons.

.... [1]

(c) The nucleus is carbon-14 ($^{14}_{6}C$). This nucleus decays to form a new nucleus by releasing a β^- particle and only one other particle of negligible mass.

(i) Calculate the nucleon number and the proton number of the **new** nucleus.

nucleon number = ...

proton number = ... [1]

(ii) State the name of the particle of negligible mass.

.... [1]

[Total: 7]

---

252. 9702_w19_qp_22 Q: 7

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

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

(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]

253. 9702_w19_qp_23 Q: 7

A stationary nucleus of a radioactive isotope X decays by emitting an α-particle to produce a nucleus of neptunium-237 and 5.5 MeV of energy. The decay is represented by

$$X \longrightarrow {}^{237}_{93}\text{Np} + \alpha + 5.5\,\text{MeV}.$$

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

number of protons = ...

number of neutrons = ... [2]

(b) Explain why the energy transferred to the α-particle as kinetic energy is less than the 5.5 MeV of energy released in the decay process.

....

.... [1]

(c) A sample of X is used to produce a beam of α-particles in a vacuum. The number of α-particles passing a fixed point in the beam in a time of 30 s is 6.9×10^{11}.

(i) Calculate the average current produced by the beam of α-particles.

current = ... A [2]

(ii) Determine the total power, in W, that is produced by the decay of 6.9×10^{11} nuclei of X in a time of 30 s.

power = ... W [2]

[Total: 7]

254. 9702_m18_qp_22 Q: 6

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]

255. 9702_w18_qp_21 Q: 5

(a) State what is meant by an *electric field*.

....

.... [1]

(b) A particle of mass m and charge q is in a uniform electric field of strength E. The particle has acceleration a due to the field.

Show that

$$a = \frac{Eq}{m}.$$

[2]

(c) A stationary nucleus X decays by emitting an α-particle to form a nucleus of plutonium, $^{240}_{94}\text{Pu}$, as shown.

$$\text{X} \longrightarrow {}^{240}_{94}\text{Pu} + \alpha$$

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

number of protons = ...

number of neutrons = ...
[2]

(ii) The total mass of the plutonium nucleus and the α-particle is less than that of nucleus X. Explain this difference in mass.

....

....

....

.... [2]

(iii) The plutonium nucleus and the α-particle are both accelerated by the same uniform electric field.

Use the expression in **(b)** to determine the ratio

$$\frac{\text{acceleration of the } \alpha\text{-particle}}{\text{acceleration of the plutonium nucleus}}.$$

ratio = ... [2]

[Total: 9]

256. 9702_w18_qp_23 Q: 5

A particle of mass m and charge q is in a uniform electric field of strength E. The particle has acceleration a due to the field.

(a) Show that

$$\frac{q}{m} = \frac{a}{E}.$$

[2]

(b) The particle has a charge of $4e$ where e is the elementary charge. The electric field strength is $3.5 \times 10^4\,\mathrm{V\,m^{-1}}$. The acceleration of the particle is $1.5 \times 10^{12}\,\mathrm{m\,s^{-2}}$.

Use the expression in **(a)** to show that the mass of the particle is 9.0 u.

[2]

(c) The particle is a nucleus. State the number of protons and the number of neutrons in the nucleus.

number of protons = ...

number of neutrons = ...
[1]

(d) A second nucleus that is an isotope of the nucleus in **(c)** is in the same uniform electric field.

State and explain whether the electric field produces, for the two nuclei, the same magnitudes of

(i) force,

....

....[1]

(ii) acceleration.

....

....[1]

[Total: 7]

257. 9702_m17_qp_22 Q: 7

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]

258. 9702_w17_qp_23 Q: 7

(a) A nucleus X decays by emitting a β^+ particle to form a new nucleus, $^{23}_{11}Na$.

State the number of nucleons and the number of neutrons in nucleus X.

number of nucleons = ...

number of neutrons = ...
[2]

(b) State one similarity and one difference between a β^+ particle and a β^- particle.

similarity: ....

difference: ....
[2]

[Total: 4]

259. 9702_s15_qp_22 Q: 7

A uranium-235 nucleus absorbs a neutron and then splits into two nuclei. A possible nuclear reaction is given by

$$^{235}_{92}\text{U} + {}^{a}_{b}\text{n} \rightarrow {}^{93}_{37}\text{Rb} + {}^{c}_{d}\text{X} + 2{}^{a}_{b}\text{n} + \text{energy.}$$

(a) State the constituent particles of the uranium-235 nucleus.

.... [1]

(b) Complete Fig. 7.1 for this reaction.

	value
a	
b	
c	
d	

[3]

Fig. 7.1

(c) Suggest a possible form of energy released in this reaction.

.... [1]

(d) Explain, using the law of mass-energy conservation, how energy is released in this reaction.

....

....

.... [2]

260. 9702_s15_qp_23 Q: 7

The equation represents the spontaneous radioactive decay of a nucleus of bismuth-212.

$$^{212}_{83}\text{Bi} \rightarrow \text{X} + {}^{208}_{81}\text{T}l + 6.2\,\text{MeV}$$

(a) **(i)** Explain the meaning of *spontaneous* radioactive decay.

....

....[1]

(ii) State the constituent particles of X.

....[1]

(b) **(i)** Use the conservation of mass-energy to explain the release of 6.2 MeV of energy in this reaction.

....

....

....[2]

(ii) Calculate the energy, in joules, released in this reaction.

energy = ... J [1]

261. 9702_w15_qp_21 Q: 7

Two parallel, vertical metal plates in a vacuum are connected to a power supply and a switch, as shown in Fig. 7.1.

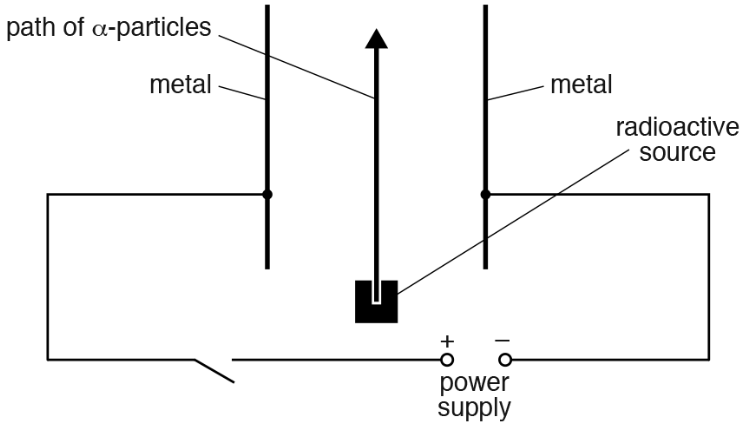


Fig. 7.1

A radioactive source emitting α-particles is placed below the plates. The path of the α-particles is shown on Fig. 7.1. The switch is closed producing a potential difference (p.d.) across the plates. This gives rise to a uniform electric field between the plates.

The separation of the plates is 12 mm.

(a) **(i)** On Fig. 7.1, draw the path of the α-particles. [1]

(ii) Explain why the metal plates are placed in a vacuum.

....

.... [1]

(iii) Calculate the p.d. required to produce an electric field of 140 MV m^{-1}.

p.d. = ... MV [2]

(b) The α-particle source is replaced by a β-particle source. By reference to the properties of α-radiation and β-radiation, suggest three possible differences in the deflection observed with β-particles.

1. ....

....

2. ....

....

3. ....

....

[3]

(c) Complete Fig. 7.2 to show the changes in the proton number *Z* and the nucleon number *A* of different radioactive nuclei when either an α-particle or a β-particle is emitted.

emitted particle	change in *Z*	change in *A*
α-particle		
β-particle		

Fig. 7.2

[1]

262. 9702_w15_qp_22 Q: 8

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

State two results and the associated conclusions.

result 1: ....

....

conclusion 1: ....

....

result 2: ....

....

conclusion 2: ....

....
[4]

(b) In a model of a copper atom of the isotope $^{63}_{29}Cu$, the atom and its nucleus are assumed to be spherical.

The diameter of the nucleus is 2.8×10^{-14} m. The diameter of the atom is 2.3×10^{-10} m.

Calculate the ratio

$$\frac{\text{density of the nucleus}}{\text{density of the atom}}.$$

ratio = ...[3]

263. 9702_w15_qp_23 Q: 8

(a) State the quantities, other than momentum, that are conserved in a nuclear reaction.

....

....[2]

(b) A stationary nucleus of uranium-238 decays to a nucleus of thorium-234 by emitting an α-particle. The kinetic energy of the α-particle is 6.69×10^{-13} J.

(i) Show that the kinetic energy E_k of a mass m is related to its momentum p by the equation

$$E_k = \frac{p^2}{2m}.$$

[1]

(ii) Use the conservation of momentum to determine the kinetic energy, in keV, of the thorium nucleus.

kinetic energy = ... keV [3]

13.2 Fundamental particles

264. 9702_m20_qp_22 Q: 7

(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]

265. 9702_s20_qp_22 Q: 7

(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 $+2e$, where e is the elementary charge.

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

....

.... [2]

[Total: 5]

266. 9702_s20_qp_23 Q: 7

A potential difference is applied between two horizontal metal plates that are a distance of 6.0 mm apart in a vacuum, as shown in Fig. 7.1.

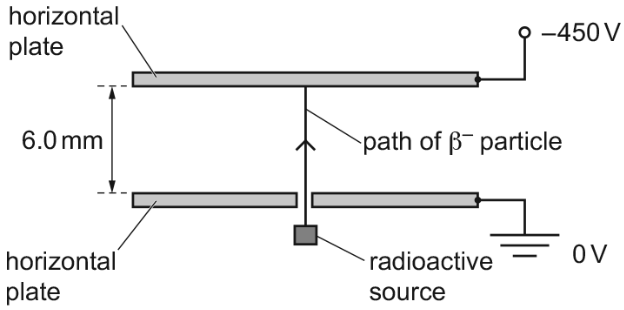


Fig. 7.1

The top plate has a potential of –450 V and the bottom plate is earthed. Assume that there is a uniform electric field produced between the plates.

A radioactive source emits a β^- particle that travels through a hole in the bottom plate and along a vertical path until it reaches the top plate.

(a) **(i)** Determine the magnitude and the direction of the electric force acting on the β^- particle as it moves between the plates.

magnitude of force = ... N

direction of force ....
[4]

(ii) Calculate the work done by the electric field on the β^- particle for its movement from the bottom plate to the top plate.

work done = ... J [2]

(b) The β⁻ particle is emitted from the source with a kinetic energy of 3.4×10^{-16} J.

Calculate the speed at which the β⁻ particle is emitted.

speed = ... $m\,s^{-1}$ [2]

(c) The β⁻ particle is produced by the decay of a neutron.

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

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

[2]

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

1. neutrons

....

2. β⁻ particles.

....

[2]

[Total: 12]

---

267. 9702_w20_qp_21 Q: 8

(a) State a similarity and a difference between a down quark and a down antiquark.

similarity: ....

difference: ....

[2]

(b) For a nucleus of aluminium-25 ($^{25}_{13}Al$):

(i) state the number of protons and the number of neutrons

number of protons = ...

number of neutrons = ...
[1]

(ii) show that the charge is 2.1×10^{-18} C.

[1]

(c) The nucleus in **(b)** is moved along a straight line from point A to point B in a uniform horizontal electric field in a vacuum, as shown in Fig. 8.1.

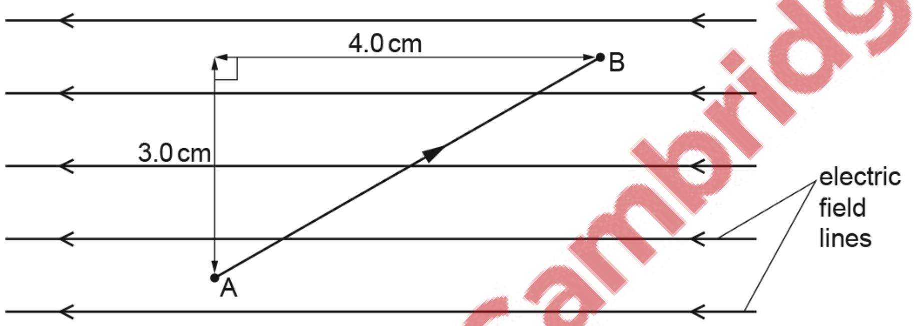


Fig. 8.1

The electric field strength is $11\,kV\,m^{-1}$.

Calculate the work done to move the charge from A to B.

work done = ... J [3]

[Total: 7]

268. 9702_w20_qp_22 Q: 7

(a) State a similarity and a difference between an up quark and an up antiquark.

similarity: ....

difference: ....
[2]

(b) Fig. 7.1 shows an electron in an electric field, in a vacuum, at an instant when the electron is stationary.

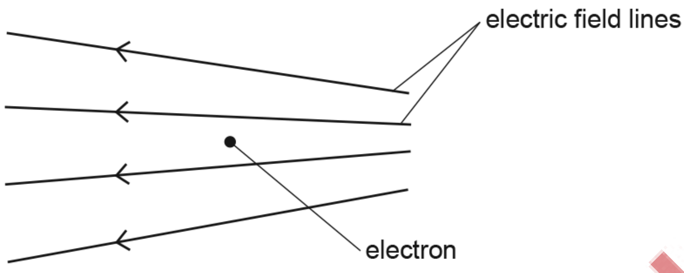


Fig. 7.1

(i) On Fig. 7.1, draw an arrow to show the direction of the electric force acting on the stationary electron. [1]

(ii) The electric field causes the electron to move from its initial position.

Describe and explain the acceleration of the electron due to the field, as the electron moves through the field.

....

....

....

.... [2]

(iii) A stationary α-particle is now placed in the same electric field at the same initial position that was occupied by the electron.

Compare the initial electric force acting on the α-particle with the initial electric force that acted on the electron.

....

....

....

.... [2]

[Total: 7]

269. 9702_m19_qp_22 Q: 7

(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 ($\overline{d}$) quark. By considering charge, state and explain the name (flavour) of the other quark.

....

....[3]

[Total: 6]

270. 9702_s19_qp_21 Q: 7

(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]

271. 9702_s19_qp_22 Q: 6

(a) State what is meant by a *field line* (*line of force*) in an electric field.

....

....[1]

(b) An electric field has two different regions X and Y. The field strength in X is less than that in Y. Describe a difference between the pattern of field lines (lines of force) in X and in Y.

....

....[1]

(c) A particle P has a mass of 0.15 u and a charge of –1 e, where e is the elementary charge.

(i) Particle P and an α-particle are in the same uniform electric field. Calculate the ratio

$$\frac{\text{magnitude of acceleration of particle P}}{\text{magnitude of acceleration of } \alpha\text{-particle}}.$$

ratio = ... [3]

(ii) Particle P is a hadron composed of only two quarks. One of them is a down (d) quark.

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

....

....[3]

[Total: 8]

272. 9702_s19_qp_23 Q: 7

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]

273. 9702_w19_qp_21 Q: 7

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

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

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]

274. 9702_s18_qp_21 Q: 7

A β^- particle from a radioactive source is travelling in a vacuum with kinetic energy 460 eV. The particle enters a uniform electric field at a right-angle and follows the path shown in Fig. 7.1.

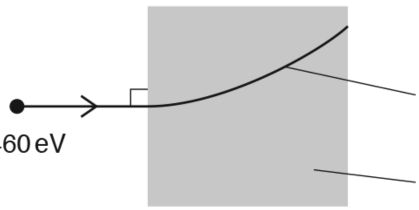


Fig. 7.1

(a) The direction of the electric field is in the plane of the paper.
On Fig. 7.1, draw an arrow to show the direction of the electric field. [1]

(b) Calculate the speed of the β^- particle before it enters the electric field.

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

(c) Other β^- particles from the same radioactive source travel outside the electric field along the same incident path as that shown in Fig. 7.1.

State and briefly explain whether those β^- particles will all follow the same path inside the electric field.

....

....

....

....[2]

[Total: 6]

275. 9702_s18_qp_22 Q: 7

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

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

(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 $\overline{\nu}$.

....[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]

276. 9702_s18_qp_23 Q: 7

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

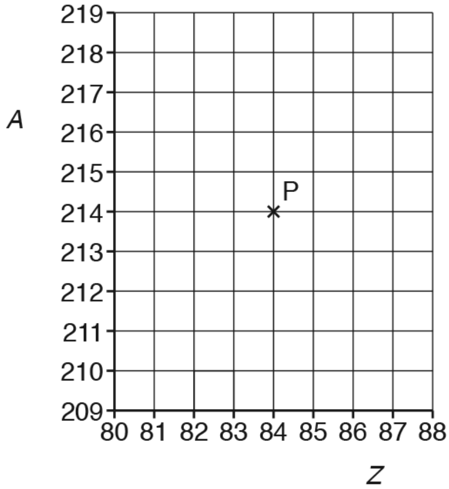


Fig. 7.1

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]

277. 9702_w18_qp_22 Q: 8

(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

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

(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]

278. 9702_s17_qp_21 Q: 7

(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]

279. 9702_s17_qp_22 Q: 8

(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]

---

280. 9702_s17_qp_23 Q: 7

(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]

---

281. 9702_w17_qp_21 Q: 8

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

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

(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]

282. 9702_w17_qp_22 Q: 7

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]

283. 9702_m16_qp_22 Q: 6

A neutron decays by emitting a β^- particle.

(a) Complete the equation below for this decay.

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

[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]

284. 9702_s16_qp_21 Q: 7

(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 $\longrightarrow$ .... + ... + ... [1]

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

....[1]

[Total: 5]

285. 9702_s16_qp_22 Q: 8

(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.

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

[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]

286. 9702_s16_qp_23 Q: 8

(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]

287. 9702_w16_qp_21 Q: 7

(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]

288. 9702_w16_qp_22 Q: 6

(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

$$^{1}_{1}\text{p} \rightarrow {}^{1}_{0}\text{n} + {}^{.....}_{.....}\,...... + {}^{.....}_{.....}\,......$$

(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]

289. 9702_w16_qp_23 Q: 7

(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]