OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE **2864/01**

PHYSICS B (ADVANCING PHYSICS)

Field and Particle Pictures

WEDNESDAY 11 JUNE 2008 Morning

Time: 1 hour 15 minutes

Candidates answer on the question paper.
Additional materials: Data, Formulae and Relationships Booklet
Electronic calculator

CUP/T42964

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is **70**.
- You are advised to spend about 20 minutes on Section A and 55 minutes on Section B.
- There are four marks available for the quality of written communication in Section B.
- The values of standard physical constants are given in the Data, Formulae and Relationship Booklet. Any additional data required are given in the appropriate question.

FOR EXAMINER'S USE		
Section	**Max.**	**Mark**
A	**20**	
B	**50**	
TOTAL	**70**	

This document consists of **16** printed pages.

Answer **all** the questions.

Section A

1 Here are some units.

Bq **J kg^{-1}** **Hz** **J s^{-1}**

(a) Which one is the correct unit for the activity of a radioisotope?

answer .... [1]

(b) Which one is the correct unit for absorbed dose from a radioactive source?

answer .... [1]

2 Fig. 2.1 shows a simple generator.

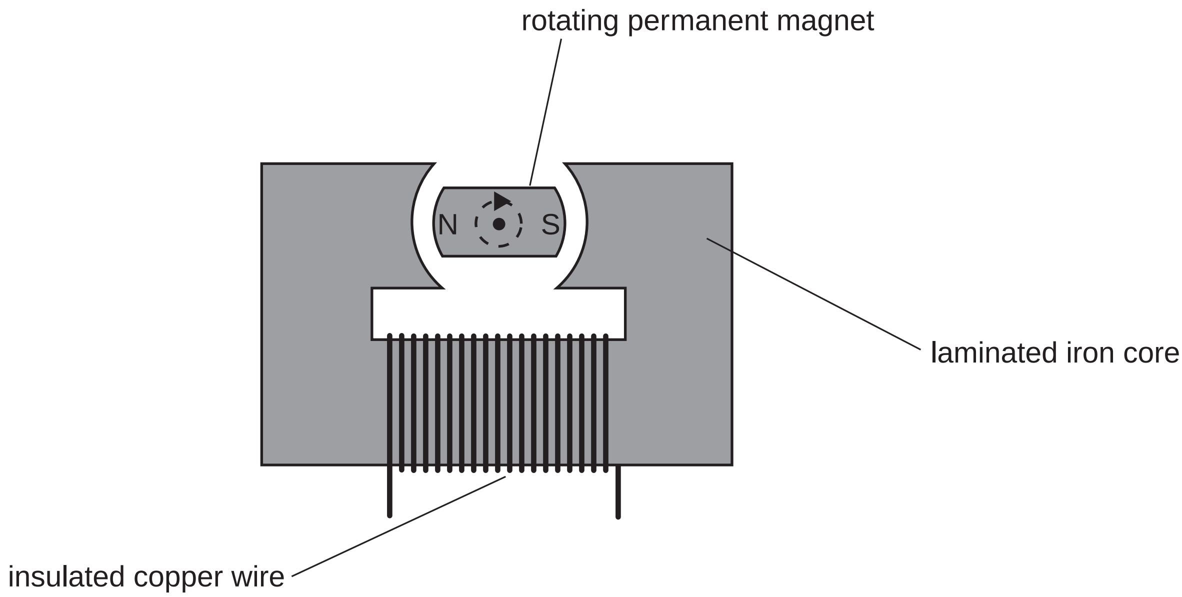

Fig. 2.1

The peak value of the emf induced in the coil can be increased by winding more turns of wire around the laminated iron core.

State **two** more ways of increasing the peak value of the emf **without** altering its frequency.

[2]

3 Fig. 3.1 shows the path of an alpha particle being scattered from a nucleus of uranium-238.

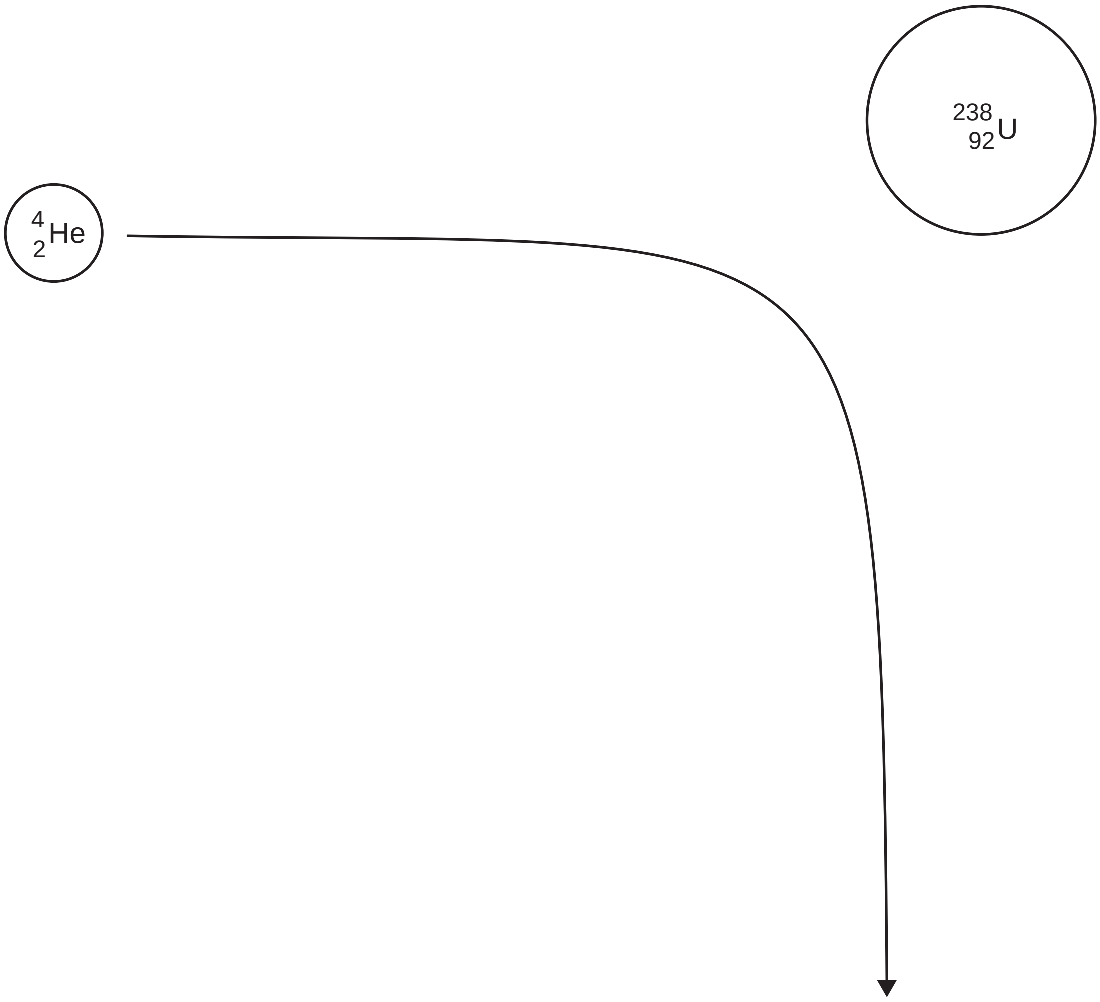

Fig. 3.1

(a) On Fig. 3.1, sketch the path followed by the alpha particle when it follows the same initial path but with more kinetic energy. [1]

(b) The table contains statements about the scattering of alpha particles by a thin sheet of metal. Put a tick in the appropriate box to indicate whether each statement is true or false.

The number of alpha particles scattered through more than 90° …	**false**	**true**
… increases as the sheet is made thicker.		
… increases as the proton number of the metal is increased.		
… increases as the energy of the alpha particles is increased.		

[1]

4 Fig. 4.1 shows an electromagnet supporting a load.

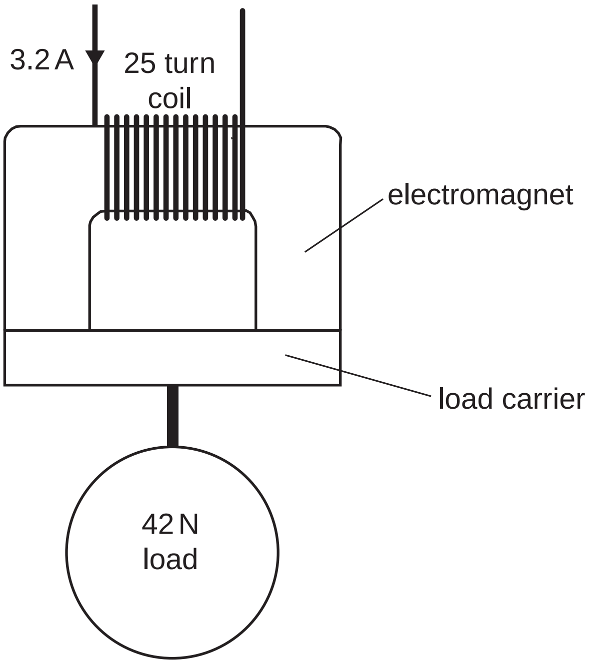

Fig. 4.1

A current of 3.2 A in the 25 turn coil of wire is just able to support a load from the poles of the electromagnet.

(a) The table shows different combinations of current and turns of wire.

Put a tick (✓) against the combinations which will support a load of 42 N.

current / A	turns of wire	supports 42 N?
3.2	25	✓
3.2	30	
6.4	10	
2.0	50	

[1]

(b) Explain why inserting a sheet of paper between the poles of the electromagnet and the load carrier reduces the load which can be supported.

[2]

5 It has been suggested that if everyone had a chest X-ray every six months, many cases of lung cancer could be diagnosed at an early stage, before they become difficult to treat.

A single chest X-ray delivers a dose equivalent of 0.05 mSv. If the risk of developing cancer is 3% per Sv, estimate the risk of having two chest X-rays a year for 60 years.

risk = ... [2]

6 Fig. 6.1 shows four different particles, each made from a trio of u and d quarks.

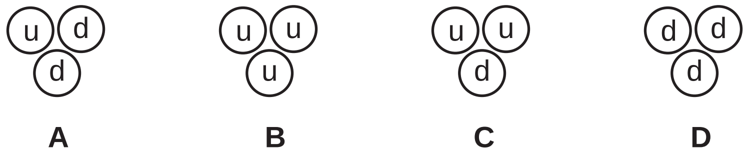

Fig. 6.1

The charge of u and d quarks are $+\frac{2}{3}e$ and $-\frac{1}{3}e$ respectively.

(a) Which particle is a proton?

answer .... [1]

(b) Which particle has the same charge as an anti-proton?

answer .... [1]

(c) Which particle has the same charge as its anti-particle?

answer .... [1]

7 Beams of neutrons can be obtained by firing deuterium nuclei ${}^{2}_{1}\text{H}$ into a target of tritium nuclei ${}^{3}_{1}\text{H}$. The nuclear reaction is as follows.

$$ {}^{2}_{1}\text{H} + {}^{3}_{1}\text{H} \rightarrow {}^{4}_{2}\text{He} + {}^{1}_{0}\text{n} $$

(a) Use data from the table to show that the energy released in the reaction is about 3×10^{-12} J.

nucleus	mass / u
neutron	1.008665
deuterium	2.014102
tritium	3.016050
helium	4.002603

$u = 1.66 \times 10^{-27}$ kg

$c = 3.0 \times 10^{8}\ \text{m s}^{-1}$

[2]

(b) Explain why the deuterium nuclei need to be accelerated to an energy of about 2×10^{-14} J before any neutrons are produced. No calculations are required.

[2]

8 Naturally occurring radioactive materials emit three types of radiation:

alpha particles

beta particles

gamma photons

Each type has a different effect on living tissue.

Here are three sentences about radiation.

Draw straight lines to join the **start** of each sentence to its correct **middle** and **end**.

start	**middle**	**end**
Alpha particles	have no charge	and damage tissues to a depth of about 10 mm.
Beta particles	are easily deflected	and damage tissues deep below the surface.
Gamma photons	are highly ionising	and damage tissues to a depth of about 10 μm.

[2]

[Section A Total: 20]

Section B

In this section, four marks are available for the quality of written communication.

9 This question is about using a special transformer to alter the emf of an alternating voltage.

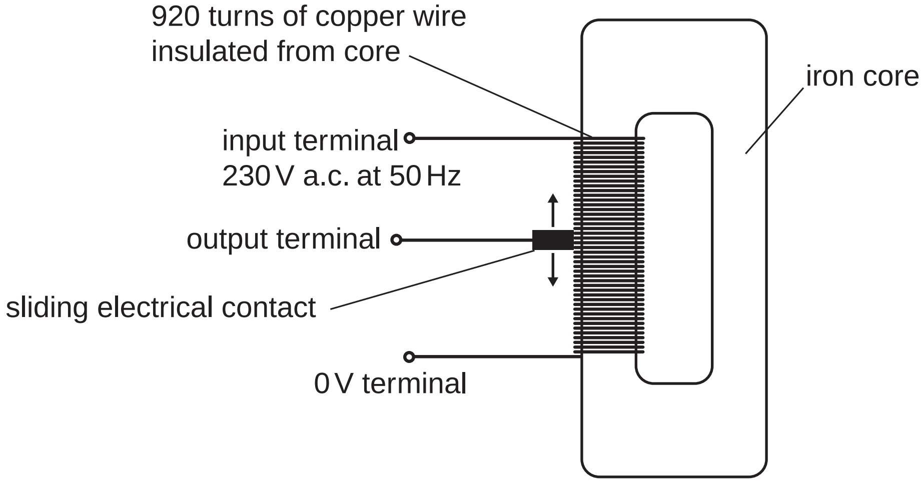

Fig. 9.1

Fig. 9.1 shows the construction of a special transformer whose output can be altered by moving a sliding electrical contact along a **single** coil of wire wound around an iron core.

(a) On Fig. 9.1, sketch **two** loops of flux in the core when there is a current in the coil of wire. [1]

(b) The graph of Fig. 9.2 shows how the emf at the input terminal varies with time.

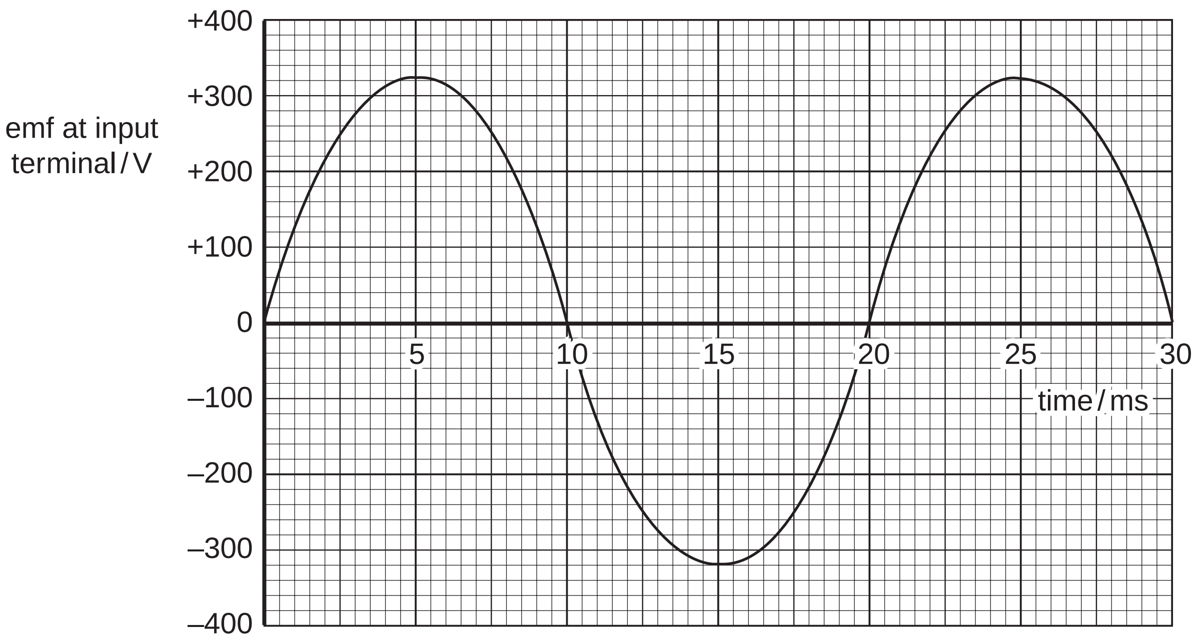

Fig. 9.2

(i) On Fig. 9.2, sketch a graph showing how the flux linkage in the coil of wire changes with time. [2]

(ii) Explain why the area under the emf-time graph for the first 5 ms equals the peak **flux linkage** of the coil of wire.

[2]

(iii) By estimating the area under the emf graph for the first 5 ms, calculate the peak **flux** in the 920 turns of wire.

peak flux = ... Wb [3]

(c) The sliding contact of this transformer is placed so that it is 115 turns of wire away from the 0 V terminal.

Explain why the output terminal has an emf of about 30 V when the emf across the whole 920 turn coil is 230 V.

[2]

(d) Explain why the transformer core is made of iron, but that the iron is assembled in very thin sheets held together by an insulating glue.

[4]

[Total: 14]

10 This question is about the production of ions by needles held at a high voltage.

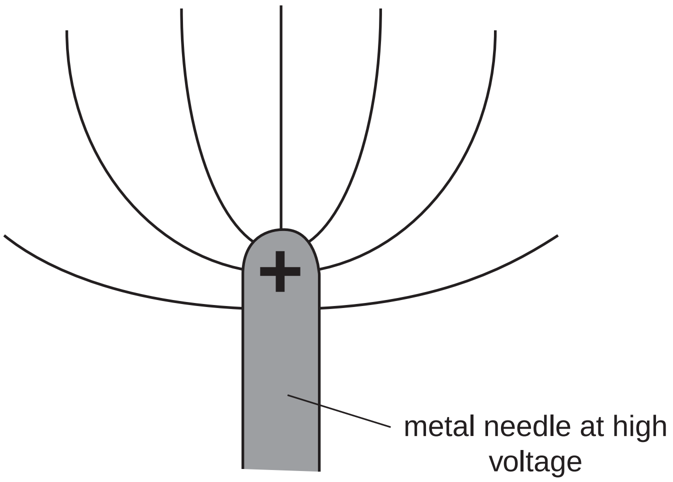

Fig. 10.1

(a) Fig. 10.1 shows some of the electric field lines around a metal needle which is held at a positive voltage.

(i) Draw arrows on all the lines to show the direction of the electric field. [1]

(ii) Draw **two** equipotential surfaces which pass through the field lines. [2]

(iii) State a feature of the diagram which shows that the electric field strength is greatest at the tip of the needle.

[1]

(b) The air at the tip of the needle is ionised when the electric field strength exceeds $5.0 \times 10^6\,\mathrm{N\,C^{-1}}$. The process can be modelled as shown in Fig. 10.2.

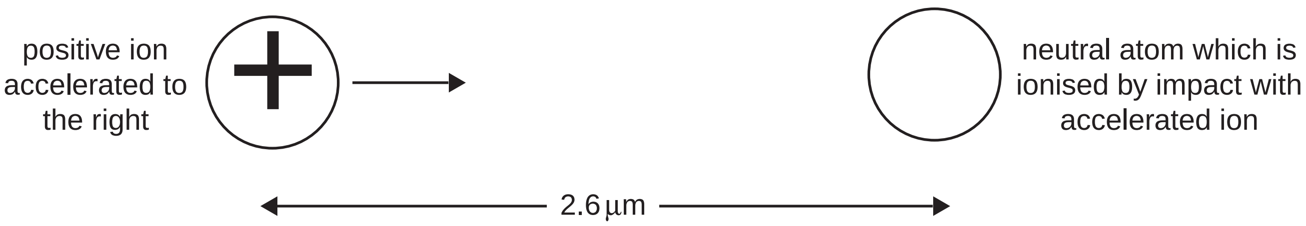

Fig. 10.2

A single ion accelerates through the electric field, moving an average distance of 2.6 μm before hitting a neutral atom. If the ion has 2.1×10^{-18} J of kinetic energy when the impact occurs, the impact will ionise the neutral atom. There are now two ions to be accelerated towards more impacts with neutral atoms.

(i) Show that an ion which moves 2.6 μm in the direction of an electric field of strength 5.0×10^{6} N C^{-1} falls through a potential difference of 13 V.

[2]

(ii) If each ion has a charge of 1.6×10^{-19} C, show that it has 2.1×10^{-18} J of kinetic energy after it has been accelerated through a distance of 2.6 μm.

[2]

(c) Sources of positive ions are widely used to clear dust particles out of the air. The particles become charged by impact with ions drifting through the air. They are then attracted to neutral conducting surfaces, as shown in Fig. 10.3.

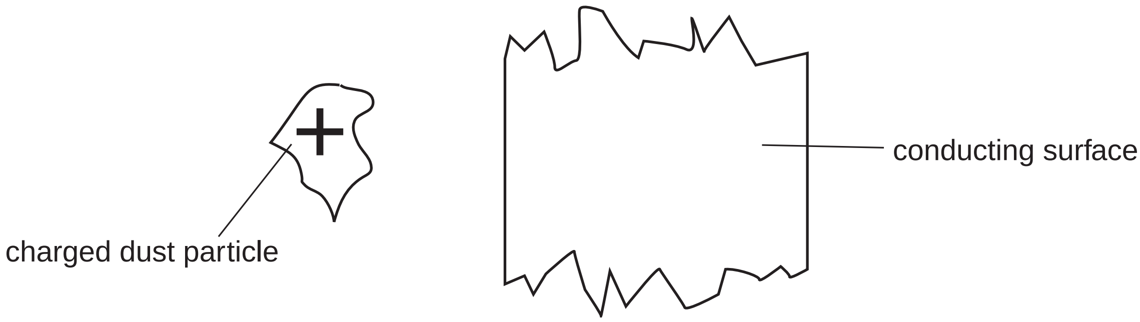

Fig. 10.3

By describing the effect of the charged dust particle on electrons in a conductor placed close by, explain why the dust particle moves towards the neutral conducting surface.

[4]

[Total: 12]

11 This question is about the absorption of photons by air.

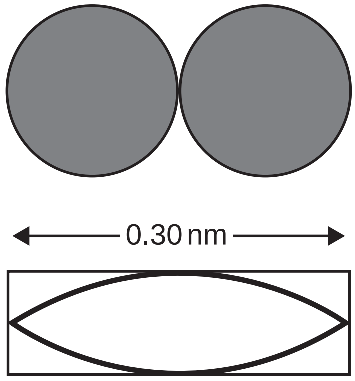

Fig. 11.1

Air is transparent because it is unable to absorb visible photons. The majority of air molecules are made from pairs of atoms, as shown in Fig. 11.1. Some electrons are able to transfer freely between the atoms. These electrons can be modelled as trapped in a box of length 0.30 nm.

(a) Fig. 11.1 shows the standing wave for an electron trapped in a box when it is in its lowest energy state (n = 1). Complete the boxes of Fig. 11.2 to show the standing waves for n = 2 and n = 3.

Fig. 11.2 [1]

(b) The energy E of an electron of mass m and momentum p is given by

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

Show that the energy of the electron in state n in a box of length d is given by

$$E = \frac{n^2h^2}{8md^2}$$

where h is the Planck constant.

[3]

(c) Fig. 11.3 shows the lowest energy level of an electron trapped in a box of length 0.30 nm.

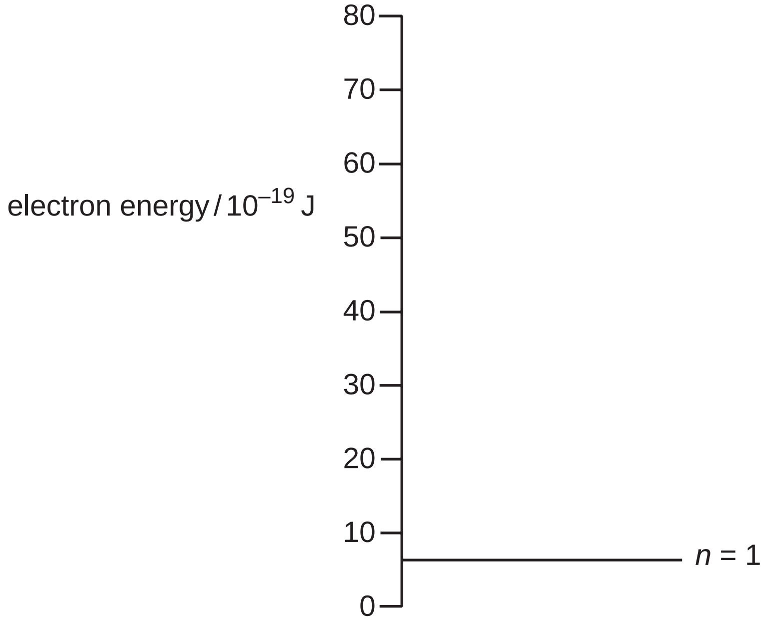

Fig. 11.3

(i) Draw lines on Fig. 11.3 to show the energy levels for $n = 2$ and $n = 3$.

$h = 6.6 \times 10^{-34}$ J s

$m = 9.1 \times 10^{-31}$ kg

[3]

(ii) Photons of visible light have a typical wavelength of 500 nm.

By calculating the energy of these photons, explain why they cannot be absorbed by a molecule whose energy levels are as shown in Fig. 11.3.

$c = 3.0 \times 10^{8}$ m s^{-1}

[4]

[Total: 11]

12 This question is about the fission of uranium-235.

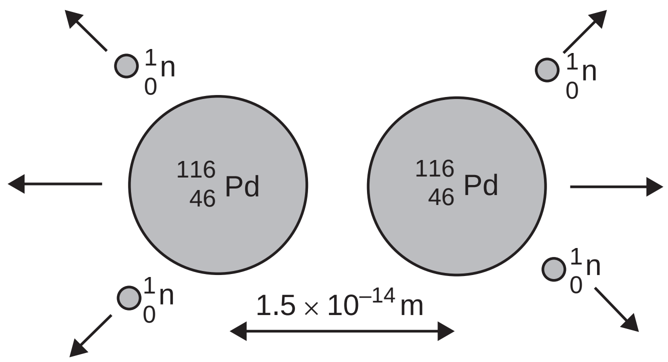

Fig. 12.1

Fig. 12.1 represents the outcome of a possible fission of a single nucleus of uranium-235 caused by the absorption of a neutron.

(a) Write down a nuclear equation for the fission of uranium-235 which results in two nuclei of palladium-116, as shown in Fig. 12.1.

[2]

(b) After the fission, the palladium-116 nuclei move apart, each with a kinetic energy of about 100 MeV. This can be modelled by assuming that each nucleus is a spherical distribution of charge, with their centres initially 1.5×10^{-14} m apart, as shown in Fig. 12.1.

(i) Show that the potential at the centre of the left-hand palladium-116 nucleus due to the charge of the right-hand nucleus is about 4 MV.

$e = 1.6 \times 10^{-19}$ C

$k = 9.0 \times 10^{9}$ N m^2 C^{-2}

[2]

(ii) Hence calculate the electrical potential energy of the two palladium-116 nuclei just after the fission process has taken place.

energy = ... eV [3]

(c) The fission shown in Fig. 12.1 releases four neutrons.

These need to be slowed down by a moderator if they are to induce the fission of other nuclei of uranium-235 in a nuclear reactor.

Explain why the average number of neutrons released by each fission must be greater than 1 for a steady chain reaction to be possible in the nuclear reactor.

[2]

[Total: 9]

Quality of Written Communication [4]

[Section B Total: 50]

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE