Candidate forename		Candidate surname	

Centre number						Candidate number				

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

ADVANCED GCE

G485

PHYSICS A

Fields, Particles and Frontiers of Physics

TUESDAY 21 JUNE 2011: Morning
DURATION: 1 hour 45 minutes

SUITABLE FOR VISUALLY IMPAIRED CANDIDATES

Candidates answer on the question paper.

OCR SUPPLIED MATERIALS:

Data, Formulae and Relationships Booklet

OTHER MATERIALS REQUIRED:

Electronic calculator
Ruler
Protractor

READ INSTRUCTIONS OVERLEAF

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INSTRUCTIONS TO CANDIDATES

- **Write your name, centre number and candidate number in the boxes on the first page. Please write clearly and in capital letters.**
- **Use 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.**
- **Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).**

INFORMATION FOR CANDIDATES

- **The number of marks is given in brackets [ ] at the end of each question or part question.**
- **The total number of marks for this paper is 100.**
- **Where you see this icon you will be awarded marks for the quality of written communication in your answer.**

  This means for example you should:

  - **ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear**
  - **organise information clearly and coherently, using specialist vocabulary when appropriate.**
- **You may use an electronic calculator.**

Answer ALL the questions.

1 (a) Define *electromotive force*.

_____

_____ **[1]**

(b) Define *magnetic flux*.

_____

_____

_____ **[1]**

(c) Fig. 1.1 shows a simple transformer.

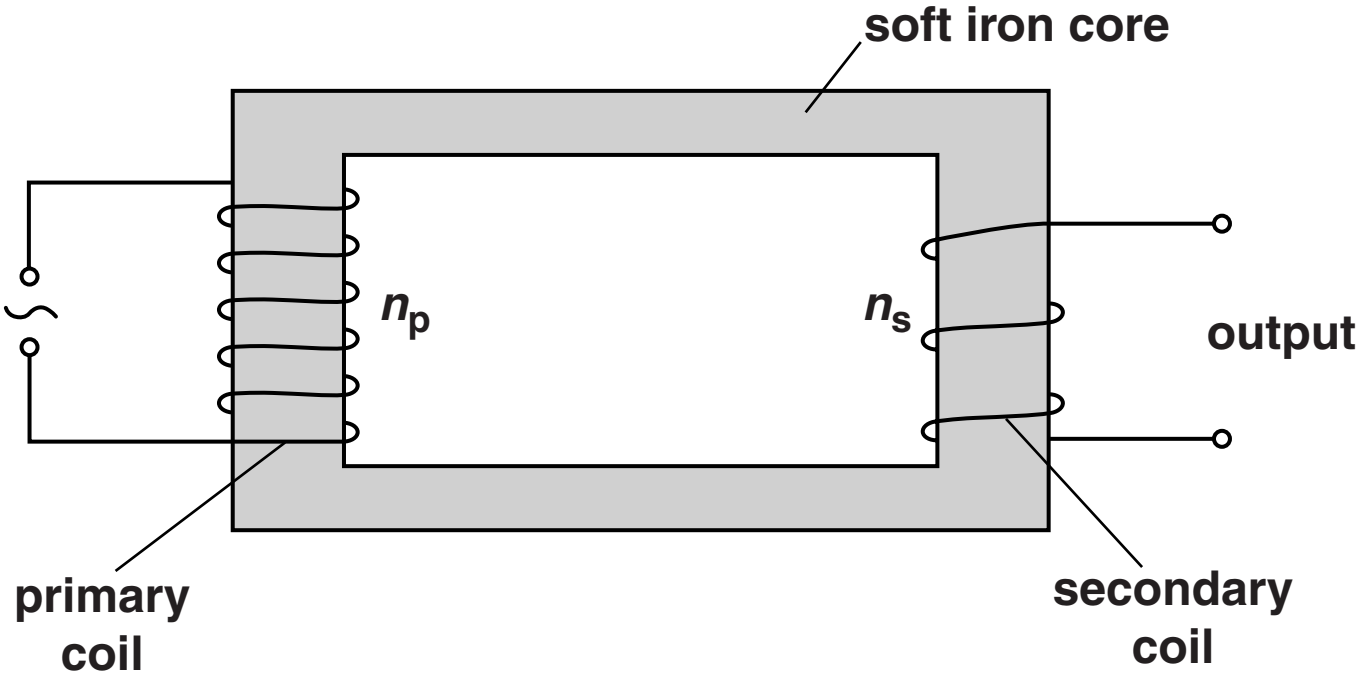

Fig. 1.1

(i) The primary coil is connected to an alternating voltage supply. Explain how an e.m.f. is induced in the secondary coil.

_____

_____

_____

_____

_____

_____

_____ **[3]**

(ii) State how you could change the transformer to increase the maximum e.m.f. induced in the secondary coil.

_____

_____

_____ **[1]**

(d) A transformer with 4200 turns in the primary coil is connected to a 230V mains supply. The e.m.f. across the output is 12V. Assume the transformer is 100% efficient.

(i) Calculate the number of turns in the secondary coil.

number of turns = _____ [2]

(ii) The transformer output terminals are connected to a lamp using leads that have a total resistance of 0.35 Ω. The p.d. across the lamp is 11.8V. Calculate

1 the current in the leads connected to the lamp

current = _____ A [2]

2 the power dissipated in the leads.

power = _____ W [2]

[Total: 12]

2 (a) Define *capacitance*.

_____

_____ **[1]**

(b) Fig. 2.1 shows two capacitors of capacitance 150 μF and 450 μF connected in series with a battery of e.m.f. 6.0 V. The battery has negligible internal resistance.

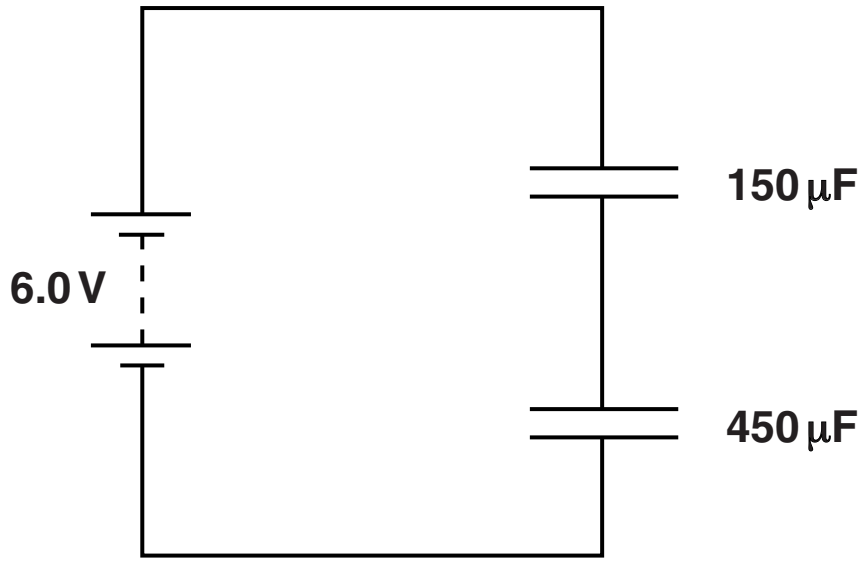

Fig. 2.1

For the circuit shown in Fig. 2.1, calculate

(i) the potential difference across the 150 μF capacitor

potential difference = _____ V [2]

(ii) the charge stored by the 150 μF capacitor

charge = _____ C [1]

(iii) the total capacitance of the circuit.

capacitance = _____ F [1]

(c) The fully charged capacitors shown in (b) are disconnected from the battery. The capacitors are then connected in series with a resistor R of resistance 45 kΩ and an open switch S as shown in Fig. 2.2.

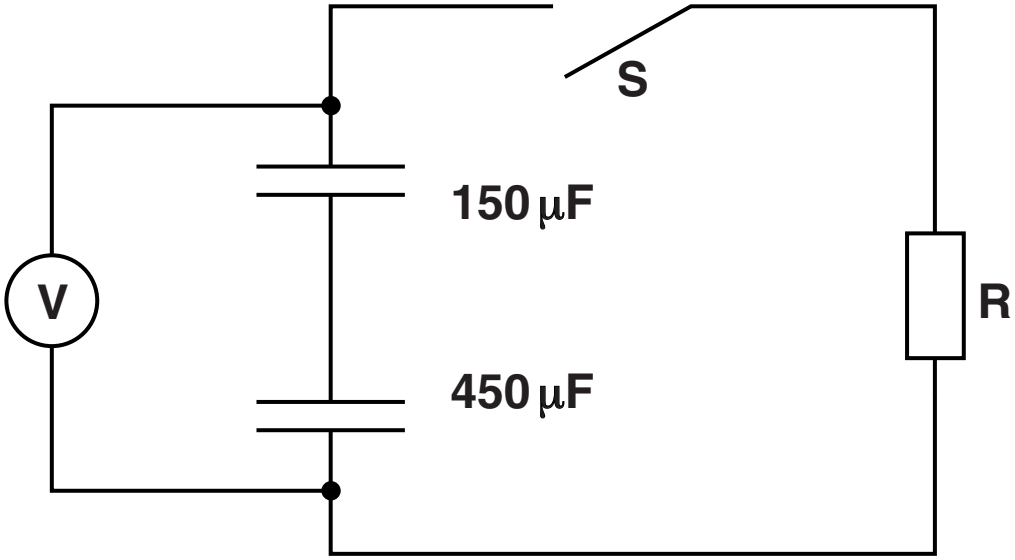

Fig. 2.2

The p.d. *V* across the capacitors is measured with a voltmeter of infinite resistance.
The switch S is closed at time $t = 0$ and measurements of *V* are made at regular time intervals.

(i) Show that the time constant for the circuit is about 5 s.

[1]

(ii) On Fig. 2.3 sketch the variation of p.d. V with time t.

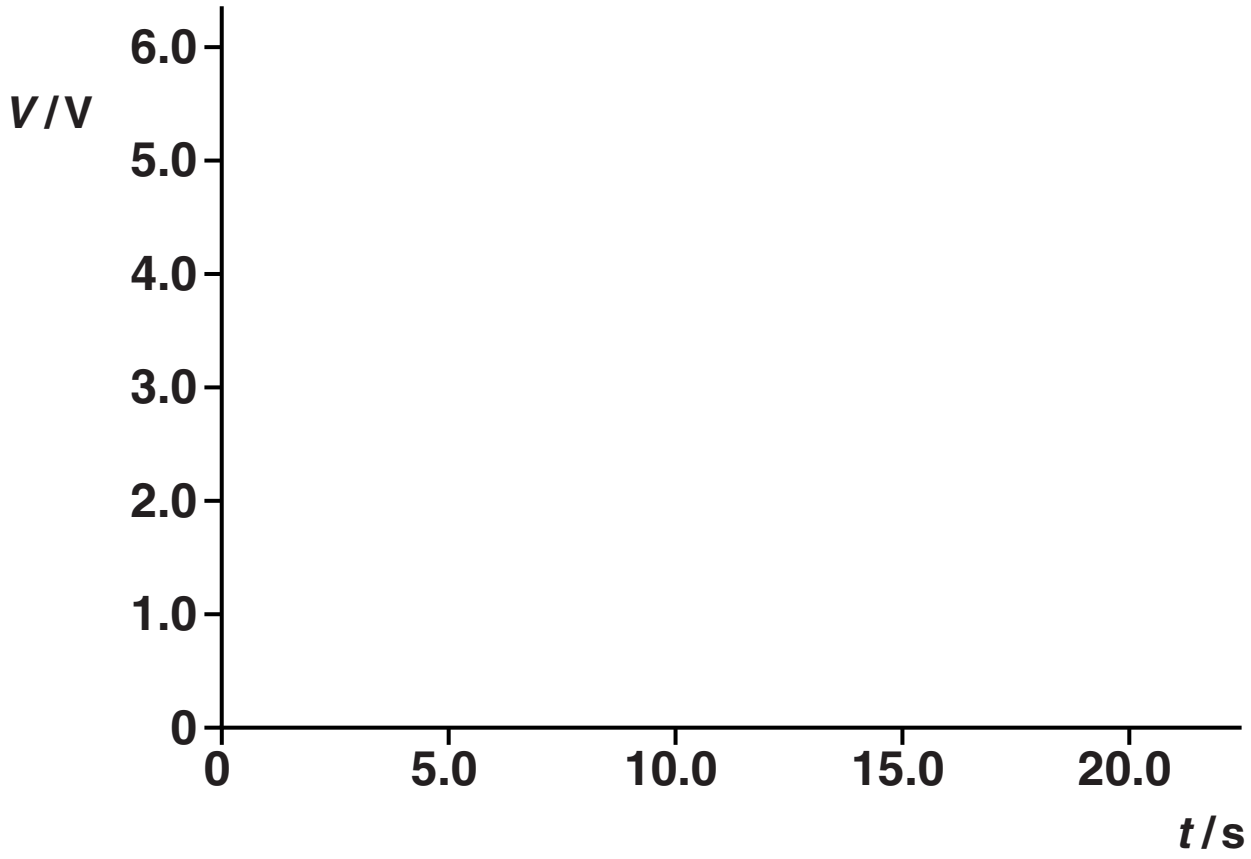

Fig. 2.3

[3]

(iii) At time $t = 0$ calculate the ratio

$$\frac{\text{energy stored by the } 150\,\mu\text{F capacitor}}{\text{energy stored by the } 450\,\mu\text{F capacitor}}.$$

ratio = _____ [2]

(iv) State and explain how the ratio varies with time.

_____

_____

_____ **[2]**

[Total: 13]

3 (a) Define *electric field strength*.

_____

_____ **[1]**

(b) Fig. 3.1 shows two horizontal, parallel metal plates A and B.

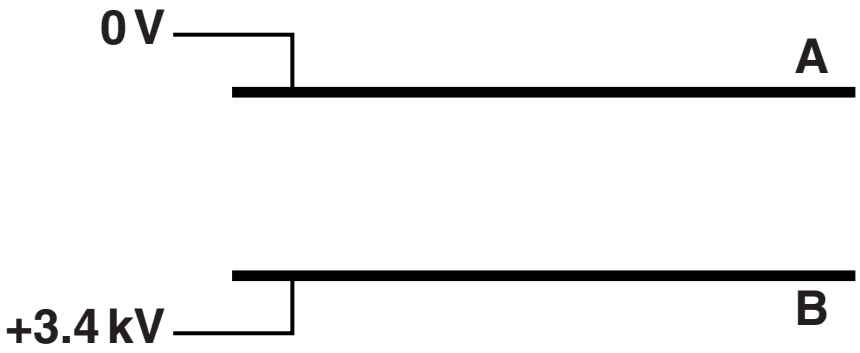

Fig. 3.1

The potential difference across the plates is 3.4 kV and the arrangement provides a uniform electric field between the plates.

ON FIG. 3.1 draw at least six lines to represent the electric field between the plates. [2]

(c) A beam of electrons enters between the plates at right angles to the electric field. The horizontal velocity of the electrons is 4.0×10^7 m s^{-1}. The path of the electrons is shown on Fig. 3.2. The horizontal length of each plate is 0.080 m and the separation of the plates is 0.050 cm. P is a point 0.040 m from where the beam enters the plates.

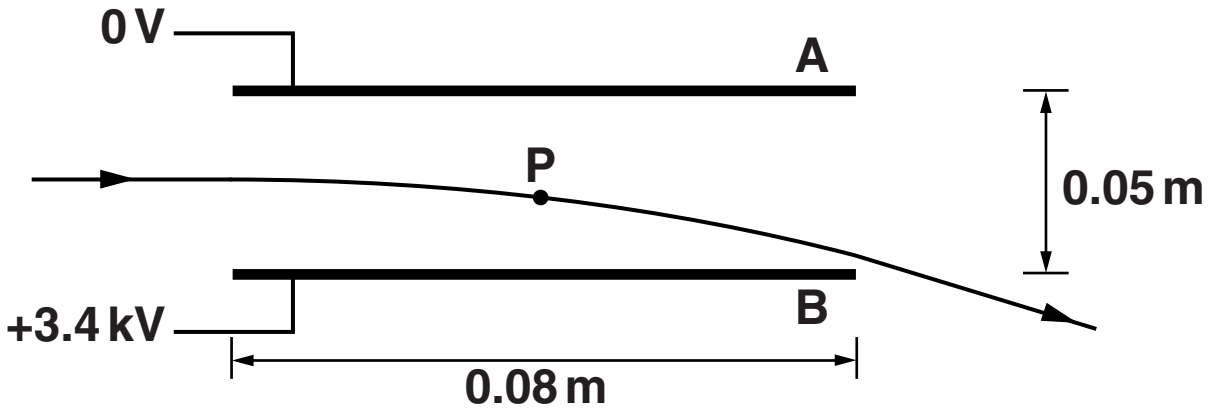

Fig. 3.2

(i) Draw an arrow on Fig. 3.2 to show the direction of the acceleration of an electron at P.

[1]

(ii) Show that the acceleration of an electron between the plates is about $1 \times 10^{16}\,m\,s^{-2}$.

[2]

(iii) Calculate the time taken for an electron on entering the plates to reach P.

time = _____ s [1]

(iv) Show that the vertical velocity of the electron at P is $1.2 \times 10^{7}\,m\,s^{-1}$.

[1]

(v) Calculate the magnitude of the resultant velocity of the electron at P.

magnitude of the velocity = _____ $m\,s^{-1}$ [2]

(vi) Calculate the kinetic energy of the electron at P.

kinetic energy = _____ J [2]

(vii) On Fig. 3.3 sketch the variation of kinetic energy E_k of the electron with the horizontal distance x it travels through the electric field and beyond. No calculations are required.

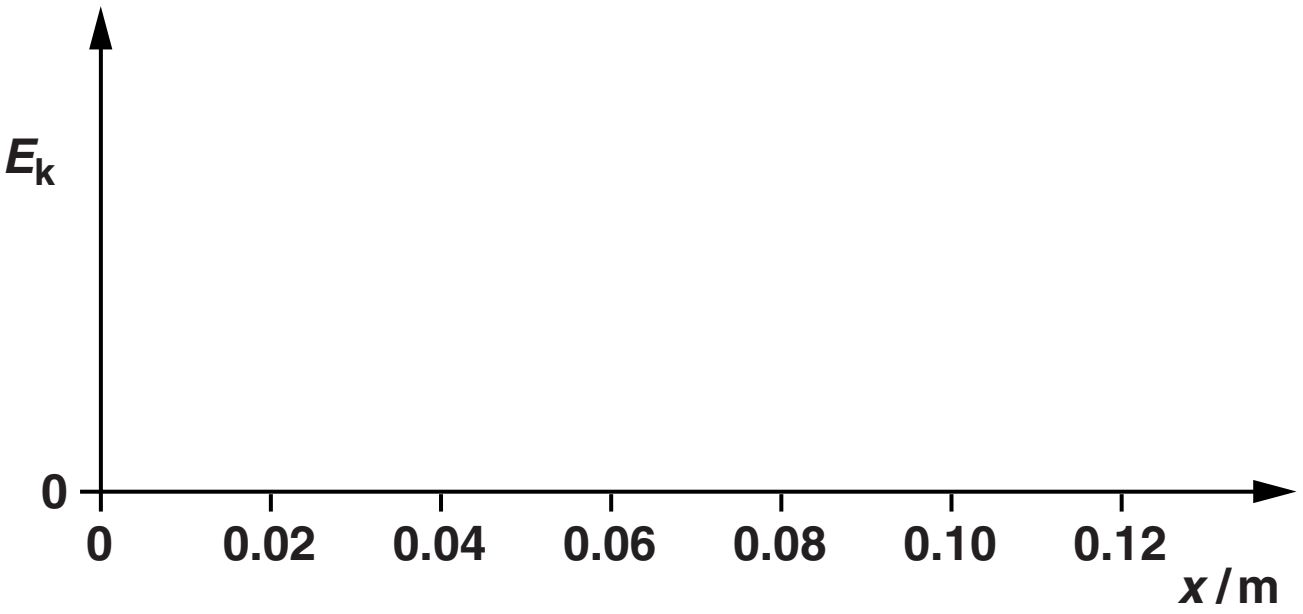

Fig. 3.3

[3]

[Total: 15]

4 A small, charged metal sphere A is hung from an insulating string. The charge on A is +5.0 nC. Fig. 4.1 shows the effect on A when a charged sphere B on an insulated rod is positioned close to it. The string makes an angle θ with the vertical.

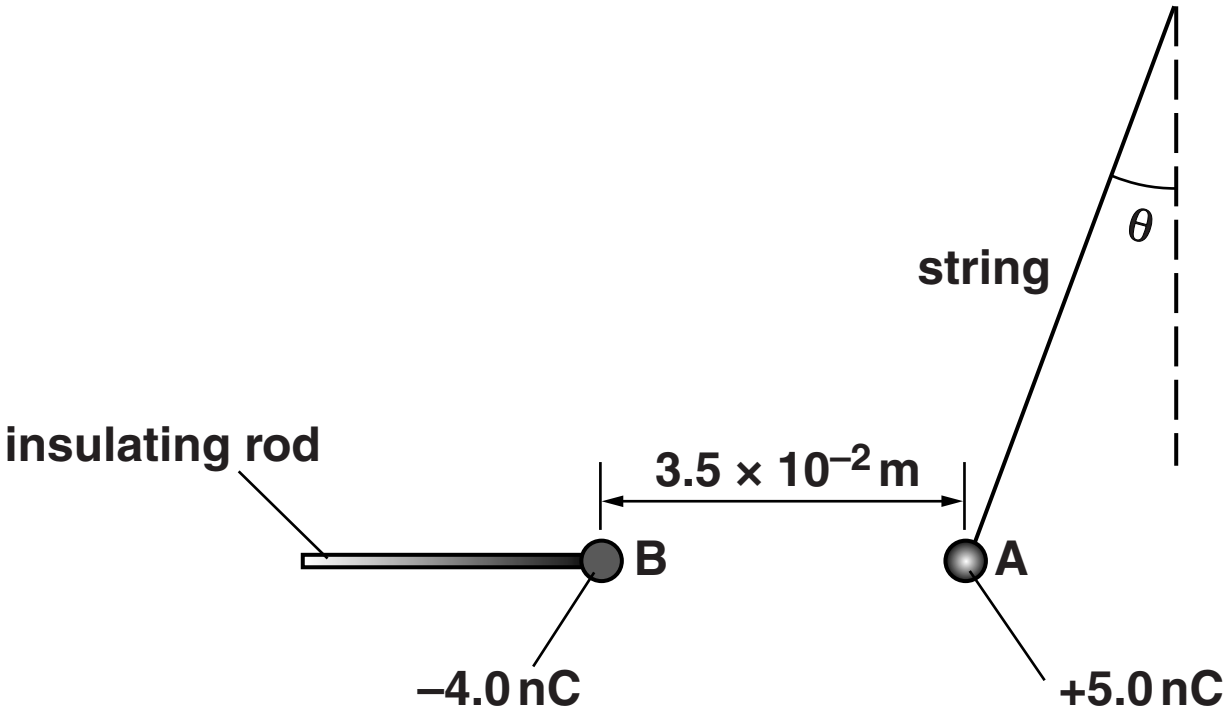

Fig. 4.1

The charge on B is –4.0 nC. The separation between the centres of the two spheres is 3.5×10^{-2} m.

(a) Determine the magnitude and direction of the electric field strength at the MIDPOINT between the two charged spheres.

electric field strength = _____ $N\,C^{-1}$

direction = _____

[4]

(b) Show that the electric force on A is 1.5×10^{-4} N.

[2]

(c) The mass of sphere A is 4.5×10^{-5} kg. Use the method of resolving vectors or a vector triangle to determine the angle θ made by the string with the vertical.

θ = _____° **[3]**

[Total: 9]

5 Fig. 5.1 shows a rigid, straight metal rod XY placed perpendicular to a magnetic field. The magnetic field is produced by two magnets that are placed on a U-shaped steel core. The steel core sits on a digital balance.

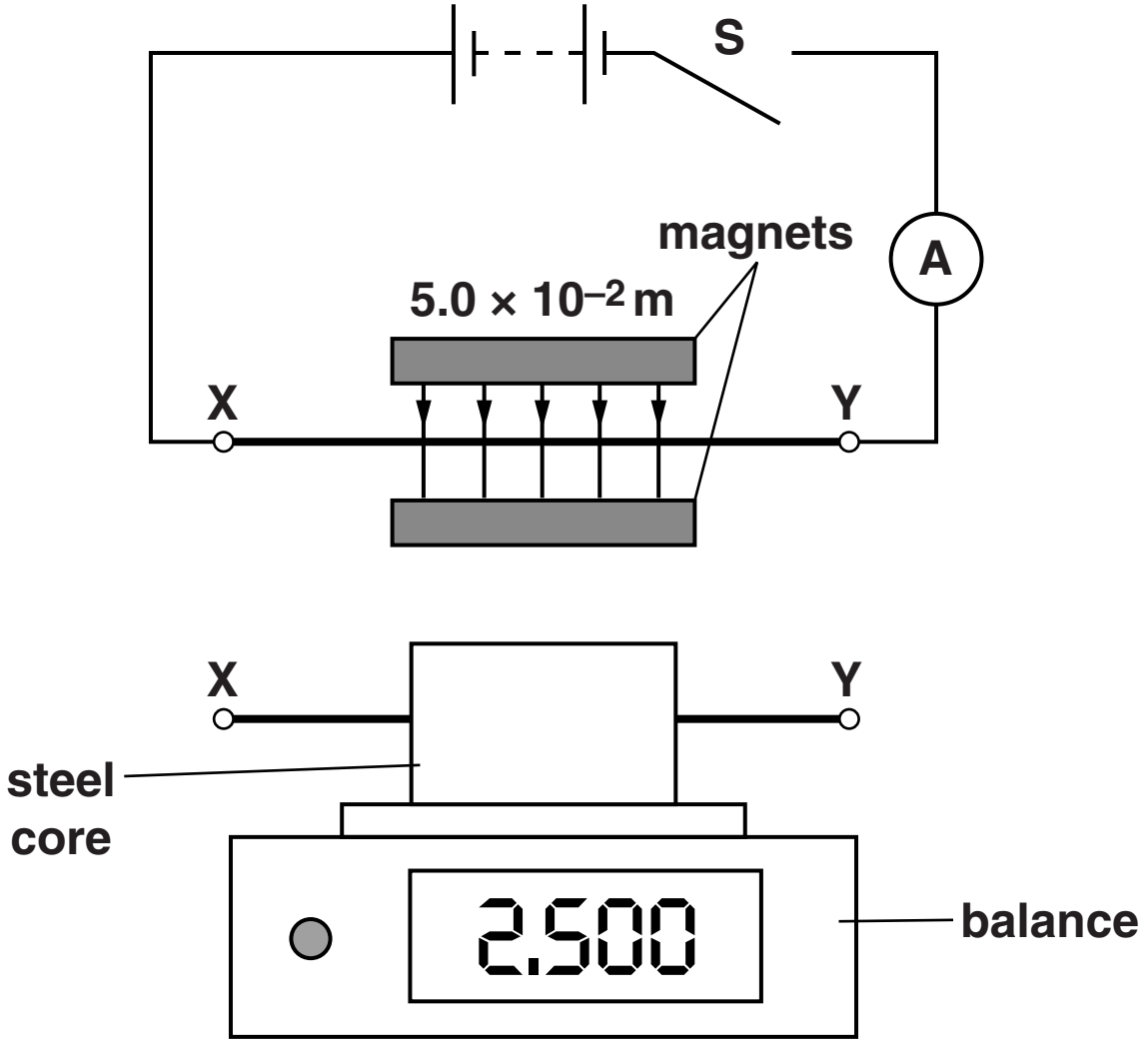

Fig. 5.1

The weight of the steel core and the magnets is 2.500 N. The rod is clamped at points X and Y. The rod is connected to a battery, switch and ammeter as shown in Fig. 5.1. The direction of the magnetic field is perpendicular to the rod.

Switch S is closed.

(a) State the direction of the force that now acts on the rod due to the magnetic field.

_____ **[1]**

(b) State how you determined the direction of the force.

_____

_____

_____ **[1]**

(c) The length of the rod in the magnetic field is 5.0×10^{-2} m and the current in the rod is 4.0 A. Assume that the magnets provide a uniform magnetic field of magnetic flux density 0.080T.

(i) Calculate the force acting on the rod due to the magnetic field.

force = _____ **N [1]**

(ii) State and explain the new reading on the balance.

reading on balance = _____ **N**

_____

_____

_____

_____

_____ **[3]**

(d) The rod is replaced by another rod of the same material having half the diameter of the first wire and the same length. The potential difference across this rod is the same. Calculate the force on this rod due to the magnetic field.

force = _____ N [3]

[Total: 9]

6 (a) In experiments carried out to determine the nature of atoms, alpha particles were fired at thin metal foils. Describe how the alpha-particle scattering experiments provide evidence for the existence, charge and size of the nucleus.

In your answer, you should make clear how your conclusions link with your observations.

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_____ **[5]**

(b) Describe the nature and range of the THREE forces acting on the protons and neutrons in the nucleus.

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_____ **[5]**

(c) The radius of a $^{235}_{92}U$ nucleus is 8.8×10^{-15} m. The average mass of a nucleon is 1.7×10^{-27} kg.

(i) Estimate the average density of this nucleus.

density = _____ kg m^{-3} [3]

(ii) State one assumption made in your calculation.

_____

_____ **[1]**

[Total: 14]

7 (a) Explain what is meant by the *critical density* of the universe.

_____

_____ **[1]**

(b) Cosmologists have determined the Hubble constant to be 65 km s^{-1} Mpc^{-1}. Calculate the Hubble constant in s^{-1} and hence determine the critical density of the universe.

1 pc = 3.1×10^{16} m

Hubble constant = _____ **s^{-1}**

critical density = _____ **kg m^{-3} [3]**

(c) (i) Explain the terms *open*, *closed* and *flat* when describing the possible evolution of the universe. On Fig. 7.1 sketch and label graphs to illustrate your answer.

Fig. 7.1

open _____

_____

_____

closed _____

_____

_____

flat _____

_____

_____ **[3]**

(ii) Suggest a reason why it is difficult to predict the future of the universe.

_____

_____

_____ **[1]**

[Total: 8]

8 (a) State one reason for using non-invasive techniques in medical diagnosis.

_____

_____ **[1]**

(b) Describe the use of medical tracers to diagnose the condition of organs.

_____

_____

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_____ **[2]**

(c) Describe the principles of positron emission tomography (PET).

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_____ **[5]**

[Total: 8]

9 (a) Describe the principles of ultrasound scanning.

In your answer, you should make clear how the steps in the process are sequenced.

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_____ **[4]**

(b) Explain the difference between an ultrasound A-scan and B-scan.

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_____

_____

_____ **[1]**

[Total: 5]

TURN OVER PAGE FOR QUESTION 10.

10 (a) Describe the process of induced nuclear fission.

_____

_____

_____

_____

_____ **[2]**

(b) Explain how nuclear fission can provide energy.

_____

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_____ **[2]**

(c) Suggest a suitable material which can be used as a moderator in a fission reactor and explain its role.

_____

_____

_____

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_____

_____ **[3]**

[Total: 7]

END OF QUESTION PAPER

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