RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced GCE

PHYSICS B (Advancing Physics) PILOT 7734/1
Field and Particle Pictures

Monday **18 JUNE 2001** Morning 1 hour 10 minutes

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

TIME 1 hour 10 minutes

INSTRUCTIONS TO CANDIDATES
- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above. .Answer all the questions.
- Write your answers in the spaces on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Show clearly the working in all calculations, and round answers to only a justifiable number of significant figures.

INFORMATION FOR CANDIDATES
- The number of marks is given in brackets [ ] at the end of each question or part question.
- The values of standard physical constants are given in the Data, Formulae and Relationships Booklet. Any additional data required are given in the appropriate question.
- You are advised to spend about 20 minutes on Section A and 50 minutes on Section B. You will be awarded marks for the quality of written communication in Section B.

SECTION A

1 In the list below, $e = 1.6 \times 10^{-19}$ C

0 $+2e/3$ +e $+2e$ $+4e$

Which value is the charge of

(a) a photon? …………………

(b) an alpha particle? …………………

(c) an up quark? ………………… [3]

2 A photon can convert into a positron and an electron, each of mass 9.11×10^{-31} kg. Calculate the minimum energy for a photon to be able to do this.

photon energy =……………… J [2]

3 Which of the units in the list below is the correct choice for the activity of a radioactive source?

Bq g cm^{-2} Gy Sv

……………… [1]

4 Fig. 4.1 shows a cross-section through an electromagnet.

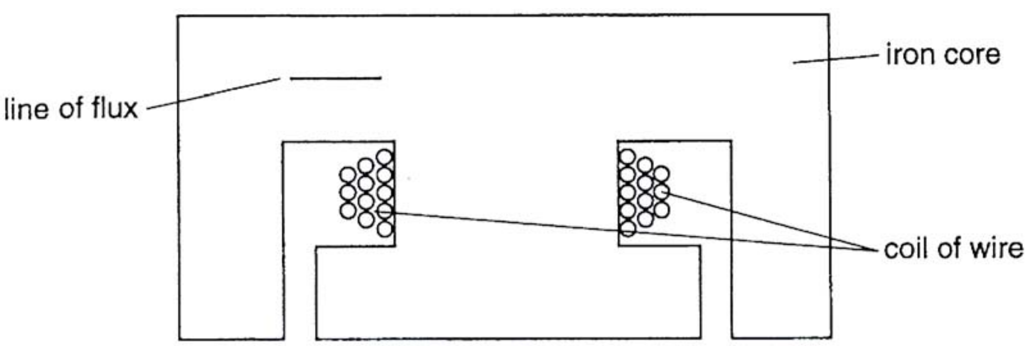

Fig.4.1

There is a current in the coil of wire. Complete the line of flux shown in the diagram. [2]

5 A metal sphere at +200 V is held above a metal plate at 0 V. The electric field between the sphere and the plate is shown in Fig. 5.1.

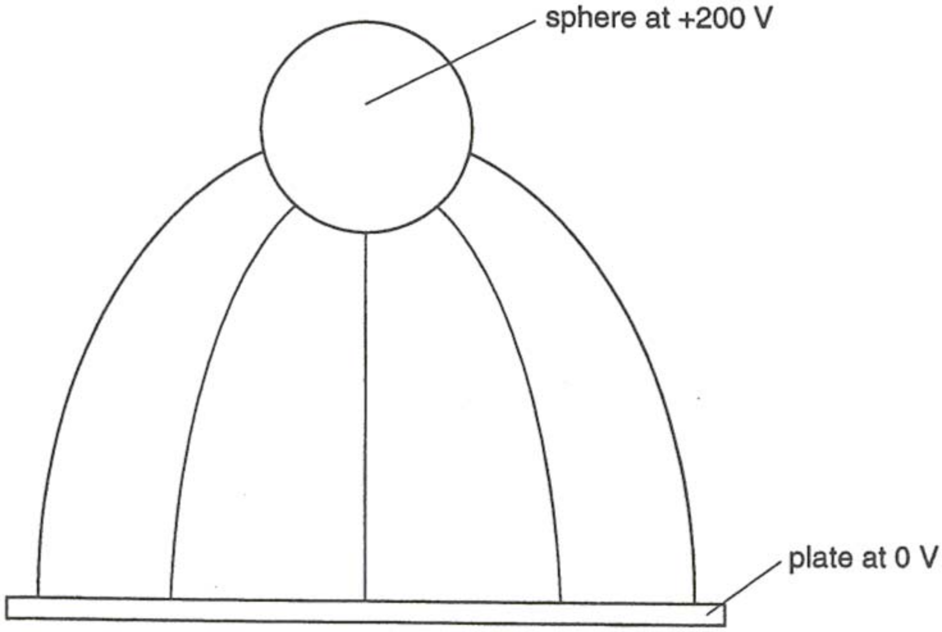

Fig.5.1

(a) Draw an arrow on each field line to show the field direction. [1]

(b) Sketch the equipotential line for + 100 V in the region between the sphere and the plate. [2]

6 A hospital uses a radioactive source to sterilise instruments. When the source is new it has an activity of 7.5×10^5 Bq.
The source has a decay constant of 0.14 yr^{-1}.
Show that it has an activity of 4.6×10^4 Bq when it is 20 years old.

[2]

7 Fig. 7.1 shows a cross-section through a simple a.c. generator.

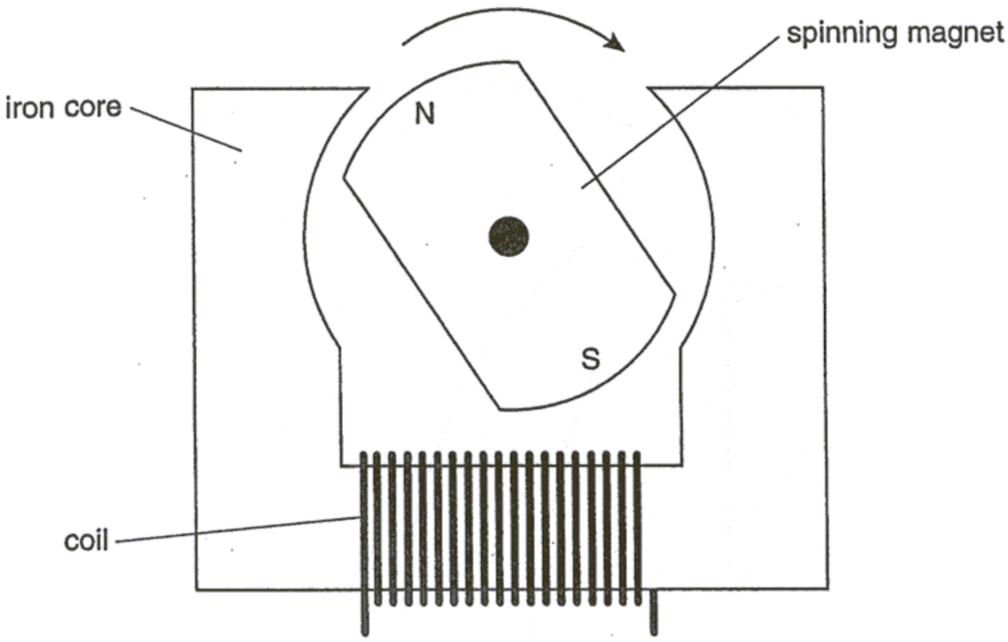

Fig. 7.1

(a) The emf induced in the coil has a frequency of 60 Hz. How many complete revolutions does the spinning magnet make in one second? .

revolutions per second = ……………………. [1]

(b) Here is a list of changes which can be made to the generator.

A Increase the size of the air gap.

B Spin the magnet around faster.

C Increase the turns of wire in the coil.

D Replace the iron with aluminium.

Which two of the changes will increase the emf induced in the coil?

answer: ………………… and …………………. [2]

8 In a scattering experiment, high energy protons are directed at a thin foil of platinum. Most of the protons pass straight through the foil.
Which **one** of the following is the most likely reason for this?

A The protons are repelled by the platinum nuclei.

B The diameters of the platinum nuclei are small compared with the distances between them.

C The mass of one platinum nuclei is large compared with the mass of one proton.

most likely reason …………………. [1]

9 Fig 9.1 shows how the electric potential changes with distance from a point.

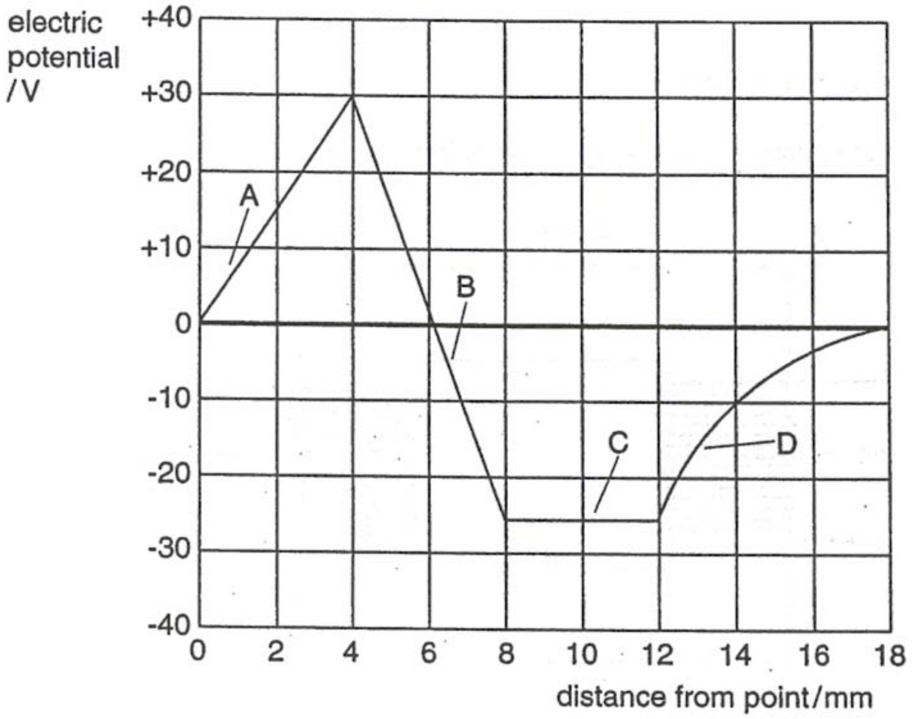

Fig.9.1

The graph has four separate regions labelled A, B, C and D. In which regions is the electric field strength

(a) zero? ………………….

(b) uniform and 7500 V m^{-1}? …………………. [2]

SECTION B

Up to four marks in this section will be awarded for the quality of communication.

10 This question is about transformers.

Fig. 10.1 shows the construction of a typical transformer.

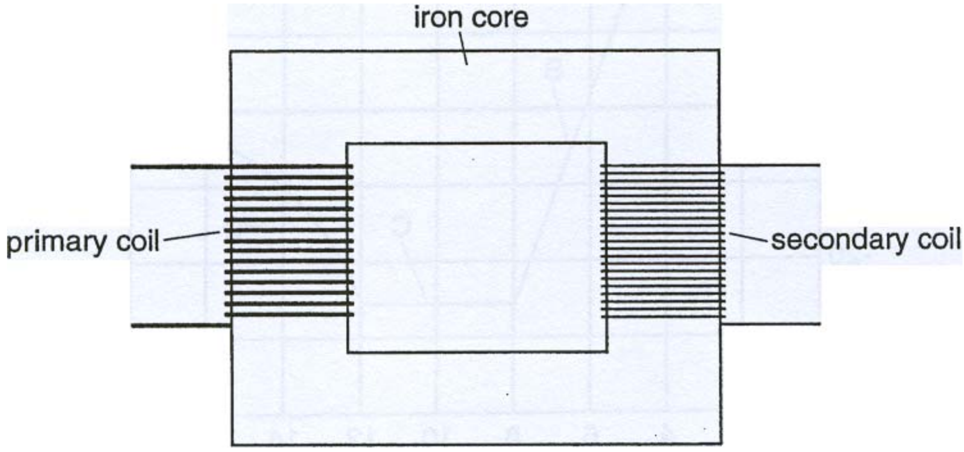

Fig. 10.1

(a) Explain why an alternating current in the primary coil induces an emf in the secondary coil.

[3]

10 Fig. 10.2 shows how the current in the primary coil varies with time.
There is no current in the secondary coil.

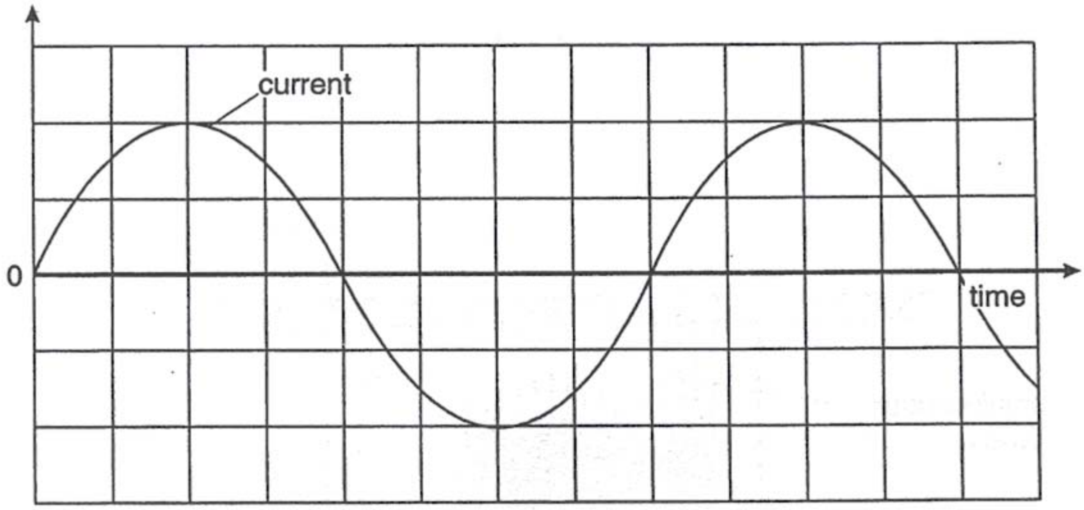

Fig. 10.2

(b) On Fig. 10.2, sketch a graph to show how the flux in the secondary coil varies with time. Label the graph **flux.**
[2]

(c) On Fig. 10.2, sketch a graph to show how the emf induced in the secondary coil varies with time. Label the graph **emf**. [2]

(d) The maximum flux density in the core is 1.6 T.
The emf induced in the secondary coil has a peak emf of 400 V and a frequency of 50 Hz.
Calculate estimates for

(i) the maximum flux linkage of the secondary coil,

flux linkage = ……………….. Wb [3]

(ii) the minimum cross-sectional area for the core, assuming the secondary coil has 600 turns.

area = ………………. m^2 [2]

11 This question is about the radioactive decay of plutonium

(a) Plutonium-238 is an emitter of alpha particles. Complete the equation for its decay.

$$^{238}_{94}\mathrm{Pu} \rightarrow \, ^{---}_{---}\mathrm{U} + \, ^{---}_{---}\mathrm{He}$$

Study Fig. 11.1.

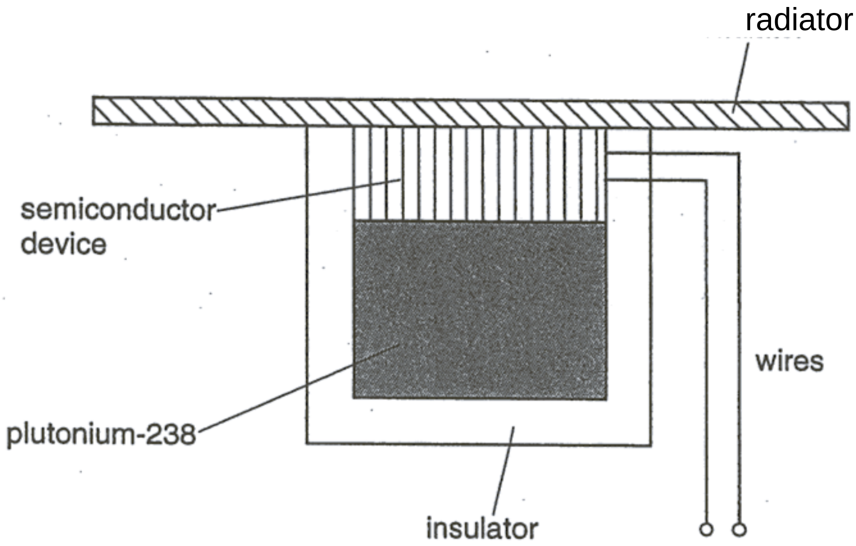

Fig.11.1

Energy from the decay of the plutonium makes the plutonium hot.
This produces a temperature difference across the semiconductor device as energy is conducted through it and radiated away.
The temperature difference across the semiconductor device generates an emf.

(b) Describe, in detail, how the decay of the plutonium results in a rise of its temperature.

[4]

(c) Each alpha particle emitted by the decay of plutonium-238 has an energy of 8.8×10^{-13}J. 15% of the energy from the decay of the plutonium appears as electrical output from the semiconductor device.
The output power of the semiconductor device is 100W.

(i) Show that the plutonium must decay at a rate of approximately 10^{15}Bq.

[2]

(ii) Plutonium-238 has a half-life of 86 years. By calculating a value for its decay constant, calculate the mass of plutonium required for an activity of 10^{15}Bq.
$1 \text{ u} = 1.66 \times 10^{-27}$kg

mass = ………………… kg [3]

12 This question is about the forces on charged particles due to electric and magnetic fields in a vacuum.

Fig. 12.1 shows a beam of protons entering a piece of apparatus.

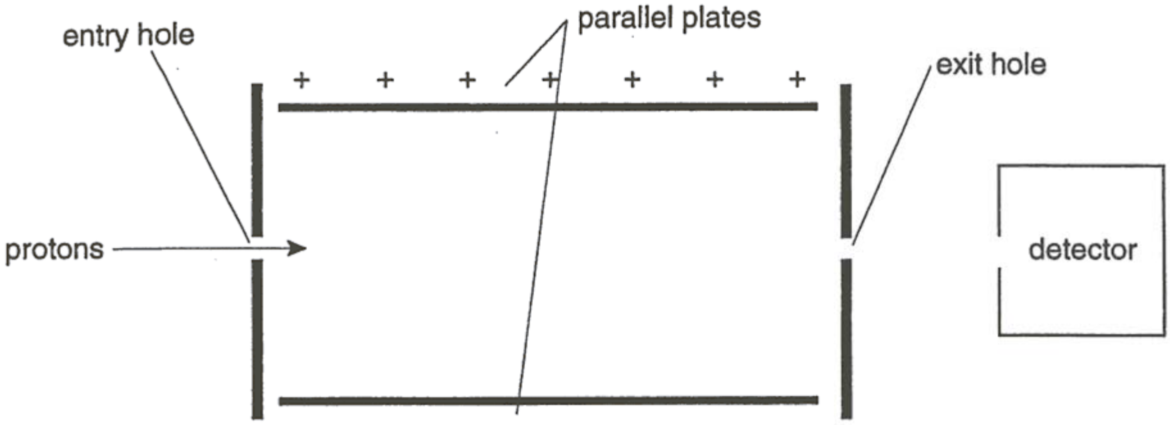

Fig. 12.1

(a) The electric field in the space between the plates is uniform.

(i) Draw lines between the plates to represent the electric field.

(ii) Sketch a likely path for the protons as they pass between the parallel plates.

[3]

(b) A uniform magnetic field is now applied at right angles to the plane of the diagram.

(i) With both the electric and magnetic fields present, it is now possible for protons to pass straight through to the detector without being deflected. Explain why.

[2]

(ii) Each proton which reaches the detector has a speed v and charge q. By writing expressions for the electric and magnetic forces on the protons as they pass between the plates, show that

$$v = \frac{E}{B}$$

where E is the electric field strength and B is the magnetic flux density.

[2]

(iii) The magnetic flux density is fixed at 3.0×10^{-2}T. The protons reach the detector when the electric field strength is 150 kV m^{-1}. Calculate their speed.

speed = …………………. m s^{-1}. [2]

(c) The proton beam is created by ionising a sample containing hydrogen gas and accelerating it through an electric field. Fig. 12.2 shows the variation in detector output when the voltage difference between the plates is swept from 0 V to 20 kV.

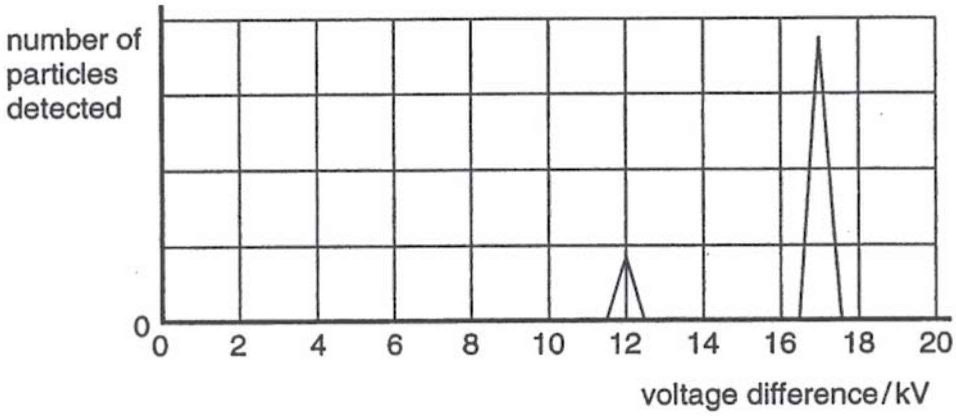

Fig. 12.2

Suggest what you can deduce about the sample from the graph. You do not need to do any calculations.

[4]

13 This question is about energy levels in atoms.

The allowed energies E of a hydrogen atom are given by the formula

$$E = \frac{-21.8 \times 10^{-19}}{n^2} \text{ J}$$

where n = l, 2, 3 …..

(a) Fig. 13.1 shows the energy level for n = 1

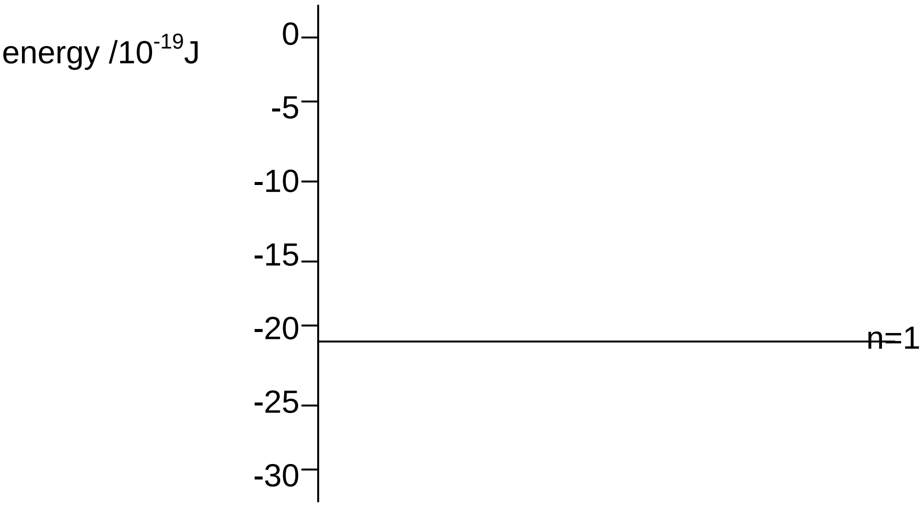

Fig. 13.1

Calculate and draw the energy levels for n = 2 and n = 3.

(b) The atom is raised to the n = 3 level by collision with an electron.

(i) Draw three vertical arrows on the diagram to show the subsequent transitions between energy levels which result in the emission of photons.[3]

(ii) Calculate the wavelength of the photon with the lowest energy of the three.

wavelength = ………………… m [3]

(c) Electrons which have energies of less than 10.2 eV nearly always collide elastically with hydrogen atoms. Yet if they have energies of above 10.2 eV, electrons will often have inelastic collisions with hydrogen atoms.

Use the information on the previous page to explain this.

[3]

Quality of Written Communication [4]