OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

PHYSICS A — 2822

Electrons and Photons

Friday **31 MAY 2002** Afternoon 1 hour

Candidates answer on the question paper.
Additional materials:
Electronic calculator

Candidate Name	Centre Number	Candidate Number

TIME 1 hour

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.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	6	
2	5	
3	10	
4	7	
5	7	
6	6	
7	9	
8	8	
QWC	2	
TOTAL	60	

This question paper consists of 16 printed pages.

Data

speed of light in free space,	$c = 3.00 \times 10^8\ \mathrm{m\,s^{-1}}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$
elementary charge,	$e = 1.60 \times 10^{-19}\ \mathrm{C}$
the Planck constant,	$h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$
molar gas constant,	$R = 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
gravitational constant,	$G = 6.67 \times 10^{-11}\ \mathrm{N\,m^2\,kg^{-2}}$
acceleration of free fall,	$g = 9.81\ \mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
refractive index,	$n = \frac{1}{\sin C}$
capacitors in series,	$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots$
capacitors in parallel,	$C = C_1 + C_2 + \ldots$
capacitor discharge,	$x = x_0 e^{-t/CR}$
pressure of an ideal gas,	$p = \frac{1}{3}\frac{Nm}{V}<c^2>$
radioactive decay,	$x = x_0\, e^{-\lambda t}$
	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$
critical density of matter in the Universe,	$\rho_0 = \frac{3H_0^2}{8\pi G}$
relativity factor,	$= \sqrt{(1 - \frac{v^2}{c^2})}$
current,	$I = nAve$
nuclear radius,	$r = r_0 A^{1/3}$
sound intensity level,	$= 10 \lg \left(\frac{I}{I_0}\right)$

Answer **all** questions.

1 **(a)** Fig. 1.1 shows the electromagnetic spectrum.

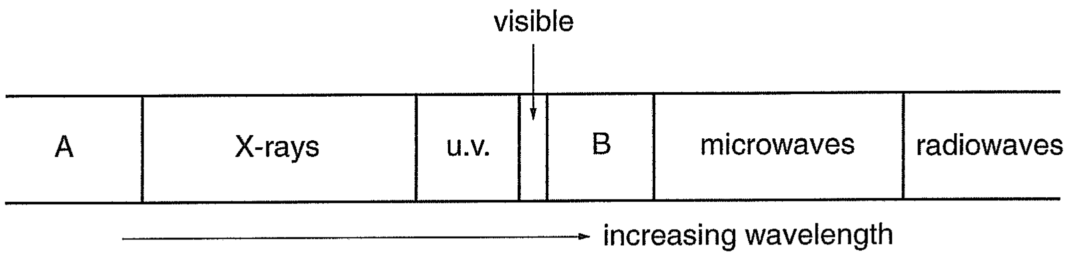

Fig. 1.1

In the spaces of Fig. 1.2, identify the principal radiations A and B and suggest a typical value for their wavelength λ.

	principal radiation	λ/m
A		
B		

Fig. 1.2 [4]

(b) State **two** features common to all types of radiation in the electromagnetic spectrum.

....

....

....

.... [2]

[Total: 6]

For Examiner's Use

2 **(a)** **(i)** State what is meant by *electric current*.

.... [1]

(ii) A mobile phone is connected to a charger for 600 s. The charger delivers a constant current 350 mA during this interval. Calculate the total charge supplied to the mobile phone.

charge = ... C [3]

(b) Fig. 2.1 shows a resistor connected to a d.c. supply.

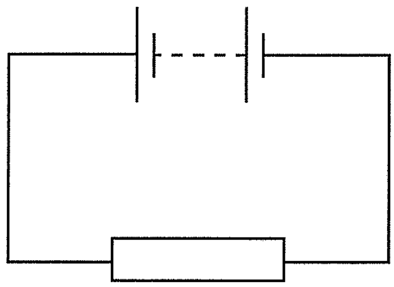

Fig. 2.1

On Fig. 2.1, indicate the direction of the electron flow in the circuit. [1]

[Total: 5]

For Examiner's Use

3 **(a)** The electrical resistance of a conducting wire depends on a number of factors. Complete the sentence below.

The resistance of a wire is directly proportional to its .... and inversely proportional to its .... It also depends on the type of .... used for the wire and on its .... [4]

(b) Fig. 3.1 shows the dimensions of a pencil lead.

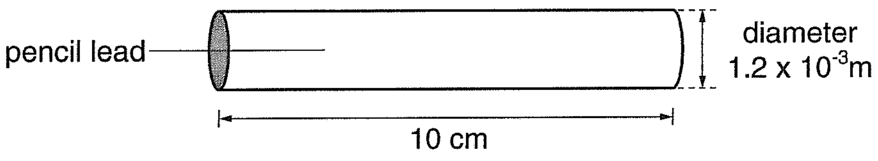

Fig. 3.1

The lead is made of a material of resistivity $8.0 \times 10^{-6}\,\Omega\,m$.

(i) Calculate the resistance of the pencil lead.

resistance = ...Ω [4]

(ii) A student connects the ends of the pencil lead to a d.c. supply. The potential difference across the ends is 12 V. Calculate the current in the pencil lead.

current = ... A [2]

[Total: 10]

4 Fig. 4.1 shows an electrical circuit for a small dryer used to blow warm air.

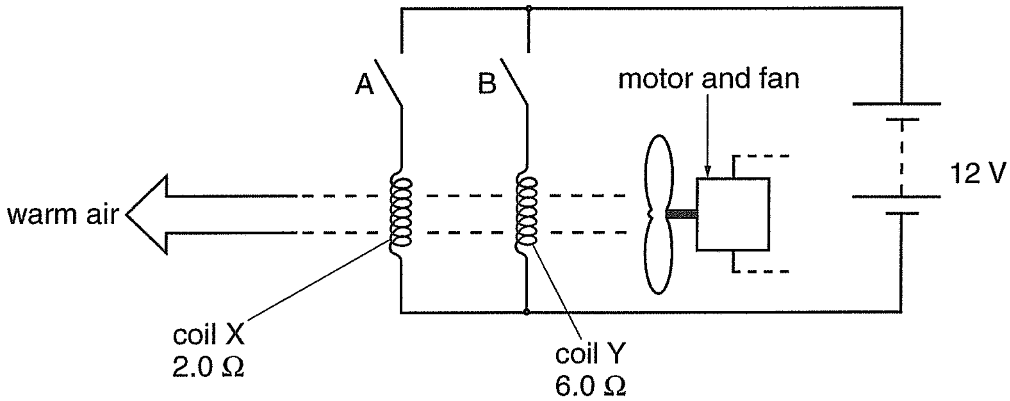

Fig. 4.1

It may be assumed that coils X and Y have constant resistances of 2.0 Ω and 6.0 Ω respectively. The 12 V supply has negligible internal resistance.

(a) Calculate the total resistance of the circuit with both switches closed.

resistance = ... Ω [3]

(b) Calculate the power dissipated by the coil X with only switch A closed.

power = ... unit = ... [4]

[Total: 7]

For Examiner's Use

5 **(a)** **(i)** Place a tick (✓) in the box for an alternative unit for the volt.

JC ☐

Js^{-1} ☐

JC^{-1} ☐ [1]

(ii) The statement below is that for Kirchhoff's second law.

The algebraic sum of the e.m.f.s around a loop in a circuit is equal to the algebraic sum of the p.d.s around the loop.

Fig. 5.1 shows an electrical circuit.

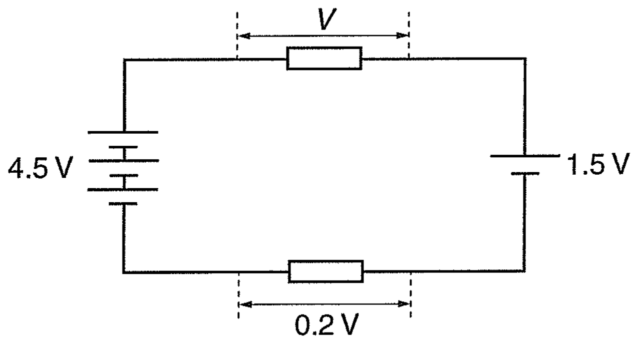

Fig. 5.1

Use this law to determine the p.d. *V*.

V = ... V [2]

For Examiner's Use

(b) Fig. 5.2 shows a potential divider circuit.

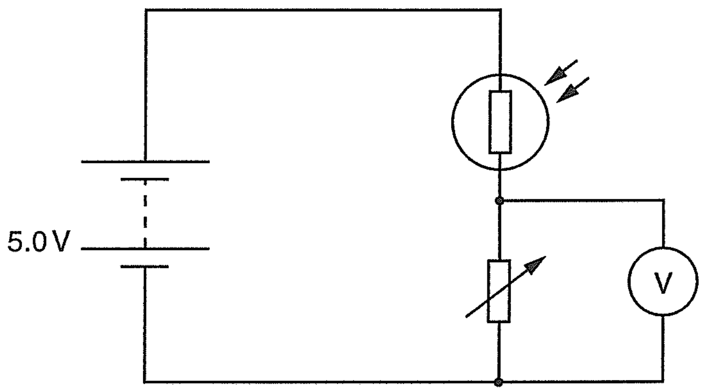

Fig. 5.2

The voltmeter has a very large resistance and the battery may be assumed to have negligible internal resistance.

For a particular intensity of light, the resistance of the LDR is 2.4 kΩ. The variable resistor is set on its maximum resistance of 4.7 kΩ.

(i) Calculate the reading on the voltmeter.

voltmeter reading = ... V [3]

(ii) State how the answer to **(b)(i)** changes when the light intensity is decreased.

....

....

.... [1]

[Total: 7]

[Turn over

6 **(a)** Fig. 6.1 shows a cell connected to two terminals on a plastic box. When the switch S is closed, a magnetic field pattern shown is detected around the box.

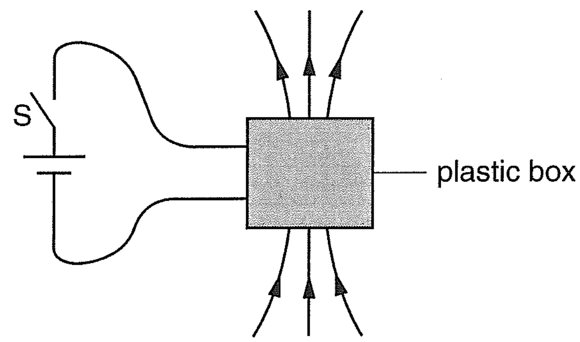

Fig. 6.1

State what is inside the box that produces this field pattern.

.... [1]

(b) Fig. 6.2 shows a wire placed at right angles to a magnetic field. The wire rests on two metal supports.

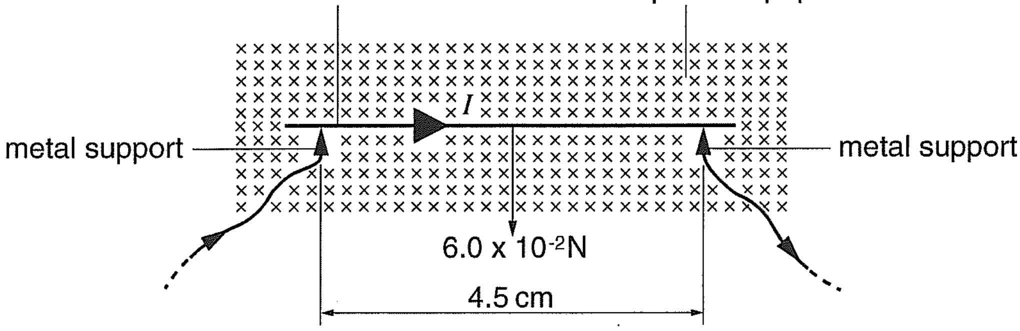

Fig. 6.2

The length of the wire between the supports is 4.5 cm, and this length has weight 6.0×10^{-2} N. The current in the wire is slowly increased from zero until the wire starts to lift off the metal supports.

For Examiner's Use

Calculate the current I in the wire. The magnetic flux density is 0.36 T.

I = ... A [3]

(c) Suggest why the overhead cables for the National Grid cannot be freely supported by the Earth's magnetic field.

....

....

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.... [2]

[Total: 6]

For Examiner's Use

7 **(a)** State the de Broglie equation. Define any symbols used.

....

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.... [2]

(b) Outline the evidence for believing that electrons behave like waves.

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.... [2]

(c) High speed electrons may be used to probe inside atomic nuclei.

(i) Calculate the de Broglie wavelength for a single electron which has a momentum (mv) of $2.3 \times 10^{-19}\,\text{kg m s}^{-1}$.

wavelength = ... m [2]

For Examiner's Use

(ii) Explain how your answer to **(c)(i)** would change for

1. a neutron of the same momentum

....

....

2. an electron of half the momentum.

....

.... [3]

[Total: 9]

For Examiner's Use

8 *In this question, 2 marks will be available for the quality of written communication.*

According to wave-particle duality, electromagnetic radiation can either behave as a *wave* or as a *photon* (which exhibits *particle*-like behaviour).

Describe the behaviour which supports this dual nature of electromagnetic radiation.

Wave behaviour:

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For Examiner's Use

Particle-like behaviour:

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[Total: 8]

Quality of Written Communication [2]