

**OXFORD CAMBRIDGE AND RSA EXAMINATIONS**  
**Advanced Subsidiary GCE**

**PHYSICS A**

**2822**

Electrons and Photons

Monday

**12 JANUARY 2004**

Morning

1 hour

Candidates answer on the question paper.

Additional materials:

Electronic calculator

Candidate Name	Centre Number	Candidate Number										
	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="width: 15px; height: 15px;"></td> <td style="width: 15px; height: 15px;"></td> <td style="width: 15px; height: 15px;"></td> <td style="width: 15px; height: 15px;"></td> <td style="width: 15px; height: 15px;"></td> </tr> </table>						<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="width: 15px; height: 15px;"></td> <td style="width: 15px; height: 15px;"></td> <td style="width: 15px; height: 15px;"></td> <td style="width: 15px; height: 15px;"></td> <td style="width: 15px; height: 15px;"></td> </tr> </table>					

**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 provided 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	7	
2	9	
3	6	
4	5	
5	16	
6	17	
<b>TOTAL</b>	<b>60</b>	

**This question paper consists of 12 printed pages.**

**Data**

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

**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,

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$$

capacitors in parallel,

$$C = C_1 + C_2 + \dots$$

capacitor discharge,

$$x = x_0 e^{-t/CR}$$

pressure of an ideal gas,

$$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$$

radioactive decay,

$$x = x_0 e^{-\lambda t}$$

$$t_{\frac{1}{2}} = \frac{0.693}{\lambda}$$

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** the questions.

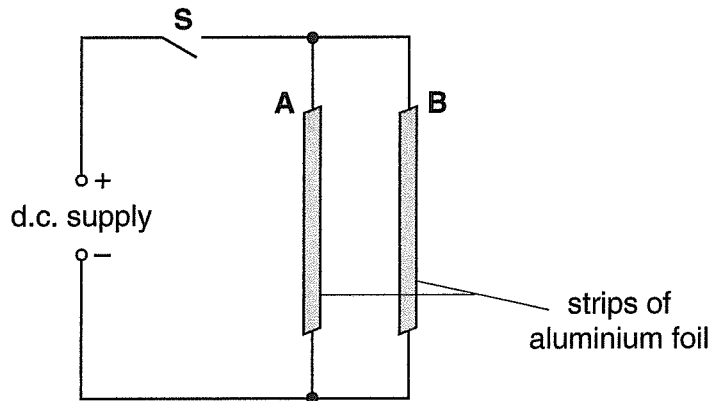
1 (a) Explain what is meant by *electric current*.

..... [1]

(b) The SI unit of electric charge is the coulomb. Define the *coulomb*.

.....  
..... [1]

(c) Fig. 1.1 shows two strips of aluminium foil connected to a d.c. supply.



**Fig. 1.1**

The switch **S** is closed.

(i) The charge flow past a particular point in one of the aluminium strips is 340 C in a time of 50 s. Calculate the current in this aluminium strip.

current = ..... A [2]

(ii) 1 There is a force between the two aluminium strips when the switch is closed. State why each of the aluminium strips experiences a force.

.....  
.....

2 Name the rule that may be used to determine the direction of the force on a current-carrying wire in an electric motor.

.....

3 State the direction of the force experienced by the aluminium strip **B**.

..... [3]

[Total: 7]



- 3 (a) State Kirchhoff's first law.

.....  
 .....  
 ..... [2]

- (b) Fig. 3.1 shows part of an electrical circuit.

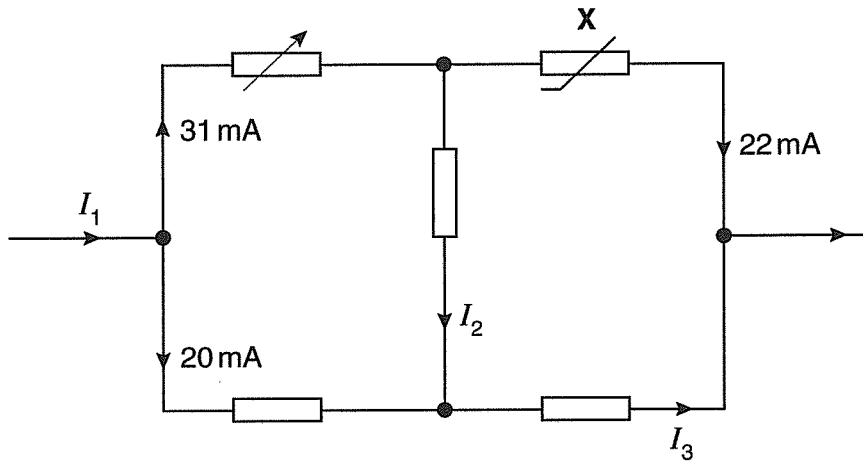


Fig. 3.1

- (i) Name the component marked X.

..... [1]

- (ii) Determine the magnitude of the currents  $I_1$ ,  $I_2$  and  $I_3$ .

$$I_1 = \text{..... mA}$$

$$I_2 = \text{..... mA}$$

$$I_3 = \text{..... mA}$$

[3]

[Total: 6]

- 4 Fig. 4.1 shows an electrical circuit.

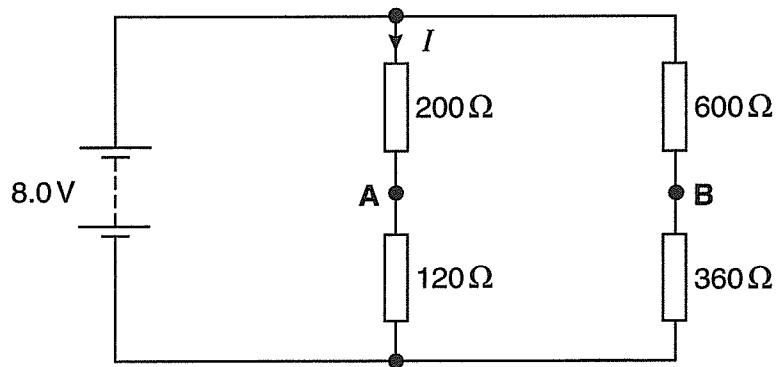


Fig. 4.1

The battery has negligible internal resistance.

- (a) Show that the current  $I$  is 25 mA.

[2]

- (b) Calculate the potential difference (p.d.) across the resistor of resistance 120  $\Omega$ .

p.d. = ..... V [1]

- (c) Explain why a voltmeter connected between points **A** and **B** will read 0 V.

.....  
 .....  
 ..... [2]

[Total: 5]

- 5 Fig. 5.1 shows a plan view of an electrical circuit that includes a flat circular coil.

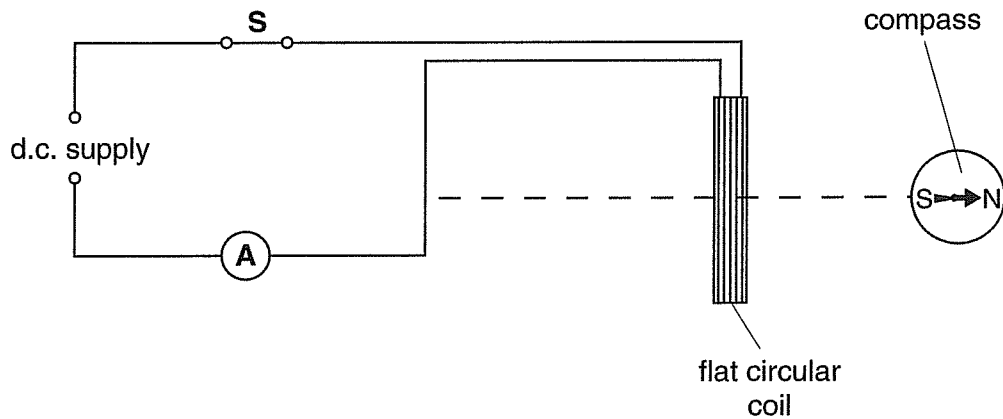


Fig. 5.1

- (a) A small compass is placed close to the coil along its axis. When the switch **S** is closed, the compass needle deflects so that it points in the direction shown in Fig. 5.1.

On Fig. 5.1, draw the magnetic field pattern for the flat circular coil. [2]

- (b) The coil is made from insulated wire of cross-sectional area  $8.4 \times 10^{-7} \text{ m}^2$ . At room temperature, the material of the wire has resistivity  $4.9 \times 10^{-7} \Omega \text{ m}$ . The coil consists of 20 turns and has a mean radius 2.8 cm.

- (i) Show that the total length of the wire is 3.5 m.

[1]

- (ii) Calculate the resistance of the coil.

resistance = .....  $\Omega$  [3]





6 (a) State what property of electromagnetic radiation is demonstrated by the photoelectric effect.

..... [1]

(b) Define each of the following terms

(i) photon

.....  
..... [1]

(ii) threshold frequency.

.....  
..... [1]

(c) An argon-laser emits electromagnetic radiation of wavelength  $5.1 \times 10^{-7} \text{ m}$ . The radiation is directed onto the surface of a caesium plate. The work function energy for caesium is 1.9 eV.

(i) Name the region of the electromagnetic radiation emitted by the laser.

..... [1]

(ii) Show that the work function energy of caesium is  $3.0 \times 10^{-19} \text{ J}$ .

[1]

(iii) Calculate

1 the energy of a single photon

energy = ..... J [2]

2 the maximum kinetic energy of an electron emitted from the surface of caesium.

kinetic energy = ..... J [3]

- (iv) State and explain what change, if any, occurs to the maximum kinetic energy of an emitted electron if the intensity of the laser light is reduced.

.....  
 .....  
 .....  
 ..... [2]

- (v) The power of the laser beam is 80 mW. Calculate the number of electrons emitted per second from the caesium plate assuming that only 7.0% of the incident photons interact with the surface electrons.

number = .....  $\text{s}^{-1}$  [2]

- (d) Moving electrons have a wave-like property. Calculate the speed  $v$  of an electron having a de Broglie wavelength equal to the wavelength of the laser light in (c).

$v = \dots\dots\dots \text{m s}^{-1}$  [3]

[Total: 17]

**END OF QUESTION PAPER**

