OCR
RECOGNISING ACHIEVEMENT

**ADVANCED SUBSIDIARY GCE UNIT** **2822**

# PHYSICS A

Electrons and Photons

**FRIDAY 12 JANUARY 2007** Afternoon

Time: 1 hour

Additional materials:
Electronic calculator

Candidate Name

Centre Number

Candidate Number

**INSTRUCTIONS TO CANDIDATES**

- Write your name, Centre Number and Candidate number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. ANSWERS WRITTEN ELSEWHERE WILL NOT BE MARKED.

**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 60.
- 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 | 8 | |
| 2 | 4 | |
| 3 | 11 | |
| 4 | 6 | |
| 5 | 10 | |
| 6 | 11 | |
| 7 | 10 | |
| Total | 60 | |

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

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)** State **two** main features that are common to all waves in the electromagnetic spectrum.

.....

.....

.....[2]

**(b)** Complete the table below, naming the principal electromagnetic radiation with each specified wavelength. [3]

| wavelength/m | $6\times10^{2}$ | $5\times10^{-6}$ | $2\times10^{-15}$ |
|---|---|---|---|
| name of principal radiation | | | |

**(c)** The particle-like behaviour of electromagnetic waves is modelled using the idea of photons. What is a photon?

.....

.....[1]

**(d)** Fig. 1.1 shows a graph of photon energy $E$ against frequency $f$ of electromagnetic waves.

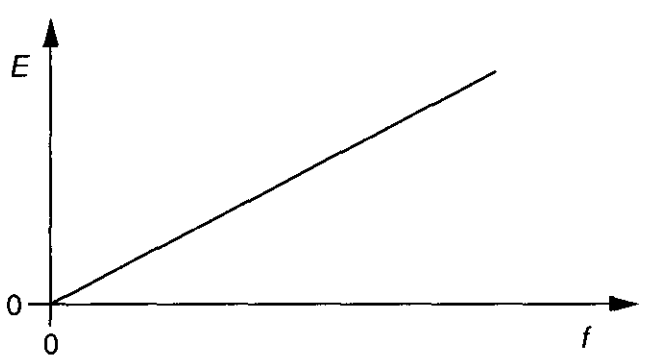


**Fig. 1.1**

Name the fundamental constant represented by the gradient of the graph.

.....[1]

**(e)** For the ratio $\frac{\text{wavelength of red light}}{\text{wavelength of violet light}} = 2$

determine the ratio $\frac{\text{photon energy of red light}}{\text{photon energy of violet light}}$.

ratio = ..... [1]

[Total: 8]

**2** A small radio receiver uses a battery that is capable of delivering a constant current of 40 mA for a period of 5.0 hours.

**(a)** Calculate the total charge delivered by the battery.

charge = ..... unit ..... [3]

**(b)** Fig. 2.1 shows the graph of current against time for a different battery.

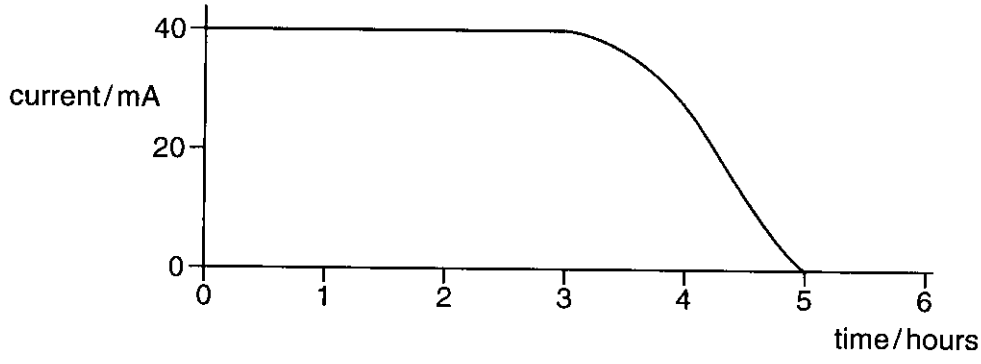


**Fig. 2.1**

Explain whether the charge delivered by this battery is the same as, greater than or less than your answer to **(a)**.

.....

.....[1]

[Total: 4]



**[Turn over**

3 **(a)** State Ohm's law in words.

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.....[2]

**(b)** The *I*/*V* characteristic of a filament lamp is shown in Fig. 3.1.

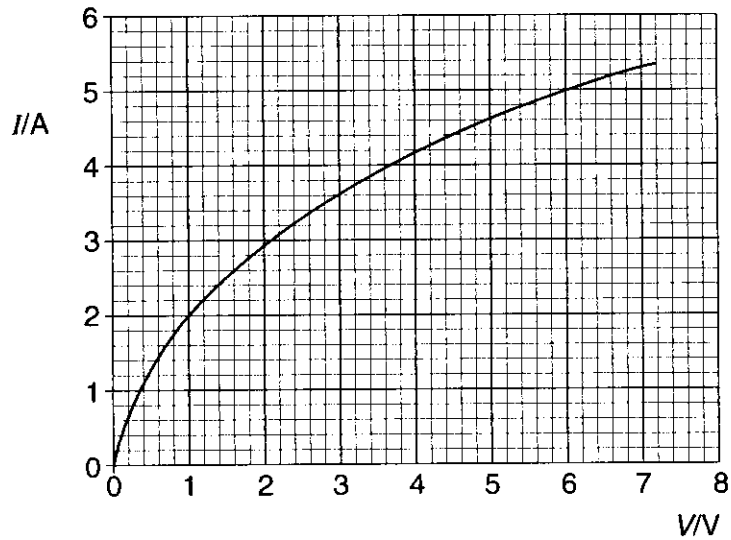


**Fig. 3.1**

**(i)** On Fig. 3.1, mark a point on the graph, and label it with the letter **M**, where the resistance of the filament lamp is **maximum**. [1]

**(ii)** Calculate the power dissipated by the lamp when operating at 6.0 V.

power = ..... W [3]

**(iii)** Fig. 3.2 shows the same filament lamp and a resistor of resistance 1.2 Ω connected in series with a battery.

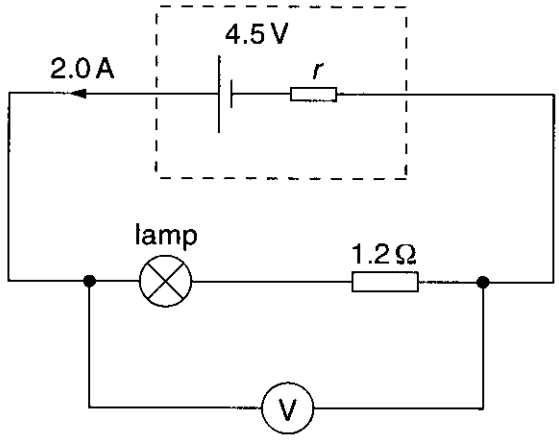


**Fig. 3.2**

The battery has e.m.f. 4.5 V and internal resistance *r*. The voltmeter has very high resistance. The current in the circuit is 2.0 A.

**1** Show, with the help of Fig. 3.1, that the voltmeter reading is 3.4 V.

[3]

**2** Calculate the internal resistance *r* of the battery.

resistance = ..... Ω [2]

[Total: 11]

**4** **(a)** Fig. 4.1 shows a long solenoid carrying a large current.

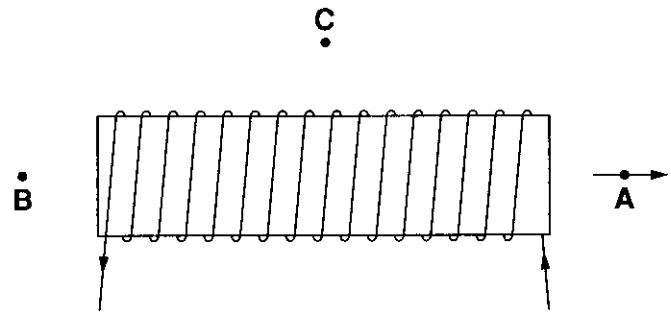


**Fig. 4.1**

The direction of the magnetic field at point **A** is shown in Fig. 4.1.
On Fig. 4.1, show the directions of the magnetic field due to the current-carrying solenoid at points **B** and **C**. [2]

**(b)** Fig. 4.2 shows apparatus designed by a student to determine the magnetic flux density of the magnetic field at the end of a long solenoid.

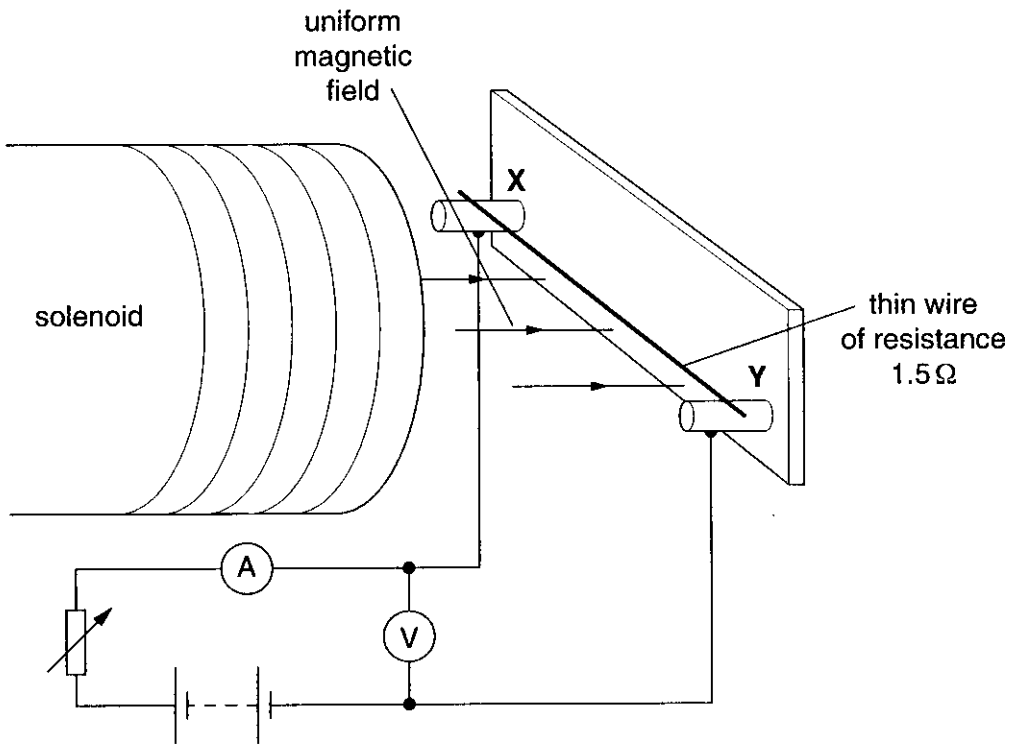


**Fig. 4.2**

A thin wire is placed on the contacts **X** and **Y** at right angles to the magnetic field. The distance **XY** is 5.0 cm. The wire has weight $4.0 \times 10^{-3}$ N and resistance 1.5 Ω. The current in the circuit is increased until the wire momentarily lifts off the two contacts. The reading on the high resistance voltmeter is 3.0 V as the wire lifts off.

Calculate

**(i)** the current in the wire that causes it to lift off

current = ..... A [1]

**(ii)** the magnetic flux density of the magnetic field.

magnetic flux density = ..... T [3]

[Total: 6]

5 Fig. 5.1 shows an incomplete circuit with a battery and a resistance wire made of a material of resistivity $\rho$.

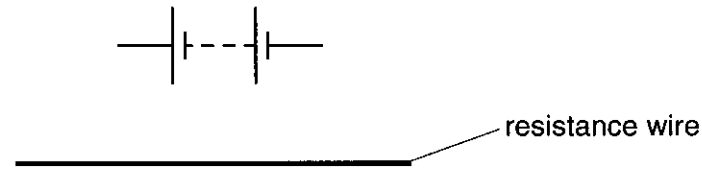


**Fig. 5.1**

**(a)** Complete the circuit of Fig. 5.1 and show how you would connect suitable meters to determine the current in the resistance wire and the potential difference across the resistance wire. [2]

**(b)** In this question, two marks are available for the quality of written communication.

Use your answer to **(a)** to describe an experiment to determine the resistivity $\rho$ of the material of the resistance wire. Your description should include

- the measurements taken
- the instruments used to take the measurements
- how the measurements are used to determine the resistivity of the material.

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.....[6]

Quality Of Written Communication [2]

[Total: 10]

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6 **(a)** Fig. 6.1 shows an electrical circuit.

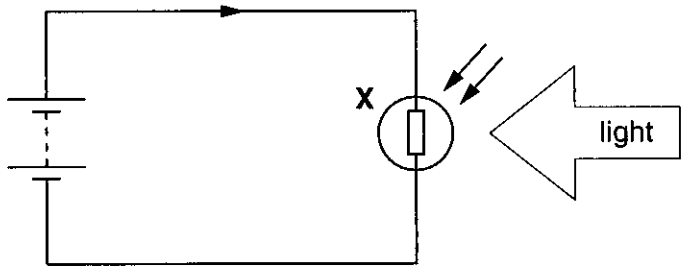


**Fig. 6.1**

The battery has negligible internal resistance.

**(i)** Name the component **X**.

.....[1]

**(ii)** Explain what happens to the current in the circuit when the intensity of the light incident on the component **X** is increased.

.....

.....

.....[2]

**(iii)** Describe what happens to the current in the circuit when the intensity of the light is kept the same, but a battery of half the e.m.f. is used.

.....

.....[1]

**(b)** Fig. 6.2 shows a network of identical resistors.

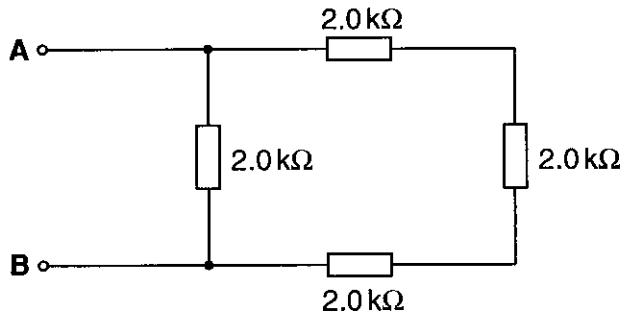


**Fig. 6.2**

Calculate the total resistance between points **A** and **B**.

resistance = ..... kΩ [3]

**(c)** The circuit shown in Fig. 6.3 is used to monitor the variation of light intensity in a room.

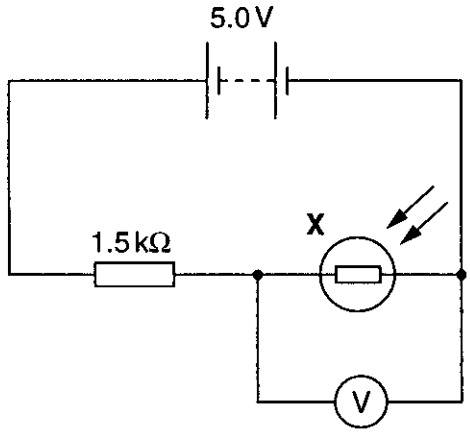


**Fig. 6.3**

The battery of e.m.f. 5.0 V has negligible internal resistance. The voltmeter has a very large resistance and it shows a reading of 1.2 V. Calculate

**(i)** the potential difference across the 1.5 kΩ resistor

potential difference = ..... V [1]

**(ii)** the resistance $R$ of the component **X**.

$R$ = ..... Ω [3]

[Total: 11]

7 **(a)** Write down the de Broglie equation and define the symbols. Explain how this important equation relates to both particle and wave-like properties of the electron.

.....

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.....

.....[4]

**(b)** **(i)** The surface of a metal is illuminated with electromagnetic radiation. The photons interact with the surface electrons of the metal.

**1** Explain what is meant by *threshold frequency*.

.....

.....

.....[1]

**2** Suggest what happens to the **metal** surface when the incident electromagnetic radiation is below the threshold frequency.

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.....[1]

**(ii)** The work function energy of potassium is 2.2 eV. The surface of potassium is illuminated with electromagnetic radiation of a specific wavelength. Experiments show that the photoelectrons from potassium have kinetic energy in the range zero to 1.9 eV. Determine the wavelength of the incident electromagnetic radiation.

wavelength = ..... m [4]

[Total: 10]

**END OF QUESTION PAPER**

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