OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE **2822**

PHYSICS A

Electrons and Photons

FRIDAY 11 JANUARY 2008 Afternoon

Time: 1 hour

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

CUP/T27964

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use blue or 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.
- Do **not** write in the bar codes.
- Do **not** write outside the box bordering each page.
- Write your answer to each question in the space provided.

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	**9**	
3	**9**	
4	**7**	
5	**12**	
6	**15**	
TOTAL	**60**	

This document consists of **15** printed pages and **1** blank page.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant,	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant,	$N_A = 6.02 \times 10^{23}$ mol^{-1}
gravitational constant,	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall,	$g = 9.81$ 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,	$x = x_0 e^{-\lambda t}$
	$t_{\frac{1}{2}} = \frac{0.693}{\lambda}$
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 cell, a resistor of resistance 120 Ω and a negative temperature coefficient (NTC) thermistor are connected in **series**.

(a) In the space below, sketch a circuit diagram of this arrangement.

[2]

(b) The cell has e.m.f. 1.4 V and negligible internal resistance. At a particular temperature, the current in the resistor is 5.0×10^{-3} A.

(i) Calculate the potential difference across the resistor.

potential difference = ... V [2]

(ii) Calculate the resistance of the thermistor at this temperature.

resistance = ... Ω [2]

(c) State and explain how the potential difference across the resistor changes when the temperature of the thermistor is lower.

....

....

....[2]

[Total: 8]

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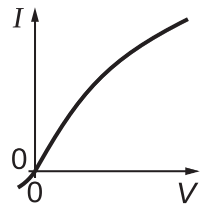
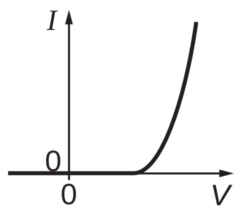
2 **(a)** Draw a line from each of the named components on the left-hand side to the correct I-V characteristic on the right-hand side.

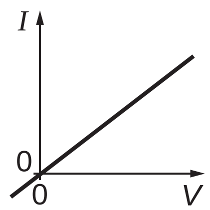
metallic wire at constant temperature



semiconductor diode



filament lamp



[1]

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

Explain, in terms of resistance, the shape of the I-V graph for each component below.

(i) Metallic wire at constant temperature.

....

....

....

....

....

(ii) Semiconductor diode.

....

....

....

....

....

(iii) Filament lamp.

....

....

....

....

....

[6]

Quality of Written Communication [2]

[Total: 9]

3 **(a)** State **one** similarity between *potential difference* and *electromotive force*.

....

....[1]

(b) Define the *volt*.

....

....[1]

(c) **(i)** Define the *kilowatt-hour* (kW h).

....

....[1]

(ii) Determine the value of the kilowatt-hour in joules.

1 kW h = ... J [1]

(d) A d.c. supply is connected across a variable resistor. The resistance of the variable resistor is changed. Fig. 3.1 shows the variation of the power *P* dissipated in the resistance *R* of the variable resistor.

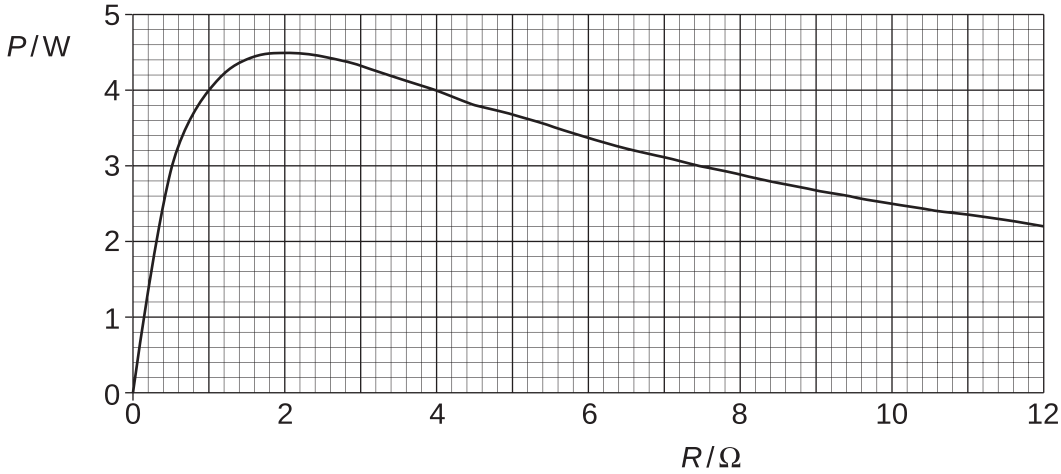


Fig. 3.1

(i) Use Fig. 3.1 to determine the potential difference across the variable resistor when it dissipates maximum power.

potential difference = ... V [3]

(ii) Explain why your answer to **(i)** is not equal to the e.m.f. of the supply.

....

....

....[2]

[Total: 9]

4 Fig. 4.1 shows a section through a loudspeaker.

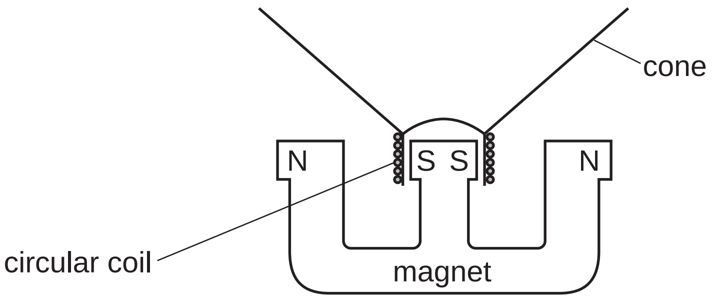


Fig. 4.1

The circular coil is free to move up and down in the space between the North and South poles of the magnet. The coil is connected to a d.c. supply of e.m.f. 1.5 V and of negligible internal resistance.

(a) On Fig. 4.1, draw arrows to show the directions of the magnetic field between the poles of the magnet. [1]

(b) The length of the wire in the coil is 24 m and its resistance is 8.0 Ω. The magnetic flux density of the magnetic field at the position of the coil is 1.2×10^{-2} T. Calculate the force experienced by the wire in the coil due to the magnetic field.

force = ... unit .... [4]

(c) Wire of the same length and material but half the diameter of the original wire is used to make a similar coil. State and explain the change to your answer to **(b)** when this coil is used in place of the original one.

....

....

....

....[2]

[Total: 7]

5 **(a)** State Ohm's law.

....

....

....[2]

(b) From the list below, circle the quantity that is conserved in Kirchhoff's second law.

charge **e.m.f.** **energy** **time** [1]

(c) Fig. 5.1 shows an electrical circuit.

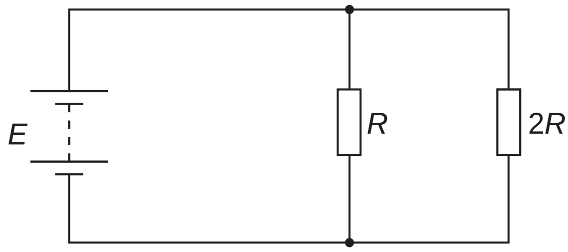


Fig. 5.1

The battery has e.m.f. E and negligible internal resistance. The resistances of the resistors are R and $2R$. Calculate

(i) the total resistance of the circuit in terms of R

resistance = ……………………….[2]

(ii) the current from the battery in terms of E and R.

current = ……………………………..[1]

(d) Fig. 5.2 shows a circuit.

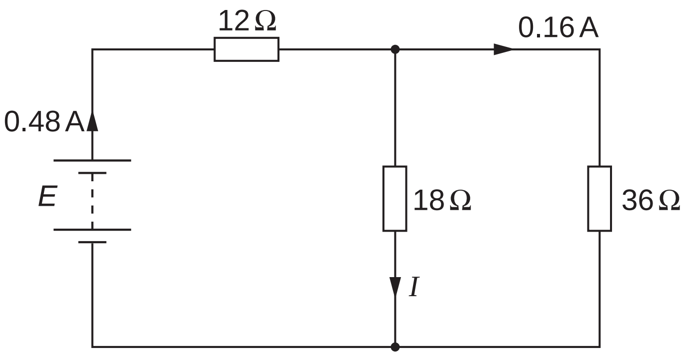


Fig. 5.2

The battery has negligible internal resistance.

Determine

(i) the charge passing through the battery in a time of 150 s

charge = …………………………. C [2]

(ii) the number of electrons responsible for the charge in **(i)**

number = ……………………………[1]

(iii) the current I in the 18 Ω resistor

current = ………………….. A [1]

(iv) the e.m.f. *E* of the battery.

e.m.f. = ……………………………… V [2]

[Total: 12]

Please turn over for question 6.

6 **(a)** State **one** main property of an electromagnetic wave.

....

....[1]

(b) Arrange the following electromagnetic radiations in the order of increasing wavelengths. Start with the **shortest** wavelength.

infrared visible light gamma rays microwaves

....[1]

(c) The table below shows the work function energies of some metals.

metal	work function energy (eV)
beryllium	5.0
magnesium	3.7
potassium	2.3
silver	4.7
zinc	4.3

(i) Define the *work function energy* of a metal.

....

....[1]

(ii) State and explain which metal has the **lowest** threshold frequency.

....

....

....[2]

(iii) A plate made of magnesium is illuminated with electromagnetic waves of wavelength 3.2×10^{-7} m. The electrons emitted from the surface of the plate have a range of kinetic energies.

1 Describe how the incident radiation interacts with the metal to release electrons from its surface and explain why these electrons are emitted with a range of kinetic energies.

....

....

....

....

....

....

....

....[4]

2 Show that the maximum kinetic energy of the electrons emitted from the surface of the magnesium plate is 3.0×10^{-20} J.

[3]

3 Calculate the de Broglie wavelength of an electron emitted with maximum kinetic energy.

wavelength = ………………………….. m [3]

[Total: 15]

END OF QUESTION PAPER

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