Rewarding Learning

Centre Number

71	

Candidate Number

ADVANCED
General Certificate of Education
January 2011

Physics

Assessment Unit A2 1

assessing

Momentum, Thermal Physics, Circular Motion, Oscillations and Atomic and Nuclear Physics

[AY211]

AY211

THURSDAY 27 JANUARY, AFTERNOON

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 90.
Quality of written communication will be assessed in question **2(a)**.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question.
Your attention is drawn to the Data and Formulae Sheet which is inside this question paper.
You may use an electronic calculator.
Question 9 contributes to the synoptic assessment required of the specification. Candidates should allow approximately 20 minutes for this question.

For Examiner's use only	
Question Number	Marks
1	
2	
3	
4	
5	
6	
7	
8	
9	
Total Marks	

Examiner Only	
Marks	Remark

1 **(a)** Define momentum.

____

____ [1]

(b) A railway truck T_1 of mass 1200 kg is rolling along a track at a speed of 6.0 m s^{-1} towards a stationary truck T_2 as shown in **Fig. 1.1**.

Fig. 1.1

(i) Calculate the initial momentum of the truck T_1.

Momentum = ________________ kg m s^{-1} [1]

(ii) On collision, trucks T_1 and T_2 become joined. They now move with a common velocity of 2.0 m s^{-1}. Find the mass of truck T_2.

Mass = ________________ kg [3]

Examiner Only	
Marks	Remark

(iii) Is this an example of an **elastic** or an **inelastic** collision?
Explain your answer.

[2]

Examiner Only	
Marks	Remark

2 In part (a) of this question you will be assessed on the quality of your written communication.

(a) (i) The relationship between the pressure of a fixed mass of gas and its temperature when the volume of the gas is kept constant is referred to as the pressure law or Gay Lussac's law. In the space below draw a fully labelled diagram of the apparatus which would be used to show this relationship.

[3]

(ii) State the relationship between the pressure of a gas and its temperature.

____

____ [1]

(iii) State what measurements are taken and how they are used to verify the relationship.

____

____

____

____

____

____ [3]

Quality of written communication [2]

(b) A flask contains air at a temperature of 17 °C and is sealed with a rubber bung. A capillary tube of diameter 3.0 mm containing a short column of mercury is inserted into the bung. The volume of air trapped is 40 cm^3. The arrangement is shown in **Fig. 2.1**.

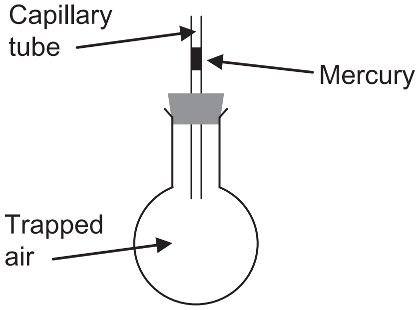


Fig. 2.1

The flask is warmed gently. Calculate the temperature reached when the mercury column moves 120 mm up the capillary tube if the pressure remains at atmospheric level throughout.

Temperature = ______________________ °C [4]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

3 A motorcyclist goes round a bend in a horizontal road at a constant speed of 40 km h^{-1}. The radius of curvature of the bend is 12.0 m.

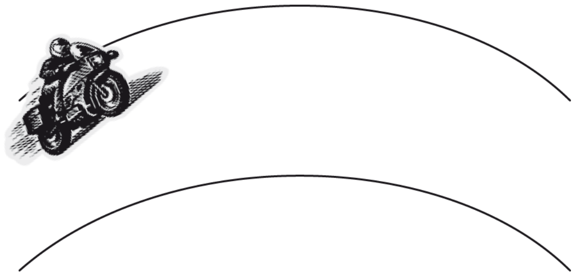


Fig. 3.1

(a) (i) Explain why this motorcyclist has an angular velocity.

____

____ [1]

(ii) Calculate the value of the angular velocity, ω, of the motorcyclist as he rounds the bend.

ω = ____________________ rad s^{-1} [3]

(b) (i) Explain why a force is needed if the motorcyclist is to get round the bend.

____

____ [2]

(ii) State how this force is produced.

____

____ [2]

(c) The motorcyclist has a mass of 90 kg and the motorcycle has a mass of 260 kg. Calculate the magnitude of the force needed to go round the bend at 40 km hr^{-1}.

Force = ___________________ N [3]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

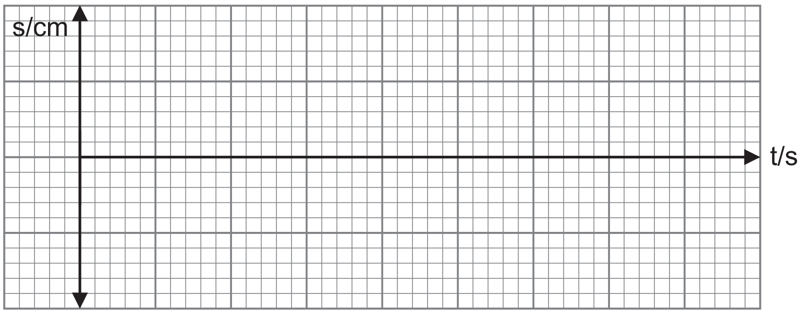
4 **(a)** Define simple harmonic motion.

____

____

____ [2]

(b) A body is pulled down and released. It then undergoes simple harmonic motion of amplitude 10 cm and frequency 2.5 Hz in a vertical plane. On the axes in **Fig. 4.1**, draw a graph of the variation of the displacement, s, of the body with time, t. Include values on the displacement and time axes.



[3]

Fig. 4.1

(c) Use the graph to find the velocity of the body 0.60 s from the start. Explain your answer.

Velocity = _______________ $m\,s^{-1}$

____

____

____ [3]

Examiner Only	
Marks	Remark

5 **(a)** Experimental evidence for the existence of atomic nuclei was provided by the scattering of α particles through a thin gold foil. State two significant observations from the experiment and explain their significance.

Observation 1. ______________________________

____

Explanation ______________________________

____

Observation 2. ______________________________

____

Explanation ______________________________

______________________________ [4]

Examiner Only

Marks	Remark

(b) Equation 1 states the relationship between nuclear radius and atomic mass number. r_0 is the mean nucleon radius and equals 1.2 fm.

$$r = r_0 A^{\frac{1}{3}}$$ **Equation 1**

Equation 2 states the relationship between the volume of a sphere and its radius.

$$V = \frac{4}{3}\pi r^3$$ **Equation 2**

(i) Given that the mean mass of a nucleon is 1.66×10^{-27} kg, use **Equations 1** and **2** to determine the density of a ${}^{12}_{6}C$ (carbon 12) nucleus.

Density = _______________ kg m^{-3} [3]

(ii) Carbon 12 has an atomic density of 2.3 g cm^{-3}. Titanium 48 has an atomic density of 4.5 g cm^{-3}. State the nuclear density of titanium 48 and explain your reasoning.

Nuclear density of titanium 48 = _______________ kg m^{-3} [1]

Explanation ____

____ [1]

Examiner Only	
Marks	Remark

6 Radon 222 has a half-life of 3.8 days.

(a) Define half life.

____

____

____ [1]

(b) Calculate the initial number of radon 222 nuclei present in the sample if its initial activity is 1.52×10^{15} Bq.

Initial number of nuclei = ______________________________ [3]

(c) Hence calculate the number of radon 222 nuclei present after a period of 8.6 days.

Number of radon 222 nuclei = ______________________________ [3]

Examiner Only	
Marks	Remark

7 **Fig. 7.1** shows how the binding energy per nucleon varies with mass number.

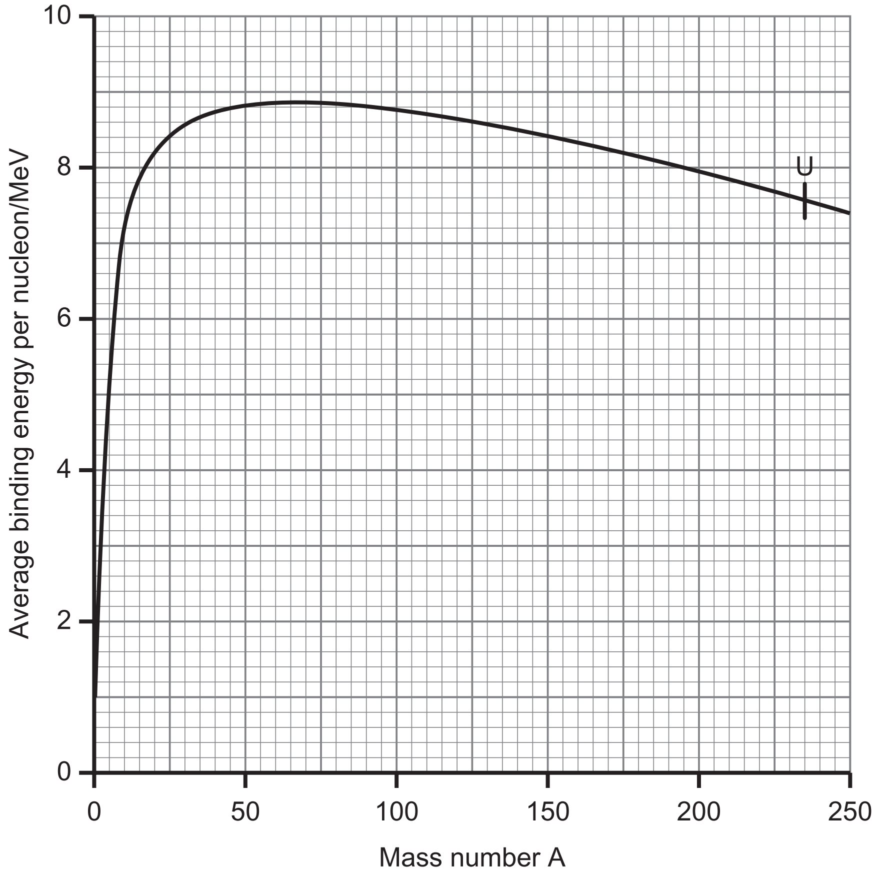


Fig. 7.1

Equation 7.2 gives one possible fission reaction for U^{235}

$$^{235}_{92}U \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 2\,{}^{1}_{0}n + Q$$ **Equation 7.2**

where Q represents a quantity of heat energy.

(a) Explain, making reference to **Fig. 7.1**, why this reaction could occur spontaneously.

____

____

____

____ [2]

(b) Calculate the energy Q released in the reaction in **Equation 7.2**.
Use the following values.

Mass of $^{235}_{92}U$ = 235.04u

Mass of $^{141}_{56}Ba$ = 140.91u

Mass of $^{92}_{36}Kr$ = 91.91u

Mass of neutron = 1.01u

Energy released = ________________ MeV [3]

Examiner Only	
Marks	Remark

(c) **Fig. 7.3** shows a simplified diagram for a fission reactor.

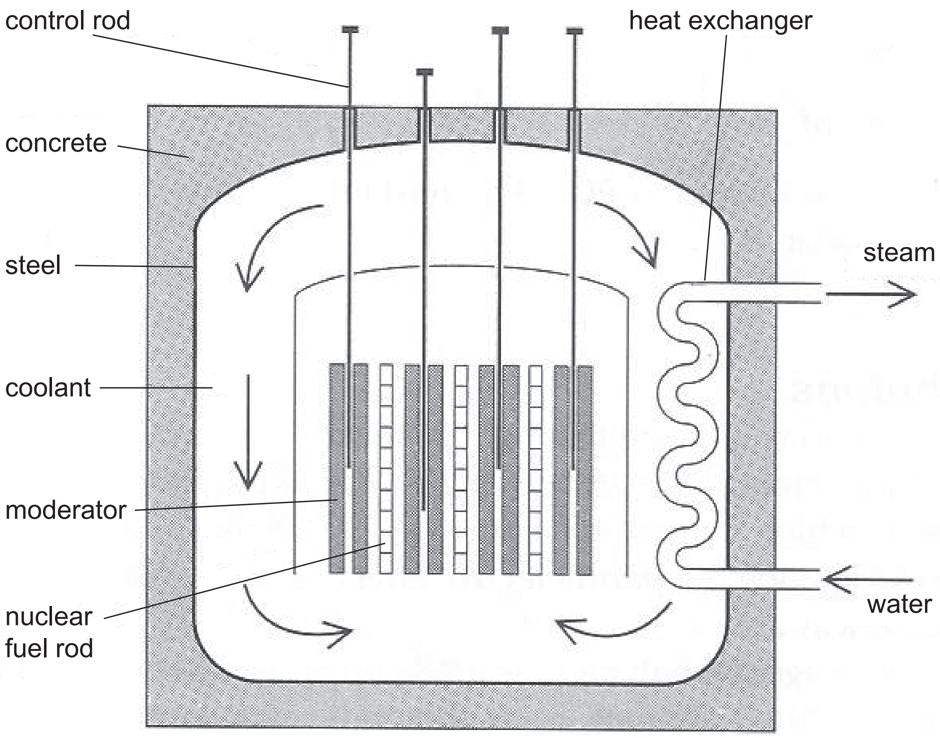


Fig. 7.3

(i) Explain briefly the purpose and name a suitable material for

1. the moderator:

____

____

2. the control rods:

____

____ [4]

(ii) Why must the total amount of uranium in the reactor core be greater than the critical size?

____

____ [1]

(iii) Why must the total amount of uranium in a fuel rod be less than the critical size?

____

____ [1]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

8 **(a)** In the JET prototype fusion reactor charged plasma particles circulate. Very high temperatures are needed if nuclear fusion is to take place. Explain why such high temperatures are necessary.

____

____ [2]

(b) Explain why, in a nuclear fusion reaction, the plasma must be confined.

____

____ [1]

(c) Briefly describe the three main forms of plasma confinement.

1. ____

____

2. ____

____

3. ____

____ [3]

Examiner Only	
Marks	Remark

9 The internal resistance *r* of a cell of EMF *E* can be found using the circuit shown in **Fig. 9.1**. YZ is a length of resistance wire connected to a 3V battery of zero internal resistance.

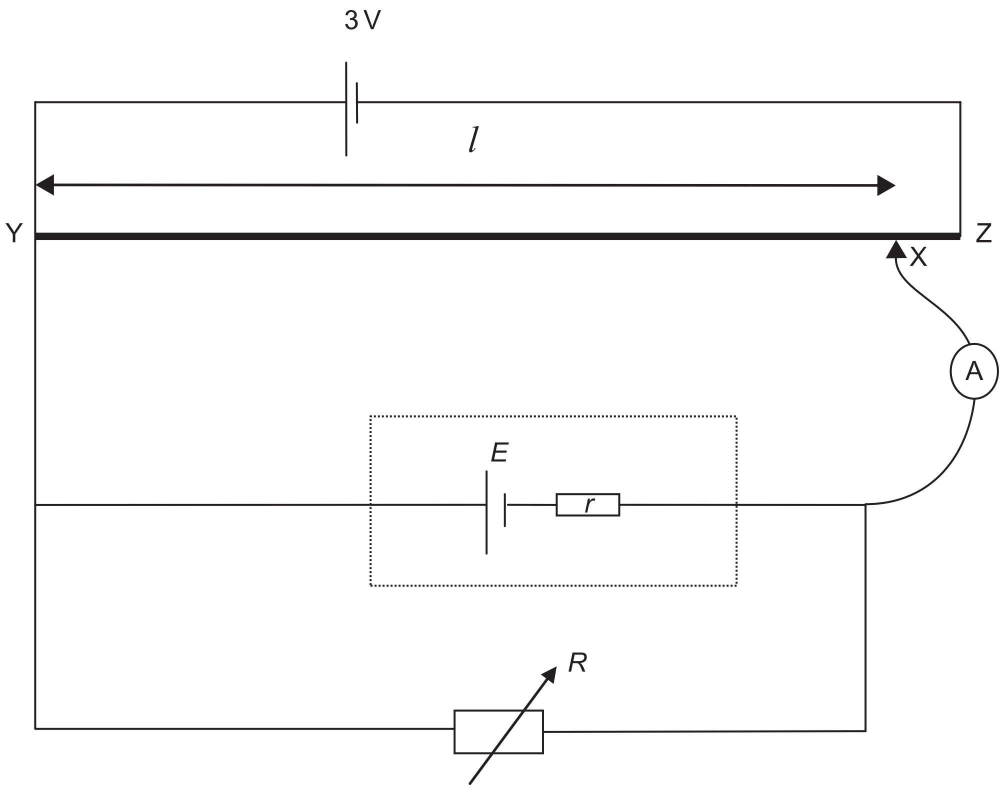


Fig. 9.1

Initially the variable resistor *R* is set to its highest resistance of 20Ω.The sliding contact X is then moved slowly along the wire until the reading on the sensitive ammeter A, is zero. The length of wire *l* is then recorded. This process is repeated for four further values of *R* and the results recorded in Table 9.1.

Table 9.1

Resistance R/Ω	Length l/m		
20	0.91		
10	0.83		
5.0	0.71		
2.0	0.50		
1.0	0.33		

Theory shows that the relationship between *R* and *l* is of the form

$$\frac{1}{R} = \frac{E}{3lr} - \frac{1}{r}$$ **Equation 9.1**

where E is the EMF of the cell and its value is not known.

Examiner Only

Marks	Remark

(a) **(i)** A graph of $\frac{1}{R}$ against $\frac{1}{l}$ should be plotted to enable r to be determined. Show why this graph is suitable.

[2]

(ii) Additional values are needed to enable you to plot the graph suggested in **(a)(i)**. Calculate these values to 2 significant figures and use the blank columns in **Table 9.1** to record them. Remember to include units. [3]

(b) **(i)** Using the graph paper with the origin (0,0) as shown in the grid of **Fig. 9.2**, plot the graph.

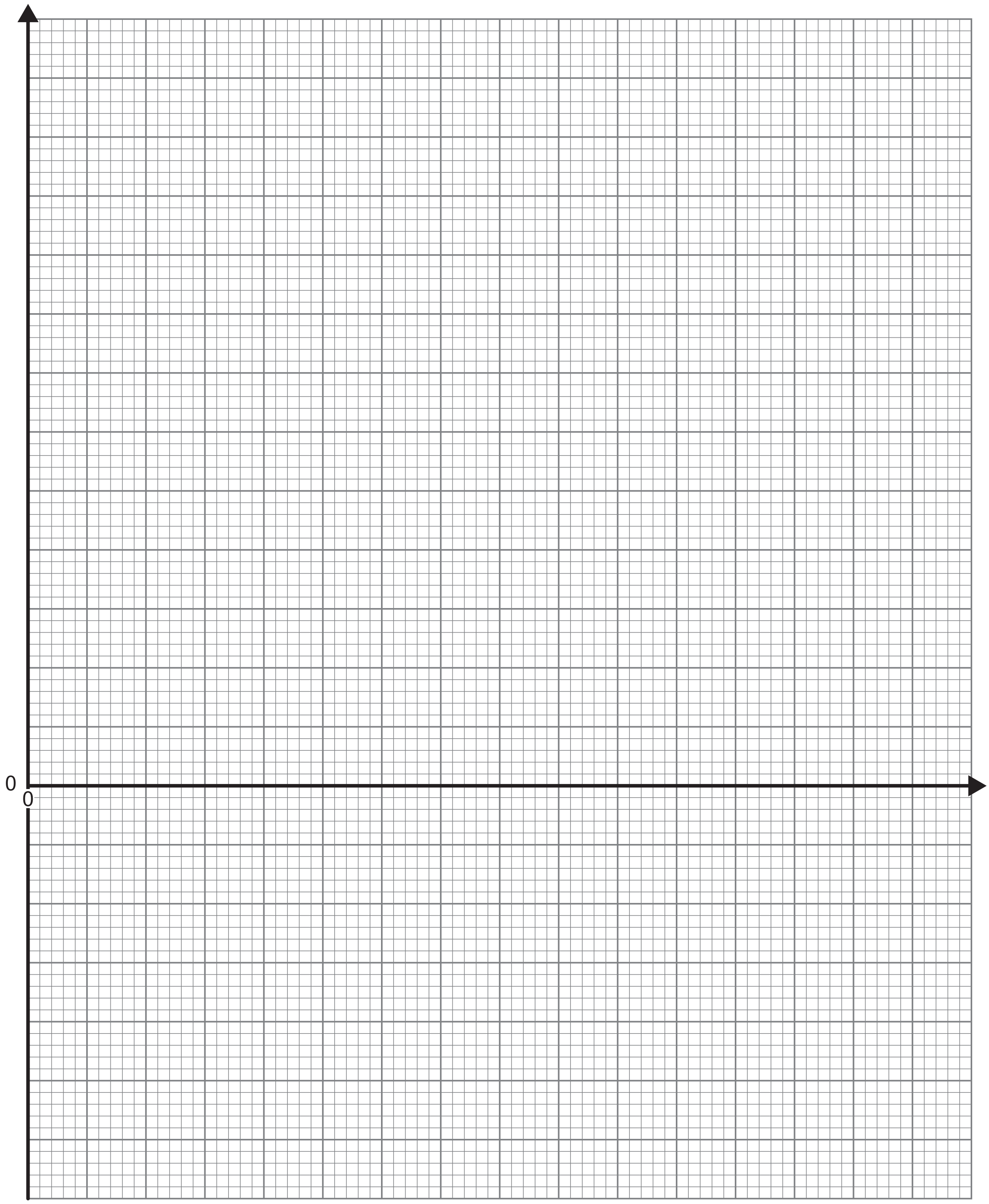


Fig. 9.2 [5]

Examiner Only	
Marks	Remark

Examiner Only

Marks	Remark

(ii) Hence calculate the value of *r*, the internal resistance of the cell.

r = ______________ Ω [2]

The unknown value of the EMF, E, of the cell can also be determined.

(iii) Calculate the value of *E*.

E = ________________ V [4]

(c) The cell is now replaced with one which has a higher internal resistance but the same EMF. How will the graph you have drawn in **(b)(i)** be affected?

____

____

____ [2]

THIS IS THE END OF THE QUESTION PAPER

GCE Physics

Data and Formulae Sheet for A2 1 and A2 2

Values of constants

speed of light in a vacuum	$c = 3.00 \times 10^{8}$ m s^{-1}
permittivity of a vacuum	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$\left(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\ \text{F}^{-1}\ \text{m}\right)$
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
(unified) atomic mass unit	1 u = 1.66×10^{-27} kg
mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
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}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall on the Earth's surface	$g = 9.81$ m s^{-2}
electron volt	1 eV = 1.60×10^{-19} J

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The following equations may be useful in answering some of the questions in the examination:

Mechanics

Conservation of energy	$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = Fs$	for a constant force
Hooke's Law	$F = kx$ (spring constant k)	

Simple harmonic motion

Displacement	$x = A \cos \omega t$

Sound

Sound intensity level/dB	$= 10 \lg_{10} \frac{I}{I_0}$

Waves

Two-source interference	$\lambda = \frac{ay}{d}$

Thermal physics

Average kinetic energy of a molecule	$\frac{1}{2}m\langle c^2 \rangle = \frac{3}{2}kT$
Kinetic theory	$pV = \frac{1}{3}Nm\langle c^2 \rangle$
Thermal energy	$Q = mc\Delta\theta$

Capacitors

Capacitors in series	$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$
Capacitors in parallel	$C = C_1 + C_2 + C_3$
Time constant	$\tau = RC$

Light

Lens formula	$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$
Magnification	$m = \frac{v}{u}$

Electricity

Terminal potential difference	$V = E - Ir$ (E.m.f. E; Internal Resistance r)
Potential divider	$V_{out} = \frac{R_1 V_{in}}{R_1 + R_2}$

Particles and photons

Radioactive decay	$A = \lambda N$
	$A = A_0 e^{-\lambda t}$
Half-life	$t_{\frac{1}{2}} = \frac{0.693}{\lambda}$
de Broglie equation	$\lambda = \frac{h}{p}$

The nucleus

Nuclear radius	$r = r_0 A^{\frac{1}{3}}$