Centre Number	Candidate Number	Name

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

PHYSICS **9702/31**

Paper 31 Advanced Practical Skills

Specimen Paper

2 hours

Candidates answer on the Question Paper.
Additional Materials: As specified in the Confidential Instructions.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **both** questions.
You will be allowed to work with the apparatus for a maximum of one hour for each question.
You are expected to record all your observations as soon as they are made, and to plan the presentation of the records so that it is not necessary to make a fair copy of them. The working of the answers is to be handed in.
Additional answer paper and graph paper should be submitted only if it becomes necessary to do so.
You are reminded of the need for good English and clear presentation in your answers.

At the end of the examination, fasten all your work securely together.
All questions in this paper carry equal marks.

For Examiner's Use	
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Total	

This document consists of **10** printed pages and **2** blank pages.

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For Examiner's Use

1 In this experiment you will measure the e.m.f. *E* and internal resistance *r* of a dry cell by changing the resistance *R* in the circuit and measuring the current *I*.

(a) Connect the circuit shown in Fig. 1.1 using one of the 10 Ω resistors.

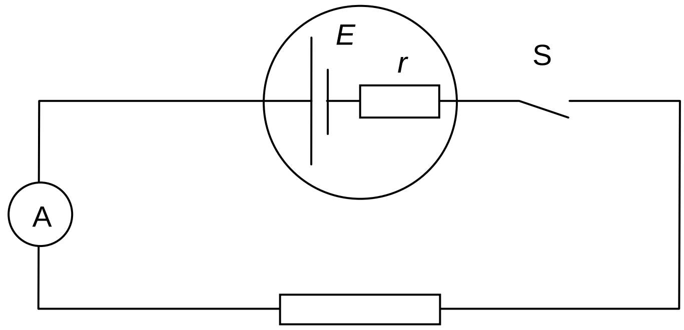

Fig. 1.1

(b) (i) Close switch S.

(ii) Record the value of the current *I* and the resistance *R*.

I = ...

R = ...

(iii) Open switch S.

(c) Change the value of *R* by using different combinations of the 10 Ω resistors and repeat **(b)** until you have six sets of readings for *I* and *R*.

You may need to twist the ends of the resistors together when joining them. Include values of 1/*I* in your table of results.

(d) (i) Plot a graph of 1/*I* (*y*-axis) against *R* (*x*-axis).

(ii) Draw the line of best fit.

(iii) Determine the gradient and the *y*-intercept of the graph.

gradient = ...

y-intercept = ...

For Examiner's Use

For Examiner's Use

(e) I and R are related by the equation

$$\frac{1}{I} = \frac{1}{E}R + \frac{r}{E}.$$

Using your answers from **(d)**, determine values of E and r.
You should include appropriate units in each case.

E = ...

r = ...

2 In this question you will investigate how the mass flow rate of salt passing through the hole in a funnel depends on the mass of salt in the funnel.

You are supplied with two small beakers containing salt and an empty beaker. The mass of salt in container A is m_A and the mass of salt in container B is m_B.

(a) Use a top pan balance to determine m_A and m_B.

m_A = ...

m_B = ...

  [Turn over

For Examiner's Use

(b) Mount the funnel in a stand and clamp and place a beaker underneath, as shown in Fig. 2.1.

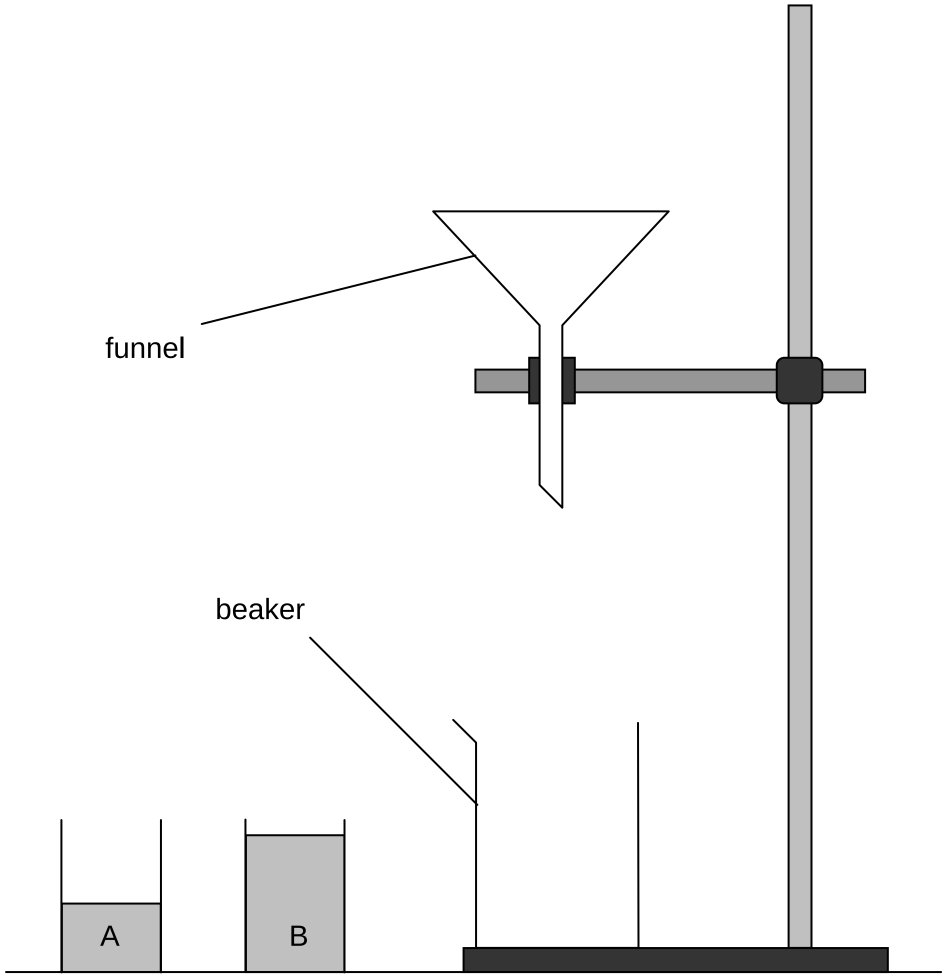

Fig. 2.1

(c) **(i)** Place your finger over the hole at the bottom of the funnel and pour the salt from container A into the funnel.

(ii) Move your finger away from the hole and at the same time start the stopwatch. Make and record measurements to find the time t_A for all of the salt to leave the funnel.

t_A = ... s

For Examiner's Use

(iii) Repeat the procedure for the salt in container B.

t_B = ... s

(d) Estimate the percentage uncertainty in t_B. Show your working.

% uncertainty in t_B = ...

For Examiner's Use

(e) (i) Calculate the mass flow rate in each case by dividing the mass of salt by the time taken for it to pass through the hole in the funnel.

mass flow rate$_A$ = ...

mass flow rate$_B$ = ...

(ii) Use your answer in **(i)** to comment on whether the mass of salt in the funnel affects the rate at which salt passes out of the funnel.

....

....

....

....

For Examiner's Use

(f) (i) State four sources of error or limitations of the procedure in this experiment.

1 ....

....

2 ....

....

3 ....

....

4 ....

....

(ii) Suggest four improvements that could be made to the experiment. You may suggest the use of other apparatus or different procedures.

1 ....

....

2 ....

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3 ....

....

4 ....

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

PHYSICS **9702/31**

Paper 31 Advanced Practical Skills

Specimen Paper

2 hours

CONFIDENTIAL INSTRUCTIONS

Great care should be taken to ensure that any confidential information given does not reach the candidates either directly or indirectly.

This document consists of **6** printed pages and **2** blank pages.

UNIVERSITY *of* CAMBRIDGE International Examinations

Preparing apparatus

These instructions detail the apparatus required for the experiments in the Question Paper. It is essential that absolute confidentiality is maintained in advance of the examination: the contents of these instructions must not be revealed either directly or indirectly to candidates.

No access is permitted to the Question Paper in advance of the examination.

If you have any problems or queries regarding these instructions, please contact CIE:

by e-mail: international@ucles.org.uk,
or by telephone: +44 1223 553554,
or by fax: +44 1223 553558,

stating the nature of the query and quoting the syllabus and paper numbers (9702/31).

It is assumed that the ordinary apparatus of a Physics laboratory will be available.

Number of sets of apparatus

The number of sets of apparatus provided for each experiment should be ½*N*, where *N* is the number of candidates taking the examination. There should, in addition, be a few spare sets of apparatus available in case problems arise during the examination.

Organisation of the examination

Candidates should be allowed access to the apparatus for each experiment for one hour only. After spending one hour on one experiment, candidates should change over to the other experiment. The order in which a candidate attempts the two experiments is immaterial.

Assistance to candidates

Candidates should be informed that, if they find themselves in real difficulty, they may ask the Supervisor for practical assistance, but that the extent of this assistance will be reported to the Examiner, who may make a deduction of marks.

Assistance should only be given:

when it is asked for by a candidate,
or as directed in the Notes sections of these instructions,
or where apparatus is seen to have developed a fault.

Assistance should be restricted to enabling candidates to make observations and measurements. Observations and measurements must not be made for candidates, and no help should be given with data analysis or evaluation.

All assistance given to candidates must be reported on the Supervisor's Report Form.

Faulty apparatus

In cases of faulty apparatus (not arising from a candidate's mishandling) that prevent the required measurements being taken, the Supervisor may allow extra time to give the candidate a fair opportunity to perform the experiment as if the fault had not been present. The candidate should use a spare copy of the Question Paper when the fault has been rectified or when working with a second set of apparatus.

Supervisor's Report

The Supervisor should complete the Supervisor's Report Form on pages 7 and 8 and enclose it in the envelope containing the answers of the candidates. If more than one envelope is used, a copy of the report must be enclosed in each envelope.

Question 1

Apparatus requirements (per set of apparatus unless otherwise specified)

Five 10 Ω carbon film resistors.

Mounted 1.5 V dry cell. One of the 10 Ω resistors should be placed in series with the dry cell. Candidates must not be able to make connections to the cell without including the 10 Ω resistor. If necessary, candidates should be informed that the 10 Ω resistor is an integral part of the power supply.

Digital milliammeter, range 0 to 200 mA.

Switch.

Two crocodile clips.

Four connecting wires.

Notes

1 At the beginning of the experiment, Supervisors must be vigilant to ensure that candidates have connected the circuit correctly, and may give assistance with the connections where necessary. The extent of any help given to candidates must be detailed on the Supervisor's Report form.

2 At the changeover, the apparatus should be dismantled and laid out on the bench ready for the next candidate to use.

Information required by Examiners

None.

Question 2

Apparatus requirements (per set of apparatus unless otherwise specified)

Stand, boss and clamp.

250 ml glass beaker.

Two smaller beakers labelled A and B.

90 g of ordinary table salt. The salt must be dry and be composed entirely of small crystals. Salt that has added anti-caking agents has been found to be suitable. It may be necessary to stir the salt for a short time to remove any large crystals that may affect the flow rate of the salt. 30 g of salt should be placed in A and 60 g of salt should be placed in B.

Funnel. The funnel should be large enough to hold 60 g of salt. The 60 g sample of salt should pass through the funnel in not less than 10 seconds.

Reasonable access to a top-pan balance.

Stopwatch reading to 0.1 s or better.

Note

At the changeover, Supervisors must ensure that the mass of salt in A is 30 g, the mass of salt in B is 60 g, and the 250 ml beaker is empty. The apparatus should be dismantled and laid out on the bench ready for the next candidate to use.

Information required by Examiners

None.

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9702/31
Specimen

This form should be completed and sent to the Examiner with the scripts.

SUPERVISOR'S REPORT FORM

General Certificate of Education Advanced Subsidiary Level and Advanced Level

The Supervisor's Report should give full details of:

(a) any help given to a candidate (including the nature of the help given and the name and candidate number of the candidate);

(b) any cases of faulty apparatus (including the nature of the problem, the action taken to rectify it, any additional time allowed, and the name and candidate number of the candidate);

(c) any accidents that occurred during the examination;

(d) any other difficulties experienced by candidates, or any other information that is likely to assist the Examiner, especially if this information cannot be discovered in the scripts.

Cases of individual hardship, such as illness, bereavement or disability, should be reported direct to CIE on the normal Special Consideration form.

Supervisor's Report

continued overleaf

Supervisor's Report (continued)

Declaration
(to be signed by the Supervisor)

The preparation of this practical examination has been carried out so as to maintain fully the security of the examination.

Signed ....

Name ....

Centre Number ....

Name of Centre ....

Specimen Paper

GCE A AND AS LEVEL

MARK SCHEME

MAXIMUM MARK: 40

SYLLABUS/COMPONENT: 9702/31

PHYSICS
Paper 31 (Advanced Practical Skills)

Question 1

Manipulation, measurement and observation (9 marks)

Successful collection of data (7 marks)

(c) Measurements **6**
One mark for each set of readings for I and R.

(c) Repeats **1**

Range and distribution of values (1 mark)

(c) Range of resistance values **1**
Should cover the whole range from 2.5 Ω to 40 Ω.

Quality of data (1 mark)

Graph Quality of results **1**
Judge by scatter of points about the best fit line.
At least 5 plots are needed for this mark to be scored.

Presentation of data and observations (7 marks)

Table of results: layout (1 mark)

(c) Layout: Column headings **1**
Each column heading must contain a quantity and a unit.
Ignore units in the body of the table.
There must be some distinguishing mark between the quantity and the unit (i.e. solidus is expected, but accept, for example, I (A)).

Table of results: raw data (1 mark)

(c) Consistency of presentation of raw readings **1**
All values of I must be given to the same number of decimal places.

Table of results: calculated quantities (2 marks)

(c) Significant figures in calculated quantities **1**
Apply to $1/I$. Accept two or three significant figures only.

(c) Correct values of total resistance and $1/I$ calculated **1**
All values should be correct for this mark.

Graph: layout (1 mark)

Graph Axes **1**
Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed.
Scales must be chosen so that the plotted points occupy at least half the graph grid in both *x* and *y* directions.
Scales must be labelled with the quantity which is being plotted.

Graph: plotting of points (1 mark)

Graph Plotting of points **1**
All observations must be plotted.
Ring and check a suspect plot. Tick if correct. Re-plot if incorrect.
Work to an accuracy of half a small square.

Graph: trend line (1 mark)

Graph Line of best fit **1**
Judge by scatter of points about the candidate's line.
There must be a fair scatter of points either side of the line.
Indicate best line if candidate's line is not the best line.

Analysis, conclusions and evaluation (4 marks)

Interpretation of graph (2 marks)

(d)(iii) Gradient **1**
The hypotenuse of the Δ must be greater than half the length of the drawn line.
Read-offs must be accurate to half a small square.
Check for $\Delta y/\Delta x$ (i.e. do not allow $\Delta x/\Delta y$).

(d)(iii) y-intercept **1**
Values must be read to the nearest half square.
If a false origin has been used, then label FO.
The value can be calculated using ratios or $y = mx + c$.

Drawing conclusions (2 marks)

(e) Value for E **1**
Unit required.

(e) Value for r **1**
Unit required.

Question 2

Manipulation, measurement and observation (7 marks)
Successful collection of data (6 marks)

(a)	Measurements of m_A and m_B with mass of beaker included One mark each.	**2**
(a)	Measurement of mass of empty beaker measured	**1**
(c)(ii)	Measurement of t_A	**1**
(c)(iii)	Measurement of t_B	**1**
(c)(iii)	Repeated measurements for both t_A and t_B	**1**

Quality of data (1 mark)

(c)(iii)	Quality of results ($t_B = 2t_A \pm 10\%$) Do not allow this mark if the stopwatch has been misread.	**1**

Presentation of data and observations (3 marks)
Display of calculation and reasoning (3 marks)

(a)	Correct calculation of m_A and m_B (i.e. subtraction of mass of beaker)	**1**
(e)(i)	Calculation of mass flow rates One mark each. Correct unit (g s^{-1} or kg s^{-1}), consistent with candidate's working, required for both marks to be awarded.	**2**

Analysis, conclusions and evaluation (10 marks)
Drawing conclusions (1 mark)

(e)(ii)	Sensible comment relating to <u>constant</u> mass flow rate e.g. rate not affected by mass.	**1**

Estimating uncertainties (1 mark)

(d)	Percentage uncertainty in t If repeated readings have been done, then the uncertainty must be half the range. Accept Δt = 0.1 s to 0.4 s. Correct ratio idea required.	**1**

Identifying limitations (4 marks)

(f)(i) Sources of error or limitations of procedure **4**

Relevant points might include:
Two readings are not enough to draw a valid conclusion
Difficulty with removing finger and starting the stopwatch at the same time
Length of pipe at bottom of funnel may affect results
Salt may contain 'lumps' which affect the flow rate
Moisture content of salt may affect flow rate
Hard to see the point at which all the salt has passed out of the container
Human error in starting/stopping the stopwatch
Salt sticks to the sides of the funnel

(f)(i) Improvements **4**

Relevant points might include:
Take many readings and plot a graph of the results
Use greater masses of salt to increase t
Greater masses reduce uncertainty in t
Use mechanical method (joined to timer) to start the flow
Use light gates to determine when salt ceases to pass out of the hole
Use of a second person
Do not allow 'repeated readings'.
Do not allow 'use a computer to improve the experiment'.

Centre Number	Candidate Number	Name

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

PHYSICS **9702/04**

Paper 4

Specimen Paper

1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen in the spaces provided on the Question Paper.
You may use a pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
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10	
11	
12	
Total	

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Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_0	=	8.85×10^{-12} F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + ½at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
gravitational potential	$\phi = -\frac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
simple harmonic motion	$a = -\omega^2 x$
velocity of particle in s.h.m.	$v = v_o \cos \omega t$
	$v = \pm\omega\sqrt{(x_o^2 - x^2)}$
electric potential	$V = \frac{Q}{4\pi\varepsilon_o r}$
capacitors in series	$1/C = 1/C_1 + 1/C_2 + ...$
capacitors in parallel	$C = C_1 + C_2 + ...$
energy of charged capacitor	$W = {}^1/_2 QV$
resistors in series	$R = R_1 + R_2 + ...$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + ...$
alternating current/voltage	$x = x_o \sin \omega t$
radioactive decay	$x = x_o \exp(-\lambda t)$
decay constant	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

For Examiner's Use

Section A

Answer **all** the questions in the spaces provided.

1 **(a)** **(i)** On Fig. 1.1, draw lines to represent the gravitational field outside an isolated uniform sphere.

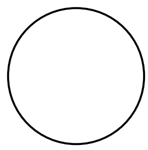

Fig. 1.1

(ii) A second sphere has the same mass but a smaller radius. Suggest what difference, if any, there is between the patterns of field lines for the two spheres.

....

.... [3]

(b) The Earth may be considered to be a uniform sphere of radius 6380 km with its mass of 5.98×10^{24} kg concentrated at its centre, as illustrated in Fig. 1.2.

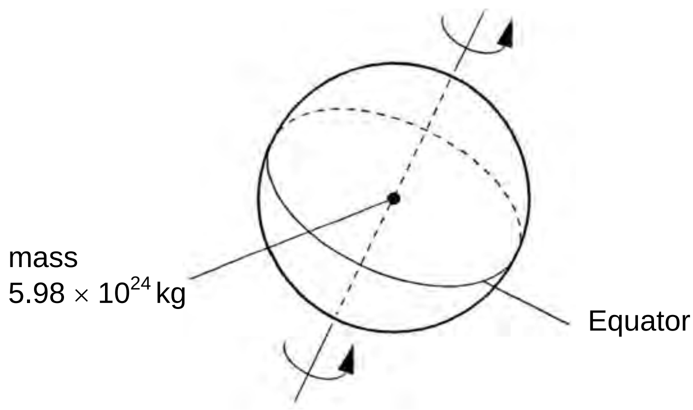

Fig. 1.2

A mass of 1.00 kg on the Equator rotates about the axis of the Earth with a period of 1.00 day (8.64×10^4 s).

Calculate, to three significant figures,

(i) the gravitational force F_G of attraction between the mass and the Earth,

F_G = ... N

(ii) the centripetal force F_C on the 1.00 kg mass,

F_C = ... N

(iii) the difference in magnitude of the forces.

difference = ... N [6]

(c) By reference to your answers in **(b)**, suggest, with a reason, a value for the acceleration of free fall at the Equator.

....

....

.... [2]

For Examiner's Use

2 **(a)** The defining equation of simple harmonic motion is

$$a = -\omega^2 x.$$

(i) State the relation between ω and the frequency f.

....

(ii) State the significance of the negative (-) sign in the equation.

....

.... [2]

(b) A frictionless trolley of mass m is held on a horizontal surface by means of two similar springs, each of spring constant k. The springs are attached to fixed points as illustrated in Fig. 2.1.

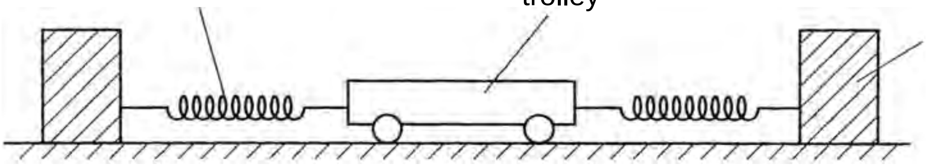

Fig. 2.1

When the trolley is in equilibrium, the extension of each spring is e.
The trolley is then displaced a small distance x to the right along the axis of the springs.
Both springs remain extended.

(i) Show that the magnitude F of the restoring force acting on the trolley is given by

$$F = 2kx.$$

[2]

(ii) The trolley is then released. Show that the acceleration a of the trolley is given by

$$a = \frac{-2kx}{m}$$

[2]

For Examiner's Use

(iii) The mass *m* of the trolley is 900 g and the spring constant *k* is 120 N m^{-1}. By comparing the equations in **(a)** and **(b)(ii)**, determine the frequency of oscillation of the trolley.

frequency = ... Hz [3]

3 The rectified output of a sinusoidal signal generator is connected across a resistor **R** of resistance 1.5 kΩ as shown in Fig. 4.1.

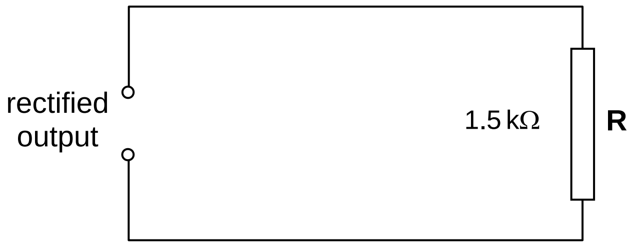

Fig 4.1

The variation with time *t* of the potential difference *V* across **R** is shown in Fig. 4.2.

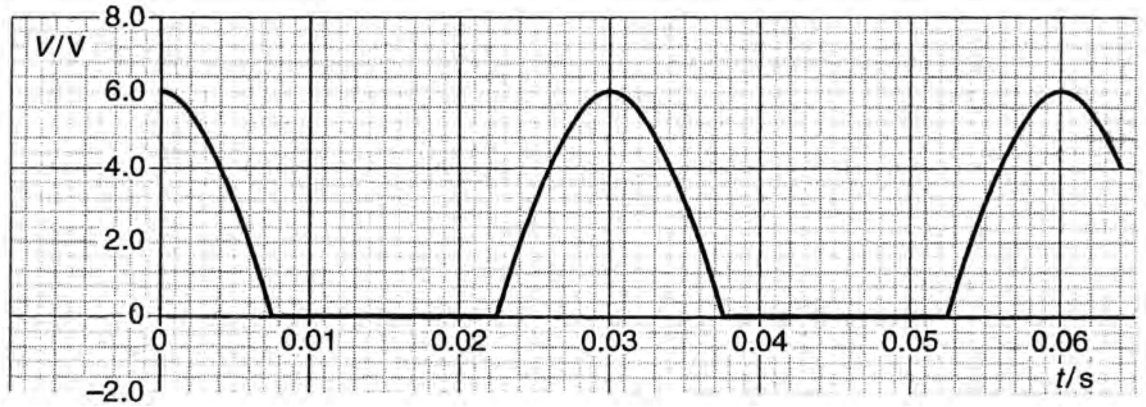

Fig. 4.2

(a) State how the rectification shown in Fig. 4.2 may be achieved.

....

.... [2]

(b) A capacitor is now connected in parallel with the resistor **R**. The resulting variation with time *t* of the potential difference *V* across **R** is shown in Fig. 4.3.

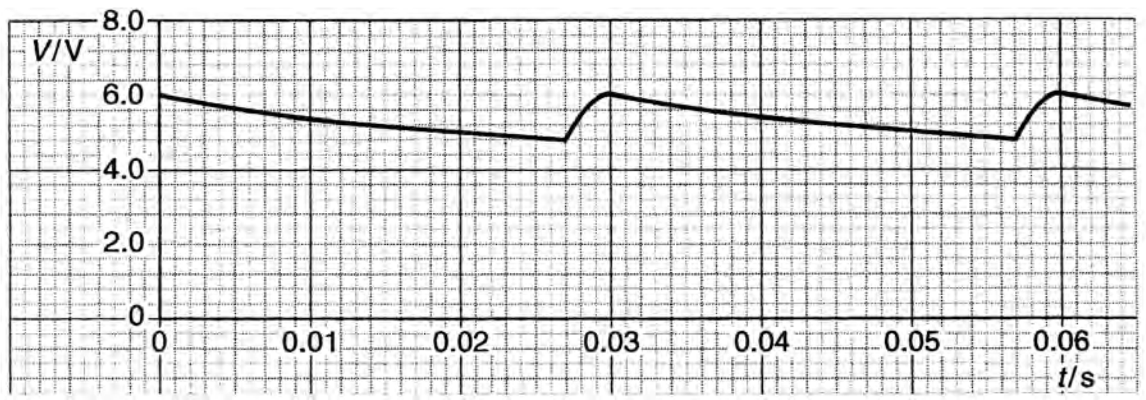

Fig. 4.3

For Examiner's Use

(i) Using Fig. 4.3, determine

1. the mean potential difference across the resistor **R**,

potential difference = ... V

2. the mean current in the resistor,

mean current = ... A

3. the time in each cycle during which the capacitor discharges through the resistor.

time = ... s

[4]

(ii) Using your answers in **(i)**, calculate

1. the charge passing through the resistor during one discharge of the capacitor,

charge = ... C

2. the capacitance of the capacitor.

capacitance = ... F

[4]

(c) A second capacitor is now connected in parallel with the resistor **R** and the first capacitor. On Fig. 4.3, draw a line to show the variation with time *t* of the potential difference *V* across the resistor. [1]

For Examiner's Use

4 A small coil is positioned so that its axis lies along the axis of a large bar magnet, as shown in Fig. 5.1.

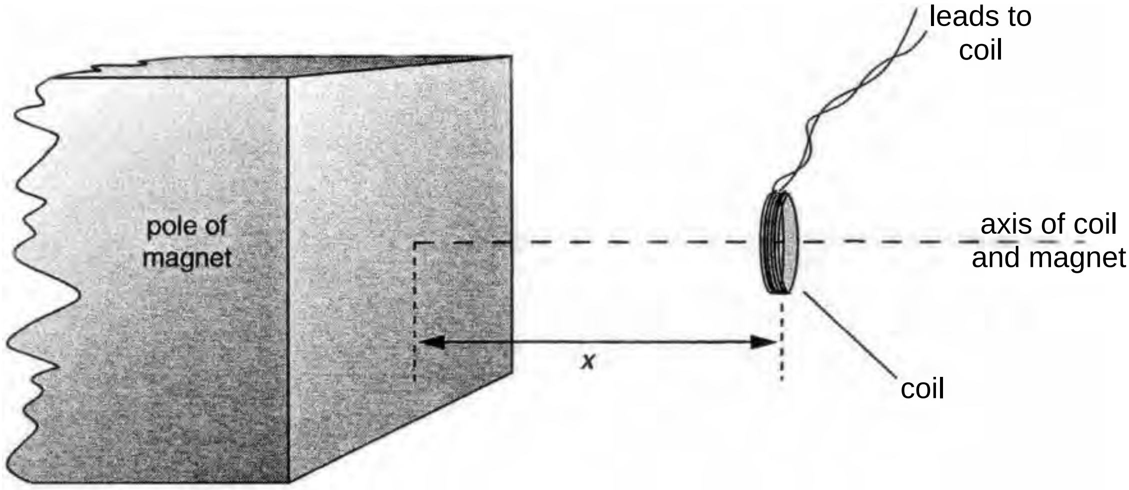

Fig. 5.1

The coil has a cross-sectional area of $0.40\,cm^2$ and contains 150 turns of wire.

The average magnetic flux density *B* through the coil varies with the distance *x* between the face of the magnet and the plane of the coil, as shown in Fig. 5.2.

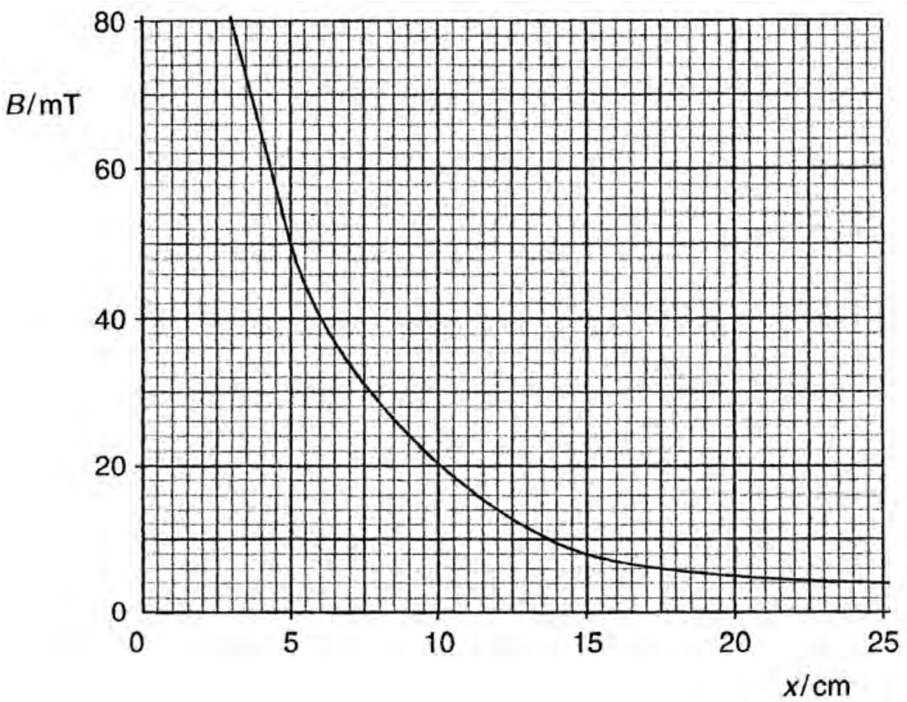

Fig. 5.2

For Examiner's Use

(a) **(i)** The coil is 5.0 cm from the face of the magnet. Use Fig. 5.2 to determine the magnetic flux density in the coil.

magnetic flux density = ... T

(ii) Hence show that the magnetic flux linkage of the coil is 3.0×10^{-4} Wb.

[3]

(b) State Faraday's law of electromagnetic induction.

....

....

.... [2]

(c) The coil is moved along the axis of the magnet so that the distance x changes from x = 5.0 cm to x = 15.0 cm in a time of 0.30 s. Calculate

(i) the change in flux linkage of the coil,

change = ... Wb [2]

(ii) the average e.m.f. induced in the coil.

e.m.f. = ... V [2]

(d) State and explain the variation, if any, of the speed of the coil so that the induced e.m.f. remains constant during the movement in **(c)**.

....

....

....

.... [2]

For Examiner's Use

5 A charged particle passes through a region of uniform magnetic field of flux density 0.74 T, as shown in Fig. 6.1.

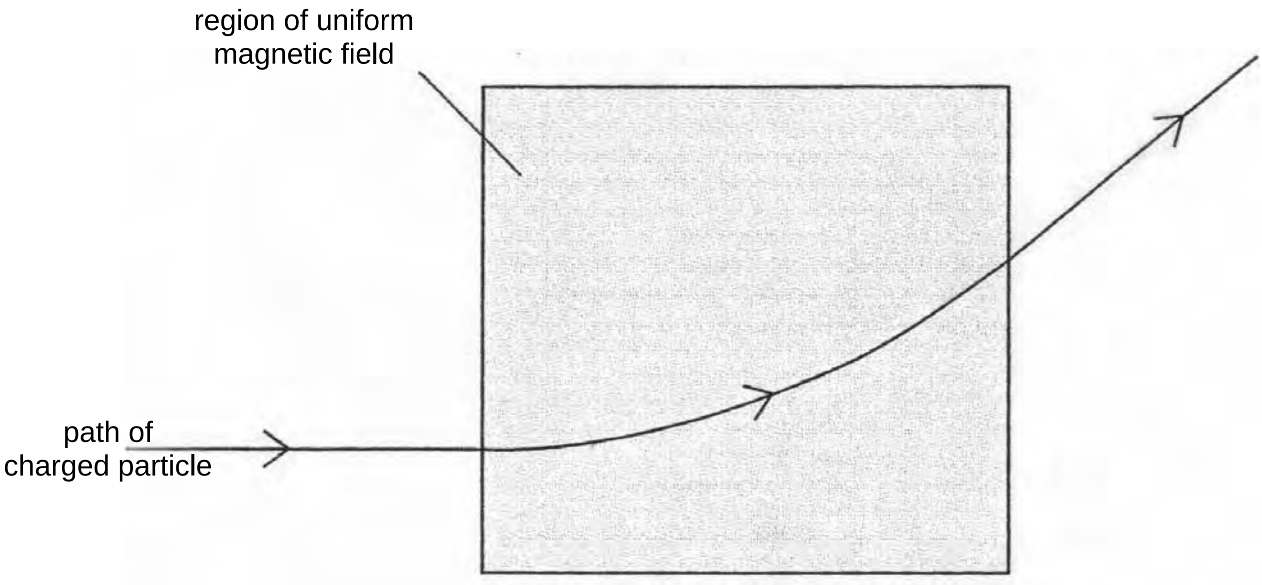

Fig. 6.1

The radius r of the path of the particle in the magnetic field is 23 cm.

(a) The particle is positively charged. State the direction of the magnetic field.

.... [1]

(b) (i) Show that the specific charge of the particle (the ratio $\frac{q}{m}$ of its charge to its mass) is given by the expression

$$\frac{q}{m} = \frac{v}{rB},$$

where v is the speed of the particle and B is the flux density of the field.

[2]

(ii) The speed v of the particle is $8.2 \times 10^6\,\mathrm{m\,s^{-1}}$. Calculate the specific charge of the particle.

specific charge = ... $\mathrm{C\,kg^{-1}}$ [2]

For Examiner's Use

(c) **(i)** The particle in **(b)** has charge 1.6×10^{-19} C. Using your answer to **(b)(ii)**, determine the mass of the particle in terms of the unified mass constant *u*.

mass = ... *u* [2]

(ii) The particle is the nucleus of an atom. Suggest the composition of this nucleus.

....

.... [1]

For Examiner's Use

6 The volume of some air, assumed to be an ideal gas, in the cylinder of a car engine is 540 cm^3 at a pressure of 1.1×10^5 Pa and a temperature of 27 °C. The air is suddenly compressed, so that no thermal energy enters or leaves the gas, to a volume of 30 cm^3. The pressure rises to 6.5×10^6 Pa.

(a) Determine the temperature of the gas after the compression.

temperature = ... K [3]

(b) (i) State and explain the first law of thermodynamics.

....

....

....

.... [2]

(ii) Use the law to explain why the temperature of the air changed during the compression.

....

....

....

....

.... [4]

7 The isotopes Radium-224 ($^{224}_{88}Ra$) and Radium-226 ($^{226}_{88}Ra$) both undergo spontaneous α-particle decay. The energy of the α-particles emitted from Radium-224 is 5.68 MeV and from Radium-226, 4.78 MeV.

(a) (i) State what is meant by the *decay constant* of a radioactive nucleus.

....

....

.... [2]

(ii) Suggest, with a reason, which of the two isotopes has the larger decay constant.

....

....

....

.... [3]

(b) Radium-224 has a half-life of 3.6 days.

(i) Calculate the decay constant of Radium-224, stating the unit in which it is measured.

decay constant = ... [2]

(ii) Determine the activity of a sample of Radium-224 of mass 2.24 mg.

activity = ... Bq [4]

Section B

Answer **all** the questions in the spaces provided.

8 **(a)** Fig. 8.1 is the symbol for a light-emitting diode (LED).

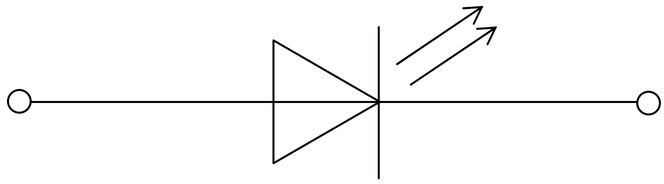

Fig. 8.1

On Fig. 8.1, mark the polarity of the diode such that the diode is emitting light. [1]

(b) Fig. 8.2 is a circuit diagram for a temperature-sensing device.

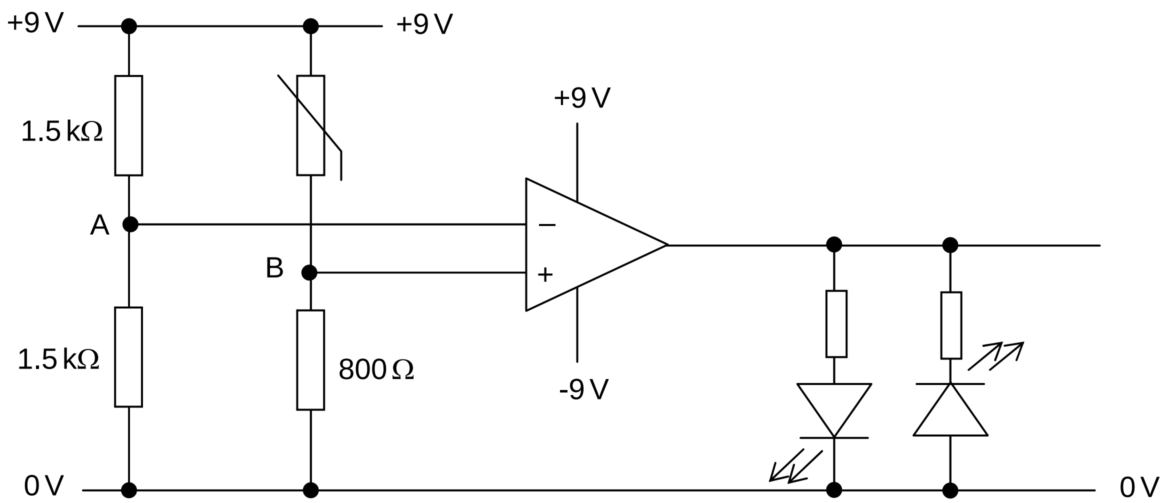

Fig. 8.2

The operational amplifier (op-amp) is ideal.
Some values for the resistance of the thermistor at different temperatures are given in Fig. 8.3.

temperature / °C	resistance / Ω
15	2200
30	1200
60	800
100	680

Fig. 8.3

For Examiner's Use

The thermistor is held in a water bath at a temperature of 15 °C.

(i) Determine the voltage

1. at A,

voltage = ... V

2. at B,

voltage = ... V

3. at the output of the operational amplifier.

voltage = ... V

[4]

(ii) State which LED is emitting light.

.... [1]

(c) Describe and explain what is observed as the temperature of the thermistor is raised from 15 °C to 100 °C.

....

....

.... [2]

For Examiner's Use

9 **(a)** The quality of an image produced using X-rays depends on sharpness and contrast. State what is meant by

(i) *sharpness*,

....

....

(ii) *contrast*.

....

.... [2]

(b) A parallel beam of X-ray photons is produced by an X-ray tube with 80 keV between the anode and cathode. The beam has its intensity reduced to one half of its original value when it passes through a thickness of 1.0 mm of copper.

(i) Determine the linear absorption coefficient μ of the X-ray photons in copper.

μ = ... mm^{-1} [2]

(ii) Suggest, with a reason, the effect on the linear absorption coefficient if the beam is comprised of 100 keV photons.

....

....

.... [2]

For Examiner's Use

10 A sinusoidal wave of frequency 75 kHz is to be amplitude modulated by a wave of frequency 5.0 kHz.

(a) Explain what is meant by *amplitude modulation*.

....

....

.... [2]

(b) On the axes of Fig. 10.1, sketch a graph to show the variation with frequency f of the power P of the modulated wave. Give labelled values on the frequency axis. [3]

Fig. 10.1

(c) State the bandwidth of the modulated wave.

bandwidth = ... kHz [1]

11 Fig. 11.1 shows a microphone connected directly to an amplifier having a gain of 63 dB.

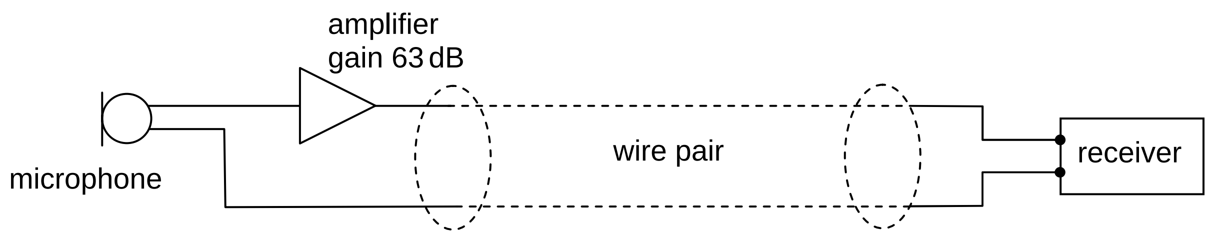

Fig. 11.1

The microphone and amplifier are connected to a receiver by means of a wire pair having an attenuation of 12 dB per kilometre length. The output signal from the microphone is 2.5 μW and there is a constant noise power in the wire pair of 0.035 μW.

(a) Explain what is meant by *noise*.

....

.... [1]

(b) Calculate the power output of the amplifier.

power output = ... W [3]

For Examiner's Use

(c) Calculate the length of the wire pair for the signal power to be reduced to the level of the noise power.

length = ... km [2]

For Examiner's Use

12 Fig. 12.1 illustrates part of a mobile phone network.

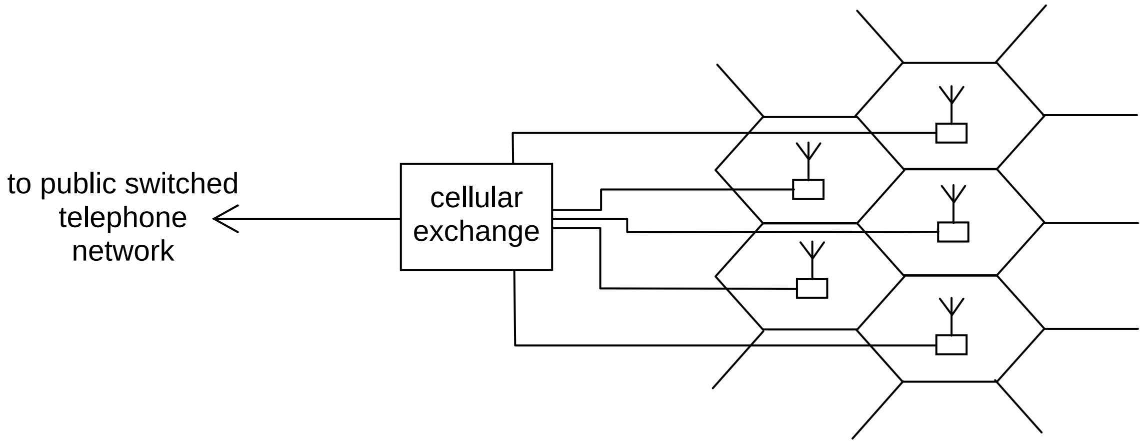

Fig. 12.1

State four functions of the cellular exchange.

1. ....

2. ....

3. ....

4. .... [4]

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Specimen Paper

GCE A LEVEL

MARK SCHEME
MAXIMUM MARK: 100
SYLLABUS/COMPONENT: 9702/04 **PHYSICS** **Paper 4**

Section A

1	**(a)**	**(i)**	radial lines	B1	
			pointing inwards	B1	
		(ii)	no difference *OR* lines closer near surface of smaller sphere	B1	[3]
	(b)	**(i)**	$F_G = GMm / R^2$	C1	
			$= (6.67 \times 10^{-11} \times 5.98 \times 10^{24}) / (6380 \times 10^3)^2$		
			$= 9.80$ N	A1	
		(ii)	$F_C = mR\omega^2$	C1	
			$\omega = 2\pi / T$	C1	
			$F_C = (4\pi^2 \times 6380 \times 10^3) / (8.64 \times 10^4)^2$		
			$= 0.0337$ N	A1	
		(iii)	$F_G. – F_C = 9.77$ N	A1	[6]
	(c)		because acceleration (of free fall) is (resultant) force per unit mass	B1	
			acceleration = 9.77 m s^{-2}	B1	[2]
2	**(a)**	**(i)**	$\omega = 2\pi f$	B1	
		(ii)	(-)ve because *a* and *x* in opposite directions *OR* *a* directed towards mean position / centre	B1	[2]
	(b)	**(i)**	forces in springs are $k(e + x)$ and $k(e - x)$	C1	
			resultant $= k(e + x) - k(e - x)$	M1	
			$= 2kx$	A0	[2]
		(ii)	$F = ma$	B1	
			$a = -2kx / m$	A0	
			(-)ve sign explained	B1	[2]
		(iii)	$\omega^2 = 2k / m$	C1	
			$(2\pi f)^2 = (2 \times 120) / 0.90$	C1	
			$f = 2.6$ Hz	A1	[3]

3	**(a)**	single diode		M1	
		in series with R *OR* in series with a.c. supply		A1	[2]
	(b) (i) 1	5.4 V (allow ±0.1 V)		A1	
	(i) 2	$V = iR$			
		$I = 5.4 / 1.5 \times 10^{3}$		C1	
		$= 3.6 \times 10^{-3}$ A		A1	
	(i) 3	time = 0.027 s		A1	[4]
	(ii) 1	$Q = it$			
		$= 3.6 \times 10^{-3} \times 0.027$		C1	
		$= 9.72 \times 10^{-5}$ C		A1	
	(ii) 2	$C = \Delta Q / \Delta V$ (allow $C = Q/V$ for this mark)		C1	
		$= (9.72 \times 10^{-5}) / 1.2$			
		$= 8.1 \times 10^{-5}$ F		A1	[4]
	(c)	line: reasonable shape with less ripple		B1	[1]
4	**(a) (i)**	50 mT		A1	
	(ii)	flux linkage $= BAN$		C1	
		$= 50 \times 10^{-3} \times 0.4 \times 10^{-4} \times 150 = 3.0 \times 10^{-4}$ Wb		A1	[3]
		(*allow 49 mT $\rightarrow 2.94 \times 10^{-4}$ Wb or 51 mT $\rightarrow 3.06 \times 10^{-4}$ Wb*)			
	(b)	e.m.f. / induced voltage (*do not allow current*)			
		proportional/equal to		B1	
		rate of change/cutting of flux (linkage)		B1	[2]
	(c) (i)	new flux linkage $= 8.0 \times 10^{-3} \times 0.4 \times 10^{-4} \times 150$			
		$= 4.8 \times 10^{-5}$ Wb		C1	
		change $= 2.52 \times 10^{-4}$ Wb		A1	[2]
	(ii)	e.m.f. $= (2.52 \times 10^{-4}) / 0.30$		C1	
		$= 8.4 \times 10^{-4}$ V		A1	[2]
	(d)	*either*	flux linkage decreases as distance increases	B1	
			so speed must increase to keep rate of change constant	B1	[2]
		or	at constant speed, e.m.f. / flux linkage decreases as *x* increases	(B1)	
			so increase speed to keep rate constant	(B1)	

5 **(a)** into (plane of) paper / downwards B1 [1]

(b) **(i)** the <u>centripetal force</u> = mv^2 / r B1
$mv^2/r = Bqv$ <u>hence</u> $q/m = v/r B$ (*some algebra essential*) B1 [2]

(ii) $q/m = (8.2 \times 10^6) / (23 \times 10^{-2} \times 0.74)$ C1
$= 4.82 \times 10^7$ C kg^{-1} A1 [2]

(c) **(i)** mass $= (1.6 \times 10^{-19}) / (4.82 \times 10^7 \times 1.66 \times 10^{-27})$ C1
$= 2u$ [2]

(ii) proton + neutron B1 [1]

6 **(a)** pV / T = constant C1
$T = (6.5 \times 10^6 \times 30 \times 300) / (1.1 \times 10^5 \times 540)$ C1
= 985 K A1 [3]
(*if uses ℃, allow 1/3 marks for clear formula)*

(b) **(i)** $\Delta U = q + w$
symbols identified correctly M1
directions correct A1 [2]

(ii) q is zero B1
is positive *OR* $\Delta U = w$ and U increases B1
ΔU is rise in kinetic energy of <u>atoms</u> M1
and mean kinetic energy $\propto T$ A1 [4]
(*allow 1 of the last two marks if states 'U increases so T rises'*)

7 **(a)** **(i)** *either* probability of decay per unit time *or* $dN/dt = (-)\lambda N$ OR $A = (-)\lambda N$ with symbols explained M1 A1 [2]

(ii) greater energy of α-particle means M0
(parent) nucleus less stable A1
nucleus more likely to decay A1
hence Radium-224 A1 [3]

(b) **(i)** *either* λ = ln2 / 3.6 = 0.193, unit day^{-1} *or* λ = ln2 / 3.6 × 24 × 3600 = 2.23×10^{-6}, unit s^{-1} A1 A1 [2]
(*one sig.fig., -1, allow λ in hr^{-1}*)

(ii) $N = \{(2.24 \times 10^{-3}) / 224\} \times 6.02 \times 10^{23}$ C1
$= 6.02 \times 10^{18}$ C1
activity = λN
$= 2.23 \times 10^{-6} \times 6.02 \times 10^{18}$ C1
$= 1.3 \times 10^{13}$ Bq A1 [4]

Section B

8	**(a)** + –		B1	[1]
	(b) (i)	**1.** 4.5 V	B1	
		2. Use of potential divider formula $9 \times 800 / (800 + 2200)$	C1	
		2.4 V	A1	
		3. – 9.0 V	B1	[4]
	(ii)	green (*e.c.f. from (a) and (i)3*)	B1	[1]
	(c) as temperature rises, potential/voltage at B increases		M1	
	at 60 °C, green goes out, red comes on		A1	[2]
9	**(a) (i)**	clear distinction of boundaries between regions	B1	
	(ii)	significant difference in blackening of different regions	B1	[2]
	(b) (i)	$\frac{1}{2} = e^{-\mu}$	C1	
		$\mu = 0.693\ \text{mm}^{-1}$	A1	[2]
	(ii)	X-ray (photons) are more penetrating	M1	
		μ is smaller	A1	[2]
10	**(a)** amplitude of carrier wave varies		M1	
	in synchrony with (displacement of information) signal		A1	[2]
	(b) three vertical lines		B1	
	symmetrical with smaller sidebands		B1	
	at frequencies 70, 75 and 80 kHz		B1	[3]
	(c) bandwidth = 10 kHz		B1	[1]
11	**(a)** unwanted energy / power that is random or that covers whole spectrum		B1	[1]
	(b) number of dB = $10 \lg(P_{OUT} / P_{IN})$		C1	
	$63 = 10 \lg (P_{OUT} / (2.5 \times 10^{-6})$		C1	
	$P_{OUT} = 5.0$ W		A1	[3]
	(c) attenuation = $10 \lg(5 / 3.5 \times 10^{-8}) = 81.5$ dB		C1	
	length = 81.5 / 12 = 6.8 km		A1	[2]
12	e.g. permits entry to PSTN			
	selects base station for any handset			
	allocates a carrier frequency/channel			
	monitors handset signal to re-allocate base station			
	allocates time slot for multiplexing etc			
	(*any four sensible suggestions, 1 each to max 4)*		B4	[4]

Centre Number	Candidate Number	Name

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

PHYSICS **9702/05**

Paper 5 Planning, Analysis and Evaluation

Specimen Paper

1 hour 15 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **both** questions.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
Total	

This document consists of **7** printed pages and **1** blank page.

UNIVERSITY *of* CAMBRIDGE International Examinations

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For Examiner's Use

1 Two students are having a discussion about an experiment in which the air inside a bell jar is gradually removed. The sound of a ringing bell inside the jar is heard to diminish in intensity during this process.

One student suggests that the frequency f of a sound wave and the pressure p are related by the equation

$$f = kp^2$$

where k is a constant.

Design a laboratory experiment to find out whether the student is correct. You should draw a diagram showing the arrangement of your equipment. In your account, you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements that would be taken,

(c) how the frequency of the sound would be measured using a cathode-ray oscilloscope,

(d) the control of variables,

(e) how the data would be analysed,

(f) any safety precautions that you would take.

[15]

For Examiner's Use

Diagram

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For Examiner's Use

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2 In the early part of the twentieth century, experiments were carried out to measure the range and energies of α-particles in air using a number of different radioactive nuclides in the thorium series.

Data relating to the range R and the energy E is given in the table below.

nuclide	R / cm	E / MeV		
$^{228}_{90}Th$	4.00 ± 0.05	5.38		
$^{228}_{90}Th$	4.35 ± 0.05	5.68		
$^{228}_{90}Th$	4.80 ± 0.05	6.05		
$^{220}_{86}Em$	5.05 ± 0.05	6.28		
$^{216}_{84}Po$	5.70 ± 0.05	6.77		

It is suggested that R and E are related by the equation

$$R = cE^{3/2}$$

where c is a constant.

(a) Explain why plotting a graph of R^2 against E^3 would enable you to confirm whether the relationship between R and E is valid for the data in the table.

....

.... [1]

(b) Calculate and record values of R^2 and E^3 in the table. Include the absolute errors in R^2. [3]

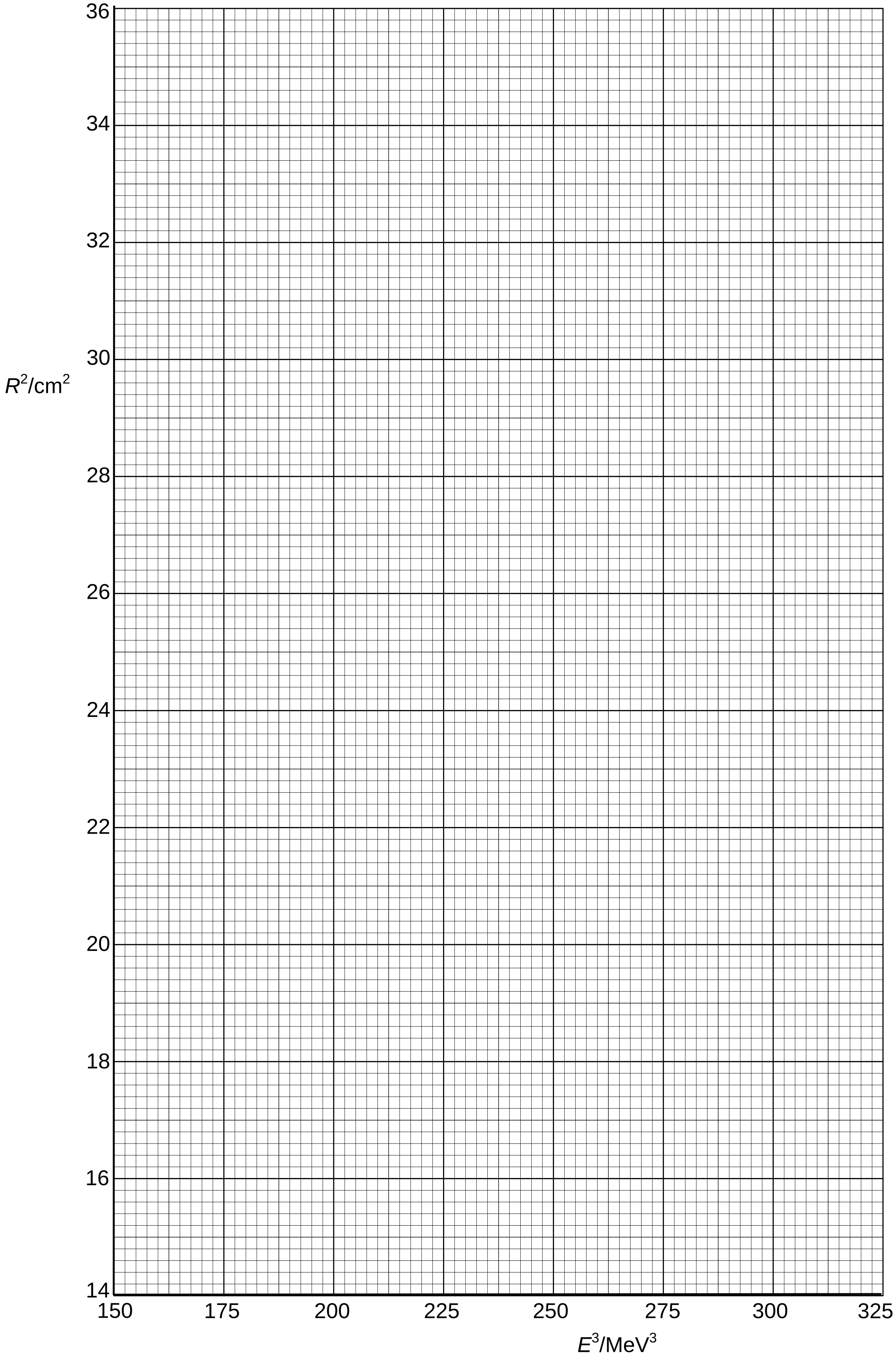
(c) **(i)** Plot a graph of R^2 (y-axis) against E^3 (x-axis). Include error bars for R^2. [2]

(ii) Draw the line of best fit. [1]

(iii) Determine the gradient of the line. Include the error in your answer.

gradient = ... [3]

For Examiner's Use



For Examiner's Use

(d) Determine the value of *c*. Include the error and the unit in your answer.

c = ... [5]

Specimen Paper

GCE A LEVEL

MARK SCHEME
MAXIMUM MARK: 30
SYLLABUS/COMPONENT: 9702/05 **PHYSICS** **Paper 5 (Planning, Analysis and Evaluation)**

Question 1

Planning (15 marks)

Defining the problem (3 marks)

p is the independent variable OR vary *p*	**1**
f is the dependent variable OR measure *f* and *p*	**1**
Variable to be controlled e.g. temperature, frequency of sound source	**1**

Methods of data collection (5 marks)

Workable arrangement Should include container, source of sound, pump, microphone, CRO Doubtful arrangement, poor diagram or one missing detail scores one mark	**2**
Method of varying *p* e.g. use of pump to remove air or valve to allow air in	**1**
Method of measuring *p* e.g. Bourdon gauge/pressure gauge/manometer	**1**
Method of measuring *f* Should include reference to CRO timebase and f = 1/period	**1**

Method of analysis (2 marks)

Plot *f* against p^2	**1**
Equation is correct if graph is a straight line through the origin	**1**

Safety considerations (1 mark)

Safety precaution, e.g. screen/goggles/fuses	**1**

Additional detail (4 marks)

Additional details Relevant points might include: Second variable to be controlled Method of controlling variables Specified sound source (e.g. electric bell/buzzer/speaker) Use of signal generator with speaker Difficulty of detecting quiet sounds at low pressures Using CRO *y*-sensitivity to adjust for sound levels Need to seal points where wires pass through bell jar Monitor temperature with thermometer	**4**

Question 2

Analysis, conclusions and evaluation (15 marks)

Approach to data analysis (1 mark)

(a) $R^2 = c^2E^3$, so expect a straight line <u>through the origin</u> **1**

Table of results (2 marks)

Table Column headings **1**
R^2 / cm^2 and E^3 / MeV^3
Allow R^2 (cm^2) and E^3 (MeV^3)

Table Values of R^2 and E^3 **1**

16.0	156
18.9	183
23.0	221
25.5	248
32.5	310

All correct for one mark.
3 significant figures required (allow 4 s.f.)

Graph (3 marks)

Graph Points plotted correctly **1**
All five required for the mark

Graph Line of best fit **1**
Must be within tolerances.

Graph Worst acceptable straight line **1**
Must be within tolerances.

Conclusion (4 marks)

(c)(iii) Gradient of best-fit line **1**
The hypotenuse of the Δ must be greater than half the length of the drawn line.
Read-offs must be accurate to half a small square.
Check for $\Delta y/\Delta x$ (i.e. do not allow $\Delta x/\Delta y$).

(d) Gradient = c^2 **1**
Does not have to be explicitly stated: may be implicit from working
Check in part (a)

(d) Value of c **1**
= 0.107 (allow ± 0.007)

(d) Unit of c **1**
$cm^2\,MeV^{-3}$

Treatment of errors (5 marks)

Table	Errors in R^2		**1**
	0.4		
	0.4	allow 0.5	
	0.5	allow 0.4	
	0.5		
	0.6		
Graph	Error bars plotted correctly		**1**
(c)(iii)	Error in gradient Must be calculated using gradient of worst acceptable straight line		**1**
(d)	Method of finding error in *c* i.e. limit of error range in c from square root of limit of error range in gradient Allow 0.5 x percentage error in gradient		**1**
(d)	Value for error in *c* 0.007 (allow ±0.001) Allow 7%		**1**