

A Level · Topics 12–25

Circular motion and gravitational fields, temperature, ideal gases and thermodynamics, oscillations, electric fields and capacitance, magnetic fields and alternating currents, quantum and nuclear physics.

SUGGESTED TIME	TOTAL MARKS	QUESTIONS	MULTIPLE CHOICE
100 minutes	82	12	6

SECTION

A2 · A Level extension

IN THE FORMAT OF

Paper 4 (A Level structured questions), closing in the style of Paper 5

DEMAND

Recall 1 · Routine 2 · Demanding 6 · Discriminating 3

Written to the real level of Paper 4, which is a hard paper. Multi-step calculations where nothing tells you which equation comes first; "show that" parts with the answer given so that partial credit depends on the working; explanations marked for the mechanism, not the name of the effect. The last question on each paper is in Paper 5's format, where the marks are for the design and the uncertainty treatment rather than for physics recall.

SYLLABUS POINTS

12 · 13 · 14 · 15 · 16 · 17 · 18 · 19 · 20 · 21 · 22 · 23

INSTRUCTIONS

- Answer all questions in the spaces provided.
- Show your working. Method marks are awarded even where the final answer is wrong.
- Give your answers to a sensible number of significant figures, with a unit.
- The mark scheme for this paper follows the last question.

Written by GioPhysics from the published syllabus. These are practice papers in the style of Cambridge International AS & A Level Physics 9702; they are not Cambridge papers, contain no past-paper questions, and the official syllabus and specimen materials remain the authority.

Cambridge International AS & A Level Physics 9702 syllabus — <https://www.cambridgeinternational.org/Images/664565-2025-2027-syllabus.pdf>

A Level · Topics 12–25

Answer all questions. 82 marks in 100 minutes.

1 MULTIPLE CHOICE · ROUTINE · 13 [1]

A LEVEL A satellite is in a circular orbit at a height above the Earth's surface equal to the radius R of the Earth. The gravitational field strength at the Earth's surface is g . What is the acceleration of the satellite?

- A** g
- B** $g/2$
- C** $g/4$
- D** $g/8$

Answer

2 MULTIPLE CHOICE · DEMANDING · 15 [1]

A LEVEL An ideal gas is at a thermodynamic temperature of 300 K. To what temperature must it be raised to double the root-mean-square speed of its molecules?

- A** 424 K
- B** 600 K
- C** 1200 K
- D** 2400 K

Answer

3 MULTIPLE CHOICE · ROUTINE · 17 [1]

A LEVEL A body moves with simple harmonic motion of amplitude 2.0 cm and frequency 5.0 Hz. What is the magnitude of its maximum acceleration?

- A** 0.63 m s^{-2}
- B** 3.1 m s^{-2}
- C** 20 m s^{-2}
- D** 200 m s^{-2}

Answer

4

MULTIPLE CHOICE · DEMANDING · 19

[1]

A LEVEL

A capacitor of capacitance $470\ \mu\text{F}$, charged to a potential difference V_0 , is discharged through a resistor of resistance $22\ \text{k}\Omega$. After what time has the charge on the capacitor fallen to 25% of its initial value?

- A 3.6 s
- B 7.2 s
- C 14 s
- D 21 s

Answer

5

MULTIPLE CHOICE · RECALL · 20

[1]

A LEVEL

An electron enters a uniform magnetic field with its velocity perpendicular to the field. What is its subsequent path within the field?

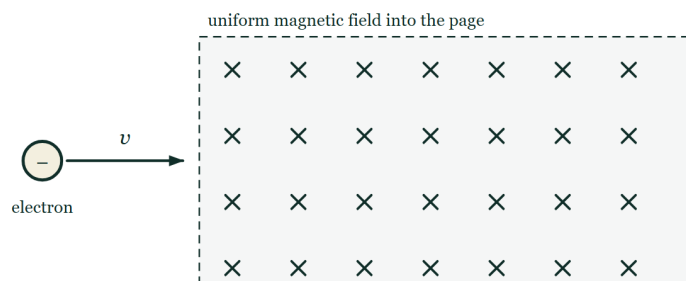


Fig. 5.1 An electron, drawn as a small circle marked with a negative sign, travels horizontally to the right, and an arrow labelled v gives its velocity. Ahead of it lies a large rectangular region with a dashed boundary, filled with a regular array of crosses and labelled as a uniform magnetic field directed into the page. The electron is shown outside that region, at the instant before it crosses the boundary, with its velocity lying in the plane of the page.

- A a straight line at constant speed
- B a straight line with increasing speed
- C a circular arc at constant speed
- D a parabolic arc with increasing speed

Answer

A LEVEL

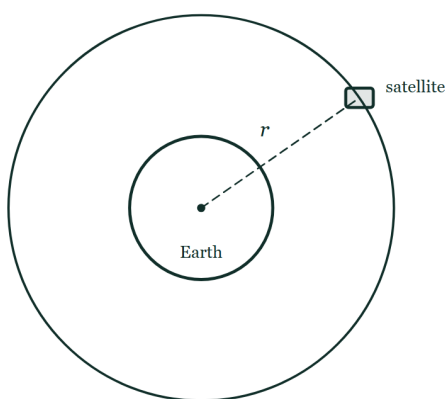
Light of wavelength 450 nm is incident on a metal surface of work function 2.0 eV. What is the maximum kinetic energy of the emitted photoelectrons?

- A 0.76 eV
- B 2.0 eV
- C 2.8 eV
- D 4.8 eV

Answer

A LEVEL

A satellite is in a circular geostationary orbit about the Earth. The product GM for the Earth is $3.99 \times 10^{14} \text{ m}^3 \text{ s}^{-2}$, and one day may be taken as 24 hours.



not to scale

Fig. 7.1 The Earth is drawn as a circle, labelled, with a dot marking its centre. A second, larger circle drawn concentric with it is the satellite's circular orbit. The satellite itself is a small block sitting on that larger circle, above and to the right of the Earth, and a dashed straight line runs from the dot at the centre of the Earth out to the satellite, labelled r . The figure is marked not to scale.

- (a) EXPLAIN
- [3]

Explain what is meant by a geostationary orbit.

- (b) SHOW (THAT)
- [4]

The gravitational force provides the centripetal force. Show that the radius of a geostationary orbit is approximately $4.2 \times 10^7 \text{ m}$.

- (c) **CALCULATE** [2]
Calculate the linear speed of the satellite in this orbit.

.....

.....

- (d) **EXPLAIN** [3]
A student suggests placing a geostationary satellite in orbit above London. Explain why this is not possible.

.....

.....

.....

.....

A LEVEL

A sealed cylinder contains an ideal gas of volume $2.0 \times 10^{-3} \text{ m}^3$ at a pressure of $1.5 \times 10^5 \text{ Pa}$ and a temperature of 290 K . The Boltzmann constant is $1.38 \times 10^{-23} \text{ J K}^{-1}$.

(a) CALCULATE

[3]

Calculate the number of molecules of gas in the cylinder.

(b) DETERMINE

[3]

Determine the total kinetic energy of the molecules in the cylinder.

(c) DEDUCE

[4]

The gas is now compressed slowly at a constant temperature of 290 K . During the compression, 120 J of work is done on the gas. Deduce the change in internal energy of the gas and the thermal energy transferred to or from it.

(d) EXPLAIN

[2]

Explain why the internal energy of an ideal gas depends only on its temperature, whereas that of a real gas does not.

A LEVEL

A mass suspended from a spring oscillates vertically with simple harmonic motion of amplitude 4.0 cm and period 0.80 s.

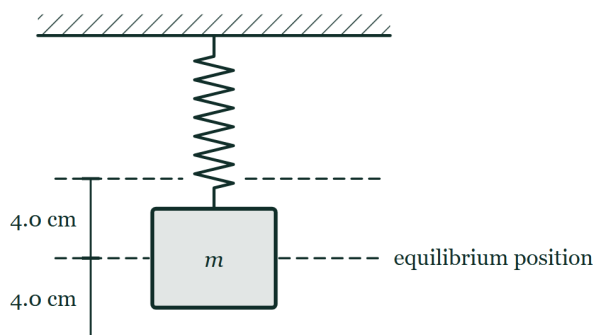


Fig. 9.1 A spring hangs vertically from a rigid horizontal support drawn with hatching above it, and a block labelled m is attached to the lower end of the spring. A dashed horizontal line level with the centre of the block is labelled equilibrium position. Two further dashed horizontal lines, one above it and one below it, mark the highest and lowest positions the block reaches, and the distance from the equilibrium line to each of them is marked 4.0 cm.

(a) **DEFINE**

[2]

Define simple harmonic motion.

.....

.....

(b) **CALCULATE**

[3]

Calculate the maximum speed of the mass.

.....

.....

.....

(c) **CALCULATE**

[3]

Calculate the speed of the mass when its displacement from the equilibrium position is 2.0 cm.

.....

.....

.....

(d) **EXPLAIN**

[4]

The mass is now made to oscillate by a driver whose frequency can be varied, and the system is lightly damped. Describe how the amplitude of the oscillations varies with the driving frequency, and explain what happens to the response curve if the damping is increased.

Two large parallel metal plates are 5.0 mm apart in a vacuum. A potential difference of 2.0 kV is maintained between them. A separate circuit contains a capacitor of capacitance $22\ \mu\text{F}$ charged to a potential difference of 12 V.

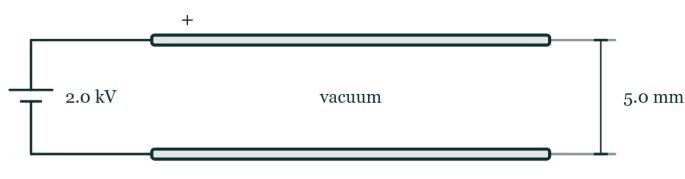


Fig. 10.1 Two long horizontal metal plates are drawn one directly above the other and connected by wires at their left-hand ends to a battery labelled 2.0 kV; the upper plate carries a plus sign and the lower plate a minus sign. The space between the plates is empty and labelled vacuum, and a dimension at the right-hand end gives the separation of the plates as 5.0 mm. No field lines are drawn between the plates.

(a) CALCULATE

[2]

Calculate the magnitude of the electric field strength between the parallel plates.

.....

.....

(b) EXPLAIN

[3]

Compare the field between the parallel plates with the field around an isolated point charge, and explain the difference in how each varies with position.

.....

.....

.....

.....

(c) CALCULATE

[2]

Calculate the energy stored in the $22\ \mu\text{F}$ capacitor.

.....

.....

(d) DETERMINE

[4]

The charged capacitor is discharged through a $150\ \text{k}\Omega$ resistor. Determine the time taken for the potential difference across it to fall to 3.0 V.

.....

.....

.....

.....

.....

A LEVEL

Electrons are accelerated from rest through a potential difference of 250 V. Separately, a nucleus of $^{56}_{26}\text{Fe}$ has a nuclear mass of 55.9206 u. The mass of a proton is 1.00728 u, the mass of a neutron is 1.00867 u, and 1 u is equivalent to 931.5 MeV.

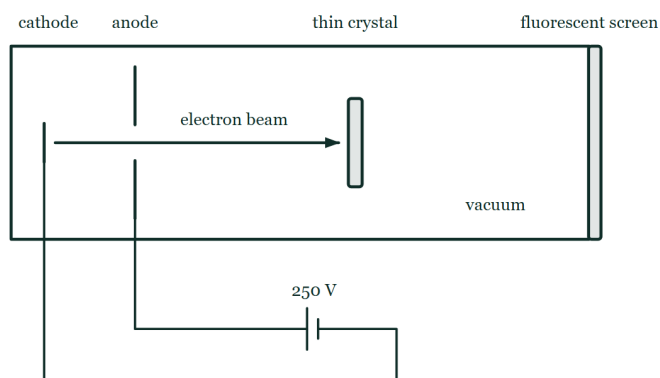


Fig. 11.1 An evacuated tube is drawn as a long horizontal rectangle, closed at its right-hand end by a bar labelled fluorescent screen. Near the left-hand end is a short vertical cathode, and beyond it a vertical anode plate with a gap at its centre; leads from both pass out of the tube to a cell labelled 250 V, whose positive terminal is joined to the anode. An arrow along the axis shows a beam of electrons passing through the gap in the anode and travelling to a thin crystal mounted upright across the middle of the tube. The screen is drawn blank.

(a) CALCULATE

[4]

Calculate the de Broglie wavelength of the accelerated electrons.

.....

.....

.....

.....

.....

(b) EXPLAIN

[3]

Explain how the diffraction of a beam of such electrons by a thin crystal provides evidence for the wave nature of matter.

.....

.....

.....

.....

.....

(c) DETERMINE

[4]

Determine the binding energy per nucleon of $^{56}_{26}\text{Fe}$, in MeV.

.....

.....

.....

.....

.....

(d) EXPLAIN

[3]

Iron-56 lies near the peak of the binding energy per nucleon curve. Explain why energy is released both when light nuclei fuse and when heavy nuclei undergo fission.

.....

.....

.....

.....

12

A LEVEL

DATA ANALYSIS · ANALYSIS, CONCLUSIONS AND EVALUATION – PAPER 5 STYLE · DISCRIMINATING · 19 · 23

[15]

A student investigates the discharge of a capacitor of capacitance C through a resistor of resistance $R = 100\text{ k}\Omega$. The potential difference V across the capacitor is recorded at intervals, and $\ln(V/V)$ is calculated. The student expects $V = V_0 e^{(-t/RC)}$.

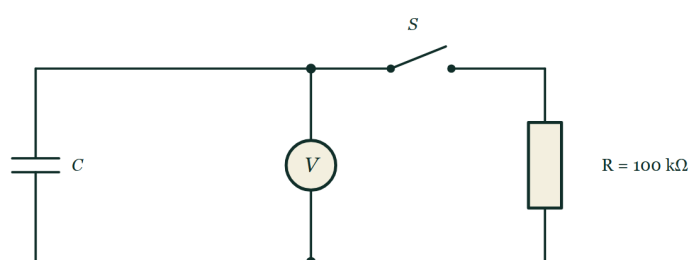


Fig. 12.1 A circuit with three branches between an upper and a lower horizontal wire. On the left is a capacitor labelled C ; in the middle is a voltmeter connected permanently across it, with junction dots where its branch joins each of the two wires; on the right is a resistor labelled $R = 100\text{ k}\Omega$. An open switch S lies in the upper wire between the voltmeter branch and the resistor branch, so that closing it connects the resistor across the capacitor.

The student's processed results

t / s	0.0	10.0	20.0	30.0	40.0
V / V	9.00	6.05	4.07	2.73	1.84
$\ln(V/V)$	2.197	1.800	1.404	1.004	0.610

(a) EXPLAIN

[4]

Explain why a graph of $\ln V$ against t should be a straight line if the discharge is exponential, and state what its gradient and intercept represent.

.....

.....

.....

.....

.....

- (b) **DETERMINE** [4]

Use the first and last data points to determine the gradient of the line, and hence determine the capacitance C .

- (c) **DETERMINE** [4]

The resistance is quoted as $100 \pm 2 \text{ k}\Omega$, and the uncertainty in the gradient is $\pm 1.5\%$. Determine the percentage uncertainty in C , and state the value of C with its absolute uncertainty.

- (d) **SUGGEST** [3]

The voltmeter used has a finite resistance connected across the capacitor throughout the experiment. Suggest how this affects the value obtained for C , and suggest an improvement.

A Level · Topics 12–25 — mark scheme

One line per mark, as an examiner would award them. A note under a part is the error that part is set to catch.

1 MULTIPLE CHOICE · ROUTINE · 13 **[1]**

A LEVEL A satellite is in a circular orbit at a height above the Earth's surface equal to the radius R of the Earth. The gravitational field strength at the Earth's surface is g . What is the acceleration of the satellite?

KEY C $g/4$

B halves rather than squaring — the error of a candidate who remembers that the distance has doubled but not that the field follows an inverse square law. The distance from the centre, not from the surface, is what enters the law, and it has gone from R to $2R$.

A02

2 MULTIPLE CHOICE · DEMANDING · 15 **[1]**

A LEVEL An ideal gas is at a thermodynamic temperature of 300 K. To what temperature must it be raised to double the root-mean-square speed of its molecules?

KEY C 1200 K

B doubles the temperature, which doubles the mean kinetic energy but multiplies the r.m.s. speed by only $\sqrt{2}$ — and A is that $\sqrt{2}$ factor applied to the temperature instead. Since $\frac{1}{2}m\langle c^2 \rangle \propto T$, the speed goes as $\sqrt{T}$, so doubling the speed needs four times the temperature.

A02

3 MULTIPLE CHOICE · ROUTINE · 17 **[1]**

A LEVEL A body moves with simple harmonic motion of amplitude 2.0 cm and frequency 5.0 Hz. What is the magnitude of its maximum acceleration?

KEY C 20 m s^{-2}

B uses f rather than $\omega = 2\pi f$, which loses a factor of $(2\pi)^2 \approx 39$. The amplitude must also be converted to metres; leaving it in centimetres gives D.

A02

4 MULTIPLE CHOICE · DEMANDING · 19 **[1]**

A LEVEL A capacitor of capacitance $470 \mu\text{F}$, charged to a potential difference V_0 , is discharged through a resistor of resistance $22 \text{ k}\Omega$. After what time has the charge on the capacitor fallen to 25% of its initial value?

KEY C 14 s

D is two time constants, which is the answer of a candidate who assumes the charge falls to $1/e^2$ rather than to a quarter. The time constant is 10.3 s and $t = RC \ln 4 = 14.3 \text{ s}$.

A02

5 MULTIPLE CHOICE · RECALL · 20 **[1]**

A LEVEL An electron enters a uniform magnetic field with its velocity perpendicular to the field. What is its subsequent path within the field?

KEY C a circular arc at constant speed

D is the path in a uniform electric field, and is the answer of a candidate who has not separated the two cases. The magnetic force is always perpendicular to the velocity, so it does no work: the speed cannot change, only the direction.

A01

6 A LEVEL	MULTIPLE CHOICE · DEMANDING · 22 Light of wavelength 450 nm is incident on a metal surface of work function 2.0 eV. What is the maximum kinetic energy of the emitted photoelectrons?	[1]
	KEY A 0.76 eV <i>C is the photon energy itself, $hc/\lambda = 2.76$ eV, offered to candidates who stop before subtracting the work function. D adds the work function instead of subtracting it.</i>	A02
7 A LEVEL	STRUCTURED · DISCRIMINATING · 12 · 13	[12]
	A satellite is in a circular geostationary orbit about the Earth. The product GM for the Earth is $3.99 \times 10^{14} \text{ m}^3 \text{ s}^{-2}$, and one day may be taken as 24 hours.	
	(a) EXPLAIN · A01 Explain what is meant by a geostationary orbit. - the satellite has a period of 24 hours, equal to the Earth's period of rotation - it orbits in the same direction as the Earth's rotation, in the plane of the equator - so it remains vertically above the same point on the Earth's surface <i>All three conditions are required, and the equatorial plane is the one candidates omit. An orbit of 24-hour period inclined to the equator does not stay above one point.</i>	[3]
	(b) SHOW (THAT) · A02 The gravitational force provides the centripetal force. Show that the radius of a geostationary orbit is approximately $4.2 \times 10^7 \text{ m}$. $GMm/r^2 = mr\omega^2$, so $GM = r^3\omega^2$ $\omega = 2\pi/T = 2\pi/86400 = 7.27 \times 10^{-5} \text{ rad s}^{-1}$ $r^3 = GM/\omega^2 = 3.99 \times 10^{14} / (7.27 \times 10^{-5})^2 = 7.55 \times 10^{22}$ $r = 4.2 \times 10^7 \text{ m}$ <i>A "show that" with the answer printed: every line of the working has to be there, because a candidate who writes only the final number earns one mark at most.</i>	[4]
	(c) CALCULATE · A02 Calculate the linear speed of the satellite in this orbit. $v = 2\pi r/T = 2\pi \times 4.2 \times 10^7 / 86400$ $v = 3.1 \times 10^3 \text{ m s}^{-1}$	[2]
	(d) EXPLAIN · A02 A student suggests placing a geostationary satellite in orbit above London. Explain why this is not possible. - the centre of a circular orbit must be at the centre of the Earth, because that is where the gravitational force is directed - an orbit whose plane passes above London at a fixed latitude would have its centre away from the Earth's centre - so the satellite would have to be held up by some force other than gravity, which there is none to provide <i>The hardest three marks on the paper, and worth setting: the geometry of the orbit follows from the direction of the force, which is a point candidates rarely have to use explicitly.</i>	[3]

A LEVEL

A sealed cylinder contains an ideal gas of volume $2.0 \times 10^{-3} \text{ m}^3$ at a pressure of $1.5 \times 10^5 \text{ Pa}$ and a temperature of 290 K . The Boltzmann constant is $1.38 \times 10^{-23} \text{ J K}^{-1}$.

(a) CALCULATE · A02

[3]

Calculate the number of molecules of gas in the cylinder.

1 $pV = NkT$

2 $N = pV/kT = (1.5 \times 10^5 \times 2.0 \times 10^{-3}) / (1.38 \times 10^{-23} \times 290)$

3 $N = 7.5 \times 10^{22}$

(b) DETERMINE · A02

[3]

Determine the total kinetic energy of the molecules in the cylinder.

1 mean kinetic energy per molecule = $(3/2)kT = 1.5 \times 1.38 \times 10^{-23} \times 290 = 6.0 \times 10^{-21} \text{ J}$

2 total = $N \times 6.0 \times 10^{-21}$

3 total = $4.5 \times 10^2 \text{ J}$ (450 J)

Also obtainable as $(3/2)pV$, and a candidate who spots that earns full marks in one line.

(c) DEDUCE · A02

[4]

The gas is now compressed slowly at a constant temperature of 290 K . During the compression, 120 J of work is done on the gas. Deduce the change in internal energy of the gas and the thermal energy transferred to or from it.

1 the temperature is unchanged, so the mean kinetic energy per molecule is unchanged

2 the internal energy of an ideal gas is entirely kinetic, so $\Delta U = 0$

3 first law: $\Delta U = q + w$, so $0 = q + 120$

4 $q = -120 \text{ J}$: 120 J of thermal energy is transferred out of the gas to the surroundings

(d) EXPLAIN · A01

[2]

Explain why the internal energy of an ideal gas depends only on its temperature, whereas that of a real gas does not.

1 an ideal gas is defined to have no forces between its molecules except during collisions, so there is no potential energy contribution and the internal energy is the total random kinetic energy alone

2 a real gas has intermolecular forces, so its internal energy also includes potential energy, which depends on the separation of the molecules and hence on the volume

A LEVEL

A mass suspended from a spring oscillates vertically with simple harmonic motion of amplitude 4.0 cm and period 0.80 s.

(a) DEFINE · A01

[2]

Define simple harmonic motion.

- 1 motion in which the acceleration is proportional to the displacement from a fixed point
- 2 and is always directed towards that point (opposite in direction to the displacement)

(b) CALCULATE · A02

[3]

Calculate the maximum speed of the mass.

- 1 $\omega = 2\pi/T = 2\pi/0.80 = 7.85 \text{ rad s}^{-1}$
- 2 $v_{\text{max}} = \omega x_0 = 7.85 \times 0.040$
- 3 $v_{\text{max}} = 0.31 \text{ m s}^{-1}$

(c) CALCULATE · A02

[3]

Calculate the speed of the mass when its displacement from the equilibrium position is 2.0 cm.

- 1 $v = \omega\sqrt{(x_0^2 - x^2)}$
- 2 $v = 7.85 \times \sqrt{(0.040^2 - 0.020^2)} = 7.85 \times 0.0346$
- 3 $v = 0.27 \text{ m s}^{-1}$

(d) EXPLAIN · A02

[4]

The mass is now made to oscillate by a driver whose frequency can be varied, and the system is lightly damped. Describe how the amplitude of the oscillations varies with the driving frequency, and explain what happens to the response curve if the damping is increased.

- 1 the amplitude is small at low driving frequencies, rises to a sharp maximum when the driving frequency equals the natural frequency of the system, then falls again
- 2 this maximum is resonance, and at it the driver transfers energy to the system most efficiently
- 3 increasing the damping lowers the peak amplitude and makes the peak broader (flatter)
- 4 and the peak occurs at a slightly lower frequency than the undamped natural frequency

The shift of the peak to a lower frequency is the fourth mark and is regularly omitted from teaching. The first three are available to any candidate who has drawn the curve.

A LEVEL

Two large parallel metal plates are 5.0 mm apart in a vacuum. A potential difference of 2.0 kV is maintained between them. A separate circuit contains a capacitor of capacitance 22 μF charged to a potential difference of 12 V.

(a) CALCULATE · A02

[2]

Calculate the magnitude of the electric field strength between the parallel plates.

$$1 \quad E = V/d = 2000 / 5.0 \times 10^{-3}$$

$$2 \quad E = 4.0 \times 10^5 \text{ V m}^{-1}$$

(b) EXPLAIN · A01

[3]

Compare the field between the parallel plates with the field around an isolated point charge, and explain the difference in how each varies with position.

1 the field between the plates is uniform — the field lines are parallel and equally spaced, so E has the same magnitude and direction everywhere between them

2 the field of a point charge is radial, with lines spreading out from the charge

3 so the point-charge field falls off as $1/r^2$, while the field between the plates does not vary with position at all

(c) CALCULATE · A02

[2]

Calculate the energy stored in the 22 μF capacitor.

$$1 \quad W = \frac{1}{2}CV^2 = \frac{1}{2} \times 22 \times 10^{-6} \times 12^2$$

$$2 \quad W = 1.6 \times 10^{-3} \text{ J}$$

(d) DETERMINE · A02

[4]

The charged capacitor is discharged through a 150 k Ω resistor. Determine the time taken for the potential difference across it to fall to 3.0 V.

$$1 \quad \text{time constant } RC = 150 \times 10^3 \times 22 \times 10^{-6} = 3.3 \text{ s}$$

$$2 \quad V = V_0 e^{(-t/RC)}, \text{ so } 3.0 = 12 e^{(-t/3.3)}$$

$$3 \quad t = RC \ln(V_0/V) = 3.3 \times \ln 4$$

$$4 \quad t = 4.6 \text{ s}$$

Electrons are accelerated from rest through a potential difference of 250 V. Separately, a nucleus of $^{56}_{26}\text{Fe}$ has a nuclear mass of 55.9206 u. The mass of a proton is 1.00728 u, the mass of a neutron is 1.00867 u, and 1 u is equivalent to 931.5 MeV.

[14]

(a) CALCULATE · A02

[4]

Calculate the de Broglie wavelength of the accelerated electrons.

1 kinetic energy = eV = $1.60 \times 10^{-19} \times 250 = 4.0 \times 10^{-17} \text{ J}$

2 $p = \sqrt{2mE_k} = \sqrt{2 \times 9.11 \times 10^{-31} \times 4.0 \times 10^{-17}}$

3 $p = 8.5 \times 10^{-24} \text{ kg m s}^{-1}$

4 $\lambda = h/p = 6.63 \times 10^{-34} / 8.5 \times 10^{-24} = 7.8 \times 10^{-11} \text{ m}$

Candidates who find the speed first and then use $\lambda = h/mv$ reach the same answer and earn the same marks. Those who set $eV = hc/\lambda$ have used the photon relation on a particle with mass and earn nothing.

(b) EXPLAIN · A01

[3]

Explain how the diffraction of a beam of such electrons by a thin crystal provides evidence for the wave nature of matter.

- 1 the beam produces a pattern of rings or maxima and minima rather than a single spot
- 2 diffraction and interference are effects that only waves show
- 3 the spacing of the pattern agrees with the de Broglie wavelength calculated from the electrons' momentum, so the wavelength is a property of the particles themselves

(c) DETERMINE · A02

[4]

Determine the binding energy per nucleon of $^{56}_{26}\text{Fe}$, in MeV.

1 total mass of separate nucleons = $26 \times 1.00728 + 30 \times 1.00867 = 56.4494 \text{ u}$

2 mass defect $\Delta m = 56.4494 - 55.9206 = 0.5288 \text{ u}$

3 binding energy = $0.5288 \times 931.5 = 492.6 \text{ MeV}$

4 per nucleon = $492.6 / 56 = 8.8 \text{ MeV}$

(d) EXPLAIN · A02

[3]

Iron-56 lies near the peak of the binding energy per nucleon curve. Explain why energy is released both when light nuclei fuse and when heavy nuclei undergo fission.

- 1 energy is released whenever the products have a greater binding energy per nucleon than the reactants, because the nucleons end up more tightly bound and the surplus mass is released as energy
- 2 light nuclei lie to the left of the peak, so fusing them moves the nucleons up the curve towards iron
- 3 heavy nuclei lie to the right of the peak, so splitting them also moves the nucleons up the curve towards iron

The argument has to run through the same curve twice, in opposite directions. Answers that treat fusion and fission as unrelated processes with separate explanations do not earn the third mark.

A student investigates the discharge of a capacitor of capacitance C through a resistor of resistance $R = 100 \text{ k}\Omega$. The potential difference V across the capacitor is recorded at intervals, and $\ln(V/V_0)$ is calculated. The student expects $V = V_0 e^{(-t/RC)}$.

(a) EXPLAIN · A03

[4]

Explain why a graph of $\ln V$ against t should be a straight line if the discharge is exponential, and state what its gradient and intercept represent.

- 1 taking natural logarithms of $V = V_0 e^{(-t/RC)}$ gives $\ln V = \ln V_0 - t/(RC)$
- 2 this is of the form $y = mx + c$ with $\ln V$ as y and t as x , so the points lie on a straight line if the model holds
- 3 the gradient is $-1/(RC)$
- 4 the intercept on the $\ln V$ axis is $\ln V_0$

(b) DETERMINE · A02

[4]

Use the first and last data points to determine the gradient of the line, and hence determine the capacitance C .

- 1 gradient = $(0.610 - 2.197) / (40.0 - 0.0) = -1.587 / 40.0$
- 2 gradient = -0.0397 s^{-1}
- 3 $RC = -1/\text{gradient} = 25.2 \text{ s}$
- 4 $C = 25.2 / 100 \times 10^3 = 2.5 \times 10^{-4} \text{ F (250 } \mu\text{F)}$

(c) DETERMINE · A03

[4]

The resistance is quoted as $100 \pm 2 \text{ k}\Omega$, and the uncertainty in the gradient is $\pm 1.5\%$. Determine the percentage uncertainty in C , and state the value of C with its absolute uncertainty.

- 1 percentage uncertainty in $R = (2/100) \times 100 = 2\%$
- 2 C is found by dividing by the gradient and by R , so the percentage uncertainties add: $1.5\% + 2\% = 3.5\%$
- 3 absolute uncertainty = $0.035 \times 250 = 8.75 \approx 9 \mu\text{F}$
- 4 $C = 250 \pm 9 \mu\text{F}$

Percentage uncertainties add for a product or a quotient, whichever way round the quantities appear. Candidates who subtract because one quantity is in a denominator lose all four marks, and it is a common enough error that Paper 5 sets it deliberately.

(d) SUGGEST · A03

[3]

The voltmeter used has a finite resistance connected across the capacitor throughout the experiment. Suggest how this affects the value obtained for C , and suggest an improvement.

- 1 the voltmeter provides a second discharge path in parallel with R , so the effective resistance is less than $100 \text{ k}\Omega$
- 2 the capacitor therefore discharges faster than the model assumes; the measured time constant is too small, and since C is calculated using $R = 100 \text{ k}\Omega$, the value obtained for C is too small
- 3 improvement: use a voltmeter (or digital multimeter) of much higher resistance, or a data logger with a high-impedance input

Naming the direction of the systematic error is where the marks are. This is the standard Paper 5 evaluation question and it rewards a candidate who traces the fault all the way through to the final quantity.

What the command words are asking for

Every board publishes these and marks to them. A candidate who explains where the question said state has spent four minutes earning one mark; one who states where it said explain has earned none.

Calculate	Work out from given facts, figures or information.
Deduce	Conclude from available information.
Define	Give the precise meaning.
Describe	State the points of a topic; give characteristics and main features.
Determine	Establish an answer using the information available.
Explain	Set out purposes or reasons; make relationships evident; give why and/or how.
Show (that)	Provide structured evidence that leads to a given result.
State	Express in clear terms.
Suggest	Apply knowledge and understanding to situations where there is a range of valid responses in order to make proposals.

WHAT IS BEING TESTED

A Level assessment objectives

Paper 1 is 40 multiple-choice items on AS content. Paper 2 is AS structured questions. Paper 3 is a practical exam taken in a laboratory. Paper 4 is A Level structured questions, 100 marks in two hours, and carries the largest single share of the qualification. Paper 5 is planning, analysis and evaluation — 30 marks, no recall, and the paper on which candidates most often underperform. A data sheet is provided in Papers 1, 2 and 4.

A01 14 MARKS · 17%	Knowledge with understanding Recall and use scientific ideas, terminology, conventions, instruments and apparatus.
A02 57 MARKS · 70%	Handling, applying and evaluating information Select and translate information, manipulate numerical data, solve problems, make predictions and reasoned judgements, and apply physics to unfamiliar contexts.
A03 11 MARKS · 13%	Experimental skills and investigations Plan an investigation, identify and control variables, analyse and evaluate data and methods, handle uncertainties, and draw conclusions.

Written by GioPhysics from the published syllabus. These are practice papers in the style of Cambridge International AS & A Level Physics 9702; they are not Cambridge papers, contain no past-paper questions, and the official syllabus and specimen materials remain the authority.

Cambridge International AS & A Level Physics 9702 syllabus — <https://www.cambridgeinternational.org/Images/664565-2025-2027-syllabus.pdf>