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Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

9237226280

PHYSICS **9702/43**

Paper 4 A Level Structured Questions **October/November 2025**

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 100.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **24** pages. Any blank pages are indicated.

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Data

acceleration of free fall	$g = 9.81\ \text{m s}^{-2}$
speed of light in free space	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19}\ \text{C}$
unified atomic mass unit	$1\ \text{u} = 1.66 \times 10^{-27}\ \text{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\ \text{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
Avogadro constant	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$
molar gas constant	$R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$
Boltzmann constant	$k = 1.38 \times 10^{-23}\ \text{J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^{2}\ \text{kg}^{-2}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{F m}^{-1}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\ \text{m F}^{-1})$
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$
Stefan–Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
hydrostatic pressure	$\Delta p = \rho g \Delta h$
upthrust	$F = \rho g V$
Doppler effect for sound waves	$f_o = \frac{f_s v}{v \pm v_s}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$

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gravitational potential	$\phi = -\dfrac{GM}{r}$
gravitational potential energy	$E_P = -\dfrac{GMm}{r}$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
simple harmonic motion	$a = -\omega^2 x$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $v = \pm\omega\sqrt{(x_0^{\,2} - x^2)}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
electrical potential energy	$E_P = \dfrac{Qq}{4\pi\varepsilon_0 r}$
capacitors in series	$\dfrac{1}{C} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \ldots$
capacitors in parallel	$C = C_1 + C_2 + \ldots$
discharge of a capacitor	$x = x_0 e^{-\frac{t}{RC}}$
Hall voltage	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 e^{-\lambda t}$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$
intensity reflection coefficient	$\dfrac{I_R}{I_0} = \dfrac{(Z_1 - Z_2)^2}{(Z_1 + Z_2)^2}$
Stefan–Boltzmann law	$L = 4\pi\sigma r^2 T^4$
Doppler redshift	$\dfrac{\Delta\lambda}{\lambda} \approx \dfrac{\Delta f}{f} \approx \dfrac{v}{c}$

1 **(a)** In terms of velocity and acceleration, describe uniform circular motion of an object.

....

....

.... [2]

(b) Fig. 1.1 shows the view from above of a polystyrene ball undergoing horizontal circular motion of radius R.

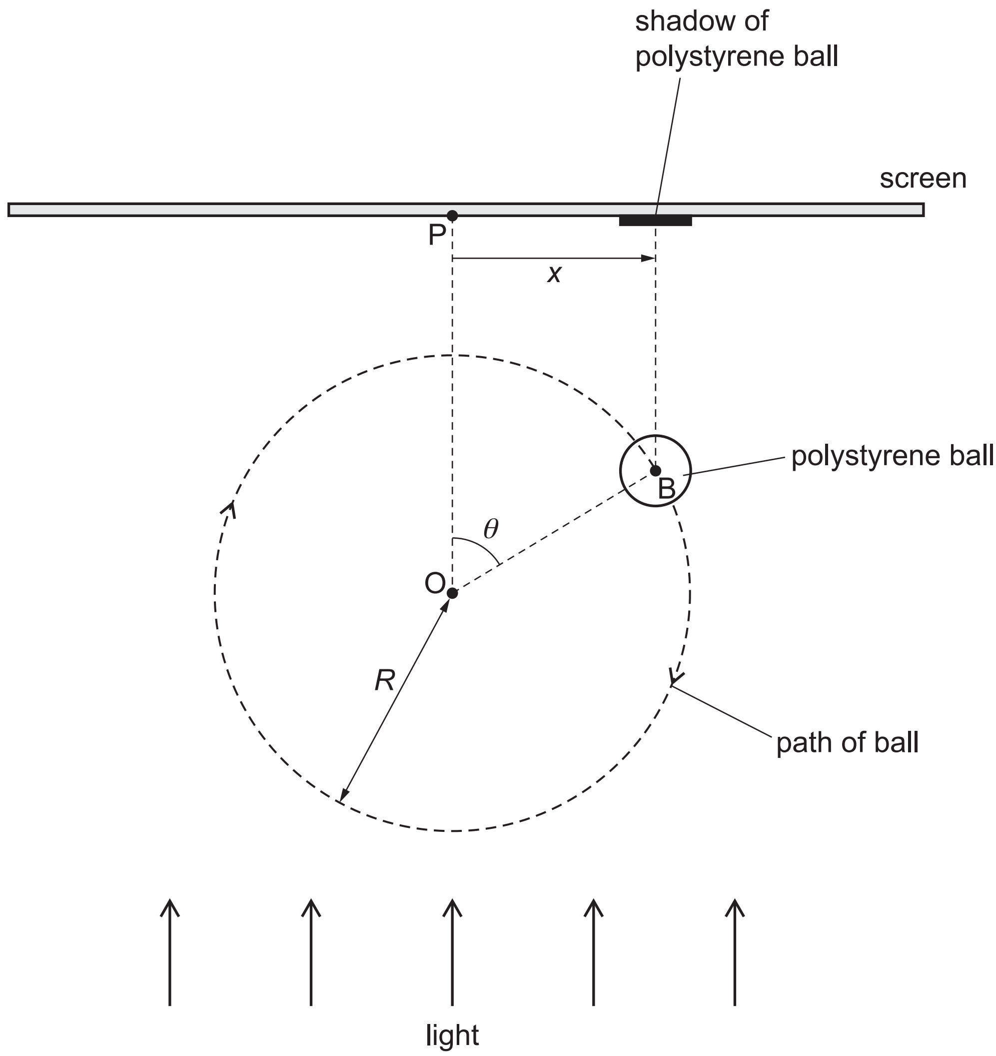

Fig. 1.1

The ball is illuminated by parallel light so that a shadow of the ball forms on a screen placed on the opposite side of the ball from the light source.

The line joining points O and P is perpendicular to the screen.

The angular speed of the circular motion is ω.

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(i) State an expression, in terms of R and ω, for the speed v of the ball.

v = ... [1]

(ii) Determine an expression, in terms of v and ω, for the centripetal acceleration of the ball.

centripetal acceleration = ... [2]

(c) The ball in **(b)** is in the position shown in Fig. 1.1, such that line OB is at an angle θ to the line OP.

(i) Determine an expression, in terms of R and θ, for the displacement x of the shadow from P.

x = ... [1]

(ii) The value of θ is zero at time $t = 0$.

State an expression for θ in terms of ω and t.

θ = ... [1]

(iii) Use your answers in **(c)(i)** and **(c)(ii)** to show that x is given by

$$x = R\sin\omega t.$$

[1]

(iv) Explain, with reference to the equation in **(c)(iii)**, why the motion of the shadow of the ball on the screen may be modelled as simple harmonic.

....

.... [1]

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(d) The circular motion of the ball in Fig. 1.1 has a diameter of 0.46 m and an angular speed of 1.9 rad s^{-1}.

For the simple harmonic motion of the shadow of the ball in Fig. 1.1, calculate:

(i) the amplitude

amplitude = ... m [1]

(ii) the period

period = ... s [2]

(iii) the maximum acceleration.

maximum acceleration = ... m s^{-2} [2]

(e) On Fig. 1.1, draw, and label with the letter A, the position of the shadow on the screen when the shadow has its maximum positive acceleration. [1]

[Total: 15]

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2 **(a)** State **two** ways in which the first law of thermodynamics describes that the internal energy of a system may be changed.

1 ....

....

2 ....

....
[2]

(b) **(i)** Use the first law of thermodynamics to explain why a bicycle pump gets hot when it is used to pump up a tyre quickly.

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....

.... [3]

(ii) With reference to molecular energies, explain why the temperature of water remains at 100 °C when it vaporises in a kettle, even though it is being heated.

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.... [3]

[Total: 8]

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3 **(a)** Define gravitational field at a point.

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.... [1]

(b) Fig. 3.1 shows an isolated point mass of mass M.

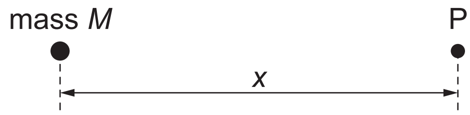

Fig. 3.1

Point P is at distance x from the point mass.

(i) By considering the force exerted by the point mass on a test mass of mass m placed at P, derive an equation for the gravitational field strength g at P, in terms of M and x. Identify any other symbols you use.

[2]

(ii) On Fig. 3.1, draw an arrow to indicate the direction of the gravitational field at P. [1]

(iii) Point Q is at distance $\frac{x}{2}$ from the point mass, on the opposite side of the mass from P, as shown in Fig. 3.2.

Fig. 3.2

Compare the gravitational field at Q with that at P.

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.... [2]

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(c) Two identical isolated uniform spheres X and Y each have radius R. The centres of the spheres are separated by distance L, as shown in Fig. 3.3.

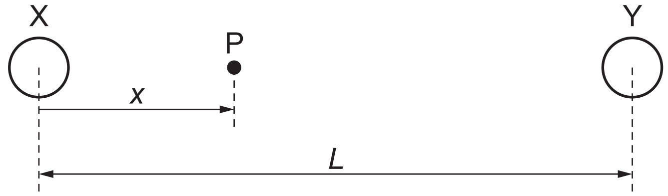

Fig. 3.3

Point P lies on the line joining the centres of X and Y, and is at a variable displacement x from the centre of sphere X.
The gravitational field strength at the surface of each sphere is g_0.

On Fig. 3.4, sketch the variation with x of the gravitational field g at point P between $x = R$ and $x = L - R$.

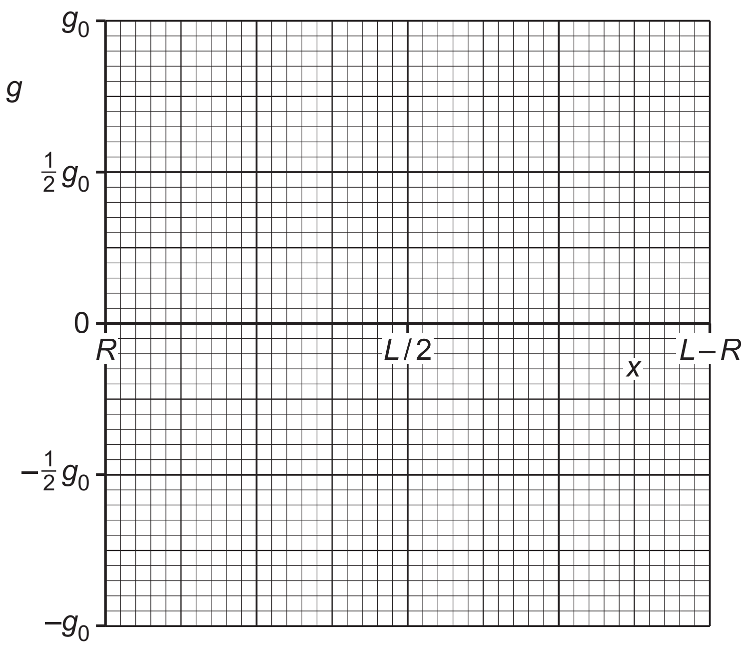

Fig. 3.4

[3]

[Total: 9]

4 **(a)** State the value of absolute zero on:

(i) the Celsius temperature scale

temperature = ... °C [1]

(ii) the thermodynamic temperature scale. Give a unit with your answer.

temperature = ... unit .... [1]

(b) A sample contains a fixed amount of gas. The gas has pressure *p*, volume *V* and thermodynamic temperature *T*.

Fig. 4.1 shows the variation of *pV* with *kT* for the sample, where *k* is the Boltzmann constant.

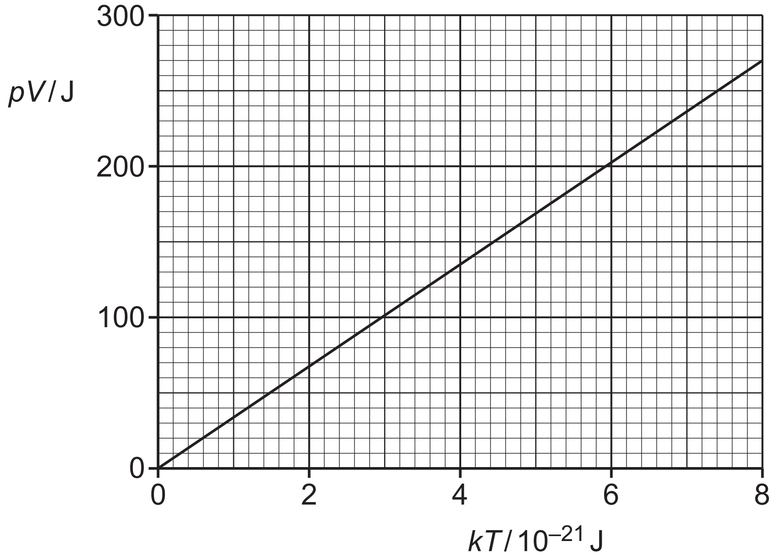

Fig. 4.1

(i) State what is indicated about the nature of the gas from the variation shown in Fig. 4.1.

.... [1]

(ii) Determine the number *N* of molecules of the gas in the sample.

N = ... [2]

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(iii) Use your answer in **(b)(ii)** to determine the amount n of gas in the sample.

n = ... mol [1]

(c) The root-mean-square (r.m.s.) speed of the molecules of the gas is $1900\,\text{m}\,\text{s}^{-1}$ when pV is equal to 270 J.

Determine the mass, in u, of one molecule of the gas, where u is the unified atomic mass unit.

mass = ... u [4]

[Total: 10]

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5 **(a)** Define electric potential at a point.

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.... [2]

(b) A hydrogen atom may be considered to consist of a proton and an electron separated by a distance of 120 pm, as shown in Fig. 5.1.

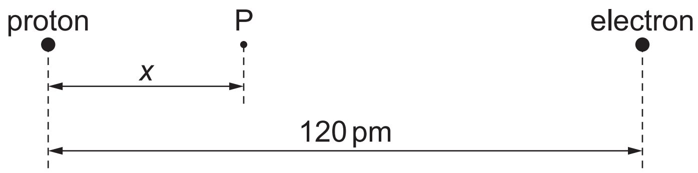

Fig. 5.1

The two particles may be considered as point charges.

Point P lies on the line joining the electron and the proton and is at a variable distance x from the proton.

(i) Show that the electric potential V at point P when x = 10 pm is equal to 130 V.

[2]

(ii) Calculate, to two significant figures, V when x = 30 pm.

V = ...V [2]

(iii) On Fig. 5.1, draw a cross (×) at one position, other than infinity, where the electric potential is zero. [1]

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(iv) On Fig. 5.2, sketch the variation of *V* with *x* between *x* = 10 pm and *x* = 110 pm.

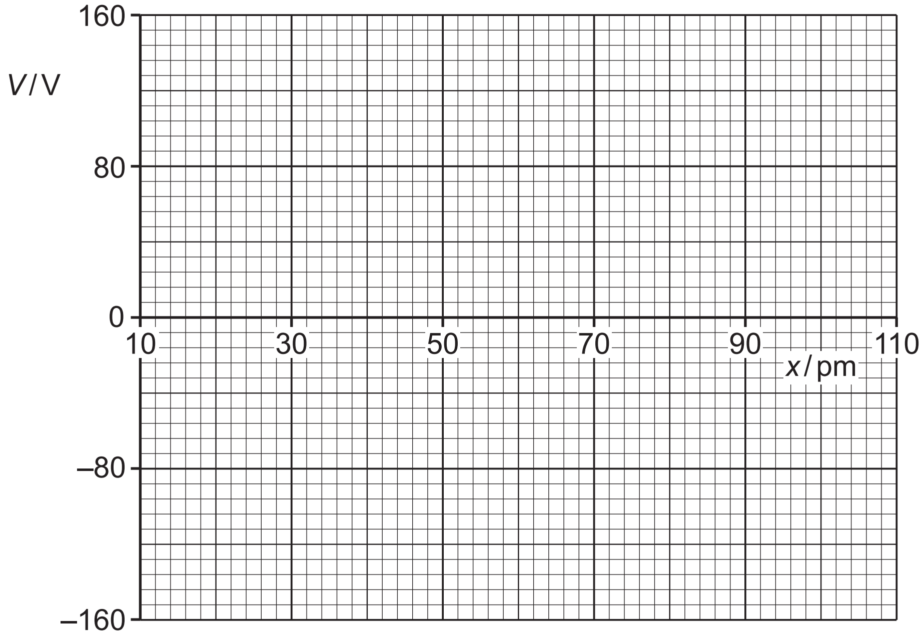

Fig. 5.2

[3]

[Total: 10]

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6 **(a)** Two parallel plate capacitors C_1 and C_2 are connected to a supply that has a potential difference (p.d.) V_S. The capacitors may be connected in series or in parallel.

The supply provides charge Q_S and the plates of the two capacitors acquire charges Q_1 and Q_2 respectively. The p.d.s across the plates of the capacitors are V_1 and V_2 respectively.

Complete Table 6.1 to indicate how Q_S, Q_1 and Q_2 relate to each other, and how V_S, V_1 and V_2 relate to each other, for series and parallel connections of the capacitors to the supply.

Table 6.1

	relationship between charges	relationship between p.d.s
series		
parallel		

[4]

(b) An isolated capacitor of capacitance 470 μF stores 19 mJ of energy.

(i) Calculate the p.d. across the capacitor.

p.d. = ... V [2]

(ii) Calculate the charge on the capacitor.

charge = ... C [2]

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(iii) The capacitor is now connected in parallel with a capacitor of capacitance 180 μF that is initially uncharged.

Determine the total energy, in mJ, now stored in the two capacitors.

energy = ... mJ [3]

[Total: 11]

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7 **(a)** State Faraday's law of electromagnetic induction.

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.... [2]

(b) An aircraft is flying horizontally at constant speed v through the Earth's magnetic field, as shown in Fig. 7.1.

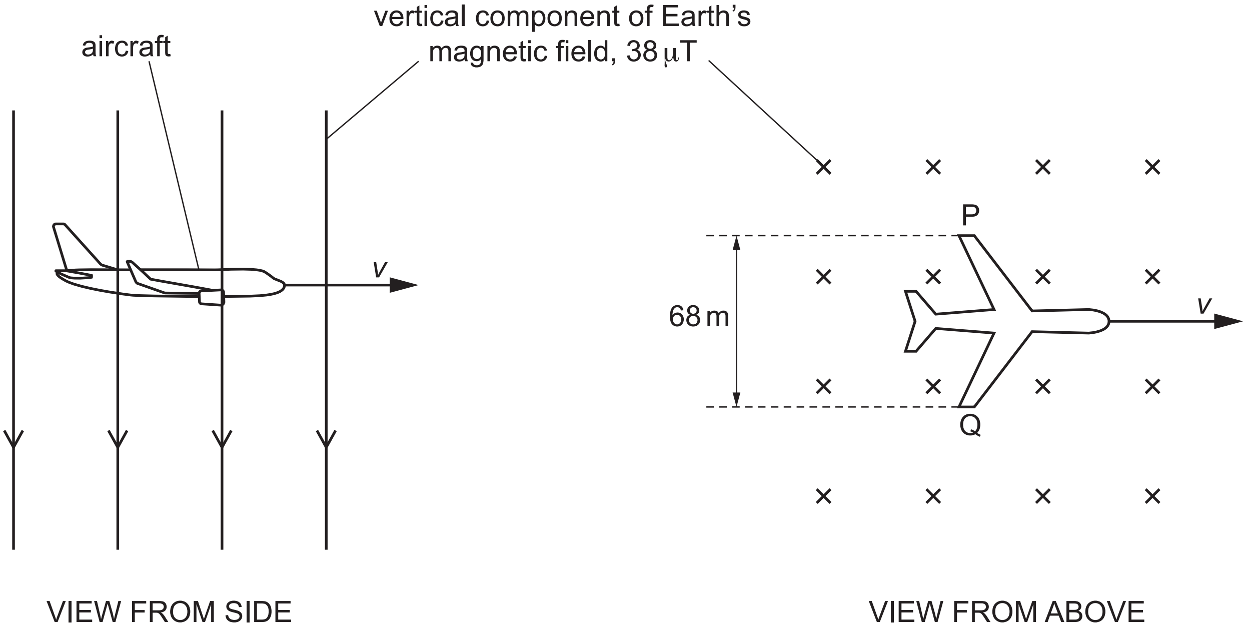

Fig. 7.1

At the location of the aircraft, the vertical component of the Earth's magnetic field is 38 μT towards the ground.

The distance between the wingtips P and Q of the aircraft is 68 m.

As the aircraft moves through the magnetic field, an electromotive force (e.m.f.) of 0.54 V is induced between the wingtips P and Q.

(i) Calculate the magnetic flux cut by the wings of the aircraft in a time of 15 s. Give a unit with your answer.

magnetic flux = ... unit .... [2]

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(ii) Determine the area of flux cut by the wings in a time of 15 s.

area = ... m^2 [2]

(iii) Use your answer in **(b)(ii)** to determine the speed *v* of the aircraft.

v = ... $m\,s^{-1}$ [2]

(iv) Use Lenz's law of electromagnetic induction to explain which of the wingtips P and Q is at the higher induced potential.

....

....

....

....

.... [3]

[Total: 11]

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8 (a) State what is meant by a photon.

....

....

.... [2]

(b) A stationary nucleus of uranium-238 ($^{238}_{92}U$) undergoes alpha decay to produce a nucleus of thorium-234 ($^{234}_{90}Th$). The kinetic energy of the emitted alpha particle is 4.200 MeV. A gamma-ray photon is also emitted during the decay.

Assume that the rebound kinetic energy of the thorium nucleus is negligible.

Table 8.1 shows the masses of the nuclides involved in the decay reaction. The mass of the uranium-238 nuclide is missing.

Table 8.1

nuclide	nuclide mass / u
$^{4}_{2}\alpha$	4.000 407
$^{234}_{90}Th$	233.915 174
$^{238}_{92}U$	

The total energy released in the decay of the nucleus of uranium-238 is 4.274 MeV.

(i) Calculate the mass, in u, of the uranium-238 nuclide. Give your answer to five decimal places.

mass = ... u [3]

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(ii) Determine a value for the wavelength of the gamma radiation emitted during the decay of the uranium-238 nucleus.

wavelength = ... m [3]

(iii) In practice, the rebound kinetic energy of the thorium nucleus is **not** negligible.

Explain, without further calculation, how your answer in **(b)(ii)** compares with the true wavelength of gamma radiation emitted during the decay of the uranium-238 nucleus.

....

....

.... [1]

(c) Gamma radiation emitted during the decay of a sample of uranium-238 has a single wavelength.

Nuclei of cobalt-60 ($^{60}_{27}Co$) decay by beta emission, and also emit gamma radiation in the process.

Suggest why there is **not** a single wavelength for the gamma radiation emitted during the decay of a sample of cobalt-60.

....

....

.... [2]

[Total: 11]

9 **(a)** State Wien's displacement law.

....

....

.... [2]

(b) Fig. 9.1 shows the variation with d^{-2} of the radiant flux intensity F observed from a star X, where d is the distance of the observer from the star. Fig. 9.2 shows the variation with wavelength λ of the rates of emission P of radiation by star X and the Sun.

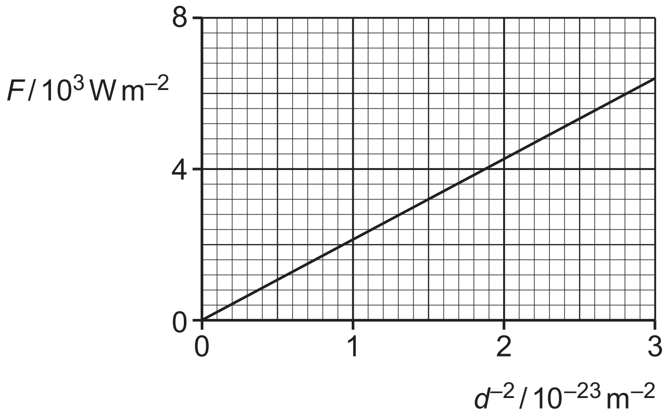

Fig. 9.1

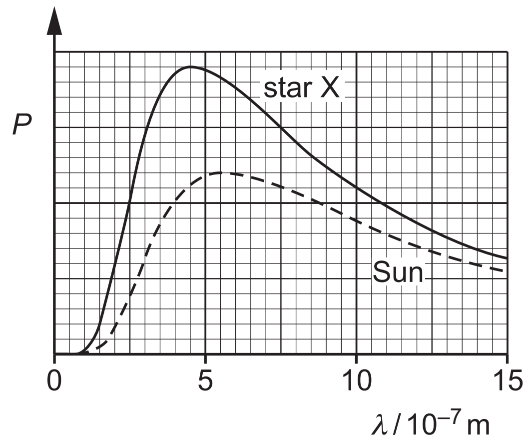

Fig. 9.2

The surface temperature of the Sun is 5770 K.

State **three** conclusions about star X that can be drawn from this data. The conclusions may be qualitative or quantitative. Use the space for any working.

1 ....

....

2 ....

....

3 ....

....

[3]

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(c) Star X is in a galaxy that is moving away from the Earth.

Suggest, with a reason, how the line for star X in Fig. 9.2 would appear differently if it had been obtained from data measured on the Earth.

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.... [2]

[Total: 7]

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10 (a) Define specific acoustic impedance.

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.... [2]

(b) Explain how ultrasound waves are detected by a piezoelectric crystal.

....

....

.... [2]

(c) Table 10.1 shows the specific acoustic impedance *Z* for body tissue, water and steel.

Table 10.1

material	Z / kg m^{-2} s^{-1}
body tissue	1.38×10^6
water	1.48×10^6
steel	4.04×10^7

(i) Calculate the intensity reflection coefficient for ultrasound incident on a water–steel boundary.

intensity reflection coefficient = ... [2]

(ii) Explain, without calculation, what is likely to happen when ultrasound is incident on a body tissue–water boundary.

....

....

.... [2]

[Total: 8]

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