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CAMBRIDGE
International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

PHYSICS **9702/44**

Paper 4 A Level Structured Questions **May/June 2026**

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. Do **not** use correction fluid or tape.
- 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.

DC (SL/SG) 362030/3

[Turn over

Data

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

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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \ldots$

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)** State Coulomb's law.

....

....

.... [2]

(b) In a model of an atom, an electron is in a circular orbit around a proton, as shown in Figure 1.1.

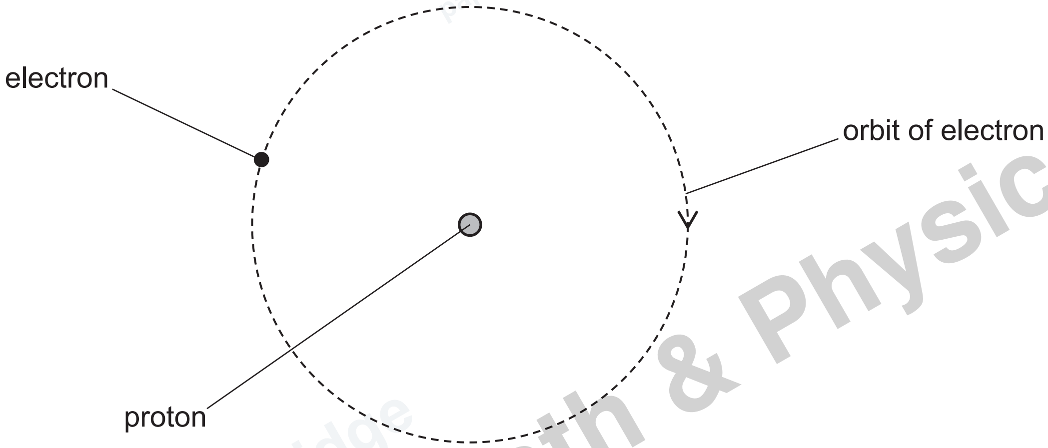

Figure 1.1

The electric potential energy of the electron is -1.09×10^{-18} J.

(i) Show that the radius of the orbit is 2.11×10^{-10} m.

[1]

(ii) Use the information in **1(b)(i)** to determine the magnitude of the electric force between the electron and the proton.

force = ... N [1]

(iii) Calculate the centripetal acceleration of the electron.

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

(iv) Use your answer in **1(b)(iii)** to determine the period of the orbit of the electron.

period = ... s [2]

(c) The electron in **1(b)** emits a photon so that the electric potential energy of the electron decreases. The electron remains in a circular orbit around the proton.

By placing **one** tick (✓) in each row, complete Table 1.1 to show how the quantities indicated for the electron change when the potential energy decreases.

Table 1.1

	decreases	**stays the same**	**increases**
radius of orbit			
centripetal acceleration			
angular speed			

[3]

[Total: 10]

2 A satellite is in geostationary orbit around the Earth. The orbit is circular.

(a) **(i)** State what is meant by a geostationary orbit.

....

....

.... [1]

(ii) State **two** properties of the orbit.

1 ....

....

2 ....

....
[2]

(b) The orbit has radius R and period T.

(i) Determine an expression, in terms of R and T, for the speed v of the satellite in its orbit.

v = ... [1]

(ii) Use Newton's law of gravitation to show that the mass M of the Earth is given by

$$M = \frac{4\pi^2 R^3}{GT^2}$$

where G is the gravitational constant.

[2]

(c) The Earth may be considered to be a sphere of radius 6370 km.
Geostationary satellites orbit at a height of 35 900 km above the surface of the Earth.

Determine a value, to three significant figures, for the mean density of the Earth.

density = ... $kg\,m^{-3}$ [4]

[Total: 10]

3 **(a)** State what is meant by two objects being in thermal equilibrium.

....

....

.... [2]

(b) An insulated container with negligible specific heat capacity contains a mass of 63 g of water at an initial temperature of 78.0 °C.

A thermistor with a mass of 8.5 g is at an initial temperature of 25.0 °C. The thermistor is connected into a circuit containing an ammeter that is accurately calibrated to give readings of temperature in °C.

The thermistor is immersed in the water. When thermal equilibrium is reached, the ammeter indicates a temperature of 76.8 °C.

(i) Explain why the thermistor does not measure the temperature as 78.0 °C.

....

....

.... [2]

(ii) The specific heat capacity of water is $4.2\,\text{J}\,\text{g}^{-1}\,\text{K}^{-1}$.

Calculate a value for the specific heat capacity, in $\text{J}\,\text{g}^{-1}\,\text{K}^{-1}$, of the material of the thermistor.

specific heat capacity = ... $\text{J}\,\text{g}^{-1}\,\text{K}^{-1}$ [3]

(c) Suggest, with a reason, how the initial temperature of the water in **3(b)** could be measured more accurately than using the thermistor in **3(b)**.

....

....

....

.... [2]

[Total: 9]

4 **(a)** State the first law of thermodynamics.

....

....

....

.... [2]

(b) A sample of an ideal gas contains 3.58×10^{24} molecules. The sample is at a temperature of 298 K and a pressure of 1.84×10^{5} Pa.

(i) Show that the volume of the gas is $0.0800\,m^3$.

[2]

(ii) Calculate the amount of gas n in the sample.

n = ... mol [1]

(iii) Determine the average translational kinetic energy E_K of one molecule of the gas.

E_K = ... J [2]

(iv) Explain why the average potential energy of one molecule of the gas is zero.

....

.... [1]

(v) Calculate the internal energy U_A of the gas.

U_A = ... J [1]

(c) The gas in **4(b)** undergoes two changes AB and BC, as shown in Figure 4.1.

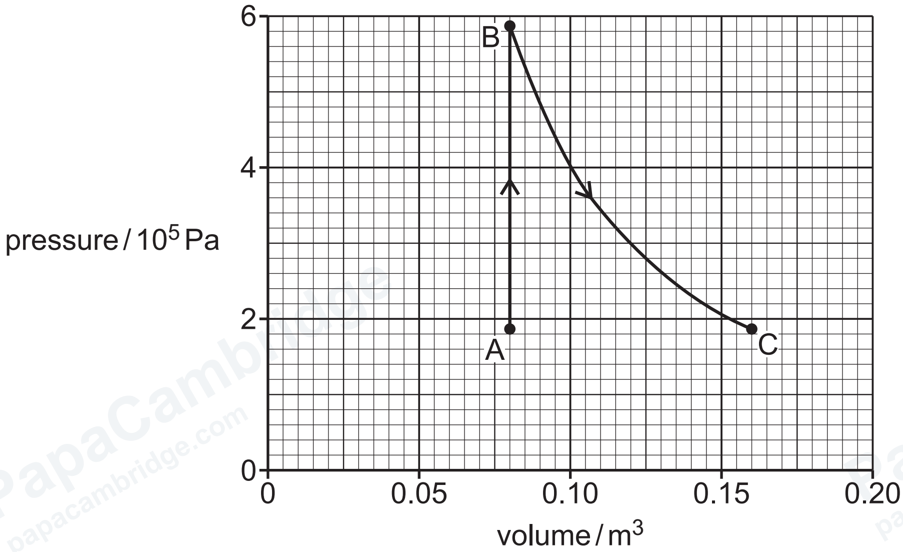

Figure 4.1

In change AB, the gas is heated at constant volume from its initial pressure of 1.84×10^5 Pa to a pressure of 5.84×10^5 Pa.

In change BC, the gas rapidly expands and returns to its original pressure with no transfer of thermal energy. The volume of the gas after this expansion is 0.160 m^3.

(i) Determine an expression, in terms of U_A, for the thermal energy Q supplied to the gas during change AB. Explain your reasoning.

Q = ... [2]

(ii) Determine an expression, in terms of U_A, for the work W done on the gas during change BC. Explain your reasoning.

W = ... [2]

[Total: 13]

5 A metal ball is attached to the lower end of a spring, as shown in Figure 5.1.

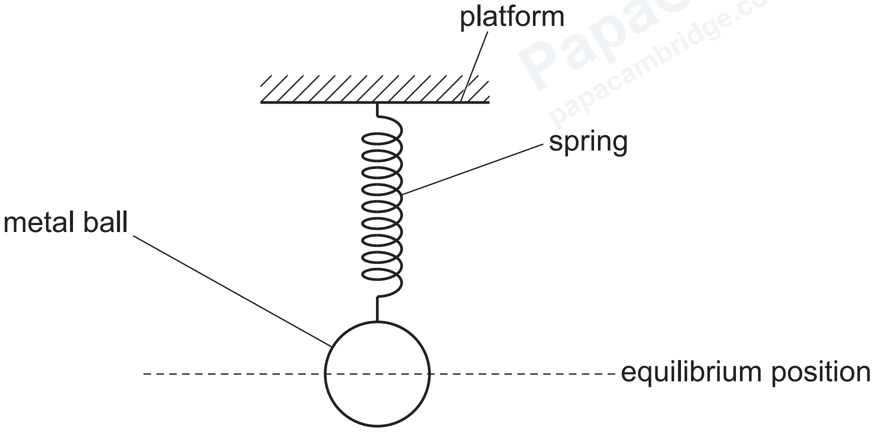

Figure 5.1

The upper end of the spring is attached to a platform that is initially stationary.

(a) The ball is pulled down by a small distance and released so that it oscillates with simple harmonic motion. The oscillations have an amplitude of 2.5 cm and a maximum speed of $4.4\,\text{cm}\,\text{s}^{-1}$.

(i) On Figure 5.2, sketch the variation of the velocity v of the ball with the displacement x from its equilibrium position as the ball undergoes one full oscillation.

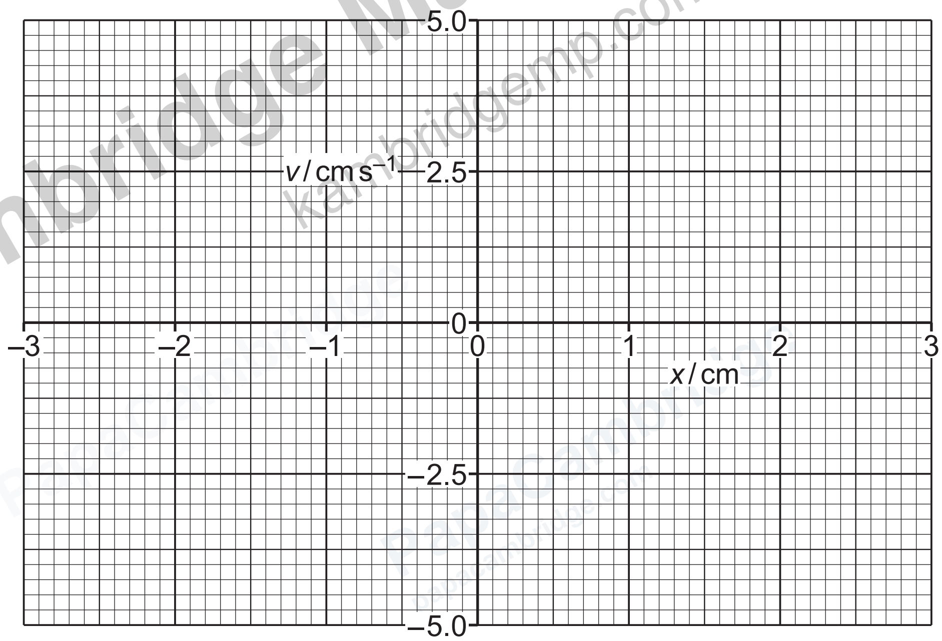

Figure 5.2

[3]

(ii) Show that the frequency of the oscillations is 0.28 Hz.

[2]

(b) The ball is returned to rest at its equilibrium position.

The platform is now moved up and down by a motor so that it oscillates vertically with simple harmonic motion of constant amplitude but variable frequency. The oscillating platform causes the ball to oscillate.

(i) State what is meant by resonance.

....

....

.... [2]

(ii) The frequency f of the oscillations of the platform slowly increases from 0 to 0.40 Hz.

On Figure 5.3, sketch the variation with f of the amplitude of the oscillations of the **ball**.

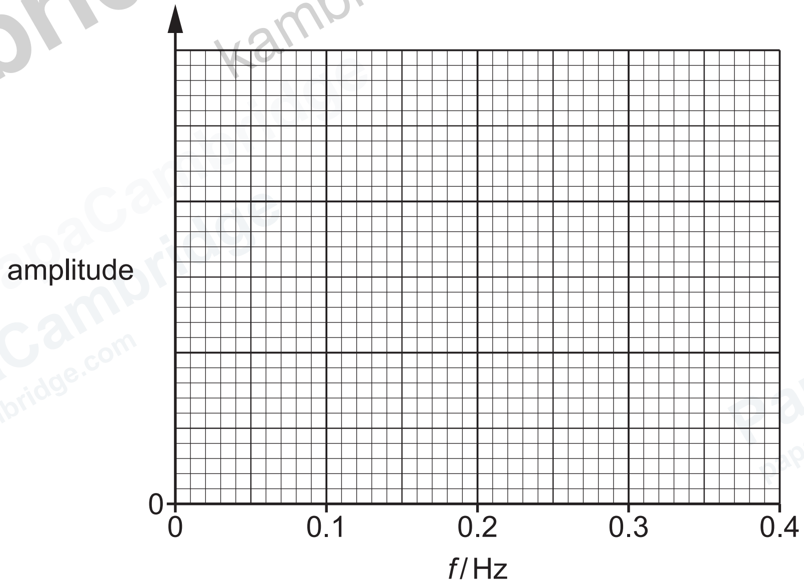

Figure 5.3

[2]

[Total: 9]

6 A capacitor of capacitance 47 μF, a cell of electromotive force (e.m.f.) 1.50 V and a resistor R are connected into the circuit of Figure 6.1.

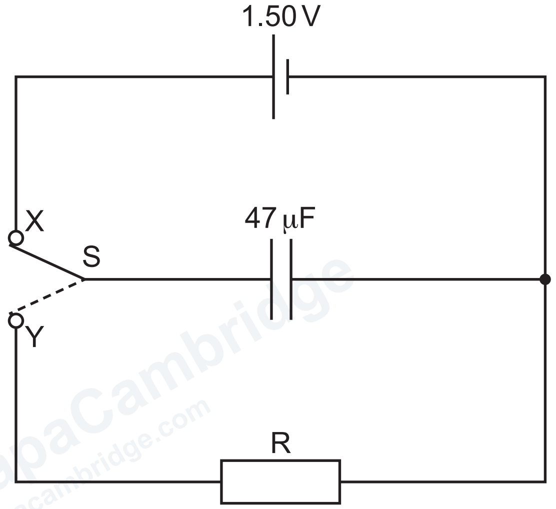

Figure 6.1

The two-way switch S alternates between terminals X and Y with a frequency of 0.20 Hz, as shown in the variation of switch position with time t in Figure 6.2.

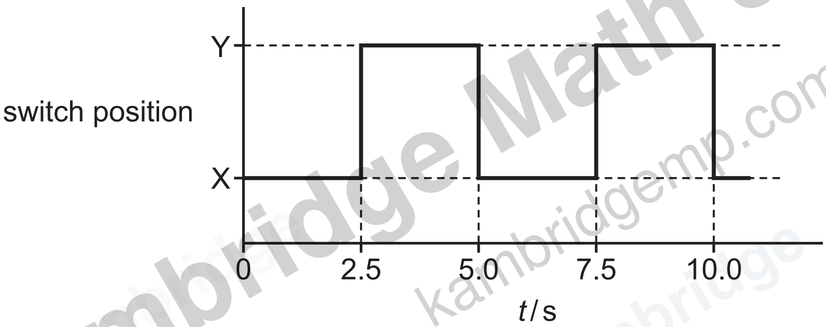

Figure 6.2

The time constant of the discharge circuit is 2.4 s.

(a) **(i)** Calculate the resistance, in kΩ, of R.

resistance = ... kΩ [2]

(ii) Show that the minimum potential difference (p.d.) across the capacitor is 0.53 V.

[2]

(b) On Figure 6.3, sketch the variation of the p.d. V_C across the capacitor with t between $t = 0$ and $t = 10.0$ s.

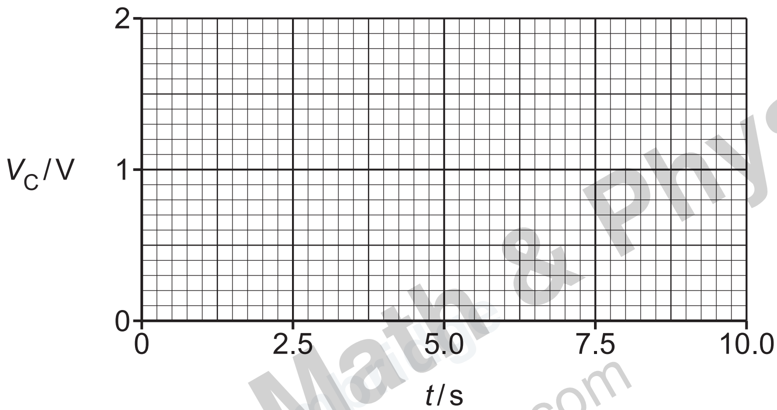

Figure 6.3

[3]

(c) The frequency at which the switch alternates is now doubled.

Explain, without calculation, whether the minimum p.d. across the capacitor is now less than, equal to or greater than 0.53 V.

....

....

.... [2]

[Total: 9]

7 **(a)** State what is meant by an alternating current.

....

.... [1]

(b) A coil of wire is wound onto a hollow insulating tube to form a solenoid, as shown in Figure 7.1.

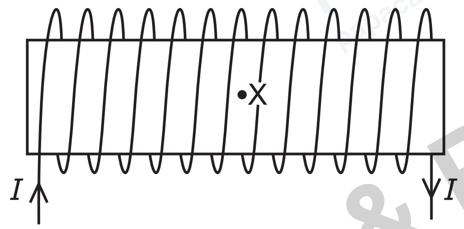

Figure 7.1

There is a constant current I in the solenoid in the direction indicated. There is a magnetic field inside and outside the solenoid due to this current.

(i) On Figure 7.1, draw five field lines to represent the magnetic field inside and outside the solenoid. [3]

(ii) On Figure 7.1, indicate, with the letters N and S, the magnetic poles of the solenoid. [1]

(c) The current I in the solenoid in **7(b)** now varies sinusoidally so that the flux density B of the magnetic field at point X varies with time t according to

$$B = 2.0 \cos 200\pi t$$

where B is in mT and t is in s.

(i) Show that the period of the alternating magnetic field is 0.010 s.

[1]

(ii) On Figure 7.2, sketch the variation of B with t between $t = 0$ and $t = 0.020$ s.

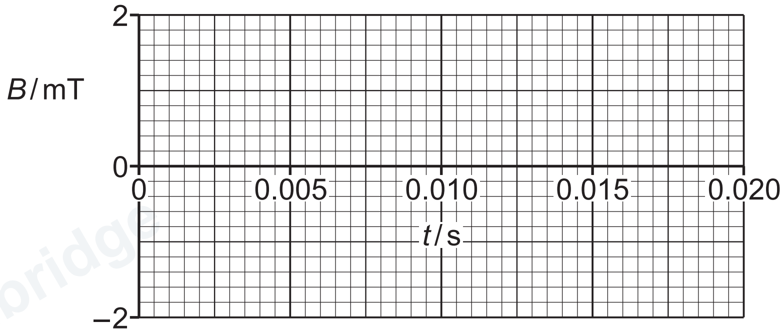

Figure 7.2

[2]

(d) A small coil is placed at point X inside the solenoid in **7(c)**, so that its axis is parallel to the axis of the solenoid.

The small coil has 45 turns, each with a radius of 2.8×10^{-3} m.

(i) Calculate the maximum magnetic flux Φ linked by the small coil. Give a unit with your answer.

Φ = ... unit .... [3]

(ii) Describe and explain how the variation of B with t in Figure 7.2 may be used to determine the maximum electromotive force (e.m.f.) induced in the small coil. No calculations are required.

....

....

....

....

.... [3]

[Total: 14]

8 **(a)** When a clean metal surface is illuminated by electromagnetic radiation, electrons may be emitted from the surface.

(i) State the name of this phenomenon.

.... [1]

(ii) State what is meant by the threshold frequency of the metal.

....

.... [1]

(iii) Explain why the existence of the threshold frequency provides evidence for the photon model of electromagnetic radiation.

....

....

....

....

.... [3]

(b) When a clean metal sheet is illuminated by radiation of wavelength 254 nm, electrons are emitted with a maximum kinetic energy of 1.91×10^{-19} J.

When the same metal sheet is illuminated by radiation of wavelength 178 nm, the maximum kinetic energy of the emitted electrons is 5.27×10^{-19} J.

(i) Use these data to calculate a value, to three significant figures, for the Planck constant.

Planck constant = ... J s [3]

(ii) Determine a value, in eV, for the work function energy of the metal. Give your answer to two significant figures.

work function energy = ... eV [3]

[Total: 11]

9 (a) Explain how ultrasound waves are generated by a piezoelectric transducer.

....

....

....

....

.... [3]

(b) Ultrasound waves are used to obtain information about a structure that consists of two materials, as shown in Figure 9.1.

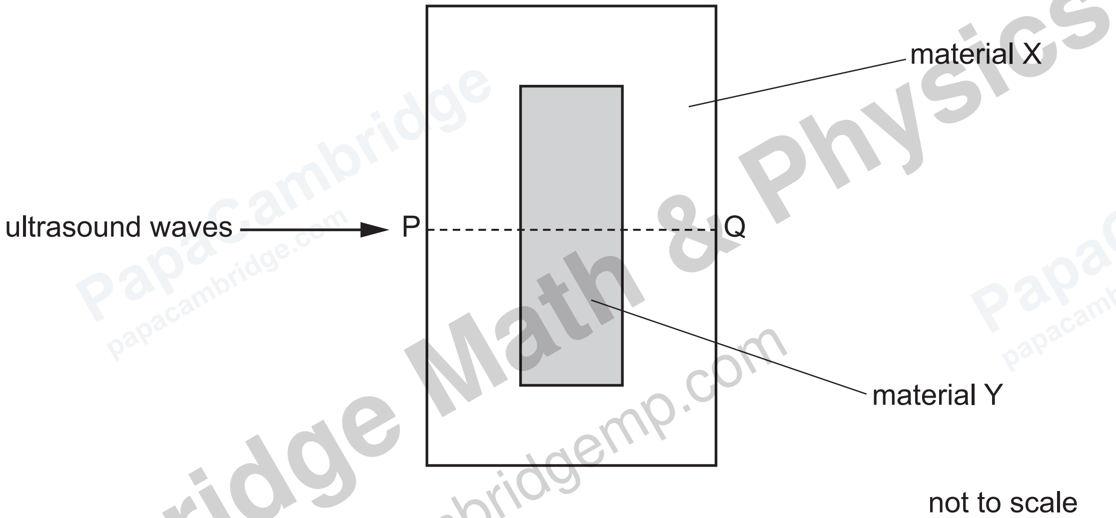

Figure 9.1

The waves enter the structure at point P and travel through the structure to point Q.

Material Y has a density of $8960\,\mathrm{kg\,m^{-3}}$. The speed of sound in material Y is $4720\,\mathrm{m\,s^{-1}}$.

(i) Calculate the specific acoustic impedance Z of material Y. Give a unit with your answer.

Z = ... unit .... [2]

(ii) The intensity of ultrasound entering the structure at point P is I_0.
The transmitted intensity of the ultrasound between P and Q at distance x from P is I.

Figure 9.2 shows the variation with x of the value of $\ln(I/I_0)$.

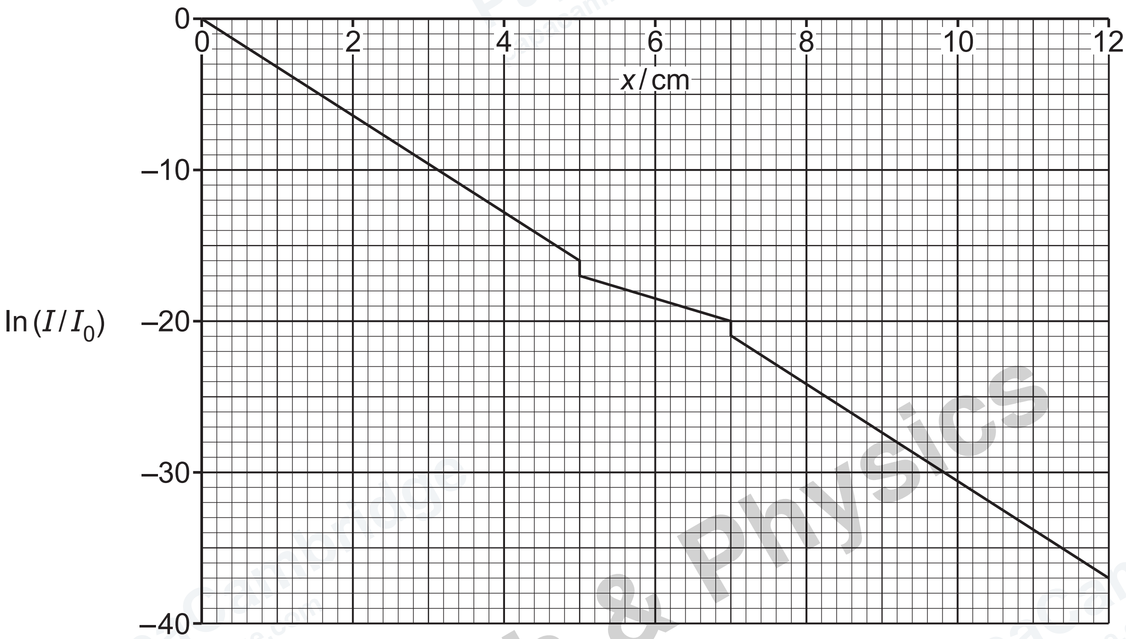

Figure 9.2

Determine **three** conclusions about the structure and the materials from which it is made that may be drawn from Figure 9.2. The conclusions may be qualitative or quantitative. Use the space for any working.

1 ....

....

2 ....

....

3 ....

....

[3]

[Total: 8]

10 (a) (i) State what is meant by a standard candle.

....

.... [1]

(ii) Explain how standard candles may be used to determine the distance of a galaxy from an observer.

....

....

.... [2]

(b) A star in a distant galaxy has luminosity L.

The star emits radiation that has maximum intensity at a wavelength that is known to be λ_{star} after correcting for redshift.

The Sun has surface temperature T_0 and emits radiation that has maximum intensity at wavelength λ_0.

(i) Explain why the wavelength of the radiation observed from the star has to be corrected for redshift.

....

....

.... [2]

(ii) State an expression, in terms of λ_{star}, λ_0 and T_0, for the surface temperature T_{star} of the star.

T_{star} = ... [1]

(iii) Determine an expression, in terms of L and T_{star}, for the radius of the star. Identify any other symbols that you use.

radius = ... [1]

[Total: 7]

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