OCR
Oxford Cambridge and RSA

A Level Physics B (Advancing Physics)

H557/02 Scientific literacy in physics

Practice paper – Set 2

Time allowed: 2 hours 15 minutes

You must have:
- the Advance Notice article (inserted)
- the Data, Formula and Relationships booklet

You may use:
- a scientific calculator
- a ruler

First name										
Last name										
Centre number						Candidate number				

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

INFORMATION
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **24** pages.

SECTION A

Answer **all** the questions.

1 Fig. 1 shows a simple charging circuit. The capacitor is initially uncharged. When the switch is closed, the capacitor begins to charge.

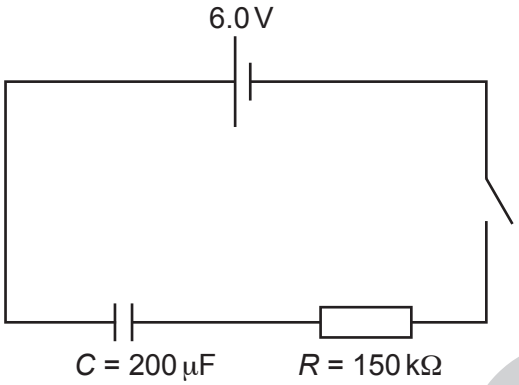

Fig. 1

(a) (i) Show that the p.d. across the capacitor after the switch has been closed for one minute is about 5.2 V.

[2]

(ii) Calculate the p.d. across the resistor after the switch has been closed for one minute.

p.d. across resistor = ... V **[2]**

(iii) Calculate the energy stored on the capacitor after the switch has been closed for one minute.

energy stored = ... J **[2]**

(b) People suffering heart problems can be fitted with **implantable defibrillators** which can deliver an electric shock to 'kick start' the heart. Fig. 1.2 shows a defibrillator in position.

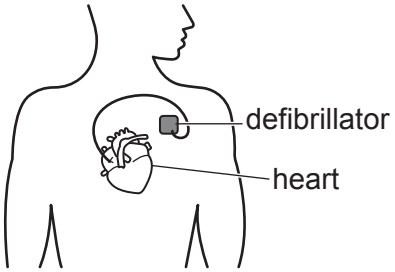

Fig. 1.2

(i) Explain why a capacitor can be considered to be fully charged after charging for 5 RC s. You may use calculations in your explanation.

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(ii) The 200 μF capacitor in the defibrillator discharges into the heart in 40 ms. Calculate an estimate for the resistance in the circuit, making your method clear.

resistance = ... Ω **[2]**

2 This question is about an LED that produces orange light.

Light from the LED passes through a diffraction grating of 300 lines per mm.
The pattern of coloured dots produced on a screen beyond the grating is shown in Fig. 2.1. The variation in intensity of the light at the screen is shown in Fig. 2.2.

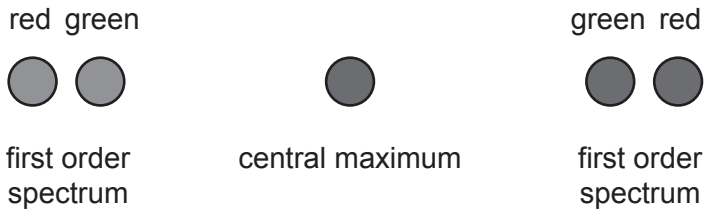

Fig. 2.1

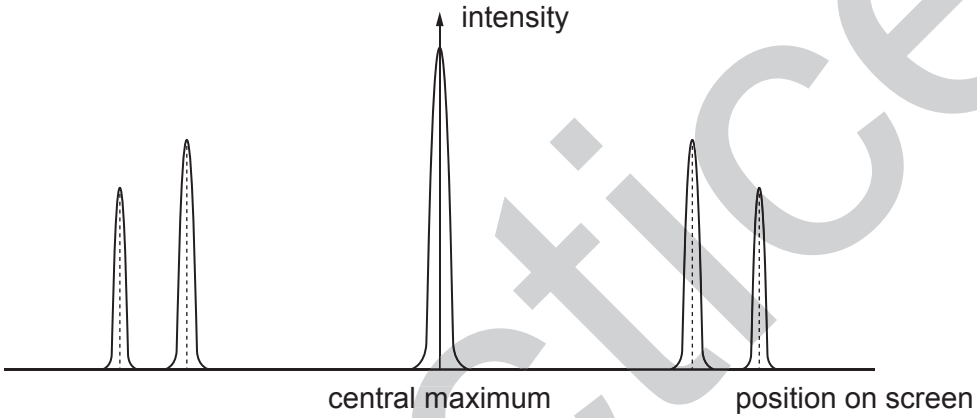

Fig. 2.2

(a) (i) State why the pattern shows that the orange light produced by the LED consists of only two colours.

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(ii) Suggest why the intensity of the central maximum is greater than the intensity of either the green or red dots in the first order spectrum.

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(b) (i) Photons of red light are emitted with an energy of 1.9 eV. Calculate the angle to the first order maximum for red light.

angle = ... ° **[3]**

(ii) Use your answer to **(b)(i)** and take measurements from Fig. 2.2 to calculate an estimate for the wavelength of the green light emitted from the LED.

wavelength = ... m **[2]**

(c) Explain why the diffraction grating produces more orders of maxima for green light than for red light.

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3 This question is about the behaviour of a pure metal and an alloy.

Fig. 3.1 shows the stress against strain graphs to breaking point for samples of a pure metal and one of its alloys.

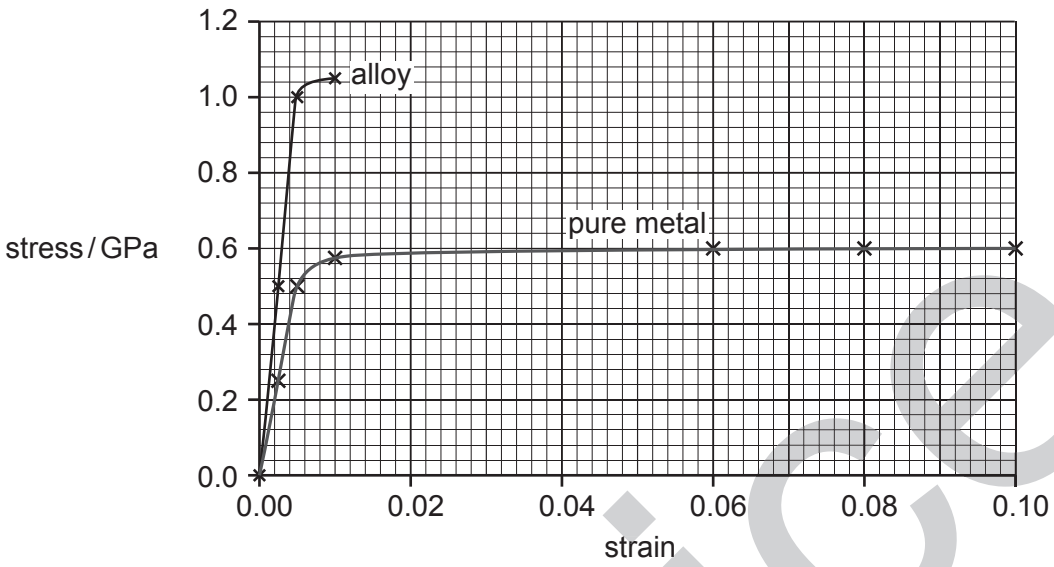

Fig. 3.1

(a) (i) Use the graph to calculate the Young modulus of the metal alloy. Make your method clear.

Young modulus = ... GPa **[3]**

(ii) Use the graphs to compare the stiffness, strength and ductility of the metal and the metal alloy. Explain your reasoning.

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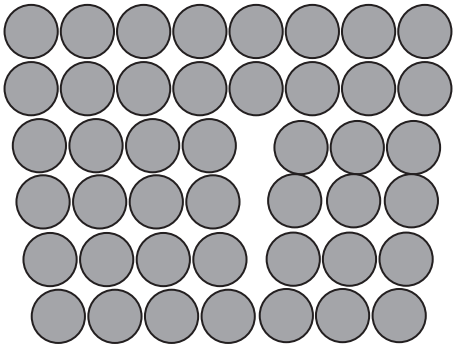
(b) The microstructure of the pure metal is shown in Fig. 3.2. State how the microstructure of the alloy is different from that in the pure metal and explain how this effects the properties you have discussed in part **(a)(ii)**.



pure metal

Fig. 3.2

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SECTION B

Answer **all** the questions.

4 This question is about the kinetic model of gas behaviour.

(a) Consider a single particle of mass m moving directly towards the shaded face of the cube as shown in Fig. 4.1. The particle makes elastic collisions with the walls of the cube.

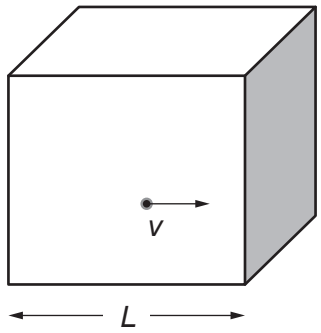

Fig. 4.1

Use the relationship $F = \frac{\Delta mv}{\Delta t}$ to show that the mean force F from repeated collisions of the particle with the shaded face is given by $F = \frac{mv^2}{L}$.

[3]

(b) Explain why, if the cube contains N particles each of mass m moving in random directions, the pressure on any face is given by $P = \frac{1}{3}\frac{Nm\,\overline{c^2}}{V}$ where V is the volume of the cube and $\overline{c^2}$ is the mean square speed of the particles.

[3]

(c) Fig. 4.2 shows the distribution of root mean square speeds in a sample of gas. The area of each bar is proportional to the fraction of molecules having a speed within that range.
Use ideas from kinetic theory to explain why gas molecules have a range of speeds but are unlikely to have speeds **much** greater than the most common speed.

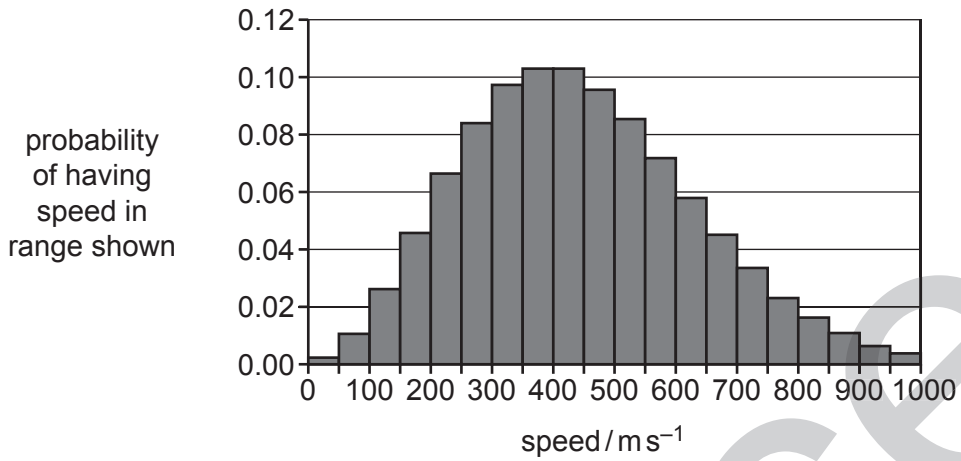

Fig. 4.2

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(d) Use the equation from **(b)** and the ideal gas equation $pV = NkT$ to show that the kinetic energy E_k of a particle in the gas is given by $E_K = \frac{3}{2}kT$.

[2]

(e) The root mean square speed of a gas molecule can be found using the equation

root mean square speed = 1.2 × most probable speed

The most probable speed in Fig. 4.1 is $400\,m\,s^{-1}$.

The mass of a molecule of the gas is 4.7×10^{-26} kg. Calculate the temperature of the gas.

temperature = ... K **[4]**

5 Fig. 5.1 shows an experimental set-up which can be used to determine *g*.

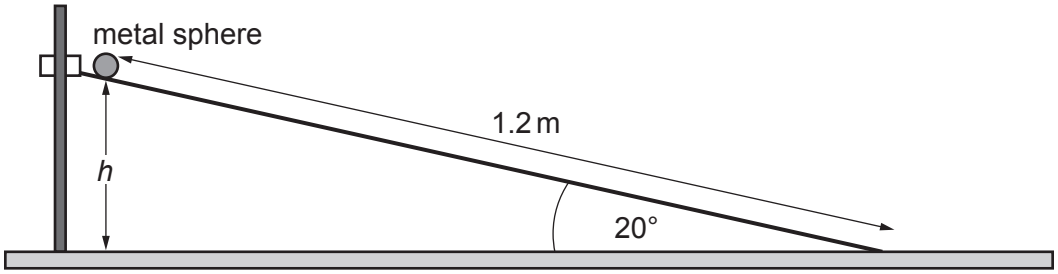

Fig. 5.1

(a)* The metal ball was filmed as it was released and travelled down the slope. The time for the ball to travel down the slope was found using stop-frame analysis.

The time was recorded as 1.1 s +/− 0.05 s.

Calculate the acceleration of the ball. Use the data given in the diagram to help explain why a student expected the journey time to be 0.85 s and suggest why the measured time was considerably longer.

[6]

(b) Fig. 5.2 shows a slope of the same length and starting height *h*. The initial gradient of the slope is greater than in the first case.

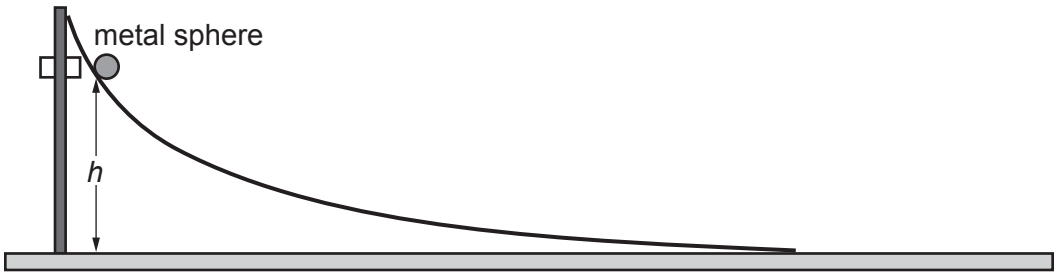

Fig. 5.2

A student says that she expects the ball to reach the end of the slope in less time **and** with greater final speed. Do you agree? Explain your reasoning and state any assumptions you have made.

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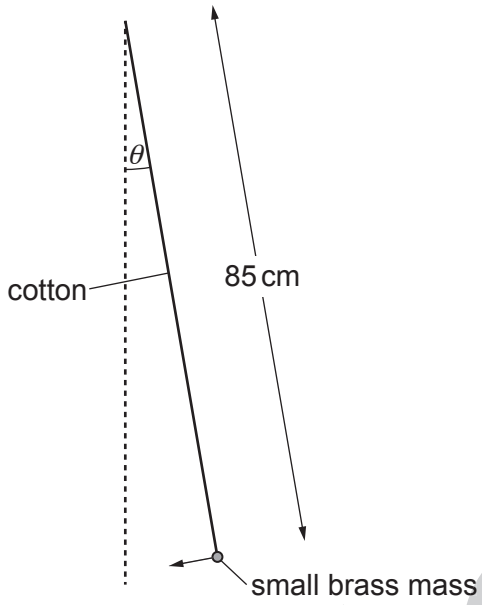
(c) A simple pendulum can also be used to determine a value for *g*.



When the pendulum is displaced through a small angle θ and released, it performs simple harmonic motion about its rest position.

(i) A student uses this 85 cm pendulum to determine a value for *g*. He times three complete oscillations, and obtains a time of 5.61 s.

Calculate the value of *g* given by this data. Express your answer to an appropriate number of significant figures.

[2]

(ii) Suggest and explain one way in which this student could refine the experiment to get a more precise value for *g*.

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..... **[2]**

6 This question is about centripetal acceleration and gravity.

(a) The Earth orbits the Sun at a radius r of 1.5×10^{11} m. The time for one orbit (the orbital period T) is 3.2×10^{7} s (one year). Calculate the centripetal acceleration of the Earth in its orbit.

circumference of orbit = $2\pi r$

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

(b) **(i)** By equating the centripetal force on a planet with the gravitational force on the planet, show that $\frac{r^3}{T^2}$ is a constant for planets orbiting the Sun, where r is the radius of the planet's orbit and T is the orbital period.

[4]

(ii) Mars orbits the Sun at an average radius of 2.28×10^{11} m.

Use the relationship in **(b)(i)** and data from **(a)** to find the orbital period of Mars in years.

orbital period = ... years **[2]**

(c) In fact, the orbit of Mars is not circular. Its distance from the Sun varies between 2.1×10^{11} m at its closest and 2.5×10^{11} m at its most distant.

(i) Show that the gravitational potential energy of the planet changes by about 7×10^{31} J between its furthest distance from the Sun and its nearest.

mass of Mars = 6.4×10^{23} kg
mass of Sun = 2.0×10^{30} kg

[3]

(ii) At its furthest point from the Sun, Mars travels at a speed of 2.7×10^{4} m s^{-1}.
Use your answer to **(i)** to calculate its speed at its closest approach to the Sun. Make your method clear.

speed at closest approach = ... m s^{-1} **[3]**

SECTION C

This section is based on the Advance Notice article, which is an Insert.

7 This question is about cobalt-60 used in radiotherapy (lines 11–14).

(a) Show that 1 g of cobalt-60 will produce an activity of roughly 4×10^{13} Bq.

Molar mass of cobalt-60 = 60 g mol^{-1}
1 year = 3.2×10^{7} s

[3]

(b) Use calculations to estimate the power output of 1.0 g of cobalt-60. State any assumptions you make.

power output = ... W **[2]**

8 This question is about a photomultiplier tube as shown in Fig. 2 in the article.

(a) Photons of visible light of wavelength 4.2×10^{-7} m are emitted from the sodium iodide crystal. Use the equation below to calculate the maximum possible work function ϕ of the surface of the photocathode for photoelectrons to be emitted.

maximum k.e. of emitted photoelectron = $hf - \phi$

work function = ... J **[2]**

(b) **(i)** A photoelectron is released from rest at the photocathode. Calculate its velocity just before it strikes the +100 V dynode, assuming non-relativistic behaviour.

mass of electron = 9.1×10^{-31} kg

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

(ii) The rest energy of an electron is 0.51 MeV. Explain whether it is reasonable to ignore relativistic effects when an electron is accelerated through 100 V. You may include calculations in your explanation.

[2]

9 This question is about the absorption of gamma rays (lines 67–73).

(a) Material Y has a half-thickness of 2.5 cm. Show that the absorption coefficient of material Y is about 0.3 cm^{-1}.

[2]

(b) A detector placed 10 cm from a gamma source records a corrected count rate of 900 Bq. The source-detector distance is increased to 40 cm and a sheet of material Y of thickness 0.5 cm is placed in front of the detector. Calculate the expected corrected count rate at the detector.

corrected count rate = ... Bq **[4]**

(c) Gamma rays used in imaging are required to pass through body tissue. Gamma rays used for treatment of tumours are required to be absorbed by body tissue. Explain how gamma rays fulfil both requirements.

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10* This question is about positron emitters and PET scans (lines 41–61).

Fluorine-18 has a half-life of 110 minutes.

Describe and explain why PET scanning facilities need easy access to particle accelerators and why patients who have been given fluorine-18 must remain in the radiography room for a few hours after the procedure. Include an explanation of any precautions the medical personnel should take.

You may include calculations in your answer. You may find it helpful to assume that the activity of the fluorine-18 at the beginning of the procedure is 3000 Bq. **[6]**

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END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).