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

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| CANDIDATE NAME | |

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| CENTRE NUMBER | | | | | | CANDIDATE NUMBER | | | | | |

**PHYSICS** **9702/21**

Paper 2 AS Structured Questions **October/November 2012**

**1 hour**

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 soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

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 | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| Total | |

This document consists of **16** printed pages.



UNIVERSITY of CAMBRIDGE International Examinations

**Data**

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|---|---|
| speed of light in free space, | $c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$ |
| permeability of free space, | $\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$ |
| permittivity of free space, | $\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$ |
| | $(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\ \mathrm{m\,F^{-1}})$ |
| elementary charge, | $e = 1.60 \times 10^{-19}\ \mathrm{C}$ |
| the Planck constant, | $h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$ |
| unified atomic mass constant, | $u = 1.66 \times 10^{-27}\ \mathrm{kg}$ |
| rest mass of electron, | $m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$ |
| rest mass of proton, | $m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$ |
| molar gas constant, | $R = 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$ |
| the Avogadro constant, | $N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$ |
| the Boltzmann constant, | $k = 1.38 \times 10^{-23}\ \mathrm{J\,K^{-1}}$ |
| gravitational constant, | $G = 6.67 \times 10^{-11}\ \mathrm{N\,m^{2}\,kg^{-2}}$ |
| acceleration of free fall, | $g = 9.81\ \mathrm{m\,s^{-2}}$ |

 

**Formulae**

| | |
|---|---|
| uniformly accelerated motion, | $s = ut + \frac{1}{2}at^2$<br>$v^2 = u^2 + 2as$ |
| 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, | $p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$ |
| simple harmonic motion, | $a = -\omega^2 x$ |
| velocity of particle in s.h.m., | $v = v_0 \cos \omega t$<br>$v = \pm \omega \sqrt{(x_0^{\,2} - x^2)}$ |
| electric potential, | $V = \frac{Q}{4\pi\varepsilon_0 r}$ |
| capacitors in series, | $1/C = 1/C_1 + 1/C_2 + \ldots$ |
| capacitors in parallel, | $C = C_1 + C_2 + \ldots$ |
| energy of charged capacitor, | $W = \frac{1}{2}QV$ |
| resistors in series, | $R = R_1 + R_2 + \ldots$ |
| resistors in parallel, | $1/R = 1/R_1 + 1/R_2 + \ldots$ |
| alternating current/voltage, | $x = x_0 \sin \omega t$ |
| radioactive decay, | $x = x_0 \exp(-\lambda t)$ |
| decay constant, | $\lambda = \frac{0.693}{t_{\frac{1}{2}}}$ |

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

For Examiner's Use

**1** **(a)** **(i)** Define *acceleration*.

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**(ii)** State Newton's first law of motion.

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**(b)** The variation with time $t$ of vertical speed $v$ of a parachutist falling from an aircraft is shown in Fig. 1.1.

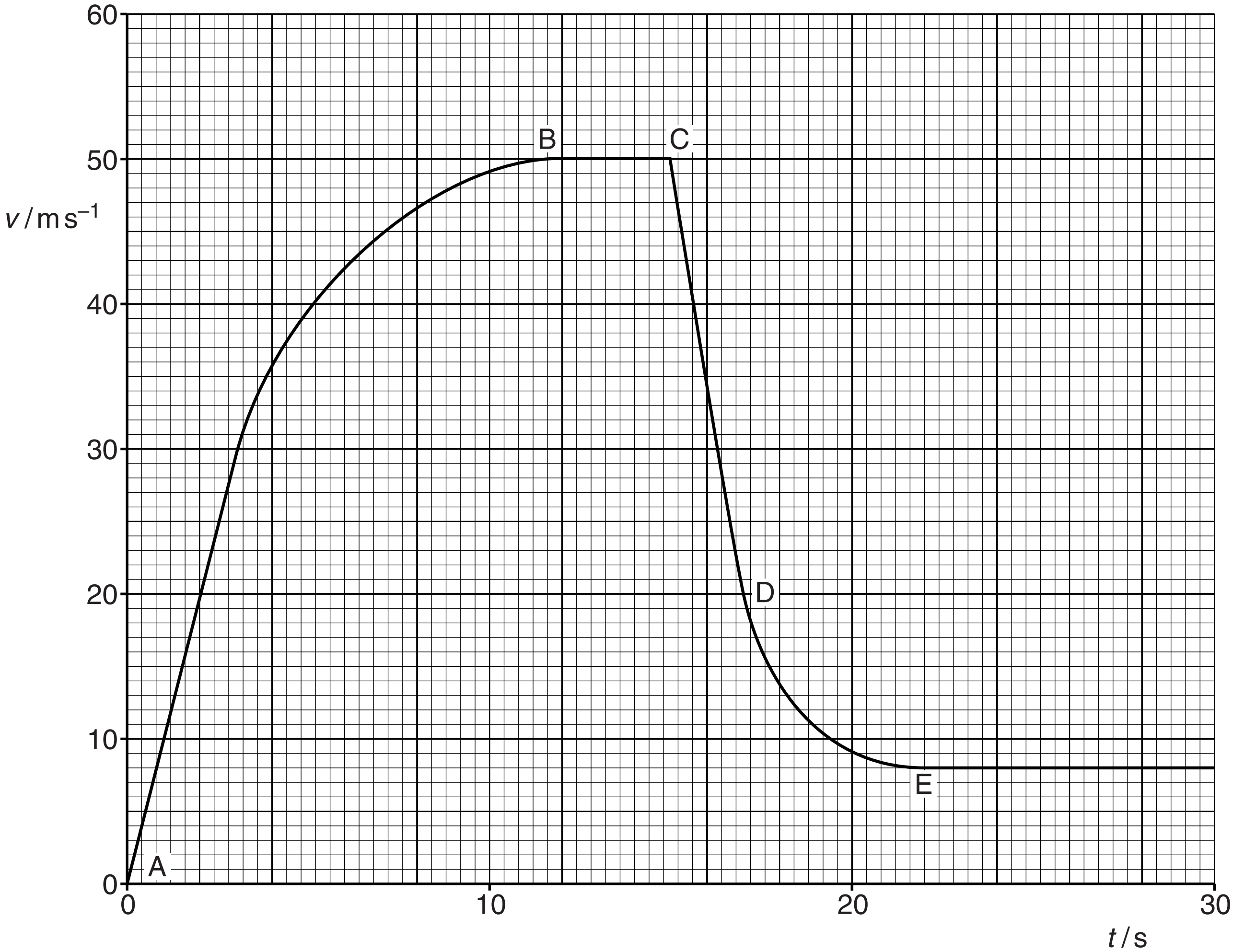


**Fig. 1.1**

 

**(i)** Calculate the distance travelled by the parachutist in the first 3.0 s of the motion.

distance = ............................................ m [2]

**(ii)** Explain the variation of the resultant force acting on the parachutist from $t$ = 0 (point A) to $t$ = 15 s (point C).

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**(iii)** Describe the changes to the frictional force on the parachutist

**1.** at $t$ = 15 s (point C),

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**2.** between $t$ = 15 s (point C) and $t$ = 22 s (point E).

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**(iv)** The mass of the parachutist is 95 kg.

Calculate, for the parachutist between $t$ = 15 s (point C) and $t$ = 17 s (point D),

**1.** the average acceleration,

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

**2.** the average frictional force.

frictional force = ............................................. N [3]

*For Examiner's Use*

**Please turn over for Question 2.**

For Examiner's Use

**2 (a)** Define electrical *resistance*.

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**(b)** A circuit is set up to measure the resistance *R* of a metal wire. The potential difference (p.d.) *V* across the wire and the current *I* in the wire are to be measured.

**(i)** Draw a circuit diagram of the apparatus that could be used to make these measurements.

[3]

**(ii)** Readings for p.d. *V* and the corresponding current *I* are obtained. These are shown in Fig. 2.1.

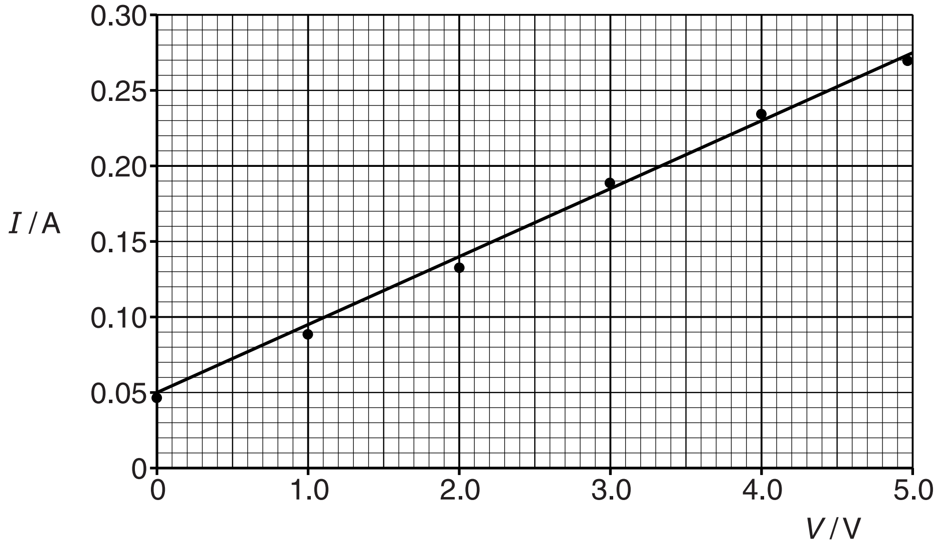


**Fig. 2.1**

Explain how Fig. 2.1 indicates that the readings are subject to



**1.** a systematic uncertainty,

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**2.** random uncertainties.

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**(iii)** Use data from Fig. 2.1 to determine *R*. Explain your working.

*R* = ............................................ Ω [3]

**(c)** In another experiment, a value of *R* is determined from the following data:

Current $I = 0.64 \pm 0.01$ A and p.d. $V = 6.8 \pm 0.1$ V.

Calculate the value of *R*, together with its uncertainty. Give your answer to an appropriate number of significant figures.

*R* = .................... ± ....................Ω [3]

**3** **(a)** Define *pressure*.

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**(b)** Explain, in terms of the air molecules, why the pressure at the top of a mountain is less than at sea level.

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**(c)** Fig. 3.1 shows a liquid in a cylindrical container.

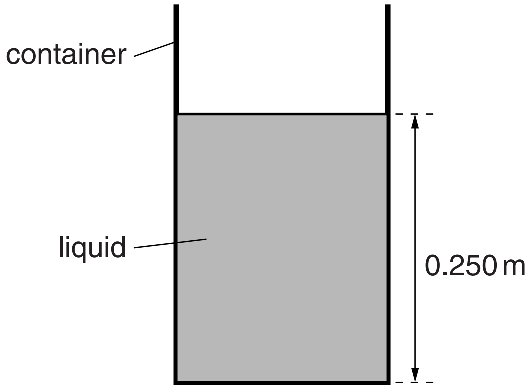


**Fig. 3.1**

The cross-sectional area of the container is 0.450 $m^2$. The height of the column of liquid is 0.250 m and the density of the liquid is 13 600 kg $m^{-3}$.

**(i)** Calculate the weight of the column of liquid.

weight = ............................................. N [3]

*For Examiner's Use*

**(ii)** Calculate the pressure on the base of the container caused by the weight of the liquid.

pressure = ........................................... Pa [1]

**(iii)** Explain why the pressure exerted on the base of the container is different from the value calculated in **(ii)**.

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**4** **(a)** Describe the diffraction of monochromatic light as it passes through a diffraction grating.

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**(b)** White light is incident on a diffraction grating, as shown in Fig. 4.1.

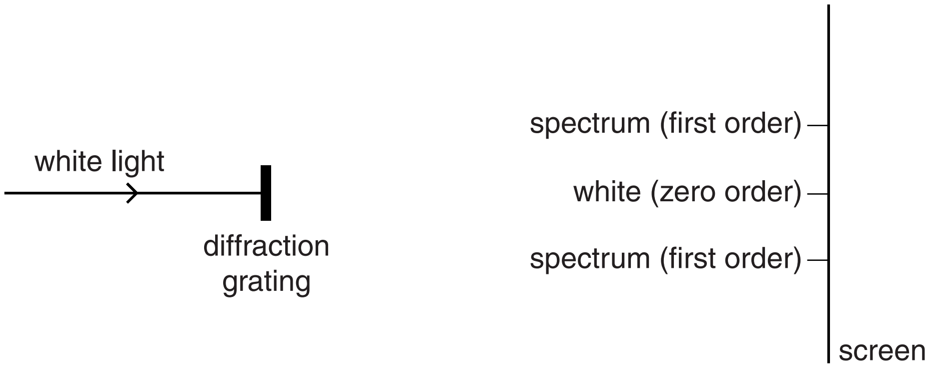


**Fig. 4.1** (not to scale)

The diffraction pattern formed on the screen has white light, called zero order, and coloured spectra in other orders.

**(i)** Describe how the principle of superposition is used to explain

**1.** white light at the zero order,

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**2.** the difference in position of red and blue light in the first-order spectrum.

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For Examiner's Use

**(ii)** Light of wavelength 625 nm produces a second-order maximum at an angle of 61.0° to the incident direction.
Determine the number of lines per metre of the diffraction grating.

number of lines = ........................................ $m^{-1}$ [2]

**(iii)** Calculate the wavelength of another part of the visible spectrum that gives a maximum for a different order at the same angle as in **(ii)**.

wavelength = ………………………..……..nm [2]

5 **(a)** Explain what is meant by *plastic deformation*.

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**(b)** A copper wire of uniform cross-sectional area $1.54 \times 10^{-6}\,m^2$ and length 1.75 m has a breaking stress of $2.20 \times 10^{8}$ Pa. The Young modulus of copper is $1.20 \times 10^{11}$ Pa.

**(i)** Calculate the breaking force of the wire.

breaking force = ............................................. N [2]

**(ii)** A stress of $9.0 \times 10^{7}$ Pa is applied to the wire. Calculate the extension.

extension = ............................................. m [2]

**(c)** Explain why it is not appropriate to use the Young modulus to determine the extension when the breaking force is applied.

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For Examiner's Use

**6** **(a)** Describe the structure of an atom of the nuclide $^{235}_{92}U$.

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**(b)** The deflection of α-particles by a thin metal foil is investigated with the arrangement shown in Fig. 6.1. All the apparatus is enclosed in a vacuum.

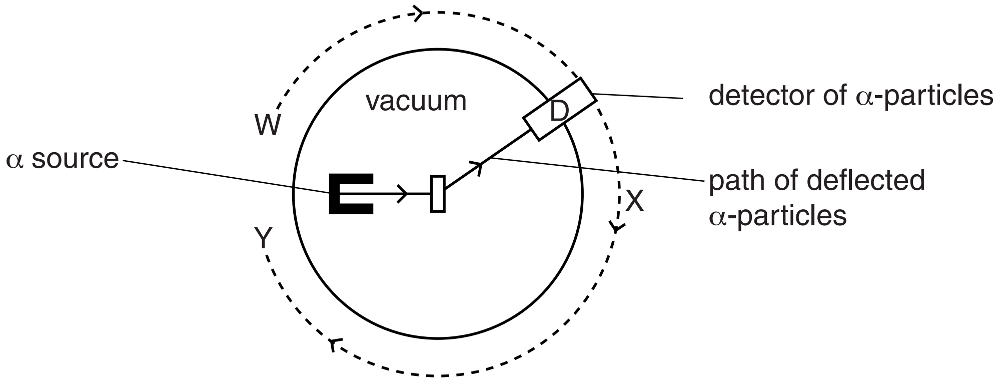


**Fig. 6.1**

The detector of α-particles, D, is moved around the path labelled WXY.

**(i)** Explain why the apparatus is enclosed in a vacuum.

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**(ii)** State and explain the readings detected by D when it is moved along WXY.

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**Question 6 continues on page 16.**

**(c)** A beam of $\alpha$-particles produces a current of 1.5 pA. Calculate the number of $\alpha$-particles per second passing a point in the beam.

*For Examiner's Use*

number = .......................................... $s^{-1}$ [3]