DUNMAN HIGH SCHOOL
Preliminary Examinations
Year 6
Higher 2

CANDIDATE NAME	

CLASS		INDEX NUMBER	

PHYSICS

9749/01

Paper 1 Multiple Choice

September 2018

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and index number on the Answer Sheet in the spaces provided unless this has been done for you.

DO **NOT** WRITE IN ANY BARCODES.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

The use of an approved scientific calculator is expected, where appropriate.

This document consists of **14** printed pages and **0** blank page.

Data

speed of light in free space,	c =	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o =	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o =	8.85×10^{-12} F m^{-1}
		$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e =	1.60×10^{-19} C
the Planck constant,	h =	6.63×10^{-34} J s
unified atomic mass constant,	u =	1.66×10^{-27} kg
rest mass of electron,	m_e =	9.11×10^{-31} kg
rest mass of proton,	m_p =	1.67×10^{-27} kg
molar gas constant,	R =	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A =	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k =	1.38×10^{-23} J K^{-1}
gravitational constant,	G =	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g =	9.81 m s^{-2}

Formulae

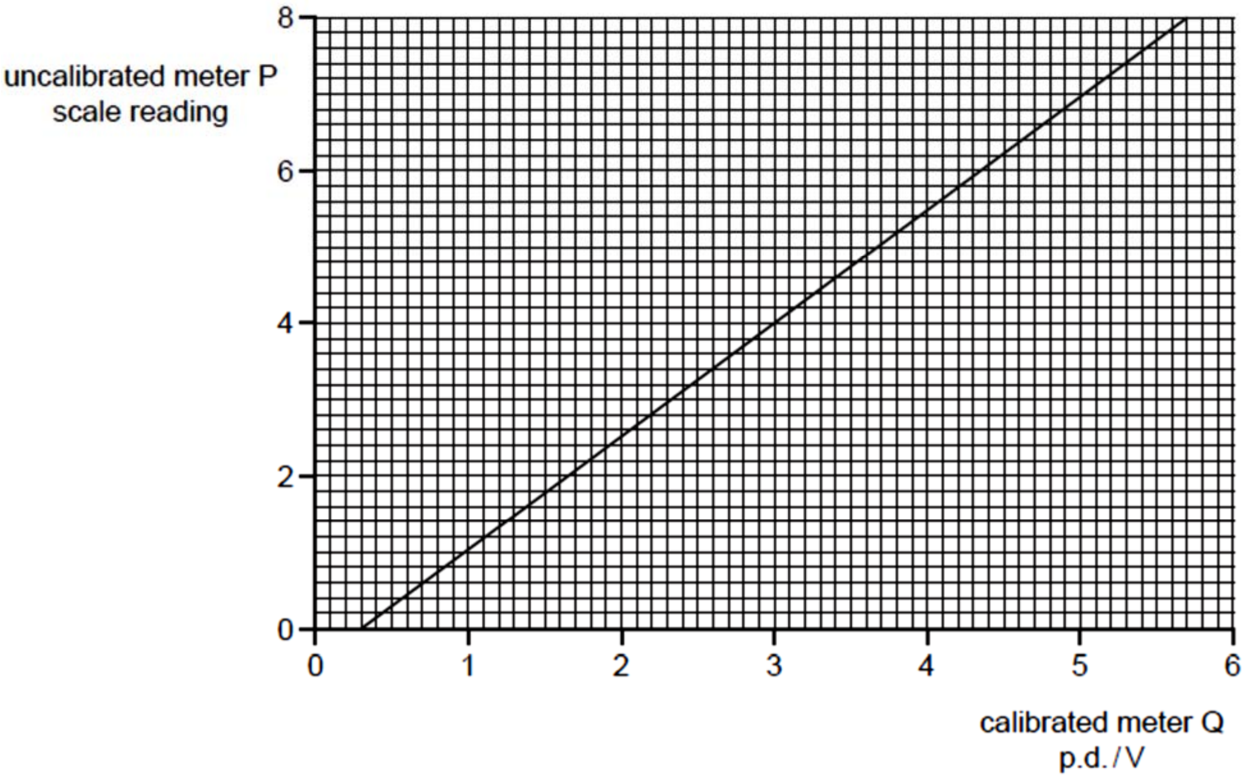
uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-\frac{Gm}{r}$
temperature	T/K	=	T/°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm \omega \sqrt{x_0^2 - x^2}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current / voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_o I}{2\pi d}$
magnetic flux denxity due to a flat circular coil	B	=	$\frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_o n I$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1 Determine the angle between two equal forces F when their resultant force is also equal to F.

A 45° **B** 60° **C** 120° **D** 135°

2 An un-calibrated analogue voltmeter P is connected in parallel with another voltmeter Q which is known to be accurately calibrated. For a range of values of potential difference (p.d.), readings are taken from the two meters.

The diagram shows the calibration graph obtained.



The graph shows that meter P has a zero error. This meter is now adjusted to remove this zero error. When the meter is re-calibrated, the gradient of the calibration graph is found to be unchanged.

What is the new scale reading on meter P when it is used to measure a p.d. of 5.0 V?

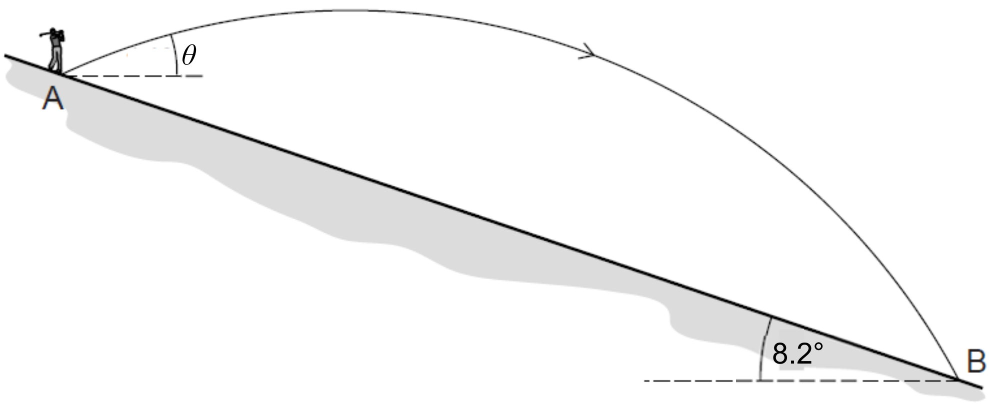
A 6.6 **B** 6.7 **C** 7.2 **D** 7.4

3 A projectile of mass 2.0 kg is launched on the Earth with some initial velocity. Another projectile of mass 4.0 kg is launched on the Moon with the same initial velocity. The acceleration of free fall on the Moon is 1.6 m s^{-2}.

Neglecting air resistance, what is the ratio $\dfrac{\text{range of projectile on the Earth}}{\text{range of projectile on the Moon}}$?

A 0.16 **B** 0.33 **C** 3.3 **D** 6.1

4 A golf ball is hit from point A on the ground and moves through the air to point B as shown in the figure which is not drawn to scale.

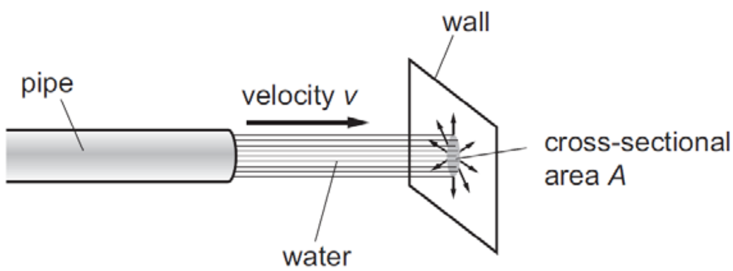


The ground slopes downhill with constant gradient of angle 8.2° to the horizontal. The ball has an initial velocity of 63 m s^{-1} at an angle of θ to the horizontal. Time taken for the ball to travel from A to B is 4.9 s.

Determine the angle θ.

A 8.0º **B** 10º **C** 12º **D** 14º

5 Water flows out of a pipe and hits a wall.

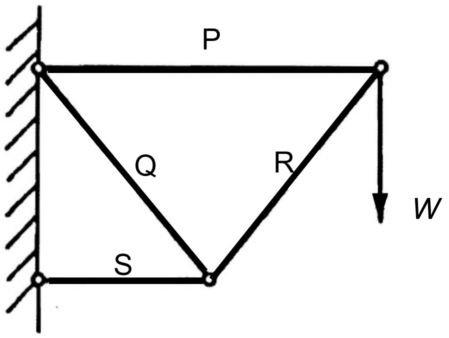


When the jet of water hits the wall, it has horizontal velocity v and cross-sectional area A. The density of the water is ρ. The water does not rebound from the wall.

What is the force exerted on the wall by the water?

A $\frac{\rho v}{A}$ **B** $\frac{\rho v^2}{A}$ **C** $\rho A v$ **D** $\rho A v^2$

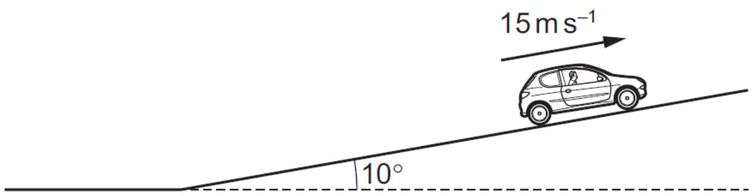
6 In order to support a load W, four light hinged rods P, Q, R and S are connected as shown below and mounted in a vertical plane.



Which rods are in compression and which in tension?

	in compression	*in tension*
A	P	Q, R, S
B	P, Q	R, S
C	Q, R	P, S
D	R, S	P, Q

7 A car of mass 1100 kg is travelling at a constant speed of 15 m s^{-1} up a slope inclined at 10º to the horizontal. The combined frictional forces acting on the car are directed down the slope and are equal to $\frac{W}{5}$, where W is the weight of the car.



What is the useful output power of the car's engine?

A 28 kW **B** 32 kW **C** 60 kW **D** 190 kW

8 An old-fashioned 60 W lamp converts 95% of its energy supply into heat. A 4.0 W modern lamp has the same power output of light as the old-fashioned lamp.

What is the efficiency of the modern lamp?

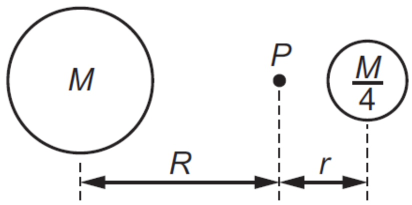
A 5.0% **B** 6.7% **C** 75% **D** 95%

9 The reading of a speedometer fitted to the front wheel of a bicycle is directly proportional to the angular velocity of the wheel. A certain speedometer is correctly calibrated for use with a wheel of diameter 61 cm but, by mistake, is fitted to a 51 cm wheel.

What is the value of $\dfrac{\text{indicated speed} - \text{actual speed}}{\text{actual speed}} \times 100\%$?

A +16% **B** −16% **C** +20% **D** −20%

10 Two large masses, one of mass M, the other of mass $\dfrac{M}{4}$, are positioned as shown.



A small mass is placed at point P such that it experiences zero gravitational force from the masses.

What is the ratio $\dfrac{R}{r}$?

A $\dfrac{1}{4}$ **B** $\dfrac{1}{2}$ **C** 2 **D** 4

11 Io and Ganymede are moons of Jupiter. The orbital period of Ganymede is four times that of Io. Io's orbital radius is 4.20×10^8 m.

What is the orbital radius of Ganymede?

A 1.06×10^9 m

B 1.68×10^9 m

C 3.36×10^9 m

D 2.70×10^{10} m

12 In deriving the equation $pV = \frac{1}{3}Nm\langle c^2 \rangle$ in the simple kinetic theory of gases, which of the following is **not** taken as a valid assumption?

A The molecules suffer negligible change of momentum on collision with the walls of the container.

B Collisions with the walls of the container and with other molecules cause no change in the average kinetic energy of the molecules.

C The duration of a collision is negligible compared with the time between collisions.

D The volume of the molecules is negligible compared with the volume of the gas.

13 Atoms of neon are at a temperature such that the root mean square (r.m.s.) speed of its atoms is 400 m s^{-1}.

What will be the r.m.s. speed of molecules of hydrogen at the same temperature?

Mass of neon atom = 20 u.
Mass of hydrogen molecule = 2 u.

A 130 m s^{-1} **B** 400 m s^{-1} **C** 1300 m s^{-1} **D** 4000 m s^{-1}

14 A particle performs simple harmonic motion according to the equation

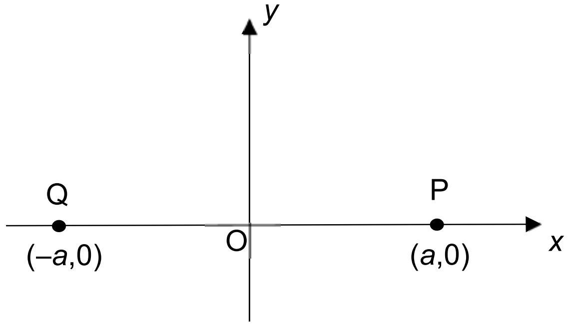
$$x = 2.0 \cos(\omega t)$$

where its displacement x is measured in cm and time t is measured in s.

If the angular frequency ω is π rad s^{-1}, what is the total distance travelled by the particle from t = 0.0 s to t = 1.5 s?

A 0 cm **B** 2.0 cm **C** 3.0 cm **D** 6.0 cm

15 An object is executing simple harmonic motion along the x-axis between P (a, 0) and Q ($-a$, 0) about the origin O. The kinetic energy of the particle is E_K, its potential energy is E_P and the total energy is E_T.



When the particle is mid-way between O and Q, what are the values of $\frac{E_K}{E_T}$ and $\frac{E_P}{E_T}$?

	$\frac{E_K}{E_T}$	$\frac{E_P}{E_T}$
A	$\frac{1}{4}$	$\frac{3}{4}$
B	$\frac{1}{2}$	$\frac{1}{2}$
C	$\frac{3}{4}$	$\frac{1}{4}$
D	$\frac{1}{8}$	$\frac{7}{8}$

16 A beam of plane-polarised light of intensity I falls normally on a thin sheet of polaroid.

If the transmitted beam has an intensity of $\frac{I}{4}$, what is the angle between the plane of incident polarisation and the polarising direction of the polaroid?

A 22.5° **B** 30° **C** 45° **D** 60°

17 S_1 and S_2 are loudspeakers facing each other and emitting continuous sound waves of frequency 1100 Hz. M is a small microphone which runs on a straight track between S_1 and S_2 at a speed of 30 m s^{-1}. The sound received by M will fluctuate with a frequency f.

If the velocity of sound is 330 m s^{-1}, what is the value of f?

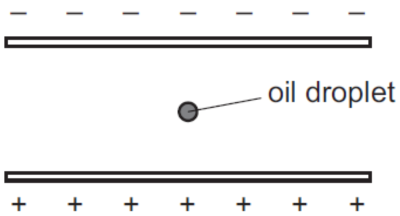
A 100 Hz **B** 200 Hz **C** 400 Hz **D** 800 Hz

18 Light of wavelength 600 nm is incident on a pair of slits. Fringes with a spacing of 4.0 mm are formed on a screen.

What will be the fringe spacing when the wavelength of the light is changed to 400 nm and the separation of the slits is doubled?

A 1.3 mm **B** 3.0 mm **C** 5.3 mm **D** 12 mm

19 A positively charged oil droplet is held stationary in an electric field of strength E.

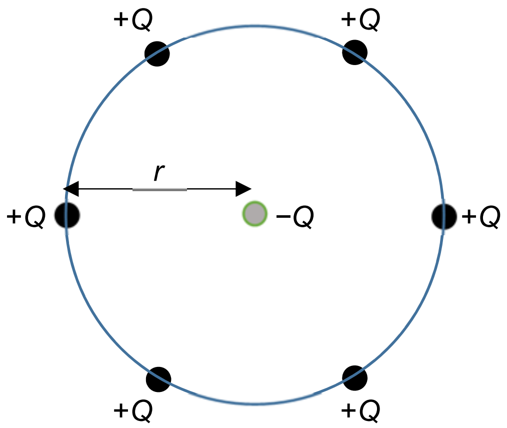


A different droplet of the same oil is held stationary in an electric field of different strength. The droplet has half the charge and twice the radius of the original droplet.

What is the electric field strength?

A $2E$ **B** $4E$ **C** $8E$ **D** $16E$

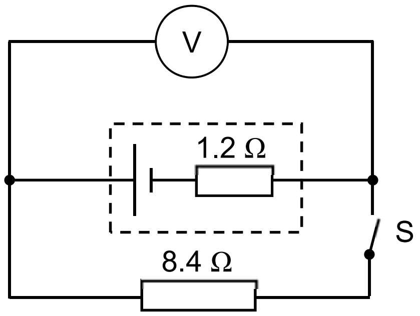
20 A negative point charge is surrounded symmetrically by six positive point charges at distance r as shown in diagram.



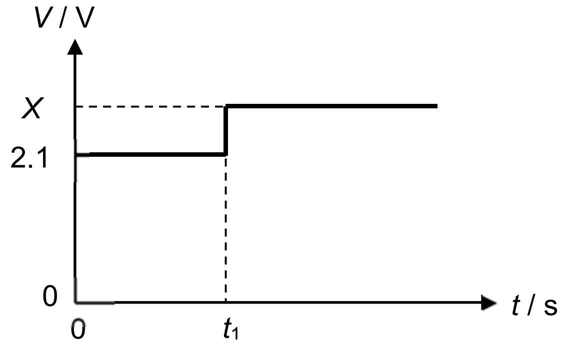
How much work is done by the forces of attraction when the point charge at the centre is removed to infinity?

A $-\frac{6Q^2}{4\pi\varepsilon_o r}$ **B** $+\frac{6Q^2}{4\pi\varepsilon_o r}$ **C** $-\frac{6Q^2}{4\pi\varepsilon_o r^2}$ **D** $+\frac{6Q^2}{4\pi\varepsilon_o r^2}$

21 A cell with internal resistance 1.2 Ω is connected in the circuit as shown.



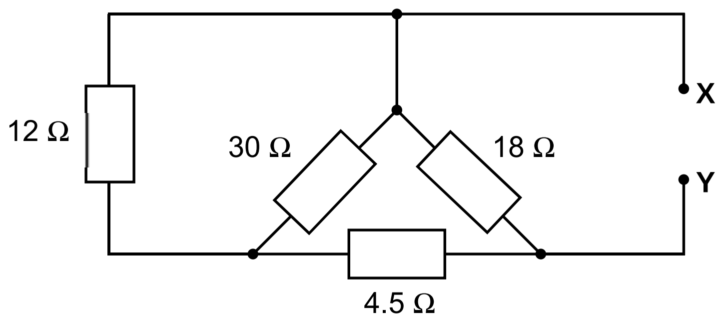
The graph shows the variation with time t of the voltmeter reading V. At time t = 0 s, switch S is closed. At time $t = t_1$, switch S is opened and a rise in the voltmeter reading V was observed.



What is the value of X?

A 2.2 V **B** 2.4 V **C** 3.6 V **D** 4.2 V

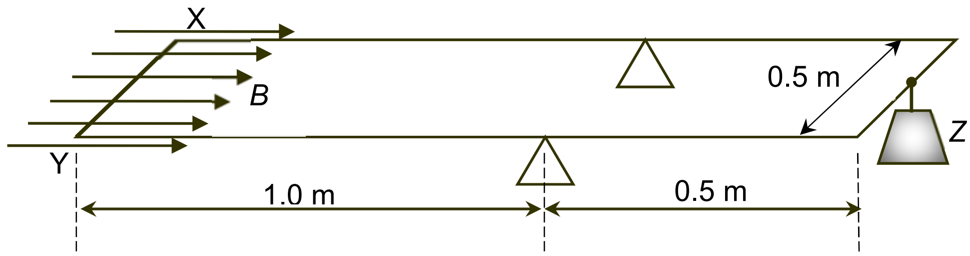
22 The circuit diagram shows a network of resistors.



What is the effective resistance between the points **X** and **Y**?

A 3.5 Ω **B** 7.6 Ω **C** 10.5 Ω **D** 15.0 Ω

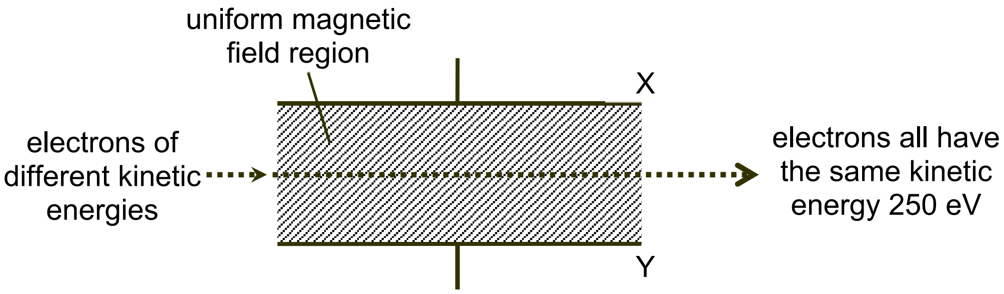
23 A 1.5 m by 0.5 m light and rigid rectangular conducting frame is pivoted along its longer sides with a weight *Z* hung on one shorter side as shown. A uniform horizontal magnetic field *B* of flux density 0.050 T is applied at right-angles to the section XY of the frame.



When a current passes through the section XY of the frame, which combination of the magnitude and direction of current flowing in section XY, and the weight *Z* makes the frame horizontal?

	magnitude of current in section XY	direction of current in section XY	*Z* / N
A	1.96 A	from X to Y	0.049
B	1.96 A	from Y to X	0.098
C	3.92 A	from X to Y	0.196
D	3.92 A	from Y to X	0.098

24 In certain experiments involving scattering of electrons by nucleus, a beam of electrons of kinetic energy 250 eV are needed. It can be obtained by passing a beam of electrons of different kinetic energies through a velocity selector as shown, with plate Y at a higher potential with respect to plate X.



Which of the following gives the correct effect on electrons that enter the velocity selector with kinetic energies that differs from the required 250 eV?

	electrons with kinetic energies greater than 250 eV	electrons with kinetic energies lower than 250 eV
A	impact on plate X	impact on plate X
B	impact on plate X	impact on plate Y
C	impact on plate Y	impact on plate X
D	impact on plate Y	impact on plate Y

25 A coil of 160 turns and area 0.20 m^2 is placed with its axis parallel to a magnetic field in the *x*-direction. The magnetic flux density changes from 0.40 T in the positive *x*-direction to 0.40 T in the negative *x*-direction in 2.0 s.

If the resistance of the coil is 16 Ω, what is the rate of energy generated in the coil?

A 5 W **B** 10 W **C** 13 W **D** 20 W

26 A sinusoidal alternating current of peak value I_o passes through a resistor of resistance *R*. The mean power developed by the current in the resistor is *P*.

Another sinusoidal alternating current passes through a resistor of resistance 2*R*. If the mean power developed by this current in it is 4*P*, what is the root-mean-square value of this current?

A 0.7 I_o **B** I_o **C** 1.4 I_o **D** 2.0 I_o

27 When electromagnetic radiation of frequency *f* irradiates a metal surface, electrons are emitted and the measured stopping potential is V_s. The frequency of the incident radiation is halved to 0.5*f*.

What change occurs in the stopping potential?

A The stopping potential decreases to less than 0.5V_s.

B The stopping potential decreases to 0.5V_s.

C The stopping potential decreases to more than 0.5V_s.

D The stopping potential remains at V_s.

28 A proton has a kinetic energy of 1.00 MeV.

If its momentum is measured with an uncertainty of 1.00 %, what is the minimum uncertainty in its position?

A 5.64×10^{-14} m

B 9.08×10^{-14} m

C 2.87×10^{-12} m

D 9.77×10^{-10} m

29 Two deuterium nuclei fuse together to form a Helium-3 nucleus, with the release of a neutron. The reaction is represented by

$$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{2}He + ^{1}_{0}n + \text{energy}$$

The binding energies per nucleon are:

for $^{2}_{1}H$	1.09 MeV,
for $^{3}_{2}He$	2.54 MeV.

How much energy is released in this reaction?

A 0.36 MeV **B** 1.45 MeV **C** 3.26 MeV **D** 5.44 MeV

30 Nuclide X decays to stable nuclide Y with a half-life of *T* years.

Geologists are sure that nuclide Y found in a particular rock sample has all came from nuclide X which was present when the rock formed.

The rock is thought to be 3*T* years old.

What is the expected ratio $\frac{\text{number of atoms of X}}{\text{number of atoms of Y}}$ for this rock?

A $\frac{1}{6}$ **B** $\frac{1}{7}$ **C** $\frac{1}{8}$ **D** $\frac{1}{9}$

\- END OF PAPER -

DUNMAN HIGH SCHOOL
Preliminary Examinations
Year 6
Higher 2

CANDIDATE NAME

CLASS

INDEX NUMBER

PHYSICS

9749/02

Paper 2 Structured Questions

September 2018

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
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.

The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions.

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	**12**
2	**7**
3	**8**
4	**8**
5	**8**
6	**8**
7	**9**
8	**20**
Total	**80**

This document consists of **21** printed pages and **1** blank page.

Data

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hydrostatic pressure,	p	=	ρgh
gravitational potential,	ϕ	=	$-Gm/r$
temperature,	T/K	=	T/°C + 273.15
pressure of an ideal gas,	p	=	$\frac{1}{3}\frac{Nm}{V}<c^2>$
mean translational kinetic energy of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.,	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_0 \cos \omega t$
		=	$\pm\omega\sqrt{x_o^2 - x^2}$
electric current,	I	=	$Anvq$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage,	x	=	$x_0 \sin \omega t$
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magnetic flux density due to a long solenoid,	B	=	$\mu_0 nI$
radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1 (a) A liquid L fills a container of very large uniform cross-sectional area to a certain depth. Another liquid M is now added to the container. The two liquids do not mix as shown in Fig. 1.1. The total depth of the liquids is 0.17 m.

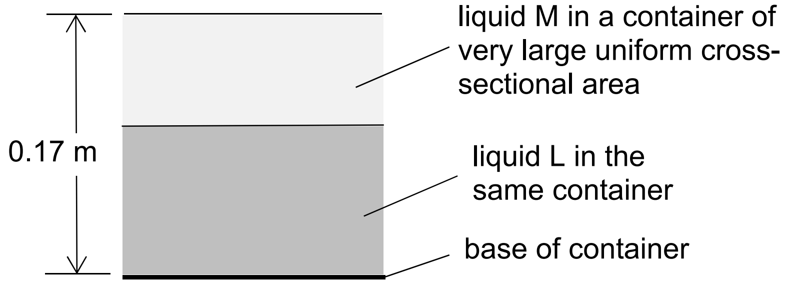

Fig. 1.1 (not to scale)

Fig. 1.2 shows how the pressure p inside the liquids varies with height x above the base of the container.

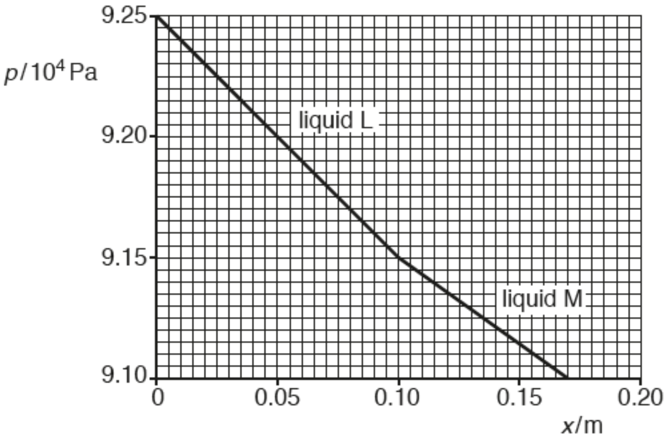

Fig. 1.2

Use Fig. 1.2 to

(i) state the value of the atmospheric pressure,

atmospheric pressure = ………………………………… Pa [1]

(ii) determine the density of liquid M.

density = ………………………………… kg m^{-3} [2]

(b) Above the liquids, a spring is attached at one end to a fixed point and hangs vertically with a cube attached to the other end. The cube is initially held so that the spring has zero extension as shown in Fig. 1.3.

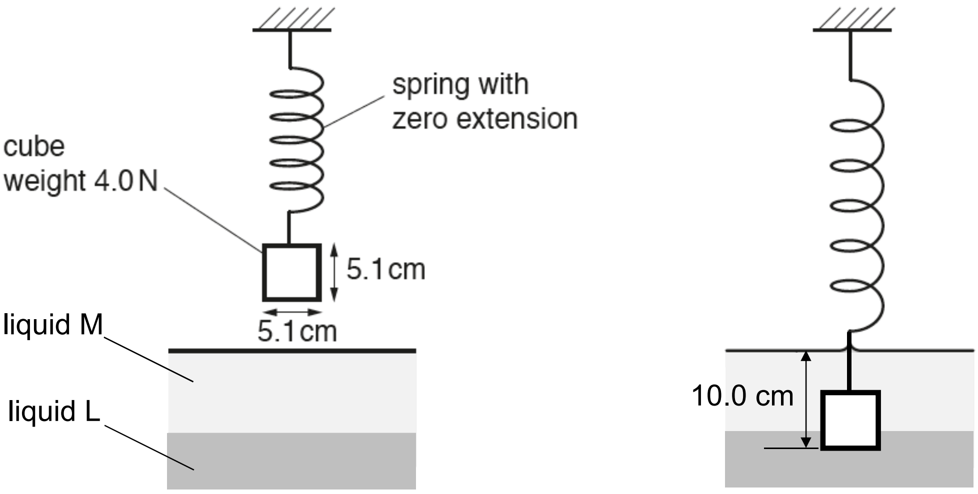

Fig. 1.3 (not to scale)

The cube has weight 4.0 N and sides of length 5.1 cm. The cube is released and sinks into the liquids as the spring extends. The cube reaches equilibrium with its base at a depth of 10.0 cm below the top surface of the liquid M, as shown in Fig. 1.3.

(i) Determine the upthrust acting on the cube.

upthrust = ………………………………… N [3]

(ii) Calculate the magnitude of the force exerted on the spring by the cube when it is in equilibrium in the liquids.

force = ………………………………… N [1]

(c) Suggest how to check that the elastic limit of the spring is not exceeded.

……

………………………………………………………………………………………………… [1]

(d) Two identical balls are placed in a smooth glass container as shown in Fig. 1.4. Each ball has a mass of 170 g. Their centres and point A lies on a straight line as shown by the dotted line.

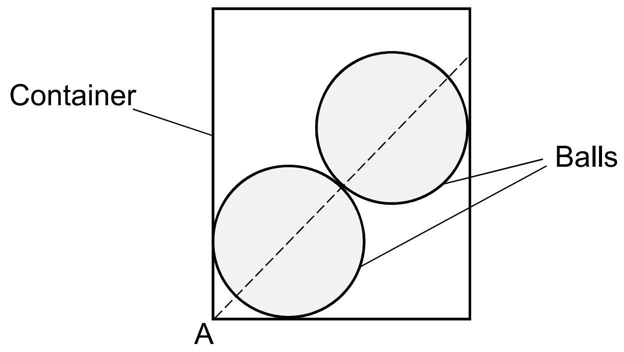

Fig. 1.4

(i) Determine the magnitude of the horizontal force by the container on the upper ball.

horizontal force = …………………………………… N [2]

(ii) Hence, or otherwise, determine the magnitude of the force exerted by the lower ball on the upper ball.

force = …………………………………… N [2]

2 Fig. 2.1 shows the variation with distance from the centre of the Earth of the gravitational field strength g.

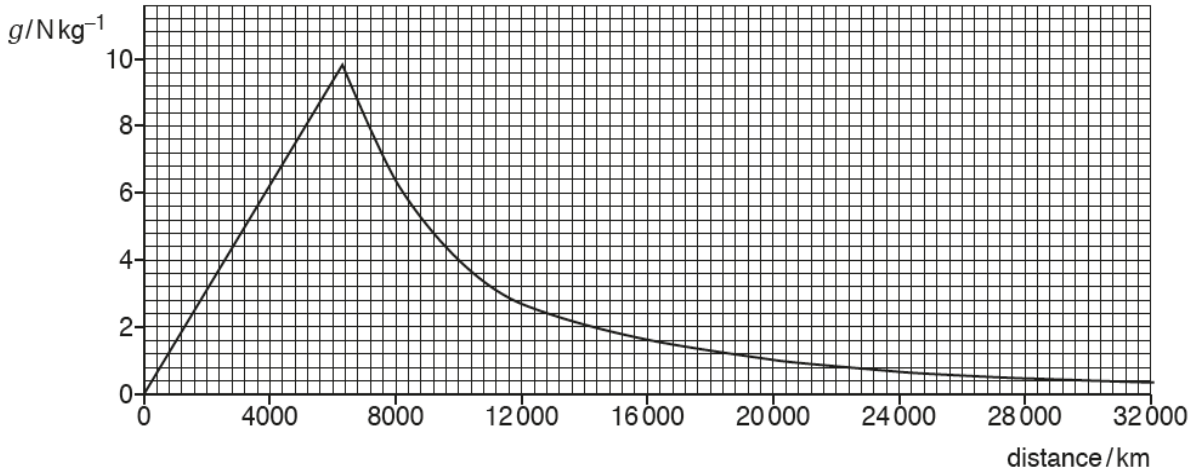

Fig. 2.1

(a) Use Fig. 2.1 to determine the gravitational force on a man-made satellite of mass 20 000 kg at a distance of 8200 km from the centre of the Earth.

gravitational force = ... N [2]

(b) Calculate the speed of the satellite in **(a)** for it to be circling the Earth at constant speed.

speed = ... m s^{-1} [2]

For Examiner's Use

(c) (i) State what is meant by *gravitational potential*.

....

.... [1]

(ii) Use Fig. 2.1 to estimate the gravitational potential at a distance of 10 000 km from the centre of the Earth.

gravitational potential = ... J kg^{-1} [2]

3 (a) A small ball rests at point P on a curved track of radius *r*, as shown in Fig. 3.1.

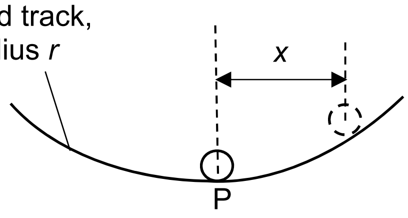

Fig. 3.1

The ball is moved a small distance to one side and is then released. The horizontal displacement *x* of the ball is related to its acceleration *a* towards P by the expression

$$a = -\frac{gx}{r}$$

where *g* is the acceleration of free fall.

(i) Show that the ball undergoes simple harmonic motion.

....

....

....

.... [2]

For Examiner's Use

(ii) The radius r of curvature of the track is 28 cm.

Determine the time interval τ between the ball passing point P and then returning to point P.

τ = ……………… s [3]

(b) The variation with time t of the displacement x of the ball in **(a)** is shown in Fig. 3.2.

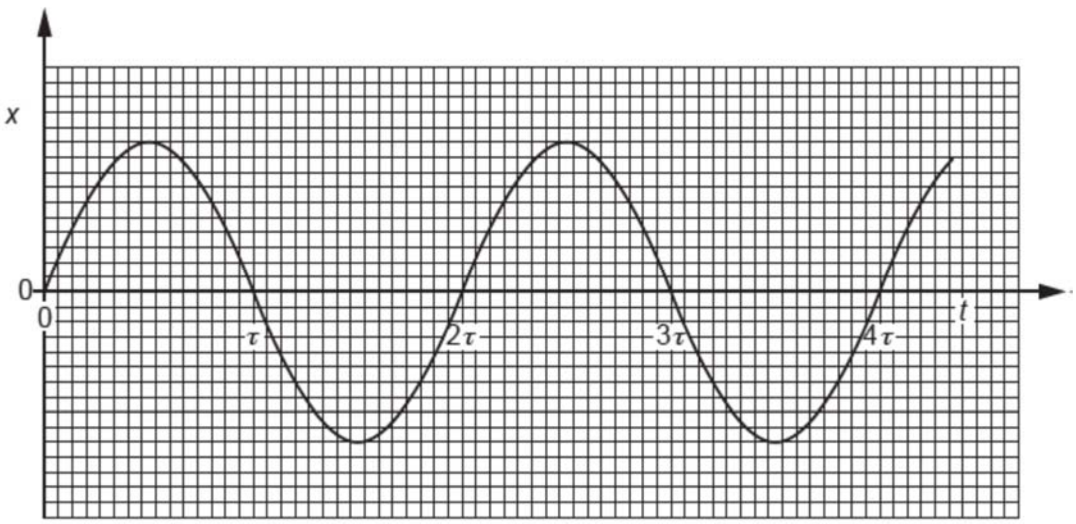

Fig. 3.2

Some moisture now forms on the track, causing the ball to come to rest after approximately 15 oscillations.

On the axes of Fig. 3.2, sketch the variation with time t of the displacement x of the ball for the first two periods after the moisture has formed. Assume the moisture forms at t = 0. [3]

For Examiner's Use

4 **(a)** A narrow beam of light of wavelength 632 nm is incident normally on a diffraction grating as shown in Fig. 4.1.

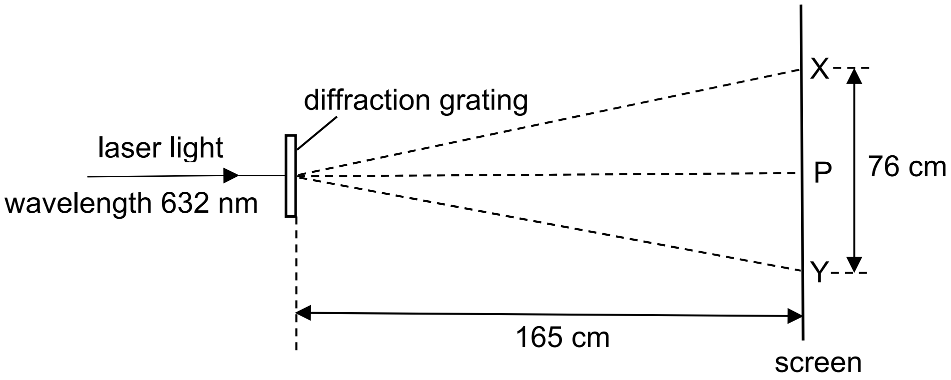

Fig. 4.1

Spots of light are observed on a screen placed parallel to the grating. The distance between the grating and the screen is 165 cm.

The brightest spot is P. The spots formed closest to P and on each side of P are X and Y. X and Y are separated by a distance of 76 cm.

(i) Calculate the number of lines per metre on the grating.

number per metre = …………………. [3]

(ii) Light of wavelengths 632 nm and 638 nm is now incident normally on the grating. Two lines are observed in the first order spectrum and two lines are observed in the second order spectrum, corresponding to the two wavelengths.

State two differences between the first order spectrum and the second order spectrum.

1. ……………………………………………………………………………………..……….…….

……………………………………………………………………………………………….....

2. ……………………………………………………………………………………..……….…….

…………………………………………………………………………………………….... [2]

For Examiner's Use

(b) **(i)** The grating in **(a)** is now rotated about an axis parallel to the incident light, as shown in Fig. 4.2.

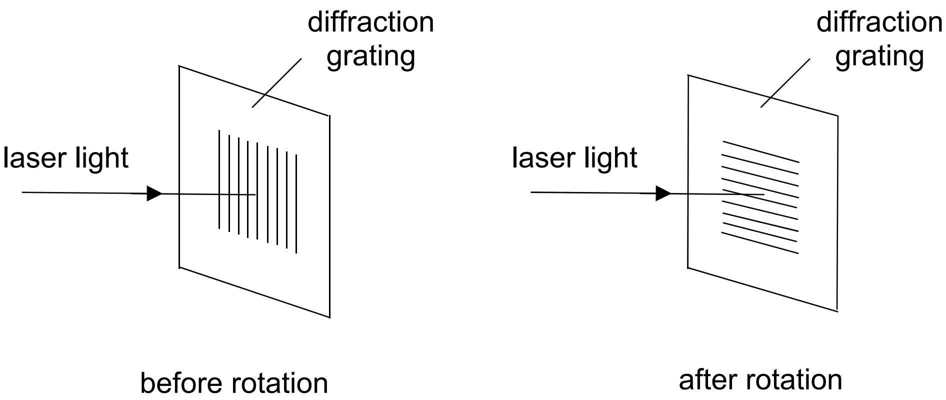

Fig. 4.2

State what effect, if any, this rotation will have on the positions of the spots P, X and Y.

....

.... [2]

(ii) In another experiment using the apparatus in **(a)**, it was noticed that the distances XP and PY, as shown in Fig. 4.1, are not equal.

Suggest a reason for this difference.

.... [1]

5 **(a)** **(i)** State what is meant by the terms *electric field* and *electric field strength*.

electric field ....

....

electric field strength ....

.... [2]

(ii) Determine the electric field strength at a distance of 25 cm from a point charge of 5.2×10^{-7} C. Give a unit for electric field strength with your answer.

electric field strength = ... unit .... [3]

(b) Fig. 5.1 shows three charges of value 1.0 μC at X, −1.0 μC at Y and 1.0 μC at Z. These charges are at the corners of an equilateral triangle.

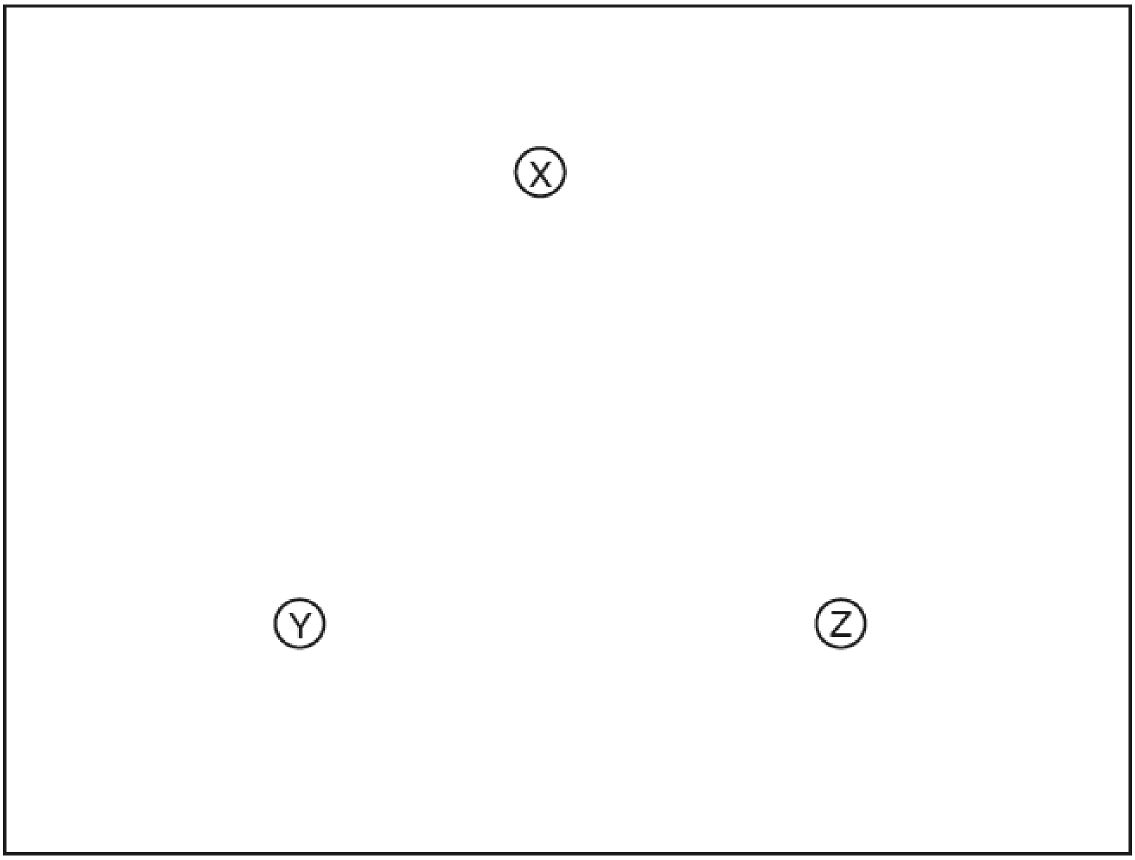

Fig. 5.1

Without making any calculations, draw on Fig. 5.1, the electric field, indicating its main characteristics, within the given rectangle area. [3]

For Examiner's Use

6 (a) Two identical wires A and B, are placed parallel to each other as shown in Fig. 6.1. Both wires carry a current of 90.0 A towards the left.

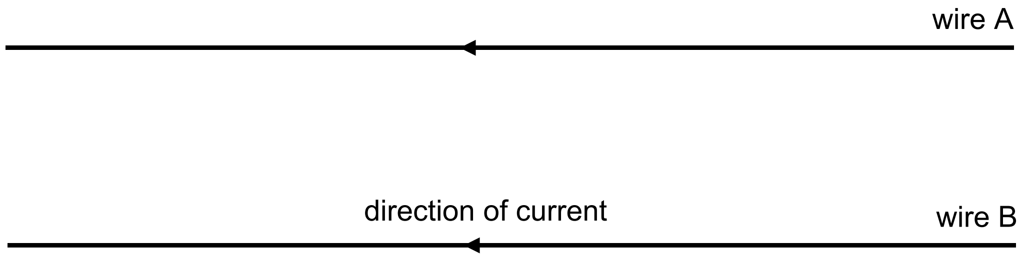

Fig. 6.1

Explain why both wires experience a force.

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(b) Fig. 6.2 shows only the wire A carrying a current of 90.0 A towards the left. Point P lies in the plane of the paper containing wire A, at a distance 50.0 cm directly above wire A. At P, a proton is travelling directly towards the wire with a speed $v = 1.0 \times 10^3$ m s^{-1}. Ignore the effects of the Earth's magnetic field.

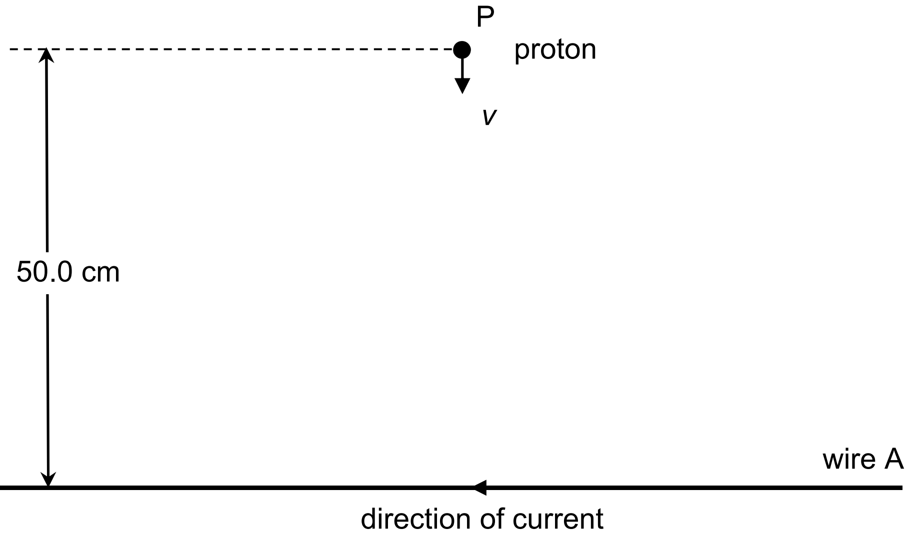

Fig. 6.2

(i) Calculate the radius of the path of the proton when it is at P.

radius = ……………........……..... m [3]

(ii) Explain how the path of the proton is affected by the magnetic field produced by the current in wire A as it moves in the region between P and wire A.

……………………………………………………………………………………………......

……………………………………………………………………………………………......

……………………………………………………………………………………………......

……………………………………………………………………………………………......

……………………………………………………………………………………………......

…………………………………………………………………………………………… [3]

7 A particular X-ray tube uses molybdenum (Mo) as the target element and another X-ray tube uses tungsten (W). An accelerating potential of 25 kV is applied to both tubes, giving rise to continuous spectrums being formed. The atomic number *Z* of molybdenum is 42 while that of tungsten is 74.

(a) Explain, with reference to the mechanism of X-ray production,

(i) how the continuous spectrum is formed, and

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………..

..………………………………………………………………………………………….. [2]

(ii) why the minimum wavelength produced is the same for both target elements.

....

....

....

.... [2]

(b) Characteristic peaks K_α and K_β occur for molybdenum, but not for tungsten at an accelerating potential of 25 kV. In order to obtain the characteristic spectra for tungsten, the accelerating potential has to be increased beyond 25 kV.

Explain

(i) why the intensity of the K_α X-ray is typically greater than the K_β X-ray for molybdenum.

....

.... [1]

(ii) why the characteristic spectra for tungsten only appear when the accelerating potential is greater than that necessary to produce characteristic spectra for molybdenum.

....

....

.... [2]

(c) The X-ray spectrum of molybdenum has a particular characteristic spectral line of wavelength 6.6×10^{-11} m, produced by electrons making transitions between two energy levels of the molybdenum atom.

Calculate, in electron-volts, the energy of an X-ray photon of wavelength 6.6×10^{-11} m.

energy = ... eV [2]

For Examiner's Use

8 The Singapore Mass Rapid Transit (SMRT) started its first train services in 1987. It was a massive nationwide project, beginning from the physical construction of the train tracks to the planning of the train arrival frequency. Amongst other professionals, the project involved the close collaboration of civil and structural engineers as well as transport engineers.

The Kawasaki Heavy Industries (KHI) C151 train as shown in Fig. 8.1, is Singapore's first generation of SMRT train fleet and has been in passenger service since 7 November 1987. All of the 396 KHI cars are built from 1986 to 1989 by four manufacturers in the consortium led by Kawasaki Heavy Industries.

Fig. 8.1

<u>Technical Specifications:</u>

Manufacturer:	Kawasaki Heavy Industries, Nippon Sharyo, Tokyu Car Corporation, Kinki Sharyo
Number built:	396 cars (66 trains)
Car body Construction:	Aluminium-alloy construction
Maximum Speed:	90 km h^{-1} (Design) 80 km h^{-1} (Service)
Train Length:	138 m (6 cars)
Width:	3.2 m
Height:	3.7 m
Train Mass:	286000 kg (fully laden)
Doors:	1.45 m, 8 per car
Seating Capacity:	208 seats

Fig. 8.2 shows a section of an elevated MRT track with a train on it. From the structural aspect, the structure load is being supported as follows:

1. Each car, with passengers in it, has its load supported by the beam below it. Car 2 is thus supported by beam 2.

2. Car 2 and beam 2 are both supported by columns 1 and 2.

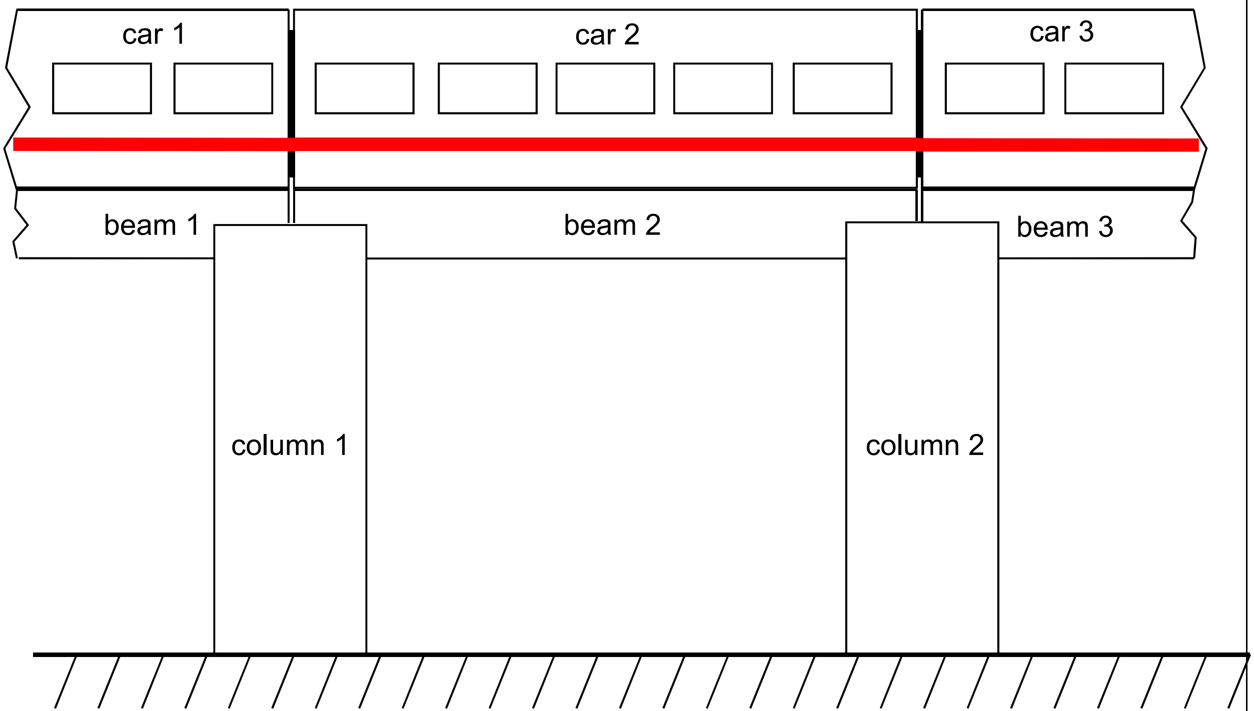

Fig. 8.2

The following set of simplified data is provided.

Weight of 1 empty car = 350 kN
Weight of 1 beam = 380 kN
Weight of 1 column = 100 kN

(a) Explain what is meant by *train arrival frequency*.

.... [1]

(b) An alloy is a combination of metals or of a metal and another element.

Suggest why trains are commonly made of aluminium alloy.

.... [1]

(c) When a train with no passengers in it, and is at the position shown in Fig. 8.2,

(i) indicate on Fig. 8.3, the portion of beam 2 that is under compression and the portion under tension when the car is on beam 2. [1]

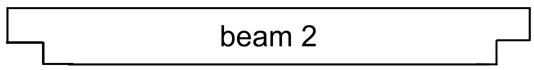

Fig. 8.3

(ii) calculate the total normal reaction force acting on beam 2 due to the supporting columns.

normal force = ……………….....……..... N [1]

(iii) state the total load that the top of column 1 has to take.

total load = ……………….....……..... N [1]

(iv) calculate the total load that the ground directly below each column has to take.

total load = ……………….....……..... N [2]

(d) An engineer needs to design the structure such that the ground does not cave in when a fully loaded train passes overhead. In designing the structure loading, a factor of safety is incorporated.

$$\text{Factor of safety} = \frac{\text{maximum stress}}{\text{applied stress}} = \frac{\text{maximum load}}{\text{applied load}}$$

Maximum stress is defined as the maximum force the ground can withstand per unit cross-sectional area.

Applied stress is defined as the applied force the ground withstands *F*, per unit cross-sectional area *A*.

Simplified data for the applied force the ground withstands *F*, and the cross-sectional area *A*, are given in Fig. 8.4.

F / kN	A / m^2
922	4.3
916	4.4
936	4.5
958	4.6
980	4.7
996	4.8
1020	4.9
1040	5.0

Fig. 8.4

The variation with A of F is as shown in Fig. 8.5.

(i) Complete Fig. 8.5 by drawing the best-fit line. [1]

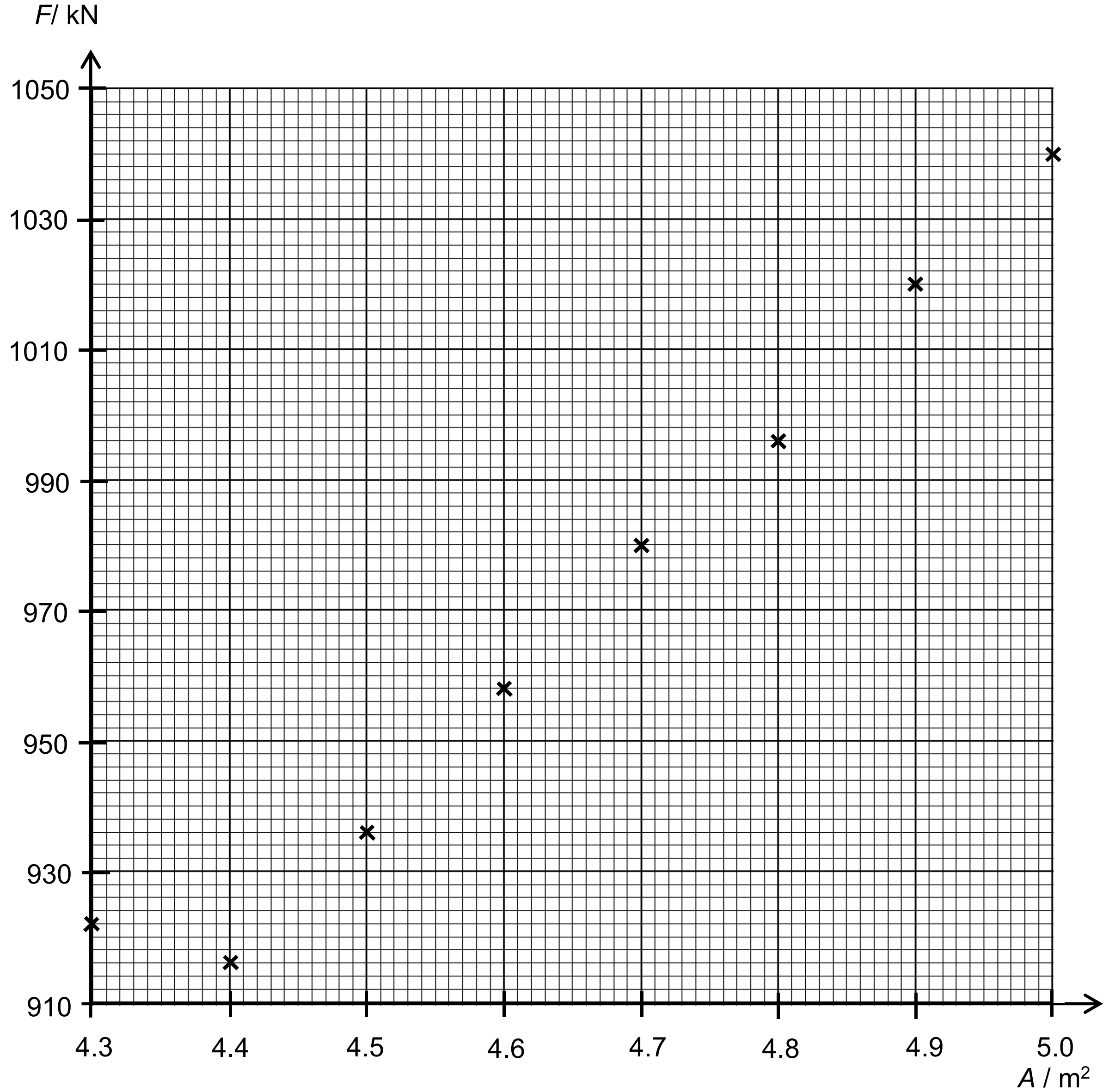

Fig. 8.5

For Examiner's Use

(ii) Use Fig. 8.5 to determine the applied stress that the ground withstands.

applied stress = …………………………… N m^{-2} [2]

(iii) The column structure is considered safe if the factor of safety is greater than 2.9. Assuming that the maximum stress the ground is designed to withstand is 645 kN m^{-2}, determine whether the column structure is safe.

column structure is ……………. [2]

(e) The simplified dimensions of each column are given in Fig. 8.6.

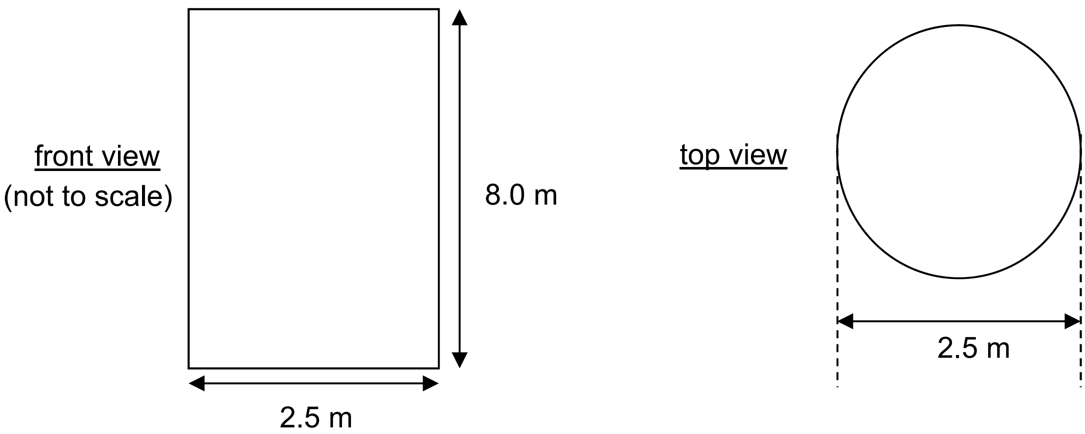

Fig. 8.6

(i) Using the value of applied stress from **(d)(ii)**, calculate the applied load that the ground withstands.

applied load = …………………………… N [2]

(ii) Hence, calculate the total allowable weight of passengers that each car can carry.

allowable weight = …………………………… N [1]

For Examiner's Use

(iii) Assuming the average mass of 1 passenger to be 60 kg and value of *g* to be 10 m s^{-2}, calculate the allowable number of passengers that a car can carry at any one time.

number of passengers = ……………..…........……..... [2]

(f) A transport engineer is employed to design the frequency of the trains arriving at Tuas Crescent MRT Station. In order not to cause the ground to sink, he needs to look into the allowable passengers that each car can take and not overload each car. The following information is available to him:

<u>Peak hours at Tuas Crescent MRT Station</u>

Average number of east-bound passengers per minute = 240

On average, an east-bound train is anticipated to be already 75% filled just before it arrives at Tuas Crescent MRT Station.

Assuming that each car takes equal number of passengers and all board the train, determine the possible longest time interval between arrival of consecutive east-bound trains at the station during peak hours.

longest time interval = ……………….....……... minutes [3]

END OF PAPER

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DUNMAN HIGH SCHOOL
Preliminary Examinations
Year 6
Higher 2

CANDIDATE NAME

CLASS

INDEX NUMBER

PHYSICS

9749/03

Paper 3 Longer Structured Questions

September 2018

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
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.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer **one** question only.

You are advised to spend one and a half hours on Section A and half an hour on Section B.

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	10
2	10
3	10
4	10
5	10
6	10
7	20
8	20
Total	80

This document consists of **25** printed pages and **1** blank page.

Data

speed of light in free space,	c =	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o =	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o =	8.85×10^{-12} F m^{-1}
		$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e =	1.60×10^{-19} C
the Planck constant,	h =	6.63×10^{-34} J s
unified atomic mass constant,	u =	1.66×10^{-27} kg
rest mass of electron,	m_e =	9.11×10^{-31} kg
rest mass of proton,	m_p =	1.67×10^{-27} kg
molar gas constant,	R =	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A =	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k =	1.38×10^{-23} J K^{-1}
gravitational constant,	G =	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g =	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	ρgh
gravitational potential,	ϕ	=	$-Gm/r$
temperature,	T/K	=	T/°C + 273.15
pressure of an ideal gas,	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.,	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_0 \cos \omega t$
		=	$\pm\omega\sqrt{x_o^2 - x^2}$
electric current,	I	=	$Anvq$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage,	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire,	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux denxity due to a flat circular coil,	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid,	B	=	$\mu_0 nI$
radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

Answer **all** the questions in this Section in the spaces provided

1 **(a)** Make estimates of the following quantities.

(i) the thickness of a sheet of A4 paper

thickness = ……………………. mm [1]

(ii) the mass of a sheet of A4 paper

mass = ……………………. g [1]

(b) The distance from the Earth to the Sun is 0.15 Tm.

Calculate the time in minutes for light to travel from the Sun to the Earth.

time = ……………………. minutes [2]

(c) The time *T* for a satellie to orbit the Earth is given by

$$T = \sqrt{\frac{KR^3}{M}}$$

where *R* is the distance of the satellite from the centre of the Earth, *M* is the mass of the Earth and *K* is a constant.

(i) Determine the SI base units of *K*.

SI base units of *K* = ……………………. [2]

(ii) Data for a particular satellite are given in Fig. 1.1

quantity	measurement	uncertainty
T	8.64×10^4 s	± 0.50%
R	4.23×10^7 m	± 1.0%
M	6.0×10^{24} kg	± 2.0%

Fig. 1.1

Express *K* with its associated uncertainty in SI units.

K = ……………………± ………………… SI units [3]

(iii) State the quantity which contributes the largest uncertainty in the value of *K*.

……………………………………………………………………………………………………

………………………………………………………………………………………………….. [1]

2 A hot-air balloon rises vertically at a constant speed. At time t = 0, a ball is released from the balloon.

Fig. 2.1 shows the variation with time t of the ball's velocity v.

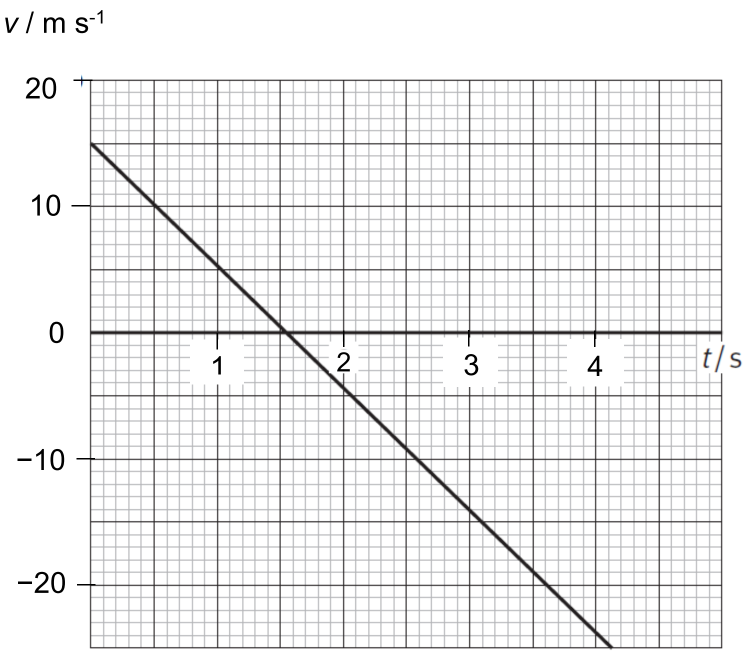

Fig. 2.1

The ball hits the ground at t = 4.1 s.

(a) State the speed of the hot-air balloon.

speed = ………………………………. m s^{-1} [1]

(b) Explain how the graph in Fig. 2.1 shows that the acceleration of the ball is constant.

……………………………………………………………………………………………………

…………………………………………………………………………………………………….[1]

(c) Use Fig. 2.1 to

(i) state the time at which the ball reaches its highest point,

time = ………………………………. s [1]

(ii) show that the ball rises for a further 12 m between release and its highest point,

[1]

For Examiner's Use

(iii) determine the distance between the point of release of the ball and the ground.

distance = ………………………………. m [2]

(d) Describe the difference between displacement of the ball and the distance it travels.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

(e) Sketch a new graph on Fig. 2.1 showing the variation with *t* of the ball's velocity *v* if air resistance is not negligible. Assume terminal velocity is attained by the ball before hitting the ground. Label the new graph N. [2]

3 **(a)** **(i)** Define *force*.

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

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

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

For Examiner's Use

(b) Fig. 3.1 shows the variation with time *t* of a jumping flea's acceleration *a*. The acceleration *a* is measured in unit of *g*, the acceleration of free fall. The flea of mass 210 μg jumped at nearly vertical take-off angle from ground.

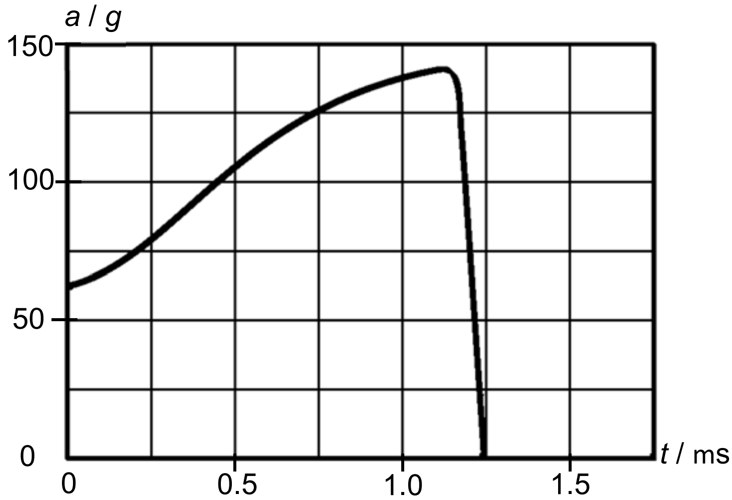

Fig. 3.1

(i) Use Fig. 3.1 to

1. determine the maximum net external force acting on the jumping flea,

force = ………………………………. N [2]

2. estimate the maximum speed achieved by the flea.

speed = ………………………………. m s^{-1} [3]

(ii) State and explain whether linear momentum is conserved during the take-off of the flea from the ground.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

4 **(a)** Explain,

(i) what is meant by a *radian*,

....

....

....[2]

(ii) why one complete revolution is equivalent to an angular displacement of 2π rad.

....

....[1]

(b) A stone of weight 3.0 N is fixed, using glue, to one end P of a rigid rod CP, as shown in Fig. 4.1.

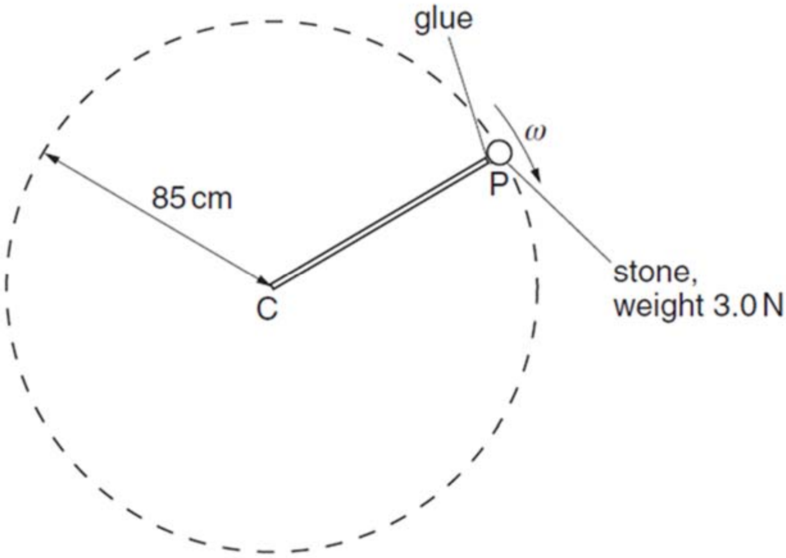

Fig. 4.1

The rod is rotated about end C so that the stone moves in a vertical circle of radius 85 cm.

The angular speed ω of the rod and stone is gradually increased from zero until the glue snaps. The glue fixing the stone snaps when the tension in it is 18 N.

For the position of the stone at which the glue snaps,

(i) mark with the letter S, the position of the stone on the dotted circle of Fig. 4.1 and [1]

(ii) calculate the angular speed ω of the stone.

angular speed = ………………………………. rad s^{-1} [3]

(c) The same stone is now fixed on a string and made to travel along a horizontal circular path, as shown in Fig. 4.2.

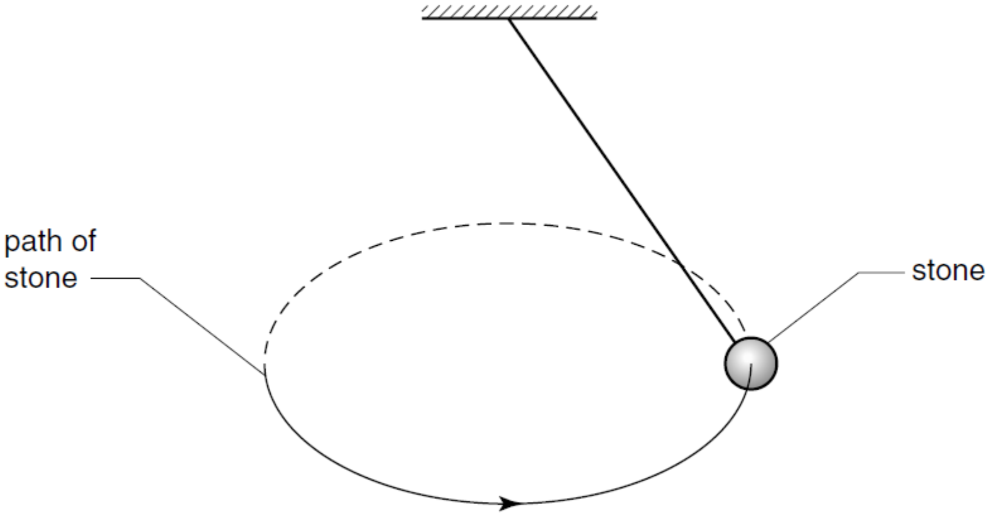

Fig. 4.2

The string makes an angle of 35° to the vertical, as illustrated in Fig. 4.3.

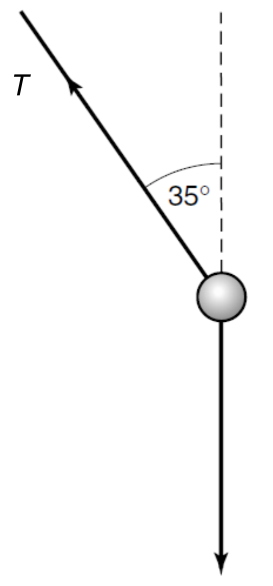

Fig. 4.3

Determine

(i) the tension T in the string, and

tension = …………………………………. N [1]

(ii) the resultant force acting on the stone in the position shown.

magnitude of force = …………………………………. N

direction of force = …………………………………. [2]

For Examiner's Use

5 A cycle of changes in pressure, volume and temperature of gas inside a cylinder of a petrol engine is illustrated in Fig. 5.1. The gas is assumed to be ideal.

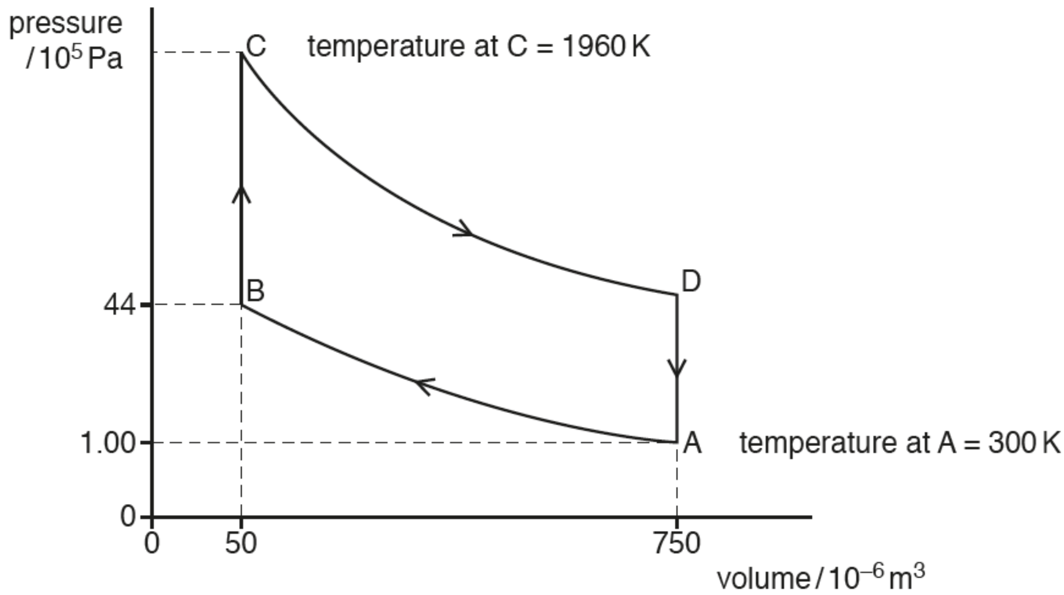

Fig. 5.1 (not to scale)

There are four stages in the cycle.

stage	description
A to B	Rapid compression of the gaseous petrol/air mixture with the temperature rising from 300 K at A and the pressure rising to 44×10^5 Pa at B.
B to C	The petrol/air mixture is exploded, resulting in an almost instant rise in pressure. At C the temperature has risen to 1960 K.
C to D	Rapid expansion and cooling of the hot gases.
D to A	Return to the starting point of the cycle.

(a) (i) State what is meant by an *ideal gas*.

....

....

....[2]

For Examiner's Use

(ii) Use the values in Fig. 5.1 to determine the number of moles present in the gases in the cycle.

number of moles = ... moles [2]

(b) Complete the table in Fig. 5.2 showing the work done on the gas, the heat supplied to the gas and the increase in the internal energy of the gas, during the four stages of one cycle.

stage	work done **on** gas /J	heat supplied **to** gas /J	**increase** in internal energy of gas / J
A to B	+ 360	0	
B to C		+ 670	
C to D		0	− 810
D to A			

[4]

Fig. 5.2

(c) Explain qualitatively how molecular movement causes the fall in temperature of the gas during the stage from C to D.

....

....

....

....

....[2]

6 **(a)** An alternating voltage of period 10 ms is being applied directly across a resistor of 5.0 Ω in a circuit. The variation with time *t* of voltage *V* is shown in Fig. 6.1.

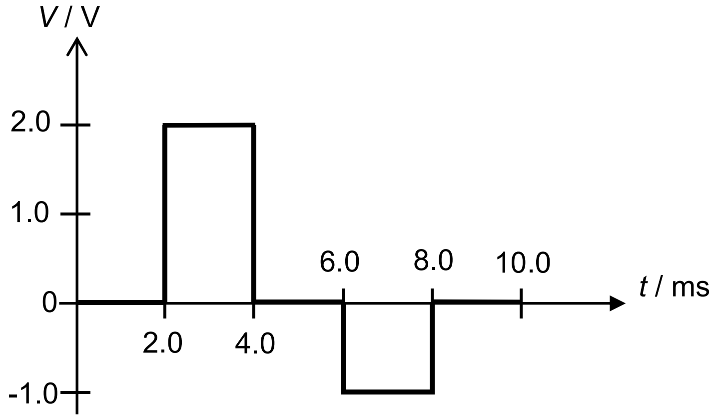

Fig. 6.1

Calculate the steady voltage passing through the same resistor that would produce an identical heating effect.

voltage = ... V [2]

(b) Explain why it is necessary to use high voltages for the efficient transmission of electrical energy.

....

....

....[2]

For Examiner's Use

(c) Another sinusoidal voltage input of 6.5 mV r.m.s. and 50 Hz is now connected to the primary coil of a transformer as shown in Fig. 6.2. The transformer is assumed to be ideal and its turns ratio, $\frac{N_s}{N_p}$ is 71. The secondary coil is connected to a resistor *R*. An average power of 0.040 W is produced in resistor *R*.

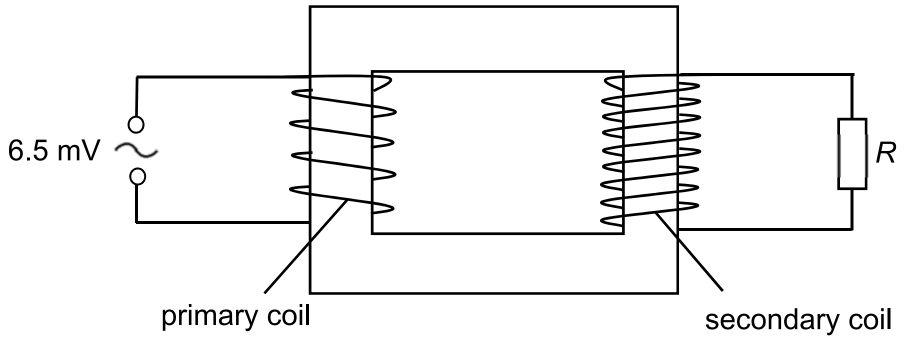

Fig. 6.2

(i) Calculate the r.m.s output voltage supplied to resistor *R*.

r.m.s. voltage = …………………. V [1]

(ii) In Fig. 6.3, sketch the variation with time *t* of the power *P* dissipated in the resistor *R.* Label all values on the axes. [2]

Fig. 6.3

For Examiner's Use

(iii) An ideal diode is now connected to the secondary coil with resistor *R* as shown in Fig. 6.4.

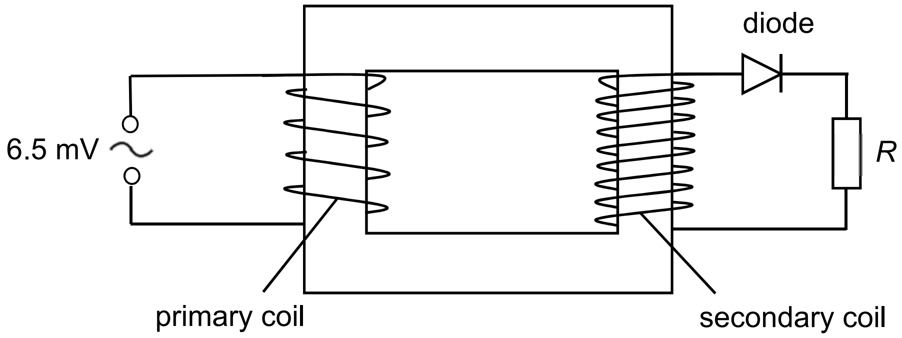

Fig. 6.4

Describe the variation with time of the

1. current flow through resistor *R*, and

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

2. voltage across resistor *R*.

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

Section B

Answer **one** question from this Section in the spaces provided.

7 **(a)** Distinguish between the *electromotive force* and the *potential difference* in terms of energy considerations.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

(b) Felix connects a voltmeter, of resistance R_V, and an ammeter, of resistance R_A, as shown in Fig. 7.1 to measure the resistance R of a resistor. V is the voltmeter reading, I is the ammeter reading and E is the e.m.f. of the cell.

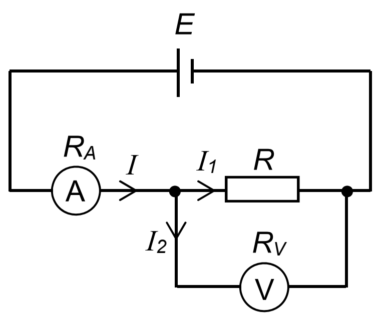

Fig. 7.1

(i) Derive an expression for the value of R in terms of I, V and R_V.

expression = …………………… [2]

(ii) Felix rearranges the circuit and connects the voltmeter and ammeter as shown in Fig. 7.2 to measure the same resistance R.

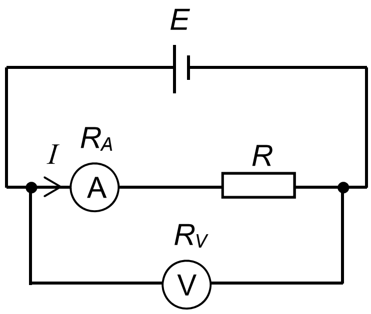

Fig. 7.2

Derive an expression for the value of R in terms of I, V and R_A.

expression = …………………… [2]

(iii) Hence, suggest what the values of R_V and R_A should be such that the value of R is equal to $\frac{V}{I}$.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………[2]

For Examiner's Use

(c) Felix set ups a potentiometer circuit as shown in Fig. 7.3. The resistivity of wire AB is 1.4×10^{-6} Ω m, with a length of 1.1 m and a circular cross-section of radius 0.304 mm. The 2.2 V and 1.8 V cells have internal resistances of 0.30 Ω and 1.1 Ω respectively.

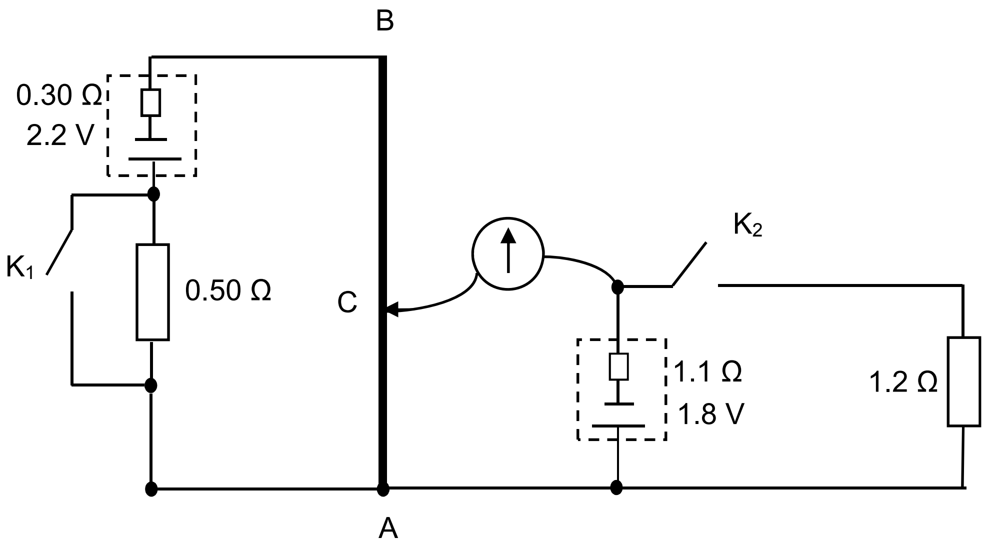

Fig. 7.3

(i) Determine the resistance of wire AB.

resistance = ... Ω [2]

(ii) **1.** Calculate the length AC required to produce zero current in the galvanometer with switch K_1 open and switch K_2 closed.

length = ... cm [2]

For Examiner's Use

2. State and explain the change in length, if any, in your answer to **(ii) 1.**, if both switches K_1 and K_2 are open.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………[2]

(iii) When both switches K_1 and K_2 are closed and there is zero current in the galvanometer,

1. calculate the power dissipated across wire AB and

power = ... W [2]

2. calculate the mean drift velocity v of the electron, if the number of electrons in one cm^3 of wire AB is 10^{23}.

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

(d) During his course of study in Physics, Felix comes across an electrical component. The variation with potential difference V of current I for the component is shown in Fig. 7.4.

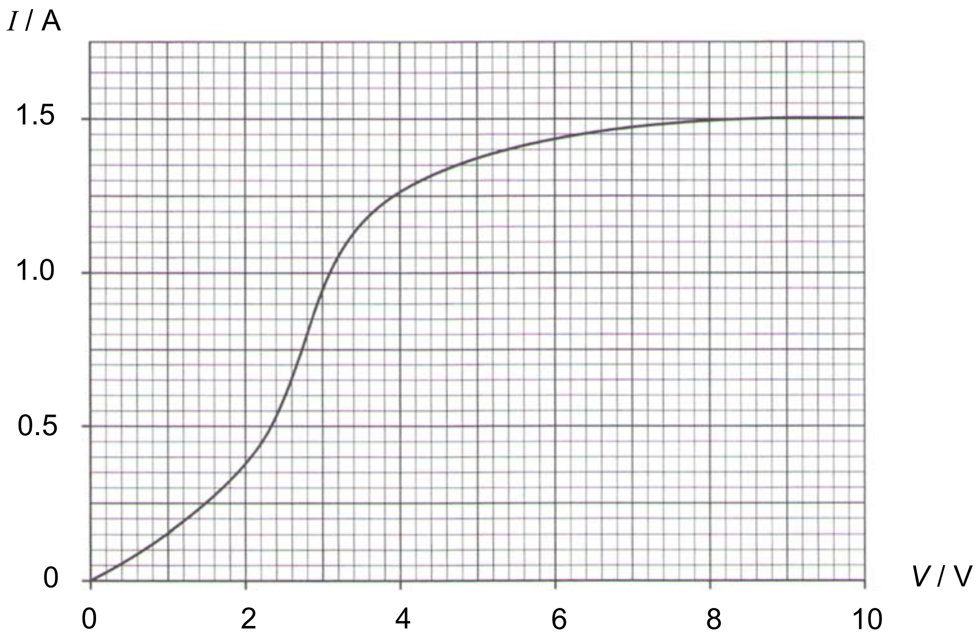

Fig. 7.4

(i) Use Fig. 7.4 to determine the resistance of the component at 3.4 V.

resistance = ... Ω [1]

(ii) Describe how the resistance of this component changes with the potential difference applied across it from 0 V to 6.0 V.

....

....

....

.... [2]

8 **(a)** Fig. 8.1 shows an α-particle A as it approaches and passes by a stationary gold nucleus N.

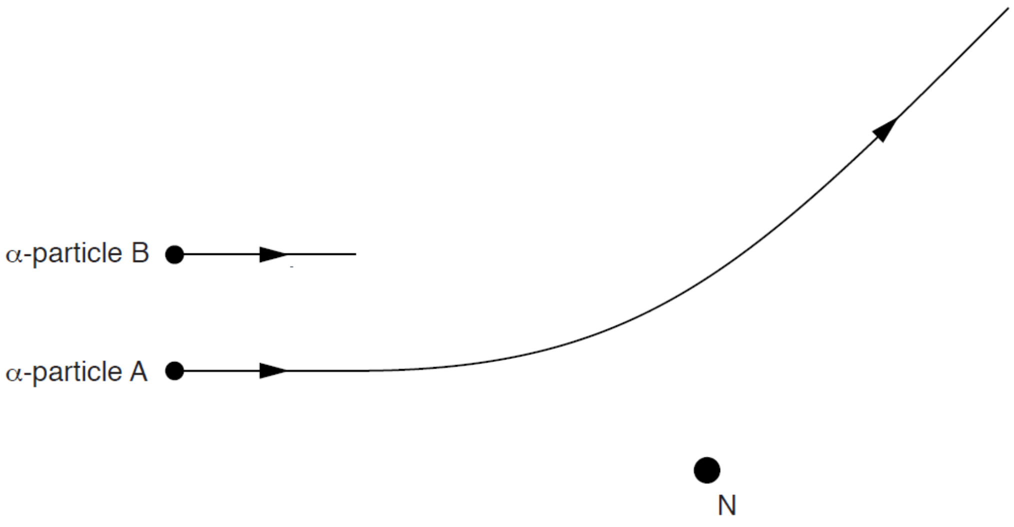

Fig. 8.1

A second α-particle B has the same initial direction and energy as α-particle A.

On Fig. 8.1, complete the path of α-particle B as it approaches and passes by the nucleus N. [2]

(b) An alpha particle has a speed of 1.30×10^7 m s^{-1}.

(i) Calculate the kinetic energy of the alpha particle.

kinetic energy = ... J [2]

(ii) The alpha particle is aimed directly at a gold nucleus which has a proton number of 79.

Calculate the distance of closest approach *r*.

r = ... m [3]

For Examiner's Use

(c) A radiation detector is placed close to a radioactive source. The detector does not surround the source.

Radiation is emitted in all directions and, as a result, the activity of the source and the measured count rate are different.

Suggest two other reasons why the activity and the measured count rate may be different.

1. ……………………………………………………………………………………………..................

………...

2. ……………………………………………………………………………………………..................

……………………………………………………………………………………………………….. [2]

(d) The variation with time *t* of the measured count rate in **(c)** is shown in Fig. 8.2.

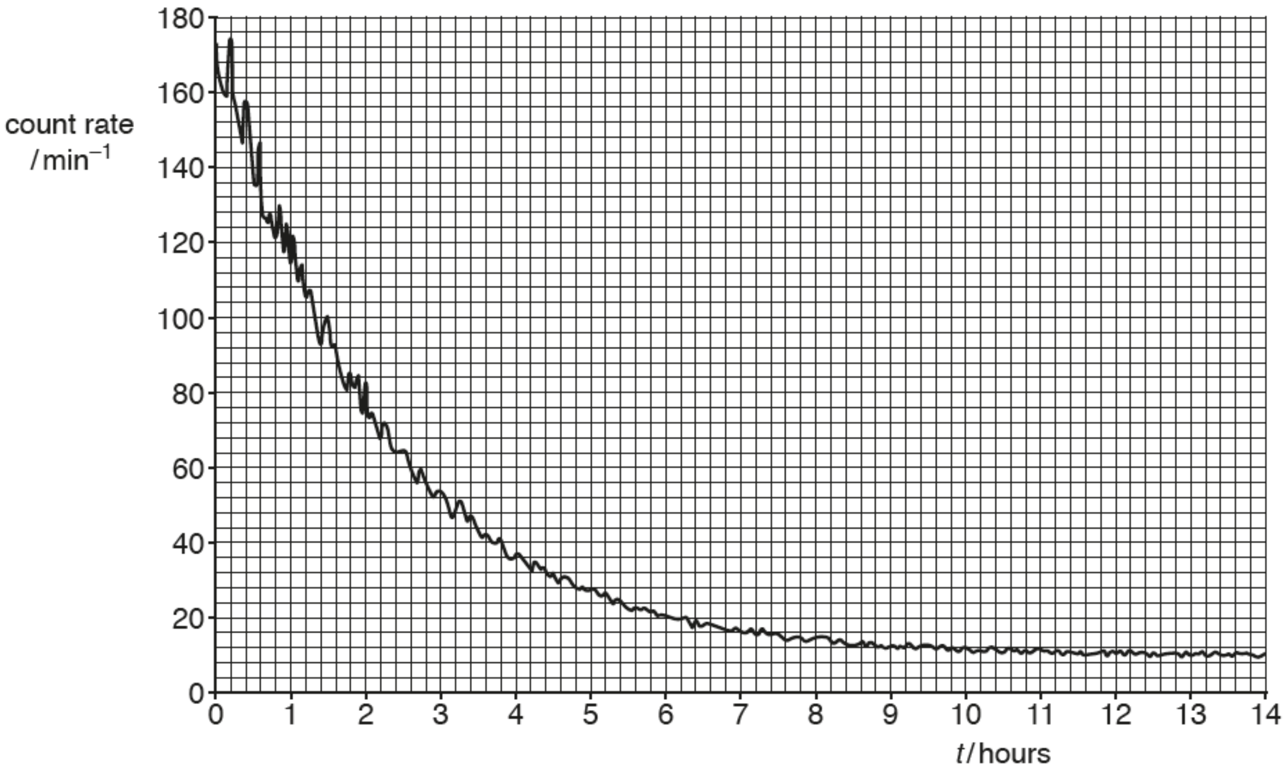

Fig. 8.2

(i) State the feature of Fig. 8.2 that indicates the random nature of radioactive decay.

……………………………………………………………………………………………...............

……………………………………………………………………………………………........ [1]

For Examiner's Use

(ii) Use Fig. 8.2 to determine the half-life of the radioactive isotope in the source.

half-life = ... hours [4]

(e) The readings in **(d)** were obtained at room temperature. A second sample of this isotope is heated to a temperature of 500 °C. The initial count rate at time t = 0 is the same as that in **(d)**. The variation with time t of the measured count rate from the heated source is determined.

State, with a reason, the difference, if any, in

1. the half-life,

……………………………………………………………………………………………………...

……………………………………………………………………………………………………...

……………………………………………………………………………………………………...

2. the measured count rate for any specific time.

……………………………………………………………………………………………………...

……………………………………………………………………………………………………...

…………………………………………………………………………………………………... [3]

For Examiner's Use

(f) A small volume of solution containing the radioactive isotope sodium-24 ($^{24}_{11}Na$) has an initial activity of 3.8×10^4 Bq. Sodium-24, of half-life 15 hours, decays to form a stable daughter isotope.

All of the solution is poured into a container of water. After 36 hours, a sample of water of volume 5.0 cm^3, taken from the container, is found to have an activity of 1.2 Bq.

Assuming that the solution of the radioactive isotope is distributed uniformly throughout the container of water, calculate the volume of water in the container.

volume = ... cm^3 [3]

END OF PAPER

For Examiner's Use

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Dunman High School 2018 Year 6 Prelim Exam H2 Physics Answers

Paper 1

1 **C**	2 **D**	3 **A**	4 **D**	5 **D**	6 **D**	7 **C**	8 **C**	9 **C**	10 **C**
11 **A**	12 **A**	13 **C**	14 **D**	15 **C**	16 **D**	17 **B**	18 **A**	19 **D**	20 **A**
21 **B**	22 **B**	23 **B**	24 **B**	25 **B**	26 **B**	27 **A**	28 **C**	29 **C**	30 **B**

Paper 2

1 **(a)** **(i)** atmospheric pressure = 9.10×10^4 Pa A1

(ii) $(9.15 – 9.10) \times 10^4 = \rho_m \times 9.81 \times (0.17 – 0.10)$ C1

$\rho_m = 728$ kg m^{-3} A1

(b) **(i)** pressure at top surface of cube = 9.135×10^4 Pa (from graph)

pressure at bottom surface of cube = 9.180×10^4 Pa (from graph) C1

Upthrust = $(9.180 – 9.135) \times 10^4 \times (0.051)^2$ C1

= 1.17 N A1

(ii) force = 4 – 1.17 = 2.83 N A1

(c) Remove the cube and check if spring returns to original length B1

(d) **(i)** free body diagram of upper ball, three forces: 1. weight, 2. horizontal force by wall on ball and 3. force by lower ball on upper ball.

Angle is 45° between horizontal and the dotted line.

So tan(45°) = (horizontal force) / (weight) C1

Horizontal force = weight = 1.67 N A1

OR taking moment about axis through point of contact between the balls:

Same moment arm C1

Hence *F* = weight of ball = 1.67 N A1

(ii) $F = \sqrt{(1.67^2 + 1.67^2)}$ C1

= 2.36 N A1

2 **(a)** $g = (6.1 \pm 0.1)$ N m^{-1} C1

Force = $mg = 6.1 \times 20000$

= (122 000 ± 2000) N A1

(b) $F = \frac{mv^2}{r}$ or $g = \frac{v^2}{r}$ C1

$v = \sqrt{(6.1 \times (8.2 \times 10^6)}$

$= (7.1 \pm 0.1) \times 10^3$ m s^{-1} A1

(c) **(i)** The gravitational potential at a point is defined as the <u>work done per unit mass</u> in bringing a <u>small test mass</u> from infinity to that point. B1

(ii) $\phi = -\frac{GM}{r} = -gr$ C1

$= – (4.0 \pm 0.1) \times 10^7$ J kg^{-1} A1

OR

recognizes that this is the <u>area under the graph</u> <u>from point to infinity</u> B1

counting squares gives total area $= – (4.0 \pm 2.0) \times 10^7$ J kg^{-1} B1

3 **(a)** **(i)** *g* and *r* are constant, so *a* is proportional to *x* B1

negative sign shows *a* and *x* are in opposite direction B1

(ii) $\omega^2 = \frac{g}{r}$ and $\omega = \frac{2\pi}{T}$ C1

$\omega^2 = \frac{9.81}{0.28} = 35$

T = 1.06 s M1

τ = 0.53 s A1

(b) Sketch: time period constant (or increases very slightly) B1

drawn lines always 'inside' given loops, up to given time duration B1

successive decrease in peak height B1

4 (a) (i) $\tan\theta = \frac{38}{165}$

$\theta = 13^o$ C1

$d \sin\theta = n\lambda$

$d = 2.82 \times 10^{-6}$ m C1

number per metre = $\frac{1}{d}$ = 3.6 x 10^5 m^{-1} A1

(ii) Lines further apart in second order, B1

Lines fainter in second order, B1

(if differences stated but without reference to the orders, max 1 mark)

(b) (i) P remains in same position B1

X and Y rotate through 90° B1

(ii) either screen not parallel to grating or grating not normal to incident light B1

5 (a) (i) a region in which a charge will experience a force B1

electric force exerted per unit positive charge placed at that point B1

(ii) $E = \frac{Q}{4\pi\varepsilon_o r^2} = \frac{5.2 \times 10^{-7}}{4\pi\varepsilon_o (0.25)^2}$ B1

$= 7.48 \times 10^4$ A1

unit: N C^{-1} or V m^{-1} B1

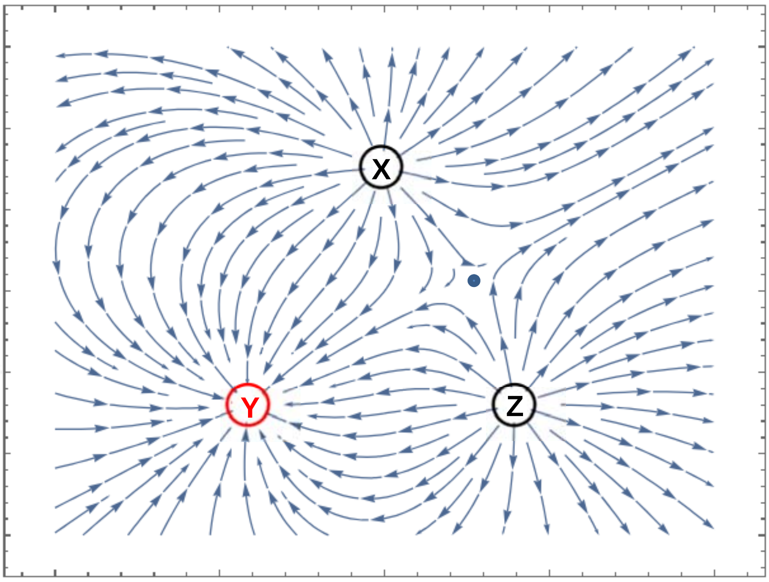
(b) lines <u>perpendicular to surface</u> going into negative charge and leaving positive charge for all charges B1

neutral point indicated consistent with field lines B1

basic pattern correct (field lines <u>near</u> each charge are <u>radial</u> <u>spherically symmetrical</u>) and <u>fills rectangle</u> B1

no crossing/joining of lines B1

max 3



6 (a) Magnetic field due to current in wire B is normal to the current in wire A, and pointing into plane of paper. By Fleming's left hand rule, this causes a magnetic force to be exerted on wire A towards wire B. B1

Based on Newton's 3rd law, a magnetic force is also exerted on wire B by wire A which is of the same magnitude but opposite in direction, giving rise to an attractive force between both wires. B1

(b) (i) $B = \frac{\mu_0 I_A}{2\pi d}$

$= \frac{4\pi \times 10^{-7}(90)}{2\pi(0.50)}$

$= 3.6 \times 10^{-5}$ T M1

$Bqv \sin 90^0 = \frac{mv^2}{r}$ M1

$r = \frac{mv}{Bq} = \frac{(1.67\times10^{-27})(1.0\times10^{3})}{(3.6\times10^{-5})(1.6\times10^{-19})}$

$= 0.29$ m A1

(ii) As proton is nearer to wire A, B increases ($B \alpha \frac{1}{r}$) and radius decreases due to the increasing magnetic force ($F = Bqv \sin\theta$). B1

Eventually at the nearest location to wire, the velocity of proton is parallel to wire, therefore force is directed away from wire, radius is smallest and proton is turned back. B1

B decreases further from wire A and radius increase due to decreasing *F*. B1

7 (a) (i) EM produced whenever charged particle is suddenly accelerated/ decelerated at the metal target (and wavelength depends on magnitude of acceleration) M1

Electrons hitting the metal target have a range/distribution of accelerations A1

(ii) All kinetic energy of one electron given up in one collision to produce a single X-ray photon. B1

Minimum wavelength for maximum energy Or $\lambda_{min} = hc/E_{max}$ B1

So independent of target metals (only depend on accelerating voltage) A0

(b) (i) More likely (higher probability) for electrons at the next higher level to drop down to fill up the hole, so higher intensity for K_α A1

(ii) At low voltages, the energy of electrons (25 keV) is not sufficient B1

to knock electrons out of the inner shells of the tungsten atom B1

So no characteristic X-rays produced by de-excitation. A0

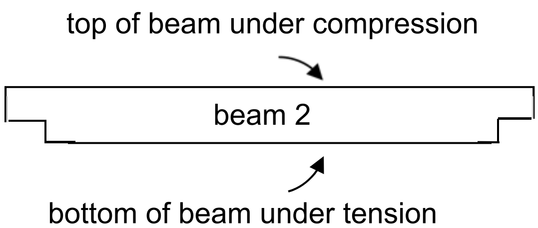
(c) $E = \frac{hc}{e\lambda} = \frac{(6.63\times10^{-34})(3\times10^{8})}{(1.6\times10^{-19})(6.6\times10^{-11})}$ M1

$= 1.88 \times 10^4$ eV A1

8 (a) It is the number of trains arriving at a station per unit time. A1

(b) Aluminium alloy has high strength-to-weight ratio, thus reduces the amount of friction by reducing the weight of the trains. It has high corrosion resistance. Aluminium's natural passivation process in which a thin aluminium oxide layer forms when the metal is exposed to oxygen, reduces the possibility of further oxidation. A1

(c) (i)



Correct labelling of compression and tension A1

(ii) Total normal reaction forces = $(350 + 380) \times 10^3$
= 730×10^3 N A1

(iii) Total load column 1 has to take = 730×10^3 N A1

(iv) Total load ground has to take = $(730 + 100) \times 10^3$ M1
= 830×10^3 N A1

(d) **(i)** Coordinate (4.3, 922) is treated as anomaly. Best fit line drawn through the rest of the seven points. A1

(ii) Gradient of line $= \dfrac{1040 - 916}{5.00 - 4.40}$ M1
= 207×10^3 N m^{-2} A1

(iii) Factor of safety = $\dfrac{645 \times 10^3}{207 \times 10^3}$
= 3.12 M1
Since factor of safety is greater than 2.9, it is safe. A1

(e) **(i)** Applied load = $(207 \times 10^3)\pi(\dfrac{2.5}{2})^2$ M1
= 1016×10^3 N A1

(ii) Total allowable weight of passengers = $(1016 - 830) \times 10^3$
= 186×10^3 N A1

(iii) Total allowable number of passengers per car = $(\dfrac{186 \times 10^3}{60 \times 10})$ M1
= 310 A1

(f) Number of passengers a car can take when train arrives at station
= $0.25 \times 310 = 77.5$ C1
Total number of passengers train can take = 77.5×6
= 465 M1
Longest time interval between train arrivals = $(\dfrac{465}{240})$
= 1.94 minutes A1

Paper 3

1 Consider a ream (500 sheets) of A4 papers (70 or 80 gsm).
Thickness of 1 ream ≈ 5 cm, so thickness of one piece ≈ 0.01 cm ≈ 0.1 mm.
Area of A4 paper ≈ 200 x 300 = 60,000 mm^2 = 0.06 m^2

(a) **(i)** 0.05 – 0.15 mm A1

(ii) 4 – 5 g A1

(b) time = $\dfrac{0.15 \times 10^{12}}{3.00 \times 10^8}$ C1
= 500 s = 8.3 min A1

(c) **(i)** SI units for *T*: s, *R*: m and *M*: kg (or seen in formula) C1
$K = \dfrac{T^2 M}{R^3}$ units of $K = \dfrac{s^2 kg}{m^3}$ A1

(ii) $K = \dfrac{(86400)^2(6 \times 10^{24})}{(4.23 \times 10^7)^3} = 5.918 \times 10^{11}$ C1
$\dfrac{\Delta K}{K} = 2\dfrac{0.5}{100} + 3\dfrac{1}{100} + \dfrac{2}{100} = 0.06$ C1
$\Delta K = 0.355 \times 10^{11}$

$K = (5.9 \pm 0.4) \times 10^{11}$ (SI units) A1
(incorrect % value, then max 1 mark)
OR, $K_{max} = 6.283 \times 10^{11}$, $\Delta K = K_{max} - K = 0.365 \times 10^{11}$
$K_{min} = 5.57 \times 10^{11}$, $\Delta K = \frac{1}{2}(K_{max} - K_{min}) = 0.355 \times 10^{11}$

(iii) R, as this has the largest fractional uncertainty. B1

2 **(a)** 15 m s^{-1} A1
(b) constant gradient (straight line graph) A1
(c) **(i)** 1.55 s A1
(ii) distance = area under the graph from 0 to 1.55 s
=½ (15)(1.55) M1
= 11.6 m
= 12 m A0
(iii) distance = ½ (25)(4.1 – 1.55) – 11.6 C1
= 31.875 – 11.6
= 20 m A1

(d) displacement is the <u>straight line / minimum distance</u> between the start and finish points in that direction. B1
distance is the <u>actual total</u> path travelled by the ball. B1

(e) Smooth curve with decreasing gradient until <u>zero</u> at terminal velocity B1
gradient of the curve at x-intercept (0 m s^{-1}) = gradient of the straight line and the curve crosses the x-axis before 1.55 s. B1

3 **(a)** **(i)** force is the rate of change of momentum B1

(ii) Force from B on body A is <u>equal in magnitude but opposite in direction</u> to force on B from A (forces act on different bodies) B1
Forces are of the <u>same type</u> B1

(b) **(i)** maximum force = $(210 \times 10^{-9}) \times (138 \text{ to } 145) \times 9.81$ C1
= 2.84×10^{-4} to 2.99×10^{-4} N A1
(ii) Initial speed ~ 0 C1
Maximum speed = the area under the $a - t$ graph C1
= 1.20 to 1.32 m s^{-1} A1
(iii) ground (and Earth) <u>gain momentum</u> M1
In <u>equal and opposite to the change</u> for the flea, so <u>momentum conserved</u> B1

4 **(a)** **(i)** angle subtended at centre of circle B1
(by) arc equal in length to the radius B1
(ii) arc = $r\theta$ and for one revolution, arc ≡ π (diameter) = $\pi(2r)$ M1
so, $\theta = \pi(2r) / r = 2\pi$ A0
(b) **(i)** point S shown vertically below C B1
(ii) [(max) force / tension – weight] provides the centripetal force C1
$18 - 3 = m r \omega^2 = (3 / 9.81)(0.85)\omega^2$ C1
$\omega = 7.6$ rad s^{-1} A1
(c) **(i)** vertically no net force, $T \cos 35^{o} = 3.0$, $T = 3.7$ N A1
(ii) resultant is horizontal component of tension
$3.7 \sin 35^{o} = 2.1$ N A1
horizontally towards the left B1

5 **(a)** **(i)** obeys the law pV/T = constant <u>or</u> any <u>two</u> named gas laws M1
at all values of p, V and T A1
<u>or</u> two correct assumptions of kinetic theory of ideal gas B1

third correct assumption B1

(ii) ($pV = nRT$ gives) $(1.00 \times 10^5)(750 \times 10^{-6}) = n(8.31)(300)$ B1

$n = 0.030$ A1

(b)

	work done on gas / J	heat supplied o gas / J	increase in internal energy of gas / J
A to B	+360	0	+360 &
B to C	0 $	+670	+670 $
C to D	-810 &	0	-810
D to A	0 @	-220 @	-220 #

&: first and third line correct B1

$: second line correct B1

#: −220 correct in right hand column B1

@: other two figures correct in last line B1

(c) the gas molecules bounce off the receding piston at lower <u>speeds</u> B1

there is a decrease in <u>kinetic energy</u> of the molecules B1

6 (a) $V_{r.m.s.} = \sqrt{\dfrac{2^2(0.002) + 1^2(0.002)}{0.01}}$ M1

$= 1.0$ V A1

Steady voltage of 1 V will produce the same heating effect as $V_{r.m.s.}$ of 1 V.

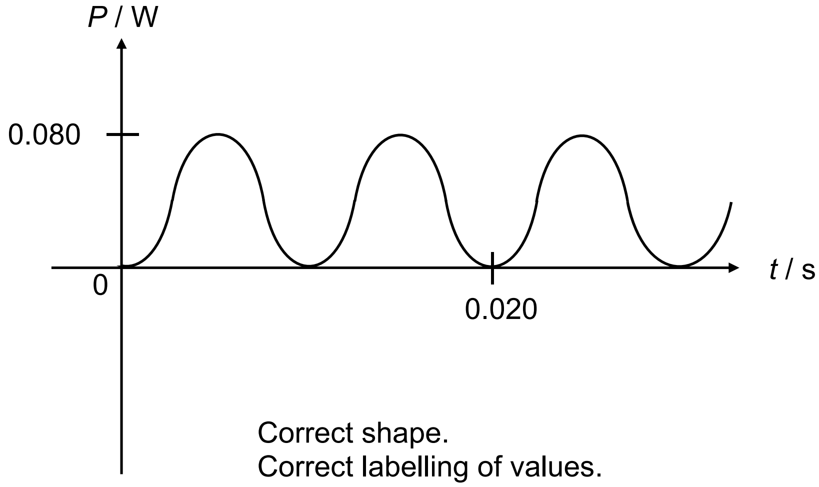
(b) Transmission of electrical energy at high voltage means that the current is low according to $P = IV$. B1

Power loss through joule heating (I^2R) is hence lowered as less electrical energy is dissipated as heat in the cables of resistance R. B1

(c) (i) $\dfrac{V_s}{V_p} = \dfrac{N_s}{N_p}$

$V_s = 71 \times 6.5 \times 10^{-3} = 0.46$ V A1

(ii)



Correct shape. B1

Correct labelling of values. B1

(iii) 1. In the forward biased direction, the diode has no resistance. <u>Current flows downwards through resistor R</u>. A1

In the reverse biased direction, diode has infinite resistance. There is no current flowing through resistor R. A1

2. In the forward biased direction, there is a <u>half-wave sinusoidal voltage</u> output across resistor R, having the same frequency as that of the input voltage. In the reverse biased direction, there is no voltage output across resistor R. A1

7 **(a)** Electromotive force is the work done in transforming non-electrical energy into electrical energy per unit charge passing through the terminals of the source. B1
Potential difference is the amount of electrical energy transformed per unit charge to some other forms of energy when the charge passes from one point to the other. B1

(b) **(i)** Since $I = I_1 + I_2$,

$$I = \frac{V}{R} + \frac{V}{R_V} \qquad \text{M1}$$

$$\frac{1}{R} = \frac{I}{V} - \frac{1}{R_V}$$

$$R = \frac{R_V V}{IR_V - V} \qquad \text{A1}$$

(ii) $V = IR + IR_A$ M1

$$\frac{V}{I} = R + R_A$$

$$R = \frac{V}{I} - R_A \qquad \text{A1}$$

(iii) For $R = \frac{V}{I}$, $R_V >> R$ and $R_A << R$. Hence, R_V should be infinite, A1

and R_A should be equal to zero. A1

(c) **(i)** $R = \rho \frac{l}{A}$

$$R = 1.4 \times 10^{-6} \times \frac{1.1}{\pi(0.304 \times 10^{-3})^2} \qquad \text{M1}$$

$R = 5.30\ \Omega$ A1

(ii) **1.** $\frac{l}{110} \times \frac{5.3}{5.3 + 0.30 + 0.50} \times 2.2 = \frac{1.2}{1.2 + 1.1} \times 1.8$ M1

$l = 54.0$ cm A1

2. E.m.f. of cell is larger than the terminal p.d. of cell M1
length AC will increase. A1

(iii) **1.** $I = \frac{V}{R} = \frac{2.2}{(0.3 + 5.3)}$ M1

$= 0.3929$ A

$P = I^2 R = (0.3929)^2 (5.30) = 0.818$ W A1

2. $I = Anve$

$0.3929 = \pi(0.304 \times 10^{-3})^2 (10^{29}) v (1.6 \times 10^{-19})$

$v = 8.46 \times 10^{-5}$ m s^{-1} A1

(d) **(i)** $R = \dfrac{3.4}{1.125}$ = 3.02 Ω A1

(ii) As the potential difference (p.d.) increases from 0 V to 3.4 V, the ratio of *V* to *I* decreases, hence resistance decreases. B1
As the p.d. increases from 3.4 V to 6.0 V, the ratio of *V* to *I* increases. Hence, resistance increases during this interval. B1

8 **(a)** smaller deviation (not zero deviation) M1
acceptable path wrt position of N A1

(b) **(i)** mass of alpha particle = $4 \times 1.66 \times 10^{-27}$ kg B1
(kinetic energy = $0.5 \times 4 \times 1.66 \times 10^{-27} \times (1.30 \times 10^{7})^{2}$ J A1

(ii) all the kinetic energy becomes electrical potential energy B1
$5.61 \times 10^{-13} = Q_{\alpha}Q_{Au} / 4\pi\varepsilon_0 r = (2e)(79e) / 4\pi\varepsilon_0 r$ C1
$r = 6.48 \times 10^{-14}$ m A1

(c)

- emission from radioactive daughter products
- self-absorption in source
- absorption in air before reaching detector
- detector not sensitive to all radiations
- window of detector may absorb some radiation
- background radiation

Any two points. B2

(d) **(i)** curve is not smooth or curve fluctuates/curve is jagged B1
(ii) clear evidence of allowance for background B1
half-life determined at least twice B1
half-life = 1.5 hours A2
(2 marks if in range 1.4 – 1.6; 1 mark if 1.6 < half-life ≤ 2.0)

(e) **1.** half-life: no change M1
because decay is spontaneous/independent of environment A1
2. count rate (likely to be or could be) different / is random / cannot be predicted B1

(f) activity = $(3.8 \times 10^{4})\, e^{(-\ln 2 / 15)(36)}$ C1
or activity = $(3.8 \times 10^{4})\,[1 / 2^{2.4}]$ (C1)
= 7200 Bq A1
volume = $(7200 / 1.2) \times 5.0 = 3.0 \times 10^{4}$ cm^{3} A1
or activity of 5.0 cm^{3} = $1.2 \times 2^{2.4}$ (C1)
= 6.3336 Bq (C1)
volume = $(3.8 \times 10^{4} / 6.3336) \times 5.0 = 3.0 \times 10^{4}$ cm^{3} (A1)

Paper 4

Qns			Skills Assessed and Marking Instructions	M
1	**b**	**(ii)**	Value of *d* to nearest mm.	1
		(ii)	Evidence of repeated measurements of *d*.	1

		(iii)	Absolute uncertainty in the range of 2 mm to 10 mm (1 s.f.). Percentage uncertainty calculated correctly. Percentage uncertainty in 2/3 s.f.	1
	c	**(ii)**	Value of h to nearest mm.	1
			Value of t in s and must be between 0.1 to 10 s	1
	d		Terminal velocity calculated correctly with unit	1
	f		Measurement and record of second value of d_2. Value of second t (t_2). Correct calculation of second v_2. Quality of result: smaller d gives greater v. Determination of a constant of proportionality k (two values of k where $k = vd$) Draw conclusion based on the calculated values of k. Candidate must test against a specified criterion (e.g. 20% difference in values of k, with reference to the uncertainty calculated *(b)(iii)*).	1 1 1 1 1
	g		Terminal velocity may not be reached at short distance, - Increase height - Measure velocity at two points to check terminal velocity reached Much faster velocity - Use light gate to trigger stopwatch to eliminate human reaction error in timing Take more readings and plot a graph to check relationship Or other valid improvement. Max: 3 marks.	 1 1 1 1

Qns			Skills Assessed and Marking Instructions	M
2	**a**	**(iii)**	Value of θ to the <u>nearest degree</u>, with unit.	1
		(iv)	cos θ calculated correctly	1
		(v)	Answer must relate sf in θ to sf in cos θ Do not allow vague answers that are given in terms of ‘raw data’	1
	b	**(iii)**	Value of T with unit. The number of oscillations n taken such that $n\ T_1$ > 10 s. Evidence of repeats.	1 1

	c		Value of *k* calculated correctly with correct unit, s^{-4}.	1
	d		Measurement of L, the value should be in the range 40 cm ± 2 cm.	1
			Correct method of working to give a value of *g* in the range 7.5 to 12.5 m s^{-2}.	1
			Correct unit of *g*	1

Qns			Skills Assessed and Marking Instructions		M
3	b	(i)	*V* and *I* recorded with unit.		1
		(ii)	Resistance of LDR calculated correctly And greater than 1 kΩ and less than 100 kΩ.		1
	c		• Award 2 marks if student has successfully collected 6 or more sets of data (*V, I*) without assistance/intervention. 5 sets one mark. 4 or fewer sets zero mark. • Deduct 1 mark if minor help from supervisor, deduct 2 if major help. • Deduct 1 mark if wrong trend in *I* (or *R*).	C1	2
			Each column heading must contain a quantity and a unit where appropriate. Ignore units in the body of the table. There must be some distinguishing mark between the quantity and the unit i.e. solidus is expected, *I*/mA. Allow lg(*R*), lg(*R*/Ω) but not lg*R*/Ω.	C2	1
			Consistency of raw readings, *I* in mA and *V* in V only.	C3	1
			For each calculated value of *lg,* the number of d.p in calculated value should reflect the number of s.f. in the raw readings. All values must be given to an appropriate number of s.f. for this mark to be awarded.	C4	1
			Correctly calculated values of *R*, *lg(R) and lg(N)*.	C5	1
	d		Linearising equation and deriving expressions that equate e.g. gradient to b and *y*-intercept to lg(*a*), lg(*R*) = lg(*a*)+*b* lg(*N*).	D1	1
			Graph: Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed. Scales must be chosen so that the plotted points occupy at least half the graph grid in both *x* and *y* directions. Scales must be labeled with the quantity which is being plotted.	D2	1
			All observations must be correctly plotted. Work to an accuracy of half a small square. Diameter of the plotted point must be less than half the small square.	D3	1
			Line of best fit – judge by scatter of points about the candidate's line. There must be a fair scatter of points either side of the line. Allow only one anomalous point if clearly indicated (i.e. labelled or circled) by the student.	D4	1
			Gradient – the hypotenuse of the Δ must be greater than half the length of the drawn line. Read-offs must be accurate to half a small square. Check for Δ*y*/Δ*x* (i.e. do not allow Δ*x*/Δ*y*). The value must be negative.	D5	1
			y-intercept – must be read off to nearest half a small square or determined from *y=mx+c* using a point on the line.	D6	1
			Values of *a* and *b* calculated correctly	D7	1
			Unit of *a*, no units of *b*	D8	1

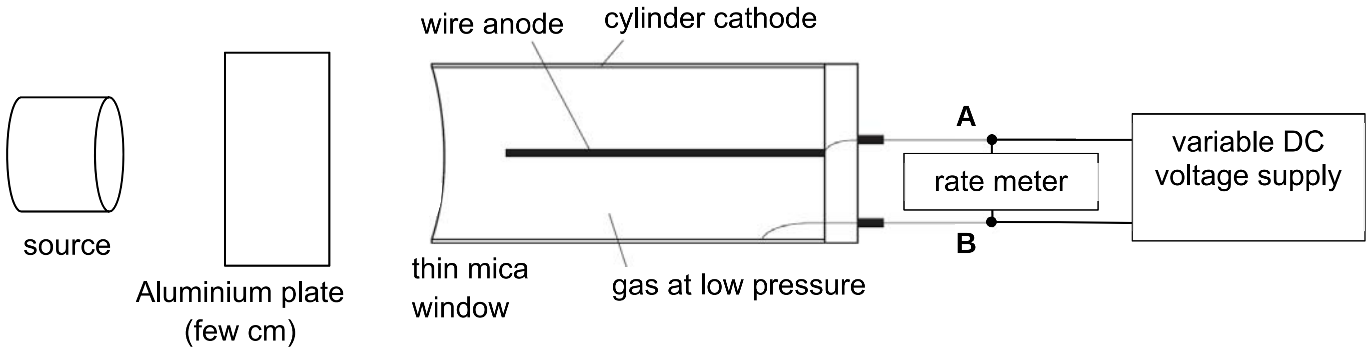
	e	**(i)**	Value of diameter, d = 1.10 mm ± 0.1 mm. Correct d.p. and unit.		1
		(ii)	Area is calculated correctly with unit.		1
		(iii)	Repeated readings of diameter of tube		1
	f		Value of R in range 100 – 1000 Ω.		1

4

Code	**Description**		
A	*Basic Procedure* ✓ Procedure OK (i.e. measure count rate and p.d.; change p.d. and measure new count rate for at least 6 sets of readings).	1	A1
	✓ Voltmeter shown in parallel with the GM tube or the variable DC power supply.	1	A2
	✓ Method of removing α or β radiation (depending on source used). Appropriate absorber is expected. ✓ Accept 'aluminium' or thin (a few mm) lead. ✓ Could be shown on the diagram. ✓ Allow electric or magnetic deflection.	1	A3
B	*Method of measuring Independent Variable/ source used* ✓ Radium or Cobalt source used	1	B1
B	*Method of measuring Dependent Variable* ✓ Ratemeter/scaler/datalogger-(connected to PC) connected to terminals A and B of GM.	1	B2
B	*Processing and Analyzing Experimental Data* ✓ Appropriate graph of the dependent variable (count rate) against the independent variable (potential difference V_{AB}) is to be plotted. (i.e. lg count rate against lg V_{AB})	1	B3
C	*Method of keeping Variables Constant (note: do NOT use control of variables)* ✓ Keep distance from source to GM tube constant/fixed/same, etc. ✓ Keep orientation of source to GM tube constant/same, etc.	1	C1
C	*Safety Aspect* ✓ use source handling tool/long tweezer/long tong. ✓ store source in lead lined box when not in use. ✓ do not point source at people/do not look directly at source. ✓ **Do not** allow 'protective clothing', 'lead suits', 'lead gloves', 'goggles', etc.	Max 2	C2 C3 C4
D	*Details in Procedure* ✓ Reason for choice of the source used. Answer must relate to half-life. This mark cannot be scored if B1 = 0 ✓ Repeat and take average readings (need to give reason: to allow for randomness of activity) ✓ Sensible value of p.d. applied to GM tube (i.e. 50 V to 1000 V). ✓ Subtract count rate due to background radiation. ✓ Aluminium sheets must be mm or cm thickness, Lead must be few mm ✓ Count-rate must be an order of magnitude higher than background count (preliminary / initial measurements)	Max 3	D1 D2 D3 D4 D5 D6
	Total	**12**	

Aim: To investigate how the count rate due to γ-radiation depends on the potential difference V_{AB}

Independent variable: Potential difference V_{AB}
Dependent variable: count rate due to γ-radiation



Procedure
1. Set up apparatus as shown in the diagram above.
2. Use the Cobalt-60 source source
    a. Half-life is sufficiently long to avoid a large change in activity during the experiment and is approximately constant
    b. Does not emit α-radiation, which is highly ionizing and hence toxic on close contact
    c. Place in front of the thin mica window at about 3 cm away.
    d. Place an aluminium plate of a few centimetre thickness between source and window to prevent α- and β- radiation from reaching the detector
3. Vary the potential difference supplied across points A and B
    a. Connect the output ends of a variable DC voltage supply to points A and B
    b. Obtain the supplied potential difference by reading off the output settings.
4. Measure the count rate across points A and B
    a. Connect the rate meter to points A and B.
    b. Read off the count rate from the display of the rate meter, C.
5. Repeat steps 3 and 4 for different outputs of potential differences, each time performing averaging for each potential difference.

Control variables:
1. Distance between source and mica window
    a. Secure the 2 in position using retort stands
2. Activity of source
    a. Keep to the same source so that the age of the source is approximately constant

Analysis
1. Assume $C = kV_{AB}^n$,
   where C is the count rate measured by the rate meter,
   V_{AB} the potential difference between points A and B,
   k and n are constants.
2. Taking logarithm on both sides of the equation, we obtain $\lg C = \lg k + n \lg V_{AB}$
3. The graph of against will be a straight line graph with y-intercept and gradient n if the equation is valid.

Safety
1. Handle the source with long tweezer.
2. Store source in lead-lined box when not in use.