SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

NAME			
CG		**INDEX NO.**	

PHYSICS 9749/01

Preliminary Examination **21st Sep 2018**
Paper 1 Multiple Choice **1 hour**

Additional Materials: OMS.

READ THIS INSTRUCTIONS FIRST

Write your name, civics group and index number in the spaces at the top of this page.

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.

There are **thirty** questions in this section. 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 OMS.

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.

For Examiners' Use	
MCQ	/ 30

DATA AND FORMULAE

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\frac{1}{36\pi} \times 10^{-9}$ 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}

DATA AND FORMULAE

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	$= \rho gh$
gravitational potential	ϕ	$= -\frac{GM}{r}$
temperature	T/K	$= T$/ºC + 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	$= Anqv$
resistors in series	R	$= R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R}$	$= \frac{1}{R_1} + \frac{1}{R_2} + \cdots$
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	$= \frac{\mu_0 I}{2\pi d}$
magnetic flux density 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	$= \frac{ln2}{t_{\frac{1}{2}}}$

Answer all questions.

1 The rate of heat flow, R, can be found using the equation

$$R = k\,A\,\frac{(T_2 - T_1)}{L}$$

where k is the thermal conductivity, A is the total cross sectional area of the conducting surface, and L is the thickness of conducting surface separating the 2 temperatures T_1 and T_2.

What is the SI base units for k?

A kg m s^{-3} K^{-1} **B** kg m s^{-2} K^{-1} **C** kg m s^{-3} **D** kg s^{-2} K^{-1}

2 With reference to Question 1, a student collected the following measurements to determine the rate of heat flow R of the object

L = (0.35± 0.05) mm
T_1 = (32.0 ± 0.5) °C
T_2 = (4.0 ± 0.5) °C

What is the fractional uncertainty in R?

A 0.11 **B** 0.14 **C** 0.16 **D** 0.18

3 A value for the acceleration of free fall on Earth is given as (10 ± 2) m s^{-2}.

Which statement is correct?

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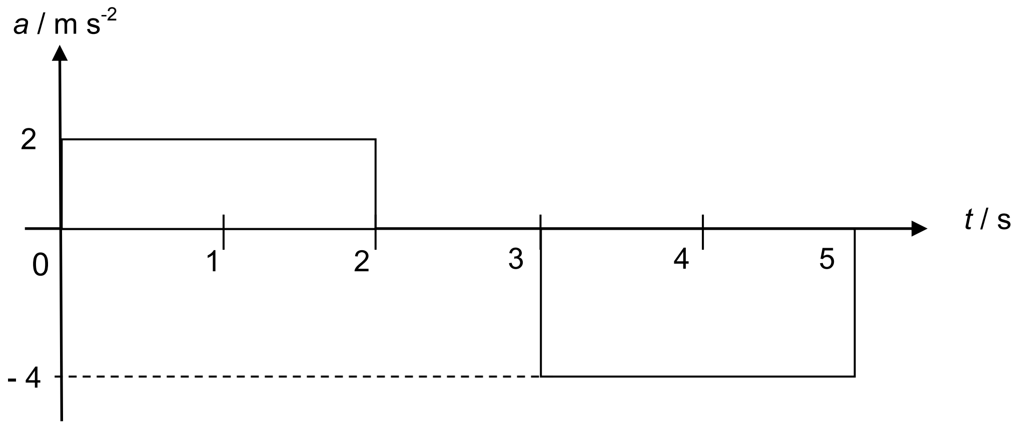
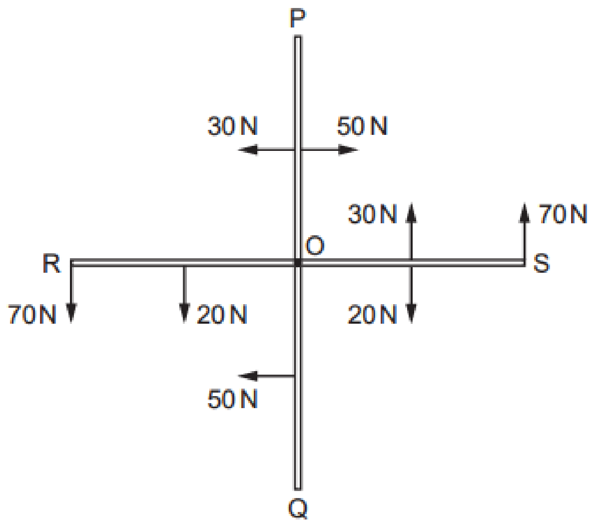


What is the total displacement of the car from the starting point at the end of 5 s?

A -4 m **B** 4 m **C** 8 m **D** 12 m

5 A rigid cross-shaped structure having four arms PO, SO, QO and RO, each 1.80 m long, is pivoted at O. Forces act on the ends of the arms and on the midpoints of the arms as shown.



What is the net moment about O?

A 54 N m **B** 108 N m **C** 216 N m **D** 432 N m

6 Forces 5 N, 12 N and 13 N act at a point which is in equilibrium.

What is the angle between the 5 N and 13 N force?

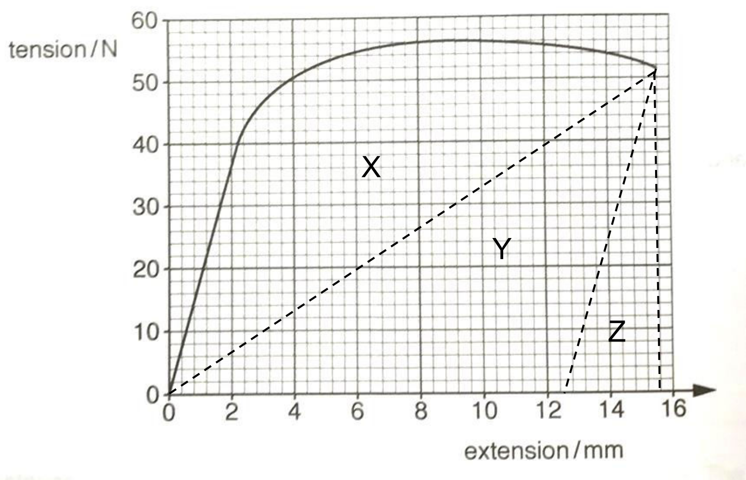
A 23° **B** 67° **C** 90° **D** 113°

7 A cube of sides 10 cm has a density of 7.8 g cm^{-3}. It floats vertically with one-eighth of its side exposed above the liquid surface.

What is the density of the liquid?

A 6.8 g cm^{-3} **B** 8.9 g cm^{-3} **C** 11.6 g cm^{-3} **D** 62.4 g cm^{-3}

8 The tension in a sample of wire varies with extension as shown in the diagram below.



The graph shows that the wire undergoes two types of deformation as it is extended to 15.6 mm. In the region where Hooke's law applies, the deformation is elastic and the wire will lose this deformation when the tension is released. In the region where Hooke's law does not apply, the deformation is plastic and the wire retains this deformation when the tension is released.

Which area represents the elastic potential energy that is stored in the wire when it is extended to 15.6 mm?

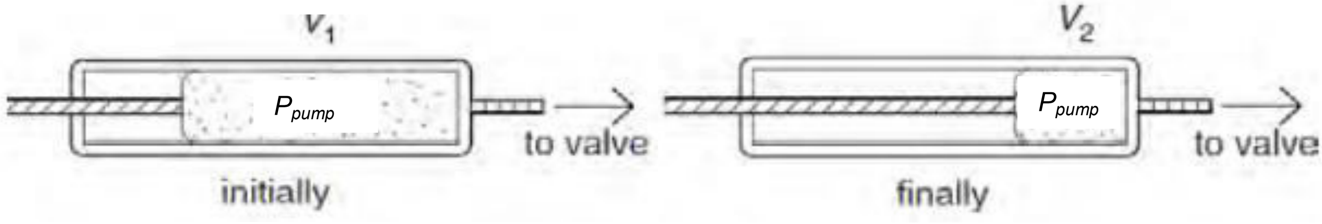
A Area Z

B Area X + Area Y

C Area Y + Area Z

D Area X + Area Y + Area Z

9 Air in a bicycle pump is forced through a valve at a constant pressure P_{pump}, to supply air to a tyre which is initially at a pressure P_{tyre}. In one stroke of the pump, the volume of air in the pump chamber is reduced from V_1 to V_2.



What is the work done on this air in one stroke of pump ?

A $P_{pump} V_1$ **B** $P_{pump} (V_2 - V_1)$ **C** $P_{tyre} V_1$ **D** $P_{tyre} (V_2 - V_1)$

10 Which one of the following statements is true about gravitational potential energy, electric potential energy and elastic potential energy?

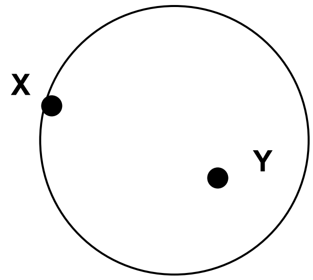
A Gravitational force and elastic force always points in the direction of decreasing potential energy but whether electric force will point towards increasing or decreasing potential energy depends on whether it is a positive or negative charge.

B Zero gravitational potential energy and zero electric potential energy is the smallest possible potential energy in a given system of 2 masses and 2 negative charges respectively.

C The magnitude of the potential energy can be found using the gradient of the force-displacement graph.

D These potential energies are energies stored in the body due to its position or the arrangement of its component parts.

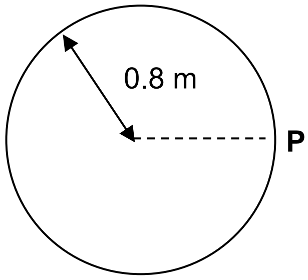
11 Sand is sprinkled on a turntable on points X and Y. The turntable is rotating with increasing speed.



Which one of the following comparing sand at points X and Y is true?

	angular speed	linear speed	which will fly off first?
A	X = Y	X > Y	X
B	X = Y	X > Y	Y
C	X > Y	X = Y	Y
D	X > Y	X > Y	Y

12 A model car moves in a circular path of radius 0.8 m at an angular speed of 0.5π rad s^{-1}.



What is its displacement from point P, 4 s after passing P?

A zero **B** 1.6 m **C** 0.8π m **D** 1.6π m

13 Which of the following is a correct description of a geostationary orbit?

The mass of Earth is 6.0×10^{24} kg.

A The moon is an example of a geostationary satellite of Earth.

B A geostationary satellite has an orbital circumference of 2.7×10^{8} m.

C A geostationary satellite moves from North pole to South pole then back to North pole in 24 hours.

D A geostationary satellite experiences zero net force as it orbits around Earth.

14 Which of the following statements about the internal energy of a monatomic ideal gas is correct?

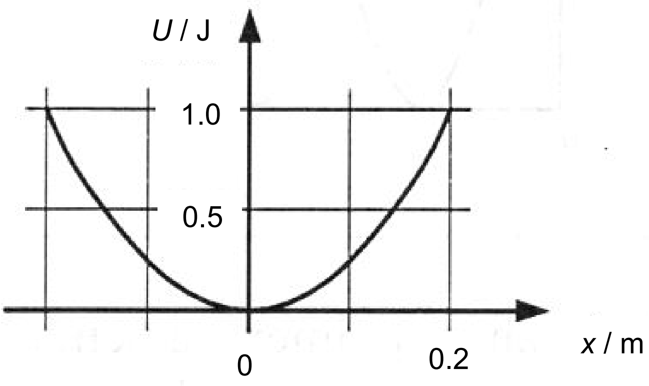
A It will increase when heat is supplied to the gas.
B It is proportional to the root-mean-square speed of the gas.
C It increases when the temperature of the gas increases.
D It is dependent on the potential energy of the gas.

15 In a mixture of two monatomic ideal gaseous X and Y, the molecules of Y have thrice the mass of those of X. The mixture is in thermal equilibrium and the molecules of Y have a mean translational kinetic energy of E_K.

What is the mean translational kinetic energy of the molecules of X?

A 1/3 E_K **B** 1/2 E_K **C** E_K **D** 3 E_K

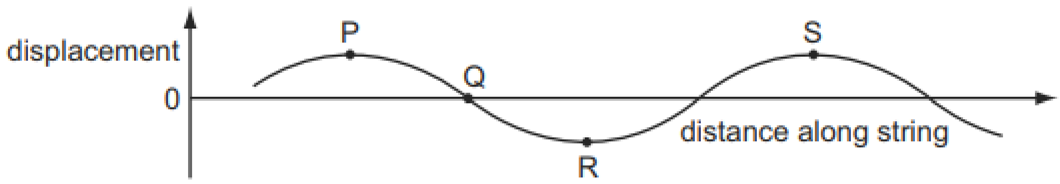
16 The given graph shows the variation with displacement x of the potential energy U of a particle of mass 4 kg moving in simple harmonic motion.



Which of the following is the period of oscillation of the mass?

A 0.3 s **B** 0.9 s **C** 1.1 s **D** 1.8 s

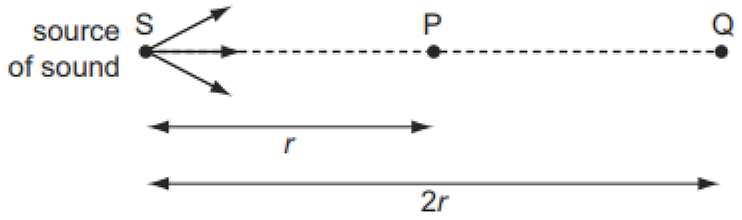
17 The string shows the shape at a particular instant of part of a progressive wave travelling along a string.



Which statement about the motion of the points along the string is correct?

A The speed at point P is maximum.
B The displacement at point Q is always zero.
C The energy at point R is entirely kinetic.
D The acceleration at point S is maximum.

18 A point source of sound is placed at point S.

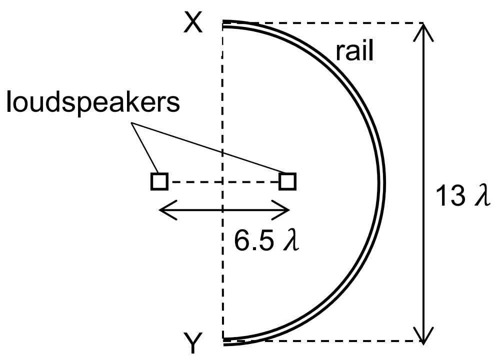


The air molecules at P, a distance *r* from S, oscillate with an amplitude of 8.0 μm. Point Q is situated at a distance 2*r* from S.

What is the amplitude of oscillation of air molecules at point Q?

A 1.4 μm **B** 2.0 μm **C** 2.8 μm **D** 4.0 μm

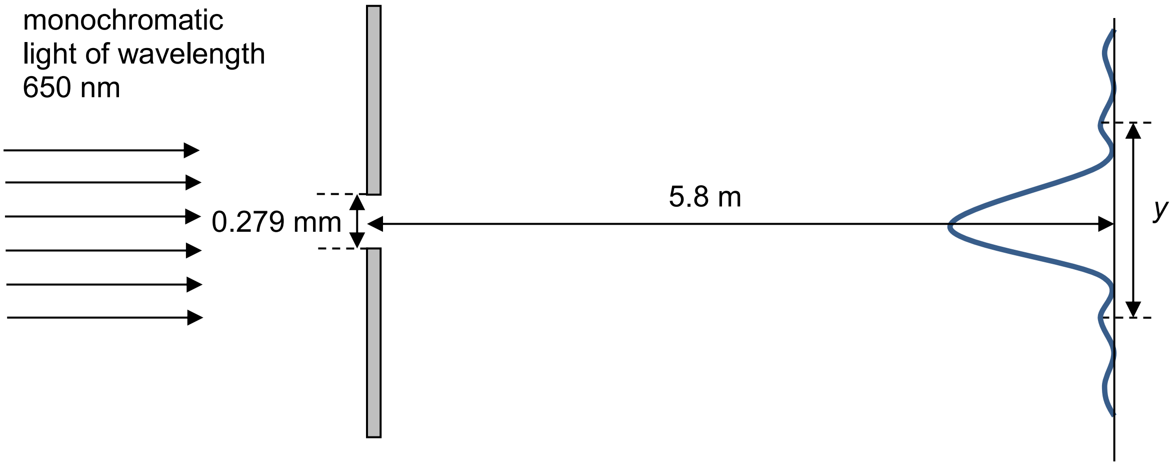
19 Two loudspeakers are emitting sound of wavelength λ in all directions. They are in phase with each other and are placed a distance 6.5 λ apart in the middle of a semicircular rail of diameter 13 λ, as shown below. Moveable microphones along the rail are used to detect the sound intensity along the rail. The midpoint of the line joining the 2 speakers coincides with the centre of line XY.



How many minima will the microphones detect?

A 7 **B** 12 **C** 13 **D** 14

20 A laser light of wavelength 650 nm is passed normally through a narrow slit. A screen is placed parallel to the slit 5.8 m away from the slit. An interference pattern is formed on the screen. The width of the slit is 0.279 mm. The distance *y* is the distance between the two first maximas.



What is the value of *y*?

A 13.5 mm **B** 27.0 mm **C** 40.5 mm **D** 54.0 mm

21 A negatively-charged sphere P is balanced halfway between two horizontal plates when a potential difference *V* is applied between the plates.

Which statement is correct?

A Increasing *V* increases both the electric and the gravitational potential energy of the sphere.

B Increasing *V* decreases the electric potential energy and increases the gravitational potential energy of the sphere.

C Decreasing *V* decreases both the electric and the gravitational potential energy of the sphere.

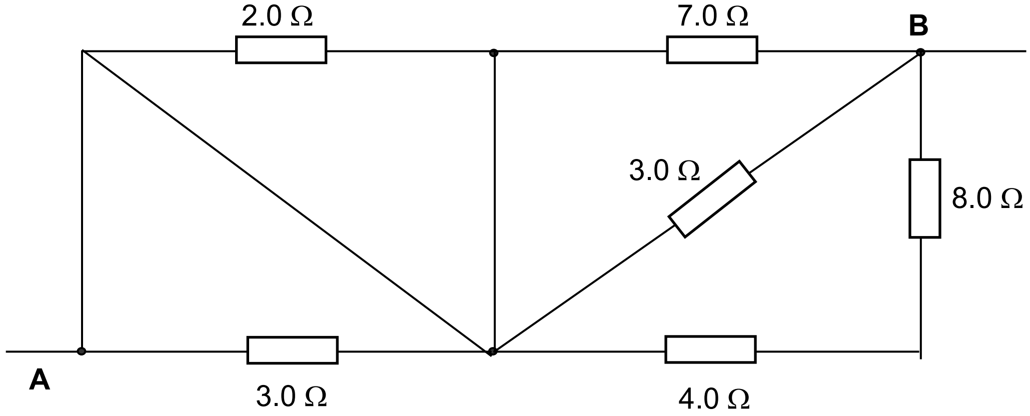
D Decreasing *V* increases both the electric and gravitational potential energy of the sphere.

22 A 8.0 A current passes through a cylindrical copper wire with a diameter of 8.0 mm. The density of copper is 8960 kg m^{-3} and the mass of a single copper atom is 1 x 10^{-25} kg.

Assuming that there is one conduction electron for each copper atom, what is the drift velocity of the electrons in the wire?

A 2.8 x 10^{-6} m s^{-1} **B** 3.4 x 10^{-6} m s^{-1} **C** 1.1 x 10^{-5} m s^{-1} **D** 5.8 x 10^{-5} m s^{-1}

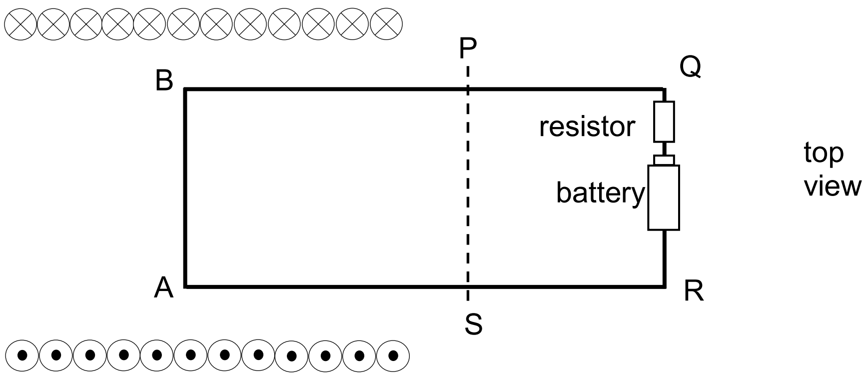
23 Six resistors are connected in a circuit as shown below.



What is the effective resistance of the circuit between terminals AB?

A 1.2 Ω **B** 1.8 Ω **C** 3.0 Ω **D** 3.4 Ω

24 The figure below shows the top view of a current balance where the rigid rectangular wire loop ABQR pivoted at PS is in equilibrium. It is connected in series with an ideal 2.0 V battery and a 0.025 Ω resistor of a total mass of 300 g. Part of the wire loop is placed inside a solenoid. The mass of the loop can be taken to be negligible and the wire has no resistance.



The length of the side AB is 6.0 cm and $SR = \frac{2}{5} ASR$.

What is the magnitude of the magnetic flux density in the solenoid?

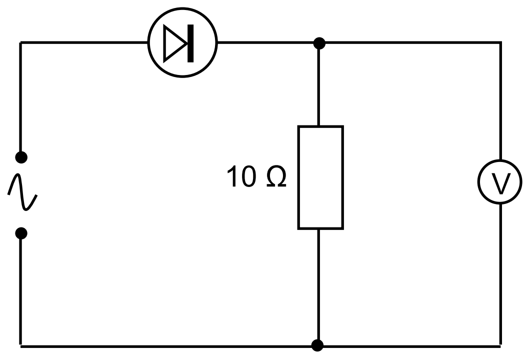
A 0.37 T **B** 0.41 T **C** 3.7 T **D** 4.1 T

25 When a light bulb is connected across an a.c. source of peak voltage 150 V, the mean power dissipated is 13 W. Two such light bulbs are now connected in series to the electrical mains of 240 V r.m.s.

What is the peak voltage across each light bulb and the total power dissipated in the light bulbs?

	peak voltage across each light bulb / V	total power dissipated in the light bulbs / W
A	120	17
B	170	33
C	120	67
D	170	17

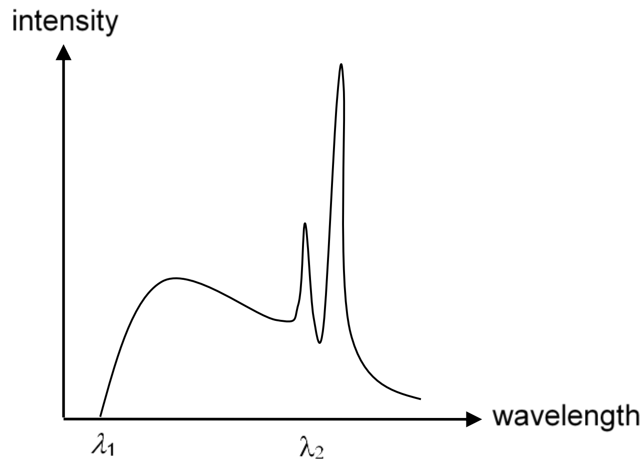
26 A voltmeter reads 80 V when measuring the potential difference across a load of 10 Ω connected to a sinusoidal power source with frequency 888 Hz.



What is the peak power dissipated by the load when the frequency is 1/3 of its original?

A 640 W **B** 850 W **C** 1280 W **D** 2560 W

27 The graph below shows the variation of X-ray intensity with wavelength emitted from an X-ray tube.



What are the factors that will affect λ_1 and λ_2?

	λ_1	λ_2
A	target metal	target metal
B	target metal	accelerating voltage
C	accelerating voltage	target metal
D	accelerating voltage	accelerating voltage

28 The momentum of an alpha particle is measured with an uncertainty of 2.0%.

Given that it has a kinetic energy of 1.00 MeV, what is the minimum uncertainty in its position?

A 2.1×10^{-19} m **B** 7.2×10^{-13} **C** 1.6×10^{-12} **D** 7.2×10^{-10}

29 Which of the following is a correct description of mass defect?

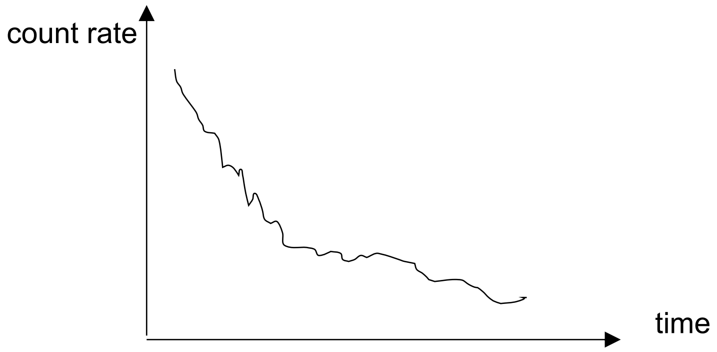
A The difference between the mass of the nucleus of the products and reactants in a nuclear reaction.

B It is the difference between the total mass of the neutrons and the mass of the nucleus.

C It is equal to the energy gained when individual nucleons comes together to form a nucleus.

D It is the binding energy of a nucleus divided by square of the speed of light.

30 The graph below shows the variation of count rate from a particular radioactive sample with time.



What does the jagged feature of the graph indicate?

A It indicates the presence of background radiation.
B It indicates that the decay obeys radioactive decay law.
C It indicates the spontaneous nature of the radioactive decay.
D It indicates the random nature of the radioactive decay.

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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	=	$Anqv$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \cdots$
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decay constant	λ	=	$\frac{ln2}{t_{\frac{1}{2}}}$

Answer all questions.

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$$R = k\,A\,\frac{(T_2 - T_1)}{L}$$

where k is the thermal conductivity, A is the total cross sectional area of the conducting surface, and L is the thickness of conducting surface separating the 2 temperatures T_1 and T_2.

What is the SI base units for k?

A kg m s^{-3} K^{-1} **B** kg m s^{-2} K^{-1} **C** kg m s^{-3} **D** kg s^{-2} K^{-1}

Ans: A

$$\lfloor k \rfloor = \left[\frac{R}{A}\frac{L}{(T_2 - T_1)}\right]$$
$$= \frac{W}{m^2}\frac{m}{K}$$
$$= W\ m^{-1}\ K^{-1} = J\ s^{-1}\ m^{-1}\ K^{-1} = kg\ m\ s^{-3}\ K^{-1}$$

2 With reference to Question 1, a student collected the following measurements to determine the rate of heat flow R of the object

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T_1 = (32.0 ± 0.5) °C
T_2 = (4.0 ± 0.5) °C

What is the fractional uncertainty in R?

A 0.11 **B** 0.14 **C** 0.16 **D** 0.18

Ans: D

$$\frac{\Delta R}{R} = \frac{\Delta L}{L} + \left|\frac{\Delta(T_2 - T_1)}{(T_2 - T_1)}\right|$$
$$= \frac{0.05}{0.35} + \left|\frac{\Delta T_2 + \Delta T_1}{(T_2 - T_1)}\right|$$
$$= \frac{0.05}{0.35} + \left|\frac{0.5 + 0.5}{(4.0 - 32.0)}\right| = 0.18$$

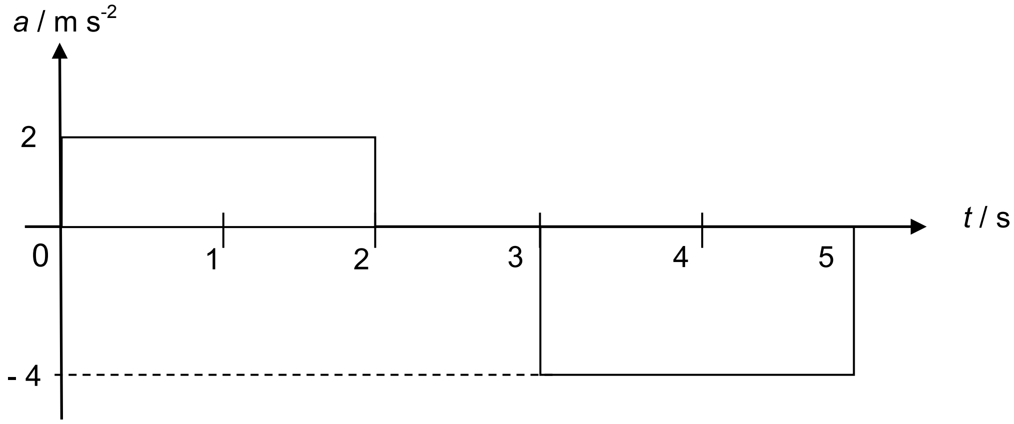
3 A value for the acceleration of free fall on Earth is given as (10 ± 2) m s^{-2}.

Which statement is correct?

A The value is accurate but not precise.
B The value is both precise and accurate.
C The value is neither precise nor accurate.
D The value is precise but not accurate.

Ans: A value is not precise but still accurate to 1 sf

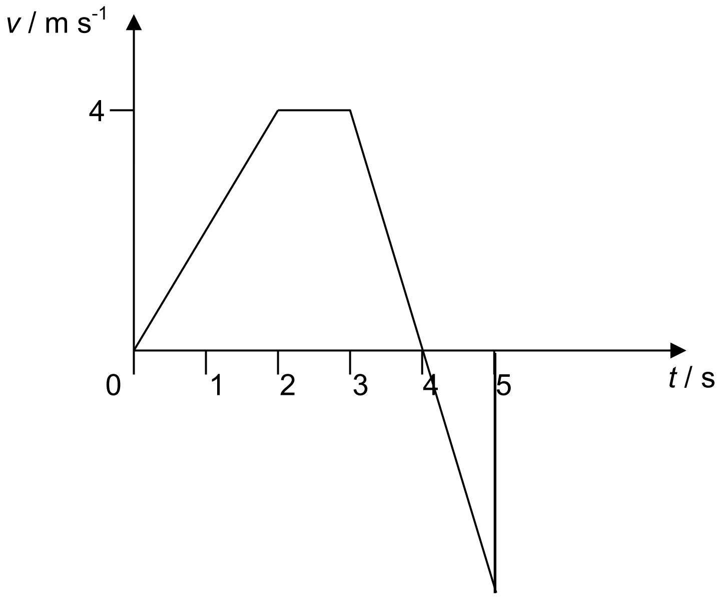
4 The graph below represents the variation with time t of the acceleration a of a car starting from rest.



What is the total displacement of the car from the starting point at the end of 5 s?

A -4 m **B** 4 m **C** 8 m **D** 12 m

Ans: C
change in displacement
= Area under the v-t graph
= ½ (1+4)(4) – ½ (1)(4)
= 8 m



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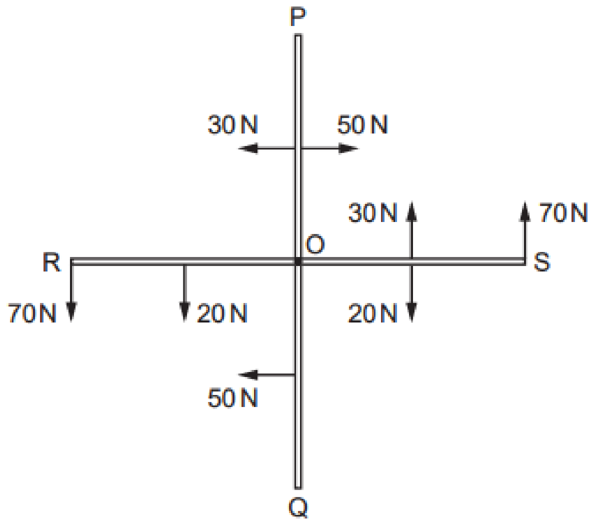


What is the net moment about O?

A 54 N m **B** 108 N m **C** 216 N m **D** 432 N m

Ans: C
sacw = (20+30+30) x 0.9 + (70+70) x1.8 = 324 N m
scw = (20+50+50) x 0.9 = 108 N m
Net moments = 216 N m

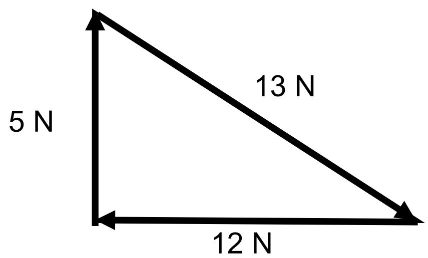
6 Forces 5 N, 12 N and 13 N act at a point which is in equilibrium.

What is the angle between the 5 N and 13 N force?

A 23° **B** 67° **C** 90° **D** 113°

Ans: D

Angle = 180 - $\tan^{-1}$ (12/5)
= 180 – 67
= 113



7 A cube of sides 10 cm has a density of 7.8 g cm^{-3}. It floats vertically with one-eighth of its side exposed above the liquid surface.

What is the density of the liquid?

A 6.8 g cm^{-3} **B** 8.9 g cm^{-3} **C** 11.6 g cm^{-3} **D** 62.4 g cm^{-3}

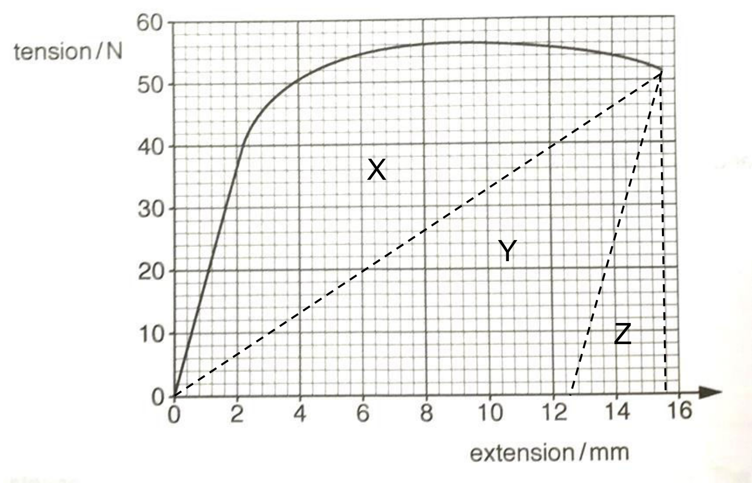
Ans: B

As object is floating, Weight of object = Upthrust

$$\rho_b V_b g = \rho_l V_{submerged} g$$

$$\rho_l = \frac{\rho_b V_b}{V_{submerged}} = \frac{(7.8)(l^3)}{\left(l^2 \times \frac{7}{8} l\right)} = 8.9 \text{ g cm}^{-3}$$

8 The tension in a sample of wire varies with extension as shown in the diagram below.



The graph shows that the wire undergoes two types of deformation as it is extended to 15.6 mm. In the region where Hooke's law applies, the deformation is elastic and the wire will lose this deformation when the tension is released. In the region where Hooke's law does not apply, the deformation is plastic and the wire retains this deformation when the tension is released.

Which area represents the elastic potential energy that is stored in the wire when it is extended to 15.6 mm?

A Area Z

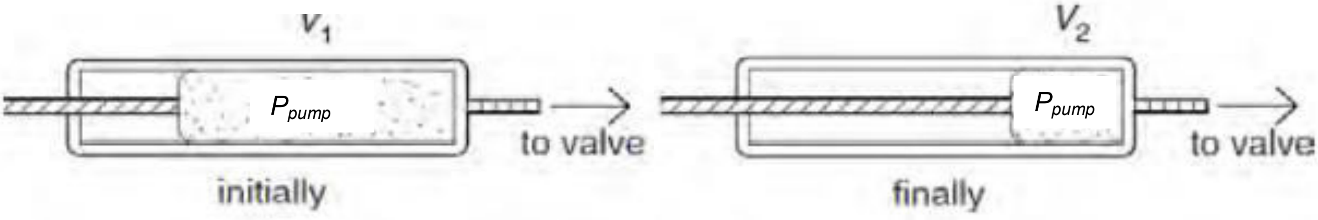
B Area X + Area Y

C Area Y + Area Z

D Area X + Area Y + Area Z

Ans : A

9 Air in a bicycle pump is forced through a valve at a constant pressure P_{pump}, to supply air to a tyre which is initially at a pressure P_{tyre}. In one stroke of the pump, the volume of air in the pump chamber is reduced from V_1 to V_2.



What is the work done on this air in one stroke of pump ?

A $P_{pump} V_1$

B $P_{pump} (V_2 - V_1)$

C $P_{tyre} V_1$

D $P_{tyre} (V_2 - V_1)$

Ans : B

10 Which one of the following statements is true about gravitational potential energy, electric potential energy and elastic potential energy?

A Gravitational force and elastic force always points in the direction of decreasing potential energy but whether electric force will point towards increasing or decreasing potential energy depends on whether it is a positive or negative charge.

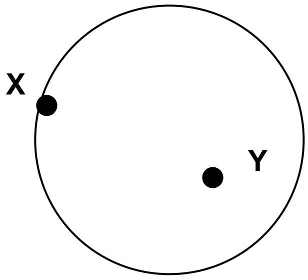
B Zero gravitational potential energy and zero electric potential energy is the smallest possible potential energy in a given system of 2 masses and 2 negative charges respectively.

C The magnitude of the potential energy can be found using the gradient of the force-displacement graph.

D These potential energies are energies stored in the body due to its position or the arrangement of its component parts.

Ans : D
By definition of potential energy.

11 Sand is sprinkled on a turntable on points X and Y. The turntable is rotating with increasing speed.

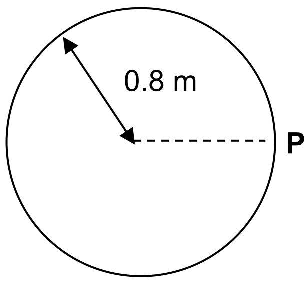


Which one of the following comparing sand at points X and Y is true?

	angular speed	linear speed	which will fly off first?
A	X = Y	X > Y	X
B	X = Y	X > Y	Y
C	X > Y	X = Y	Y
D	X > Y	X > Y	Y

Ans: A
ω on the same turntable is the same for both points.
$v = r\omega$, since $r_x > r_y$, therefore $v_x > v_y$
Centripetal force $F = mr\omega^2$ required for Sand at X is higher, so the sand at X will have a tendency to fly off 1st as the frictional force is unable to provide the higher centripetal force.

12 A model car moves in a circular path of radius 0.8 m at an angular speed of 0.5π rad s^{-1}.



What is its displacement from point P, 4 s after passing P?

A zero **B** 1.6 m **C** 0.8π m **D** 1.6π m

Ans: A
$v = r\omega = 0.8 \times \pi/2 = 0.4\pi$,
$s = vt = 0.4\pi \times 4 = 1.6\pi$
Circumference of circle $= 2\pi(0.8) = 1.6\pi$
Therefore, displacement = 0

13 Which of the following is a correct description of a geostationary orbit?

The mass of Earth is 6.0×10^{24} kg.

A The moon is an example of a geostationary satellite of Earth.

B A geostationary satellite has an orbital circumference of 2.7×10^{8} m.

C A geostationary satellite moves from North pole to South pole then back to North pole in 24 hours.

D A geostationary satellite experiences zero net force as it orbits around Earth.

Ans: B

14 Which of the following statements about the internal energy of a monatomic ideal gas is correct?

A It will increase when heat is supplied to the gas.
B It is proportional to the root-mean-square speed of the gas.
C It increases when the temperature of the gas increases.
D It is dependent on the potential energy of the gas.

Ans: C
Since for an ideal gas, internal energy is purely kinetic energy, internal energy is proportional to the temperature of the gas.

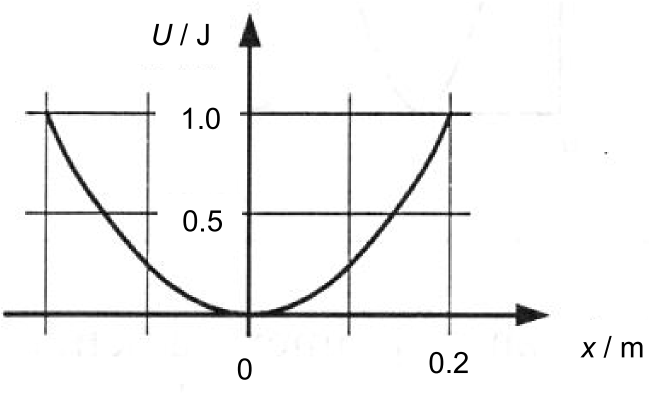
15 In a mixture of two monatomic ideal gaseous X and Y, the molecules of Y have thrice the mass of those of X. The mixture is in thermal equilibrium and the molecules of Y have a mean translational kinetic energy of E_K.

What is the mean translational kinetic energy of the molecules of X?

A 1/3 E_K **B** 1/2 E_K **C** E_K **D** 3 E_K

$T_X = T_Y$
$\langle KE \rangle_X = \langle KE \rangle_Y$
since $T \propto \langle KE \rangle$
Ans: C

16 The given graph shows the variation with displacement x of the potential energy U of a particle of mass 4 kg moving in simple harmonic motion.



Which of the following is the period of oscillation of the mass?

A 0.3 s **B** 0.9 s **C** 1.1 s **D** 1.8 s

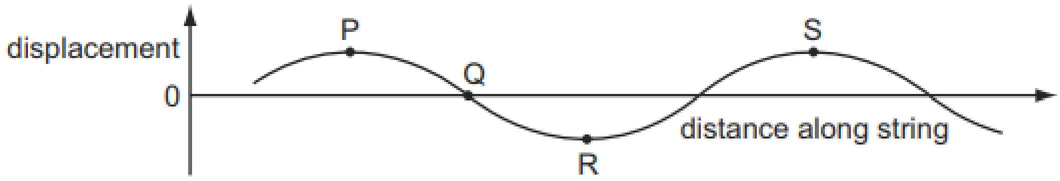
$$TE = KE_{max} = \frac{1}{2}mv_o^2 = \frac{1}{2}m(\omega x_o)^2 = \frac{1}{2}m\frac{4\pi^2}{T^2}x_o^2$$

$$1 = \frac{1}{2}(4)\frac{4\pi^2}{T^2}(0.2)^2$$

$$T = \frac{2\pi\sqrt{2}}{5}s$$

Ans: D

17 The string shows the shape at a particular instant of part of a progressive wave travelling along a string.



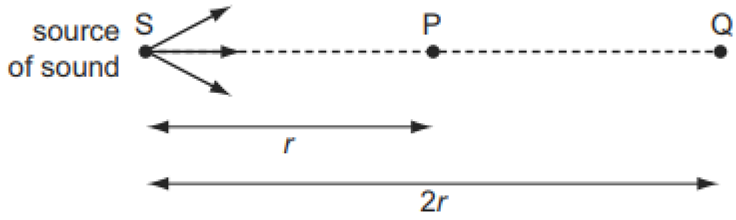
Which statement about the motion of the points along the string is correct?

A The speed at point P is maximum.
B The displacement at point Q is always zero.
C The energy at point R is entirely kinetic.
D The acceleration at point S is maximum.

Ans: D

At Point S, the displacement of the particle is maximum. Hence, by using a =- ω^2x, the acceleration will also be at a maximum.

18 A point source of sound is placed at point S.



Ans: D

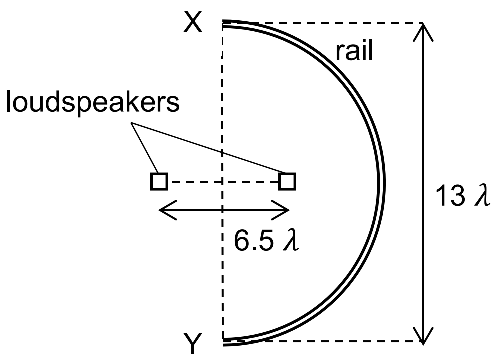
Amplitude is inversely proportional to the distance from the source.

The air molecules at P, a distance *r* from S, oscillate with an amplitude of 8.0 μm. Point Q is situated at a distance 2*r* from S.

What is the amplitude of oscillation of air molecules at point Q?

A 1.4 μm **B** 2.0 μm **C** 2.8 μm **D** 4.0 μm

19 Two loudspeakers are emitting sound of wavelength λ in all directions. They are in phase with each other and are placed a distance 6.5 λ apart in the middle of a semicircular rail of diameter 13 λ, as shown below. Moveable microphones along the rail are used to detect the sound intensity along the rail. The midpoint of the line joining the 2 speakers coincides with the centre of line XY.



Ans : C

At the centre of the rail, the path difference is 6.5 λ.
At the start and end of the rail, the path difference is 0 λ.

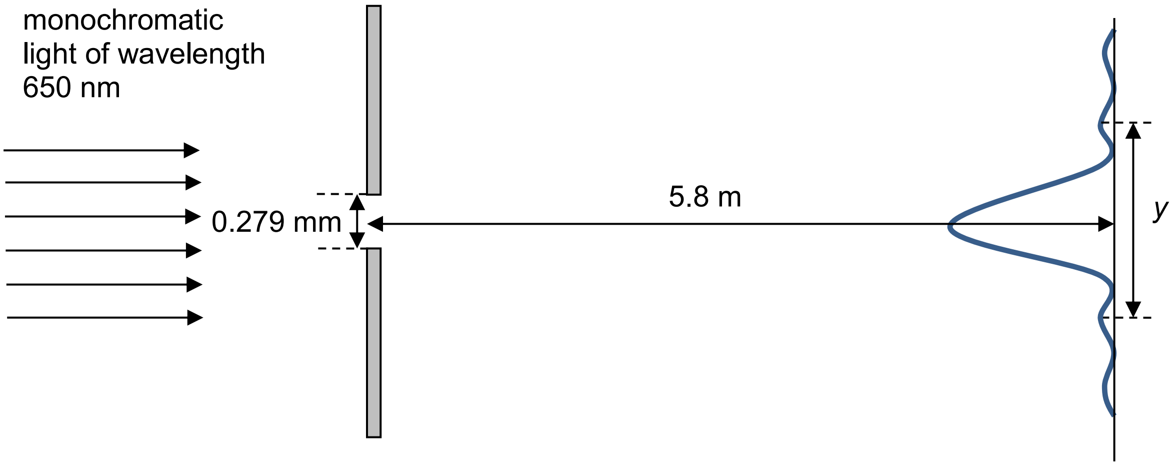
Hence, the magnitude of path difference increases from 0 to 6.5 λ and then decreases to 0

Since waves are in phase, minima will be detected at locations where path differences are (n+1/2)λ and this occurs at path differences = 0.5 λ, 1.5 λ, 2.5 λ, 3.5 λ, 4.5 λ, 5.5 λ, 6.5 λ.

How many minima will the microphones detect?

A 7 **B** 12 **C** 13 **D** 14

20 A laser light of wavelength 650 nm is passed normally through a narrow slit. A screen is placed parallel to the slit 5.8 m away from the slit. An interference pattern is formed on the screen. The width of the slit is 0.279 mm. The distance y is the distance between the two first maximas.



What is the value of y?

A 13.5 mm **B** 27.0 mm **C** 40.5 mm **D** 54.0 mm

Ans: C
Since $\sin\theta = \lambda/b$
$\theta = 0.1333°$
Distance from central maxima to first minima = 13.5 mm
y = 27 + 13.5 = 40.5 mm
(since width of subsequent maxima is half the width of central maxima)

21 A negatively-charged sphere P is balanced halfway between two horizontal plates when a potential difference V is applied between the plates.

Which statement is correct?

A Increasing V increases both the electric and the gravitational potential energy of the sphere.

B Increasing V decreases the electric potential energy and increases the gravitational potential energy of the sphere.

C Decreasing V decreases both the electric and the gravitational potential energy of the sphere.

D Decreasing V increases both the electric and gravitational potential energy of the sphere.

Ans: B
When the potential difference is increased, the sphere will experienced a greater upward electric force. Therefore, the electric force is bigger than the weight of the sphere. Net force will be upwards and hence sphere will accelerate upwards, and thus experiencing a decreasing EPE and increasing GPE.
(Answer will be the same even when the sphere is positive charged)

22 A 8.0 A current passes through a cylindrical copper wire with a diameter of 8.0 mm. The density of copper is 8960 kg m^{-3} and the mass of a single copper atom is 1 x 10^{-25} kg.

Assuming that there is one conduction electron for each copper atom, what is the drift velocity of the electrons in the wire?

A 2.8 x 10^{-6} m s^{-1} **B** 3.4 x 10^{-6} m s^{-1} **C** 1.1 x 10^{-5} m s^{-1} **D** 5.8 x 10^{-5} m s^{-1}

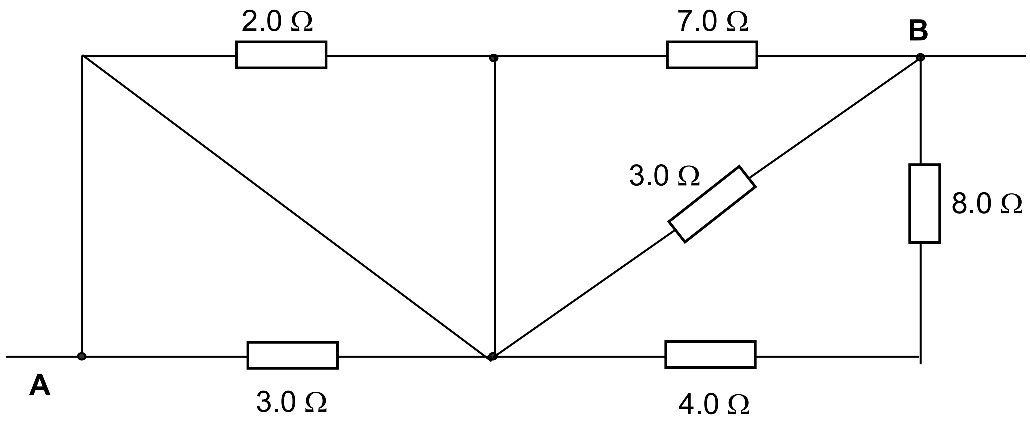
Ans:C

$I = nAvq$

$$v = \frac{I}{nAq} = \frac{8.0}{8960/(1\times10^{-25})\times\pi(4.0\times10^{-3})^2\times1.6\times10^{-19}} = 1.1\times10^{-5}\text{ m s}^{-1}$$

Distractors:
2.8 x 10^{-6}: Never convert diameter to radius.

23 Six resistors are connected in a circuit as shown below.



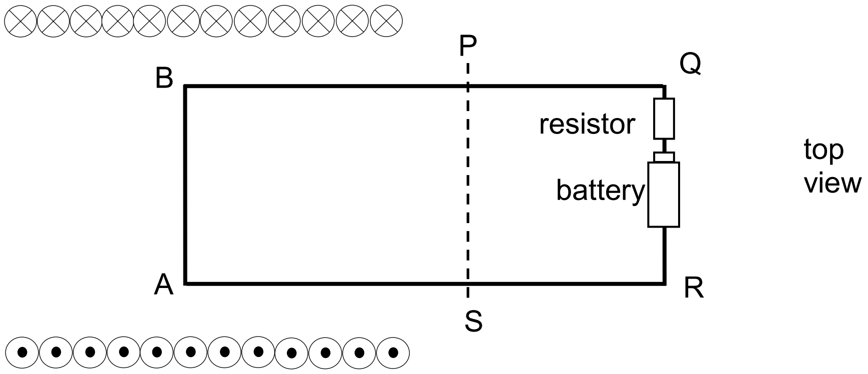
What is the effective resistance of the circuit between terminals AB?

A 1.2 Ω **B** 1.8 Ω **C** 3.0 Ω **D** 3.4 Ω

Ans: B

Distractors:
A: 7//3//8//4
Options C and D both consider the 2.0 and 3.0 resistor.
C: 2//3 + 7//3//12
D: 9 // [3 + 3// (8 and 4)]

24 The figure below shows the top view of a current balance where the rigid rectangular wire loop ABQR pivoted at PS is in equilibrium. It is connected in series with an ideal 2.0 V battery and a 0.025 Ω resistor of a total mass of 300 g. Part of the wire loop is placed inside a solenoid. The mass of the loop can be taken to be negligible and the wire has no resistance.



The length of the side AB is 6.0 cm and $SR = \frac{2}{5}ASR$.

What is the magnitude of the magnetic flux density in the solenoid?

A 0.37 T **B** 0.41 T **C** 3.7 T **D** 4.1 T

Ans: B

By principle of moments,

$$F_B \times AS = mg \times SR$$

$$B \times \frac{2}{0.025} \times 0.060 \times 3L = 0.300 \times 9.81 \times 2L$$

$$B = 0.41\text{T}$$

Distractors:
Never convert units – 4.1 T
Use wrong distance – AS = 5L and SR = 3L – 0.37 T
Use wrong distance and never convert units = 3.7 T

25 When a light bulb is connected across an a.c. source of peak voltage 150 V, the mean power dissipated is 13 W. Two such light bulbs are now connected in series to the electrical mains of 240 V r.m.s.

What is the peak voltage across each light bulb and the total power dissipated in the light bulbs?

	peak voltage across each light bulb / V	total power dissipated in the light bulbs / W
A	120	17
B	170	33
C	120	67
D	170	17

Ans: B

$$V_{rms} = \frac{150}{\sqrt{2}}$$

$$P = \frac{V_{rms}^2}{R} \Rightarrow R = 865\Omega$$

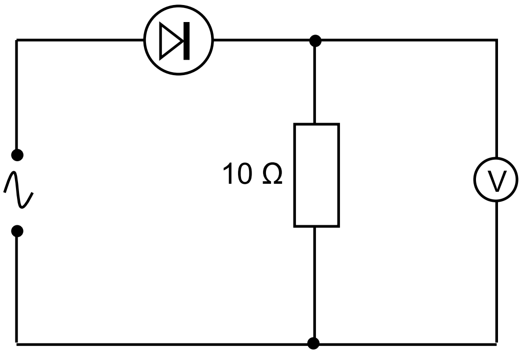
$$R_{total} = 865 \times 2$$

$$P_{total} = \frac{240^2}{865 \times 2} = 33$$

$$V_0 \text{ across each bulb} = 120\sqrt{2} = 170$$

Distractors:
For 17 W, take peak voltage as $V_{r.m.s.}$
For 67 W, assume only one bulb connected to 240 V rms source.

26 A voltmeter reads 80 V when measuring the potential difference across a load of 10 Ω connected to a sinusoidal power source with frequency 888 Hz.



What is the peak power dissipated by the load when the frequency is 1/3 of its original?

A 640 W **B** 850 W **C** 1280 W **D** 2560 W

Ans: D

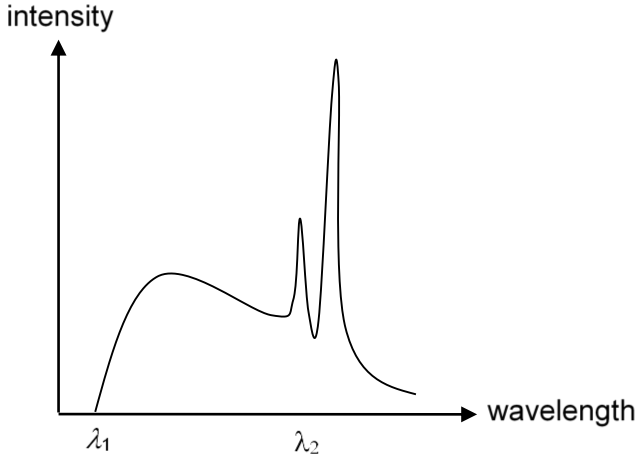
$$\frac{(V_{rms}\times 2)^2}{R} = (80\times 2)^2/10 = 2560$$

A: $\frac{V_{rms}^2}{R}$

B: $\frac{(V_{rms}\times 2)^2}{3R}$

C: $\frac{(V_{rms}\sqrt{2})^2}{R}$

27 The graph below shows the variation of X-ray intensity with wavelength emitted from an X-ray tube.



What are the factors that will affect λ_1 and λ_2?

	λ_1	λ_2
A	target metal	target metal
B	target metal	accelerating voltage
C	accelerating voltage	target metal
D	accelerating voltage	accelerating voltage

Ans: C

28 The momentum of an alpha particle is measured with an uncertainty of 2.0%.

Given that it has a kinetic energy of 1.00 MeV, what is the minimum uncertainty in its position?

A 2.1×10^{-19} m **B** 7.2×10^{-13} **C** 1.6×10^{-12} **D** 7.2×10^{-10}

Ans: B

29 Which of the following is a correct description of mass defect?

A The difference between the mass of the nucleus of the products and reactants in a nuclear reaction.

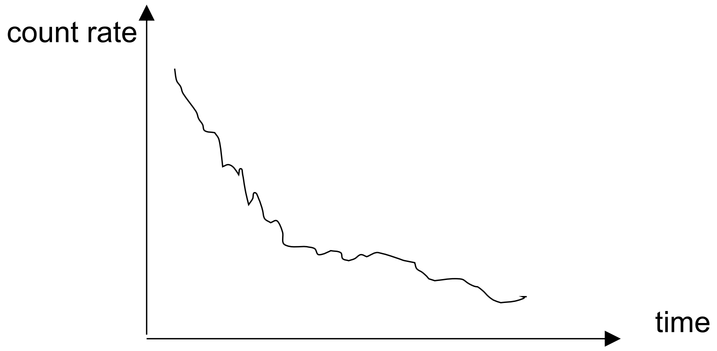
B It is the difference between the total mass of the neutrons and the mass of the nucleus.

C It is equal to the energy gained when individual nucleons comes together to form a nucleus.

D It is the binding energy of a nucleus divided by square of the speed of light.

Ans: D

30 The graph below shows the variation of count rate from a particular radioactive sample with time.



What does the jagged feature of the graph indicate?

A It indicates the presence of background radiation.
B It indicates that the decay obeys radioactive decay law.
C It indicates the spontaneous nature of the radioactive decay.
D It indicates the random nature of the radioactive decay.

Ans: D

SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

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PHYSICS 9749/02

Preliminary Examination **14th September 2018**
Paper 2 Structured Questions **2 hours**

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

READ THIS INSTRUCTIONS FIRST

Write your name, civics group and index number 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 HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

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 bracket [ ] at the end of each question or part question.

For Examiners' Use	
Q1	/ 10
Q2	/ 7
Q3	/ 14
Q4	/ 8
Q5	/ 8
Q6	/ 14
Q7	/ 19
Total marks	/ 80

DATA AND FORMULAE

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\frac{1}{36\pi} \times 10^{-9}$ 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}

DATA AND FORMULAE

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	$= \rho gh$
gravitational potential	ϕ	$= -\frac{GM}{r}$
temperature	T/K	$= T$/ºC + 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	$= Anqv$
resistors in series	R	$= R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R}$	$= \frac{1}{R_1} + \frac{1}{R_2} + \cdots$
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	$= \frac{\mu_0 I}{2\pi d}$
magnetic flux density 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	$= \frac{ln2}{t_{\frac{1}{2}}}$

For Examiner's Use

1 A raindrop falls vertically from rest.

(a) Assume that air resistance is negligible.

On Fig. 1.1, sketch a graph to show the variation with time *t* of the velocity *v* of the raindrop for the first 1.0 s of the motion. [1]

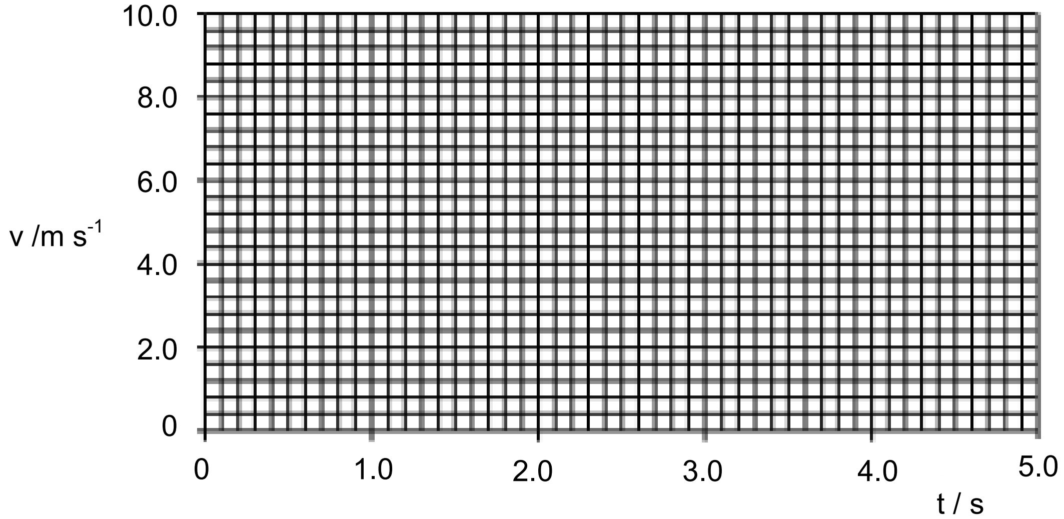

Fig. 1.1

(b) In practice, air resistance *D* on the raindrop is not negligible.

D is given by the expression

$$D = k\,v^2$$

where *k* is a constant and *v* is the speed.

(i) The raindrop has mass 1.38×10^{-5} kg and *k* is 2.76×10^{-6} N m^{-2} s^{2}.

Calculate the terminal velocity of the raindrop.

terminal velocity = …………… m s^{-1} [2]

(ii) The raindrop reaches terminal velocity at *t* = 3.0 s.

On Fig. 1.1, sketch the variation with time *t* of velocity *v* for the raindrop. The sketch should include the first 5.0 seconds of the motion. [2]

(c) A raindrop falls on a roof and rebounds off with a velocity of 5.5 m s^{-1} at an angle 60^{o} with respect to the horizontal as shown in Fig. 1.2.

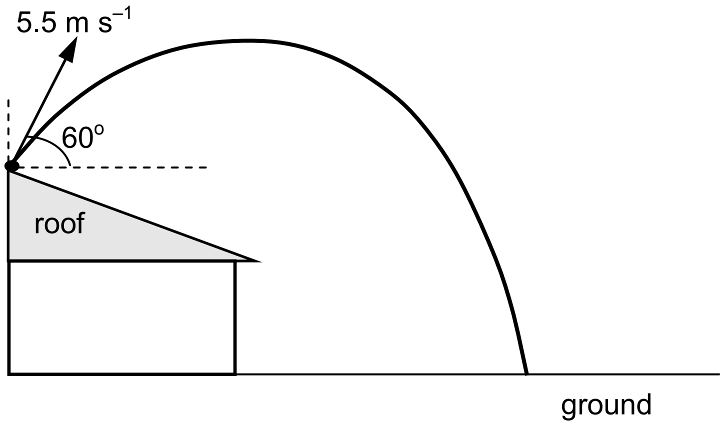

Fig. 1.2

Assume air resistance is negligible. The maximum horizontal distance travelled by the raindrop is 3.8 m.

(i) Calculate the time taken for the raindrop to hit the ground.

time = …………………. s [1]

(ii) Determine the speed of the raindrop as it hits the ground.

speed = …………………...m s^{-1} [2]

(iii) Discuss quantitatively whether the assumption that air resistance is negligible is justified by considering the vertical component of the initial velocity of the raindrop.

The raindrop has the same mass and dimension as in **(b)(i)**.

……………………………………………………………………………………………..

……………………………………………………………………………………………

…………………………………………………………………………………………[2]

2 A uniform rectangular card is suspended from a wooden rod. The card is held at one of its ends as shown in Fig. 2.1. The force by the hand on the card acts horizontally to the right.

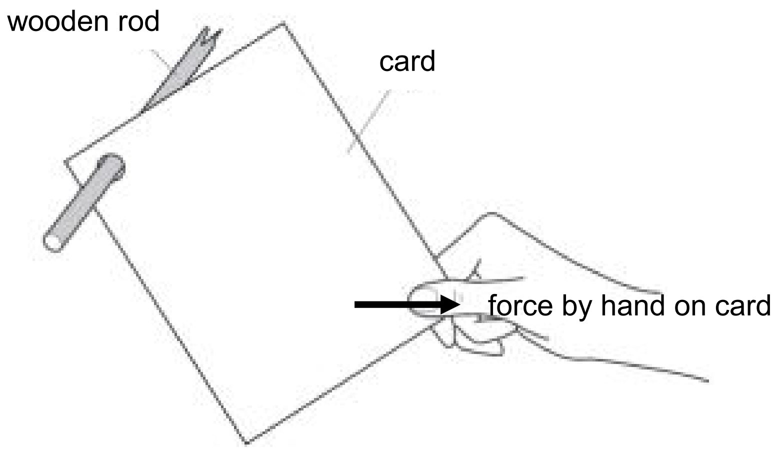

Fig. 2.1

(a) On Fig. 2.1,

(i) mark with an 'X' the position of the centre of gravity of the card. [1]

(ii) draw an arrow labelled with *W* to represent the weight of the card. [1]

(b) State the conditions for the card to be in equilibrium.

……

……

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

(c) Draw an arrow labelled with *R* on Fig. 2.1 to represent the force exerted by the wooden rod on the card.

Show your construction clearly. [2]

(d) The card is now released. It swings on the wooden rod and eventually comes to a rest.

By reference to the completed diagram in Fig. 2.1, describe the final position in which the card comes to a rest.

……

……

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

3 **(a)** An object is placed on a smooth horizontal surface and is connected to a light spring, as shown in Fig. 3.1.

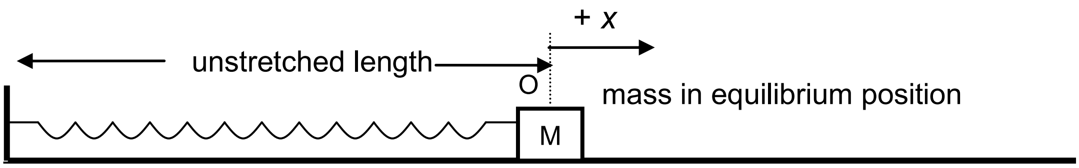

Fig. 3.1

The object is displaced to the right by 0.60 m and then released. Fig. 3.2 shows the variation with displacement x of acceleration a of the object.

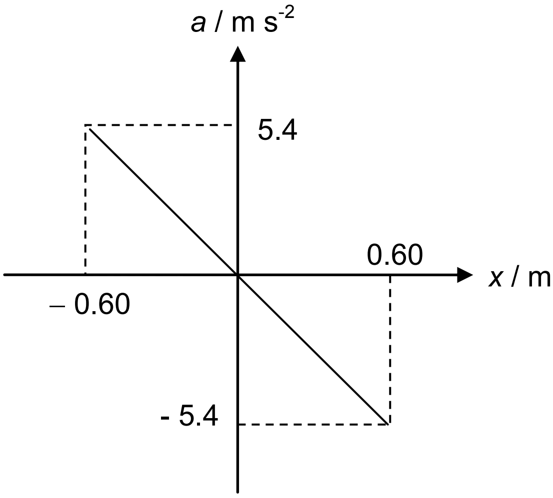

Fig. 3.2

(i) Use two features of the graph in Fig 3.2 to explain why the motion of the object is simple harmonic.

....

....

....

....

.... [2]

(ii) Calculate

1. the angular frequency,

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

For Examiner's Use

2. maximum speed of the object.

maximum speed = …………………. m s^{-1} [1]

(iii) Sketch on Fig. 3.3 the variation with time of the kinetic energy of the object for one complete oscillation. The mass of the object is 0.0020 kg.

Assume that the object just passes by the equilibrium position at time = 0 s. [2]

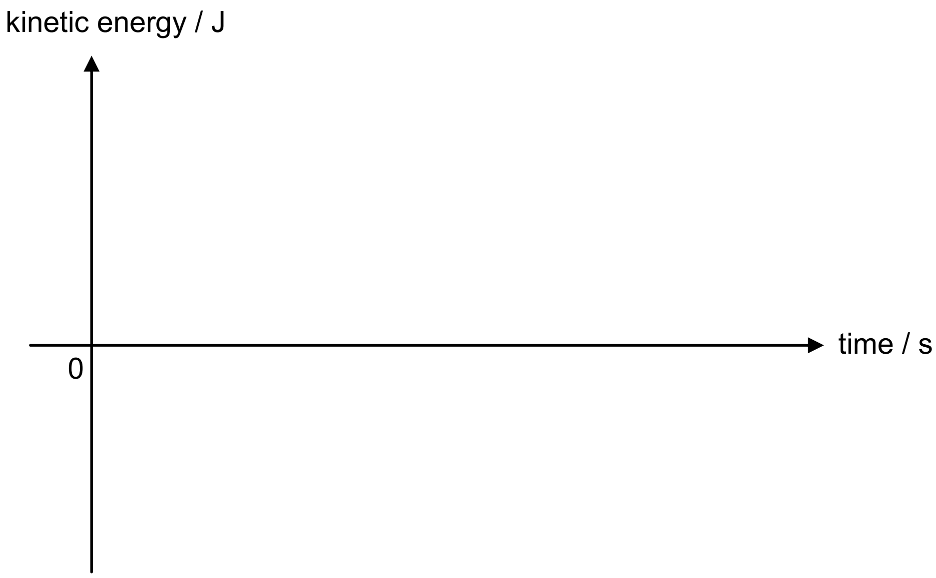

Fig. 3.3

(iv) Calculate the shortest time taken for the object to move from a point 0.30 m to the left of the equilibrium point to a point 0.30 m to the right of the equilibrium point.

time = ………………….. s [3]

For Examiner's Use

(b) A car component of mass 0.0460 kg rattles at a resonant frequency of 35.5 Hz. Fig. 3.4 shows how the amplitude of the vertical oscillation varies with frequency.

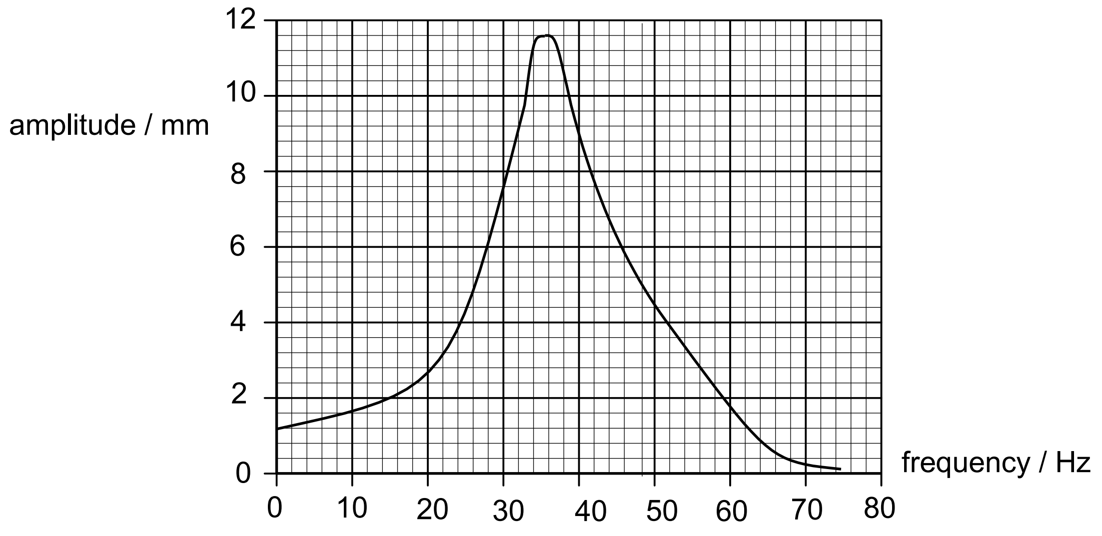

Fig. 3.4

(i) When oscillating at the resonant frequency, calculate

1. the angular frequency of the oscillation,

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

2. the total energy stored in the oscillation of the component.

energy = ... J [2]

(ii) Draw on Fig 3.4 to show how the amplitude of the oscillation varies with frequency if the component is supported on a rubber mounting. [2]

4 **(a)** Fig.4.1 shows a string stretched between two fixed points P and Q.

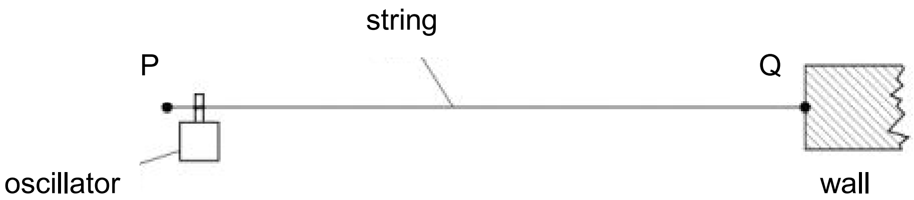

Fig. 4.1

An oscillator is attached near end P of the string. End Q is fixed to a wall. The oscillator has a frequency of 50.0 Hz.

The stationary wave produced on PQ at an instant time *t* is shown in Fig. 4.2. Each point on the string is at its maximum displacement.

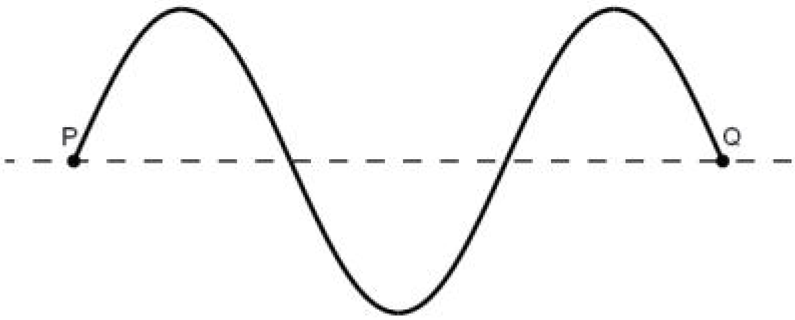

Fig. 4.2

(i) On Fig. 4.2, label all the nodes with the letter **N** and the antinodes with the letter **A** along the dotted line PQ. [1]

(ii) On Fig 4.2, draw the stationary wave at (t + 5.0 ms). [1]

For Examiner's Use

(b) Sound waves is directed from a loudspeaker towards a metal plate. A microphone, connected to a cathode ray oscilloscope (CRO), is placed in between the loudspeaker and the metal plate as shown in Fig. 4.3.

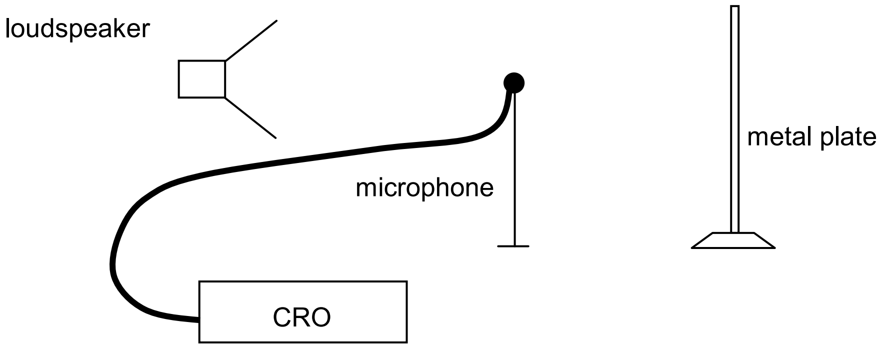

Fig. 4.3

(i) Explain how stationary waves are formed in between the loudspeaker and the metal phase.

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

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

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

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

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

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

For Examiner's Use

(ii) The trace on the CRO in Fig. 4.4 shows the variation of signal with time at an antinode.

The time-base setting on the CRO is 0.10 ms cm^{-1}.

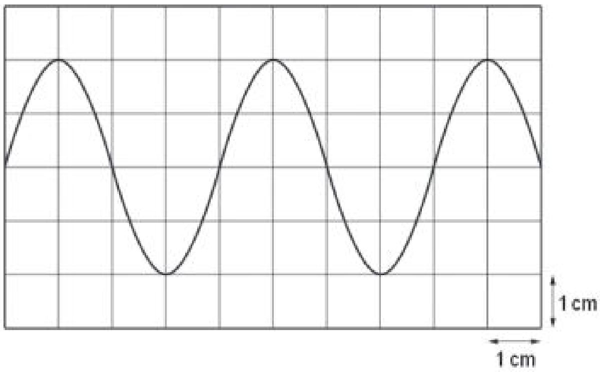

Fig. 4.4

The microphone is then moved by 3.3 cm and the trace on the CRO now records zero amplitude.

1. Determine the frequency of the sound.

frequency = …………………….. Hz [1]

2. Calculate the speed of sound.

speed = …………………….. m s^{-1} [2]

For Examiner's Use

5 **(a)** For a particular gas, the emission and absorption spectra are obtained for the visible light spectrum.

Discuss one similarity and one difference between the discrete lines of the absorption and emission spectra of this gas.

……

……

……

……

…… [2]

(b) Fig. 5.1 gives information on three lines observed in the emission spectrum of hydrogen atoms.

wavelength / nm	**energy of photon / eV**
486	2.56
656	
1880	0.66

Fig. 5.1

(i) Complete Fig. 5.1 by calculating the energy of the photon with wavelength 656 nm. [1]

(ii) Fig. 5.2 is a partially completed diagram to show energy levels of a hydrogen atom.

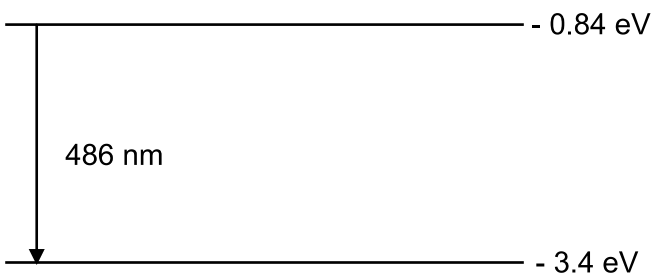

Fig. 5.2

On Fig. 5.2, draw an additional labelled energy level which will account for the emission of the photons in Fig. 5.1. [1]

For Examiner's Use

(c) Three of the energy levels of a lithium atom are shown in Fig. 5.3.

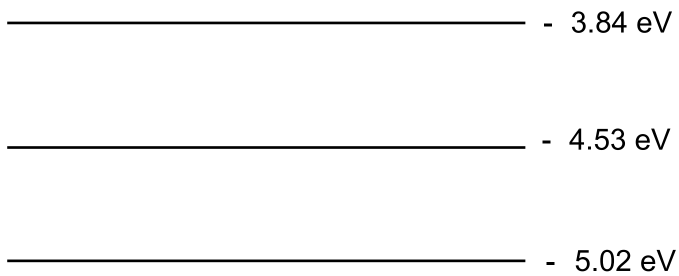

Fig. 5.3

One way to study the energy levels of an atom is to bombard the atom with electrons and measure the kinetic energies of the bombarding electrons before and after the collision. If a lithium atom which is originally in the – 5.02 eV level is bombarded with an electron of kinetic energy 0.92 eV, the scattered electron can have only two possible kinetic energies.

States these two kinetic energy values, and state what happens to the lithium atom in each case.

1st possible kinetic energy value: ………………………. eV [1]

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

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

2nd possible kinetic energy value: ………………………. eV [1]

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

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

For Examiner's Use

6 **(a)** A stationary nucleus of a radioactive nuclide, $^{218}_{84}Po$, underwent a chain of decays by the emission of an α and β–particles. The decay is represented by the two equations:

$$^{218}_{84}Po \rightarrow D + \alpha$$
$$D \rightarrow E + \beta$$

where D and E are the nuclides formed after the decay.

(i) State the nuclear notation for E. [1]

$$^{\cdots\cdots\cdots}_{\cdots\cdots\cdots}E$$

(ii) Determine the ratio of the kinetic energy of the α–particle to the total kinetic energy of D and α–particle.

ratio = ……………………… [3]

For Examiner's Use

(iii) In reality, the β–particles have a range of kinetic energies, instead of a fixed value. Explain why this is so.

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

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

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

(iv) A sample of ${}^{218}_{84}Po$ is placed on a weighing balance and a reading of 4.05 g is obtained. After 243 s, the reading drops to 4.02 g.

1. Determine the number of particles ${}^{218}_{84}Po$ in the initial sample.

number of particles = ………………….. [1]

2. Show that the total number of particles D and E after 243 s is 4.52 x 10^{21}. [1]

3. Determine the half life of ${}^{218}_{84}Po$.

half life = …………………. s [2]

(b) For many unstable parent nuclei, the daughter nuclei is itself radioactive. This may give rise to a radioactive series where there may be ten or more different radioactive daughter products.

A radioactive parent nucleus X has a radioactive daughter nucleus Y and, in turn, this daughter produces a further stable daughter Z. The variation with time *t* of the percentage number *P* of the different nuclei X, Y and Z in a radioactive sample is illustrated in Fig. 6.1

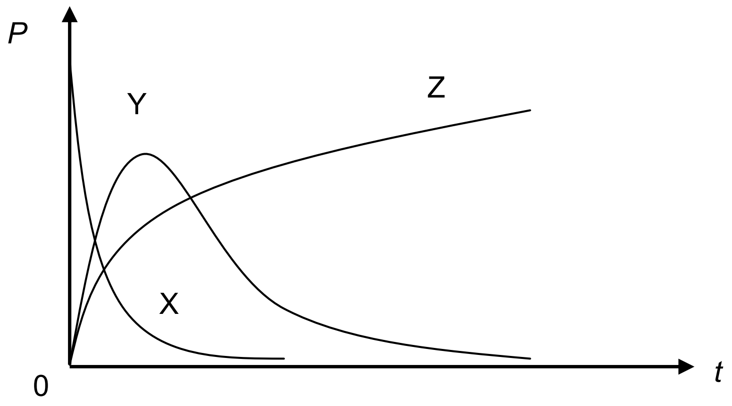

Fig 6.1

(i) X has a half life of 5 hours. The count rate at t = 0 and t = 5 hours were measured. Suggest three possible reasons why the count rate is not exactly halved after 5 hours.

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

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

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

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

3. ……………………………………………………………………………………………………

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

(ii) Explain why graph of Y increases to a maximum and then decreases.

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

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

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

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

7 Many devices are designed to create a spray of tiny droplets. The effectiveness of these devices usually depends on droplet size. One example is an agriculture pesticide spray in which a few large droplets do not coat the leaves of plants as well as many small droplets. Another example is a fuel injection system for an engine.

Measuring the size of droplets present in a spray is difficult to do by direct means but instruments called droplet sizers can be purchased which make droplet sizing a fast routine operation.

The principle of operation of one such sizer is shown in Fig. 7.1, in which light from a helium/neon laser is passed through a spray of droplets of uniform diameter and forms a circular diffraction ring of radius *x*. The diameter *d* of the droplets is related to *x* by the equation

$$d = k\frac{\lambda}{x}$$

In this equation λ, the wavelength of the light, is 6.33×10^{-7} m. *k* is a constant equal to 0.474 m, and *d* and *x* are both in metres.

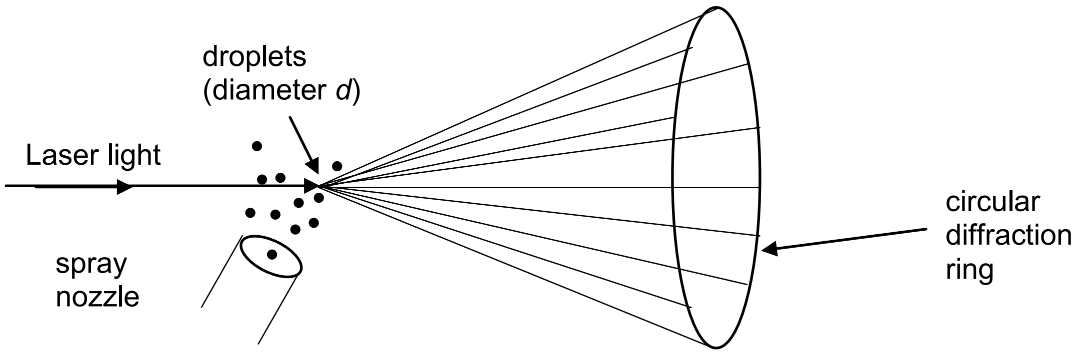

Fig. 7.1

In practice, a spray will consist of droplets of different sizes, so many rings of diffracted light will be caused. The diffraction pattern in Fig. 7.2a is projected on a flat surface containing many light sensitive detectors. The output from the detectors can be analysed by a computer and be shown in the form of a graph in Fig. 7.2b.

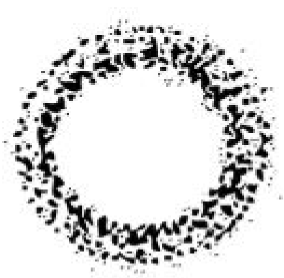

Fig. 7.2a

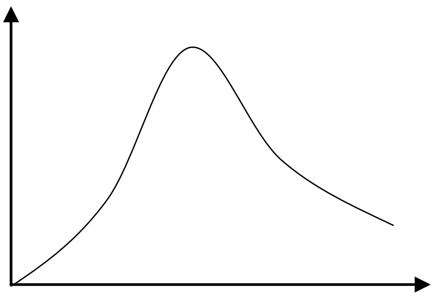

Fig. 7.2b

For Examiner's Use

(a) Suggest two devices, other than those mentioned in the first paragraph of the passage, where droplet size is important.

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

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

(b) Outline a direct method for measuring droplet diameter.
Apparatus available includes: high speed camera, stroboscope, stopwatch, rulers.

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

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

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

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

(c) Give two reasons why direct methods are likely to be difficult for measuring droplets of small diameter.

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

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

(d) Calculate the value of *x* for a droplet of diameter

(i) 10 μm

x = ……………………….. m [1]

(ii) 200 μm

x = ……………………….. m [1]

(e) State whether a small value of x corresponds to large or to small droplets.

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

(f) Suggest, with reference to the equation given, how the radius of the circular diffraction ring can be increased for the same diameter of water droplets.

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

(g) Sketch on the axes in Fig. 7.3 curves to show the general shape of graphs that would be obtained if

(i) droplets with a wide range of diameters were used. Label as **(i)**. [1]

(ii) very small droplets with a narrow range of diameters were used. Label as **(ii)** [1]

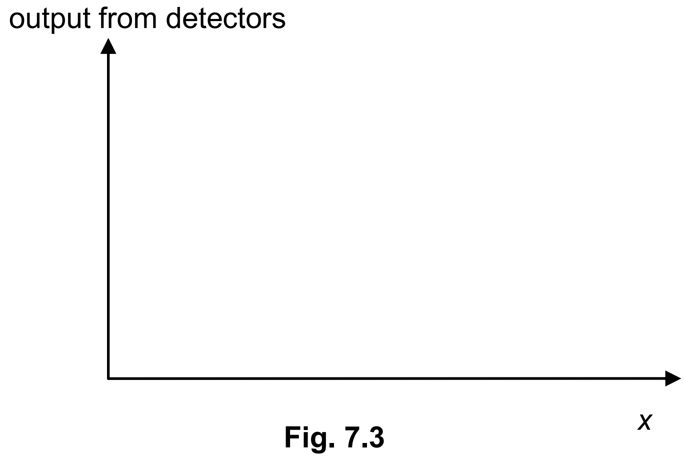

Fig. 7.3

(h) In practice, a cloud of spray droplets moves through the laser beam as shown at intervals in Fig. 7.4. The output from the detectors varies with time in the way shown in Fig. 7.5.

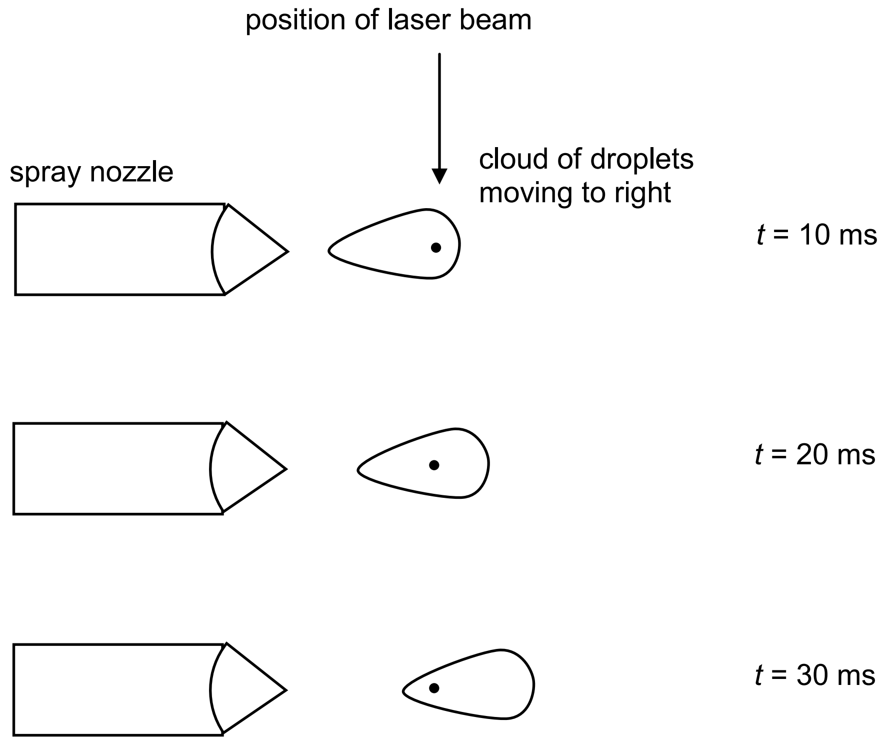

Fig. 7.4

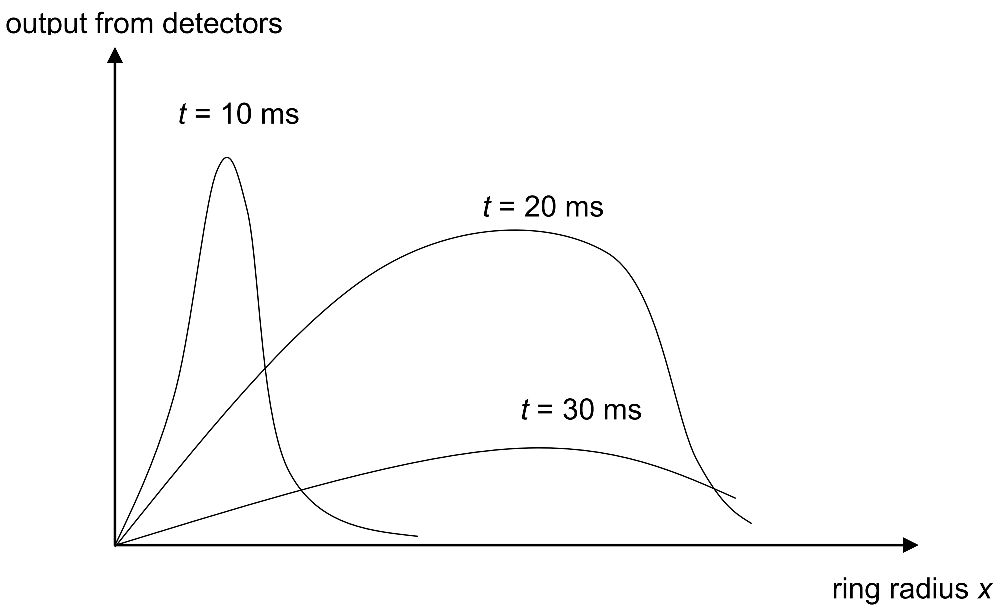

Fig. 7.5

For Examiner's Use

With reference to Fig. 7.6, describe the distribution of droplets in the cloud according to their size and concentration (i.e. amount of droplets).

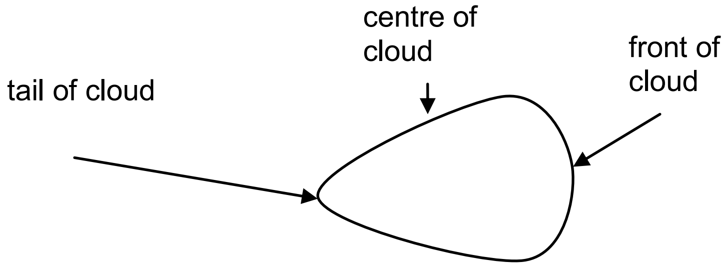

Fig. 7.6

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....[6]

END OF PAPER

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SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

NAME	
CG		**INDEX NO.**	

PHYSICS 9749/02

Preliminary Examination **14th September 2018**
Paper 2 Structured Questions **2 hours**

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

READ THIS INSTRUCTIONS FIRST

Write your name, civics group and index number 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 HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

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 bracket [ ] at the end of each question or part question.

For Examiners' Use	
Q1	/ 10
Q2	/ 7
Q3	/ 14
Q4	/ 8
Q5	/ 8
Q6	/ 14
Q7	/ 19
Total marks	/ 80

DATA AND FORMULAE

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\frac{1}{36\pi} \times 10^{-9}$ 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}

DATA AND FORMULAE

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	=	$Anqv$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \cdots$
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	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density 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	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1 A raindrop falls vertically from rest.

(a) Assume that air resistance is negligible.

On Fig. 1.1, sketch a graph to show the variation with time t of the velocity v of the raindrop for the first 1.0 s of the motion. [1]

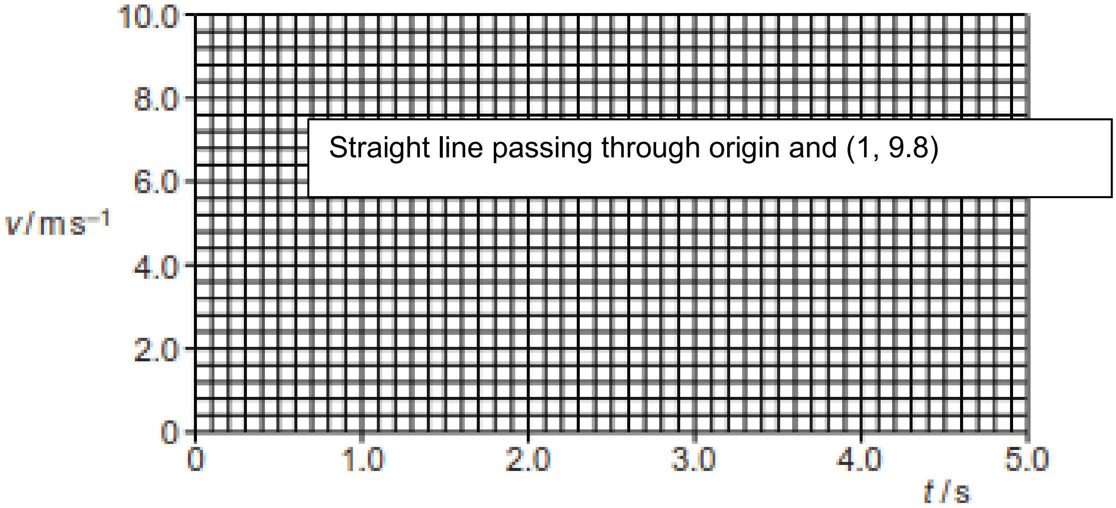

Fig. 1.1

(b) In practice, air resistance D on raindrops is not negligible.

D is given by the expression

$$D = k\,v^2$$

where k is a constant and
v is the speed

(i) The raindrop has mass 1.38×10^{-5} kg and k is 2.76×10^{-6} N m^{-2} s^2.

Calculate the terminal velocity of the raindrop.

At terminal velocity, acceleration is zero.
By Newton's Law,
Fnet = 0
Weight = D (+ upthrust)
$1.38 \times 10^{-5} \times 9.81 = \frac{1}{2}(0.63 \times 1.2 \times 7.3 \times 10^{-6})v^2$ [1]
v = 7.0 m s^{-1} [1]

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

(ii) The raindrop reaches terminal velocity at t = 3.0 s.

On Fig. 1.1, sketch the variation with time t of velocity v for the raindrop. The sketch should include the first 5.0 seconds of the motion. [2]

Same initial gradient [1]
Curve passing through origin and tends towards a horizontal line <u>and</u>
should reach terminal velocity at 3 seconds [1]

(c) A raindrop falls on a roof and rebounds off with a velocity of 5.5 m s^{-1} at an angle 60^o with respect to the horizontal as shown in Fig. 1.2.

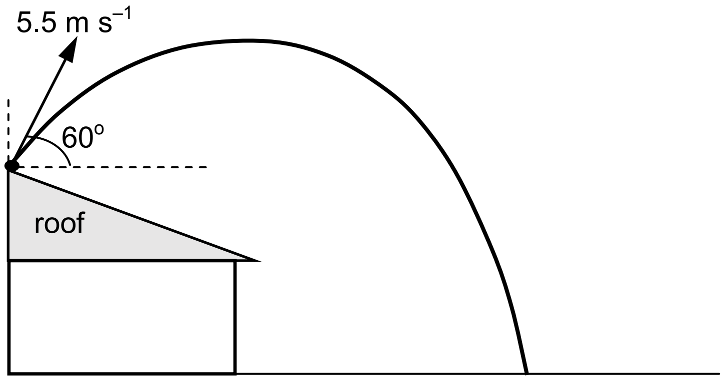

Fig. 1.2

Assume air resistance is negligible. The maximum horizontal distance travelled by the raindrop is 3.8 m.

(i) Calculate the time taken for the raindrop to hit the ground.

$S_x = u_x\, t$
$3.8 = (5.5 \cos 60^o)\, t$
$t = 1.38$ s

time = …………………. s [1]

(ii) Determine the speed of the raindrop as it hits the ground.

$v_x = u_x = 5.5 \cos 60^o = 2.75$ m s^{-1}
$v_y = (-5.5 \sin 60^o) + (9.81)(1.38) = 8.77$ m s^{-1} [M1]
$v = \sqrt{2.75^2 + 8.77^2} = 9.19$ m s^{-1} [A1]

speed = …………………...m s^{-1} [2]

(iii) Discuss quantitatively whether the assumption that air resistance is negligible is justified by considering the vertical component of the initial velocity of the raindrop.

The raindrop has the same mass and dimension as in **(b)(i)**.

Drag force = $2.76 \times 10^{-6}\, (5.5 \sin 60)^2 = 6.26 \times 10^{-5}$ N [1]

this is 0.4 times of the weight of raindrop [1]
so assumption is not justified

……………………………………………………………………………………………

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

2 A uniform rectangular card is suspended from a wooden rod. The card is held at one of its ends as shown in Fig. 2.1. The force by the hand on the card acts horizontally to the right.

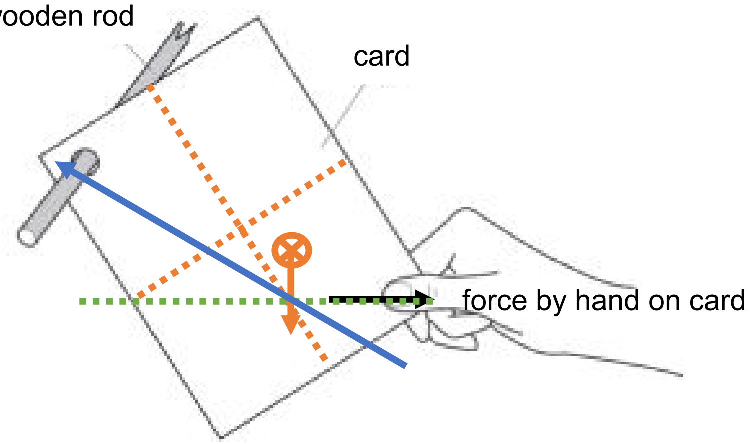

Fig. 2.1

(a) On Fig. 2.1,

(i) mark with an 'X' the position of the centre of gravity of the card. [1]

Accept answers that off-centre (below and towards the right) [1]

(ii) draw an arrow labelled with *W* to represent the weight of the card. [1]

arrow points downwards starting from X [1]

(b) State the conditions for the card to be in equilibrium.

Net force is zero [B1]
Net torque is zero [B1] <u>or</u> the sum of clockwise moments about any point is equal to the sum of anticlockwise moments about that same point <u>or</u> the lines of action of the 3 forces (weight, force by hand on card and force by rod on card) passes through a common point

[2]

(c) Draw an arrow labelled with *R* on Fig. 2.1 to represent the force exerted by the wooden rod on the card.

Show your construction clearly. [2]

Concurrent forces, 3 forces passes through same point. [B1]
Correct direction of arrow [B1]

(d) The card is now released. It swings on the wooden rod and eventually comes to a rest.

By reference to the completed diagram in Fig. 2.1, describe the final position in which the card comes to a rest.

Position of X directly below point of contact of card with rod/ line of action of W passing through the point of contact of card with rod [1]
Such that there is no resultant moment
Correct diagrams are accepted as part of the working.

[1]

3 **(a)** An object is placed on a smooth horizontal surface and is connected to a light spring, as shown in Fig. 3.1.

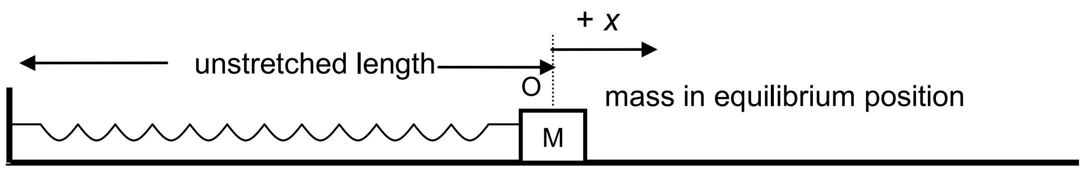

Fig. 3.1

The object is displaced to the right by 0.60 m and then released. Fig. 3.2 shows the variation with displacement *x* of acceleration *a* of the object.

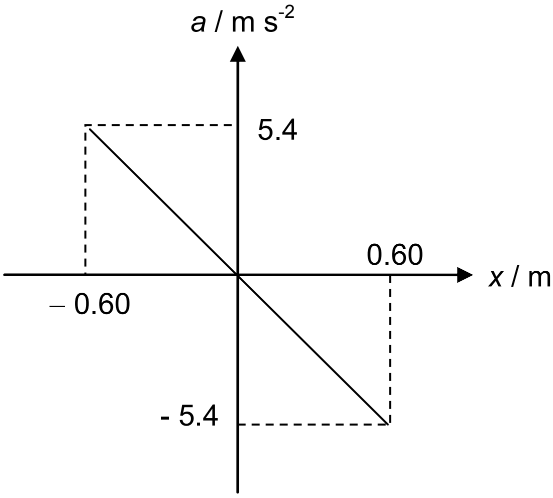

Fig. 3.2

(i) Use two features of the graph in Fig 3.2 to explain why the motion of the object is simple harmonic.

Negative gradient shows that the acceleration and displacement in opposite directions. [1]

Straight line through the origin shows that acceleration is proportional to displacement from equilibrium [1]

.... [2]

(ii) Calculate

1. the angular frequency,

$|a_0| = |\omega^2 x_0|$
$5.4 = \omega^2 (0.6)$
$\omega = 3.0$ rad s^{-1}

angular frequency = ... rad s^{-1} [1]

For Examiner's Use

2. maximum speed of the object.

Since $v_0 = \omega x_0$
$v_0 = 3\ (0.6) = 1.8\ \text{m s}^{-1}$ [1]

maximum speed = ………………… m s^{-1} [1]

(iii) Sketch on Fig. 3.3 the variation with time of the kinetic energy of the object for one complete oscillation. The mass of the object is 0.0020 kg.

Assume that the object just passes by the equilibrium position at time = 0 s. [2]

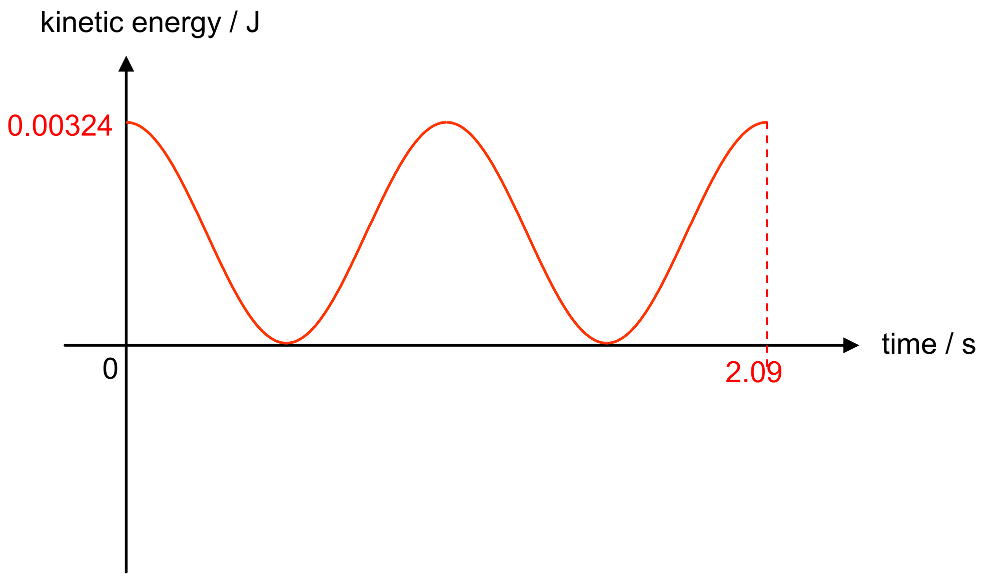

Fig. 3.3

(iv) Calculate the shortest time taken for the object to move from a point 0.30 m to the left of the equilibrium point to a point 0.30 m to the right of the equilibrium point.

At x = -0.30 m, $0.3 = 0.6 \sin (3t_1)$ [1]
$t_1 = 0.174$ s [1]
Time taken = 0.174 x 2 = 0.349 s [1]

time = ………………….. s [3]

(b) A car component of mass 0.0460 kg rattles at a resonant frequency of 35.5 Hz. Fig. 3.4 shows how the amplitude of the vertical oscillation varies with frequency.

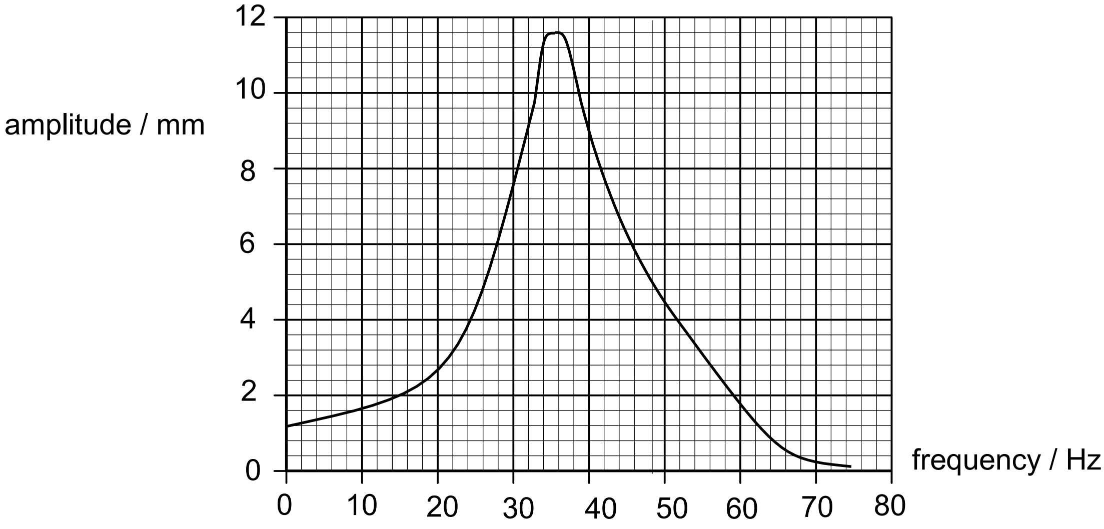

Fig. 3.4

(i) When oscillating at the resonant frequency, calculate

1. the angular frequency of the oscillation,

$\omega = 2\pi f = 2\pi \times 35.5 = 223$ rad s^{-1}

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

2. the total energy stored in the oscillation of the component.

total energy $= \frac{1}{2} m (\omega)^2 (x_0)^2$
$= \frac{1}{2} \times 0.046 \times 0.0116^2 \times 223^2$ [1]
$= 0.154$ J [1]

energy = ... J [2]

(ii) Draw on Fig 3.4 to show how the amplitude of the oscillation varies with frequency if the component is supported on a rubber mounting. [2]

maximum amplitude at <u>lower frequency</u> [1]
<u>same starting point</u> and <u>lower graph within original shape</u> [1]

4 (a) Fig.4.1 shows a string stretched between two fixed points P and Q.

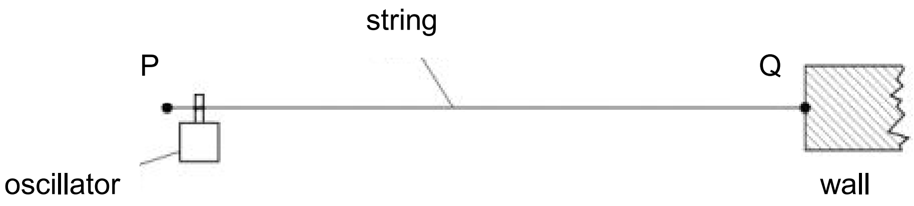

Fig. 4.1

An oscillator is attached near end P of the string. End Q is fixed to a wall. The oscillator has a frequency of 50.0 Hz.

The stationary wave produced on PQ at an instant time *t* is shown in Fig. 4.2. Each point on the string is at its maximum displacement.

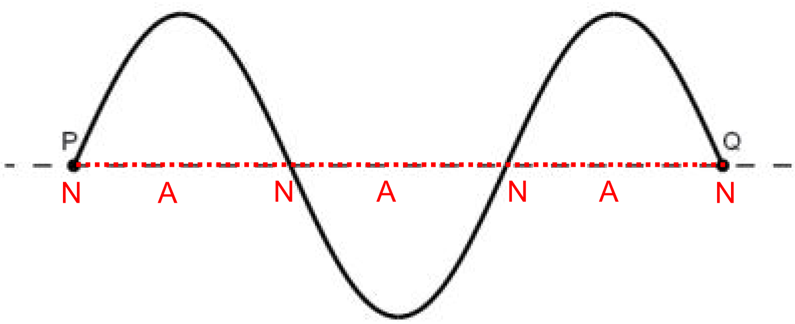

Fig. 4.2

(i) On Fig. 4.2, label all the nodes with the letter **N** and the antinodes with the letter **A** along the dotted line PQ. [1]

(ii) On Fig 4.2, draw the stationary wave at (t + 5.0 ms). [1]

Since T = 1/f = 1/50 = 20 ms, 5 ms is ¼ of a period. Correct diagram [1]

(b) Sound waves is directed from a loudspeaker towards a metal plate. A microphone, connected to a cathode ray oscilloscope (CRO), is placed in between the loudspeaker and the metal plate as shown in Fig. 4.3.

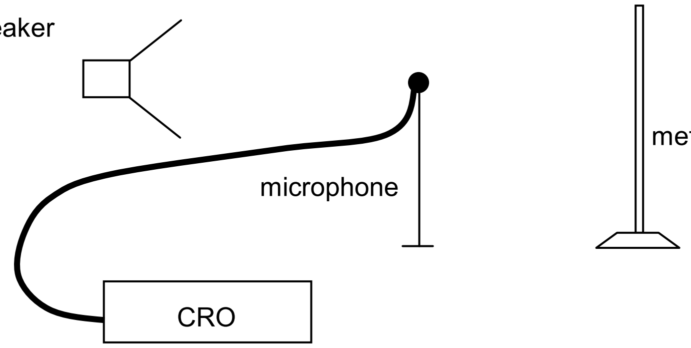

Fig. 4.3

(i) Explain how stationary waves are formed in between the loudspeaker and the metal phase.

As the sound waves reflects off the metal plate, the incident and reflected waves have the same amplitude, wavelength and frequency [B1] move in opposite direction and overlap/superpose/meet [B1].

When they experience constructive interference, they form regions of high intensity and when they experience destructive interference, they forms regions of low intensity. [B1]

………………………………………………………………………………………………

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

(ii) The trace on the CRO in Fig. 4.4 shows the variation of signal with time at an antinode.

The time-base setting on the CRO is 0.10 ms cm^{-1}.

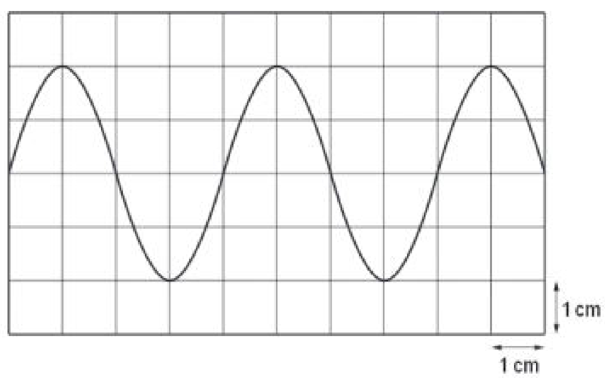

Fig. 4.4

The microphone is then moved by 3.3 cm and the trace on the CRO now records zero amplitude.

For Examiner's Use

1. Determine the frequency of the sound.

Frequency = 1/ period = 1 / 4 x 10^{-3} = 2500 Hz [A1]

frequency = …………………….. Hz [1]

2. Calculate the speed of sound.

Distance between node and antinode = ¼ wavelength.

Wavelength = 4 x 3.3 = 13.2 m [M1]

$v = f\lambda$ = 2500 x 13.2 = 330 m s^{-1} [A1]

speed = …………………….. m s^{-1} [2]

For Examiner's Use

5 **(a)** For a particular gas, the emission and absorption spectra are obtained for the visible light spectrum.

Discuss one similarity and one difference between the discrete lines of the absorption and emission spectra of this gas.

{Similarity} The discrete lines of both absorption and emission spectrum occur at same frequencies [1], but {Difference} the absorption has dark lines against a continuous spectrum whereas the emission spectrum has coloured lines against a black background [1].

.... [2]

(b) Fig. 5.1 gives information on three lines observed in the emission spectrum of hydrogen atoms.

wavelength / nm	**energy of photon / eV**
486	2.56
656	1.90
1880	0.66

Fig. 5.1

(i) Complete Fig. 5.1 by calculating the energy of the photon with wavelength 656 nm. [1]

(ii) Fig. 5.2 is a partially completed diagram to show energy levels of a hydrogen atom.

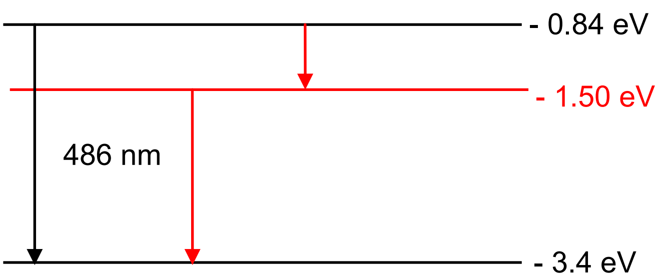

Fig. 5.2

On Fig. 5.2, draw an additional labelled energy level which will account for the emission of the photons in Fig. 5.1. [1]

(c) Three of the energy levels of a lithium atom are shown in Fig. 5.3.

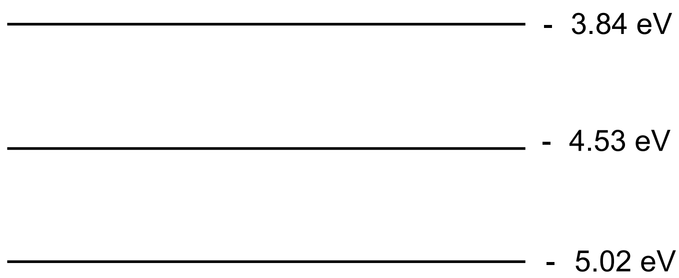

Fig. 5.3

One way to study the energy levels of an atom is to bombard the atom with electrons and measure the kinetic energies of the bombarding electrons before and after the collision. If a lithium atom which is originally in the – 5.02 eV level is bombarded with an electron of kinetic energy 0.92 eV, the scattered electron can have only two possible kinetic energies.

States these two kinetic energy values, and state what happens to the lithium atom in each case.

1^{st} possible kinetic energy value: ………………………. eV [1]

0.92 eV [1]
Nothing happens to the lithium atom (ie. it stays in the -5.02 eV level) [1]

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

2^{nd} possible kinetic energy value: ………………………. eV [1]

0.92 – (5.02 – 4.53) = 0.43 eV [1]
Atom will be excited to the -4.53 eV level [1]

…….. [1]

For Examiner's Use

6 **(a)** A stationary nucleus of a radioactive nuclide, $^{218}_{84}Po$, underwent a chain of decays by the emission of an α and β–particles. The decay is represented by the two equations:

$$^{218}_{84}Po \rightarrow D + \alpha$$
$$D \rightarrow E + \beta$$

where D and E are the nuclides formed after the decay.

(i) State the nuclear notation for E. [1]

$$\overset{\cdots\cdots\cdots}{\underset{\cdots\cdots\cdots}{}}E$$

$^{214}_{83}E$

(ii) Determine the ratio of the kinetic energy of the α–particle to the total kinetic energy of D and α–particle.

By conservation of linear momentum,

$0 = p_D + p_\alpha$

$|p_D| = |p_\alpha|$ [M1]

$$\frac{\text{KE of } \alpha\text{-particle}}{\text{total KE}}$$

$$= \frac{\dfrac{p_\alpha^2}{m_\alpha}}{\dfrac{p_\alpha^2}{m_\alpha} + \dfrac{p_D^2}{m_D}} \quad \text{[M1]}$$

$$= \frac{\dfrac{1}{m_\alpha}}{\dfrac{1}{m_\alpha} + \dfrac{1}{m_D}}$$

$$= \frac{\dfrac{1}{4u}}{\dfrac{1}{4u} + \dfrac{1}{214u}}$$

$= 0.982$ [A1]

ratio = ……………………… [3]

For Examiner's Use

(iii) In reality, the β –particles have a range of kinetic energies, instead of a fixed value. Explain why this is so.

Because there are neutrinos emitted together with the beta particles and kinetic energy is shared between the beta particles and neutrino. [A1]

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

(iv) A sample of $^{218}_{84}Po$ is placed on a weighing balance and a reading of 4.05 g is obtained. After 243 s, the reading drops to 4.02 g.

1. Determine the number of particles $^{218}_{84}Po$ in the initial sample.

No. of $^{218}_{84}Po$ particles $N_{218} = \dfrac{4.05\times10^{-3}}{218u} = 1.12\times10^{22}$ [A1]

number of particles = ………………….. [1]

2. Show that the total number of particles D and E after 243 s is 4.52 x 10^{21}. [1]

Total mass after time $t = (N_{Po} - N_{D+E})m_{Po} + (N_{D+E})m_D$

$(1.119\times10^{22} - N_{D+E})218u + (N_{D+E})214u = 4.02\times10^{-3}$ [M1]

$(1.119\times10^{22} - N_{D+E})218u + (N_{D+E})214u = 4.02\times10^{-3}$

$4.05\times10^{-3} - 4.02\times10^{-3} = (N_{D+E})4u$

$N_{D+E} = 4.518\times10^{21}$

3. Determine the half life of $^{218}_{84}Po$.

$$N = N_0\left(\frac{1}{2}\right)^{\frac{t}{t_{\frac{1}{2}}}}$$

$(1.12\times10^{22} - 4.52\times10^{21}) = 1.12\times10^{22}\left(\frac{1}{2}\right)^{\frac{243}{t_{\frac{1}{2}}}}$ [M1]

$t_{\frac{1}{2}} = 326$ s [A1]

half life = ………………… s [2]

For Examiner's Use

(b) For many unstable parent nuclei, the daughter nuclei is itself radioactive. This may give rise to a radioactive series where there may be ten or more different radioactive daughter products.

A radioactive parent nucleus X has a radioactive daughter nucleus Y and, in turn, this daughter produces a further stable daughter Z. The variation with time *t* of the percentage number *P* of the different nuclei X, Y and Z in a radioactive sample is illustrated in Fig. 6.1

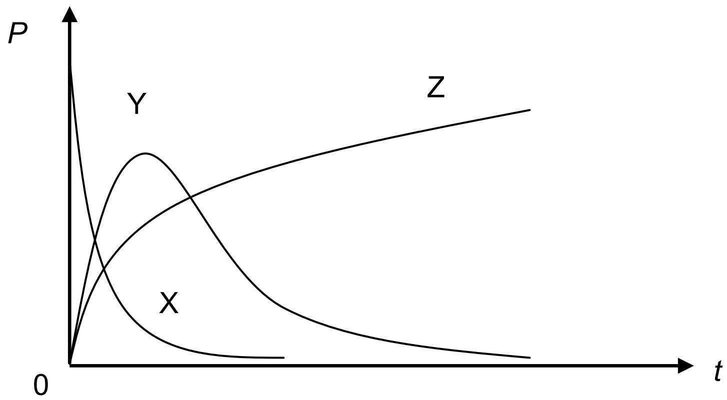

Fig 6.1

(i) X has a half life of 5 hours. The count rate at t = 0 and t = 5 hours were measured. Suggest three possible reasons why the count rate is not exactly halved after 5 hours.

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

1. Existence of background count. [B1]
2. Product Y is also giving off radiation that adds to count rate. [B1]
3. Random nature of radioactive decay. [B1]

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

3. ……………………………………………………………………………………………

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

(ii) Explain why graph of Y increases to a maximum and then decreases.

It happens because initially, there are more number of X than Y and hence, Y is being formed faster than it is decaying. [B1] As number of X decreases, there will be a point where Y decays faster than it is being formed. Hence, this will lead to a decrease in number of Y. [B1]

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

7 Many devices are designed to create a spray of tiny droplets. The effectiveness of these devices usually depends on droplet size. One example is an agriculture pesticide spray in which a few large droplets do not coat the leaves of plants as well as many small droplets. Another example is a fuel injection system for an engine.

Measuring the size of droplets present in a spray is difficult to do by direct means but instruments called droplet sizers can be purchased which make droplet sizing a fast routine operation.

The principle of operation of one such sizer is shown in Fig. 7.1, in which light from a helium/neon laser is passed through a spray of droplets of uniform diameter and forms a circular diffraction ring of radius *x*. The diameter *d* of the droplets is related to *x* by the equation

$$d = k\frac{\lambda}{x}$$

In this equation *λ*, the wavelength of the light, is 6.33×10^{-7} m. *k* is a constant equal to 0.474 m, and *d* and *x* are both in metres.

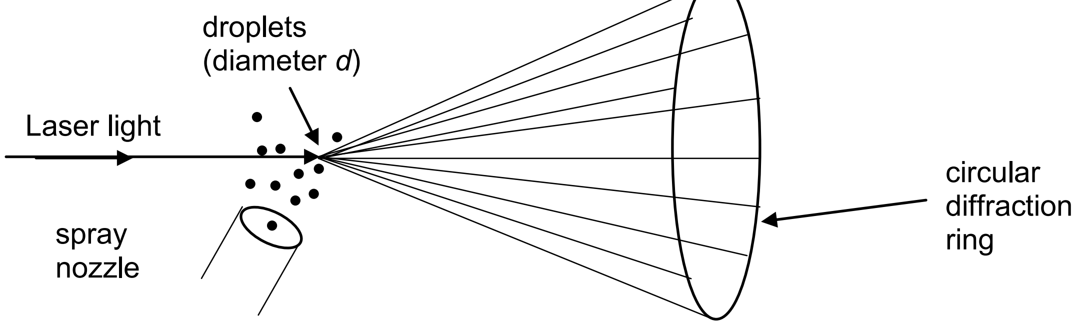

Fig. 7.1

In practice, a spray will consist of droplets of different sizes, so many rings of diffracted light will be caused. The diffraction pattern in Fig. 7.2a is projected on a flat surface containing many light sensitive detectors. The output from the detectors can be analysed by a computer and be shown in the form of a graph in Fig. 7.2b.

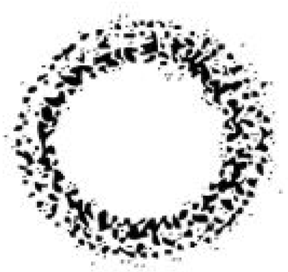

Fig. 7.2a

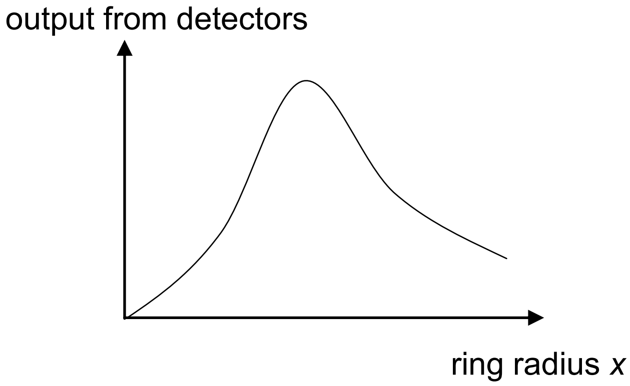

Fig. 7.2b

For Examiner's Use

(a) Suggest two devices, other than those mentioned in the first paragraph of the passage, where droplet size is important.

Spray paint [B1], Hair spray [B1]

[2]

(b) Outline a direct method for measuring droplet diameter.
Apparatus available includes: high speed camera, stroboscope, stopwatch, rulers.

Use high speed camera to capture still image of droplets. [1]
Have a backdrop of grid squares in the background to estimate size of each droplet. [1]
Use an object of known diameter at same distance from background to compare with size of droplet and thus use scaling to determine droplet diameter. [1]

[3]

(c) Give two reasons why direct methods are likely to be difficult for measuring droplets of small diameter.

1. Measurement devices may lack sufficient precision for measurement. [B1]
2. The droplets may be too packed to give a distinct image [B1]

[2]

(d) Calculate the value of *x* for a droplet of diameter

(i) 10 μm

$$d = k\frac{\lambda}{x}$$

$$x = k\frac{\lambda}{d} = 0.474(\frac{6.33\times10^{-7}}{10\times10^{-6}}) = 0.0300 \text{ m} \quad [A1]$$

x = ……………………….. m [1]

(ii) 200 μm

$$d = k\frac{\lambda}{x}$$

$$x = k\frac{\lambda}{d} = 0.474(\frac{6.33\times10^{-7}}{200\times10^{-6}}) = 0.00150 \text{ m} \quad [A1]$$

x = ……………………….. m [1]

For Examiner's Use

(e) State whether a small value of x corresponds to large or to small droplets.

Small x corresponds with large droplets [1]

.... [1]

(f) Suggest, with reference to the equation given, how the radius of the circular diffraction ring can be increased for the same diameter of water droplets.

.... Increase wavelength of laser light. [1] .... [1]

(g) Sketch on the axes in Fig. 7.3 curves to show the general shape of graphs that would be obtained if

(i) droplets with a wide range of diameter were used. Label as **(i)**. [1]

(ii) very small droplets with a narrow range of diameters were used. Label as **(ii)** [1]

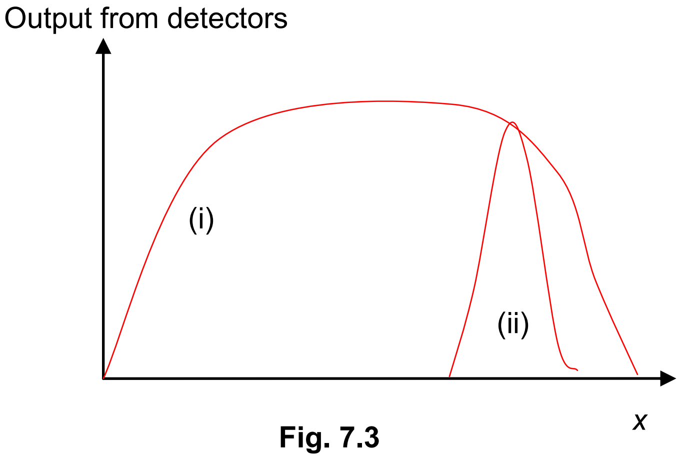

Fig. 7.3

For Examiner's Use

(h) In practice, a cloud of spray droplets moves through the laser beam as shown at intervals in Fig. 7.4. The output from the detectors varies with time in the way shown in Fig. 7.5.

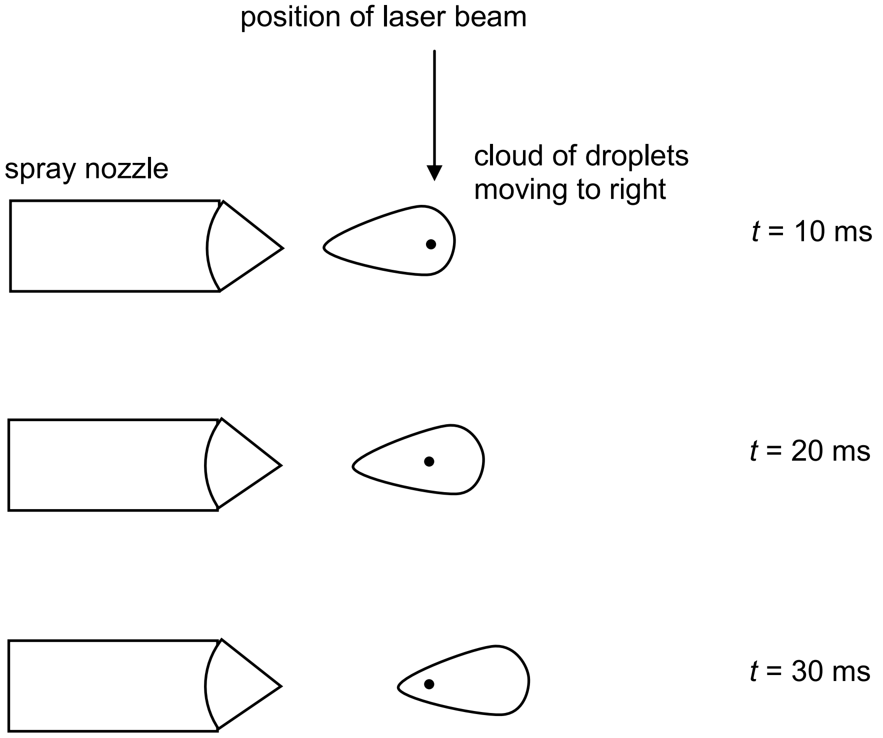

Fig. 7.4

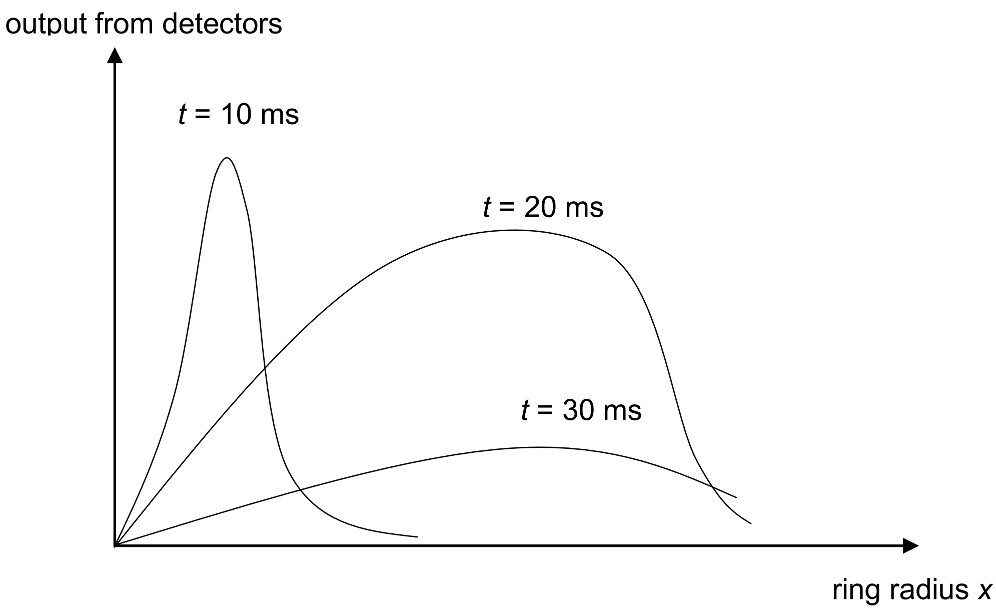

Fig. 7.5

For Examiner's Use

With reference to Fig. 7.6, describe the distribution of droplets in the cloud according to their size and concentration (i.e. amount of droplets)..

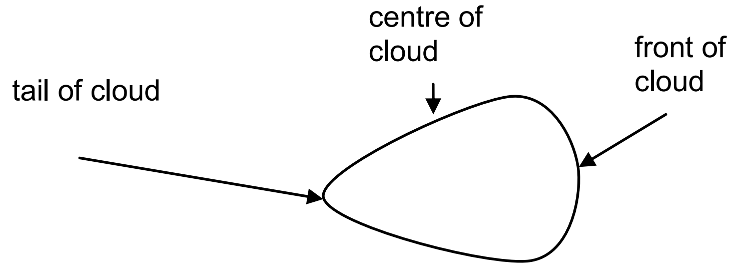

Fig. 7.6

At the front tip of the cloud,
Droplets are of uniform sizes and with a large diameter. [1] fewer droplets as compared to centre [1]

At the centre of cloud,
Droplets are of a range of sizes [1] and are large number of droplets as compared to front and tail of cloud. [1]

At tail of cloud, detected with a range of different diameters. [1] fewer droplets as compared to centre [1]

Concentration – amount of water droplets
Size – diameter + range of diameters

[6]

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SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

NAME | |

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PHYSICS — 9749/03

Preliminary Examination — **20th September 2018**
Paper 3 Longer Structured Questions — **2 hours**

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

READ THIS INSTRUCTIONS FIRST

Write your name, civics group and index number 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 HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

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

Answer **all** questions in Section A, and **one** of the two questions in Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in bracket [ ] at the end of each question or part question.

For Examiners' Use	
Q1	/ 8
Q2	/ 7
Q3	/ 10
Q4	/ 8
Q5	/ 10
Q6	/ 10
Q7	/ 7
Q8	/ 20
Q9	/ 20
Total marks	/ 80

For Examiner's Use

DATA AND FORMULAE

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\frac{1}{36\pi} \times 10^{-9}$ 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}

DATA AND FORMULAE

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	$= \rho gh$
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	$= Anqv$
resistors in series	R	$= R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R}$	$= \frac{1}{R_1} + \frac{1}{R_2} + \cdots$
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	$= \frac{\mu_0 I}{2\pi d}$
magnetic flux density 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	$= \frac{ln2}{t_{\frac{1}{2}}}$

For Examiner's Use

Section A

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

1 **(a)** Define *impulse*.

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

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

(b) In a car test, a car with a dummy driver and passenger, moving at a speed of 6.9 m s^{-1}, collides head-on into a wall. The mass of the car is 1250 kg, the mass of the driver is 85 kg and the mass of the front passenger is 65 kg. The average deceleration of the car as it comes to a stop is 48 m s^{-2}. Both passenger and driver have their seat belts tightly fastened.

For the impact,

(i) determine the magnitude of the average force exerted on the car and its occupants.

average force = …………….………. N [1]

(ii) determine the magnitude of the impulse caused by the force.

impulse = …………….………. N s [2]

(iii) Hence, calculate the time taken for the car to come to a stop.

time = …………….………. s [2]

(iv) Assuming that the average deceleration remains the same, state and explain how your answer in **(b) (iii)** will change (if any) when the total mass of car and occupants is doubled.

…………………………………………………………………………………………

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

For Examiner's Use

2 A fixed mass of an ideal monatomic gas undergoes a cycle **ABCA** of changes, as shown in Fig. 2.1.

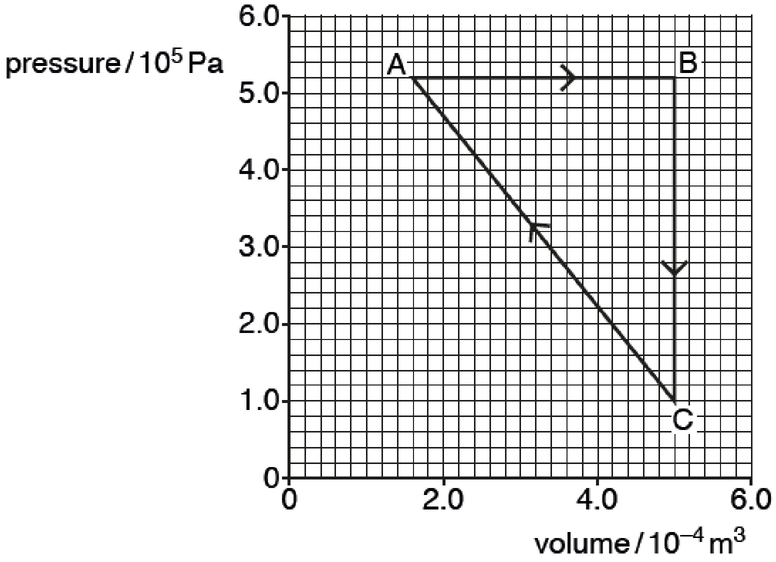

Fig. 2.1

(a) During the change from **B** to **C**, the internal energy of the gas decreases by 315 J.

By considering molecular energy, state and explain qualitatively the change, if any, in the temperature of the gas.

……..

……..

……..

…….. [2]

(b) During the change from **A** to **B**, the energy supplied to the gas by heating is 442 J.

Fig. 2.2 is a table of energy changes during one cycle. Complete Fig. 2.2.

section of cycle	heat supplied to gas / J	work done on gas / J	increase in internal energy of gas / J
A to B	442		
B to C			-315
C to A			

Fig. 2.2

[3]

For Examiner's Use

(c) Calculate the root-mean-square speed of the gas atoms at point **B** if the root-mean-square speed at point **A** is 350 m s^{-1}.

root-mean-square speed = ……………..……… m s^{-1} [2]

For Examiner's Use

3 **(a)** As seen in Fig 3.1, a monochromatic light of wavelength 580 nm is used to produce an interference pattern on screen AB. The separation between the slits is 0.41 mm and the perpendicular distance between the double slit and the screen is *D*. Point Y is at a distance x = 2 mm from point O and it is the position of the first dark fringe. The intensities of the light passing through the two slits are the same.

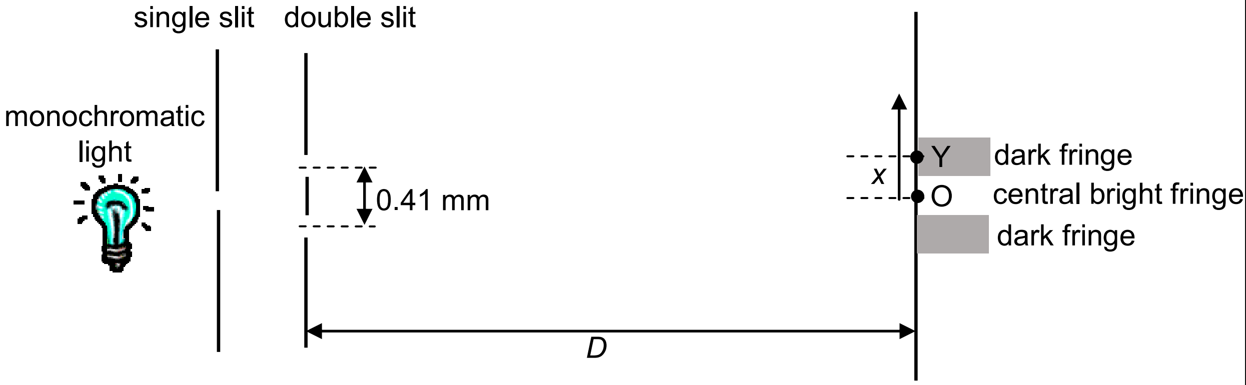

Fig 3.1

(i) Calculate the path difference between the 2 waves arriving at point Y from the slits.

distance = ……………….. nm [1]

(ii) Calculate the distance *D*.

D = ……………………… m [2]

(iii) The width of both slits is reduced by the same amount without altering their separation. The original variation with distance *x* from point O of the intensity is as shown in Fig. 3.2. Sketch the new variation of intensity on Fig. 3.2. [3]

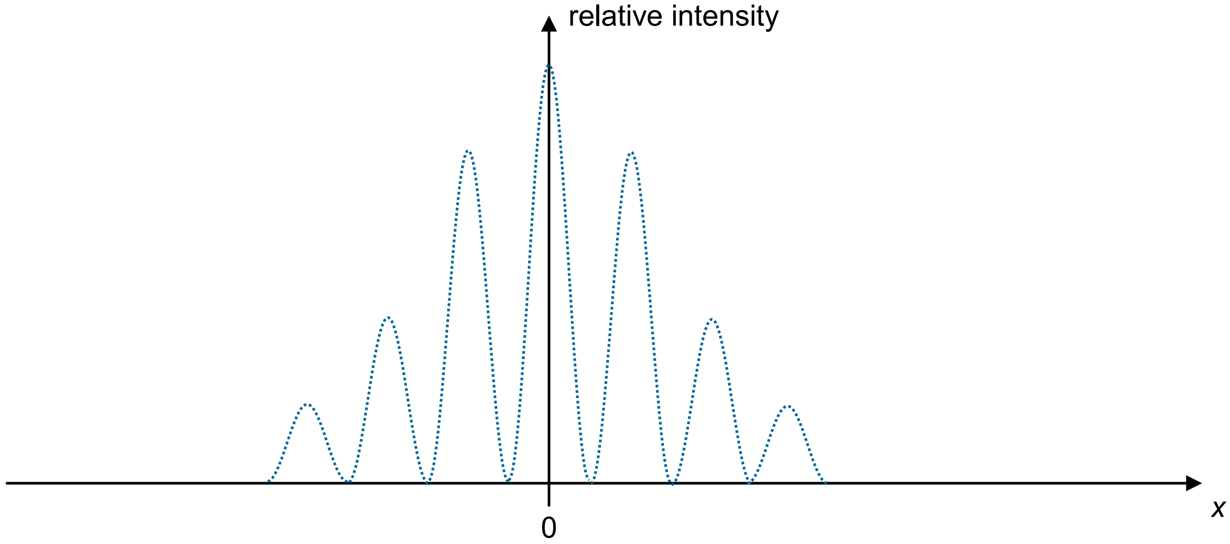

Fig. 3.2

(b) A diffraction grating is used to measure the wavelengths of light. The angle θ of the second order maximum is measured for each wavelength. The variation with wavelength λ of sin θ is shown in Fig 3.3.

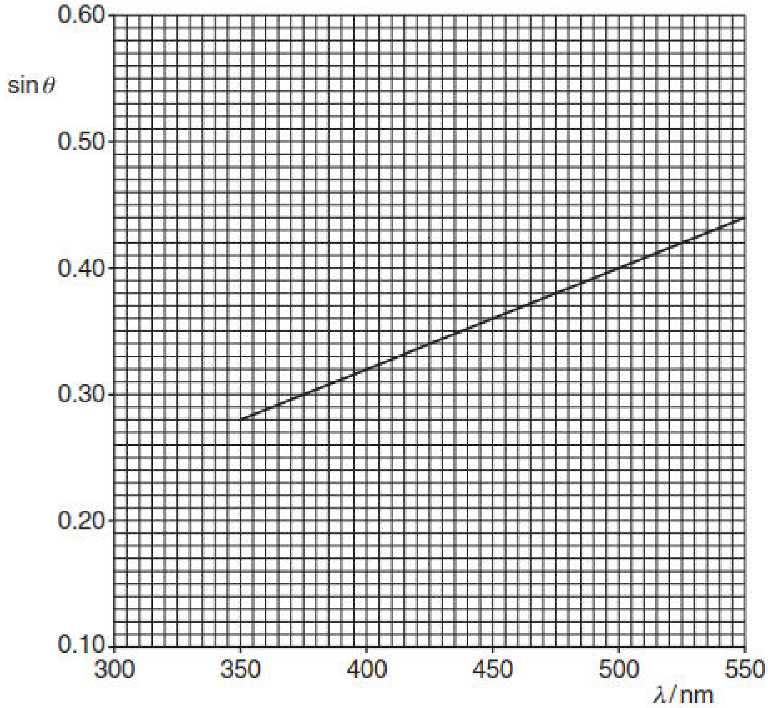

Fig. 3.3

(i) Calculate the slit separation d of the diffraction grating.

d = ……………………….m [3]

(ii) On Fig. 3.3, sketch a line to show the results that would be obtained for the first order maxima. [1]

For Examiner's Use

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

....

....

.... [2]

(b) Two charged solid spheres A and B are situated in a vacuum. Their centres are separated by a distance of 30.0 cm, as shown in Fig. 4.1. The diagram is not drawn to scale.

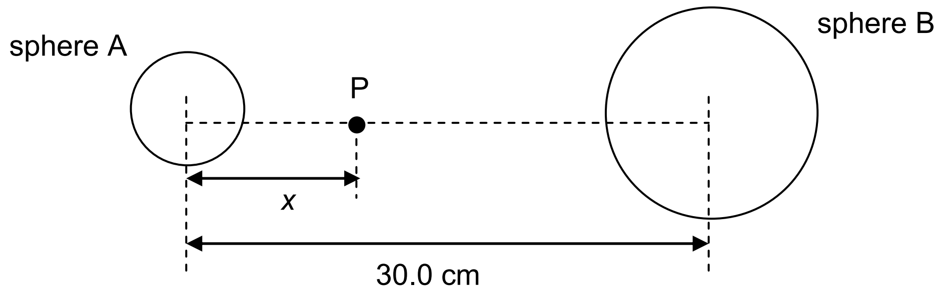

Fig. 4.1

The variation with distance x of the electric potential V_A and V_B due to sphere A and B independently is shown in Fig. 4.2.

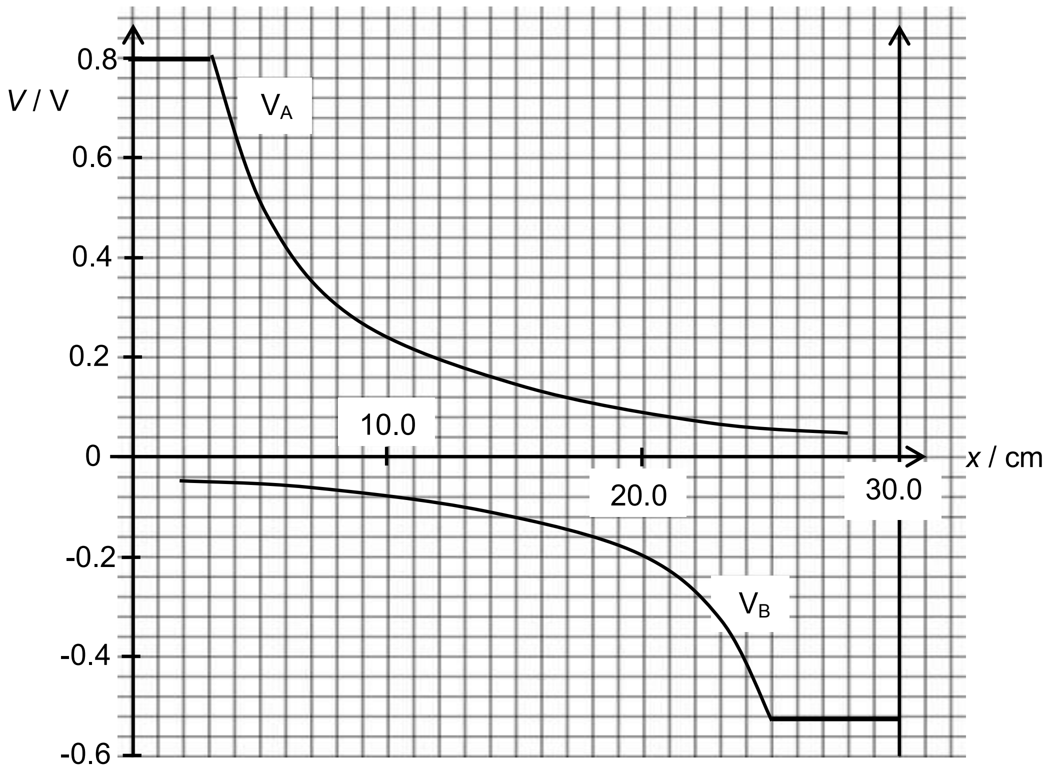

Fig. 4.2

(i) Using Fig. 4.2, state the radius of both spheres.

radius of sphere A = ……………… cm

radius of sphere B = ………………. cm [1]

(ii) State and explain the signs of both spheres.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(iii) Point P is at a distance x = 10.0 cm.
An alpha particle has kinetic energy E_K when at infinity.

Use Fig. 4.2 to determine the minimum value of E_K such that the alpha particle may travel from infinity to point P.

E_K = …………………………. J [3]

For Examiner's Use

5 An ideal transformer is connected to a sinusoidal a.c. supply, as shown in Fig. 5.1. The primary coil has a r.m.s. current of 0.85 A.

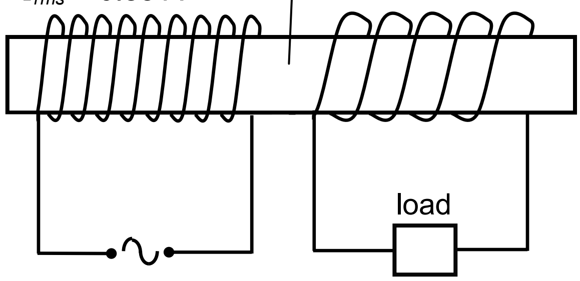

Fig. 5.1

(a) Use the laws of electromagnetic induction to explain how a potential difference can be developed across the secondary coil.

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

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

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

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

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

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

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

(b) **(i)** The primary coil contains 9 turns per cm, calculate the maximum magnetic field strength at its centre.

maximum magnetic field strength = …………………. T [2]

For Examiner's Use

(ii) The ratio of the number of turns in the primary to secondary coil is 16 : 1.

Calculate the peak current in the load.

peak current = …………………….. A [2]

(iii) The variation with time t of current I_p in the primary coil is shown in Fig. 5.2.

On Fig. 5.3, sketch the variation with time t of current I_s in the secondary coil. [1]

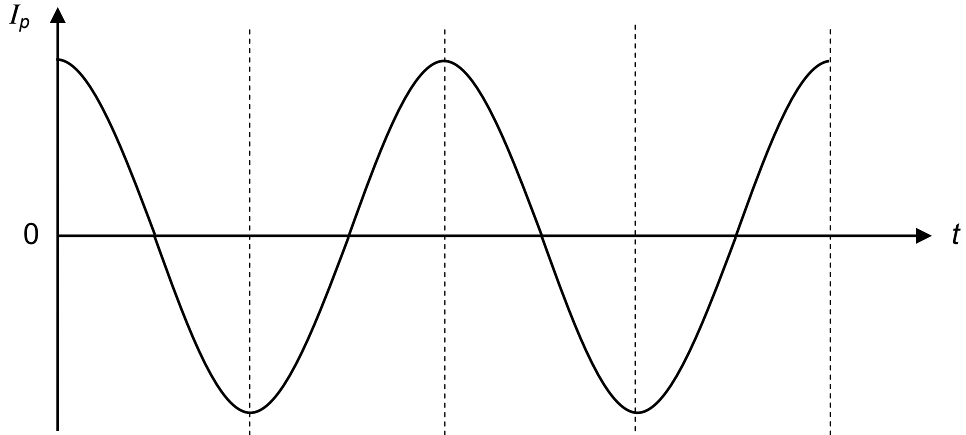

Fig. 5.2

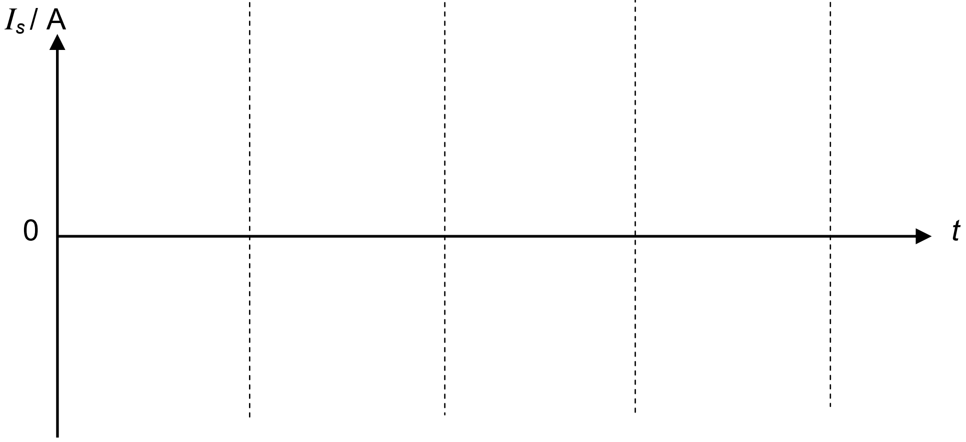

Fig. 5.3

(iv) State and explain how the answer to **b (iii)** will change if the iron core is removed from the transformer.

………

………

……… [2]

For Examiner's Use

6 Ultraviolet radiation of wavelength 122 nm is used to illuminate the cathode in the vacuum tube as shown in Fig. 6.1.

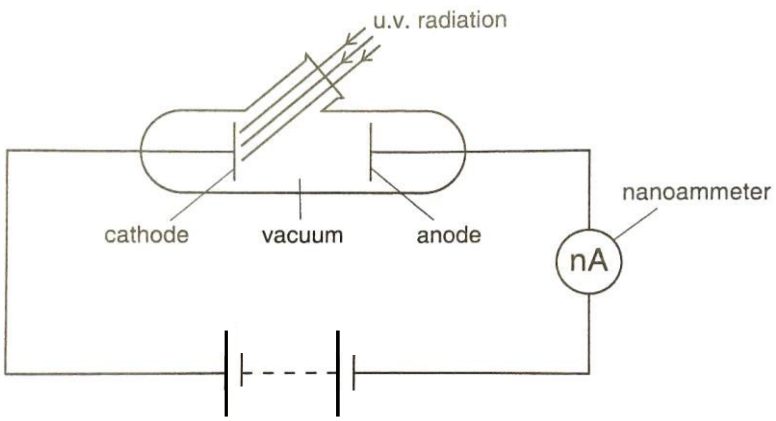

Fig. 6.1

(a) Photoelectrons are emitted from the cathode and collected at the anode. With the anode made negative and the cathode positive, some photoelectrons can still reach the anode, and by varying the battery's e.m.f, a graph of current against e.m.f. can be plotted as shown in Fig. 6.2.

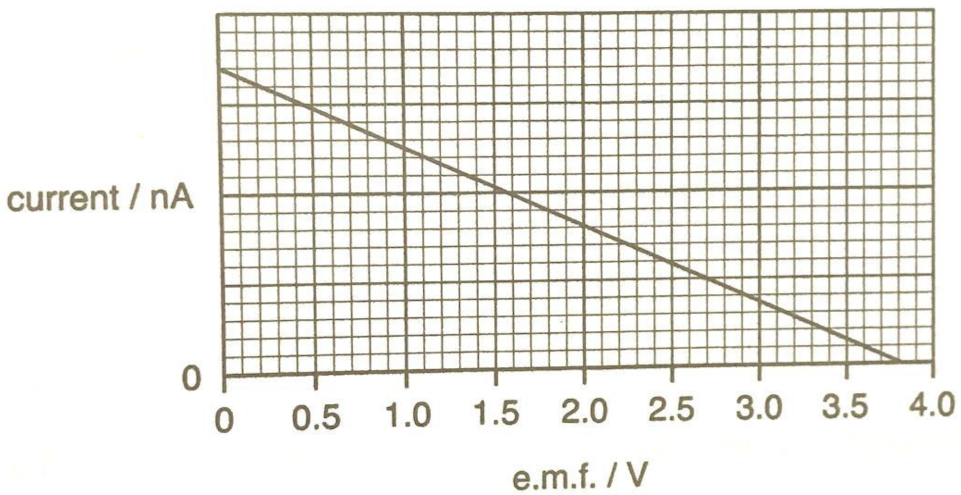

Fig. 6.2

(i) Explain why some photoelectrons are still able to reach the negative anode.

....

....

....

.... [1]

(ii) Calculate the maximum speed the photoelectrons can have when they leave the cathode.

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

(iii) Calculate the work function of the metal used in the cathode.

work function = ………………………………… J [2]

(b) The photocurrent I for different potential difference V between the cathode and the anode was measured. The experiment was then repeated using ultraviolet radiation of the same wavelength but of different intensity.

The series of graphs of I against V are shown in Fig. 6.3.

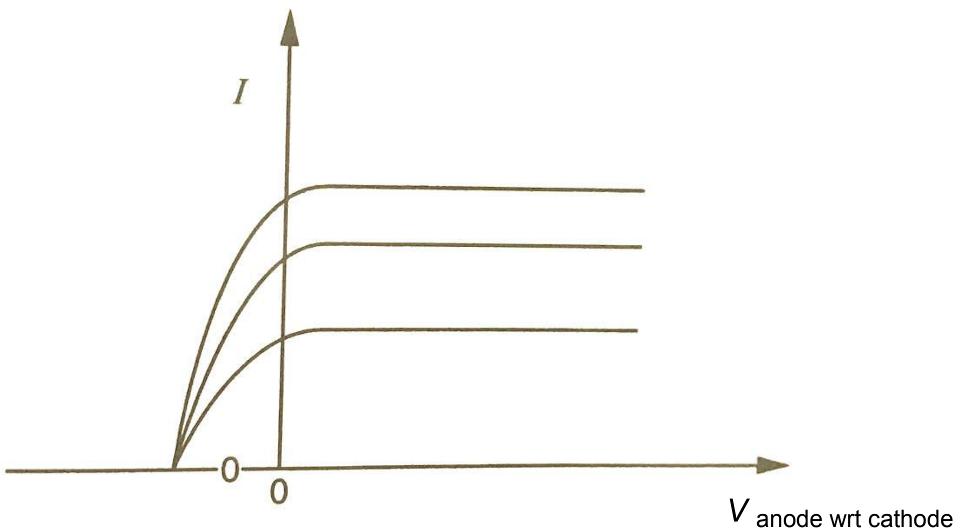

Fig. 6.3

For Examiner's Use

(i) State and explain which feature of this graph could not be explained using the wave theory of light.

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

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

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

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

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

(ii) Explain why the maximum kinetic energy of photoelectrons is independent of intensity whereas the photoelectric current is proportional to intensity of the light.

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

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

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

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

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

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

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

7 An induced nuclear fission reaction may be represented by the equation

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3^{1}_{0}n$$

(a) Sketch the variation with nucleon number of the binding energy per nucleon in Fig 7.1. [2]

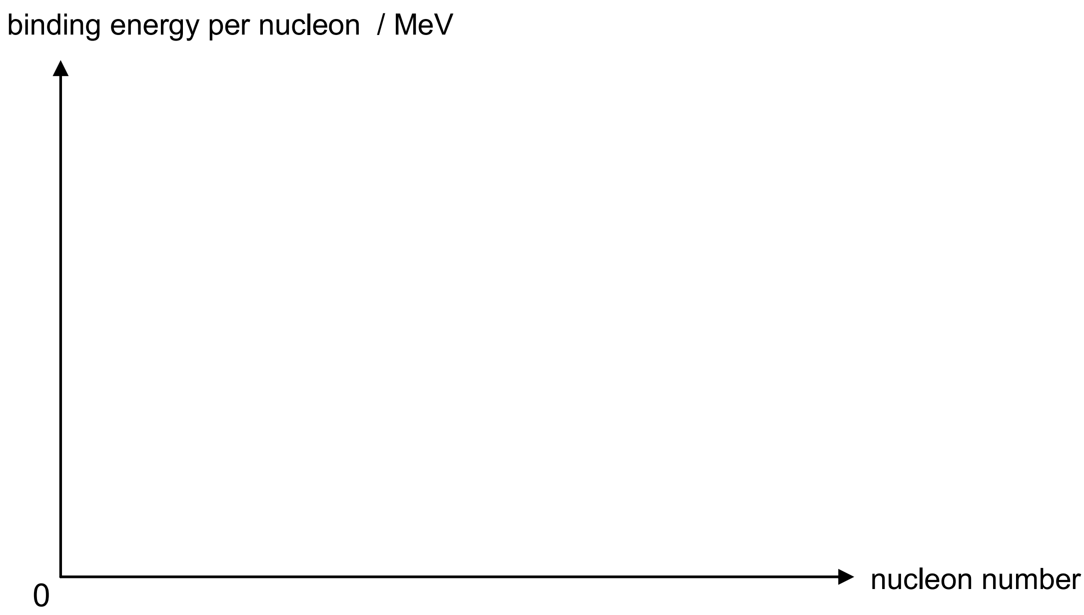

Fig 7.1

(b) Hence, explain why Uranium – 235 is more likely to undergo fission than fusion.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

For Examiner's Use

(c) The masses of the various nuclides are as listed below:

nuclide	mass / *u*
Uranium - 235	235.04393
Barium – 141	140.91441
Krypton - 92	91.92616
neutron	1.00867

Determine the energy released in the reaction.

energy released = ……………………………. J [2]

Section B

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

8 **(a)** **(i)** Define *gravitational field strength*.

....

....

.... [1]

(ii) Derive, from Newton's Law of Gravitation and **(a)(i)**, the equation for the gravitational field strength of a point mass of mass M_1, placed in a gravitational field generated by a mass M_2 and at a distance of r from M_1. [2]

(b) Information related to the Earth and the Moon is given below:

$$\frac{\text{Radius of Earth}}{\text{Radius of Moon}} = 3.7$$

$$\frac{\text{Mass of Earth}}{\text{Mass of Moon}} = 81$$

The center-to-center distance of the Moon from the Earth is 3.84×10^8 m and the gravitational field strength due to the Earth at its surface is 9.8 N kg^{-1}.

(i) Using these data, calculate the gravitational field strength due to the Moon at its surface.

gravitational field strength = ... N kg^{-1} [3]

For Examiner's Use

(ii) There is a point on the line between the Earth and the Moon at which their combined gravitational field strength is zero.

Calculate the distance between this point and the centre of the Earth.

distance = ……………………………… m [2]

(iii) The Moon orbits around the Earth with a period of 27.3 days.

1. Calculate the angular speed of the Moon.

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

2. Calculate the mass of the Earth.

mass = ………………………………… kg [2]

3. Determine the gravitational force between the Earth and the Moon.

gravitational force = ……………………………….. N [2]

4. Tidal action on the Earth's surface causes the radius of the orbit of the Moon to increase by 4.0 cm each year. Using your answer in **(b)(iii)(3)**, determine the change, in one year, of the gravitational potential energy of the Moon.

change in potential energy = ………………………….. J [2]

(c) **(i)** Explain, by considering the respective field forces, why gravitational potential energy is negative whereas electric potential energy can be positive or negative.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(ii) The Earth may be assumed to be an isolated sphere of radius 6.4×10^3 km with its mass of 6.0×10^{24} kg concentrated at its centre. A 2.0 kg mass is projected vertically from the surface of the Earth so that it reaches a maximum altitude of 1.3×10^4 km.

Calculate, for this mass,

1. the change in gravitational potential energy

change in gravitational potential energy = …………………….. J [2]

2. the speed of projection from the Earth's surface, assuming air resistance is negligible.

speed = ……………………………. m s^{-1} [2]

9 **(a)** By reference to energy transfers, distinguish between electromotive force (e.m.f.) and potential difference (p.d.).

e.m.f. ……………………………………………………………………………………………

……………………………………………………………………………………………..

p.d. ……………………………………………………………………………………………..

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

(b) A circuit is set up as shown in Fig. 9.1.

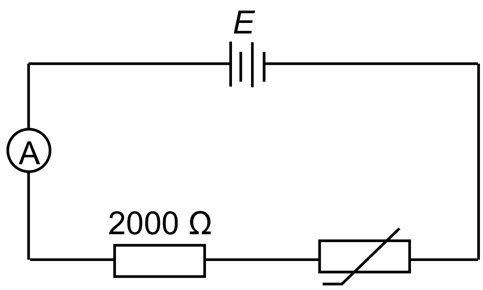

Fig. 9.1

The battery source of emf E is found to provide 2.4×10^5 J of electrical energy to the 2000 Ω resistor and thermistor when a charge of 2.2×10^4 C passes through the ammeter. At room temperature, the thermistor has a resistance of 1800 Ω.

(i) Sketch on Fig. 9.2 the variation with temperature θ of resistance R in a thermistor. [1]

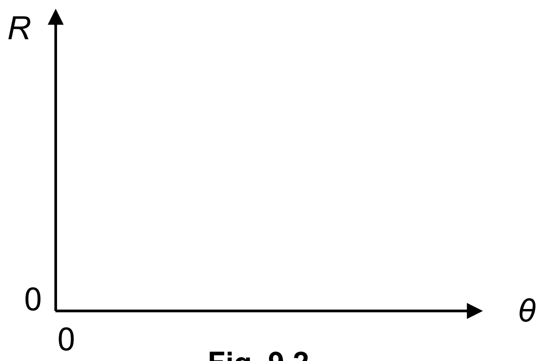

Fig. 9.2

(ii) For the thermistor at room temperature,

1. show that E is 11 V. [1]

2. determine the time taken for a charge of 2.2×10^4 C to pass through the ammeter.

time = ………………… s [2]

3. show that the fraction of power dissipated in the thermistor is 0.47. [1]

(c) A uniform resistance wire PQ of length 1.2 m is subsequently connected across the resistor and thermistor, as shown in Fig. 9.3. A sensitive voltmeter is connected between point Y and a moveable contact M on the wire.

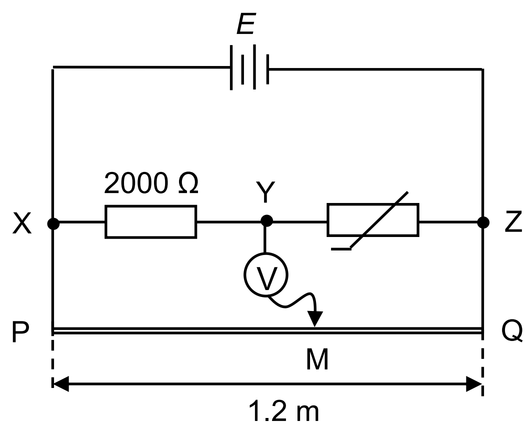

Fig. 9.3

(i) At room temperature, the contact M is moved along PQ until the voltmeter shows zero reading.

Calculate the length of wire between M and Q.

length of wire = …………………… m [2]

For Examiner's Use

(ii) State and explain the effect, if any, on the length of the wire between M and Q for the voltmeter to remain at zero deflection if each of the following changes takes place independently.

1. The thermistor is warmed slightly.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

2. A uniform wire with a bigger cross sectional area is used to replace PQ.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(d) The circuit shown in Fig. 9.4 is used to compare potential differences.

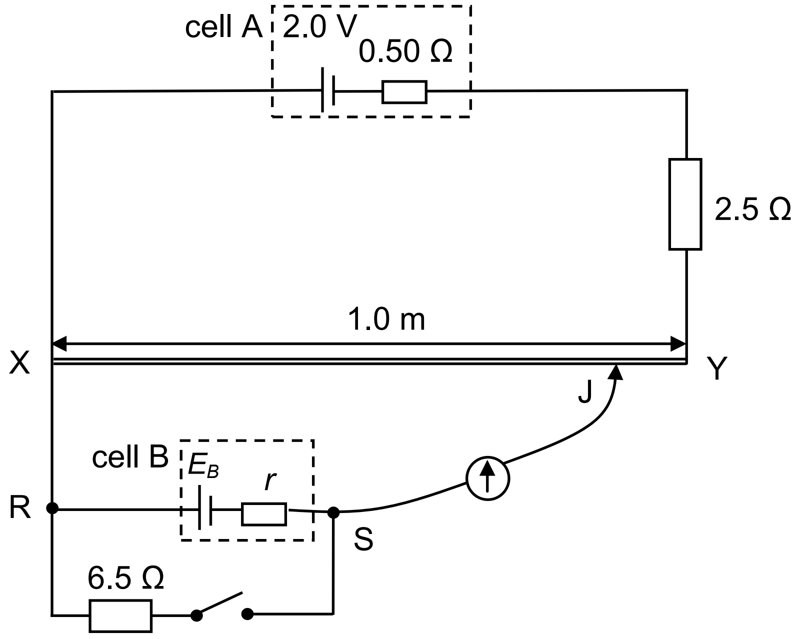

Fig. 9.4

The uniform resistance wire XY has length 1.0 m and resistance 8.0 Ω. Cell A has e.m.f. 2.0 V and internal resistance 0.50 Ω. Cell B has e.m.f. E_B and internal resistance r.

(i) The switch is opened. The galvanometer shows no deflection when the moveable contact J is adjusted so that the length XJ is 0.90 m.

Show that the e.m.f. E_B of cell B is 1.3 V. [2]

For Examiner's Use

(ii) The switch is now closed.

1. For the galvanometer to show no deflection, contact J has to be adjusted so that length XJ is 0.75 m.

Determine the internal resistance r of cell B.

r = …………………….. Ω [3]

2. A resistor is connected in parallel with the 6.5 Ω resistor.

Deduce how the balanced length XJ would be affected.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

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

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SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

NAME

CG **INDEX NO.**

PHYSICS 9749/03

Preliminary Examination **20th September 2018**
Paper 3 Longer Structured Questions **2 hours**

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

READ THIS INSTRUCTIONS FIRST

Write your name, civics group and index number 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 HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

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

Answer **all** questions in Section A, and **one** of the two questions in Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in bracket [ ] at the end of each question or part question.

For Examiners' Use	
Q1	/ 8
Q2	/ 7
Q3	/ 10
Q4	/ 8
Q5	/ 10
Q6	/ 10
Q7	/ 7
Q8	/ 20
Q9	/ 20
Total marks	/ 80

DATA AND FORMULAE

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\frac{1}{36\pi} \times 10^{-9}$ 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}

DATA AND FORMULAE

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 /ºC + 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	=	$Anqv$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \cdots$
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	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density 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	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

For Examiner's Use

Section A

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

1 **(a)** Define *impulse*.

Product of (average) force and the time that the (average) force acts on the body [1] (or time of impact)

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

(b) In a car test, a car with a dummy driver and passenger, moving at a speed of 6.9 m s^{-1}, collides head-on into a wall. The mass of the car is 1250 kg, the mass of the driver is 85 kg and the mass of the front passenger is 65 kg. The average deceleration of the car as it comes to a stop is 48 m s^{-2}. Both passenger and driver have their seat belts tightly fastened.

For the impact,

(i) determine the magnitude of the average force exerted on the car and its occupants.

average force = ma = (1250+85+65) (48) = 67200 N

average force = ……………..………. N [1]

(ii) determine the magnitude of the impulse caused by the force.

Impulse = change in momentum
= mv – mu
= 0 – (1250+85+65) (6.9) [1]
= - 9660 Ns
Ans: 9660 [1]

impulse = ……………..………. N s [2]

(iii) Hence, calculate the time taken for the car to come to a stop.

By Impulse - momentum theorem,
Ft = mv – mu
t = 9660/67200 [1]
= 0.144 s [1]

time = ……………..………. s [2]

(iv) Assuming that the average deceleration remains the same, state and explain how your answer in **(b)iii)** will change (if any) when the total mass of car and occupants has doubled.

No change [A1].
Since the change in velocity and the deceleration remains unchanged (a = Δv/Δt) [M1]
Or since the impulse (the change in momentum) and the average force both doubled, the time taken remains unchanged [M1]

[2]

For Examiner's Use

2 A fixed mass of an ideal monatomic gas undergoes a cycle **ABCA** of changes, as shown in Fig. 2.1.

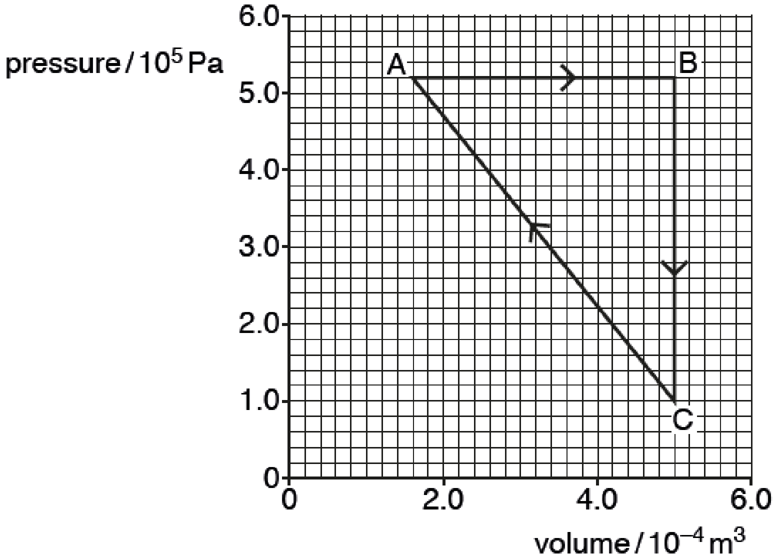

Fig. 2.1

(a) During the change from **B** to **C**, the internal energy of the gas decreases by 315 J.

By considering molecular energy, state and explain qualitatively the change, if any, in the temperature of the gas.

There is negligible potential energy PE. As such, a decrease in internal is equivalent to a decrease in kinetic energy. [B1]

Since KE is proportional to thermodynamic T, a decrease in kinetic energy will lead to a decrease in the temperature of the gas. [B1]

[2]

(b) During the change from **A** to **B**, the energy supplied to the gas by heating is 442 J.

Fig. 2.2 is a table of energy changes during one cycle. Complete Fig. 2.2.

section of cycle	heat supplied to gas / J	work done on gas / J	increase in internal energy of gas / J
A to B	442	-177	265
B to C	-315	0	-315
C to A	-55	105	50

Fig. 2.2

[3]

Since ΔU = 0 for the entire cycle **ABCA,**
ΔU (for process C to A) = 315 – 265.2 = 49.8

Work done on gas (from C to A) = area under graph
= (5 - 1.6) x 10^{-4} x (5.2 + 1) / 2
= 105.4 J
By First Law of Thermodynamics,
ΔU = Q + W
ΔQ = 49.8 – 105.4
ΔQ = - 55.6 J

All W correct – 1 mark
Last column correct (add up to 0) – 1 mark
First Law correct – 1 mark

(c) Calculate the root-mean-square speed of the gas atoms at point **B** if the root-mean-square speed at point **A** is 350 m s^{-1}.

Since ½ $<c^2>$ = 3/2 kT

$\sqrt{<c^2>}$ proportional to $\sqrt{T}$ or $\sqrt{V}$ when P is constant

$$\frac{\sqrt{<c^2>}}{350} = \sqrt{\frac{5}{1.6}}$$

$\sqrt{<c^2>}$= 619 m s^{-1}

root-mean-square speed = ……………..……… m s^{-1} [2]

3 **(a)** As seen in Fig 3.1, a monochromatic light of wavelength 580 nm is used to produce an interference pattern on screen AB. The separation between the slits is 0.41 mm and the perpendicular distance between the double slit and the screen is *D*. Point Y is at a distance *x* = 2 mm from point O and it is the position of the first dark fringe. The intensity of the light passing through the two slits is the same.

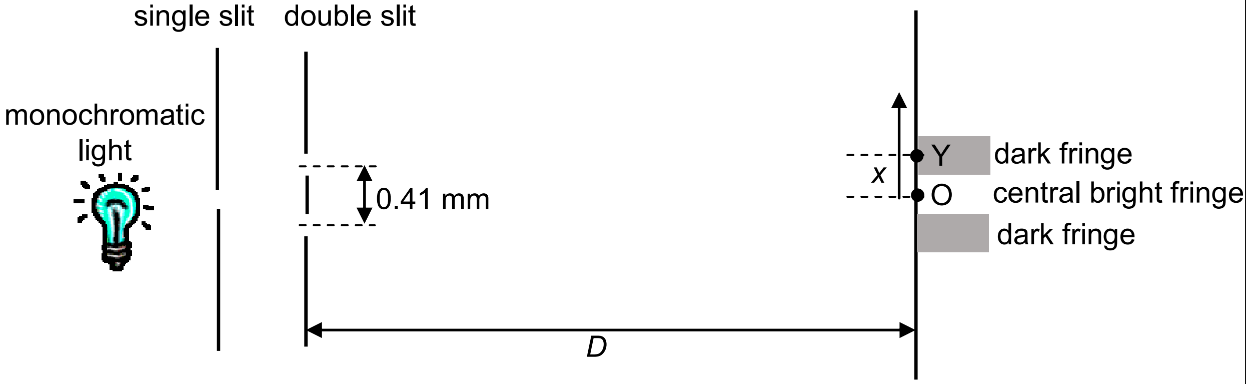

Fig 3.1

(i) Calculate the path difference between the 2 waves arriving at point Y from the slits.

Path difference = λ/2 = 580 /2 = 290 nm

distance = ……………….. nm [1]

(ii) Calculate the distance *D*.

By using x = λD/a

$D = 0.41 \times 10^{-3} (2 \times 2 \times 10^{-3}) / 580 \times 10^{-9}$ [M1]

= 2.8 m [A1]

D = ……………………… m [2]

For Examiner's Use

(ii) The width of both slits is reduced by the same amount without altering their separation. The original variation with distance x from point O of the intensity is as shown in Fig. 3.2. Sketch the new variation of intensity on Fig. 3.2. [3]

Peaks at same location [1] (YDS)
More peaks & and wider envelope (minima shift outwards) [1]
Lower peaks [1]

Not marking for first maxima details.

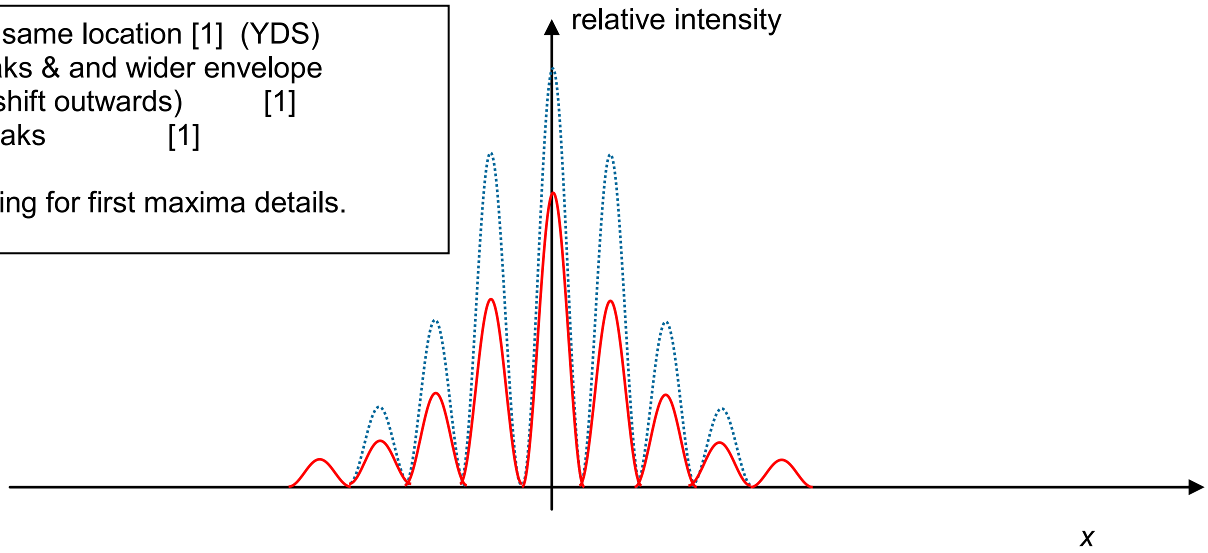

Fig. 3.2

(b) A diffraction grating is used to measure the wavelengths of light. The angle θ of the second order maximum is measured for each wavelength. The variation with wavelength λ of sin θ is shown in Fig 3.3.

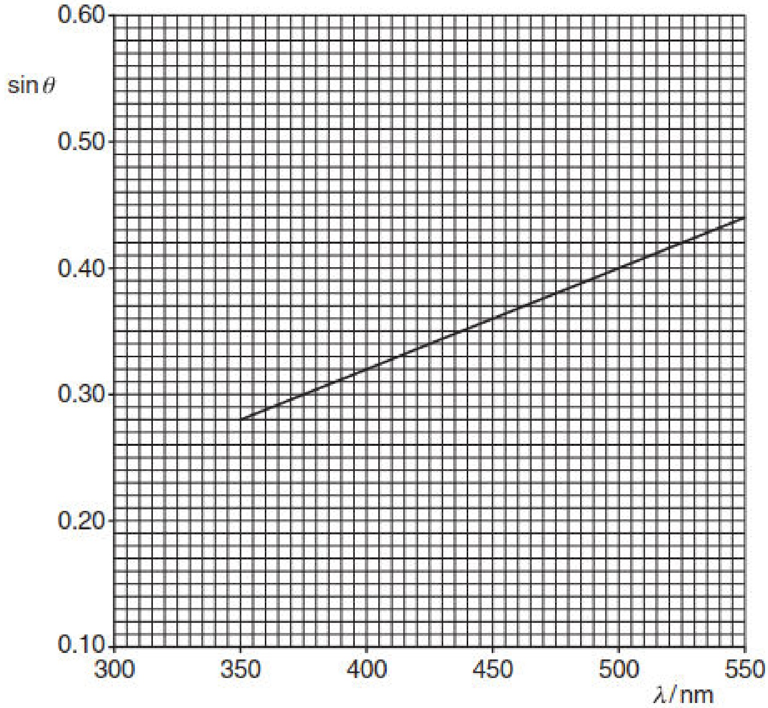

Fig. 3.3

(i) Calculate the slit separation d of the diffraction grating.

Gradient = 8.0×10^{5} [B1]

d = n / gradient = $2 / 8.0 \times 10^{5}$ [M1]

= 2.5×10^{-6} m [A1]

d = ……………………….m [3]

(ii) On Fig. 3.3, sketch a line to show the results that would be obtained for the first order maxima. [1]

straight line drawn with lower gradient (½) and all new y coordinates are ½ of the original y values

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

work done per unit positive charge by an external force [B1] in moving a small test charge from infinity to that point in the electric field [B1] (without a change in its kinetic energy).

.... [2]

(b) Two charged solid spheres A and B are situated in a vacuum. Their centres are separated by a distance of 30.0 cm, as shown in Fig. 4.1. The diagram is not drawn to scale.

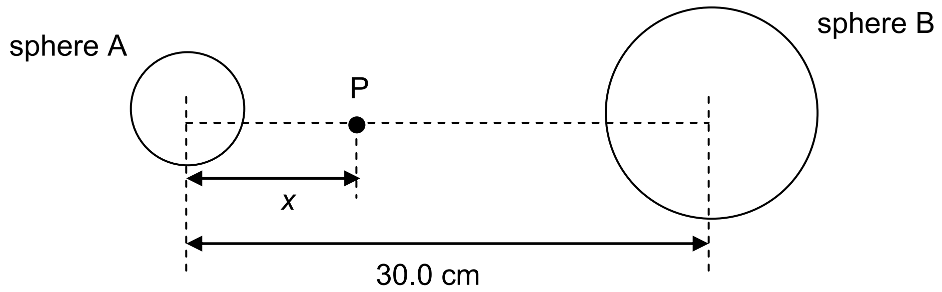

Fig. 4.1

The variation with distance x of the electric potential V_A and V_B due to sphere A and B independently is shown in Fig. 4.2.

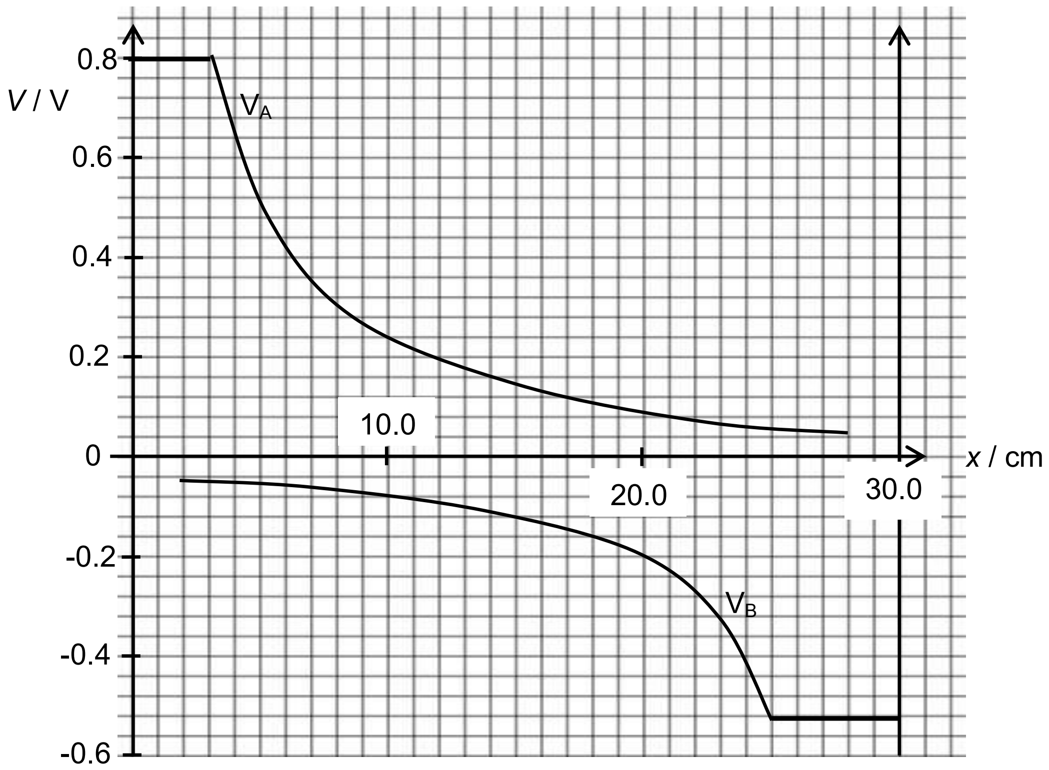

Fig. 4.2

For Examiner's Use

(i) Using Fig. 4.2, state the radius of both spheres.

Sphere A: 3.0 cm
Sphere B: 5.0 cm

radius of sphere A = ……………… cm

radius of sphere B = ………………. cm [1]

(ii) State and explain the signs of both spheres.

Since the potential of sphere A is positive and that of sphere B is negative, sphere A is positively charged while sphere B is negatively charged.

1 mark – opposite charges

(Cannot accept using gradient to determine direction of E field since no indication of which direction of *x* is positive.)

[2]

(iii) Point P is at a distance x = 10.0 cm.
An alpha particle has kinetic energy E_K when at infinity.

Use Fig. 4.2 to determine the minimum value of E_K such that the alpha particle may travel from infinity to point P.

Resultant potential (10 cm from sphere A) = 0.24 + (-0.08) = 0.16 V [B1]

By COE,

Loss in KE = Gain in EPE

$E_K - 0 = 0.16\ (2 \times 1.6 \times 10^{-19}) - 0$ [M1 – 2q, qΔV, COE]

$E_K = 5.12 \times 10^{-20}$ J [A1]

If B1 correct and M1 wrong, 1 mark.
If B1 wrong and M1 correct, 1 mark.

E_K = ………………………… J [3]

For Examiner's Use

5 An ideal transformer is connected to a sinusoidal a.c. supply, as shown in Fig. 5.1. The primary coil has a r.m.s. current of 0.85 A.

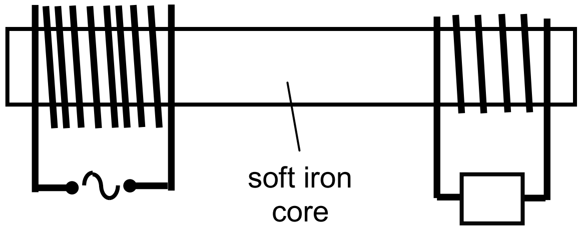

Fig. 5.1

(a) Use the laws of electromagnetic induction to explain how a potential difference can be developed across the secondary coil.

Alternating current in the primary coil results in an alternating magnetic field strength generated. [M1]
Magnetic field strength generated by primary coil linked to secondary coil (via the soft iron core).
Secondary coil experiences alternating magnetic flux linkage due to alternating magnetic field strength [M1]. By Faraday's law, an e.m.f. will be induced across the secondary coil. [A1]
Without 1st M1, max 1 mark.

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

(b) **(i)** The primary coil contains 9 turns per cm, calculate the maximum magnetic field strength at its centre.

$B = \mu_0 n I = 4\pi \times 10^{-7} \times 9 \times 100 \times 0.85\sqrt{2} = 1.36 \times 10^{-3}$ T [2]

maximum magnetic field strength = …………………. T [2]

For Examiner's Use

(ii) The ratio of the number of turns in the primary to secondary coil is 16 : 1.

Calculate the peak current in the load.

$$\frac{I_S}{I_P} = \frac{N_p}{N_S} = 16$$

I_s $= 16 \times 0.85\sqrt{2}$ [M1]

$= 19.2$ A [A1]

peak current = ... A [2]

(iii) The variation with time t of current I_p in the primary coil is shown in Fig. 5.2.

On Fig. 5.3, sketch the variation with time t of current I_s in the secondary coil. [1]

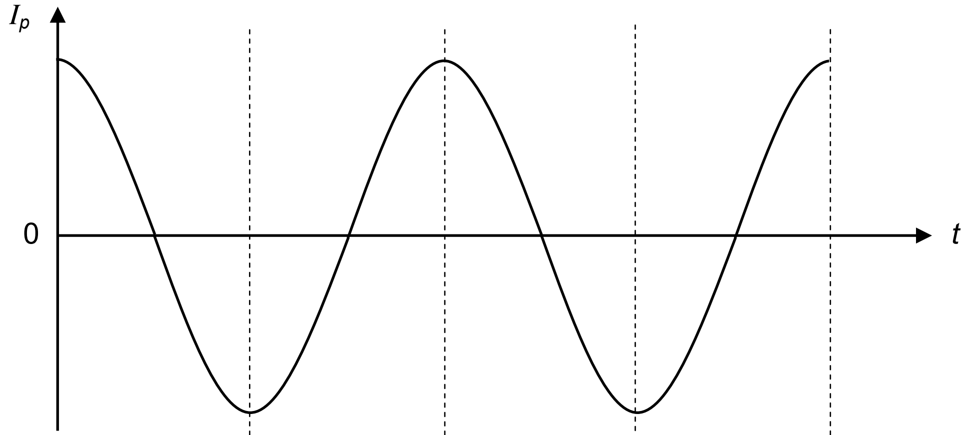

Fig. 5.2

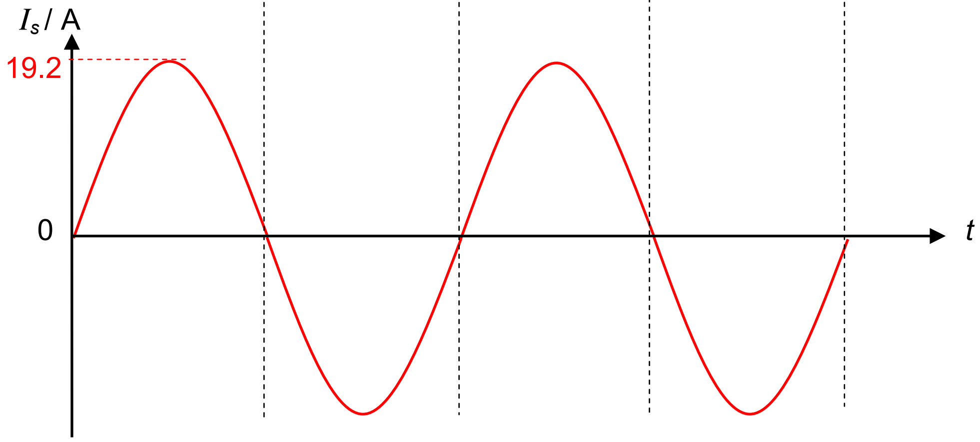

Fig. 5.3

(iv) State and explain how the answer to **b (iii)** will change if the iron core is removed from the transformer.

Magnetic flux linking secondary coil will decrease. [M1]
Hence rate of change of flux linkage will decrease. (By Faraday's law, induced e.m.f. and) hence magnitude of induced current will decrease. [A1]

.... [2]

6 Ultraviolet radiation of wavelength 122 nm is used to illuminate the cathode in the vacuum tube as shown in Fig. 6.1.

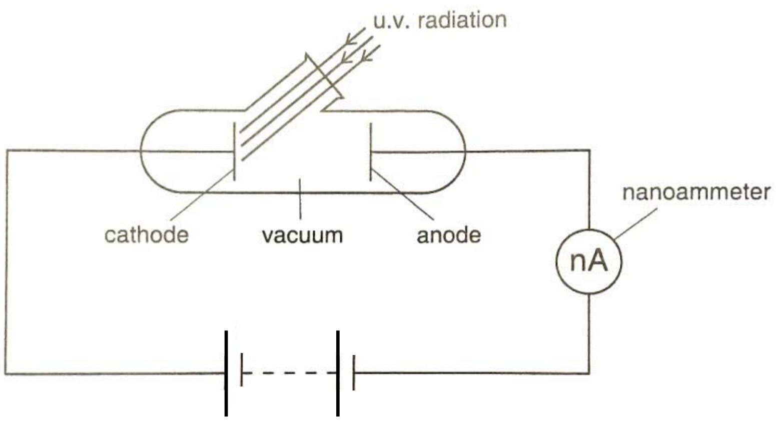

Fig. 6.1

(a) Photoelectrons are emitted from the cathode and collected at the anode. With the anode made negative and the cathode positive, some photoelectrons can still reach the anode, and by varying the battery's e.m.f, a graph of current against e.m.f. can be plotted as shown in Fig. 6.2.

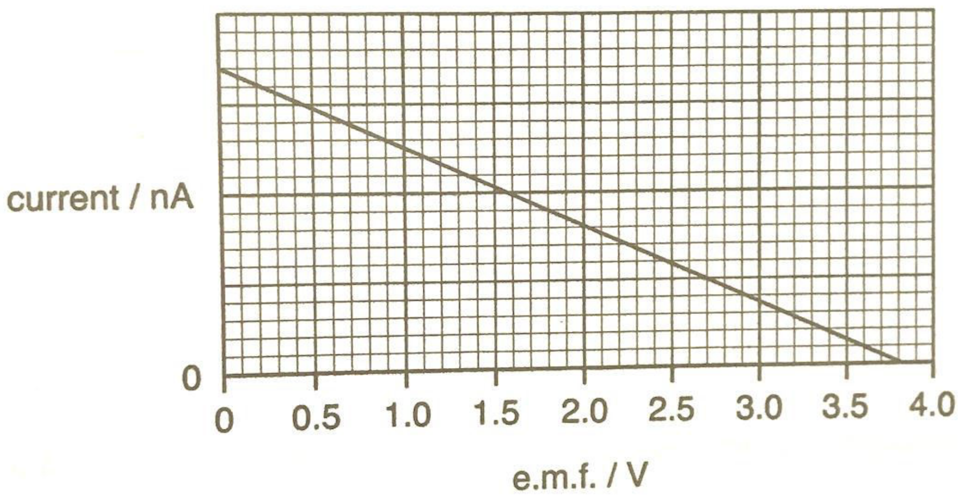

Fig. 6.2

(i) Explain why some photoelectrons are still able to reach the negative anode.

Photoelectrons emitted have kinetic energies ranging from zero to a maximum values. Those photoelectrons that **have enough energy to do work against the electric field** will be able to reach the anode.

.... [1]

For Examiner's Use

(ii) Calculate the maximum speed the photoelectrons can have when they leave the cathode.

Loss in KE = Gain in EPE
$\frac{1}{2} mv_{max}^2 = eV_s$
$\frac{1}{2} (9.11 \times 10^{-31}) V_{max}^2 = (1.6 \times 10^{-19})(3.8)$ [1]
$V_{max} = 1.16 \times 10^6$ m s^{-1} [1]

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

(iii) Calculate the work function of the metal used in the cathode.

$hf = \phi + eV_s$
$\phi = (6.63 \times 10^{-34})(3 \times 10^8)/(122 \times 10^{-9}) - 1.6 \times 10^{-19} (3.8)$ [1]
$= 1.02 \times 10^{-18}$ J [1]

work function = …………………………………. J [2]

(b) The photocurrent I for different potential difference V between the cathode and the anode was measured. The experiment was then repeated using ultraviolet radiation of the same wavelength but of different intensity.

The series of graphs of I against V are shown in Fig. 6.3.

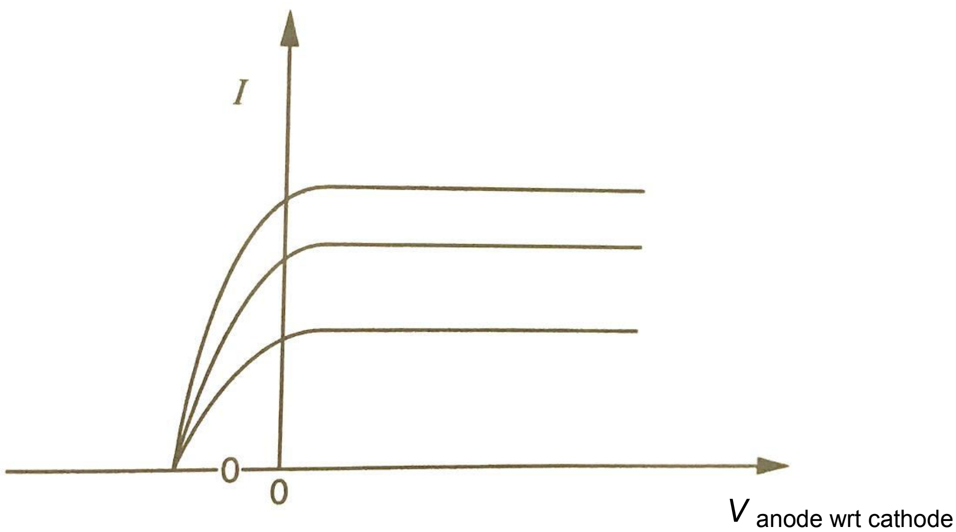

Fig. 6.3

For Examiner's Use

(i) State and explain which feature of this graph could not be explained using the wave theory of light.

The stopping potential is independent of the intensity of the radiation [1]. According to wave theory, the higher the intensity, the more energy the light would possess which would cause the **photoelectrons emitted to have higher kinetic energy**, and hence **a higher stopping potential to bring them to rest** [1].

[2]

(ii) Explain why the maximum kinetic energy of photoelectrons is independent of intensity whereas the photoelectric current is proportional to intensity of the light.

When electromagnetic radiation is irradiated on the metal surface, the energy is delivered in packets known as photons. The energy of each photon energy is *hf* (where h is Planck's constant and f is the frequency of radiation.) [B1]

Photons interact with the electrons on a 1-to-1 basis such that the maximum kinetic energy of the emitted photoelectron, $KE_{max} = hf - \phi$ is dependent only on the frequency of the radiation and ϕ, the work function of the metal. [B1]

For light of a constant frequency, intensity is directly proportional to the rate of incidence of photons which is in turn directly proportional to the rate of photoelectrons emitted, and hence the photoelectric current. [B1]

[3]

For Examiner's Use

7 An induced nuclear fission reaction maybe represented by the equation

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3^{1}_{0}n$$

(a) Sketch the variation with nucleon number of the binding energy per nucleon. [2]

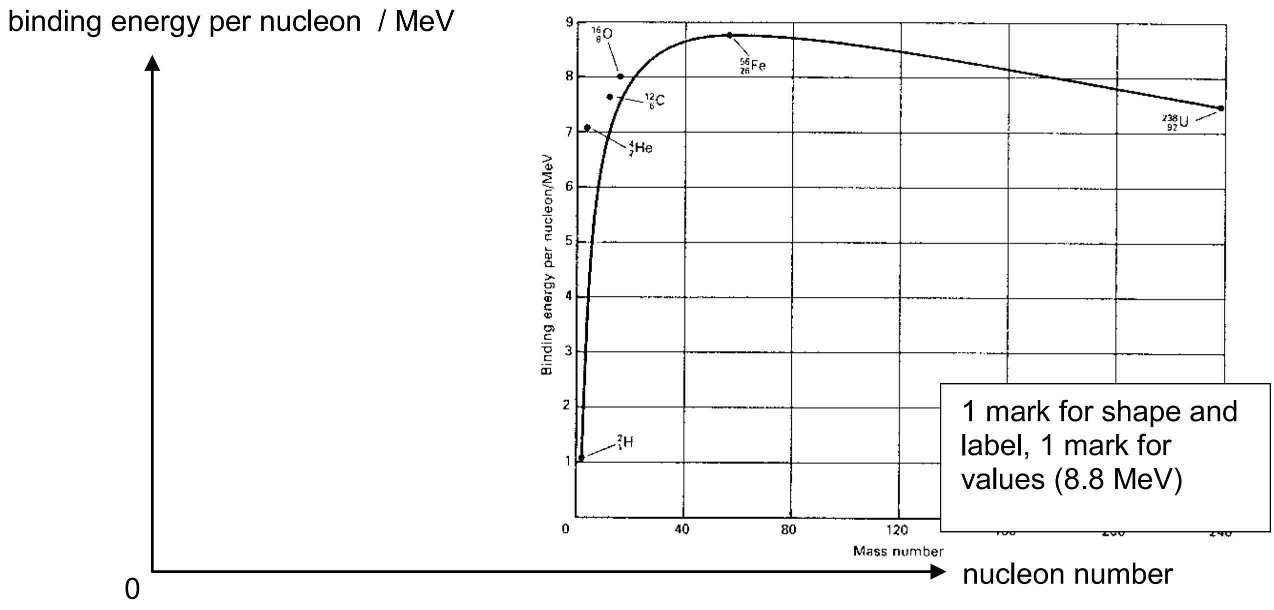

Fig. 7.1

(b) Hence, explain why Uranium – 235 is more likely to undergo fission than fusion.

Uranium-235 is on the right hand side of graph, beyond Fe-56.

BE is the BE per nucleon multiply by the number of nucleons. [B1]

Fission involves breaking a larger nucleus into smaller nuclei [B1].

Fission will involve products with higher BE per nucleon, hence more stable products and more likely to occur. [B1] or Fission implies increase of total BE and hence release of energy, hence more likely to occur. [B1]

..[3]

(c) The masses of the various nuclides are as listed below:

nuclide	mass / *u*
Uranium - 235	235.04393
Barium – 141	140.91441
Krypton - 92	91.92616
neutron	1.00867

Determine the energy released in the reaction.

Energy released = mass of reactants - mass of products

$=(235.04393+1.00867)-[140.91441+91.92616+3(1.00867)]uc^2$ [M1]

$=0.18602uc^2$

$=2.78\times10^{-11}$ J [A1]

energy released = …………………………… J [2]

For Examiner's Use

Section B

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

8 (a)(i) Define *gravitational field strength*.

The gravitational field strength at a point is the gravitational force exerted per unit mass when a small test mass is placed at that point in a gravitational field.

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

(ii) Derive, from Newton's Law of Gravitation and **(a)(i)** above, the equation for the gravitational field strength of a point mass of mass M_1, placed in a gravitational field generated by a mass M_2 and at a distance of r from M_1. [2]

Since $g = F/M_1$
and $F = GM_1M_2/r^2$ [Both equations to get 1]

Therefore, $g = GM_1M_2/r^2 / M_1$
$= GM_2/r^2$ [1]

(b) Information related to the Earth and the Moon is given below:

$$\frac{\text{Radius of Earth}}{\text{Radius of Moon}} = 3.7$$

$$\frac{\text{Mass of Earth}}{\text{Mass of Moon}} = 81$$

The center-to-center distance of the Moon from the Earth is 3.84×10^8 m and the gravitational field strength due to the Earth at its surface is 9.8 N kg^{-1}.

(i) Using these data, calculate the gravitational field strength due to the Moon at its surface.

Since $g \propto M/r$,
$\frac{g_M}{g_E} = \left(\frac{M_M}{M_E}\right)\left(\frac{r_E}{r_M}\right)^2$ [M1]
$= (1/81)(3.7)^2$
$= 0.169$

Therefore, g due to Moon $= 0.169 \times 9.81$
$= 1.66$ N kg^{-1} [A1]

gravitational field strength = …………………. N kg^{-1} [3]

For Examiner's Use

(ii) There is a point on the line between the Earth and the Moon at which their combined gravitational field strength is zero.

Calculate the distance between this point and the centre of the Earth.

$$\frac{GM_E}{r^2} = \frac{GM_M}{(3.84\times10^8 - r)^2}$$

$$81 = \frac{r^2}{(3.84\times10^8 - r)^2} \text{ [1]}$$

r = 3.46 x 10^8 m [1]

distance = ……………………………… m [2]

(iii) The Moon orbits around the Earth with a period of 27.3 days.

1. Calculate the angular speed of the Moon.

$\omega = 2\pi/T$
$= 2\pi/(27.3 \times 24 \times 60 \times 60)$
$= 2.66 \times 10^{-6}$ rad s^{-1} [1]

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

2. Calculate the mass of the Earth.

Gravitational acceleration provides centripetal acceleration.

$GM/r^2 = r\omega^2$
$M = r^3\omega^2/G$ [M1]
$= (3.84 \times 10^8)^3 \times (2.66 \times 10^{-6})^2 / 6.67 \times 10^{-11}$
$= 6.0 \times 10^{24}$ [A1]

……… kg [2]

3. Determine the gravitational force between the Earth and the Moon.

Mass of Moon = 1/81 Mass of Earth

$F = GM_EM_M/r^2$
$= [6.67 \times 10^{-11} (6.0 \times 10^{24})^2 / 81] / (3.84 \times 10^8)^2$ [1]
$= 2.01 \times 10^{20}$ [1]

gravitational force = ……………………………….. N [2]

For Examiner's Use

4. Tidal action on the Earth's surface causes the radius of the orbit of the Moon to increase by 4.0 cm each year. Using your answer in **(b)(iii)(3)**, determine the change, in one year, of the gravitational potential energy of the Moon.

Change in potential energy
= Work done by external force
= $2.01 \times 10^{20} \times 0.04$ [1]
= 8.04×10^{18} J [1]

change in potential energy = ………………………….. J [2]

(c) **(i)** Explain, by considering the respective field force, why gravitational potential energy is negative whereas electric potential energy can be positive or negative.

Gravitational forces are **always attractive**, whereas electric forces **can be attractive or repulsive**. [1]

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

(ii) The Earth may be assumed to be an isolated sphere of radius 6.4×10^3 km with its mass of 6.0×10^{24} kg concentrated at its centre. A 2.0 kg mass is projected vertically from the surface of the Earth so that it reaches a maximum altitude of 1.3×10^4 km.

Calculate, for this mass,

1. the change in gravitational potential energy

Change in GPE
= $-GMm/r_2 - (-GMm/r_1)$
= $GMm(1/r_1 - 1/r_2)$
= $6.67 \times 10^{-11} \times 6.0 \times 10^{24} \times 2.0 (1/6.4 \times 10^6 - 1/(6.4 \times 10^6 + 1.3 \times 10^7)$ [M1]
= 8.38×10^7 J [A1]

change in gravitational potential energy = …………………….. J [2]

2. the speed of projection from the Earth's surface, assuming air resistance is negligible.

By COE, Loss in KE = Gain in GPE
$\frac{1}{2} m v^2 = 8.38 \times 10^7$
$\frac{1}{2} (2) v^2 = 8.38 \times 10^7$ [M1]
$v = 9150$ m s^{-1} [A1]

speed = …………………………….. m s^{-1} [2]

For Examiner's Use

9 **(a)** By reference to energy transfers, distinguish between electromotive force (e.m.f.) and potential difference (p.d.).

e.m.f. ……

Emf: electrical energy converted from other forms of energy per unit charge delivered round a complete circuit.

Pd: The potential difference between two points in a circuit is the amount of energy converted from electrical to other forms of energy per unit charge passing from one point to the other

p.d. …… [2]

(b) A circuit is set up as shown in Fig. 9.1.

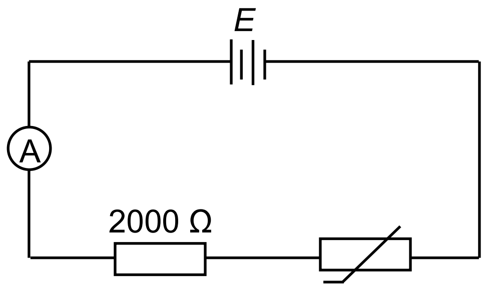

Fig. 9.1

The source of e.m.f. *E* is found to provide 2.4×10^5 J of electrical energy to the 2000 Ω resistor and thermistor when a charge of 2.2×10^4 C passes through the ammeter. At room temperature, the thermistor has a resistance of 1800 Ω.

(i) Sketch on Fig. 9.2 the variation with temperature θ of resistance *R* in a thermistor. [1]

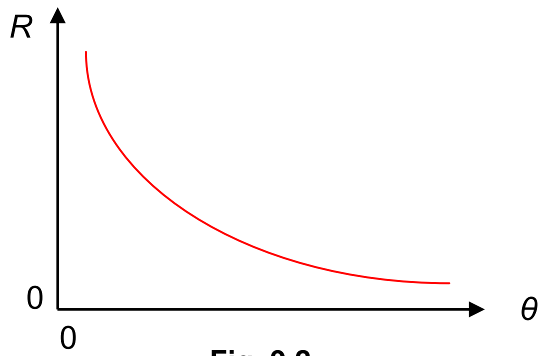

Fig. 9.2

(ii) For the thermistor at room temperature,

1. show that *E* is 11 V. [1]

$$E = \frac{W}{Q} = \frac{2.4 \times 10^5}{2.2 \times 10^4} = 11\text{V}$$ [M1]

For Examiner's Use

2. determine the time taken for a charge of 2.2 x 10^4 C to pass through the ammeter.

$$Q = It = \frac{E}{R}t$$

$$\Rightarrow t = \frac{QR}{E} = \frac{2.2\times10^4\times3800}{11} \quad \text{[M1]}$$

$$= 7.6\times10^6\,\text{s} \quad \text{[A1]}$$

time = ………………… s [2]

3. show that the fraction of power dissipated in the thermistor is 0.47. [1]

$$\text{fraction} = \frac{I^2R_T}{I^2R_T + I^2R} = \frac{R_T}{R_T+R} = \frac{1800}{1800+2000} \quad \text{[M1]}$$

$$= 0.474$$

(c) A uniform resistance wire PQ of length 1.2 m is subsequently connected across the resistor and thermistor, as shown in Fig. 9.3. A sensitive voltmeter is connected between point Y and a moveable contact M on the wire.

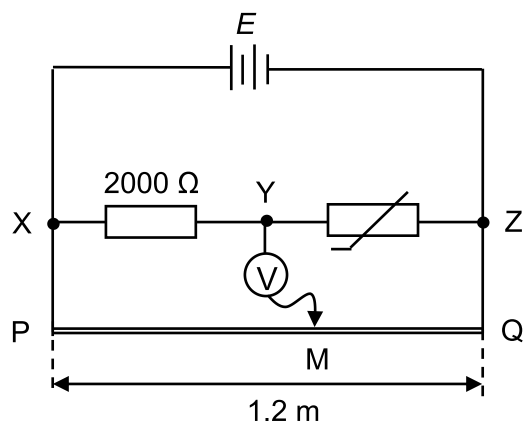

Fig. 9.3

(i) At room temperature, the contact M is moved along PQ until the voltmeter shows zero reading.

Calculate the length of wire between M and Q.

Potential difference between MQ and YZ has to be the same for voltmeter to register zero reading.

$$\frac{L}{1.2} = \frac{1800}{3800} \quad \text{[M1]}$$

L = 0.568 m [A1]

length of wire = …………………… m [2]

(ii) State and explain the effect, if any, on the length of the wire between M and Q for the voltmeter to remain at zero deflection if each of the following changes takes place independently.

1. The thermistor is warmed slightly.

(As temperature rises), resistance of thermistor decreases and by Potential Divider Principle, the potential difference across the thermistor drops.

For zero deflection, the potential difference across the thermistor and across MQ have to be the same. Since the pd across MQ is proportional to its length, MQ is shorter. [2]

2. A uniform wire with a bigger cross sectional area is used to replace PQ.

While the bigger cross-sectional area will result in a lower resistance in the wire PQ, as the potential difference across PQ did not change, the potential difference per unit length remains the same.

Since potential difference across thermistor (and resistor) did not change, the length of wire will not need to change. [2]

(d) The circuit shown in Fig. 9.4 is used to compare potential differences.

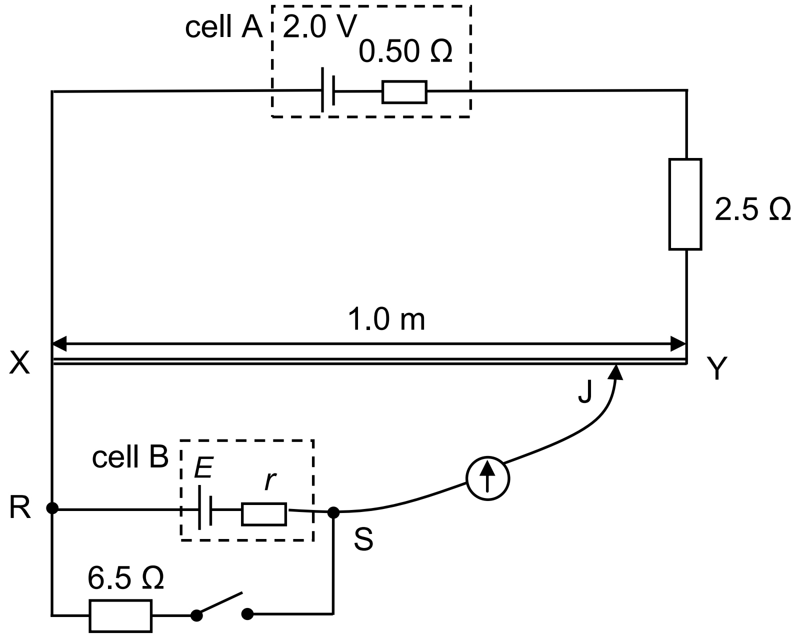

Fig. 9.4

The uniform resistance wire XY has length 1.0 m and resistance 8.0 Ω. Cell A has e.m.f. 2.0 V and internal resistance 0.50 Ω. Cell B has e.m.f. *E* and internal resistance *r*.

(i) The switch is opened. The galvanometer shows no deflection when the moveable contact J is adjusted so that the length XJ is 0.90 m.

Show that the e.m.f. *E* of cell B is 1.3 V. [2]

$$V_{XY} = \frac{8.0}{8.0 + 0.50 + 2.5} \times 2.0 = 1.455 \text{ V} \quad \text{[M1]}$$

At null deflection, V_{XJ} = e.m.f. of cell B.

$$E = \frac{0.90}{1.0} \times 1.455 = 1.31 \text{ V} \quad \text{[M1]}$$

(ii) The switch is now closed.

1. For the galvanometer to show no deflection, contact J has to be adjusted so that length XJ is 0.75 m.

Determine the internal resistance *r* of cell B.

At null deflection, $V_{XJ} = V_{RS}$

$V_{XJ} = \frac{0.75}{1.0} \times 1.455 = 1.091$ V [M1]

$I = \frac{V}{R} = \frac{1.091}{6.5} = 0.1679$ A [M1]

$E = V + Ir \Rightarrow r = \frac{E - V}{I} = \frac{1.3 - 1.091}{0.1679} = 1.25\ \Omega$ [A1]

r = …………………….. Ω [3]

2. A resistor is connected in parallel with the 6.5 Ω resistor.

Deduce how the balanced length XJ would be affected.

With resistor connected in parallel, load resistance of cell B would decrease.
This would cause terminal p.d. of cell B to decrease. [1]
Since no change in potential difference per unit length along wire XY,
Balance length XJ would decrease. [A1]

……. [2]

END OF PAPER

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SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

NAME

CG | INDEX NO.

PHYSICS 9749 / 04

Preliminary Examination **28th August 2018**
Paper 4 Practical **2 hour 30 minutes**

Candidates to answer all questions in the Question Booklet.

Additional Material: Question Booklet for Question 4

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and index number in the spaces at the top of this page.

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.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or do not use appropriate units.

Give details of the practical shift and laboratory in the boxes provided.

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.

Shift
Laboratory

For Examiner's Use	
1	/ 10
2	/ 12
3 (a) to (d)	/ 17
subtotal	/ 39
3 (e)	/ 5
4	/ 11
Planning subtotal	/ 16

For Examiner's Use

1 In this experiment, you are provided with a ball suspended by a thread so that it is next to a wooden block. You will investigate how the rebound distance is related to the release distance when it swings against the wooden block.

(a) Assemble the apparatus as shown in Fig. 1.1, with the thread clamped between the two small wooden blocks so that l is about 50 cm, and with the big wooden block positioned so that it is just touching the stationary ball.

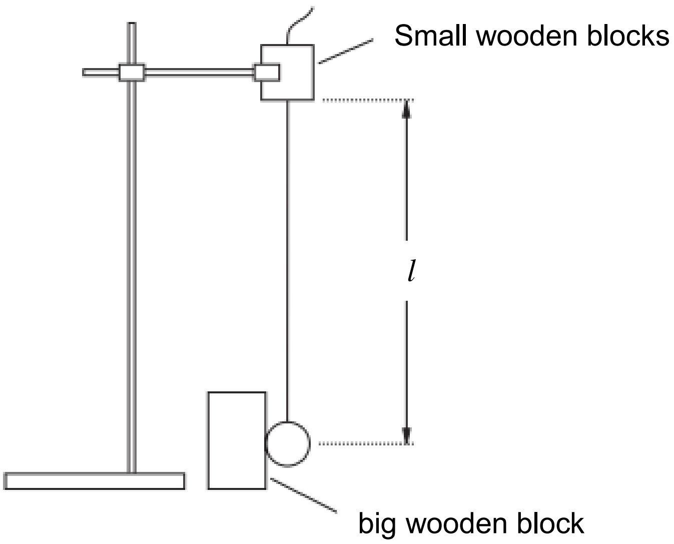

Fig. 1.1

Measure and record l.

l = …………………………….. [1]

(b) **(i)** Pull back the ball as shown in Fig. 1.2.

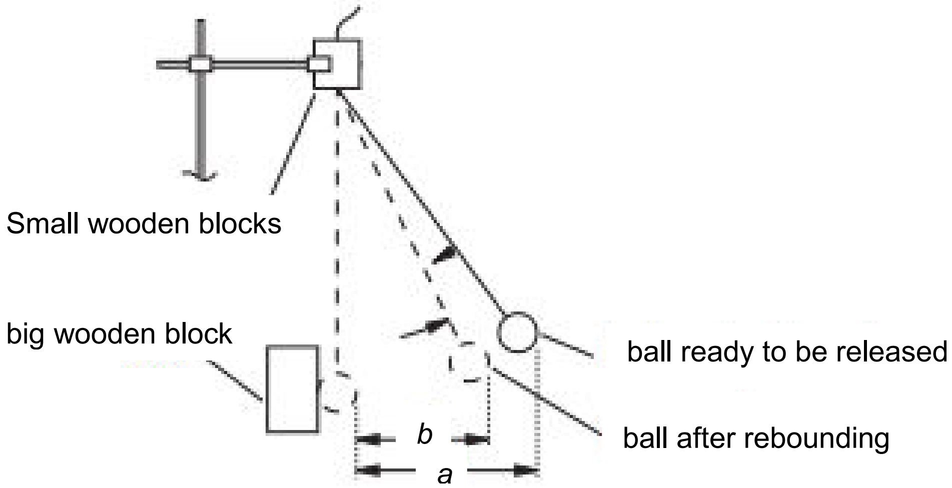

Fig. 1.2

Measure the distance *a.* Do not exceed *a* = 25 cm.

a = …………………………….. [1]

For Examiner's Use

(ii) Release the ball and make measurements to determine the rebound distance *b* as shown in Fig. 1.2.

b = …………………………….. [2]

(c) **(i)** Explain how you used the apparatus to ensure that the rebound distance *b* was measured as accurately as possible.

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

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

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

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

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

(ii) Estimate the percentage uncertainty in the value of *b*.

percentage uncertainty = …………………………….. [1]

(d) For values of *a* less than 25 cm, theory predicts that

$$k = \frac{l - \sqrt{l^2 - b^2}}{l - \sqrt{l^2 - a^2}}$$

where *k* is a constant. Calculate *k*.

k = ……………………………..[1]

(e) Repeat **(b)(i)**, **(b)(ii)** and **(d)** using a different value of *a*.

a = ……………………………..

b = ……………………………..

k = ……………………………..
[1]

(f) State whether the results of your experiment indicates that *k* is a constant.
Justify your conclusion by referring to **(c)(ii)**.

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

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

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

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

[Total : 10 marks]

For Examiner's Use

2 In this experiment, you will calculate the amount of charge that flows through a resistor.

(a) **(i)** Set up the circuit as shown in Fig. 2.1, taking care to connect component Y the right way round.

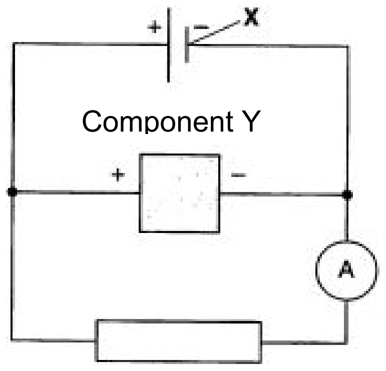

Fig. 2.1

(ii) Read and record the reading I on the ammeter.

I = ……………………………………[1]

(b) When the wire at X is disconnected, the current in the resistor gradually decreases to zero.

(i) Disconnect the wire at X and start the stopwatch.

(ii) Take at least five more sets of I and time t up to a value of t = 50 s. Tabulate your results.
(You may need several attempts. Reconnect wire at X for one minute before making another attempt.)

[2]

(iii) 1. Plot your values from **(b)(ii)** on Fig. 2.2. and draw a curve through your points.

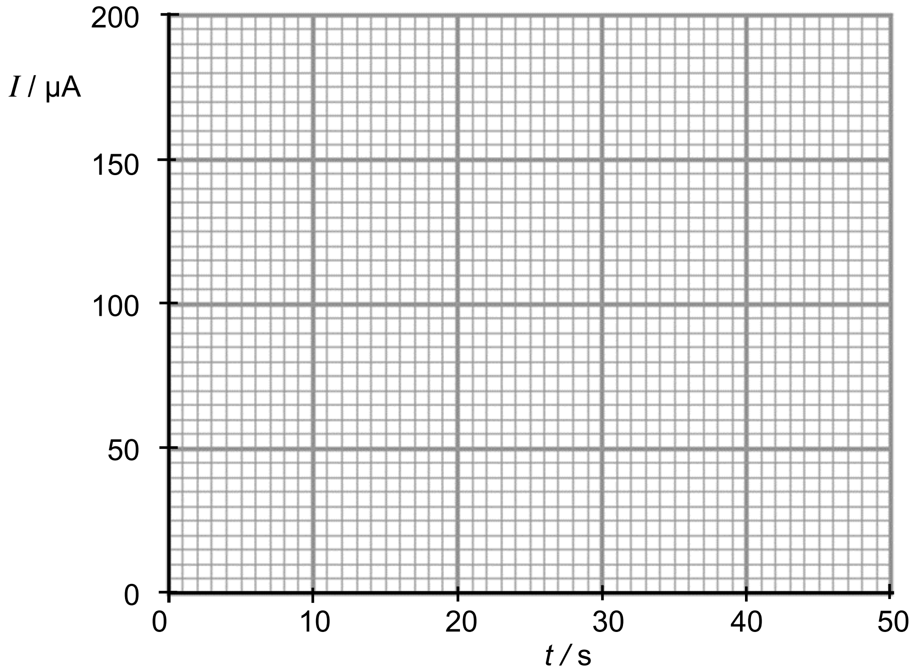

Fig. 2.2

[2]

2. The area under the graph represents the charge Q that has flowed through the resistor during 50 s. Estimate Q.

Q = ………………………………….[1]

(c) It is suggested that the time taken for the current in the 10 kΩ resistor to decrease to zero is shorter when the total effective resistance of the circuit is lower.

With an aid of circuit diagram(s), suggest how you can verify this.

……

……

……

……

……

……

……………………………………………………………………………………………………… [4]

(d) Theory suggests that $Q = kV$ where V is the potential difference across the resistor and k is a constant equal to 1.0×10^{-3} C V^{-1}.

(i) Use the analogue voltmeter to measure V.

V = …………………………………[1]

(ii) Use your answer to **(d)(i)** to determine Q.

Q = …………………………………[1]

[Total : 12 marks]

For Examiner's Use

3 In this experiment, you will investigate how the motion of two pendulums depends on the tension in the string connecting them.

(a) Measure and record the unstretched length l_0 of the coiled part of the spring as shown in Fig. 3.1.

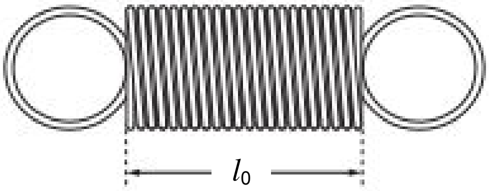

Fig. 3.1

l_0 = ...[1]

(b) **(i)** Set up the apparatus as shown in Fig. 3.2. Tie strings X and Y such that the spring is horizontal.

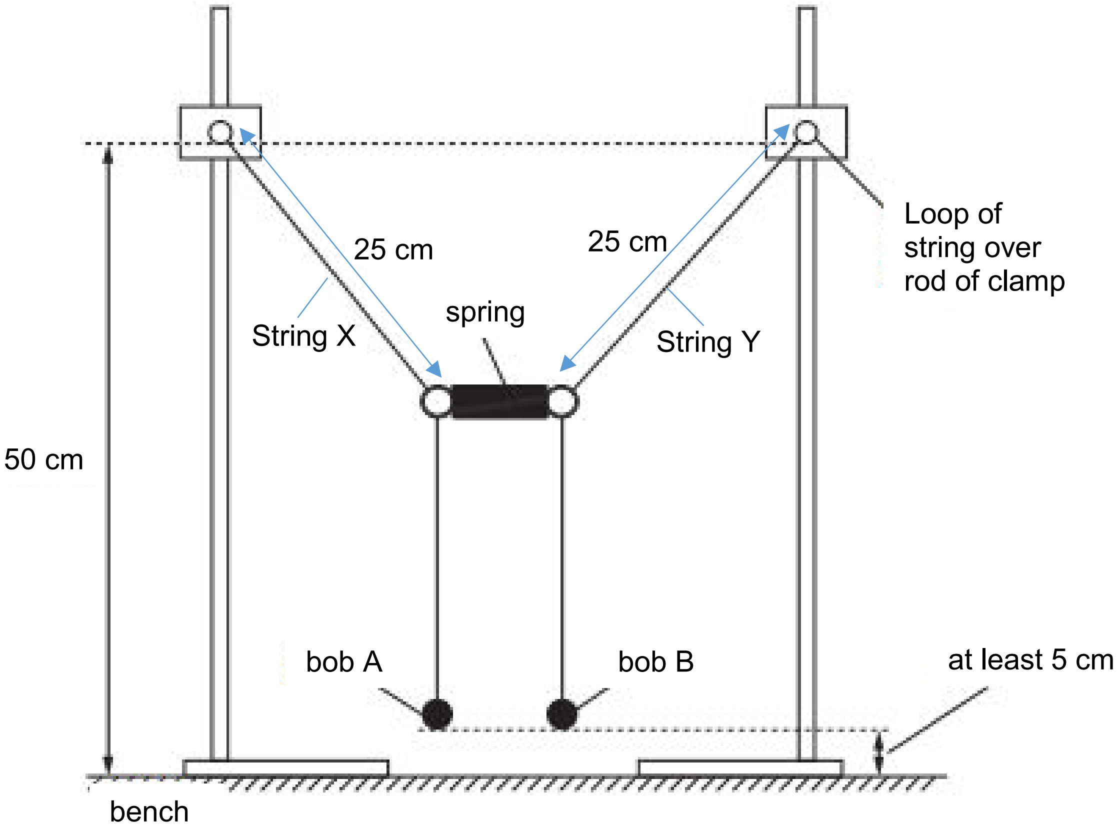

Fig. 3.2

(ii) Position the stands so that the coiled part of the spring has approximate length l_0 + 2 cm (so that the spring is extended by approximately 2 cm).

For Examiner's Use

(iii) Measure and record the length l of the coiled part of the spring. Calculate the extension x of the spring where $x = l - l_0$.

l = ……………………………..

x = …………………………. [1]

(iv) Gently pull bob A towards you. Release the bob and watch the movement of the two bobs.

Bob A will eventually stop and start moving again. It will then stop for a second time.

Determine and record the time T between these two stops.

T = …………………………. [1]

(c) By moving the stands further apart, repeat **(b)(iii)** and **(b)(iv)** until you have further readings of l, x and T, with x in the range 2 cm ≤ x ≤ 10 cm.

[4]

(d) It is suggested that T and x are related by the expression

$$T = p\,x + q$$

where p and q are constants.

(i) Plot a suitable graph to determine p and q.

p = ……………………………..

q = ……………………………..

[5]

(ii) Hence determine the extension x that would be expected to give a value of T = 75 s.

x = …………………………. [1]

For Examiner's Use

For Examiner's Use

(iii) Comment on any anomalous data or results you may have obtained. Explain your answer.

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

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

(iv) On your graph on page 11, draw a new graph when q is increased. Label this graph Z. [1]

(v) Suggest a significant source of error in this experiment.

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

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

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

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

(vi) Suggest an improvement that could be made to the experiment to address the error identified in **(d)(v)**. You may suggest the use of other apparatus or a different procedure.

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

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

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

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

For Examiner's Use

(e) It is suggested that the mass of the identical pendulums A and B will affect the time *T* between the two stops of pendulum A such that the mass *m* of a pendulum is directly proportional to the time *T* between the two stops of pendulum A.
Plan an investigation to verify this.

Your account should include:

- your experimental procedure
- details of the table of measurements with appropriate units

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....[5]

[Total: 22 marks]

Question 4:

Write your answer in the Question Booklet for Question 4.

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For Examiner's Use

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For Examiner's Use

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SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

NAME			
CG		**INDEX NO.**	

PHYSICS — 9749 / 04

Preliminary Examination — **28th August 2018**
Paper 4 Practical — **2 hour 30 minutes**

Question Booklet for Question 4

Candidates to answer all questions in the Question Booklet.

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and index number in the spaces at the top of this page.

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.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or do not use appropriate units.

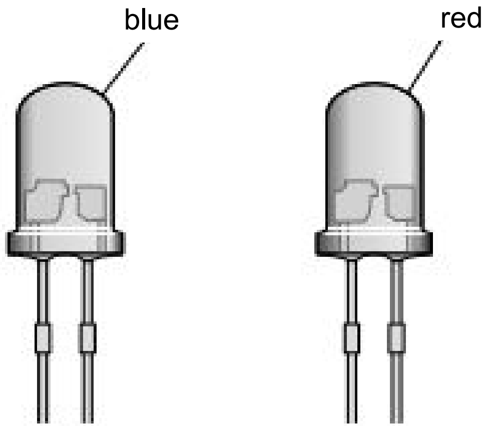
Give details of the practical shift and laboratory in the boxes provided.

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.

Shift
Laboratory

For Examiner's Use	
4	/ 11
Total	/ 11

4 A student is investigating the characteristics of different light-emitting diodes (LEDs). Fig. 4.1 shows examples of LEDs and the circuit symbol for an LED.



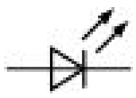
Circuit symbol: 

Fig. 4.1

Each LED needs a minimum potential difference V across it to emit light. The student is investigating the relationship between V and the wavelength λ of the light emitted by the LED for several different LEDs.

Design an experiment to investigate the relationship between V and λ.

You are provided with the following equipment:

Power supply	Metre rule
Resistors	Ammeter
Diffraction grating	Voltmeter
Double slit	Different LEDs
Micrometer screw gauge	Vernier callipers

You may also use any of the other equipment usually found in a Physics laboratory.

You should draw a labelled diagram to show the arrangement of your apparatus. In your account you should pay particular attention to

(a) the equipment you would use,
(b) the procedure to be followed,
(c) the control of variables,
(d) the analysis of the data,
(e) any precautions that would be taken to improve the accuracy of the experiment.

For Examiner's Use

Diagram

[Total: 11 marks]

For Examiner's Use

END OF PAPER

SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

NAME			
CG		**INDEX NO.**	

PHYSICS **9749 / 04**

PRELIMINARY Examination **28th August 2018**
Paper 4 Practical **2 hour 30 minutes**

Candidates to answer all questions in the Question Booklet.

Additional Material: Question Booklet for Question 4

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and index number in the spaces at the top of this page.

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.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or do not use appropriate units.

Give details of the practical shift and laboratory in the boxes provided.

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.

Shift
Laboratory

For Examiner's Use	
1	/ 10
2	/ 12
3 (a) to (d)	/ 17
subtotal	/ 39
3 (e)	/ 5
4	/ 11
Planning subtotal	/ 16

For Examiner's Use

1 In this experiment, you are provided with a ball suspended by a thread so that it is next to a solid vertical surface. You will investigate how the rebound distance is related to the release distance when it swings against the solid surface.

(a) Assemble the apparatus as shown in Fig. 1.1, with the thread clamped between the two small wooden blocks so that l is about 50 cm, and with the big wooden block positioned so that it is just touching the stationary ball.

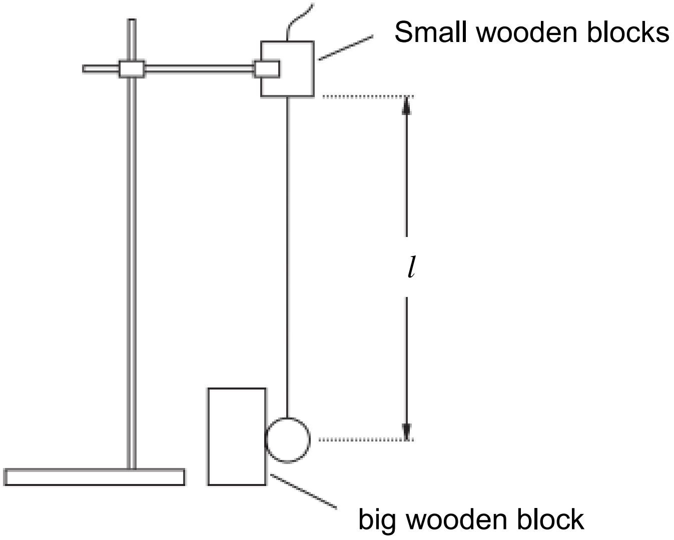


Fig. 1.1

(ii) Measure and record l.

3 d.p in m
Correct precision and within range (48.0 cm to 52.0 cm) with units

.... [1]

(b) **(i)** Pull back the ball as shown in Fig. 1.2.

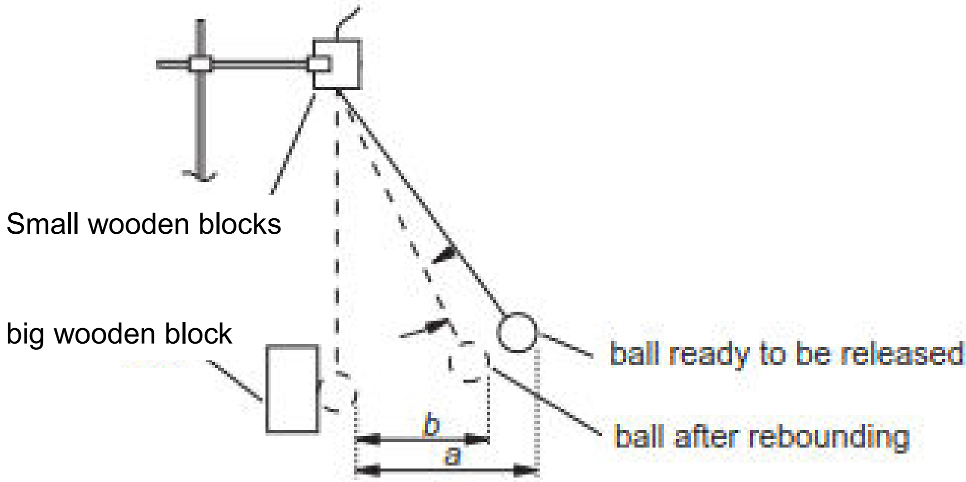


Fig. 1.2

Measure the distance *a*. Do not exceed *a* = 25 cm.

Part (b)(i) and (b)(ii) marked together for:
1) Correct precision
2) Correct units
$a \leq 25.0$ cm

a = ... [1]

(ii) Release the ball and make measurements to determine the rebound distance *b* as shown in Fig. 1.2.

3 d.p in m
within range (< a)
Measurements for *b* must be repeated.

b = …………………………….. [2]

(c) **(i)** Explain how you used the apparatus to ensure that the rebound distance *b* was measured as accurately as possible.

Place ruler under path and view directly from above OR
Use protractor to determine angle of release and use *Lsinθ* to calculate.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(ii) Estimate the percentage uncertainty in your value of *b*.

Δ*b* between 0.2 cm and 0.5 cm
with 1 or 2 sf as final answer [1]

percentage uncertainty = …………………………….. [1]

For Examiner's Use

(d) For values of a less than 25 cm, theory predicts that

$$k = \frac{l - \sqrt{l^2 - b^2}}{l - \sqrt{l^2 - a^2}}$$

where *k* is a constant.
Calculate *k*.

Correct calculation of k with no units [1]

k = ……………………………[1]

(e) Repeat **(b)(i)**, **(b)(ii)** and **(d)** using a different of *a*.

Value of b shows correct trend with *a* within range ($a \leq 25.0$ cm). [1]

a = ……………………………

b = ……………………………

k = ……………………………
[1]

(f) State whether the results of your experiment indicates *k* is a constant.
Justify your conclusion by referring to **(c)(ii)**.

show calculation of percentage difference = $\frac{k_2 - k_1}{k_1} \times 100\%$

(1 or 2 sf) [1 correct calculation & sf]

If the percentage difference is large as compared to the percentage uncertainty of b, k is not a constant . [1 for conclusion]

…………………………………………………………………………………… [2]

[Total : 10 marks]

For Examiner's Use

2 In this experiment, you calculate the amount of charge that flows through a resistor.

(a) **(i)** Set up the circuit as shown in Fig. 2.1, taking care to connect Y the right way round.

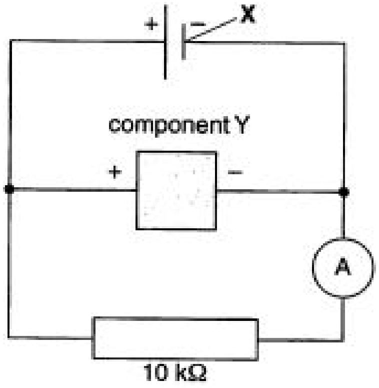


Fig. 2.1

(ii) Read and record the reading *I* on the ammeter.

correct precision of *I* at least 3 dp and units [1]
0.100 mA - 0.250 mA

I = ...[1]

(b) When the wire at X is disconnected, the current in the resistor gradually decreases to zero.

(i) Disconnect the wire at X and start the stopwatch.

(ii) Take at least five more sets of *I* and time up to a value of *t* = 50 s. Tabulate your results.
(You may need several attempts. Reconnect wire at X for one minute before making another attempt.)

Successfully collected 6 sets data including correct trend [1]
Repeated readings &
Processed data of average *I, calculation & precision [1]*

[2]

For Examiner's Use

(iii) **1.** Plot your values from **(b)(ii)** on Fig. 2.2. and draw a curve through your points.

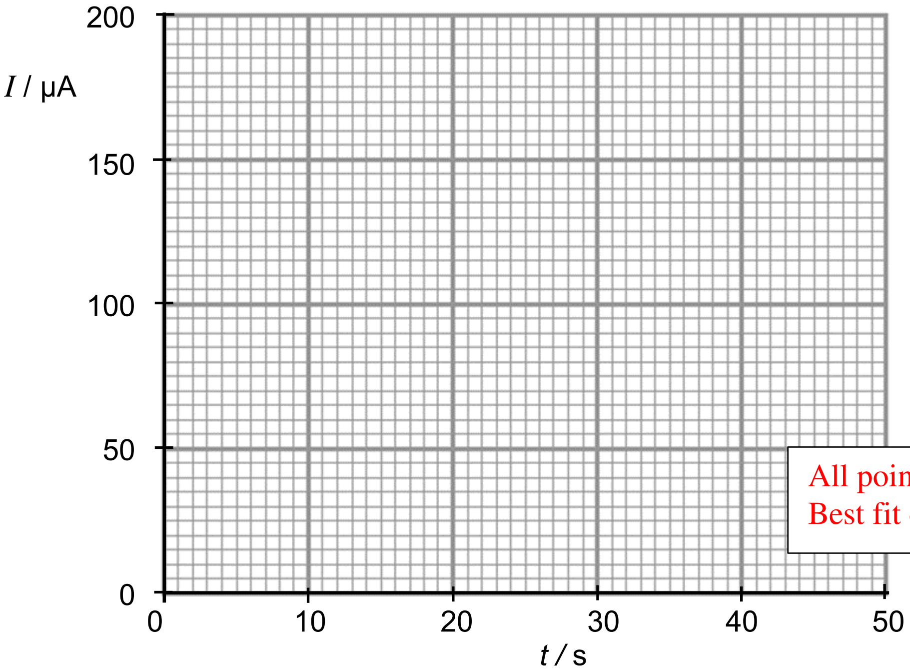


Fig. 2.2

All points correctly plotted [1]
Best fit curve [1]

[2]

2. The area under the graph represents the charge Q that has flowed through the resistor during 50 s. Estimate Q.

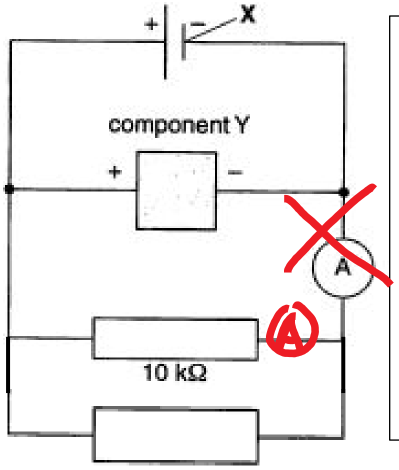
Correct method to estimate area under graph with correct units [1]

Q = ...[1]

For Examiner's Use

(c) It is suggested that the time taken for the current in the 10 kΩ resistor to decrease to zero is shorter when the total effective resistance of the circuit is lower.

With an aid of circuit diagram(s), suggest how you can verify this.



Ammeter placed at correct position [1], method to change resistor with indication of whether effective R increases when R is added. [1]
Charge the capacitor
Disconnect wire at X and start stopwatch
Stop the stopwatch when the reading in ammeter becomes zero and record as T1.
Repeat the experiment with additional resistor removed [1] and record the time taken for ammeter reading to be zero as T2.
If T1>T2, verified [A1]

.... [4]

(d) Theory suggests that $Q = kV$ where V is the potential difference across the resistor and k is a constant equal to 1.0×10^{-3} C V^{-1}.

(i) Use the analogue voltmeter to determine V.

correct precision of V to 2 dp and units [1]

V = ...[1]

(ii) Use your answer to **(d)(i)** to determine Q.

correct calculations and units [1]

Q = ...[1]

[Total : 12 marks]

For Examiner's Use

3 In this experiment, you will investigate how the motion of two pendulum depends on the tension in the string connecting them.

(a) Measure and record the unstretched length l_0 of the coiled part of the spring as shown in Fig. 3.1.

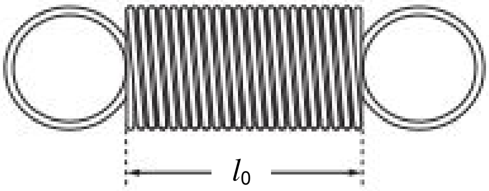


Fig. 3.1

correct precision at least 1 dp in cm and units for both (a) & (b)(iii)
range :1.8 - 2.2 cm

l_0 = ... [ ]

(b) **(i)** Set up the apparatus as shown in Fig. 3.2. Tie strings X and Y such that the spring is horizontal.

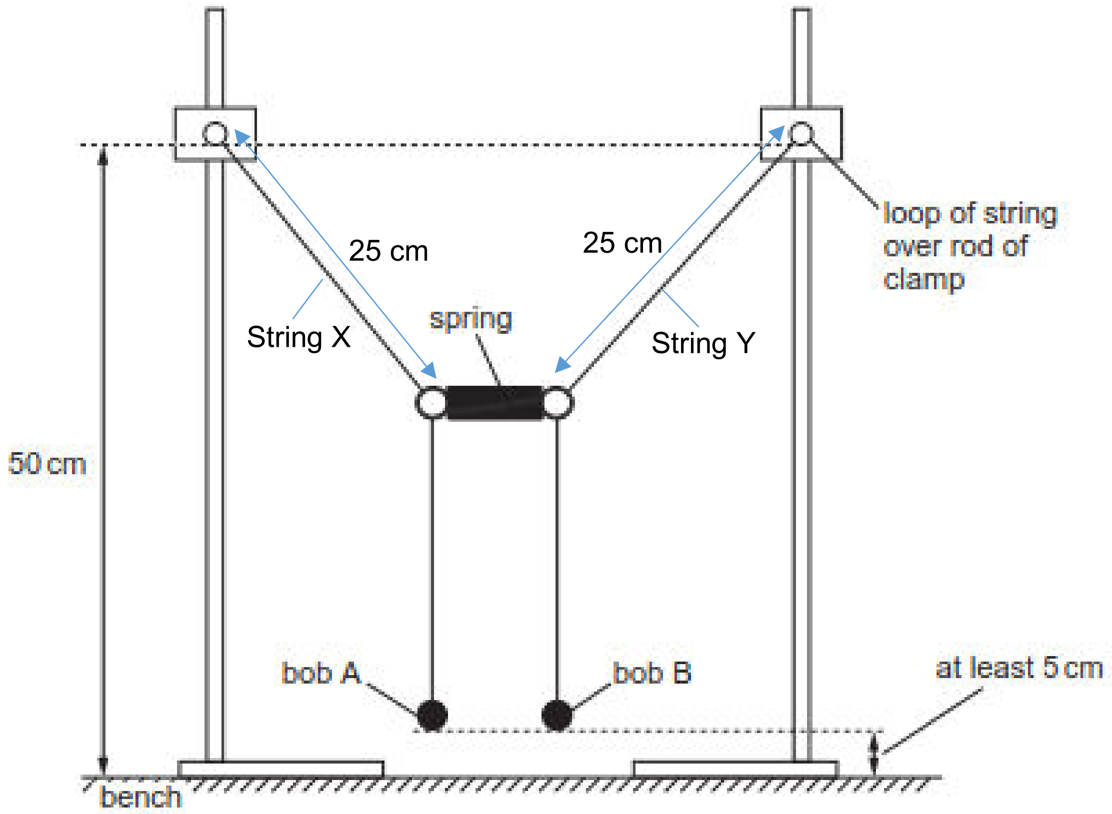


Fig. 3.2

(ii) Position the stands so that the coiled part of the spring has approximate length l_0 + 2 cm (so that the spring is extended by approximately 2 cm).

For Examiner's Use

(iii) Measure and record the length l of the coiled part of the spring. Calculate the extension x of the spring where $x = l - l_0$.

correct calculation of x of 3 dp and units

range of x :1.5 cm - 2.5 cm

l = ………………………………

x = ………………………… [1]

(iv) Gently pull bob A towards you. Release the bob and watch the movement of the two bobs.

Bob A will eventually stop and start moving again. It will then stop for a second time.

Determine and record the time T between these two stops.

correct precision of 1 dp and units [1]

T = ………………………… [1]

(c) By moving the stands further apart, repeat **(b)(iii)** and **(b)(iv)** until you have further readings of l, x and T, with x in the range 2 cm ≤ x ≤ 10 cm.

[2] successfully collected data of at least 6 sets
- [-1] if 1 of set T < 6.0 s
- [0] if more than 1 set of T < 6.0 s
- [0] wrong trend
- [-1] if spread of x (2.5cm to 9.5 cm)
- [-1] for 5 sets only, [0] for less than 5 sets

[1] for correct table headings/units (l, x, T)
[1] repeated reading, correct calculation for T_{ave}

[4]

For Examiner's Use

(d) It is suggested that T and x are related by the expression

$$T = p\,x + q$$

where p and q are constants.

(i) Plot a suitable graph to determine p and q.

[1] for appropriate scale with labelling of axes
[1] for best fit line
[1] for correct plotting of ALL points
[-1] if no big gradient triangle with coordinates read to the half a small square
[1] correct calculation of P with units
[1] correct calculation of q with units

p = ...

q = ...

[5]

(ii) Hence determine the extension x that would be expected to give a value of T = 75 s.

correct calculation 3 sf and units [1]

x = ... [1]

For Examiner's Use

For Examiner's Use

(iii) Comment on any anomalous data or results you may have obtained. Explain your answer.

There is no anomalous data as all points are fairly scattered about the best fit line. *OR*
There is a anomalous points at (_ , _) as it lies further away from the best fit line as **compared to all the other points**.

[0] if more than 1 anomalous points

......

.....[1]

(iv) On your graph on page 11, draw new graph when *q* is increased. Label this graph Z. [1]

Graph Z is above and parallel to the plotted graph.

(v) Suggest a significant source of error in this experiment.

1) Difficult to determine the exact time when the ball stops and hence affecting T
2) Difficult to determine the length of the spring due to shaky hands and hence affects x
3) Difficult to ensure the spring is horizontal, hence affecting T
4) Oscillation is wobbly, hence affecting T

[1]

(vi) Suggest an improvement that could be made to the experiment to address the error identified in **(d)(v)**. You may suggest the use of other apparatus or a different procedure.

1) Placed light gates connected with a datalogger and a computer such that pendulum A is between the light gates at its equilibrium position. The time between the 2 stops of pendulum A can be analysed from the signal on the computer.
2) Clamp the ruler such that it is parallel to the spring.
3) Use spirit level/ measure height from 2 points and ensure it is equal/ use teacher's bench/cupboard as the plane for reference

[1]

For Examiner's Use

(f) It is suggested that the mass of the identical pendulums A and B will affect the time *T* between the two stops of pendulum A such that the mass *m* of a pendulums is directly proportional to the time *T* between the two stops of pendulum A.
Plan an investigation to verify this.

Your account should include:

- your experimental procedure
- details of the table of measurements with appropriate units

1. **Weigh the mass *m* of the sphere using a top pan balance [1]**
2. **Set up the apparatus as shown in Fig. 3.1**
3. Position the stands so that the spring is extended by approximately 2 cm.
4. Gently pull bob A towards you. Release the bob and watch the movement of the two bobs. Bob A will eventually stop and start moving again. It will then stop for a second time.
5. Determine and record the time T between these two stops.
6. **Repeat steps 3 and 4 for reliability to obtain the average time *T*.**
7. **Repeat the steps 1 to 5 by replacing with <u>6 different spherical pendulums of the different masses</u> [1] <u>but same dimension</u> and extension [1]**
8. **Record the readings in the following table [1]**

m / g	T_1 / s	T_2 / s	T_{ave} / s

9. **Plot a graph of T_{ave} vs m**
10. **If the graph is a straight line passing through the origin, the relationship is verified. [1 for 9 & 10]**
[-1 for incorrect procedure]

[5]

[Total: 22 marks]

Question 4:

Write your answer in the Question Booklet for Question 4.

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SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

NAME

CG **INDEX NO.**

PHYSICS 9749 / 04

PRELIMINARY Examination **28th August 2018**
Paper 4 Practical **2 hour 30 minutes**

Question Booklet for Question 4

Candidates to answer all questions in the Question Booklet.

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and index number in the spaces at the top of this page.

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.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or do not use appropriate units.

Give details of the practical shift and laboratory in the boxes provided.

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.

Shift
Laboratory

For Examiner's Use	
4	/ 11
Total	/ 11

4 A student is investigating the characteristics of different light-emitting diodes (LEDs). Fig. 4.1 shows examples of LEDs and the circuit symbol for an LED.

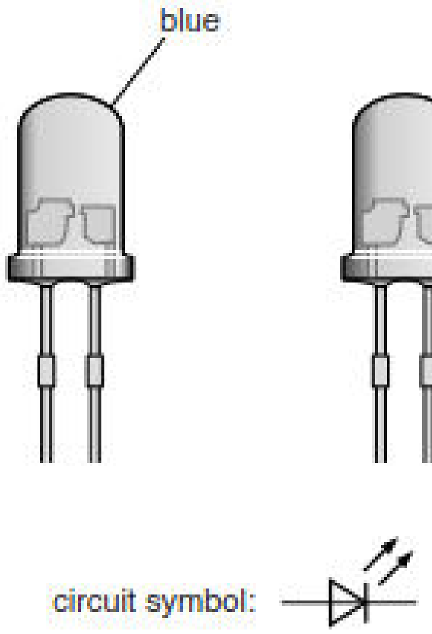

Fig. 4.1

Each LED needs a minimum potential difference V across it to emit light. The student is investigating the relationship between V and the wavelength λof the light emitted by the LED for several different LEDs.

Design an experiment to testinvestigate the relationship between V and λ.

You are provided with the following equipment:

Power supply	Metre rule
resistors	Ammeter
Diffraction grating	Voltmeter
Double slit	Different LEDs
Micrometer screw gauge	Vernier callipers

You may also use any of the other equipment usually found in a Physics laboratory.

You should draw a labelled diagram to show the arrangement of your apparatus. In your account you should pay particular attention to

(a) the equipment you would use,
(b) the procedure to be followed,
(c) the control of variables,
(d) the analysis of the data,
(e) any precautions that would be taken to improve the accuracy of the experiment.

For Examiner's Use

Diagram

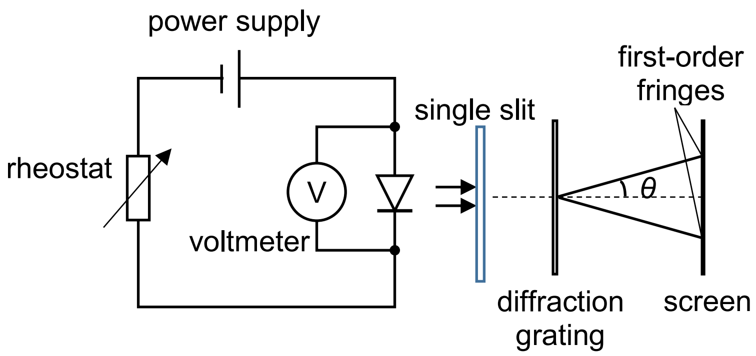

Fig. 4a

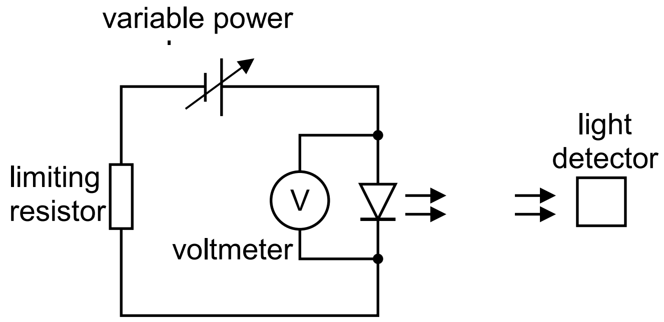

Fig. 4b

For Examiner's Use

[Total: 11 marks]

Diagram (max 2 marks):
Correct positioning of voltmeter and rheostat [D1]
Correct labelling of the various lengths to be measured for determining wavelength (e.g. slit to screen distance, distance between two slits and fringe separation for double slit interference method. [D1]
Measurement (max 2 marks):
Correctly identify means of measuring potential difference as voltmeter. [M1]
Correctly describe means of determining wavelength. For example, when using double slit, correctly identify apparatus for measuring slit to screen distance, distance between two slits and fringe separation and stating the correct equation for calculating wavelength. [M1]
Procedure (max 3 marks):
Correct identification of potential difference across LED as dependent variable and wavelength of light as independent variable. [P1]
Correctly state that to change wavelength, must use LED that gives light of different wavelengths. [P1]
Correctly describe when to record voltmeter reading as when the resistance of rheostat is slowly decreased from maximum till the LED light <u>first</u> lights up. [P1]
Analysis (max 2 marks):
Correctly states a hypothesis that relates potential difference across LED and wavelength. [D1]
Correctly state the graph to be plotted and that <u>a straight line graph will be obtained if the hypothesis is true</u> and how the constants can be determined. [D1]
Accuracy (max 1 mark):
States that experiment should be conducted in a dark room. [A1]
States that the intensity meter at a fixed distance from LED should be used to determine when first light is observed. [A1]
States that instead of measuring fringe separation between 0^{th} and first order maxima, measure distance across multiple maxima and take average. [A1]
Control variable (max 1 mark):
Distance between LED and intensity meter for detecting first light. [C1]

For Examiner's Use

END OF PAPER