EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2024
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME	

CIVICS GROUP	2	3	-			REGISTRATION NUMBER		

PHYSICS

9749/03

Longer Structured Questions

September 2024

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number on all the work you hand in.
The use of an approved scientific calculator is expected where appropriate.

Section A
Answer **all** questions.

Section B
Answer **one** question only.

Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use paper clips, highlighters, glue or correction fluid.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Q1	7
Q2	8
Q3	7
Q4	10
Q5	10
Q6	10
Q7	8
Q8	20
Q9	20
s.f.	
P3 Total	80

This document consists of **24** printed pages.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant,	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant,	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant,	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant,	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall,	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure,	$p = \rho gh$
gravitational potential,	$\phi = -\frac{Gm}{r}$
temperature,	$T / \text{K} = T / {}^\circ\text{C} + 273.15$
pressure of an ideal gas,	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $= \pm\, \omega \sqrt{(x_0^2 - x^2)}$
electric current,	$I = Anvq$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
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	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

Answer all questions in this section in the spaces provided.

1 Fig. 1.1 shows a simple pendulum consisting of a mass m attached to a light inextensible string of length L. The pendulum is secured to a fixed point and made to undergo oscillations when displaced sideways by a small angle θ.

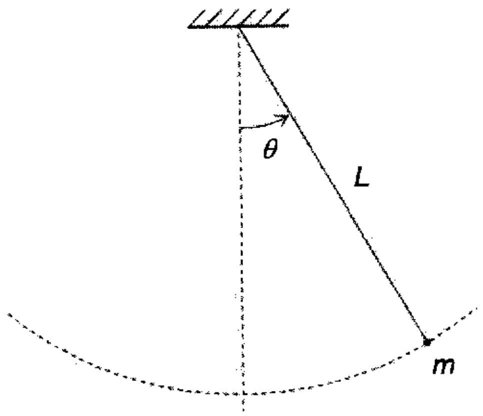


Fig. 1.1 (not to scale)

The following equation describes the period T of the oscillation:

$$T^2 = 4\pi^2 \frac{L}{g}$$

where g is the acceleration of free fall.

(a) Given L = 50.0 ± 0.2 cm and g = 9.8 ± 0.1 m s^{-2}, find T with its associated uncertainty.

T = ... ± .... s [4]

(b) A student measures the period of an oscillation using two methods.

In the first method, he measures the period of one oscillation directly.

In the second method, he measures the total time for 20 oscillations, and then divides the total time by 20 to obtain the period for one oscillation.

(i) The student took three readings each using the two methods.

Using suitable calculation, predict which set of data will be more precise.

....

....

.... [2]

(ii) In reality, the student mistook the time for half an oscillation to be one period.

Explain whether calculating the period by dividing the total time taken for multiple oscillations by the number of oscillations will reduce this type of error committed.

....

.... [1]

[Total: 7]

2 (a) Define *acceleration*.

....

....[1]

(b) An object is released from rest in a viscous fluid. Fig. 2.1 shows the variation with time t of the acceleration a of the object as it falls in the fluid.

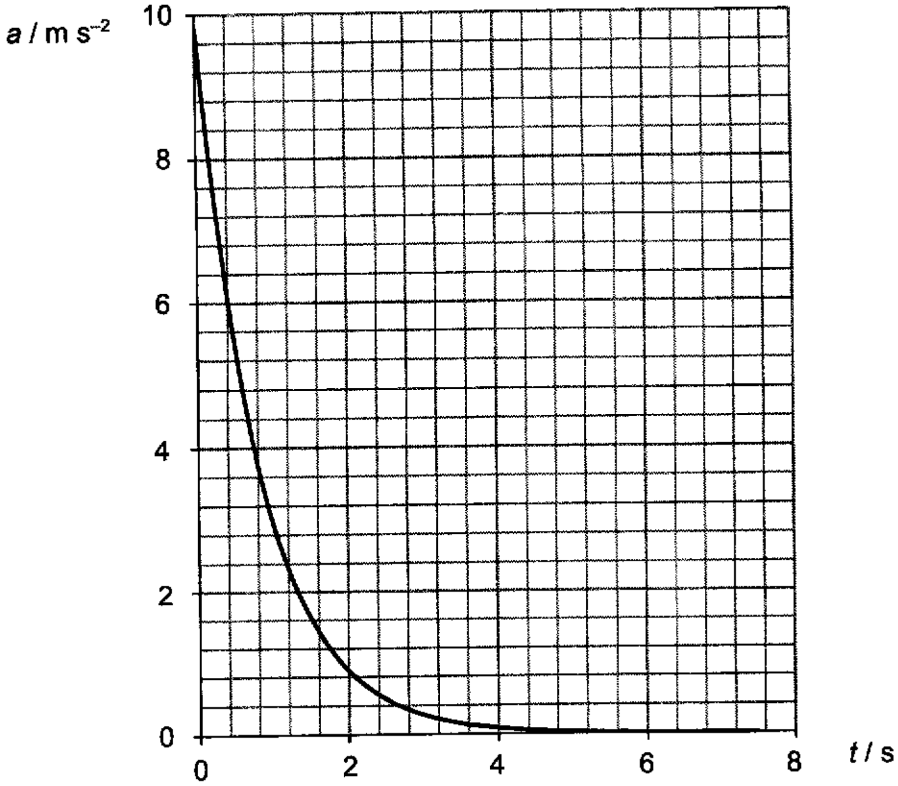


Fig. 2.1

(i) Explain why the acceleration of the object decreases with time.

....

....

.... [2]

(ii) Explain why the initial value of the acceleration is 9.81 m s^{-2}.

....

.... [1]

(iii) Use Fig. 2.1 to estimate the speed of the object when its acceleration is zero. Explain your working clearly.

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

(iv) In Fig. 2.2, sketch the variation of the displacement s of the object with time t, from t = 0 s to t = 8 s. There is no need to label the displacement axis.

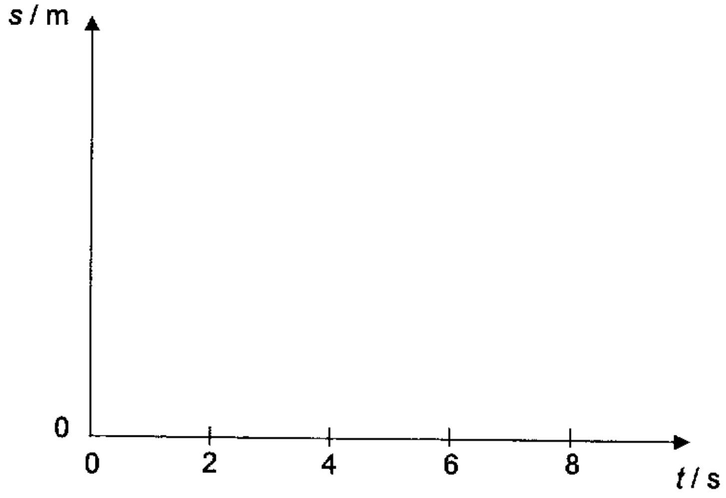


Fig. 2.2

[2]

[Total: 8]

3 A 12 V cell of internal resistance 30 Ω, a light-dependent resistor (LDR) and a 600 Ω resistor are connected as shown in Fig. 3.1.

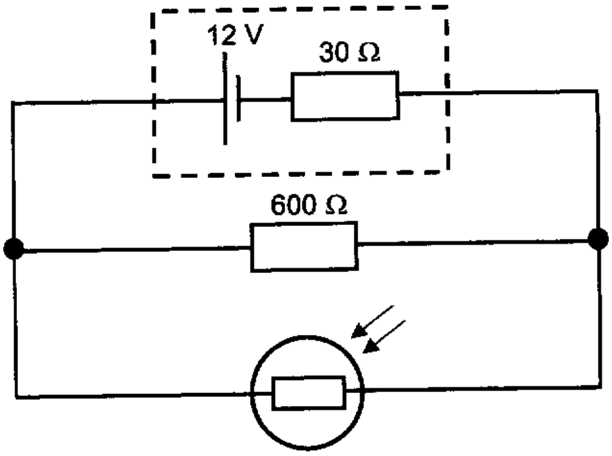


Fig. 3.1

(a) In conditions of low intensity light, the resistance of the LDR is 3000 Ω.

(i) Show that the current through the LDR is 3.8 mA.

[3]

(ii) Hence or otherwise, determine the power dissipated in the LDR.

power = ... W [1]

(b) The LDR is exposed to bright sunlight.

State and explain what would happen to the terminal potential difference.

....

....

....

....

.... [3]

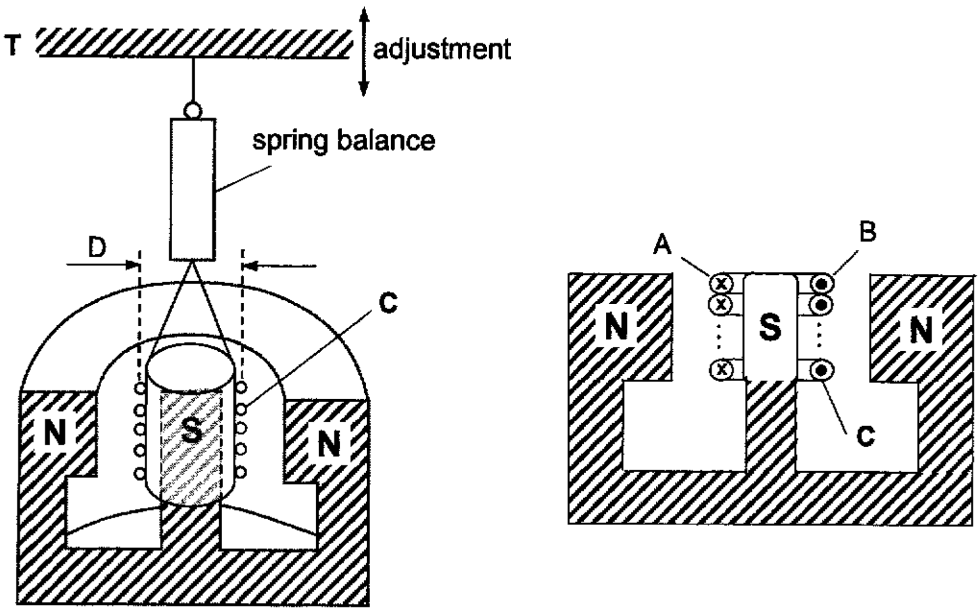
[Total: 7]

4 **(a)** Define magnetic flux density.

....

....[1]

(b) Fig. 4.1 shows a loudspeaker magnet consisting of a circular north pole **N** and a cylindrical south pole **S**. Part **C** is a moving coil that coils around **S**, and it is attached to a spring balance, which is attached to an adjustable support **T**.



(a) section view **(b)** side view

Fig. 4.1

Current was passed through the coil **C**, and the adjustable support **T** was then adjusted so that the coil **C** was restored to its original position. The readings F on the balance for various currents I are recorded in Table 4.1 below.

Table 4.1

I / A	0.20	0.41	0.60	0.81
F / N	1.50	2.02	2.48	3.05

(i) The direction of current flowing in the coil is indicated in Fig. 4.1(b). Draw two arrows, one each at positions A and B, to indicate the direction of the magnetic force acting on the coil. Explain your answer.

....

....

....

.... [3]

(ii) In Fig 4.2, draw a graph using values from Table 4.1 to determine the force per unit current required to restore coil **C** to its original position, and find the zero error of the balance.

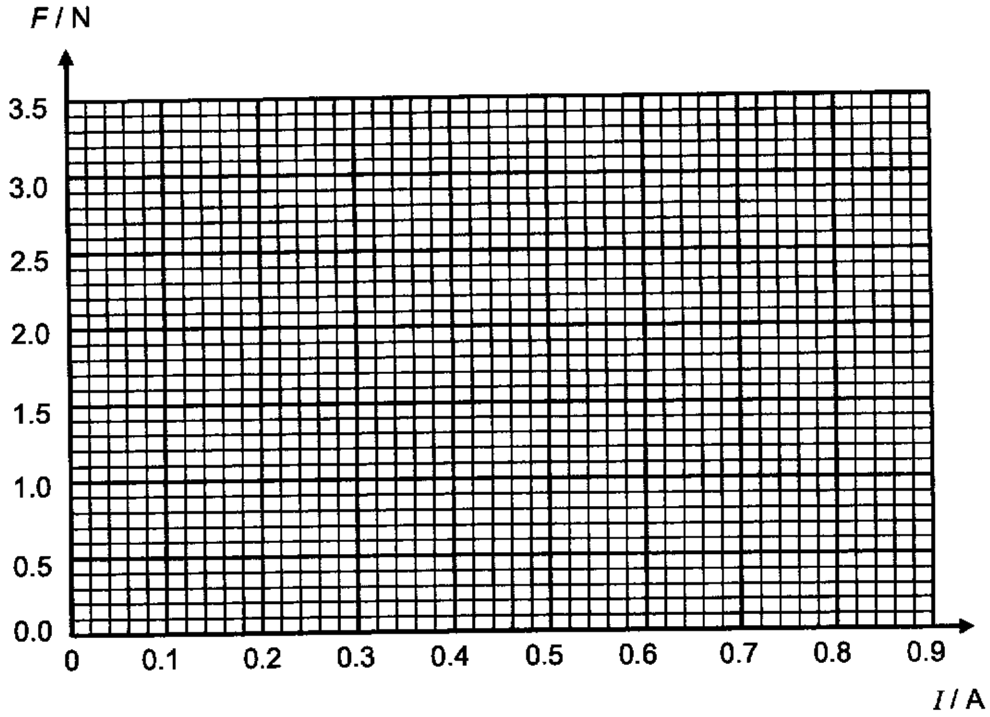


Fig. 4.2

force per unit current = ...N A^{-1}

zero error of the balance = ... N [4]

(iii) If the mean diameter, D, of the coil is 0.025 m and the number of turns is 50, calculate the flux density at the coil, assuming that the field is radial.

magnetic flux density= ....T [2]

[Total:10]

5 (a) Explain what is meant by *gravitational field strength* at a point.

....

....[1]

(b) A satellite of mass m orbits a planet of mass M in a circular orbit, with orbital radius r.

Show that its kinetic energy E_K and gravitational potential energy E_P are related by

$$E_K = -\frac{E_P}{2}.$$

[2]

(c) The variation of gravitational potential ϕ with distance r from the centre of Jupiter is shown in Fig. 5.1.

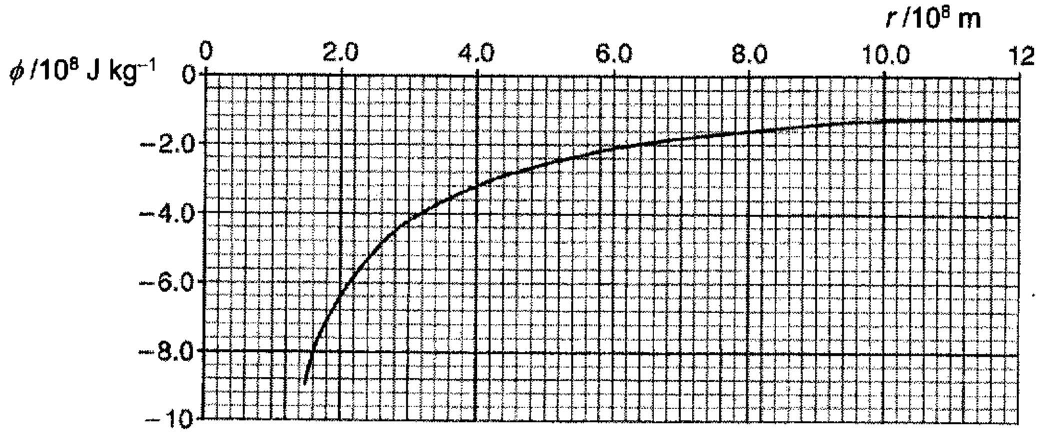


Fig. 5.1

(i) A satellite orbiting Jupiter has a mass of 8.93×10^{22} kg and orbital radius 4.0×10^{8} m.

Determine the total energy of the satellite.

total energy = ... J [3]

(ii) The orbital radius of the satellite is reduced. State and explain the effect on

1. the kinetic energy of the satellite,

....

....[1]

2. the total energy of the satellite.

....

....[1]

(iii) Use Fig. 5.1 to determine the gravitational field strength due to Jupiter at a distance of 4.0×10^8 m from its centre.

gravitational field strength = ... m s^{-2} [2]

[Total: 10]

6 (a) State the first law of thermodynamics.

....

....

....[2]

(b) The temperature of a sample of ideal gas is raised via two different processes.

In the first process, the ideal gas is heated up with its volume kept constant.

In the second process, the ideal gas is heated up at constant pressure.

The initial and final temperatures of the ideal gas are the same for the two processes.

Using the first law of thermodynamics, explain why the second process requires more heat transfer to the gas than the first.

....

....

....

....

....

....[3]

(c) A car tyre has a fixed internal volume of 0.036 m^3. The temperature and pressure of the air inside the car tyre are 25 °C and 2.6×10^5 Pa, respectively.

Assume that the air inside the tyre can be considered as an ideal gas.

(i) Determine the number of air particles in the car tyre.

number of air particles = ... [2]

(ii) The average molar mass of the air is 6.5 g.

Calculate the root mean square (r.m.s.) speed of the air molecules.

r.m.s. speed of molecules = ... m s^{-1} [3]

[Total: 10]

7 **(a)** Define electric potential.

....

.... [1]

(b) Fig. 7.1 is a **full-scale** diagram that shows a series of equipotential lines around a few point charges. A, B and C are points within the field.

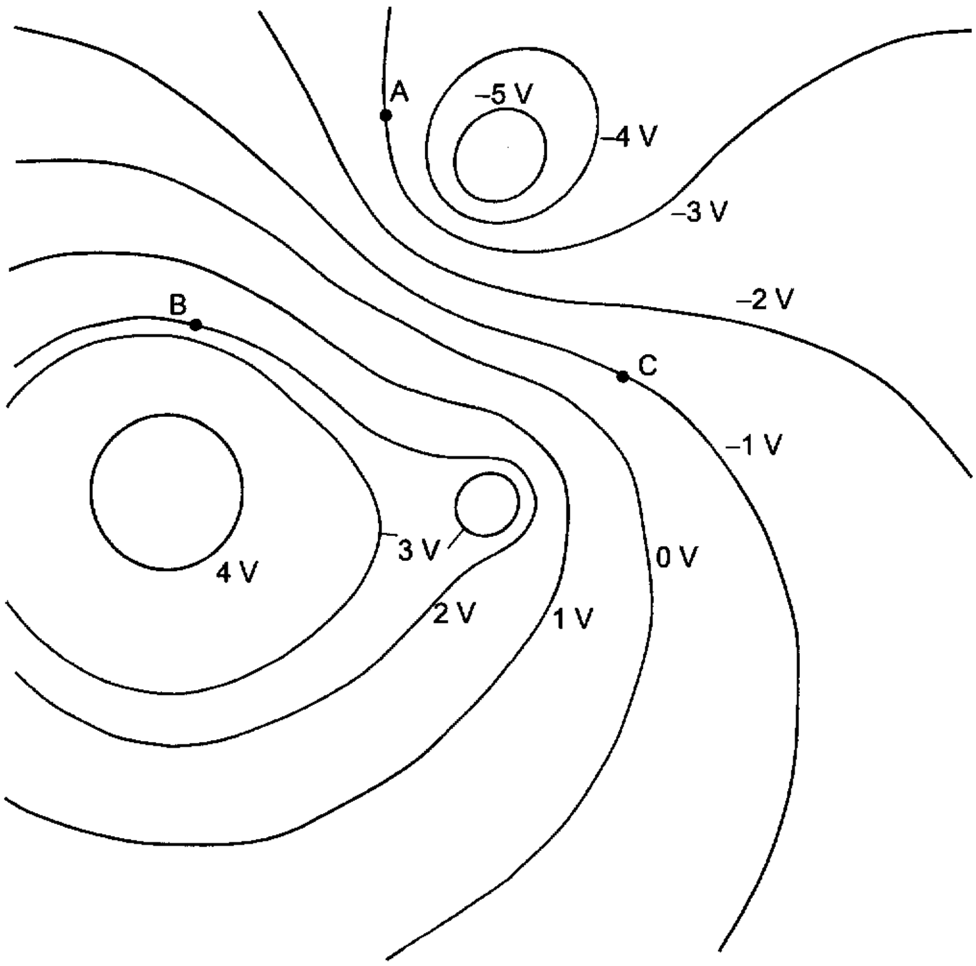


Fig. 7.1 (drawn to scale)

(i) On Fig 7.1, sketch the electric field line that joins points A and B. Label the line E.

Indicate the direction of the field line with an arrow drawn on the line.

[2]

(ii) An electron moves from point A with an initial speed of 2.6×10^6 m s^{-1}, eventually reaching point B.

Calculate the speed of the electron at point B.

speed = ... m s^{-1} [3]

(iii) Using Fig. 7.1, determine the magnitude of the electric force experienced by an electron placed at point C. Show your working clearly.

electric force = ... N [2]

[Total: 8]

Section B

Answer one question in this section in the spaces provided.

8 **(a)** **(i)** State what is meant by a polarized wave.

....

....[2]

(ii) Explain what is meant by coherent light waves.

....[1]

(b) A double slit consists of two parallel slits of the same width *x*. The separation of the slits is 1.40 mm, as illustrated in Fig. 8.1.

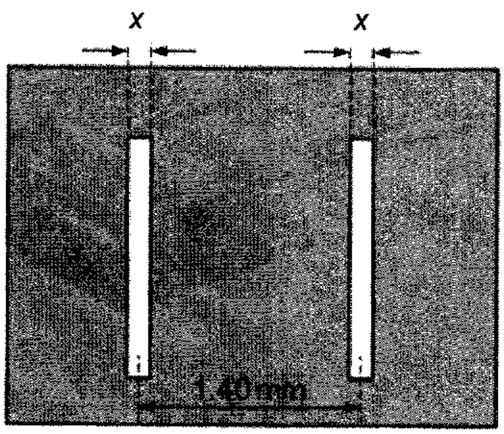


Fig. 8.1

A parallel beam of light of wavelength 590 nm is incident normally on the double slit.

A screen is placed parallel to the plane of the double slit at a distance of 2.60 m from the slits, as illustrated in Fig. 8.2. Point N on the screen is on the central axis of the double slit.

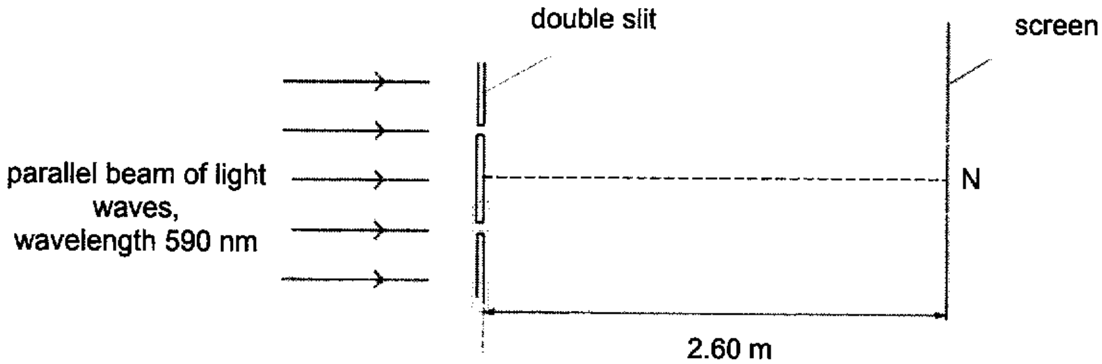


Fig. 8.2

Initially, one of the two slits is covered, and a central maximum of width 30.7 mm is observed on the screen.

(i) Determine x.

x = ... m [2]

(ii) Calculate the minimum angular separation between two objects, such that their images can be resolved by the slit.

minimum angular separation = ... rad [2]

(iii) Both slits are now uncovered. Describe how the central maximum changes.

....

....[2]

(iv) The intensity at point N is I_{single} when one slit is uncovered and I_{double} when both slits are uncovered.

Determine

$$\frac{I_{single}}{I_{double}}.$$

$\frac{I_{single}}{I_{double}}$ = ... [1]

(v) Another experiment is conducted, where the two slits are replaced by lights from two separate point sources.

Suggest two reasons why the pattern in **(b)(iii)** may not be observed in the new experiment.

1. ....

....

2. ....

.... [2]

(c) Some electron energy levels of the mercury atom are illustrated in Fig. 8.3.

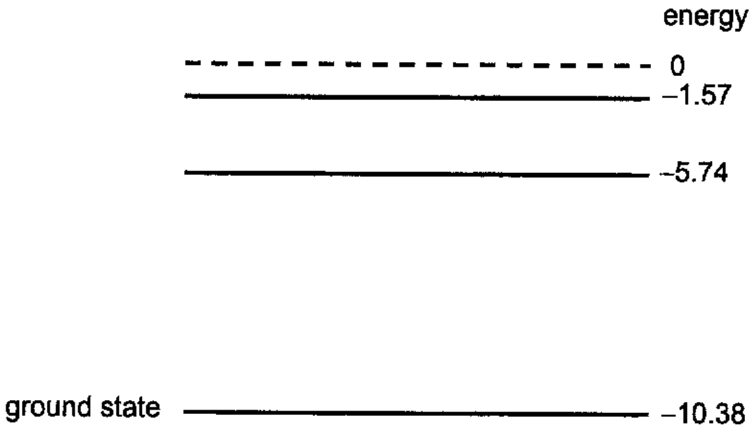


Fig. 8.3 (not to scale)

(i) Explain the significance of the energy levels being negative.

....

.... [1]

(ii) State the ionisation energy of the mercury atom.

ionisation energy = ... eV [1]

(iii) An electron with energy 8.9 eV collides with a mercury atom in its ground state.

Consider only the three energy levels shown in Fig. 8.3.

1. On Fig. 8.3, draw arrows to show electron transitions between energy levels that produce the emission spectrum.

[2]

2. determine the longest wavelength of the spectral lines.

wavelength = ... nm [2]

(iv) A photon with energy 8.9 eV interacts with a mercury atom in its ground state.

For the three energy levels shown in Fig. 8.3, state and explain the number of transition lines in the resulting spectrum.

....

....

....

.... [2]

[Total: 20]

9 (a) (i) Explain what is meant by diffraction of light.

....

.... [1]

(ii) A parallel beam of red light is incident normally on a diffraction grating, and a diffraction pattern is observed. The red light in is then replaced with blue light.

State and explain the effect on the diffraction pattern, apart from the change in color.

....

....

.... [2]

(b) A loudspeaker is held above a vertical tube of liquid, as shown in Figure 9.1.

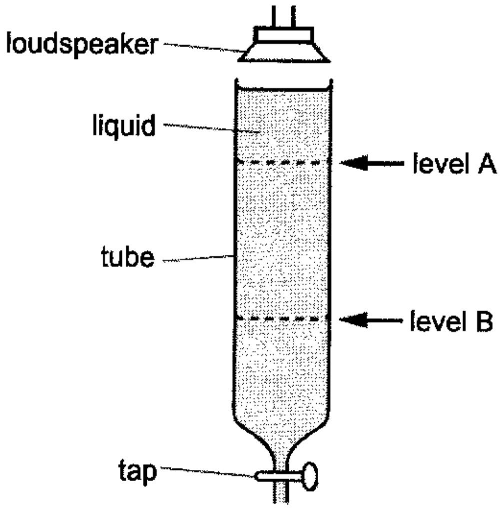


Fig. 9.1

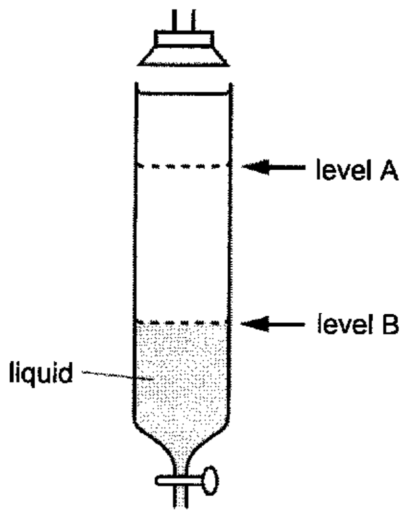


Fig 9.2

A tap at the bottom of the tube is opened so that liquid drains out slowly. The wavelength of the sound from the loudspeaker is 0.30 m.

The sound that is heard first becomes much louder when the liquid surface reaches level A. The next time that the sound becomes much louder is when the liquid surface reaches level B, as shown in Fig. 9.2.

(i) Calculate the vertical distance between level A and level B.

distance = ... m [1]

(ii) On Fig. 9.2, label with the letter N the positions of the displacement nodes of the stationary wave that is formed in the air column when the liquid surface is at level B.

[1]

(c) S_1 and S_2 are two loudspeakers directly facing each other, emitting continuous sound waves of frequency 1100 Hz. **M** is a microphone which runs on a straight track from S_1 to S_2 at a speed of 20 m s^{-1}, as shown in Fig. 9.3.

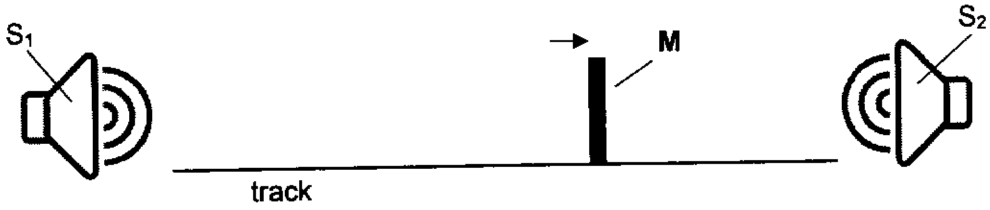


Fig. 9.3

(i) The intensity of sound received by **M** fluctuates regularly. Explain.

....

....

....

.... [2]

(ii) If the speed of sound is known to be 330 m s^{-1}, calculate the frequency at which the maxima in sound are detected by **M**.

frequency = ... Hz [3]

(d) **(i)** With reference to the photoelectric effect, explain why the existence of the threshold frequency provides evidence for the particulate nature of EM radiation.

....

....

....

....

....

.... [3]

(ii) Electromagnetic radiation of wavelength λ is incident on a metal surface. Electrons are emitted from the surface, with maximum kinetic energy E_{max}.

The variation of E_{max} with λ is shown in Fig. 9.4.

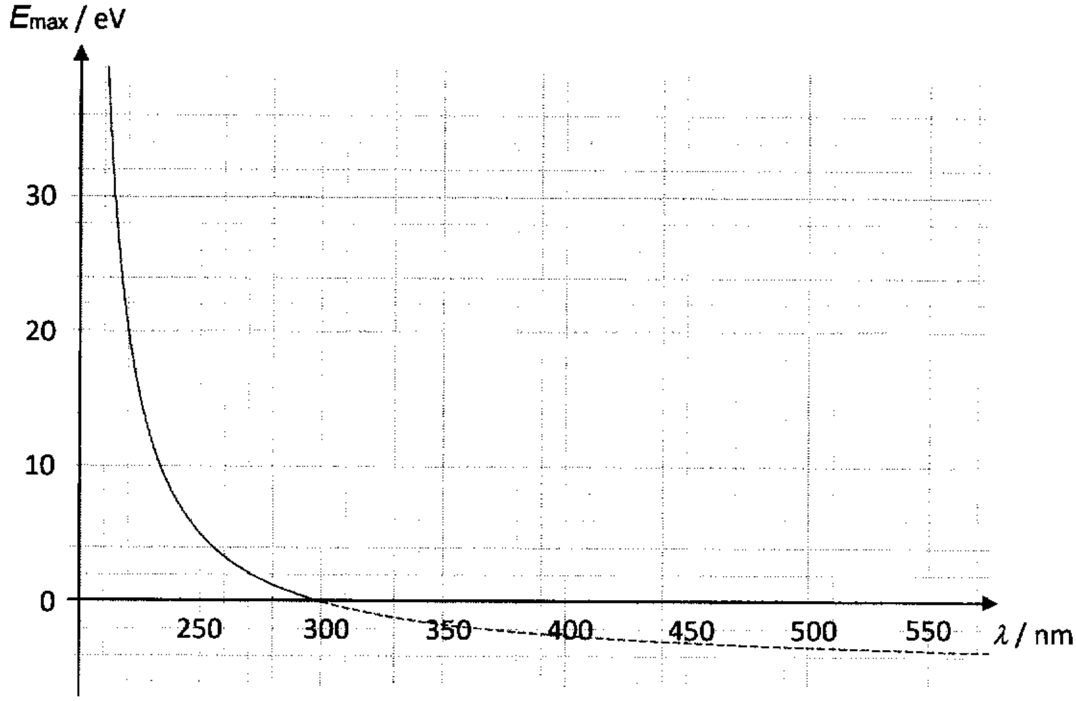


Fig. 9.4

Using Fig. 9.4, determine

1. the work function of the metal,

work function = ... eV [2]

2. the threshold frequency of the metal, and threshold frequency = ... Hz [1]

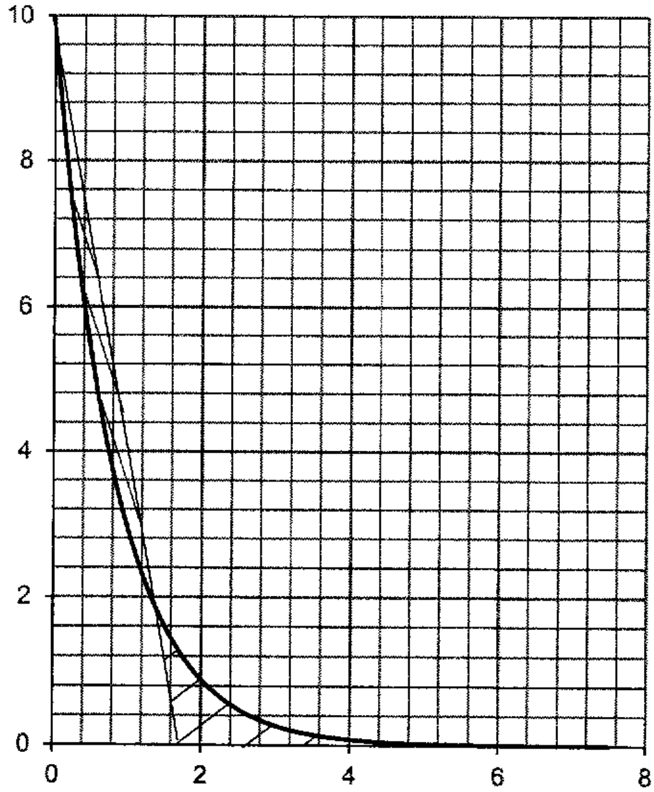
3. the stopping potential when λ = 220 nm.

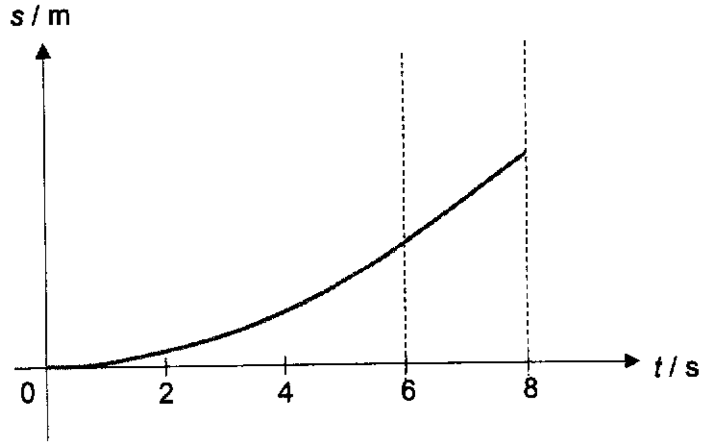
stopping potential = ... V [2]

(iii) On Fig. 9.4, sketch a curve to show the variation with λ of E_{max} for a metal with a higher work function.

[2]

[Total: 20]

Qns	Answer	Marks
2(a)	Acceleration is the rate of change of velocity.	B1
(b)(i)	As the object accelerates downwards, its velocity increases with time. Since the drag force (due to viscous fluid) on the object increases with speed,	B1
	net force (weight – resistive/drag force) acting on the object decreases, hence the acceleration decreases with time.	B1
(b)(ii)	Initially the velocity of the object is zero, hence the drag force is also zero. The acceleration of the object is only due to its weight / gravitational force , hence acceleration 9.8 m s^{-2}. (Assume upthrust is negligible since given that acceleration is 9.8 m s^{-2})	B1
(b)(iii)	Change in velocity = area under *a-t* graph	C1
	$v - 0 \approx$ (50 small squares)(0.4 x 0.4) = 8.0 m s^{-1} (range: 7.5-9.0 m s^{-1})	A1
	One way to estimate the area under the curve is to draw a line as shown in the diagram below. The line chosen is such that the area shaded in red is roughly equal to the area shaded in blue. The area under the original curve is then roughly equal to the area of the triangle, with base 1.7 and height 9.8. Thus, $\text{velocity} = \text{area under curve} \approx \frac{1}{2} \times 9.8 \times 1.7 = 8.3 \text{ m s}^{-1}$. Better estimation of the area can be achieved by using more triangles/trapeziums to approximate it.  Some students used kinematics equations without understanding that the acceleration graph already shows that the acceleration is not constant.	

(b)(iv)	 **Gradient = 0 at t = 0 s**, then gradually increasing till $t \approx 5.2$ s . After $t \approx 6$ s, gradient is constant (terminal velocity reached) at the value that was reached at 6 s - no kink allowed.	B1 B1

Qns	Answer	Marks

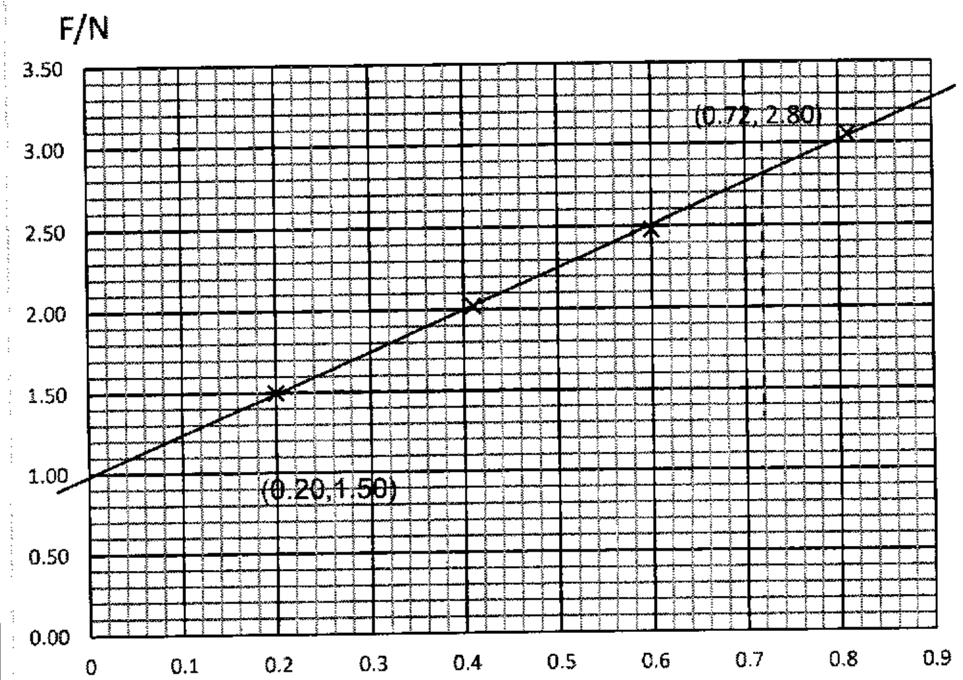
3(a)(i)	$R_{total} = R_{//} + r$
	$= (\frac{1}{600} + \frac{1}{3000})^{-1} + 30 = 530\ \Omega$
	$V_{LDR} = V_{terminal} = \varepsilon - Ir$
	$= 12 - (\frac{12}{530})(30) = 11.3\text{ V}$
	$I_{LDR} = \frac{V_{LDR}}{R_{LDR}}$
	$= \frac{11.3}{3000} = 3.77\text{ mA} = 3.8\text{ mA (2sf) (shown)}$
	
	OR
	
	$R_{//} = (\frac{1}{600} + \frac{1}{3000})^{-1} = 500\ \Omega$
	$V_{LDR} = V_{//} = \frac{R_{//}}{R_{//} + r} \times \varepsilon$
	$= \frac{500}{500 + 30} \times 12 = 11.3\text{ V}$
	$I_{LDR} = \frac{V_{LDR}}{R_{LDR}}$
	$= \frac{11.3}{3000} = 3.77\text{ mA} = 3.8\text{ mA (2sf) (shown)}$
	
	OR
	
	$R_{total} = R_{//} + r$
	$= (\frac{1}{600} + \frac{1}{3000})^{-1} + 30 = 530\ \Omega$
		M1
		
		M1
		
		M1

	$I_{Tot}=\dfrac{\varepsilon}{R_{Tot}}=\dfrac{12}{530}=0.0226\text{ A}$ $I_{\text{LDR}}=\dfrac{600}{600+3000}\times I_{Tot}$ $=\dfrac{600}{600+3000}\times 0.0226=3.77\text{ mA}=3.8\text{ mA (2sf) (shown)}$	

(a)(ii)	$P_{LDR} = I_{LDR}{}^2 R_{LDR}$ $= (3.8\times10^{-3})^2(3000)$ $= 0.043$ W (2sf)	A1
(b)	**Explanation 1 (preferred):** Resistance of LDR decreases in bright light, thus effective total resistance of entire circuit decreases. Total current I_{Tot} in circuit increases, resulting in larger potential drop V_r across the internal resistance r Since $V_{terminal} = \varepsilon - V_r = \varepsilon - I_{Tot}r$, where $V_{terminal}$ is the terminal p.d. , ε is the e.m.f. if the cell; thus the terminal p.d. decreases. OR **Explanation 2:** Resistance of LDR decreases in bright light, thus resistance of the combination of parallel resistors decreases. By potential divider rule, potential difference (p.d.) across parallel resistors decreases. Since terminal p.d. is the same as p.d. across parallel resistor, terminal p.d. decreases.	B1 B1 B1

Qns	Answer	Marks
4(a)	Magnetic flux density *B* is the force acting per unit current per unit length on a wire carrying a current that is normal to the magnetic field.	B1
b(i)	Both arrows point vertically downwards (in diagram). The current flows perpendicular to the magnetic flux density at all parts of the coil. Hence the current carrying conductor will experience a magnetic force. The direction of the magnetic force can be deduced by Fleming's Left Hand Rule.	B1 B1 B1

(b)(ii)



B1 correct plots

B1 Best fit line

$$\text{Gradient} = \frac{2.80 - 1.50}{0.72 - 0.20} = \frac{1.30}{0.52} = 2.5$$

Force per unit current = F/L = 2.5 N A^{-1}

B1 use of gradient rather than plots, within range.

From the graph, zero error of the balance =1.00 N

OR

Use point (0.20,1.50) and gradient =2.50 to find the y-intercept:
1.50 = (0.20)(2.80) + C
C = 0.94
Zero error = C = 0.94 N

B1

(iii)

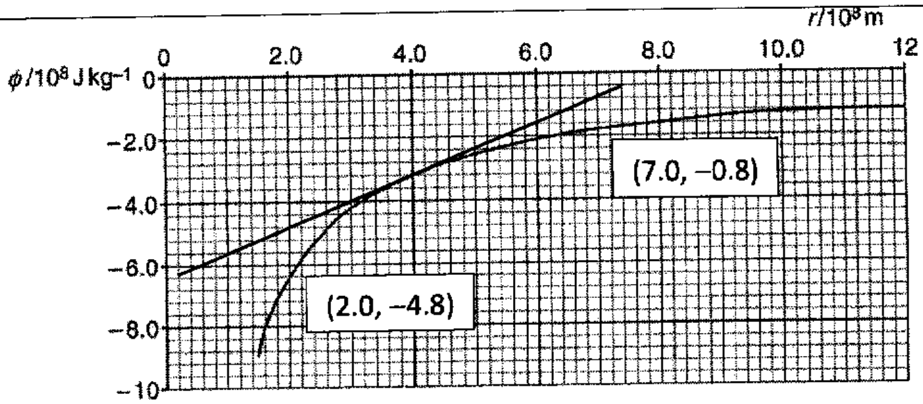
$$F = BIL \Rightarrow \frac{F}{I} = BL$$

From (b)(i), $\frac{F}{I} = 2.5 \text{ N A}^{-1}$,

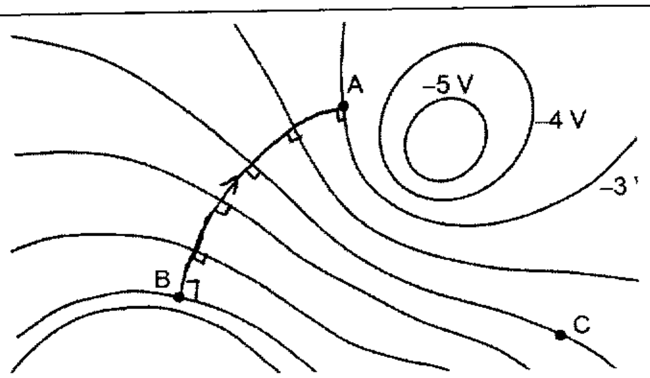
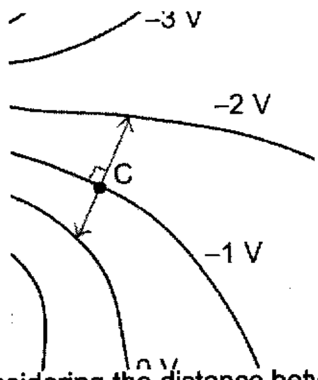
$$2.5 = B(50 \times 2\pi(0.025))$$ **M1**

$$B = 0.637 \text{ T}$$ **A1**

Qns	Answer	Marks
5(a)	The gravitational field strength at a point is the **gravitational force** (of attraction) **<u>per</u> unit mass** (acting on a small test mass) placed at that point in the field.	**B1**
(b)	**Gravitational force provides the centripetal force.** $G\frac{Mm}{r^2} = m\frac{v^2}{r}$ $G\frac{Mm}{r} = mv^2$ $\frac{1}{2}mv^2 = \frac{1}{2} \times G\frac{Mm}{r}$ Since $E_P = -G\frac{Mm}{r}$, $E_K = -\frac{E_P}{2}$	**M1** **M1** clear algebra showing proof **A0**
(c)(i)	From graph, $\phi = -3.2 \times 10^8\ \text{J kg}^{-1}$ at $r = 4.0 \times 10^8\ \text{m}$. $E_{tot} = E_K + E_P = -\frac{E_P}{2} + E_P = \frac{E_P}{2} = \frac{m\phi}{2}$ $= \frac{8.93 \times 10^{22} \times (-3.2 \times 10^8)}{2}$ $= -1.43 \times 10^{31}\ \text{J}$	**M1** **M1** **A1**

(c)(ii)	1. From **(b)**, $E_K = G\dfrac{Mm}{2r}$. Hence, when r decrease, kinetic energy **increases** 2. From **(c)(i)**, $E_{tot} = \dfrac{E_P}{2} = -G\dfrac{Mm}{2r}$. Hence, when r decrease, total energy **decreases**.	**B1** Show eqn or state relations **B1**
(c)(iii)	 **<u>Method 1</u>** <u>(preferred as it is valid in all cases)</u> Using (2.0, −4.8) and (7.0, −0.8), $g = -\dfrac{d\phi}{dr}$ $= \dfrac{[-4.8-(-0.8)]\times10^8}{(2.0-7.0)\times10^8}$ (minimum 2 s.f.) $= 0.80 \text{ m s}^{-2}$ **<u>Method 2</u>** <u>(discouraged; valid only in the case when Jupiter is the only planet contributing to the potential being graphed i.e. the ϕ - r graph is an inverse r graph, else the relationship between potential and distance does not hold)</u> $g = \dfrac{\phi}{r}$ $= \dfrac{-3.2\times10^8}{4.0\times10^8}$ $= -0.80 \text{ m s}^{-2}$	**M1** **A1**

Qns	Answer	Marks
6a	The *increase* in internal energy of a system is equal to the sum of the *heat supplied to* the system and the *work done on* the system.	B2
6b	Since the temperature increases by the same amount for the same amount of gas, the increase in internal energy (ΔU) is the same. (First process) When heated at constant volume, no work is done on the gas (W=0). By first law of thermodynamics, heat transferred to the system is solely to increase its internal energy ($Q=\Delta U$). (Second process) When heated at constant pressure, the gas expands, and work is done by the gas (W<0). By first law of thermodynamics, heat is required for the increase of internal energy AND the work done by the gas ($\Delta U=Q+W \Rightarrow Q = \Delta U - W > \Delta U$, since W<0). Hence, to increase the temperature by the same amount, the heat required at constant pressure is greater than heat required at constant volume.	B1 B1 B1
6ci	Using equation of state for ideal gas: $pV = NkT$ $(2.62\times10^5)(0.0360) = N(1.38\times10^{-23})(273.15+25)$ $N = 2.29\times10^{24} = 2.3\times10^{24}$	M1 A1
6cii	mass per molecule $m = \dfrac{6.5\times10^{-3}}{6.02\times10^{23}}$ By kinetic theory, $pV = \frac{1}{3}Nm\langle c^2\rangle$ $(2.62\times10^5)(0.0360) = \frac{1}{3}\times2.29\times10^{24}\times\dfrac{6.5\times10^{-3}}{6.02\times10^{23}}\langle c^2\rangle$ $c_{rms} = 1070\ m\ s^{-1}$	M1 (or finding n) M1 A1

Qns	Answer	Marks
7a	Electric potential at a point is <u>the work done</u> (by an external agent) <u>per unit positive charge to move a small test charge from infinity to that point</u>.	B1
7bi	 The field line must be perpendicular to all the field lines from A to B. The direction (as indicated by the arrow) is from B to A. The field line must be reasonably smooth. **–1 for each mistake (to a minimum of 0).**	
7bii	By Principle of Conservation of Energy, Gain in Kinetic energy = Loss in Electric Potential Energy $\frac{1}{2} mv^2 - \frac{1}{2} mu^2 = e\,(V_i - V_f)$ $\frac{1}{2}(9.11 \times 10^{-31})v^2 - \frac{1}{2}(9.11 \times 10^{-31})(2.6 \times 10^6)^2 = -1.6 \times 10^{-19}(-3-2)$ $v = 2.9 \times 10^6$ m s^{-1} (2.92×10^6)	C1 Statement C1 decrease in EPE A1
7biii	 Considering the distance between the nearest two equipotential lines around point C (0V and –2V) d = 1.8 cm (accept 1.7 to 1.9cm) $E = \Delta V/d = (2-0)/(1.8\times10^{-2})$ $F = eE = 1.6 \times 10^{-19} \times (2-0)/(1.8\times10^{-2})$ $= 1.8 \times 10^{-17}$ N	C1

Qns	Answer	A1 Marks
8(a)(i)	In a polarised wave, the oscillations are along one direction only, in a single plane that is normal to the direction of energy transfer of the wave	B1 B1
8(a)(ii)	Light waves that have a constant phase difference.	B1
8(b)(i)	$\sin\theta = \frac{\lambda}{x}$ For small angles, $\sin\theta \approx \tan\theta$ $\frac{\lambda}{x} = \frac{\frac{1}{2}w}{D}$ $\frac{590\times10^{-9}}{x} = \frac{\frac{1}{2}(30.7\times10^{-3})}{2.6}$ $x = 1.0\times10^{-4}$ m	C1 A1
8(b)(ii)	$\theta > \frac{\lambda}{x} = \frac{590\times10^{-9}}{1.0\times10^{-4}}$ ≈ 0.0059 rad	C1 A1
8(b)(iii)	The continuous central maximum is replaced by an interference pattern of equally spaced bright and dark fringes within the single slit envelope.	B1 B1
8(b)(iv)	$\frac{I_{single}}{I_{double}} = \frac{kA^2}{k(2A)^2} = \frac{1}{4} = 0.25$	B1
8(b)(v)	1. Waves from both sources of light might be polarized in perpendicular planes. 2. Waves from both sources of light do not have constant phase difference OR are not coherent OR have different wavelength/frequencies. 3. Waves might have different amplitudes. (The resulting interference pattern will have less contrast due to incomplete cancellation at the minima.) Any two above.	B1 B1
8(c)(i)	Negative energy levels indicate that the atom is a bound system - electron cannot escape from the atom. **OR** Energy must be supplied to the system to bring the electron to infinity. **OR** The potential energy is taken to be 0 at infinity, and negative work needs to be done to move the electron from infinity to a point. Hence, the electric potential energy is negative.	B1
8(c)(ii)	10.38 eV	B1
8(c)(iii)(1)	Downward arrows All three arrows	B1 B1

8(c)(iii)(2)	Longest wavelength corresponds to the lowest transition energy: $-1.57-(-5.74) = 4.17$ eV $\Delta E = \frac{hc}{\lambda}$ $4.17 \times 1.6 \times 10^{-19} = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{\lambda}$ $\lambda = 2.98 \times 10^{-7}$ m $= 298$ nm	**B1** **B1**
8(c)(iv)	Since the energy of the photon (8.9 eV) does not match the energy difference between any two of energy levels, the electrons will not be excited. Hence, there is no spectral lines.	**B1** **B1**

Qns	Answer	Marks
9(a)(i)	Diffraction is the spreading of a wave into the geometric shadow when it passes through a slit or past an edge of an obstacle.	B1
9(a)(ii)	Wavelength of blue light is less than wavelength of red light Hence more orders seen OR each order is at a smaller angle than for the equivalent red	B1 B1 either statement
9(b)(i)	$d = \frac{\lambda}{2} = \frac{0.30}{2} = 0.15$ m	A1
9(b)(ii)	N labelled at A and B, and nowhere else	B1
9(c)(i)	As M moves, path difference of between S_1M and S_2M changes continuously. When path difference between S_1M and S_2M is integer number of wavelength, constructive interference occurs, a loud sound is received by M When path difference between S_1M and S_2M off integer number of half wavelength, destructive interference occurs, a soft/no sound is received by M. **OR** The waves from S_1 and S_2 are of the same type, wavelength, frequency and amplitude. They travel opposite to each other, overlap and form a stationary wave, with displacement nodes and antinodes at regular intervals. M detects a large sound at displacement nodes, and soft (or no) sound at displacement antinodes.	B0 B1 B1 **OR** B1 B1
9(c)(ii)	$v = f\lambda$ $330 = 1100\lambda$ $\lambda = 0.30$ m distance between consecutive max (displacement nodes or pressure antinodes) $= 0.30 / 2 = 0.15$ m No. of max M passes through in 1 s $= \frac{20}{0.15} = 133 = 130$ (2 sf) Hence frequency of the fluctuation of the sound is 130 Hz.	C1 wavelength C1 distance between max A1

9(d)(i)	This can be explained if the EM radiation is quantized, with each **photon** having **energy** equal to ***hf***, *h* being the plank's constant and *f* being the frequency of the EM radiation. Each electron absorbs energy from a **single** photon (*hf*). If the energy of photon is less than the work function of the metal ($hf<\Phi$), the electron will not be emitted, no matter how many photons there are or how long the electron is exposed to the EM radiation.	B1 B1 B1
9(d)(ii)(1)	Method 1 When $E_{max} = 0$, $\frac{hc}{\lambda_0} = \Phi$. Hence, $\Phi = \frac{hc}{\lambda_0} = \frac{6.63\times10^{-34}\times3\times10^{8}}{300\times10^{-9}} = 6.63\times10^{-19}\text{ J} = 4.14\text{ eV}$. Method 2 Using $E_{max} = \frac{hc}{\lambda} - \Phi$: As λ approaches infinity, E_{max} approaches Φ asymptotically. From Fig. 9.4, the (dotted) curve approaches –4 eV asymptotically. Hence, $\Phi \approx 4$ eV.	M1 A1
9(b)(ii)(2)	$f_0 = \frac{c}{\lambda_0} = \frac{3\times10^{8}}{300\times10^{-9}} = 1.0\times10^{15}\text{Hz}$	B1
9(b)(ii)(3)	According to Fig. 9.4, E_{max} = 20 eV when λ = 220 nm. Using $E_{max} = eV_s$, or $V_s = \frac{E_{max}}{e} = \frac{20\text{eV}}{e} = 20$ V	M1 A1
9(c)	The same curve shifted downward (smaller *x*-intercept). Part of curve below the axis has to be dotted, same as the original curve. Curve must be reasonably smooth, and must not intersect with the original curve and the y-axis. The part of the curve below the horizontal axis must be dashed.	M1 A1 –1 for each mistake