RIVER VALLEY HIGH SCHOOL
JC 2 PRELIMINARY EXAMINATIONS

H2 PHYSICS 9749 / 2
PAPER 2

18 SEPTEMBER 2025

2 HOURS

CANDIDATE NAME					
CENTRE NUMBER	S				
INDEX NUMBER					
CLASS	2	4	J		

INSTRUCTIONS TO CANDIDATES

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

Read these notes carefully.
Write your name, centre number, index number and class in the spaces at the top of this page and on all work you hand in.

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 staples, paper clips, glue or correction fluid.

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

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

*Answer **all** questions.*

The number of marks is given in brackets [ ] at the end of each question or part question.

FOR EXAMINERS' USE	
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This document consists of **23** printed pages and **1** blank page.

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on / by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -GM/r$
temperature	T / K = T / °C + 273.15
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.,	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.,	$v = v_0 \cos \omega t$ $= \pm \omega\sqrt{(x_0^2 - x^2)}$
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,	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

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

1 **(a)** The kinetic theory of gases is based on some simplifying assumptions. Molecules of the gas are assumed to behave as hard elastic identical spheres.

State the assumption about ideal gas molecules based on

(i) the nature of their movement,

…………………………………………………………………………………………

……………………………………………………………………………………… [1]

(ii) their volume.

…………………………………………………………………………………………

……………………………………………………………………………………… [1]

(b) The pressure of an ideal gas is given by

$$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$$

where N is the number of gas molecules
m is the mass of a gas molecule
V is the volume of the gas
$< c^2 >$ is the mean square speed of the molecules

(i) Explain the significance of the " $\frac{1}{3}$ " in the equation.

…………………………………………………………………………………………

……………………………………………………………………………………… [1]

(ii) Density of nitrogen gas is found to be 1.25 kg m^{-3} at 0 °C and 101 kPa.

Assuming nitrogen gas behaves like an ideal gas, determine its root-mean-square speed.

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

(iii) Use your answer in **(b)(ii)** to determine the root-mean-square speed of the nitrogen gas at 127 °C.

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

2 **(a)** Define simple harmonic motion.

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

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

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

(b) Calculate the gain in potential energy when a mass of 150 g is raised vertically through 1.0 mm.

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

(c) A simple pendulum consists of a light inextensible string and a bob of mass 150 g attached. The variation of the potential energy V_p with the horizontal displacement of the bob x is shown in Fig. 2.1.

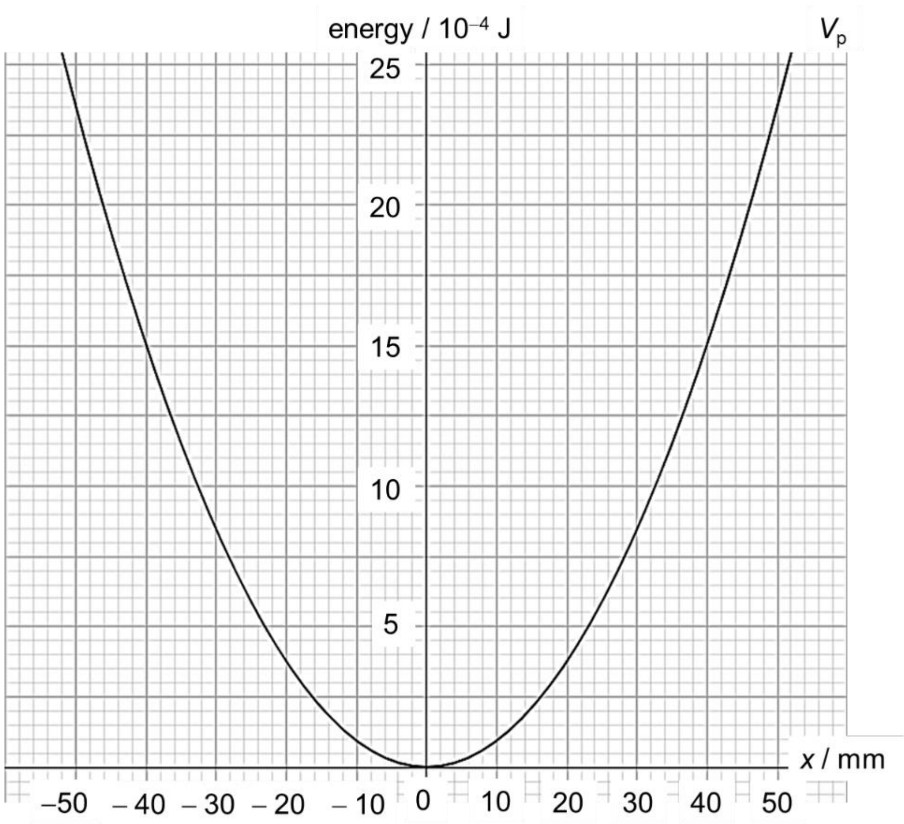

Fig. 2.1

To set the pendulum into oscillation, the bob is displaced sideways (keeping the string taut) until its centre of mass is raised vertically through 1.0 mm and then released. Using your answer in **(b)**, sketch labelled graphs on the axis of Fig. 2.1 to show the variation, as the pendulum oscillates ideally, of *x* with

(i) the total energy. Label it TE. [1]

(ii) the kinetic energy. Label it KE. [2]

(d) By reference to Fig. 2.1, or otherwise, write down the amplitude of oscillation of the pendulum.

amplitude of oscillation = ………………….. mm [1]

(e) The pendulum achieves velocity *v* in the horizontal direction during its oscillation. Using the axis of Fig. 2.2, sketch the variation as the pendulum oscillates, of *v* with *x*, as air resistance is no longer negligible, starting from initial release position until the pendulum comes to a rest, after 2 cycles.

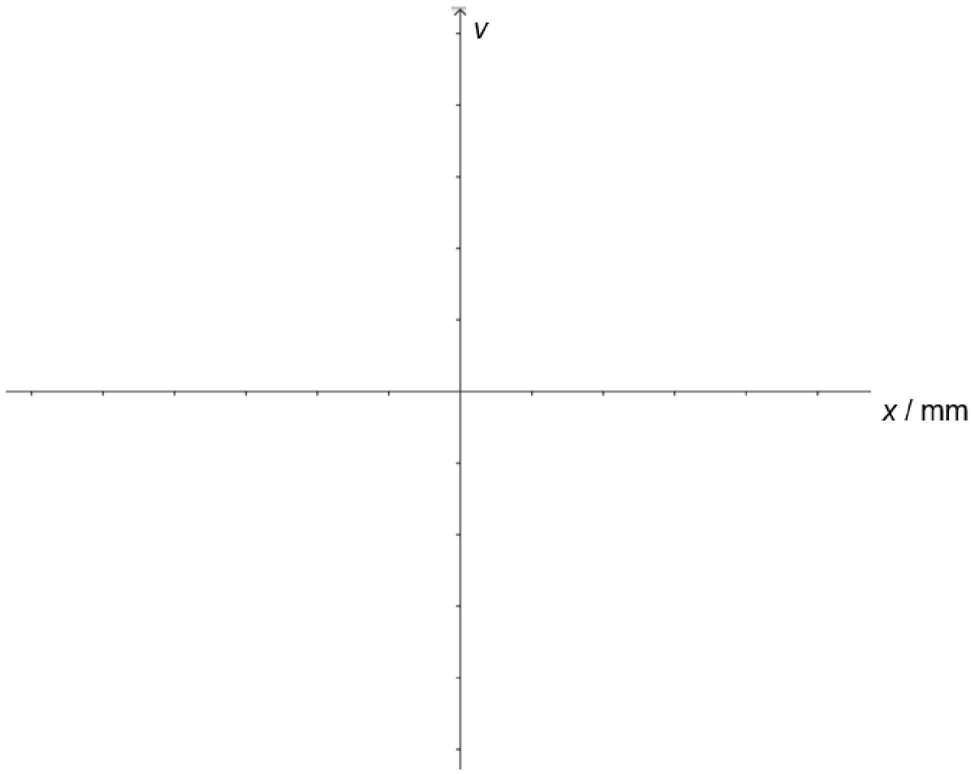

Fig. 2.2

[2]

3 Fig. 3.1 shows two coherent loudspeakers S_1 and S_2 placed 4.0 m apart in an open field. D is a detector placed in the same horizontal plane as the loudspeakers. D is placed 12.0 m away from S_2.

When the loudspeakers are switched on, sound of frequency 1780 Hz is emitted from the two loudspeakers in **antiphase**. The lines S_1S_2 and S_2D are perpendicular to each other.

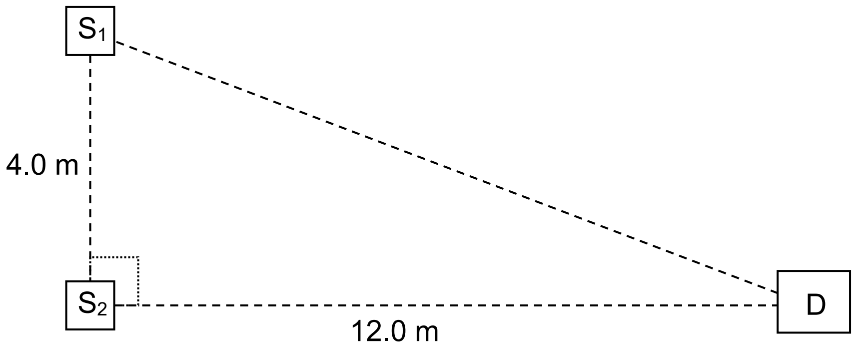

Fig. 3.1

(a) Given that the speed of sound in air is 330 m s^{-1}, calculate the wavelength λ of the sound emitted from S_1 and S_2.

λ = ………………….. m [1]

(b) Calculate the path difference, in terms of λ, between the sound waves reaching D from S_1 and S_2.

You may assume that the two loudspeakers and the detector are point objects.

path difference = ………………….. λ [2]

(c) By considering the phase difference between the sound waves reaching D from S_1 and S_2, explain whether D would detect a minimum or maximum intensity.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………… [2]

(d) As the frequency of the sound from S_1 and S_2 is gradually increased from 1780 Hz to a value f_1, the resultant intensity at D goes through a series of maxima and minima. It eventually detects 2 complete cycles of change in sound intensity.

Calculate the frequency f_1 at which the second complete cycle of change in sound intensity is detected.

f_1 = ………………….. Hz [3]

4 **(a)** State what is meant by *resistivity* of a material.

....

....

.... [1]

(b) A student attempts to measure the resistivity of soil using two parallel copper plates driven into the ground as shown in Fig. 4.1.

Each copper plate has a height of 1.040 m, a width of 0.210 m and a thickness of 0.050 m. The copper plates are driven to a depth of d = 0.800 m and separated by a distance x = 0.900 m.

When the switch is open, the student obtained a steady voltmeter reading of +0.281 V. When the switch is closed, the student obtained a voltmeter reading of +1.398 V and an ammeter reading of 0.31 mA.

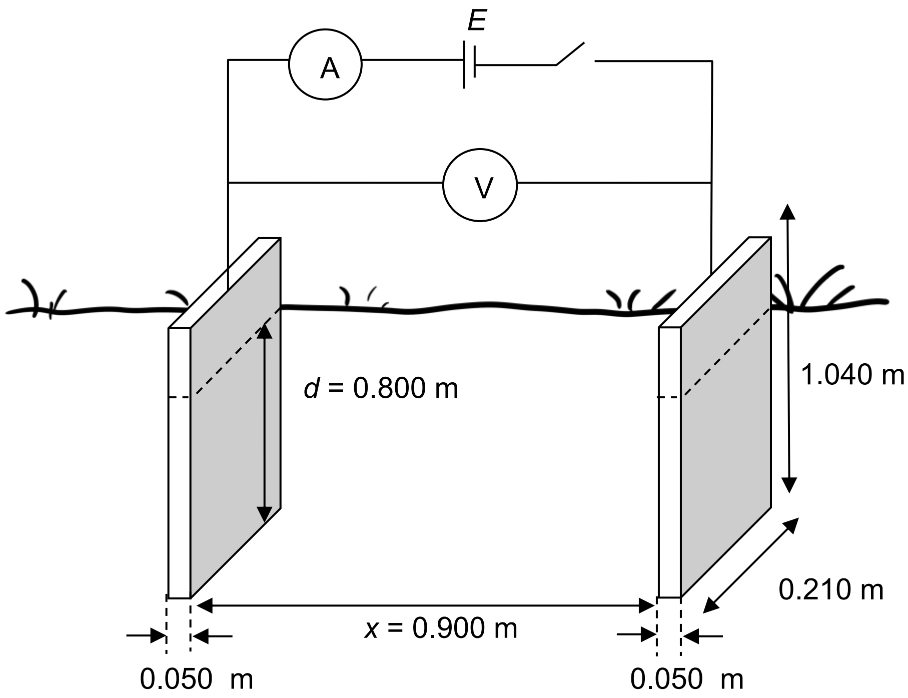

Fig. 4.1

(i) Show that the resistance of the soil between the copper electrodes is 3.6 kΩ.

[1]

(ii) Hence, find the resistivity of the soil.

resistivity = ………………….. Ω m [2]

(iii) A student suggested using a more precise ammeter to measure the current.

By using the same apparatus, suggest and explain another procedure how the value in **(b)(i)** could be determined to a higher significant figure.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

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

(c) A heating device is designed to operate on an a.c. power supply. The device has a resistance of 6.0 Ω.

(i) Calculate the average power dissipated in the device when operating at an a.c. supply of voltage 12.0 V, 50 Hz.

average power dissipated = ………………….. W [1]

(ii) On Fig. 4.2, draw a graph to show the variation with time *t* of the change in power *P* dissipated in the device for the a.c. supply in **(i)**. Mark values on both axes.

Fig. 4.2

[2]

(iii) The alternating supply of voltage 12.0 V, 50 Hz is derived from the mains supply of voltage 230 V, 50 Hz using a transformer, assuming 30% of the input energy is lost in the transformer.

Calculate the primary r.m.s. current when the heating device is in use.

primary r.m.s. current = ………………….. A [2]

(iv) State an advantage of using alternating current for the transmission of electrical energy.

……………………………………………………………………………………

……………………………………………………………………………… [1]

5 Two point charges of +2.4 μC and −2.9 μC are placed at points A and B respectively in a vacuum. The distance AB is 0.15 m as shown in Fig. 5.1.

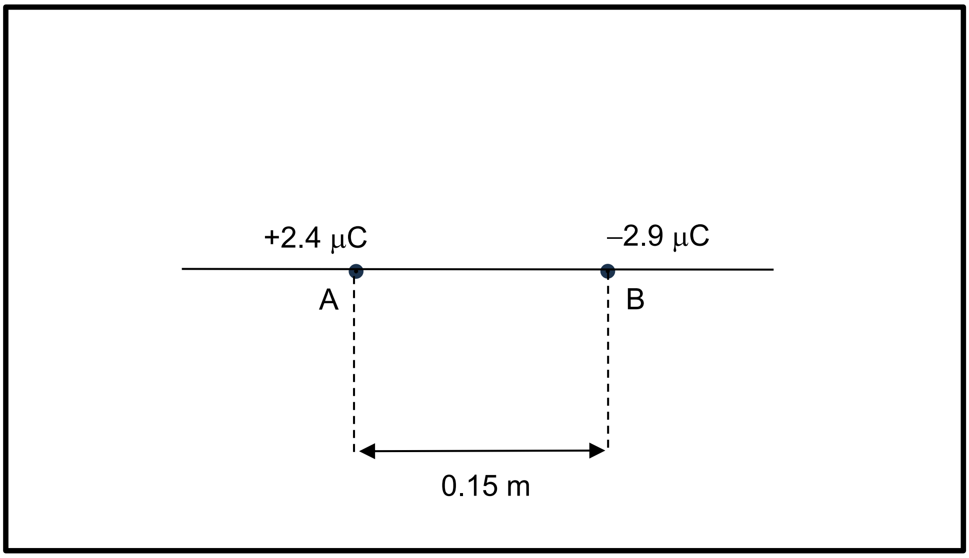

Fig. 5.1

It is required to find a point P at which the resultant electric field due to these two point charges is zero.

(a) By considering the electric field strength due to the point charges, explain why point P must lie along the straight line with points A and B on it.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

……………………………………………………………………………………… [2]

(b) Determine the position of point P from A. Show your working clearly.

distance from A = ………………….. m

direction from A = ………………………………………… [4]

(c) On Fig. 5.1, sketch the equipotential line of potential = 0 V. [2]

6 **(a)** Two long wires **X** and **Y**, separated by a distance r = 3.0 m, are at right angles to the plane of the paper. **X** has current I_1 = 5.0 A and **Y** has current I_2 = 7.0 A, both pointing out of the plane of the paper as shown in Fig. 6.1.

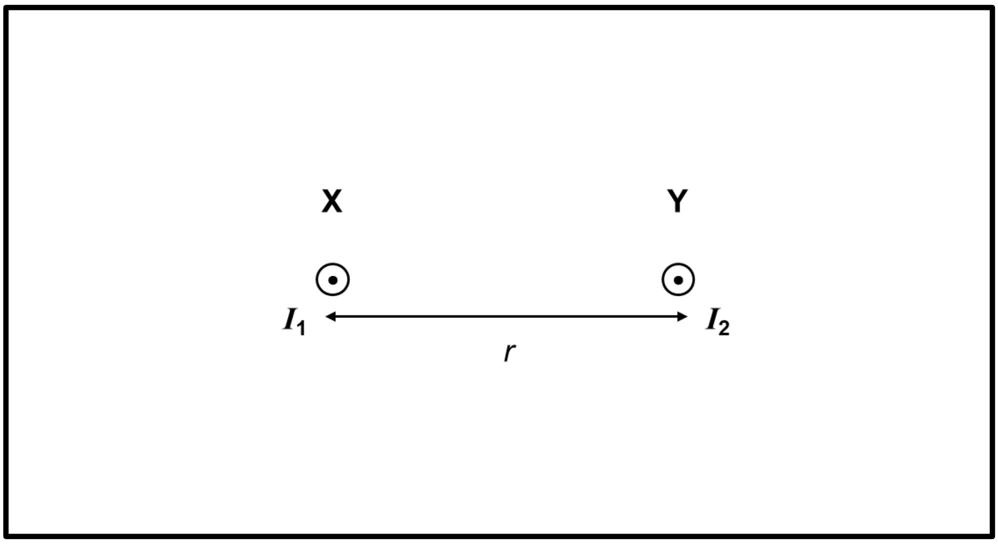

Fig. 6.1

(i) Show on Fig. 6.1 the direction of the magnetic field ***B*** which I_1 causes at **Y**. Label it ***B***. [1]

(ii) Show on Fig. 6.1 the direction of the force ***F*** which I_1 causes on wire **Y**. Label it ***F***. [1]

(iii) Determine the value of the force per unit length of wire which I_1 causes on wire **Y**.

force per unit length = ………………….. N m^{-1} [2]

(b) State Faraday's Law.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

Wires X and Y are now coiled into a solenoid, of 10-turns per cm, and search coil, respectively. The current-carrying solenoid is placed near to the search coil as shown in Fig. 6.2.

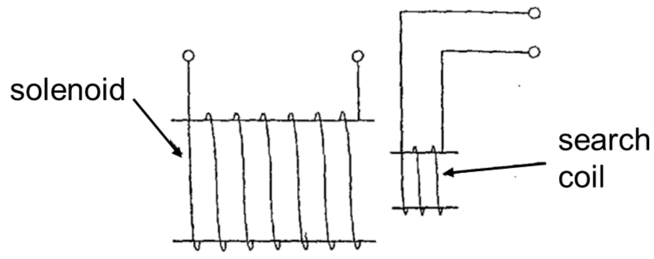

Fig. 6.2

The variation with time t of the current I in the solenoid is shown in Fig. 6.3.

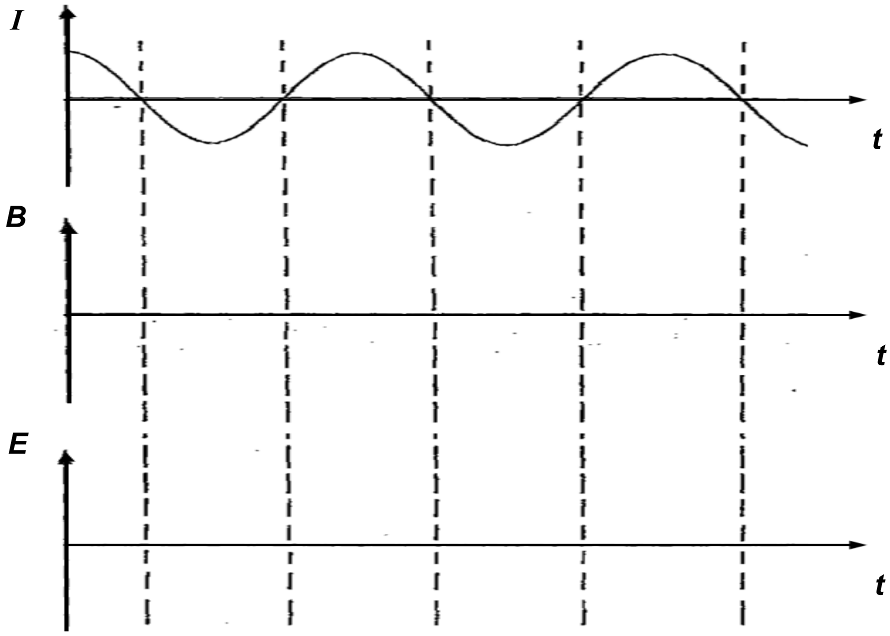

Fig. 6.3

(i) Sketch on Fig. 6.3 the variation with t of the magnetic flux density B in the solenoid. [1]

(ii) Sketch on Fig. 6.3 the variation with t of the e.m.f. E induced in the search coil. [1]

(iii) Calculate the current flowing in the solenoid to generate a maximum magnetic flux density B of 1.0 mT.

current = ………………….. mA [2]

7 **(a)** State what is a *photon*.

……………………………………………………………………………………………

……………………………………………………………………………………… [1]

(b) Two metal electrodes A and B are sealed into an evacuated glass envelope and a potential difference *V*, measured using the voltmeter, is applied between them as shown in Fig. 7.1.

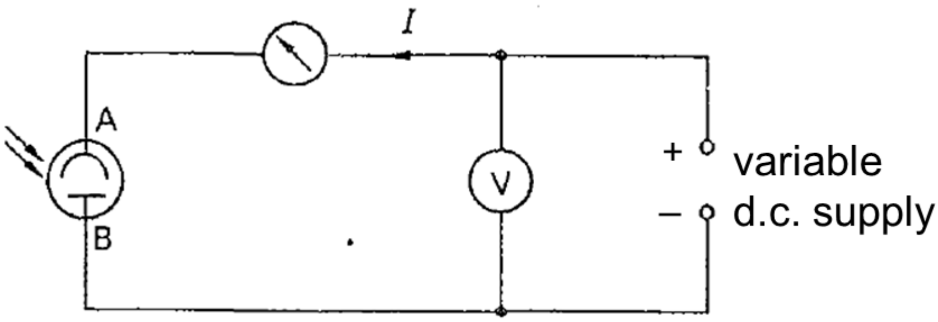

Fig. 7.1

B is then illuminated with monochromatic light of wavelength 365 nm and *I*, the photocurrent in the circuit, is measured for various values of *V*. The results are shown in Fig. 7.2.

(i) Using Fig. 7.2, determine the change in electric potential energy required to reduce the photocurrent to zero.

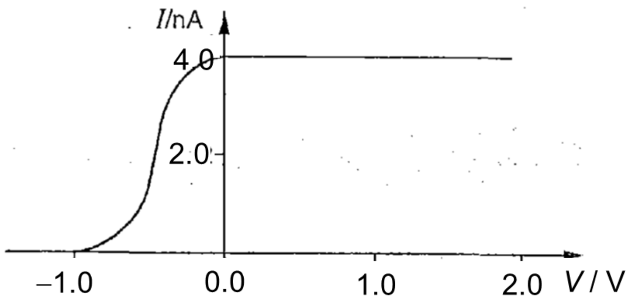

Fig. 7.2

change in electric potential energy = ………………….. J [1]

(ii) Calculate the maximum speed of the photoelectrons.

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

(iii) Hence determine the work function energy of B.

work function = ………………….. eV [2]

8 One possible reaction taking place in the core of a reactor is

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{95}_{42}Mo + ^{139}_{57}La + 2^{1}_{0}n + 7^{0}_{-1}e$$

	mass
$^{235}_{92}U$	235.123 u
$^{95}_{42}Mo$	94.945 u
$^{139}_{57}La$	138.955 u
proton	1.007 u
neutron	1.009 u

(a) Explain why large nuclei such as uranium-235 are used in nuclear fission reactor in a power plant.

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

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

Ignore the mass of electron. Using the data above,

(b) show that the energy released per fission of uranium is 200 MeV,

[3]

(c) calculate the energy available from the complete fission of 1.00 g of uranium-235, and

energy = ………………….. J [2]

(d) the mass of uranium-235 used by a 500 MW nuclear power station in one hour, assuming 30% efficiency.

mass = ………………….. g [2]

9 Passenger loading of a European Airbus Aeroplane

Fig. 9.1 shows data concerning a European Airbus aeroplane to answer the following questions.

Mass of aeroplane, including crew and all equipment	42 000 kg
Maximum number of passengers	150
Average mass of a passenger and baggage	100 kg
Capacity of fuel tanks	18 000 kg
Average fuel consumption	5.0 kg km^{-1}
Safety reserve of fuel at end of journey	3 000 kg
Take-off speed	75 m s^{-1}
Length of runway used	1 500 m

Fig. 9.1

Average fuel consumption is a measure of how much the plane uses to travel a certain distance. This is typically expressed as mass of fuel per unit distance travelled. The capacity of fuel carried at the start of a plane journey includes the safety reserve fuel. The safety reserve fuel is the extra fuel carried beyond what is needed for the planned flight. It should not be used unless during unexpected situations such as delays, diversions or changes in flight conditions.

(a) For a plane carrying maximum capacity of fuel, calculate the maximum safe distance travelled of the aeroplane.

distance travelled = ………………….. km [1]

(b) Calculate how much further could the aeroplane travel, if at the end of its scheduled flight in **(a)**, the airport it intended to land at was closed due to poor weather conditions.

distance travelled = ………………….. km [1]

(c) Determine the maximum total mass of the aeroplane, passengers and fuel at the start of a flight.

total mass = ………………….. kg [1]

(d) Fig. 9.2 shows the variation with time of the lift force on the aeroplane during taking off.

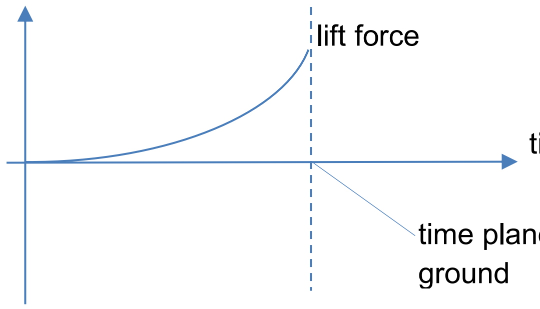

Fig. 9.2

On Fig. 9.2 sketch the variation with time,

(i) the weight of the plane, label the graph **W**, and [1]

(ii) the normal contact force by the ground on the plane, label the graph **N**. [1]

(e) Determine the horizontal acceleration of the aeroplane while it is on the runway when it is taking off.

Assume that the acceleration of the aeroplane is constant.

acceleration = ………………….. m s^{-2} [2]

(f) Hence determine the force required to cause the acceleration.

force = ………………….. N [1]

(g) Sometimes aeroplanes find it necessary to take off from shorter than normal runways.

They then have to reduce the number of passengers they carry or the amount of fuel carried. But they are not allowed to reduce their safety margin of reserve fuel.

(i) Assume that your answer in **(f)** remains constant, show that the total mass that can be accelerated to the take-off speed in a distance of 1200 m is 60 000 kg.

mass = ………………….. kg [1]

(ii) Complete Fig. 9.3 showing the maximum safe distance the aeroplane can travel when carrying different number of passengers.

Length of take-off / m	1500	1200	1200	1200
Number of passengers	150	130	110	90
Mass of aeroplane / kg	42 000			
Mass of passengers / kg	15 000	13 000	11 000	9 000
Total mass of fuel /kg	18 000			
Total mass / kg		60 000	60 000	60 000
Mass of fuel in reserve / kg	3 000			
Usable mass of fuel / kg	15 000			
Maximum safe distance / km				

Fig. 9.3 Data for Airbus with different operating conditions

[2]

(h) For most commercial aeroplane, the *maximum landing weight* is lower than the *maximum take-off weight*.

Hence if an aeroplane needs to return for an emergency landing shortly after take-off, it may need to dump fuel before landing.

Suggest a reason why the maximum landing weight of an aircraft is lower than its maximum take-off weight.

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

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

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

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