RIVER VALLEY HIGH SCHOOL
JC 2 PRELIMINARY EXAMINATIONS

H2 PHYSICS 9749 / 3
PAPER 3

19 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.
Candidates answer on the Question Paper.

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.

Section A
Answer all questions.

Section B
Answer **one** question only.

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

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

FOR EXAMINERS' USE	
Section A – do all questions	
1	**/ 6**
2	**/ 6**
3	**/ 7**
4	**/ 6**
5	**/ 6**
6	**/ 7**
7	**/ 14**
8	**/ 8**
Section B – do ONE question only	
9	**/ 20**
10	**/ 20**
Deduction	
TOTAL	**/ 80**

PAPER	1	2	3	4	TOTAL
SCORE	/30	/80	/80	/55	/245

This document consists of 27 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	$p = \rho g h$
gravitational potential	$\phi = -GM/r$
temperature	T / K = T / °C + 273.15
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.,	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.,	$v = v_0 \cos \omega t$ $= \pm\omega\sqrt{(x_0^2 - x^2)}$
electric current,	$I = Anvq$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire,	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil,	$B = \frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid,	$B = \mu_0 n I$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

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

1 **(a)** Distinguish between a *systematic* and a *random* error in the measurement of a physical quantity.

....

....

....

.... [2]

(b) A travelling microscope fitted with a vernier scale is used to measure the internal diameter of a capillary tube. Fig. 1a and Fig. 1b show the vernier when the microscope is adjusted so that the cross-wires are aligned at opposite ends of a diameter.

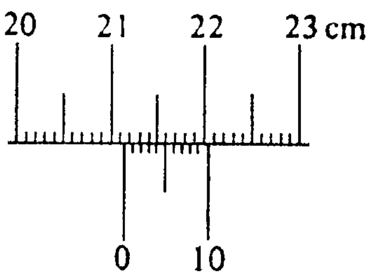

Fig. 1a

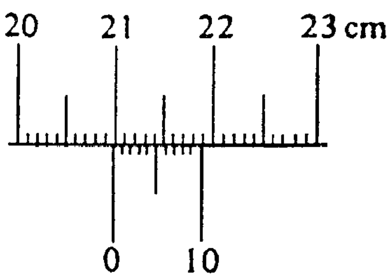

Fig. 1b

(i) Write down the two vernier readings.

Fig. 1a = ... cm

Fig. 1b = ... cm [1]

(ii) State the absolute uncertainty in a single reading of the vernier.

absolute uncertainty = ... cm [1]

(iii) Hence determine the percentage uncertainty in the cross-sectional area of the capillary tube that could arise if it were calculated using these two readings.

percentage uncertainty = ... % [2]

2 A small ball of mass 34 g is thrown horizontally with a speed of 4.0 m s^{-1}. It falls through a vertical height of 1.96 m before bouncing off a smooth horizontal plate as shown in Fig. 2.1.

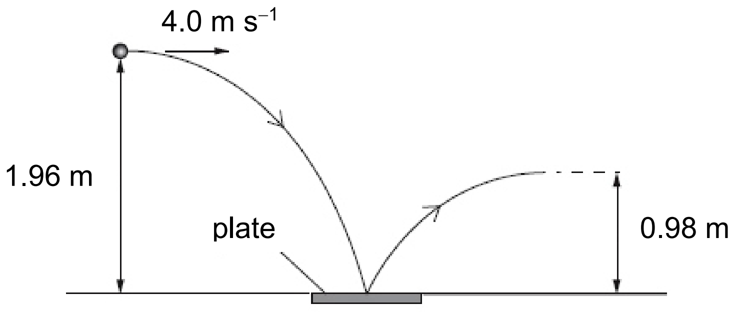

Fig. 2.1

Air resistance is negligible.

(a) Calculate the vertical component of the velocity of the ball when it hits the plate.

vertical component of the velocity = ……………… m s^{-1} [2]

(b) State and explain the change, if any, in the horizontal component of the velocity of the ball before and after the collision with the plate.

……………………………………………………………………………………….

……………………………………………………………………………………….

……………………………………………………………………………………….

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

(c) Determine the impulse of the ball during the collision.

impulse = ……………… N s [2]

3 **(a)** Define *moment of a force*.

……………………………………………………………………………………………..

…………………………………………………………………………………… [1]

(b) A person supports a load of 20 N in his hand as shown in Fig. 3.1. The system of the hand and load is represented by Fig. 3.2. The rod represents the forearm and T represents the tension exerted in the biceps. The forearm weighs 65 N.

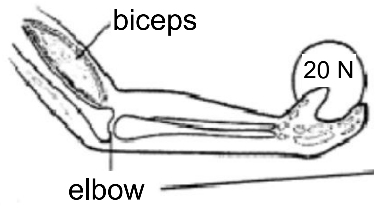

Fig. 3.1

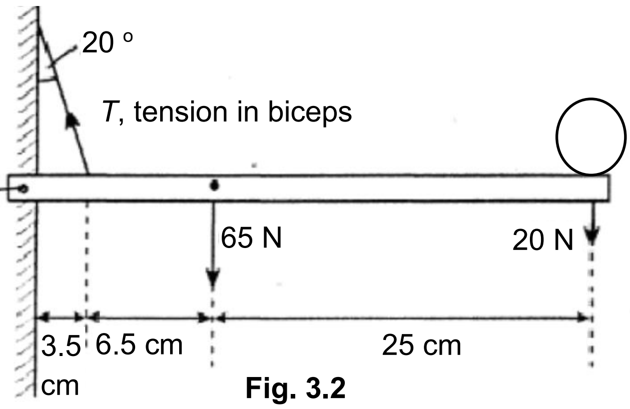

Fig. 3.2

Given that T = 410 N, determine the magnitude and direction of the force acting at the elbow.

force acting at the elbow = ………………….. N

direction of the force = …………………………………………… [4]

(c) In order to break a stack of wooden boards, a karate expert has to move his arm and hand swiftly against it with considerable speed as shown in Fig. 3.3.

Fig. 3.3

Using Newton's laws of motion, explain why he has to execute the karate strike very quickly.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

……………………………………………………………………………………… [2]

4 **(a)** A small metal sphere of mass m is moving vertically downwards through a viscous liquid.

When it reaches a constant downward velocity v, the kinetic energy achieved is given by ½ mv^2.

Explain why the kinetic energy reached a constant value.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

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

(b) Consider a constant horizontal applied force F acting on an object of mass m travelling with initial velocity u, achieving a final velocity of v, over a displacement of s as shown in Fig. 4.1.

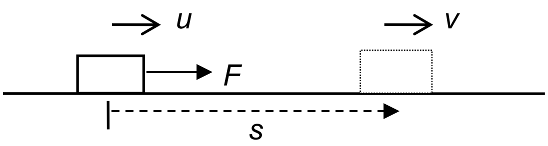

Fig. 4.1

By considering Newton's Laws and equations of motion, derive an expression for the kinetic energy ½ mv^2.

State an assumption necessary for the derivation.

……………………………………………………………………………………………..

…………………………………………………………………………………………… [4]

5 **(a)** Explain what is meant by *angular velocity*. State its SI unit.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

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

(b) A particle is suspended from a point A by an inextensible string of length L. It is projected from B with a velocity V, perpendicular to AB, which is just sufficient for it to reach point C, as shown in Fig. 5.1.

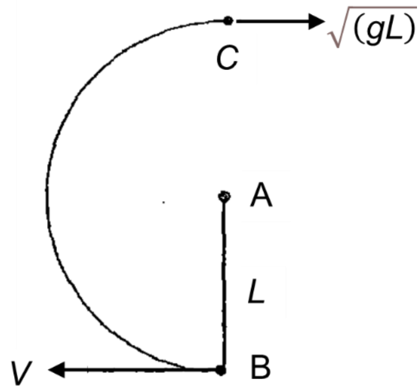

Fig. 5.1

(i) Show that, if the string is just taut when the particle reaches C, its speed at C is $\sqrt{(gL)}$.

[2]

(ii) Determine V if L is 1.0 m.

V = …………………….. m s^{-1} [2]

6 **(a)** Fig. 6.1 shows a uniform wire XY of length 150.0 cm and resistance 4.5 Ω connected in series with a cell Z of electromotive force (e.m.f.) 3.0 V with internal resistance 0.50 Ω.

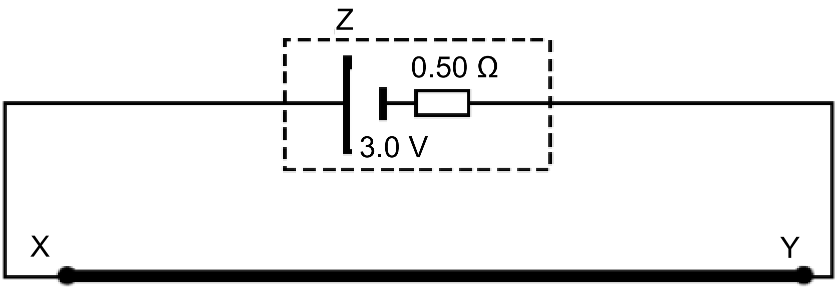

Fig. 6.1

(i) State what is meant by *electromotive force* of a cell.

....

.... [1]

(ii) Show that the potential difference between X and Y is 2.7 V.

[1]

(b) Another circuit consisting of a cell W in series with 1.0 Ω and 2.0 Ω resistors is connected to positions X and P which are 80.0 cm apart as shown in Fig. 6.2.

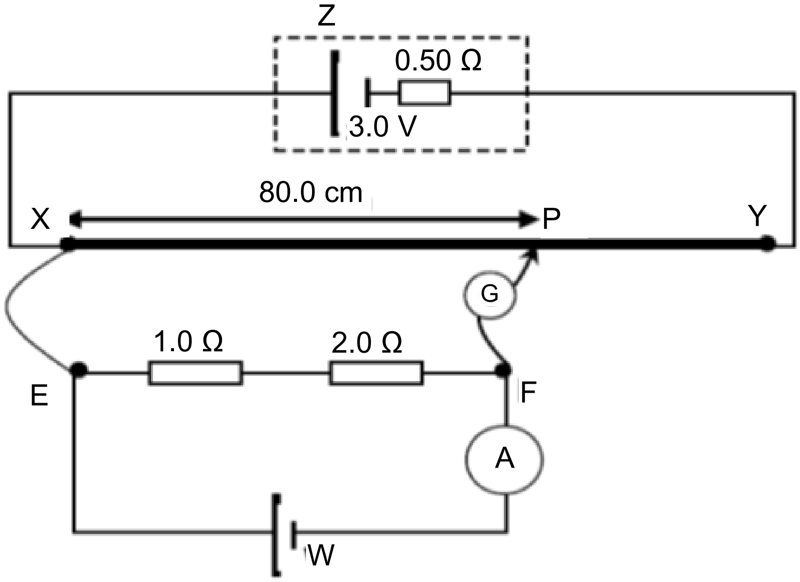

Fig. 6.2 (not drawn to scale)

If the galvanometer shows null deflection, determine the current reading shown on the ammeter.

current reading = ………………….. A [2]

(c) Wire XY is replaced with another wire of the same material and length but with a smaller cross-sectional area.

(i) State and explain the changes, if any, in the balance length.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………… [2]

(ii) Hence with reference to potential difference, explain the changes, if any, of the final ammeter reading at balance.

……………………………………………………………………………………

…………………………………………………………………………… [1]

7 A simplified representation of the 5 lowest energy levels of the outermost electron in the sodium atom is shown in Fig. 7.1.

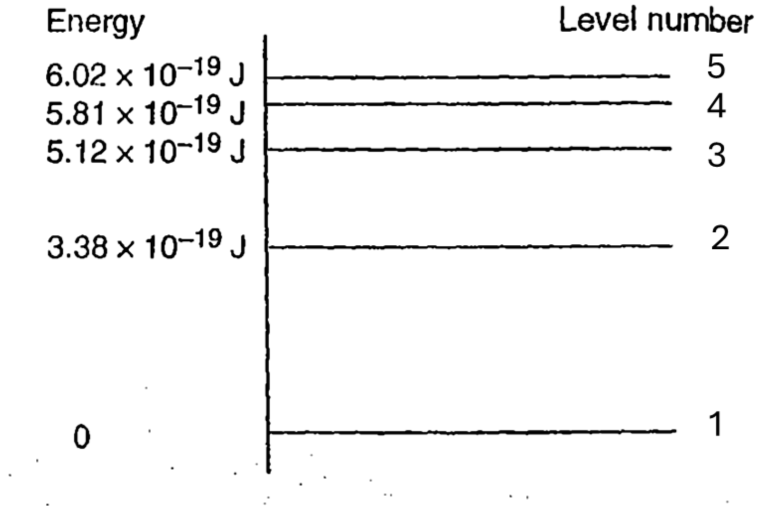

Fig. 7.1

(a) Considering transitions between only these levels,

(i) state the spectral emission transition that has the longest wavelength (give your answers in terms of level numbers),

level ………………….. to ………………….. [1]

(ii) state the number of emission lines that might be produced by transitions among these levels.

number of spectral emission lines ………………….. [1]

(iii) Cool sodium vapour at low pressure is bombarded with electrons of kinetic energy E.

Determine the number of emission transitions observed if E has the value 3.6 eV. Show your reasoning clearly.

number of observed transitions ………………… [3]

(b) State the number of absorption lines that might be visible to the human eye, if the sodium atoms are initially at Level 1. Show your working clearly.

number of visible absorption lines ………………….. [2]

When electrons bombard heavier metals, the range of spectral lines detected could be very different. Fig. 7.2 shows a spectral graph of relative intensity against frequency of x-ray detected, conducted using two different accelerating voltages, V_1 and V_2 (not labelled).

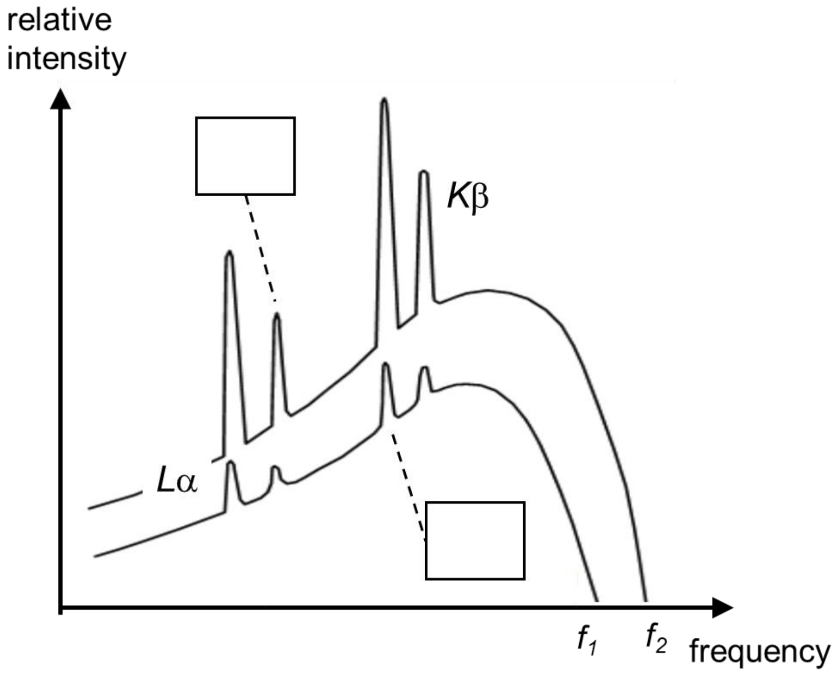

Fig. 7.2

(c) Fill in the boxes in Fig. 7.2 with appropriate notations for the characteristic lines. [1]

(d) Explain briefly for the observation of characteristic peak K_β in Fig. 7.2.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

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

(e) Explain briefly for the observation of two distinct continuous spectra in Fig. 7.2, when experiments using two different accelerating voltages, V_1 and V_2 are conducted, where V_2 is larger than V_1.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

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

(f) Explain briefly for the observation of characteristic peaks at the same frequency regardless of the voltages.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

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

8 Stable isotope of gold has an atomic number of 79 and a mass number of 197. A sample of pure gold is irradiated with neutrons to produce a small proportion of the radioactive isotope of gold of mass number 198.

(a) If chemical analysis of the sample subsequently showed that it contained a trace of mercury of atomic number 80, state and explain what you would conclude from this analysis about the radiation of the radioactive gold.

....

....

....

.... [2]

(b) **(i)** The half-life of the radioactive isotope of gold is 2.69 days.

With reference to your answer in **(a)** or otherwise, suggest a possible use for radioactive gold. Explain your answer.

....

....

....

.... [2]

(ii) A sample of Gold-198 has an activity of 64 kBq when it was initially measured.

1. Calculate the mass of radioactive isotope of Gold-198 present in the sample.

mass = ……………… g [2]

2. Calculate the activity after 13.5 days.

activity = ……………… kBq [2]

Section B

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

9 **(a)** Sample of material A and sample of material B are at different initial temperatures when they are placed in a thermally insulated container and allowed to come to *thermal equilibrium*.

Fig. 9.1 gives the graph of variation with time t of their temperature θ. Sample A has a mass of 5.0 kg; sample B has a mass of 1.5 kg.

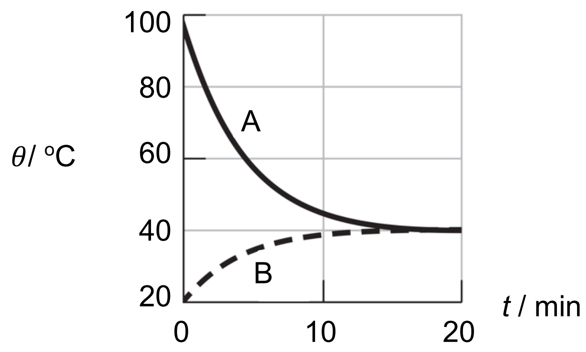

Fig. 9.1

Fig. 9.2 is a plot for material B. It shows the temperature change $\Delta\theta$ that the material undergoes when thermal energy Q is transferred to it. The change in temperature $\Delta\theta$ is plotted against the thermal energy Q per unit mass of the material.

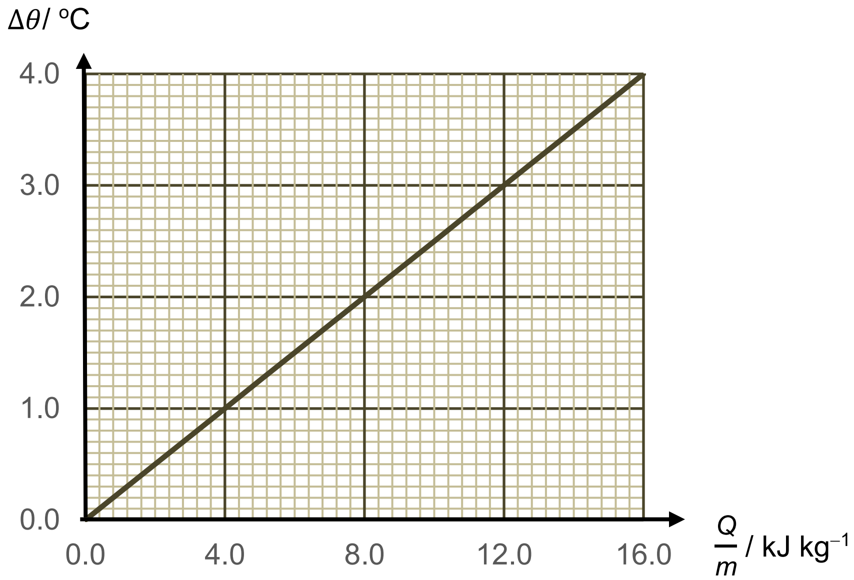

Fig. 9.2

(i) Explain what is meant by sample A and sample B in thermal equilibrium and thus comment about their temperature.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………… [2]

(ii) Use Fig. 9.2 to find specific heat capacity of material B.

specific heat capacity =………………………… J kg^{-1} K^{-1} [2]

(iii) Use your answer in **(a)(ii)** and **Fig. 9.1** to find the specific heat capacity of material A.

specific heat capacity = ………………………… J kg^{-1} K^{-1} [2]

(iv) Sketch on Fig. 9.2 the change in temperature $\Delta\theta$ versus the thermal energy Q per unit mass for material A. [1]

(b) Fig. 9.3 shows a cylinder containing ideal gas and closed by a movable piston. The cylinder is kept submerged in an ice-water mixture.

process 1: The piston is quickly pushed down from position 1 to position 2. The process occurs so fast that there is not enough time for heat to be transferred.

process 2: The piston is held at position 2 until the gas is again at the temperature of the ice-water mixture.

process 3: The piston then is slowly raised back to position 1.

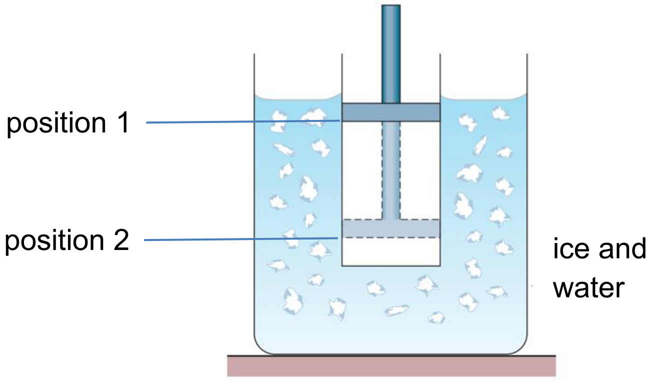

Fig. 9.3

Fig. 9.4 is a pressure-volume diagram for the processes.

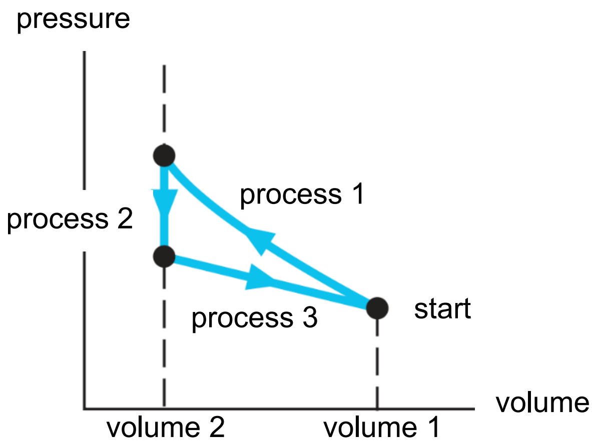

Fig. 9.4

(i) The equation below describes first law of thermodynamics

$$\Delta u = q + w$$

Explain what each term means.

Δu : ………………………………………….

q : ……………………………………………

w : ……………………………………………

[2]

(ii) For process 1, fill in 'positive' or 'negative' or 'zero' for each term in Fig. 9.5.

[1]

	Δu	q	w
process 1			
process 2			
process 3			

Fig. 9.5

(iii) For process 2, fill in 'positive' or 'negative' or 'zero' for each term in Fig. 9.5. Explain your answer.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………… [3]

(iv) For process 3, fill in 'positive' or 'negative' or 'zero' for each term in Fig. 9.5. Explain your answer.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………… [2]

(v) If 100 g of ice is melted during the cycle, determine the work done on the gas?

Specific latent heat of fusion of water = 334 J g^{-1}

work done = ………………………… J [2]

(c) **(i)** A student uses a constant-volume gas thermometer to measure the pressure of a gas at different temperatures on a Celsius scale. The results are shown in Fig. 9.6.

Temperature / °C	Pressure / kPa
0	100
100	137

Fig. 9.6

Assuming that pressure is proportional to absolute temperature, estimate the temperature in °C at which the pressure of the gas would become zero.

temperature = ………………. °C [2]

(ii) Experiments were carried out with different gases at different initial pressures. Fig. 9.7 shows that the thermometer readings tend to the same point nearly independent of the type of gas at low pressure.

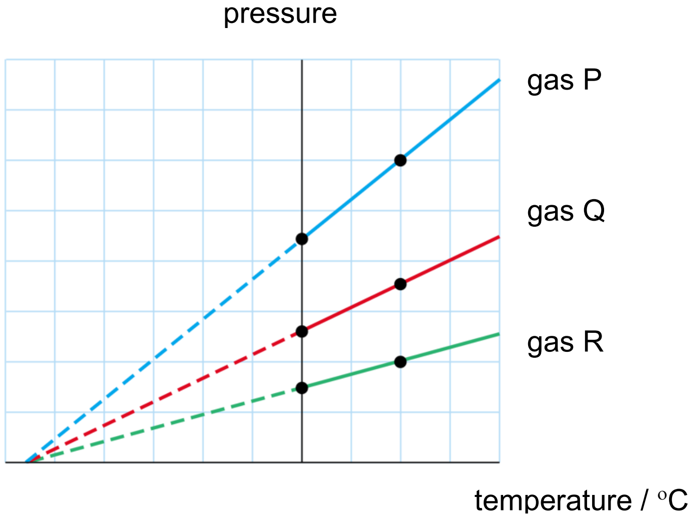

Fig. 9.7

Suggest a reason why different gases may agree only at low pressure.

....

....

....

.... [1]

10 (a) Sound is propagated in a medium as a longitudinal progressive wave, in which there is a repeated sequence of displacements of the medium particles.

(i) Explain what is meant by a *longitudinal progressive* wave.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………… [2]

(ii) A loudspeaker emits 20 W of sound waves uniformly in all directions.

Calculate the intensity of the sound wave at 5.0 m from the loudspeaker.

intensity = ………………….. W m^{-2} [2]

(iii) Directional loudspeakers are speakers that project sound in a specific direction.

Suggest why directional loudspeakers are preferred in large outdoor concerts, considering the audience and nearby residential areas.

…………………………………………………………………………………………

……………………………………………………………………………………… [1]

(b) Fig. 10.1 shows two small loudspeakers L_1 and L_2 separated by 15 cm. A sound sensor M is moved along a line XY parallel to the line joining the two loudspeakers and at a perpendicular distance 20 m away.

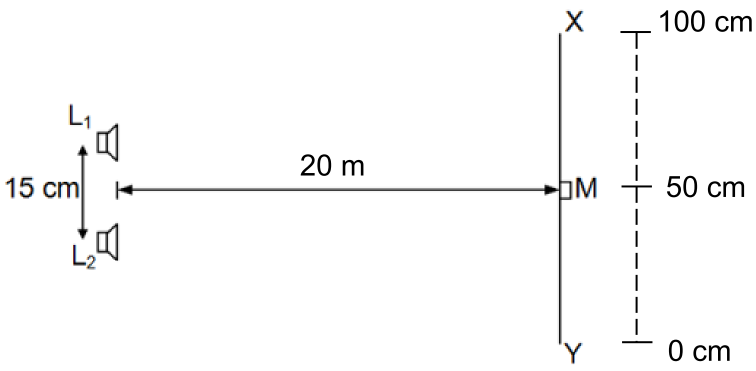

Fig. 10.1

The sound intensity detected by the sound sensor varies as shown in Fig. 10.2.

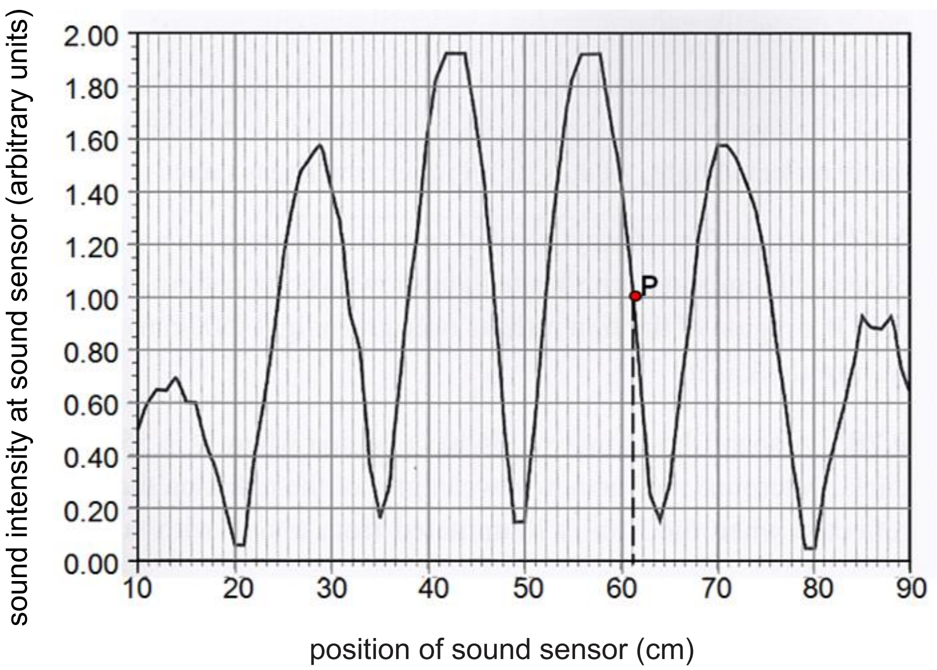

Fig. 10.2

(i) Explain how it can be deduced that the loudspeakers are coherent sources of waves.

....

.... [1]

(ii) By considering the phase difference of the waves from both speakers, explain how the central minimum in the pattern is formed.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………… [2]

(iii) Calculate the approximate frequency at which the speakers were driven. Assume the speed of sound as 343 m s^{-1}.

approximate frequency = ………………….. Hz [3]

(iv) Estimate the phase angle between the waves from the loudspeakers when the waves meet to produce the intensity at point P on the pattern of Fig. 10.2.

phase angle = ………………….. rad [2]

(v) Suggest a reason why the maxima on Fig. 10.2 are not all of the same intensity.

…………………………………………………………………………………………

……………………………………………………………………………… [1]

(c) Fig. 10.3 shows a narrow beam of coherent light of wavelength 589 nm falling normally on a diffraction grating having 500 lines per millimetre. The diffraction grating is situated at the centre of a circular scale.

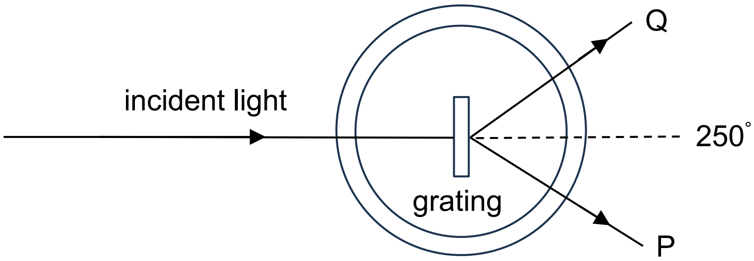

Fig. 10.3

The straight through direction is at the reading of 250° on the scale. A detector is placed at P, where the reading on the scale is 210°. The detector is then moved towards Q, where the reading on the scale is 290°.

(i) Determine the number of maxima detected as the detector moves from P to Q.

number of maxima detected = …………………... [2]

(ii) State how the angular separation between two maxima of the same order can be increased.

……………………………………………………………………………………………

…………………………………………………………………………………… [1]

(iii) State how the position of the central maximum will change if the light beam does not fall normally on the diffraction grating as shown in Fig. 10.4.

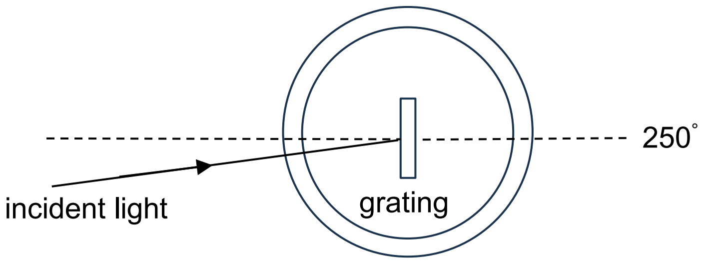

Fig. 10.4

……………………..……………………………………………………………

……………………..…………………………………………………… [1]

(iv) The light source used in the setup in Fig. 10.3 is replaced with an incident light of unknown wavelength.

Suggest one advantage and one disadvantage of obtaining the wavelength by using observations of the second-order diffracted light rather than the first-order diffracted light.

……………………..……………………………………………………………

……………………..……………………………………………………………

……………………..……………………………………………………………

……………………..…………………………………………………… [2]

End of Paper

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