EXP	PUNGGOL SECONDARY SCHOOL SECONDARY 4 EXPRESS 2024 PRELIMINARY EXAMINATION **QUESTION BOOKLET**	

NAME

CLASS

INDEX NUMBER

Physics **6091/02**

Paper 2

22 August 2024

1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your class, register number and name on all the work you hand in.
You may use a soft pencil for any diagrams, graphs, tables or rough working.
Write in dark blue or black pen.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Section A
Answer all questions.
Write your answers in the spaces provided on the question paper.

Section B
Answer **one** question.
Write your answers in the spaces provided on the question paper.

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

For Examiner's use	
Section A	/70
Section B	/10
Total	/80

Parent's Signature

This paper consists of **22** printed pages and **0** blank page.

Section A

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

1 Fig. 2.1 shows how the velocity of a vehicle changes with time.

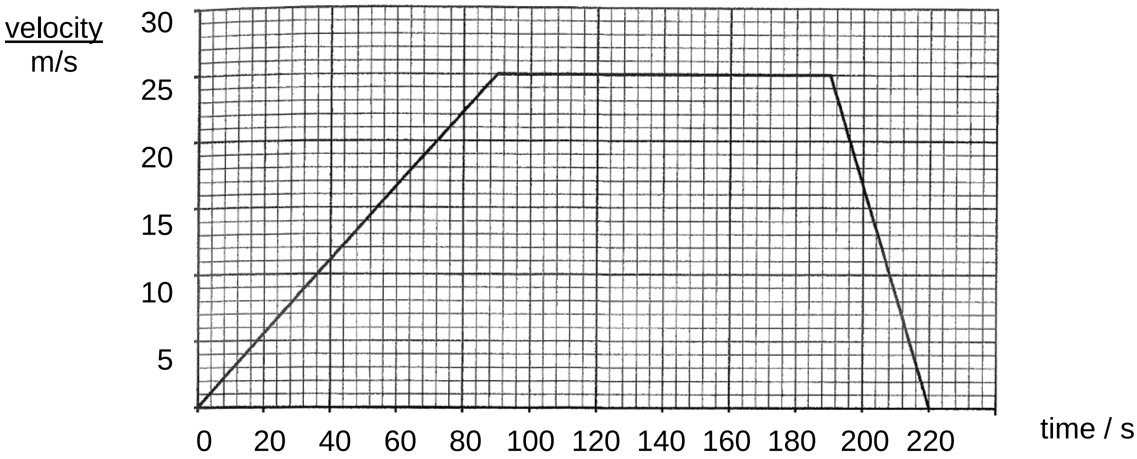

Fig. 1.1

(a) Describe how the displacement of the vehicle changes from t = 0 s to t = 80 s.

……………………………..…………………………………………………...

……………………………..…………………………………………………...

……………………………..…………………………………………………...

…………………………………………………………………………… [2]

(b) Calculate the average velocity for the whole journey.

average velocity = …………………..… [3]

(c) Calculate the deceleration of the vehicle at t = 204 s.

deceleration = ……………………… [2]

[total: 7]

2 Fig. 2.1 shows an aircraft dropping a crate of supplies to a region that is difficult to reach by land vehicles.

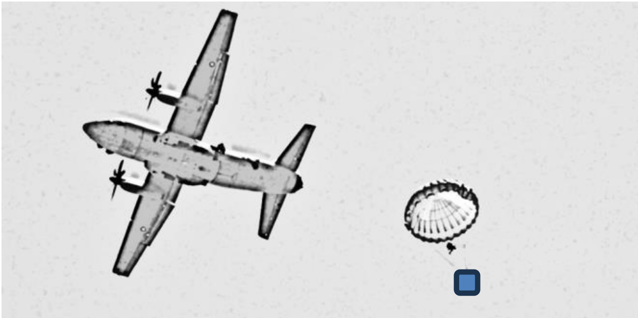

Fig. 2.1

At a certain instant in the crate's descent, it experiences a total resistive force of 1200 N. The total weight of the crate and its contents, including the parachute, is 2500 N.

(a) Draw and label the forces acting on the crate shown in Fig. 2.1 at this instant. [1]

crate

(b) Calculate the total mass of the crate and its contents.

The gravitational field strength is 10 N / kg.

mass = ………………….. [1]

(c) Calculate the acceleration of the crate at the instant shown in Fig. 2.1.

acceleration = ……………………… [3]

(d) Suggest one factor that could affect the air resistance acting on the crate.

……………………………………………………………………………... [1]

(e) As the crate continues descending, it eventually attains terminal velocity.

Explain why the crate attains terminal velocity in terms of forces.

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…………………………………………………………………………………...

…………………………………………………………………………………...

…………………………………………………………………………………...

……………………………………………………………………………………

……………………………………………………………………………... [2]

[total: 8]

3 A heater is placed at the bottom of a liquid. The liquid is heated until it becomes a gas. Fig. 3.1 shows the variation with time of the temperature of the substance.

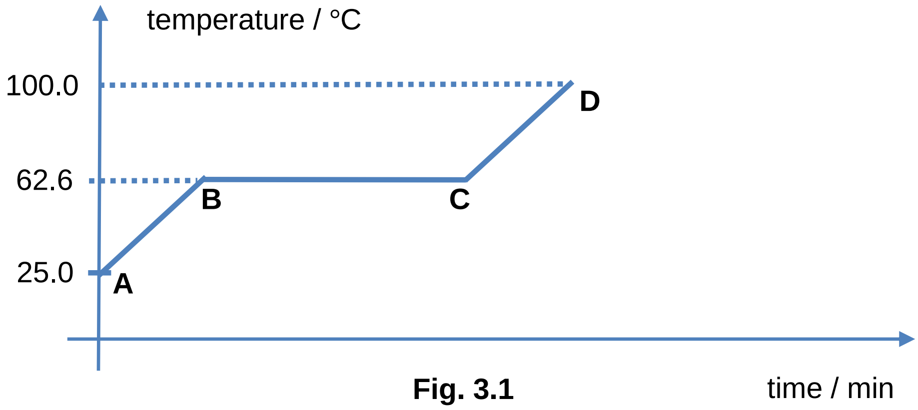

Fig. 3.1

The heater used to heat up the substance transfers energy to the substance at a steady rate.

(a) Describe how the heat is transferred efficiently throughout the liquid.

………………………………………………………………………………...

………………………………………………………………………………...

………………………………………………………………………………...

………………………………………………………………………………...

……………………………………………………………………………… [2]

(b) Explain, in terms of energy stores, why the temperature of the substance rises from **A** to **B** while the temperature remains constant from **B** to **C,** when the heater is operating normally.

………………………………………………………………………………...

………………………………………………………………………………...

………………………………………………………………………………...

………………………………………………………………………………...

……………………………………………………………………………… [2]

(c) The experiment is repeated using twice the volume of the liquid while keeping all other variables constant.

Sketch on Fig. 3.1 to show the new variation of temperature with time.

[1]

(d) Describe the changes to the arrangement of the particles from **B** to **C** using the kinetic particle model of matter.

…………………………………………………………………………………...

…………………………………………………………………………………...

……………………………………………………………………………….. [1]

[total: 6]

4 Smoke particles are observed under a microscope. The particles are observed to move about randomly.

(a) Explain why the smoke particles appear to move about randomly.

…………………………………………………………………………………...

…………………………………………………………………………………...

…………………………………………………………………………………...

……………………………………………………………………………….. [2]

(b) The lamp of the microscope heats up the sample of smoke particles being observed.

(i) Predict how the motion of the smoke particles would be different.

……………………………………………………………………………….

……………………………………………………………………………… [1]

(ii) Explain your answer to **(b)(i)**.

……………………………………………………………………………….

……………………………………………………………………………… [1]

[total: 4]

5 Fig. 5.1 shows a manometer used to measure the pressure of a gas in a syringe that is connected to one end of the manometer. The manometer is filled with mercury which has a density of 13 600 kg / m^3.

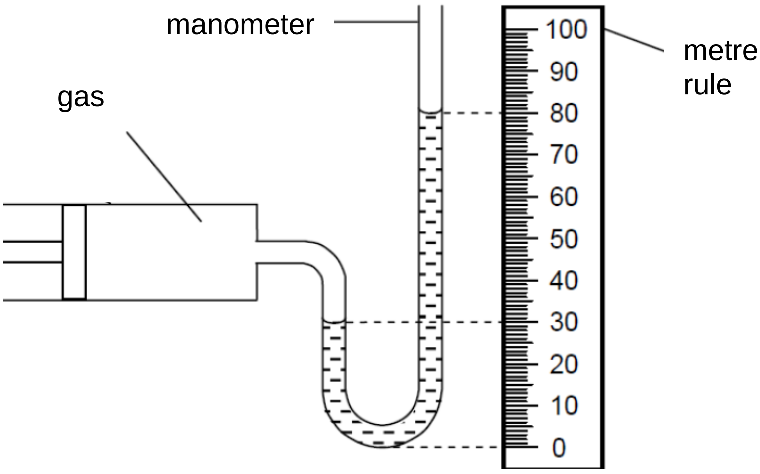

Fig. 5.1

(a) Explain how the gas particles in the syringe are able to exert such a high pressure to lift the column of mercury in the manometer on the right arm.

…………………………………………………………………………………...

…………………………………………………………………………………...

…………………………………………………………………………………...

…………………………………………………………………………………...

……………………………………………………………………………….. [2]

(b) The atmospheric pressure is 760 mm Hg.

Calculate the gas pressure. Leave your answer in mm Hg.

gas pressure = ………………………mm Hg [1]

(c) Fig. 5.2 shows the piston pushed further to the right by a force F and the mercury level on the right arm of the manometer is observed to rise.

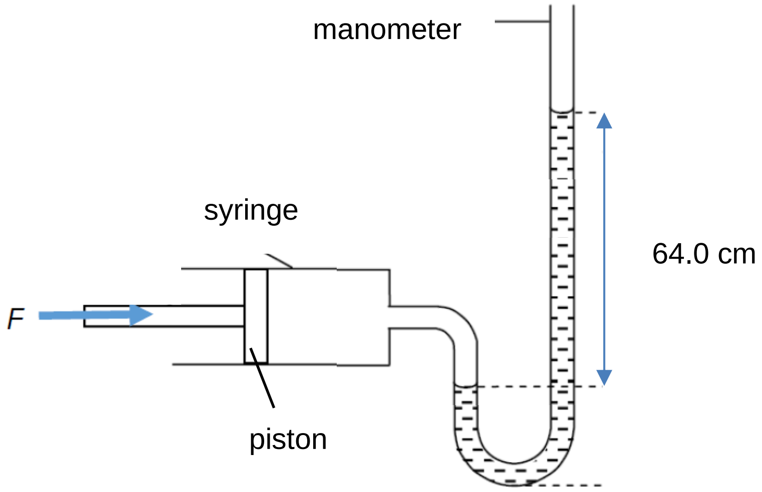

Fig. 5.2

(i) Explain why the mercury level on the right arm rises when the piston is pushed to the right using the ideas of particles.

....

....

.... [1]

(ii) Calculate the increase in gas pressure with reference to Fig. 5.1 and Fig 5.2. Leave your answer in Pa.

The gravitational field strength is 10 N / kg.

gas pressure = ... Pa [2]

(iii) The cross-sectional area of the piston is 12 cm^2. Calculate the magnitude of the force F, assuming that no energy was transferred out of the system.

force = ... [2]

[total: 8]

6 Visible light is a component of the electromagnetic (EM) spectrum, which consists of waves of different wavelengths. All EM waves can undergo reflection and refraction.

(a) State one other property that is common for all components of the electromagnetic spectrum.

………………………………………………………………………………………..

…………………………………………………………………………….. [1]

(b) Fig. 6.1 shows a ray of blue light entering a glass block from air. The refractive index of the glass block is 1.52. The ray bends to hit surface **PQ**.

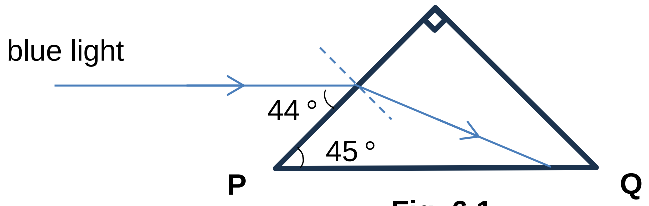

Fig. 6.1

(i) Calculate the angle of refraction for this ray.

angle of refraction = ………………. ° [2]

(ii) Calculate the critical angle for the glass block.

critical angle = ………………. ° [1]

(iii) Calculate the angle of incidence at the surface **PQ**.

angle of incidence = ………………. ° [1]

(iv) Hence, draw a ray in Fig. 6.1 to show the path of the light ray after it is incident on the surface **PQ**. [1]

[total: 6]

7 Fig. 7.1 shows a simplified model of an electrostatic precipitator.

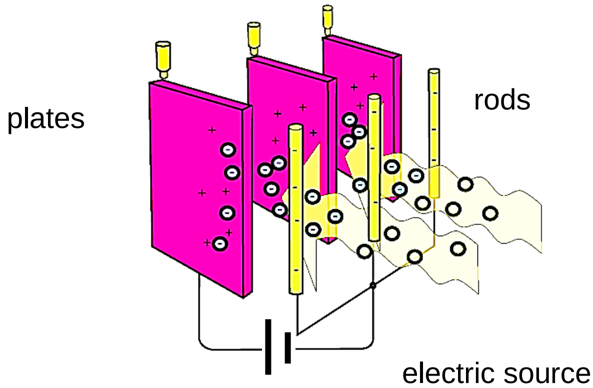

Fig. 7.1

Exhaust fumes containing dust particles are passed through metallic rods and plates that are connected to an electric source.

Dust particles passing through the rod acquire negative charges.

(a) Fig. 7.2 shows an isolated negative charge.

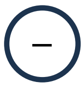

Fig. 7.2

(i) Draw the electric field pattern due to the charge on Fig. 7.2. [1]

(ii) State what is shown by the direction of the electric field.

....

.... [1]

(b) Explain how the electrostatic precipitator helps to produce cleaner air.

………………………………………………………………………………………...

………………………………………………………………………………………...

………………………………………………………………………………………...

………………………………………………………………………………………...

………………………………………………………………………………………...

…………………………………………………………………………….. [2]

[total: 4]

8 A student sets up a circuit as shown in Fig. 8.1 to investigate the brightness of a lamp of resistance 5.0 Ω. A heater is placed very near a thermistor so that the temperature of the thermistor varies.

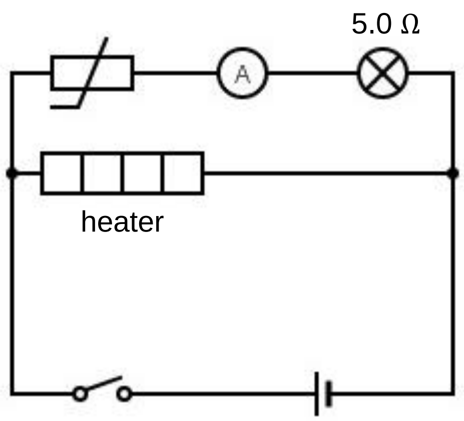

Fig. 8.1

(a) On Fig. 8.1, draw a suitable instrument to show how the potential difference across the thermistor can be measured. [1]

(b) When the switch is first closed, the lamp fails to light up.

(i) Suggest why the lamp fails to light up at first.

……………………………………………………………………………….

……………………………………………………………………… [1]

(ii) Explain why the lamp lights up after some time.

……………………………………………………………………………….

……………………………………………………………………… [1]

(c) The current and potential difference across the thermistor obtained from the experiment is shown in Fig. 8.2.

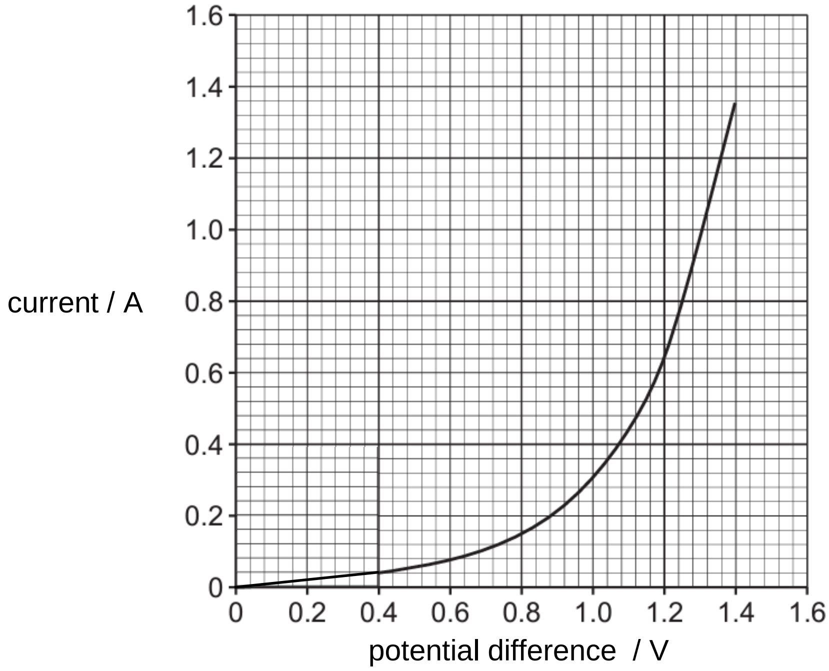

Fig. 8.2

(i) The current through the lamp is 0.48 A at one point in the experiment.

Find the e.m.f of the cell.

e.m.f = ……………………………………… [3]

(ii) The student discusses the graph in Fig. 8.2 with another student, and they conclude that the thermistor exhibits ohmic properties under certain conditions.

Suggest why they came to this conclusion.

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…………………………………………………………………………….

……………………………………………………………………… [1]

[total: 7]

9 Fig. 9.1 shows an instrument that can be used to detect earthquakes. A bar magnet is suspended from a spring hanging from a metal rod. The metal rod is firmly attached to the base of the instrument and transmits vibrations on the ground to the magnet, causing it to oscillate. The coil is connected to a monitor which measures and displays the induced e.m.f in the coil.

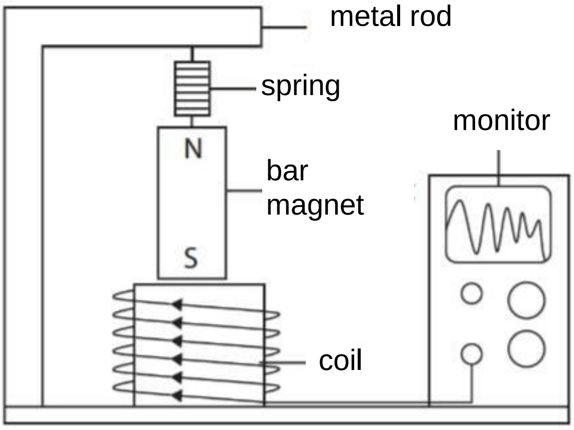

Fig. 9.1

(a) In a test, a student lowers the bar magnet into the coil and then withdraws the bar magnet. The monitor registers a reading momentarily, indicating that an e.m.f is induced.

(i) Explain why an e.m.f is induced in the circuit.

……………………………………………………………………………………

…………………………………………………………………………… [1]

(ii) The direction of the current induced at one moment in this test is shown in Fig. 9.1.

Deduce whether the bar magnet was moving in or out of the coil at the moment shown in Fig. 9.1

…………………………………………………………………………… [1]

(iii) Explain your answer to **(a)(ii)**.

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……………………………………………………………………………………

…………………………………………………………………………… [2]

(b) During an earthquake, the monitor registers 50 vibrations in a second and a maximum e.m.f of 500 mV.

On Fig. 9.2, sketch the voltage-time graph showing the induced e.m.f registered by the monitor.

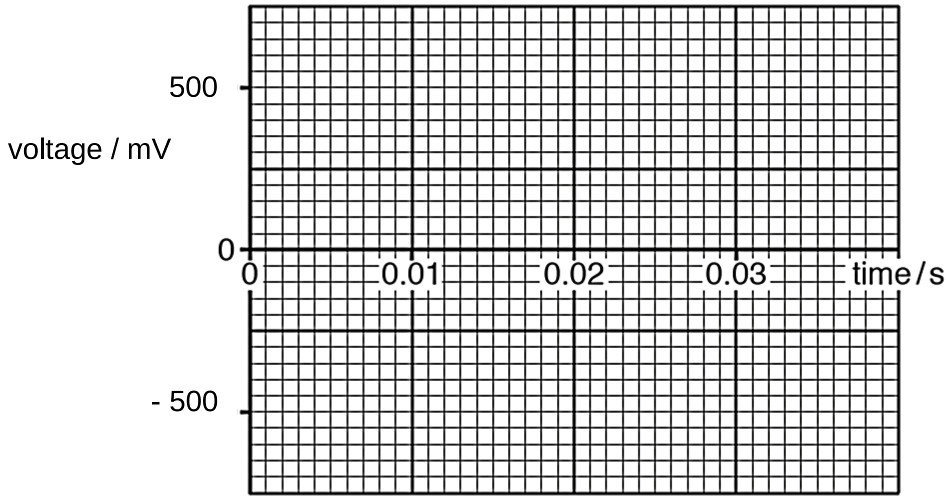

Fig. 9.2

[2]

(c) Describe two differences in your sketch in Fig. 9.2 if an earthquake that creates 25 vibrations in one second is registered by the instrument shown in Fig. 9.1.

………………………………………………………………………………………...

…………………………………………………………………………….. [1]

(d) In another test, it was found that the monitor registered no reading when the tremors are small. Suggest how the instrument could be modified so that the induced e.m.f is larger.

………………………………………………………………………………………...

………………………………………………………………………………………...

…………………………………………………………………………….. [1]

(e) The coil is removed from the set up in Fig. 9.1, and connected to a battery, as shown in Fig. 9.3. An iron core is inserted into the coil, and an iron pendulum bob is suspended near the coil.

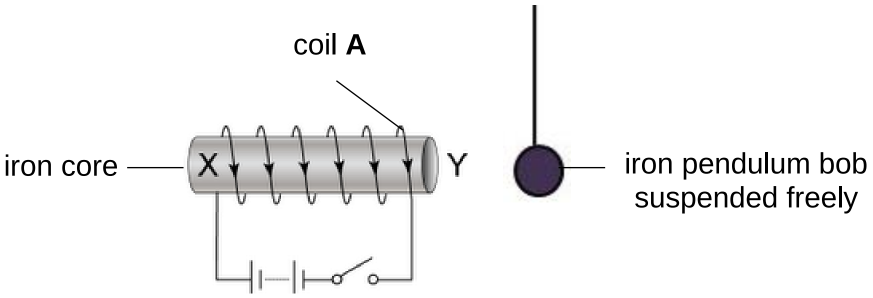

Fig. 9.3

The switch is closed and the iron pendulum bob is observed to swing towards **Y**, one end of the iron core.

Explain why the pendulum bob swings towards Y when the switch is closed.

…………………………………………………………………………………...

…………………………………………………………………………………...

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…………………………………………………………………………………...

………………………………………………………………………………….. [3]

[total: 11]

10 Bubble tea is a popular beverage made by mixing flavoured syrup to tea. Chewy starch balls, called "pearls", are often added to the beverage.

Fig. 10.1 shows a typical drink where fixed volumes of syrup, tea, ice, and pearls are mixed together.

Fig. 10.1

Table 10.2 shows the amount of each ingredient used for drinks of different sizes, the values of their specific heat capacities and specific latent heat of fusion, and the temperature of each ingredient before they are first mixed.

Table 10.2

	tea		syrup		pearls		ice	
size	small	large	small	large	small	large	small	large
mass added / g	300	450	35	50	120	150	300	450
specific heat capacity J / (g K)	4.5		3.1		3.5		2.1	
specific latent heat of fusion J / g	340		390		-		330	
temperature before they are first mixed °C	65		26		36		0	

(a) Explain what is meant by a *specific heat capacity of 4.5 J / (g K)*.

…………………………………………………………………………………..

…………………………………………………………………………………..

……………………………………………………………………………… [1]

(b) A drink is usually served at 4 °C

(i) Suggest why more ice is added when a large drink is prepared.

……………………………………………………………………………….

…………………………………………………………………………… [1]

(ii) Using information from Table 10.2, calculate the amount of energy transferred out of the internal store of the syrup for its temperature to decrease to 4 °C for a small-sized beverage.

amount of energy = ... [2]

(iii) Using information from Table 10.2, calculate the total amount of energy transferred out of the internal stores of the ingredients for a small-sized beverage to be 4 °C.

total amount of energy = ... [1]

(iv) State the amount of energy transferred to the internal store of the ice when it attains thermal equilibrium with the beverage at 4 °C.

amount of energy = ... [1]

(v) Hence, calculate the minimum mass of ice required to obtain a small beverage at 4 °C using information from Table 10.2.

The specific heat capacity of water is 4.2 J / (g K).

minimum mass = ... [3]

[total: 9]

Section B

Answer **one** question from this section.

11 Isotopes of some elements may be unstable and undergo nuclear decay, releasing radiation. One example is the isotope radium-226, which decays into radon-222 with the emission of an alpha particle.

(a) In nuclide notation, radium-226 is written as ${}^{226}_{88}\mathrm{Ra}$. Write the equation to represent the alpha decay of radium-226 to radon-222. The chemical symbol for radon is Rn.

[2]

(b) Radioactive substances are used in some medical procedures, and they should be handled with care as they can be dangerous to living organisms.

(i) Explain why exposure to alpha particles could be more harmful than exposure to gamma radiation.

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………….. [1]

(ii) Suggest how medical professionals who handle the radioactive isotope radium-226 frequently may protect themselves from the harmful effects of radioactivity.

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………….. [1]

(c) The isotope radon-222 is also unstable and continues to decay into smaller nuclides. The half-life of radon-222 is 8.3 days.

The initial mass of a sample of radon-222 before decay is observed to be 100 g. Calculate the number of days it will take for 12.5 g of radon-222 to be left in the sample.

number of days = …………………….. [2]

(d) A student measures the count rate of a sample of radon-222 to determine its half-life.

Describe how he could determine an accurate count rate for the sample of radon-222 using a named apparatus.

…………………………………………………………………………………..

…………………………………………………………………………………..

…………………………………………………………………………………..

……………………………………………………………………………… [2]

(e) A beam of the alpha particles is directed into a uniform magnetic field as shown in Fig. 11.1.

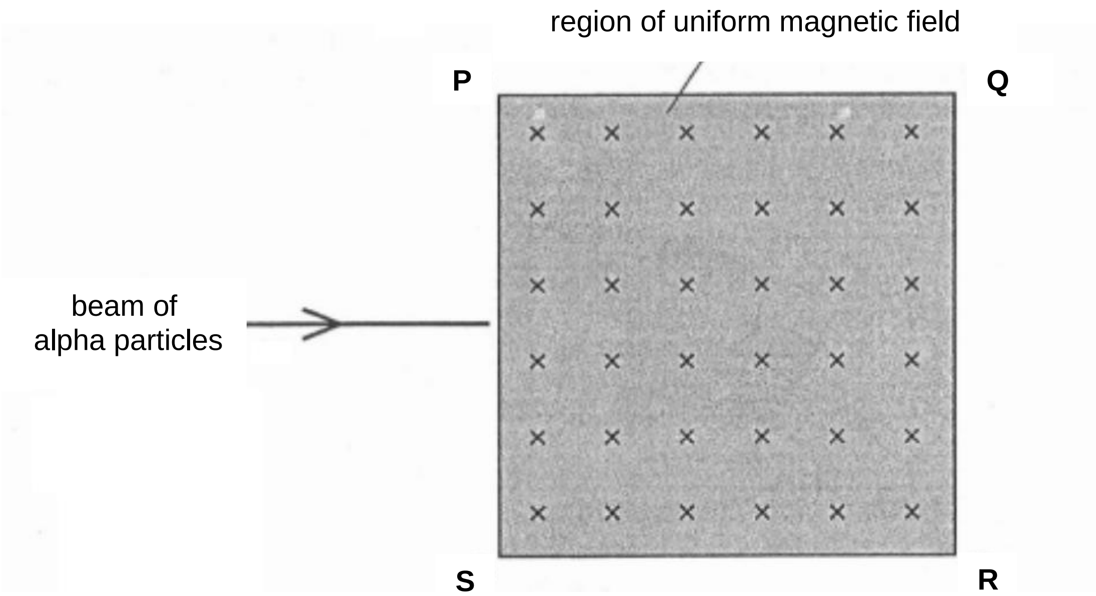


Fig. 11.1

(i) Draw the subsequent path of the alpha particles as they pass into the magnetic field in Fig. 11.1. [1]

(ii) The beam of alpha particles is replaced with a beam of gamma radiation.

Explain how your answer to **(e)(i)** will be different.

………………………………………………………………………………

………………………………………………………………………………

…………………………………………………………………………… [1]

[total: 10]

12 A crane uses a motor to lift a concrete slab of weight 2400 N as shown in Fig. 12.1.

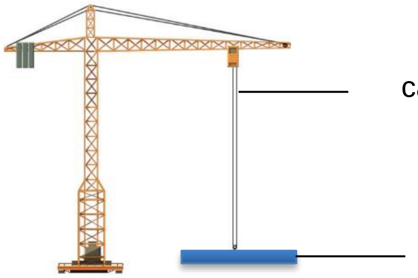


Fig. 12.1

(a) State the *principle of conservation of energy*.

…………………………………………………………………………………...

…………………………………………………………………………………...

……………………………………………………………………………….. [2]

(b) The concrete slab was lifted from the ground to a height of 25 m in 1.2 minutes at constant speed.

(i) Calculate the useful power output of the motor.

useful power output = …………………… [2]

(ii) The efficiency of the motor is 65%. Calculate the minimum power input required by the motor.

minimum power input = …………………… [1]

(iii) In a safety simulation, engineers conducted an experiment to find out the damage that faulty cables could cause to the construction site, in the event that the cables snap and the concrete slab falls.

The concrete slab is released 25 m above the ground. Calculate the maximum speed of the slab just before reaching the ground.

speed = …………………… [2]

(c) Fig. 12.2 shows a counterweight of 12 000 N used to balance the crane, which is pivoted at **X**. The weight of the frame of this crane is 150 000 N, and its centre of gravity is at the point **G**, 0.20 m away **X**.

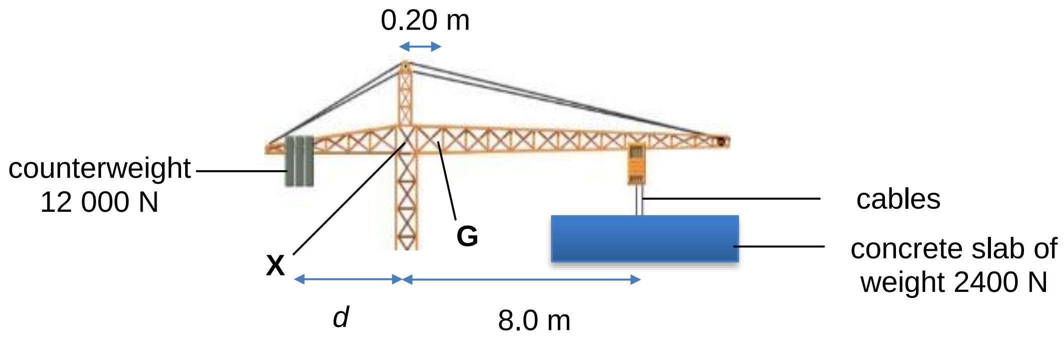


Fig. 12.2

Given that the crane is in equilibrium when the concrete slab is 8.0 m away from the pivot **X**, calculate *d*, the distance the counterweight is from **X**.

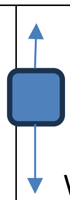
d = ... [3]

[total: 10]

– End of paper –

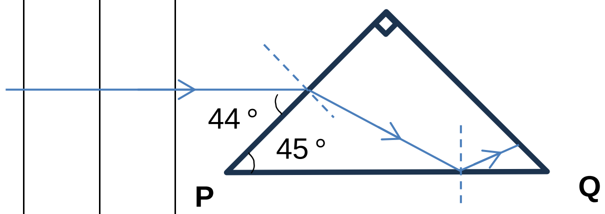
<u>Suggested Marking Scheme for PSS 6091 Prelim 2024</u>

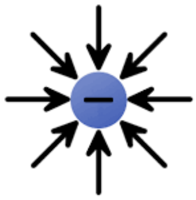
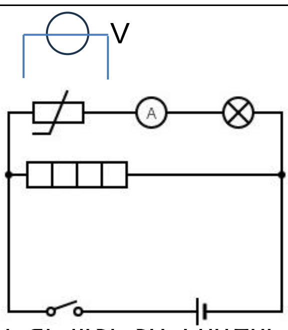
- Correct units are expected for all questions, unless otherwise stated. Penalise units up to once in section A, and up to once in section B.
- Expect lowest sf after multiplication and division, condone 1 more sf than expected. Penalise dp/sf once for the entire paper.

Question			Marking point	Mark	Markers comments
1	a		The displacement is increasing from t = 0 s to t = 80 s Since rate of change of displacement is velocity, the displacement is <u>increasing at an increasing rate</u>.	B1 B1	Many students could not see that displacement was increasing at an increasing rate
	b		displacement = area under graph $= \frac{1}{2}[(190-90)+220)\times 25.0$ = 4000 m average velocity = $\frac{4000}{220}$ = 18.2 = 18 m / s (2sf)	M1 M1 A1	Some did not read values correctly
	c		$a=\frac{v-u}{t}$ $=\frac{0-25}{30}$ (or $\frac{0-13}{16}$ or $\frac{13-25}{14}$) =–0.83 m/s^2 (or -0.81 or -0.86) d=0.83 m/s^2 penalize for units once with 2c	M1 A1	
					[total: 7]
2	a		 resistive forces = 1200 N W = 2500 N	B1 for both forces	Some did not label name or values
	b		W=mg 2500 = m × 10 m=250 kg	B1	this question was well done
	c		F_R=2500 – 1200 = 1300 N $F_R=ma$ 1300 = 250 a $a=\frac{1300}{250}$ = 5.2 m/s^2 penalise for unit once with 1c	M1 M1 A1 / ECF1	this question was well done

Question			Marking point	Mark	Markers comments
	d		• The surface area of the crate in contact with air. • The surface area of the parachute in contact with air • Presence of wind. • Speed of travel	B1 for any	this question was well done
	e		• As speed increases, air resistance increases • until it is equal in magnitude to weight. • so resultant force is 0.	B1 for any 1 point B2 for all 3 points	some did not explain why air resistance increased.
					[total: 8]
3	a		Liquid that is heated at the bottom expands, resulting in a lower density, and rises. Cooler liquid, being denser, sinks, to be heated. Process repeats to form a convection current.	B1 for any 1 point B2 for all 3 points	some students mentioned "particles expand" or "particles increase in volume" this is incorrect.
	b		From **A** to **B**, energy is transferred to the internal kinetic store and so the temperature of the substance rises. From **B** to **C**, energy is transferred to the internal potential store to separate the particles and not to the internal kinetic store.	B1 B1	avoid the use of "energy is converted to…"
	c		• less steep AB and CD • longer BC • same boiling point	B1	new BC should be about twice as long
	d		Particles are changing from closely and disorderly packed to far apart and randomly arranged.	B1	
					[total: 6]

Question			Marking point	Mark	Markers comments
4	a		air particles (molecules) are in constant random motion and collide with the smoke particles randomly, exerting a force	B1 B1	many students did not describe a force
	b	i	The smoke particles change directions more frequently. Reject "more randomly"	B1	"more randomly" or "move faster" were common answers
		ii	Air particles move more quickly and collide with the smoke particles more frequently.	B1	
					[total: 4]
5	a		• The gas particles travel at high speeds and • collide frequently with the mercury and • exerting a force • Since pressure is force per unit area, a pressure is exerted (which pushes the column of mercury)	B1 for any 2 B2 for all 4	focus should be on the collision of the gas particles with the mercury surface.
	b		$P_{gas} = P_{atm} + P_{mercury}$ $= 760 + 500$ $= 1260$ mm Hg	B1	
	c	i	• Less space for gas or shorter distance to travel (or more particles per unit volume) • Increased frequency of collision with walls of manometer • Increase in gas pressure	B1 for all 3	some students mentioned area instead of volume (area should be used on surfaces)
		ii	$P_{new} – P_{old}$ $= (P_{atm} + P_{new\ Hg}) – (P_{atm} + P_{old\ Hg})$ $= P_{new\ Hg} – P_{old\ Hg}$ = 640 mm Hg – 500 mm Hg = 140 mm Hg $= 13\ 600 \times 10 \times (140 \times 10^{-3})$ = 19 040 = 19 000 Pa (3sf)	M1 A1	some students had issues with sf.
		iii	F=PA $= 19\ 040 \times \frac{12}{100^2}$ = 22.8 = 23 N (2sf)	M1 A1 / ECF1	
					[total: 8]

Question			Marking point	Mark	Markers comments
6	a		Accept any correct answer. • Travel at 3.0 x 10^8 m / s in vacuum (insist on 3.0 or 3.00) • They are all transverse waves. • They transfer energy without transferring mass. • They can travel through vacuum.	B1 for any 1 point	some students left out units for speed
	b	i	$\frac{\sin i}{\sin r} = 1.52$ $\frac{\sin 46°}{\sin r} = 1.52$ $\sin r = \frac{\sin 46°}{1.52}$ $r = \sin^{-1}\left(\frac{\sin 46°}{1.52}\right)$ $= 28.2°$	M1 A1	this question was well done
		ii	c = $\sin^{-1}\left(\frac{1}{n}\right)$ = $\sin^{-1}\left(\frac{1}{1.52}\right)$ =41.1°	B1	this question was well done.
		iii	 Angle of incidence = 90 – (180 – 45 – 90 – 28.2) = 73.2 °	B1 / ECF1	some students were unable to use angle properties of triangles to obtain the required angle.
		iv	• Total internal reflection occurs at PQ, expect $i \approx r$. • Arrows on rays	B1	some students did not realise $i > c$ so did not consider TIR
					[total:6]

Question			Marking point	Mark	Markers comments
7	a	i	 • Arrows pointing in • Symmetric	B1	this question was well done.
		ii	It shows the direction of a force that a positive test charge would experience if placed at that point.	B1	This was poorly done.
	b		• The metal plates are positively charged • The dust particle are negatively charged as they acquire electrons from the rods. • Opposite charges attract • The dust particles are attracted to the metal plates and stay there.	B1 for any 2 points B2 for all 4	"poles" were mentioned by some students, which was incorrect since this is on charges.
			[total: 4]		
8	a		 	B1	this was well done.
	b	i	R[illegible] very high at first so current in that branch is too low to light the lamp. Reject short circuit.	B1	Most people could identify low current due to high resistance.
		ii	the resistance of the thermistor decreased with increasing temperature as it is heated up by the heater so current in that branch increased. penalize for current once for b(i) and b(ii).	B1	most students could identify resistance decrease with higher temperature and thus current increases.
	c	i	from graph, when I = 0.48 A, V=1.12 V (across thermistor) pd across 5.0 Ω bulb, V = IR =0.48 x 5.0 =2.4 V E.M.F = 1.12 + 2.4 (parallel) = 3.5 V (accept 3.52 V)	M1 M1 A1	many students were not able to meaningfully use the graph to find the relevant potential differences

<table>
<tr><th colspan="3">Question</th><th>Marking point</th><th>Mark</th><th>Markers comments</th></tr>
<tr><td></td><td></td><td>i</td><td>or $R_{thermistor} = \frac{V}{I}$
$= \frac{1.12}{0.48}$
$= 2.33\ \Omega$

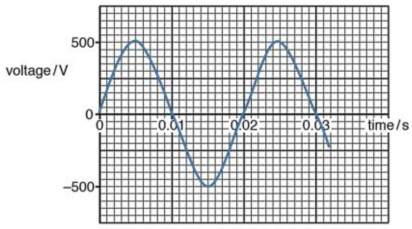
$R_{total} = 2.33 + 5.0$
$= 7.33\ \Omega$

V=IR
$= 0.48 \times 7.33$
$= 3.5$ V</td><td>M1

M1
A1</td><td></td></tr>
<tr><td></td><td></td><td>ii</td><td>The graph
• Passed through the origin
• and is straight when V was between 0 V to 0.40 V.

(or I is directly proportional to V between 0 V to 0.40 V)</td><td>B1 for both points</td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="3">[total: 7]</td></tr>
<tr><td>9</td><td>a</td><td>i</td><td>There is a <u>change in magnetic flux</u> as <u>the magnet was moving</u> into and out of the coil. (By Faraday's Law, and e.m.f is induced.)</td><td>B1</td><td>some mentioned a changing magnetic flux but did not mention why it was changing</td></tr>
<tr><td></td><td></td><td>ii</td><td>It was moving into the coil</td><td>B1</td><td></td></tr>
<tr><td></td><td></td><td>iii</td><td>As a <u>south pole is induced</u> at the end near the bar magnet (using RHGR),

the coil was <u>repelling the magnet to oppose the change</u>, and thus by Lenz's Law, the magnet bar was moving into the coil</td><td>B1

B1</td><td>Some students did not mentioned that a S pole was produced. Some confused this with magnetic induction.</td></tr>
<tr><td></td><td>b</td><td></td><td>

period of 0.02 s

shape (sine on the t-axis)

amplitude at 500 mV</td><td>B1 for any 2 points

B2 for all 3</td><td>some did not use the frequency given to identify the period of the wave.</td></tr>
<tr><td></td><td>c</td><td></td><td>smaller amplitude and larger period.</td><td>B1</td><td>some students mentioned “lower frequency” which does not describe the graph.</td></tr>
</table>

Question			Marking point	Mark	Markers comments
	d		Increase the number of coils in the solenoid Use a stronger magnet Insert a soft iron core into the solenoid.	B1 for any	
	e		When switch is closed, a N pole is produced at Y using the right-hand grip rule. As iron is a magnetic material, a S pole is induced on the end of the pendulum bob nearer Y. Since unlike poles attract, the bob swings towards the solenoid.	B1 B1 B1	Many students did not mention the poles, and did not mention induced magnetism.
					[total: 11]
10	a		4.5 J of energy is required to raise the temperature of 1 g of the substance (or tea) by 1 K (or 1 °C)	B1	definition was not well quoted, with quantity missing or concept of "per unit mass" not discussed
	b	i	more energy needs to be absorbed (or transferred out of the internal store of the ingredients) to reduce the temperature of the drink when the mass of tea is larger. or heat capacity of a larger drink is larger with a bigger volume/mass	B1	many students gave answers that did not involve any physics concepts "e.g. larger drink so need more ice".
	b	ii	$Q_{syrup} = m_{syrup}c_{syrup}\,\Delta\theta_{syrup}$ $= 35 \times 3.1 \times (26 - 4)$ $= 2387$ $= 2400$ J (2sf)	M1 A1	most were able to identify the quantities required
		iii	$Q_{tea} = m_{tea}c_{tea}\,\Delta\theta_{tea}$ $= 300 \times 4.5 \times (65 - 4)$ $= 82\,350$ J $Q_{pearls} = m_{pearl}c_{pearl}\,\Delta\theta_{pearl}$ $= 120 \times 3.5 \times (36 - 4)$ $= 13440$ J total energy $= 2387 + 82\,350 + 13\,440$ $= 98\,177$ $= 98\,000$ J (2sf)	B1	A portion of students included the energy transferred to ice in the calculations, which is not required.
		iv	98 000 J	B1/ ECF1	

Question			Marking point	Mark	Markers comments
		v	energy transferred out from ingredients = energy transferred into internal store of ice = energy required to melt the ice + energy required to raise to $4°C$ = $m_{ice}l_{f\,ice} + m_{ice}c_{water}\Delta\theta_{water}$ $m_{ice}l_{f\,ice}$ = m_{ice} 330 = 330 m_{ice} $m_{ice}c_{water}\Delta\theta_{water} = m_{ice} \times 4.2 \times 4$ = 16.8 m_{ice} 98 177= 330 m_{ice} +16.8 m_{ice} 98 177=346.8 m_{ice} m_{ice} = 283.1 = 280 g (2sf)	M1 (or M1 if not already awarded) M1 A1 / ECF1	Some students use the specific heat capacity of ice here.
			[total: 9]		
11	a		$^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + {}^{4}_{2}He\ (or\ {}^{4}_{2}\alpha)$ correct reactants and products correct number of nucleons and protons	B1 B1	
	b	i	<u>Alpha particles are more ionizing</u> than gamma radiation	B1	This was well answered.
		ii	• Use thongs to handle the radioactive substances • Wear protective gears when handling the substances • Minimize contact with the substances whenever possible • Reduce exposing the substance to colleagues accept reasonable answers.	B1	This was well answered.
	c		100 → 50 → 25 → 12.5 3 half-lives 3 x 8.3 = 25 days (2 sf)	M1 A1	Most students were able to work this out.

Question			Marking point	Mark	Markers comments
	d		take the background count using a GM-counter (or Geiger-Muller tube) by measuring without a radioactive source. subtract the background count from the measured count to get the corrected count rate. accept description of measurement taken without the source then with the source.	B1 B1	Some students could not describe how to obtain the background count
	e	i	curve upwards towards PQ (circular)	B1	This was well done.
		i	no deviation as the gamma radiation has no electric charge, so no magnetic force is produced.	B1	This was also well done.
12	a		• Energy cannot be created or destroyed. • It can be transferred from one store to another store. • Total energy in the (closed) system remains constant.	B1 for any 1 point B2 for all 3 points	This was well done.
	b	i	$E_p = mgh$ $= 2400 \times 25$ $= 60\,000$ J P = $\frac{W}{t}$ $= \frac{60\,000}{60 \times 1.2}$ = 833.3 = 830 W (2 s.f)	M1 A1	This was well done.
		ii	$\frac{useful\ power\ output}{total\ input\ power} \times 100 = 65$ $\frac{833.3}{input\ power} \times 100 = 65$ input power = 1282 W = 1300 W (2sf)	B1	Many students had difficulty working backwards to obtain the input power.

Question			Marking point	Mark	Markers comments
		iii	All the E_p is transferred to the kinetic store. $E_k = E_p$ $\frac{1}{2}mv^2 = 60\ 000$ $\frac{1}{2} \times 240 \times v^2 = 60000$ $v^2 = 500$ $v = 22.4$ = 22 m / s (2sf)	 M1 A1	This question was well done.
	c	i	total cw momemts = 2400 × 8.0 + 150 000 × 0.20 = 49 200 Nm 12 000 d = 49200 d = 4.1 m	 M1 M1 A1	Most students were able to obtain the answer.
			[total:10]		