

Class:	Index No.:	Name: Marking Scheme
 CRESCENT GIRLS' SCHOOL SECONDARY FOUR PRELIMINARY EXAMINATION PHYSICS Paper 2 Structured and Free Response 6091 / 02 02 September 2025 1 hour 45 minutes		

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class in the spaces provided at the top of this page and on all separate answer sheets used.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluids.

Section A

Answer **all** questions.

Write your answers on the spaces provided.

Section B

Answer **one** question.

Write your answers on the spaces provided.

Candidates are reminded that all quantitative answers should include appropriate units.

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

Candidates are advised to show all their working in a clear and orderly manner, as more marks are awarded for sound use of Physics than for correct answers.

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

Note to markers:

1. Penalty for errors in significant figures – 1 mark for whole paper
2. Penalty for errors in units or missing units – 1 mark per whole question

Section A

Answer **all** questions in this section.

- 1 Two small tugboats are pulling a ship in a harbour. Fig. 1.1 represents the view from above and shows the directions of the forces on the ship.

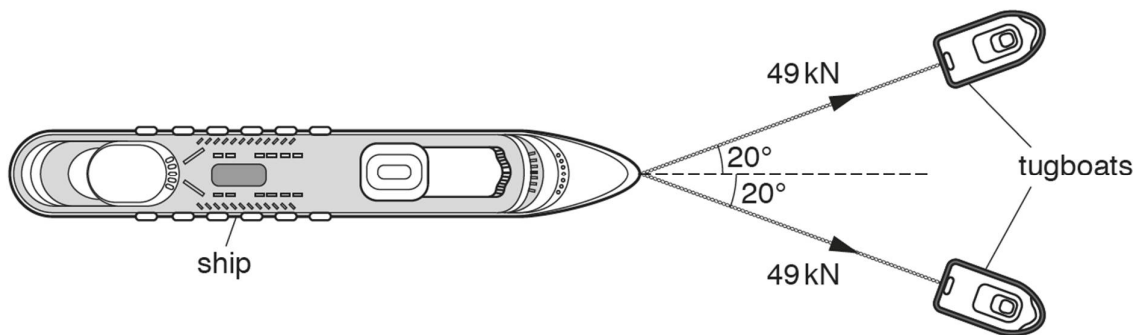


Fig. 1.1 (not to scale)

Each of the tugboats is exerting a horizontal force of 49 kN on the ship.

- (a) By drawing a scaled vector diagram, determine the resultant of these two forces.
Label your forces.

Answer	Marks
appropriate scale used (e.g., 1 cm represents 10 kN)	B1
correct vector diagram, including direction and labelling	M1
90 kN ≤ resultant ≤ 94 kN	A1 with units

- (b) The engines of the ship are not operating and the water in the harbour is stationary. The ship is moving at a constant speed in a straight line in the direction of the resultant of the two forces exerted by the tugboats.

Explain, in terms of the forces acting, why the ship is moving in a straight line at constant speed.

Answer	Marks
water resistance / drag	B1
same magnitude and acts in opposite direction to the resultant of the forces by tugboat	B1
no resultant force on the ship	B1

- (c) Both cables connecting the tugboats and the ship are detached at the same instant.

The mass of the ship is 2.4×10^7 kg.

Determine the magnitude of the acceleration, and its direction relative to the motion of the ship, at this instant.

Answer	Marks
$F = ma$ $92 \times 10^3 = (2.4 \times 10^7) a$ $a = 3.8 \times 10^7 \text{ m s}^{-2}$ accept $3.83 \times 10^7 \text{ m s}^{-2}$	A1 – allow e.c.f. from (a)
direction relative to motion of ship: opposite / 180°	A1

magnitude = [1]

direction relative to motion of the ship = [1]

[Total: 8 marks]

- 2 Fig. 2.1 shows a man sitting on a chair resting on four legs. Fig. 2.2 shows the same man with his chair tilted backwards slightly.



Fig. 2.1

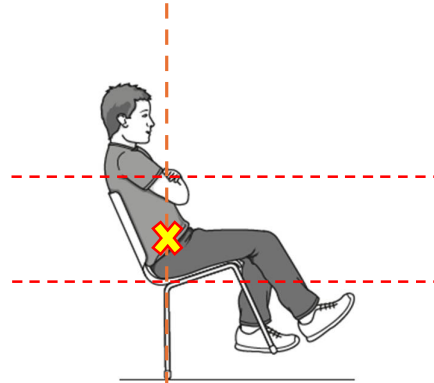


Fig. 2.2

The man has a weight of 650 N and the chair has a weight of 20 N. Each base area of each leg is 5.0 cm².

- (a) Calculate the pressure exerted on the floor when the chair is in the position shown in Fig. 2.1.

Answer	Marks
pressure = force / area = (650 + 20) / (4 × 5.0) = 670 / 20 cm ² OR 670 / (2.0 × 10 ⁻³ m ²)	C1 - seen
34 N/cm ² accept 33.5 N/cm ² ; 330 kPa; 335 kPa; 335 kN/m ²	A1 – with units

pressure =34 N/cm²..... [2]

- (b) State and explain, without any calculations, how the pressure of the chair on the floor differs in the two positions.

Answer	Marks
<u>Greater/larger pressure in Fig. 2.2 (than in Fig. 2.1)</u> [not accepted: <u>large/big</u> pressure in Fig. 2.2]	B1 – comparative answer
Since pressure is <u>force per unit area</u>, with the <u>same weight</u>, the pressure is greater with a <u>smaller contact area in Fig 2.2</u>.	B1

- (c) In Fig. 2.2, the chair and man are about to fall over.

On Fig. 2.2, draw an "X" to indicate the position of the centre of gravity of the chair and man. [1]

Answer	Marks
X is marked clearly along the vertical axis of the back legs of the chairs within the 2 horizontal dotted boundaries.	B1

- (d) The chair and man fall over if the chair is tilted backwards more than in Fig. 2.2. Explain why.

Answer	Marks
- The (combined) centre of gravity is outside the base / legs / chair - Weight acts on left or outside of chair leg	B1
<u>Net anticlockwise / unbalanced moment</u> is created causing the chair to tilt backwards.	B1

[Total: 7 marks]

- 3 Fig. 3.1 shows the plan of a bedroom and part of the main room of a house. Other parts of the house are not shown.

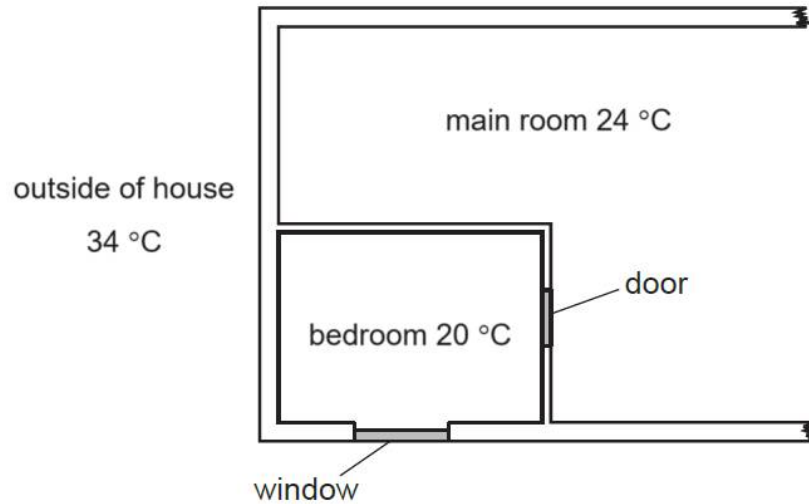


Fig. 3.1

The temperatures of the main room, the bedroom and the outside of the house are shown in Fig. 3.1.

Fig. 3.2 shows the thermal energy transfers to the bedroom in one hour.

through the door and walls from the main room	60 000 J
through the walls from the outside	1 500 000 J
through the window	200 000 J

Fig. 3.2

- (a) State the key process of heat transfer to the bedroom.

Answer	Marks
Heat / thermal conduction (through the walls)	B1

- (b) Suggest why more thermal energy enters the bedroom from the outside of the house than from the main room.

Answer	Marks
- Larger temperature difference between the bedroom and outside of house OR - Outside of the house is hotter than the main room	B1

- (c) Suggest two ways to reduce the different heat transfers into the bedroom through the walls from the outside.

Answer	Marks
Any 2 of following answers • Paint the (exterior) walls white (or light colours). • Make the (exterior) wall surface smooth / shiny • Add insulating material to the (exterior) wall surface. • Double-glaze the walls (any answer that implies the same effect) • Any logical answer that reduces heat transfer by conduction and/or radiation [not accepted – specific solutions without relating the property that affects rate of heat transfer. E.g., cover walls with foil, vs cover the walls with <u>shiny</u> foil]	B1 each

- (d) An air conditioner is installed in each room to keep the room at the temperatures shown in Fig. 3.1. The air conditioners are installed at the top of each room.

Explain how this set-up helps to cool the air in the rooms.

Answer	Marks
Air at the <u>top</u> of the rooms is <u>cooled</u> and <u>becomes denser</u> .	B1
<u>Cold air sinks</u> and the <u>warmer air that is less dense rises</u> (from the bottom of the room)	B1
Convection current is set up (to continue cooling the room).	B1

[Total: 7 marks]

- 4 Both sound and ultrasound are longitudinal waves that travel in solids, liquids and gases. Both consist of compressions and rarefactions.

(a) (i) State how sound differs from ultrasound.

Answer	Marks
frequency of sound waves smaller (than ultrasound) OR its frequency is less than 20 kHz (whereas ultrasound has a frequency greater than 20 kHz)	B1

(ii) Explain what is meant by a wave and state the direction of vibration of the wave particles in relation to the wave motion.

Answer	Marks
transfer / propagation of energy by vibrating (medium) particles	B1
<u>with no net transfer of (medium) particles</u>	B1
vibrations of (medium) particles parallel to direction of energy transfer / propagation in the longitudinal wave (no comparison needed)	B1

(b) Fig. 4.1 represents a longitudinal wave of frequency 25 kHz traveling in oil.

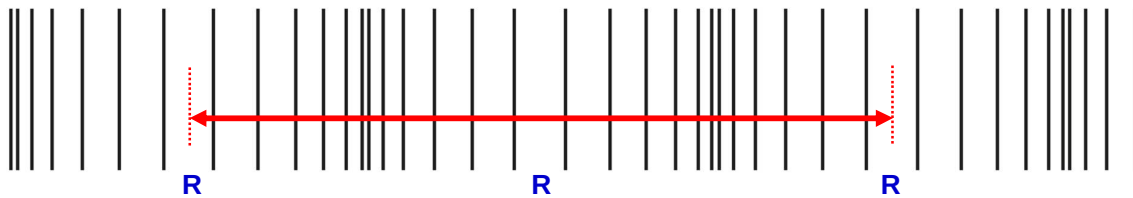


Fig. 4.1 (full scale)

(i) On Fig. 4.1,

1. mark one point at the centre of a rarefaction and label it **R**. [1]

Answer	Marks
Any of the points labelled R in Fig. 4.1 shown	B1

2. draw a double-headed arrow to indicate a distance that is equal to one wavelength of the wave. [1]

Answer	Marks
Any double-headed arrow drawn between two consecutive points that are in phase / two consecutive compressions / rarefactions – see sample in Fig. 4.1	B1

- (ii) Measure the length of the arrow drawn in **(b)(i)(2)**. and use it to determine the speed of the wave in the oil.

Answer	Marks
$v = f\lambda$ $= 25\,000 \times 0.048$	M1 – allow e.c.f. from (i)
$= 1200 \text{ m s}^{-1} (\pm 50 \text{ m s}^{-1})$	A1 – no e.c.f.

magnitude = [2]

[Total: 8 marks]

- 5 A girl rubs a polythene rod with a dry cloth. The polythene rod becomes positively charged and the cloth becomes negatively charged.

(a) Describe, in terms of the movement of electrons, how the polythene rod becomes positively charged.

Answer	Marks
Electrons / negative charges are transferred/moved from the rod to the cloth during rubbing	B1
There are excess positive charges on the rod, thus it becomes positively charged.	B1

(b) There is an electric field around the charged rod.

(i) Explain what is meant by an *electric field*.

Answer	Marks
Electric field is a region where a (electric) charge experiences an electric force . OR Electric field is a region where an electric force is exerted on a (electric) charge .	B1

(ii) State the direction of this electric field around the charged rod with reference to the rod.

Answer	Marks
Outwards from the rod	B1

(c) The charged rod is placed near a stream of water from a tap as shown in Fig. 5.1.

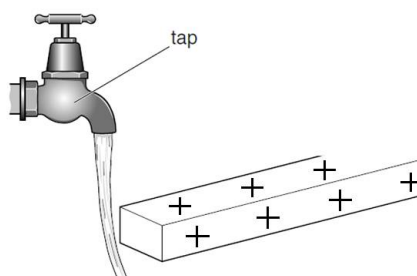


Fig. 5.1

The stream of water bends because the rod is charged.

Explain how the stream of water bends in Fig. 5.1.

Answer	Marks
Negative charges are induced in the stream of water near/closer to the rod	M1
<u>Unlike charges attract</u> , the <u>stream of water is attracted to</u> the (positively charged) rod	A1

[Total: 6 marks]

- 6 (a) Fig. 6.1 and Fig. 6.2 show views of a wire carrying a current downwards through a horizontal board.

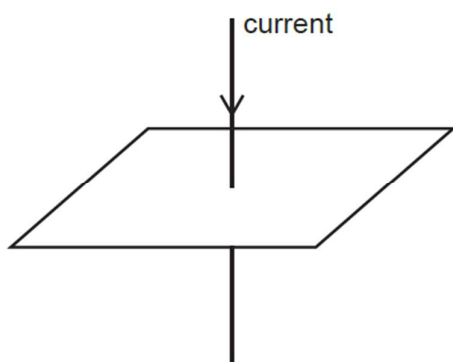


Fig. 6.1

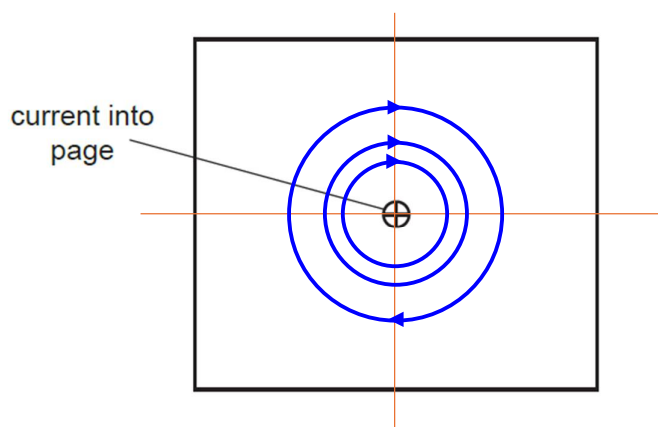


Fig. 6.2 (viewed from above)

On Fig. 6.2, draw the magnetic field due to the current in the wire.

[3]

Answer	Marks
At least 2 circles centred on the wire, no crossing/overlap	B1
Clockwise arrow drawn on one of the circles	B1
3 or more circles drawn with increasing gap between circles	B1

- (b) The wire is coiled around an iron core and is connected to a power source to form an electromagnet, as shown in Fig. 6.3.

With the switch open, a beam of electrons is projected between the poles of the electromagnet and produces a bright spot on a special screen. The whole set-up is enclosed in a vacuum.

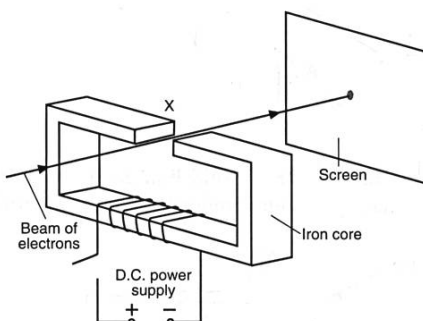


Fig. 6.3

The switch of the circuit is subsequently closed.

- (i) State the magnetic pole produced at the end marked X.

Answer	Marks
North (pole)	B1

- (ii) State and explain the movement of the spot on the screen.

Answer	Marks
Either set of answers below	
<u>Set 1</u> Using Fleming's left-hand rule. (i) Index finger represents magnetic field lines which is from North to South pole of magnet / from X to opposite pole (ii) Middle finger represents current, outwards from the screen / opposite to the direction electron beam (iii) Thumb represents force which is upwards. (iv) (3 fingers are perpendicular to each other)	M1 M1 – (i) & (ii) A1 – (iii)
<u>Set 2</u> (i) (interaction of the two magnetic fields due to the permanent magnet and the electron beam) (ii) <u>stronger magnetic field below the beam</u> compared to the top of the beam. (iii) <u>a net force acting from the stronger magnetic field below towards the weaker magnetic field above.</u> (iv) The <u>force acts upwards</u> on the beam	M1 – (ii) M1 – (iii) A1 – (iv)

- (iii) State what would be the effect on the position of the spot on the screen if the polarity of the d.c. power supply is reversed.

Answer	Marks
The spots will move downwards / opposite direction to (ii).	B1 – e.c.f. (ii)

[Total: 8 marks]

- 7 Fig. 7.1 shows two coils of insulated wire wound on an iron ring. Coil A is connected to a power source and a switch. The switch is open. Coil B is connected to a sensitive centre-zero voltmeter.

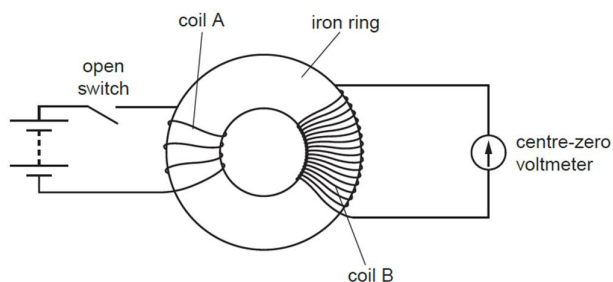


Fig. 7.1

The switch is closed. There is a current in coil A.

- (a) As the switch is closed, the voltmeter deflects to the right and then returns to zero.
Explain why there is a deflection on the voltmeter.

Answer	Marks
Increase in current in coil A produces a (momentary/intermittent/temporary) changing/increasing magnetic field.	B1
results in a change/increase in the magnetic flux linkage through coil B.	B1
Induces an e.m.f. / voltage in B	B1

- (b) The switch is then opened.
State and explain what happens to the deflection on the voltmeter.

Answer	Marks
Deflects to the left / in opposite direction to (a) (and returns to zero)	B1
The magnetic flux linkages in B decreases. AND The induced e.m.f. / voltage reverses in polarity to oppose this change in magnetic flux linkages (in B)	B1

- (c) Without changing coil A, suggest one change to the apparatus that causes a greater deflection on the voltmeter.

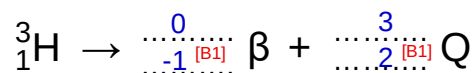
Answer	Marks
Any 1 of the following - More turns in coil B - Larger emf / more cells in primary source - Laminate the iron ring - Coil A and B are closer on the ring - Any logical answers that would induce a larger e.m.f. in B	B1

[Total: 6 marks]

- 8 (a) The nuclide notation for the radioactive isotope hydrogen-3 is ${}^3_1\text{H}$.

Hydrogen-3 has a half-life of 12.3 years and decays by the emission of beta particles to an isotope of a different element. This element is represented in the equation by Q.

- (i) Complete the nuclide equation for the decay of hydrogen-3.



[2]

Answer	Marks
β - mass no. = 0; proton no. = -1	B1
Q - mass no. = 3; proton no. = 2	B1

- (ii) A sample of hydrogen-3 is placed on a laboratory bench next to a Geiger-Müller tube and a counter.

The count rate is recorded at the same time on four successive days and data obtained are as shown in Table 8.1.

Table 8.1

day	1	2	3	4
count rate (counts / s)	154	149	156	150

State why the count rate decreases and increases.

Answer	Marks
(due to) <u>random</u> nature of (radioactive) decay	B1

- (b) Leaks in shallow underground water pipes are detected using hydrogen-3 as a radioactive tracer.

- (i) Explain why alpha emissions are not suitable for use in this situation.

Answer	Marks
(all) emitted <u>alpha</u> particles will be <u>stopped by the soil</u> and <u>not reach the detector</u>	B1

- (ii) Explain why the radioactive tracer must **not** have a very **short** half-life in this situation.

Answer	Marks
count rate/ activity decreases in a short time to too low a level for detection	B1

- (iii) Before hydrogen-3 is added to the water, the detector measures the background radiation above the pipe. The average background radiation is 40 counts / minute.

Suggest one source of radiation that may make a significant contribution to the background count rate.

Answer	Marks
radioactive gases (i.e. radon) / rocks / food / cosmic rays / any other sources	B1 - any

- (iv) Hydrogen-3 is added to the water and the detector shows a count rate of 79 counts / second above the leak in the water pipe.

Determine the count rate due to the tracer.

Answer	Marks
corrected count rate = count rate – background = (79×60) – 40	M1
= 4700 counts / minute	A1

count rate = [2]

[Total: 8 marks]

- 9 An object of mass 1.5 kg is released from a stationary hot air balloon at time $t = 0$ s. Fig. 9.1 shows how the velocity of the object varies with time.

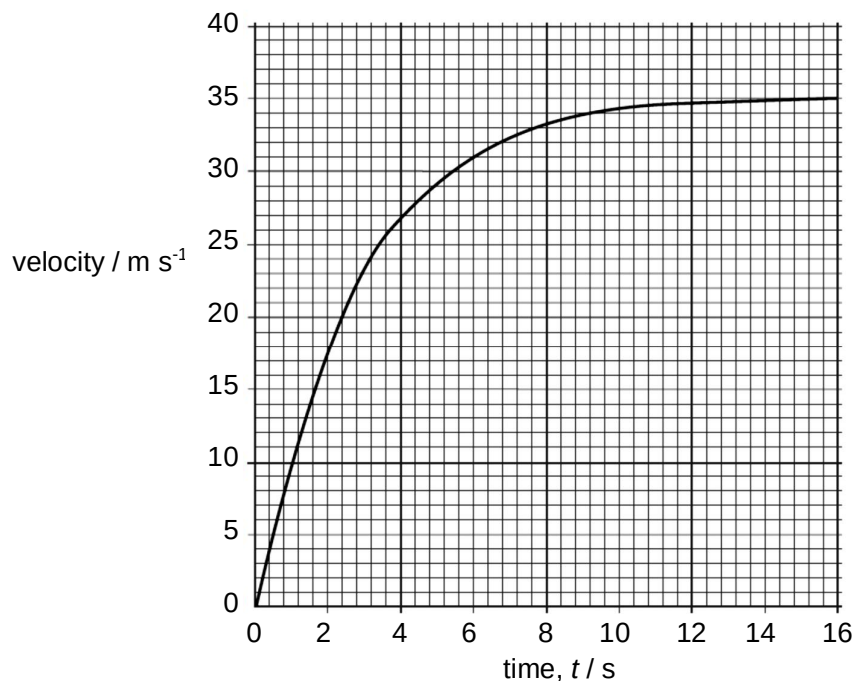


Fig. 9.1

- (a) Define *velocity*.

Answer	Marks
rate of change of displacement OR change in displacement per unit time	B1

- (b) Describe the motion of the object from

- (i) $t = 0$ s to $t = 1$ s

Answer	Marks
moving downwards with speed/velocity increasing at a constant rate	B1

- (ii) $t = 4$ s to $t = 12$ s

Answer	Marks
moving downwards with speed/velocity increasing at a decreasing rate	B1

- (c) Using Fig. 9.1, determine the acceleration of the object at 6.0 s after it was released.

Answer	Marks
acceleration = gradient of tangent to the graph at 6.0 s = 1.6 m s^{-2} ($\pm 0.2 \text{ m s}^{-2}$) OR = 1.6 m s^{-2} ($\pm 0.1 \text{ m s}^{-2}$)	M1 A1 or A2

acceleration = [3]

(d) The object falls through a height of 450 m in the first 16 s after it was released.

(i) Explain how the distance of 450 m may be determined from Fig. 9.1.

Answer	Marks
area under graph between $t = 0$ s and $t = 16$ s	B1

(ii) The gravitational field strength g is 10 N kg^{-1}

For the 16 s after the object was released, calculate

1. the loss in energy in the gravitational potential store of the object ΔE_p , and

Answer	Marks
$\Delta E_p = mgh$ $= 1.5 (10)(450)$ $= 6800 \text{ J}$ accept 6750 J	A1

$\Delta E_p = \dots\dots\dots$ [1]

2. the gain in energy in the kinetic store of the object ΔE_k .

Answer	Marks
$\Delta E_k = \frac{1}{2}mv^2$ (- $\frac{1}{2}mu^2$) $= \frac{1}{2} (1.5)(35.0)^2$ $= 920 \text{ J}$ accept 919 J	A1

$\Delta E_k = \dots\dots\dots$ [1]

(iii) Using your answers to (ii), determine the average air resistance f_{air} acting on the object for the 16s after it was released.

Answer	Marks
$WD_{\text{against air resistance}} = \Delta E_p - \Delta E_k$	M1
$(f_{\text{air}})(450) = 6750 - 919$	C1
$f_{\text{air}} = 13.1 \text{ N}$ accept 13.0 N	A1 – allow e.c.f. from (ii)

$f_{\text{air}} = \dots\dots\dots$ [3]

[Total: 12 marks]

Section B

Answer **one** question from this section.
Answer either **Question 10** or **Question 11**.

- 10** A student sets up the circuit shown in Fig. 10.1.

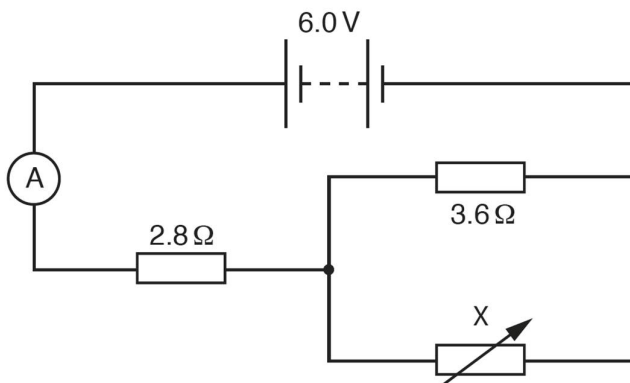


Fig. 10.1

The electromotive force (e.m.f.) of the battery is 6.0 V.

- (a) State what is meant by the *electromotive force* of a battery.

Answer	Marks
It is the work done per unit charge by the battery in driving charges around a complete circuit	B1

- (b) The resistance of the variable resistor X is set to 1.8 Ω.

Determine

- (i) the total resistance of the circuit,

Answer	Marks
total resistance of circuit = $(1/3.6 + 1/1.8)^{-1} + 2.8$	C1
= 4.0 Ω	A1

resistance = [2]

- (ii) the reading on the ammeter,

Answer	Marks
reading on ammeter = V/I = 6.0 / 4.0 = 1.5 A	A1
accept 1.50 A	

reading = [1]

(iii) the potential difference across the 3.6Ω resistor.

Answer	Marks
By potential divider principle: p.d. across 3.6Ω resistor $= 1.2 / 4.0 \times 6.0$	M1
$= 1.8 \text{ V}$ accept 1.80 V	A1

potential difference = [2]

(c) The resistance of X is increased.

State and explain how this affects the current through

(i) the 2.8Ω resistor, and

Answer	Marks
total resistance of the circuit increases	M1
current through 2.8Ω resistor decreases	A1

(ii) the 3.6Ω resistor

Answer	Marks
(effective resistance across parallel segment and hence) p.d. across the 3.6Ω resistor increases (by potential divider principle)	M1
current through 3.6Ω resistor increases	A1

[Total: 10 marks]

- 11 A student investigates the effects of heating on evaporation by using a setup with a small electrical heater is placed inside a cup of water, as shown in Fig. 11.1. The mass of water is 200 g.

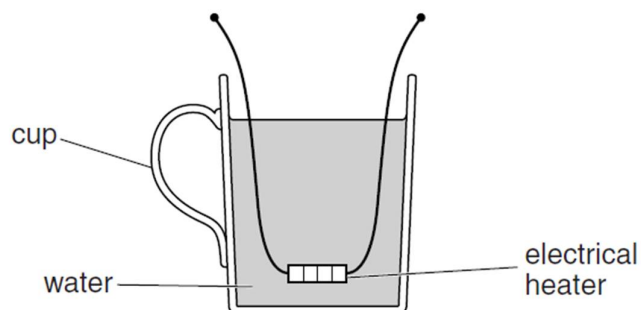


Fig. 11.1

The heater has an output power of 480 W. The water is heated from 30 °C and the temperature of water rises to 60 °C after 8.0 minutes. The specific heat capacity of water is 4.2 J / (g °C) and the specific latent heat of vaporisation for water is 2.26×10^6 J/kg. Assume that there are no other heat losses.

- (a) Calculate the amount of energy needed to raise the temperature of water from 30 °C to 60 °C.

Answer	Marks
Energy used = $mc\Delta\theta$ = $200 \times 4.2 \times (60 - 30)$	M1
25000 J accept 25 kJ; 25200 J; 25.2 kJ	A1 – with units

amount of energy = 25000 J [2]

- (b) It is noticed that some of the water evaporates during heating.

- (i) Calculate the mass of the water that has evaporated during heating.

Answer	Marks
Let m_v be the mass of water that has evaporated. Energy supplied = $mc\Delta\theta + m_v l_v$ $480 \times 8.0 \times 60 = 25000 + (m_v \times 2.26 \times 10^6)$ Or $480 \times 8.0 \times 60 = 25000 + (m_v \times 2260)$	M1 – correct substitution in equation
$m_v = 0.091 \text{ kg or } 0.0909 \text{ kg or } 91 \text{ g or } 90.9 \text{ g}$	A1 – with units

mass of water evaporated =91 g..... [2]

(ii) State two differences in the process between evaporation and boiling.

Answer	Marks
Any two: - Evaporation occurs at the surface while boiling occurs throughout the liquid. - Evaporation occurs at any temperature (accepts room temperature) while boiling occurs at the boiling point / fixed temperature / 100 °C. - Evaporation does not require a heat source but boiling needs one. - Temperature of liquid remains constant during boiling, but temperature of liquid tends to drop during evaporation.	B1 each - there must be relevant point-to-point comparison

(iii) Describe, using ideas about molecules of water, what happens during evaporation.

Answer	Marks
Faster moving / more energetic water molecules at the surface	B1
escape from the liquid / break free from other water molecules to become gas / vapour	B1

(iv) Suggest and explain one change that could reduce the rate of evaporation.

Change – M1	Explanation – A1
lower temperature of liquid or surroundings	molecules have less energy to escape from the liquid (surface)
OR reduce surface area	lower chance / less space for molecules to escape
OR reduce wind / air movement	escaped molecules are not moved away
OR increase humidity	more molecules return from air
OR increase atmospheric pressure	higher chance of colliding with fast moving air particles and moving back into the liquid

[Total: 10 marks]