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Section A

Answer all questions in this section.

For Examiner's Use

1 During the SG50 National Day Parade performance, a parachutist leaped off a plane and experienced free fall.

(a) On Fig. 1.1, draw and label the forces acting on the parachutist if he fell vertically downwards. [2]

Fig. 1.1

(b) Fig. 1.2 shows how the speed of the parachutist varied with time.

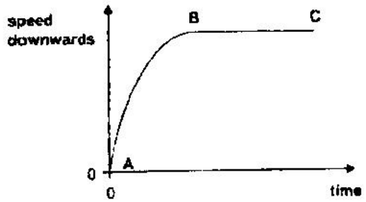


Fig. 1.2

(i) What would be the initial value of the acceleration of the parachutist?

Initial acceleration: ....[1]

(ii) Explain why the acceleration of the parachutist decreases from A to B and why he finally fell at a constant speed after B.

....

....

....

....

.... [2]

(iii) On Fig. 1.3, draw the acceleration-time graph for the parachutist from A to C. Label your graph clearly with the letters A, B and C. [1]

For Examiner's Use

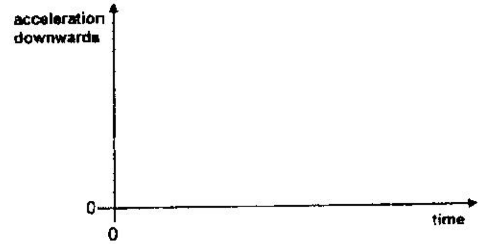


Fig. 1.3

2 Fig. 2.1 shows a firefighter of total weight 840 N in equilibrium at the top of the ladder that is pivoted at point P.

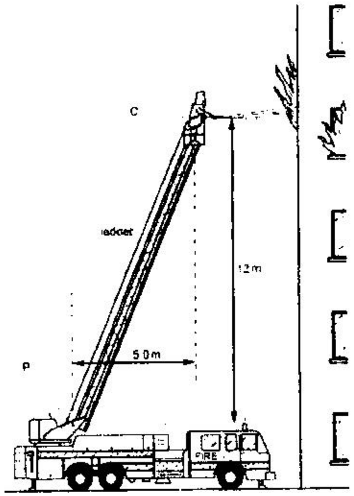


Fig. 2.1

(a) The ladder leans towards a burning building at an angle such that the centre of gravity C of the fire-fighter is 12 m above and 5.0 m to the right of P. The firefighter holds a hose that directs a high-speed jet of water horizontally into a burning building.

(i) Calculate the moment M of the firefighter's weight about P.

moment M = ... [2]

(ii) The jet of water causes a horizontal force R on the firefighter that acts towards the left, through C. This opposes the turning effect of his weight.

Calculate the size of R that, **on its own**, ensures that M is exactly cancelled.

force = ... [2]

(iii) Suggest a third force that has a turning effect about P on the ladder.

.... [1]

(b) Fig. 2.2 shows the firefighter.

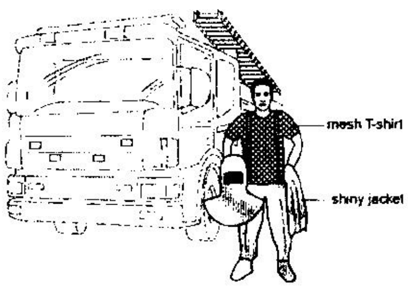


Fig. 2.2

The jacket of his protection suit has a **shiny, silver-coloured outer surface**. Underneath it, he wears a **loosely-woven mesh** T-shirt. Explain how wearing the shiny jacket and the mesh T-shirt helps to keep the firefighter cool when he is close to a source of intense heat.

....

....

....

....

....

....

.... [4]

3 A small amount of helium gas is trapped in a test-tube as shown in Fig. 3.1.

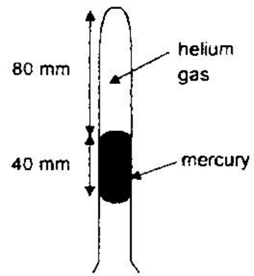


Fig. 3.1

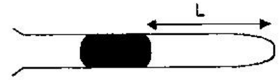


Fig. 3.2

(a) Calculate the pressure of the helium gas in Pa given that the atmospheric pressure is 760 mmHg. Take the density of mercury to be 13 600 kg/m^3 and the acceleration due to gravity to be 10 m/s^2.

pressure = ... Pa [2]

(b) The test-tube is slowly rotated 90° as shown in Fig. 3.2. Assuming that there is no change in temperature, state whether the length L will remain as 80 mm, longer than 80 mm or shorter than 80 mm. Explain your answer.

....

....

....

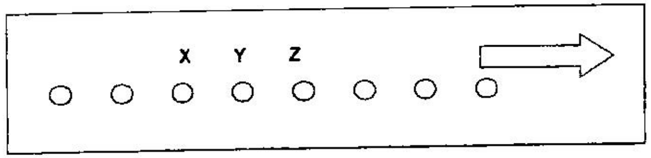
....

.... [2]

4 (a) Light is a transverse wave and sound is a longitudinal wave. Illustrate and explain their differences *in separate diagrams below* using particles **X**, **Y** and **Z** to represent in a medium which the waves are passing continuously in the direction indicated by the arrow. [4]

For Examiner's Use

Transverse Wave

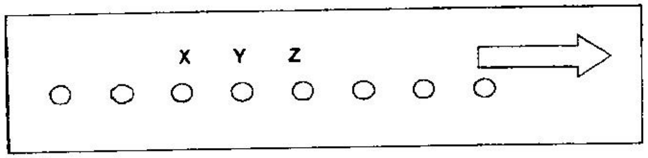


Explanation: ....

....

....

Longitudinal Wave



Explanation: ....

....

....

(b) A boy, using a stopwatch, notes that there is a 3.0 seconds delay between seeing a flash of lightning and hearing the sound of the thunder. How far is he from the thunderstorm? Take the velocity of sound in air to be 330 ms^{-1}.

distance = ... [2]

(c) Fig. 4.1 shows an incorrect electromagnetic spectrum drawn by a student. The parts of the spectrum and the wavelengths are in the wrong order. The values of the wavelengths do not match the correct parts of the spectrum.

For Examiner's Use

[illegible]						[illegible]
microwaves	radio waves	ultraviolet rays	infra-red rays	gamma rays	X-rays	visible light
10^3 m	10^{-14} m	10^{-10} m	10^{-6} m	10^{-2} m	10^{-8} m	10^{-5} m

Fig. 4.1

(i) On Fig. 4.2, complete the table of the electromagnetic spectrum. Radio waves and their correct wavelength have been inserted for you. [3]

short wavelength						[illegible]
						radio waves
						10^3 m

Fig. 4.2

(ii) State the magnitude of the speed of all electromagnetic waves in air.

.... [1]

(iii) State two applications of ultra-violet rays.

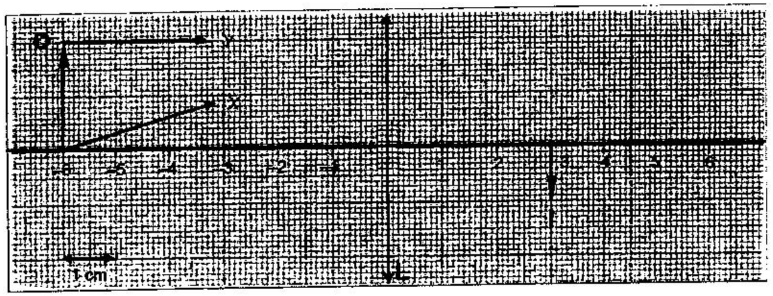
....

....

....

.... [2]

5 The scale diagram below represents a converging lens **L**, object **O** and image **I**. Object **O** is 6.0 cm away from **L** while image **I** is 3.0 cm away from **L**.



(a) Complete the ray diagram above such that light rays **X** and **Y** from the object **O** passes through the lens L and end up on the image I. [2]

(b) From the completed ray diagram in part (a), determine the focal length of L.

focal length of L = ... [1]

(c) Object **O** is now moved such that it is 3.0 cm away from the lens. State the characteristics of the image produced.

....

.... [2]

6 When an aircraft is being refuelled as shown in Fig. 6, the fuel can become negatively charged as it flows along the metal pipe to the fuel tanks.

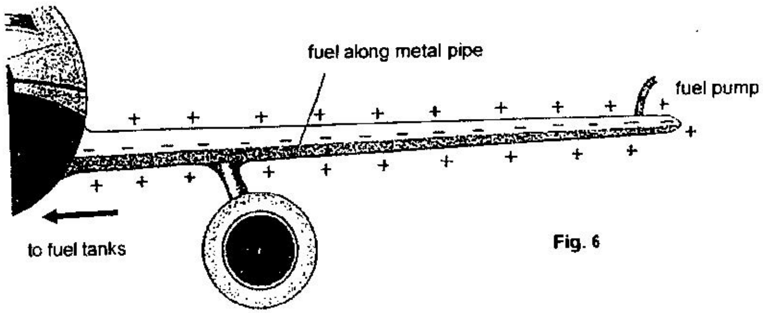


Fig. 6

(a) How does the fuel become negatively charged?

.... [1]

6 (b) Why is the metal pipe positively charged?

.... [1]

(c) The build-up of charge on the wings of the aircraft could be **dangerous**. State a reason for this.

.... [1]

(d) During refuelling, the metal air frame of the aircraft is connected to the ground. Give a reason for this.

.... [1]

7 Fig. 7 shows a circuit containing a light-dependent resistor (LDR) in series with a resistor of resistance 1500 Ω. It also contains two resistors of resistance 250 Ω each, connected in series. The circuit is connected to a power supply of 9.0 V.

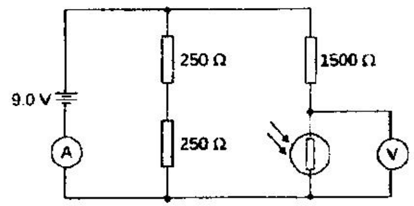


Fig. 7

When no light falls on the LDR, its resistance is 3000 Ω. Calculate

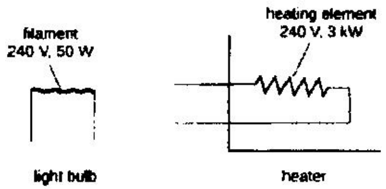
(a) the reading on the ammeter;

ammeter reading = ... [2]

(b) the reading on the voltmeter.

voltmeter reading = ... [2]

8 The diagrams below show the filament in a light bulb and the heating element in a heater with different power ratings.



(a) Which one, filament in a light bulb or the heating element in a heater, has a higher resistance? Explain your answer.

....

....

....

....

.... [2]

(b) The connecting wires have a large cross-sectional area.
Explain how this feature helps the connecting wires of the heating element in the heater to remain relatively cool even when the heater has been turned on for a period of time.

....

....

....

....

.... [2]

(c) Determine a suitable fuse rating for the heater. Show your working clearly.

fuse rating = ... [2]

For Examiner's Use

Section B

Answer **all** the questions in this section.
Answer only one of the two alternative questions in **Question 11**.

9 **Water from icebergs**

Some hot countries cannot rely on rain or the water from rivers to supply enough water.

One suggestion is to use water from icebergs found in the Atlantic Ocean. Icebergs made from fresh water can be towed to a port in the hot country. When they arrive, they are allowed to melt in the Sun or energy from a local power station can be used to melt them.

You are asked to make calculations on this suggestion using the data provided.

Data

Distance to tow an iceberg	1.0×10^4 km
Towing speed	0.80 m/s
Mass of iceberg	1.0×10^{11} kg
Effective surface area of iceberg exposed to Sun	4.0×10^5 m^2
Sun's radiation at the Earth's surface	600 W/m^2
Specific latent heat of ice	3.4×10^5 J/kg
Electrical power output from local power station	500 MW

(a) Estimate the time taken to tow an iceberg to the port.

time = ... [2]

(b) Show that 3.0×10^{15} J of energy from the Sun are incident on the iceberg whilst it is towed to the port.

energy = ... [2]

For Examiner's Use

(c) (i) Estimate the mass of ice melted by the Sun as it is towed to the port.

mass = ... [2]

(ii) State one assumption that you have made in your estimate for (i).

....

.... [1]

(d) Discuss, using suitable calculations, the choice between allowing the ice to melt in the Sun and melting the ice with energy from the power station.

....

....

....

....

....

.... [3]

10 (a) A torch contains a filament lamp connected to a battery. The battery contains four 1.5 V cells connected in series.

Fig. 10.1 shows the current/potential difference (voltage) graph for the filament lamp.

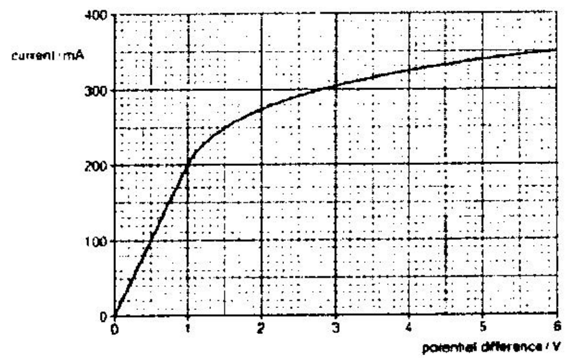


Fig. 10.1

(i) State what is meant by the *potential difference* (p.d.) across the lamp.

....

.... [1]

(ii) Fig. 10.1 shows that the current in the lamp is not proportional to the p.d.

1. State how Fig. 10.1 shows this.

....

.... [1]

2. Suggest why the current is not proportional to the p.d.

....

.... [1]

(iii) The lamp is at normal brightness and there is a p.d. of 6.0 V across the lamp.

1. Use Fig. 10.1 to find the current in the lamp.

current = ... [1]

2. Calculate the charge that passes through the lamp in 2.0 hours.

charge = ... [2]

3. The battery in the torch is able to keep the lamp lit for 2.0 hours.
Estimate the initial energy stored in the battery.

energy = ... [2]

4. Explain why your value is only an estimate.

....

.... [1]

(b) Suggest an advantage of using two cells in parallel rather than a single cell.

....

.... [1]

11 EITHER

(a) Fig. 11.1 shows a light aluminium rod AB resting between the poles of a U-shaped magnet. A current is passed through the rod from the two brass strips connected to a power supply.

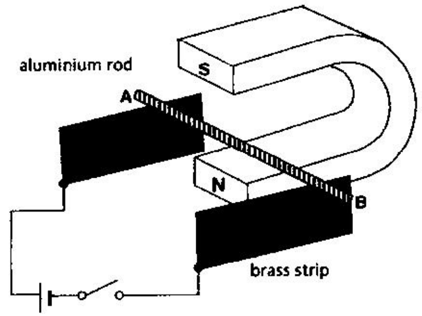


Fig. 11. 1

(i) State which way the rod moves when the switch is closed. Give a reason for your answer.

....

....

....

.... [2]

(ii) State the effect on the movement of the rod when

1. the current is increased;

.... [1]

2. the current is reversed.

.... [1]

(b) The set-up is modified as shown in Fig. 11.2. A stiff wire, CD, is connected to a galvanometer by flexible wires so that it can move freely in any direction. The wire CD is set swinging by pulling the wire outwards and then releasing it as shown in Fig. 11.3.

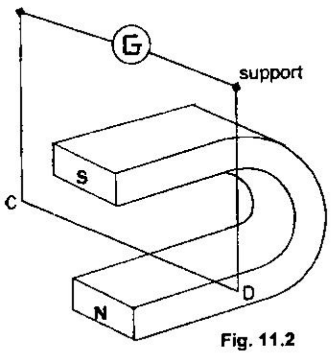


Fig. 11.2

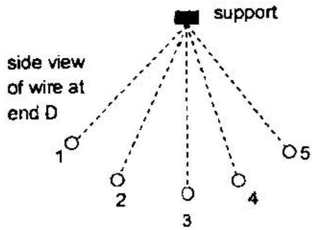


Fig. 11.3

Fig. 11.4 shows how the reading on the galvanometer varies with time after the wire has been set swinging.

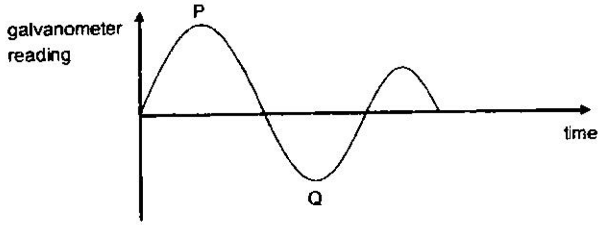


Fig. 11.4

(i) Briefly explain why there is a deflection in the galvanometer.

....

....

.... [1]

(ii) State the direction of the current in the stiff wire CD when it is released from position 1.

.... [1]

For Examiner's Use

(iii) Which of the stages 1 to 5 corresponds to the reading shown as 'P' on the graph? Explain your answer.

....

....

....

....

.... [2]

(iv) Explain why the magnitude of the reading on the galvanometer is less at 'Q' than at 'P'.

....

....

....

....

.... [2]

11 OR

(a) Fig. 11.5 shows a simple alternating current generator.

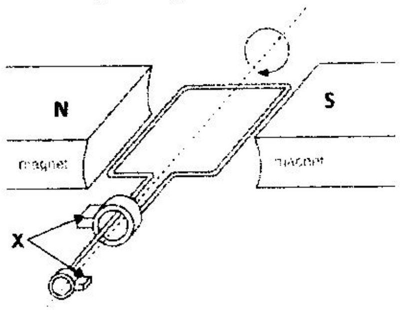


Fig. 11.5

(i) Indicate on Fig. 11.5 the direction of the current induced in the coil when the coil is in the horizontal position as shown. [1]

(ii) The current changes direction as the coil rotates. At which position(s) of the coil will the current change its direction?

.... [1]

(iii) Name and describe the purpose of component X.

....

....

.... [2]

(b) Transformers are used to step up voltage in order to transmit electrical power at very high voltage using alternating currents.

(i) Why should electrical power be transmitted at high voltage and using alternating current?

....

....

....

....

.... [2]

(ii) A transformer has 2000 turns in its primary coil and 100 turns in its secondary coil. The output voltage is 12 V. Calculate the voltage of the a.c. supply.

voltage = ... [2]

(iii) Suggest two ways in which the efficiency of a practical transformer can be improved.

....

....

....

....

....

.... [2]

PAPER 2 SECTION A

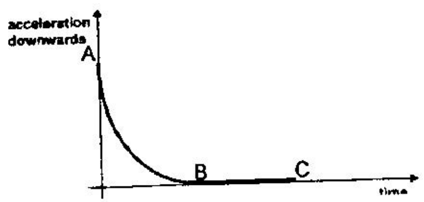
1 a)
- Arrow for weight / gravitational force
- Arrow for air resistance

Note: penalise 1 mark
- if arrows not drawn from c.g. or touching the body
- if symbols are used for labelling forces

b) i) Initial acceleration = 10 m/s^2

ii)
- From A to B, air resistance increases as he fell and **resultant force decreases** (which decreases his acceleration)
- At B, air resistance is equal to his weight, **resultant force** /acceleration is **zero** (and he fell at constant speed)

iii)



2 a) i) Moment M = 840 x 5.0
= 4200 Nm

ii) 4200 = R x 12
R = 350 N
ECF from (i)

iii) the weight of the ladder or
the weight of the hose & water

b)
- Shiny surface is a good reflector or poor absorber of radiation
- hence **suit/jacket** gets heated up at a slow rate.
- Mesh T-shirt traps **air** which is an insulator/poor conductor
- therefore heat is **conducted** to the **body** at a slow rate.

3 a) pressure due to helium + pressure due to mercury = atm pressure
p = (760 – 40) mmHg = 720 mm Hg
= 0.720 x 10 x 13600
= 9.79 x 10^4 Pa

b) Atmospheric pressure does not need to support the mercury column and hence will be greater than pressure of helium gas. Mercury column will be pushed inward, making L smaller. Length will be shorter than 80 mm.
OR
Pressure of helium gas will be equal to the atmospheric pressure and hence is greater than before.
For pressure to increase, volume must decrease and hence length will decrease. Length will be shorter than 80 mm.

4 a) **Transverse Wave**

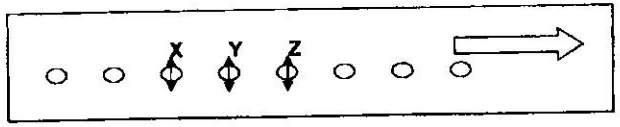


Diagram shows perpendicular vibration for X, Y, Z (all 3)
Explanation: In a transverse waves, the **particles vibrate perpendicularly** to the wave motion.

Longitudinal Wave

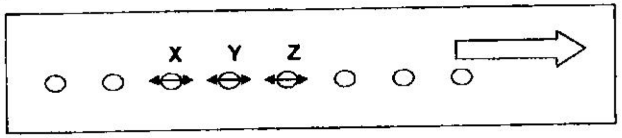


Diagram shows parallel vibration for X, Y, Z (all 3)
Explanation: In a longitudinal waves, the **particles vibrate parallel** to the wave motion.

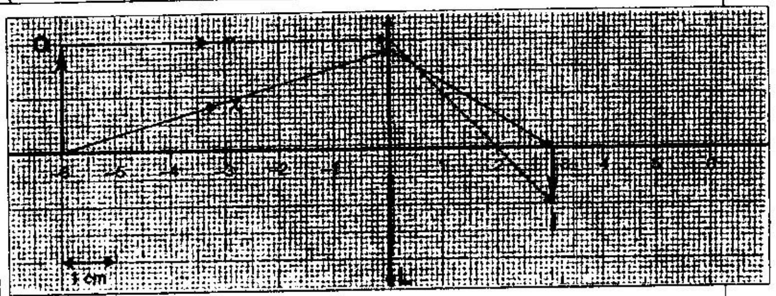
b) Distance = speed x time
= 330 x 3
= 990 m

c) i)

Gamma rays	X-rays	Ultra violet rays	Visible Light	Infra red rays	Micro waves	radio waves
10^{-14}	10^{-10}	10^{-8}	10^{-6}	10^{-5}	10^{-2}	10^{3} m

Correct order of magnitude of wavelength – 1 mark
Correct order of waves – 2 marks; 2 errors – 1 mark

ii) 3.0×10^8 m/s

	iii)	Any 2 correct uses for UV • to detect fake notes • in sun-bed for artificial sun-tanning • to sterilise hospital equipment (or any other suitable uses) (do not accept 1 word answer eg sun-bed, bank, sterilisation)
5	a)	
	b)	f = 1.9 cm or 2.0 cm (or based on diagram)
	c)	real, inverted, magnified (since f < u < 2f ; based on (b) answer)
6	a)	It gains electrons from metal pipe **by friction** (or as it rubs against the metal pipe)
	b)	It loses electrons to the fuel
	c)	The build-up of charges can produce **sparks** which can ignite the fuel / cause an explosion
	d)	To the earth/discharge the metal aircraft OR electrons flow up (from ground) to neutralise the aircraft
7	a)	$\frac{1}{R} = \frac{1}{250+250} + \frac{1}{1500+3000}$ R = 450 Ω I = 9 / 450 = 0.020 A
	b)	$V = \frac{3000}{3000 + 1500} \times 9.0$ V = 6.0 V

8	a)	The power of the filament is lower than that of the heating element and since $P = \frac{V^2}{R}$ (and V is the same), the resistance of the filament is higher. OR The power of the filament is lower and hence the current through it is lower. Since V is the same, the resistance of the filament is higher.
	b)	A larger cross-sectional area means that the wire has a lower resistance. Hence, the heat produced ($E = I^2Rt$) will be much lower and hence it remains relatively cooler.
	c)	I = 3000 / 240 = 12.5 A Fuse rating : 13A, 14 A or 15 A
9	a)	$t = \frac{s}{v} = \frac{1.0 \times 10^4 \times 10^3\ m}{0.80\ m/s}$ t = 1.25×10^7 s (208000 min / 3470 h / 145 days)
	b)	P = 600 W/m² x (4.0×10^5 m²) = 2.4×10^8 W E = (2.4×10^8) x (1.25×10^7) = 3.0×10^{15} J
	c) i)	Q = mℓ 3.0×10^{15} = m x 3.4×10^5 m = 8.82×10^9 kg
	ii)	Any one of the following or other reasonable assumption: • surface of the iceberg remains the same • Sun is shining throughout the journey • Power of /energy from the sun is constant • iceberg is not melted by any other means like water etc
	d)	Power from the Sun to melt the ice = 2.4×10^8 W (part b) Power from the power station = 500 MW = 5.0×10^8 W OR Time taken by Sun to melt remaining iceberg = (1.0×10^{11} - 8.8×10^9) x 3.4×10^5 / 500 x 10^6

		$= 6.2 \times 10^7$ s Time taken by power station to melt = $(1.0\times10^{11} - 8.8\times10^9) \times 3.4\times10^5 / 600 \times 4.0 \times 10^5$ $= 1.29 \times 10^8$ s Hence, it will be **more efficient** to melt the ice using the energy from power station since it has a larger power OR it takes a shorter time. *Bonus points (max score for question is 3 marks):* *Power from the power station can be more controlled than power from the Sun.* *Energy from the Sun is free but need to use fossil fuel in power station.*
10	a) i)	P.d. is the work done by one coulomb of charges passing through **the lamp** P.d. is the energy per unit charge converted as it passes through **the lamp**
	ii) 1)	Graph is not straight or is a curve or its gradient changes
	2)	Filament gets hotter or its temperature increases or its resistance increases
	iii) 1)	350 mA or 0.35 A
	2)	$Q = 0.35 \times (2 \times 60 \times 60)$ (ECF) $= 2520$ C or 2500 C Accept: $Q = 350$ mA $\times$ 2 h $= 700$ mAh
	3)	$E = QV = 2520 \times 6.0$ $= 15100$ J or 15000 J
	4)	Any one of the following: • current and / or voltage falls / varies • or some energy remains (in cell) • or some energy / heat produced in cell / in connecting wires • or correct argument involving internal resistance of cell
	b)	Any one of the following: • cells will be able to supply current for a longer period / last longer

		• if one cell fails, the other cell can still supply current • *cells in parallel supply higher current as internal resistance is decreased*
11 E	a) i)	Rod moves out of the magnet / to the left. Current flows from A to B/magnetic field from N to S and using Fleming's Left Hand Rule, the direction of the force on the rod is out of the magnet.
	ii) 1)	The rod moves out of the magnet at a faster rate / moves further outwards.
	2)	The rod moves into the curved part of magnet or in the opposite direction.
	b) i)	As the wire swings, it is cutting the magnetic field and an emf is induced and an induced current flow to cause deflection.
	ii)	Current flows from C to D
	iii)	Stage 3. Speed of the wire is greatest at this position as it has the greatest K.E.. Hence, the **rate of cutting of magnetic field is greatest** and emf induced is largest (Faraday's Law).
	iv)	The induced current flows in such a way that it opposes the swinging of the wire (Lenz's Law). Hence, maximum speed of wire as it swings back is reduced and induced emf is also reduced. (note: effect of friction or air resistance is not as significant to cause the decrease so quickly)
11 O	a) i)	Direction of current – clockwise around the coil
	ii)	when the coil is in the vertical position
	iii)	carbon brushes To provide electrical contact between the coil and the external circuit

	b) i)	At high voltage, current in the cable is very low and hence it reduces power loss during transmission. Transformers are needed for transmission and they can only work using alternating current. OR Alternating current is required to create a continuous changing magnetic field in order for the **transformer** to work.
	ii)	$\frac{V_p}{V_s} = \frac{N_p}{N_s}$ $V_p = \frac{2000}{100} \times 12$ $= 240V$
	iii)	Any two of the following: • **Low resistance copper wires** should be used to reduce heat loss • Using **laminated core** to reduce eddy currents • **Design the core** to reduce magnetic field leakage between primary and secondary coils • Use **effective** soft magnetic material for the core to reduce energy loss in flipping magnetic fields