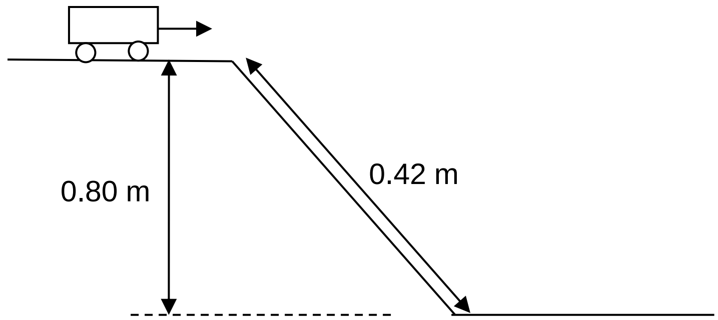
1 The diagram shows a model car with a mass of 0.25 kg. The car is travelling at a constant speed of 1.70 m/s as it approaches the rough ramp. The average friction opposing the motion of the car down the ramp is 0.15 N. Assume air resistance is negligible.



(a) Calculate the work done against friction as it moves down the rough ramp.

work done = f x d
= 0.15 x 0.42
= 0.0630 J [1]

(b) Calculate

(i) the loss in gravitational potential energy as the car moves down the the ramp,

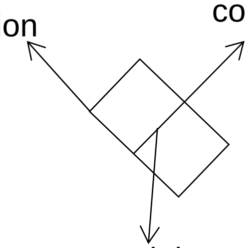
E_p = 0.25 x 10 x 0.8
= 2.00 J [1]

(ii) the speed of the car at the bottom of the rough ramp.

$E_k = 2 + (½ \times 0.25 \times 1.7^2) – 0.063$
= 2.29825 [1]

$2.29825 = ½ \times 0.25 \times v^2$
$v^2 = 18.386$
v = 4.29 m/s [1]

(c) Draw a free body diagram of the other forces acting on the car when it moves down the ramp, labelling the forces acting on the car.



[2]

[Total: 6]

2 Fig. 2.1 shows a lorry accelerating along a straight road. The driving force exerted on the lorry in the forward direction is D and the total backward force acting on the lorry is B.

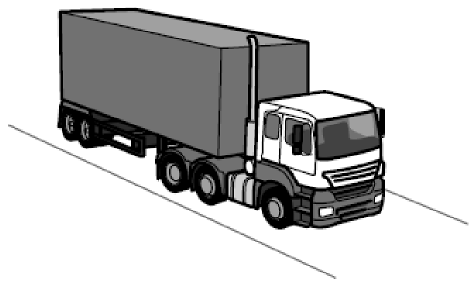


Fig. 2.1

The gravitational field strength is 10 N/kg.

(a) Compare the magnitude of the forces D and B. Give a reason for your answer.

Force D is greater than force B, so that the resultant force acting on the lorry is in the forward direction, causing it to accelerate forward. [1]

(b) The lorry subsequently turns a corner at a constant speed of 12 m/s.

(i) Express the speed of the lorry in km/h.

12 m/s = (12/1000)/(1/3600)

= 43.2 km/h [1]

(ii) State and explain whether the lorry is accelerating when it turns the corner.

Since the direction of the lorry's velocity changes as it turns the corner, there is a change in its velocity. Hence the lorry is accelerating, even though its speed is constant. [1]

[Total: 3]

3 Fig. 3.1 shows a uniform plank of mass 5.0 kg and length 2.0 m resting horizontally on two trestles, P and Q.

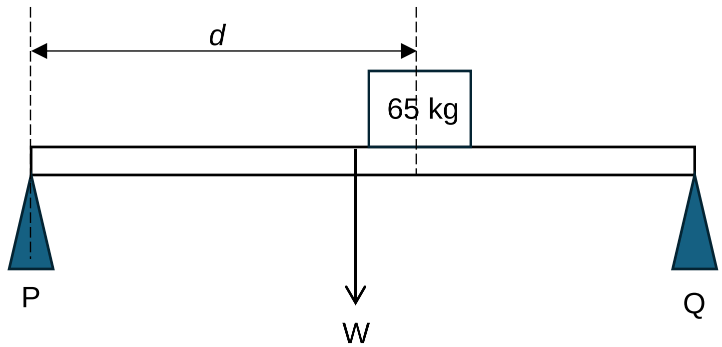


Fig. 3.1

Trestle Q exerts a force of 440 N on the plank when an object of mass 65.0 kg is placed at a distance, *d*, from P. The gravitational field strength, *g* = 10 N/kg.

(a) Calculate the moment due to the weight of the plank.

moment = 50 x 1
= 50 Nm [1]

(b) State the principle of moment.

<u>For an object to be in equilibrium, the sum of clockwise moment about the pivot is equal to sum of anti-clockwise moment about the same pivot.</u> [1]

(c) Determine the distance *d*, of the object from P.

sum of clockwise moment = sum of anti-clockwise moment
(50 x 1) + (650 x d) = 440 x 2 [1]
5 + 650d = 880
650d = 830
d = 830/650
= 1.2769 [1]
= 1.28 m

[Total: 4]

4 (a) Fig. 4.1 shows a ray of light XY being directed at the surface AB of an irregular-shaped glass block ABCDE.

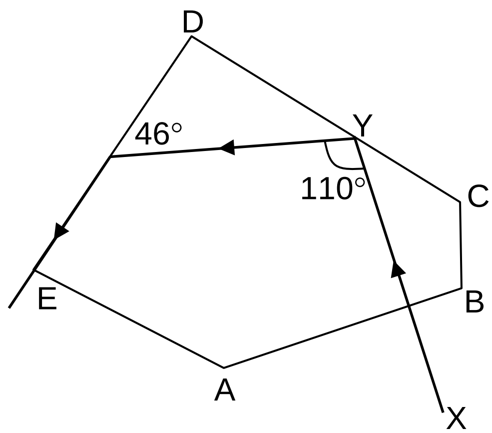


Fig. 4.1

(i) Explain why the ray XY enters surface AB without bending.

<u>The light is travelling alone the normal and thus no refraction of light.</u> [1]

(ii) Determine the critical angle of the glass.

critical angle = <u>44.0°</u> [1]

(iii) Calculate the speed of the light ray in the glass block.

$n = 1/(\sin 44^{o})$
$= 1.43956$
$= 1.44$ (3 s.f.)- [1]

$n = c/v$
$v = c/n$
$= 3 \times 10^{8}/1.43956$
$= 2.08 \times 10^{8}$ m/s [1]

(b) Fig. 4.2 shows how a thin converging lens L made of the same glass is used to produce a sharp image of an arrow that is twice the size of the illuminated object.

In the space below, complete the diagram from the top of the object to show how the sharp image is formed.

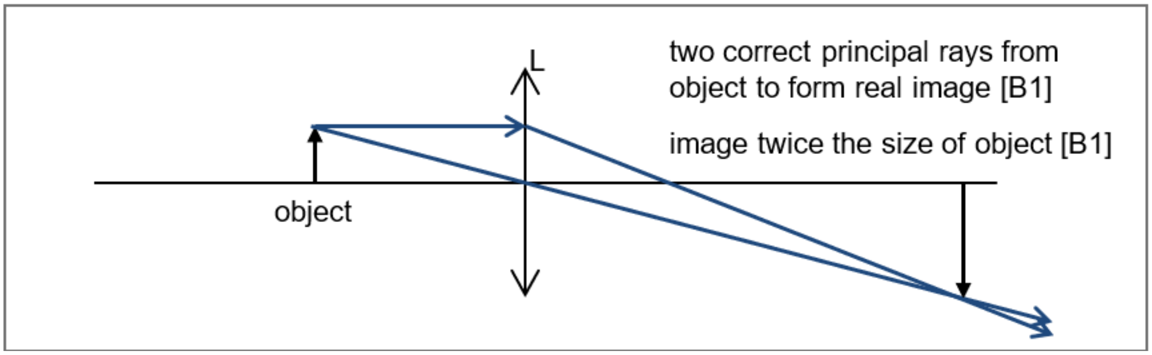
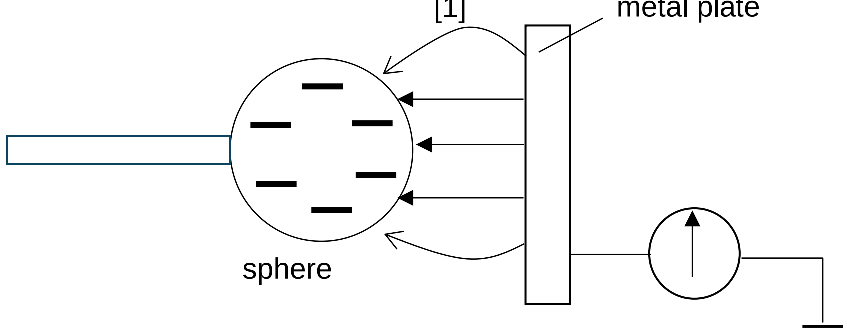


Fig. 4.2

[2]

[Total: 8]

5 The diagram shows a negatively charged metallic sphere held with an insulating handle. When the sphere is brought towards a metal plate, the sensitive galvanometer registers a momentary deflection.



(a) Explain why the galvanometer registered a momentary deflection when the charged sphere was brought near.

The electrons from the metal plate is being repelled by the negatively charged sphere as like charges repel. [1]
As the metal plate is earthed this will allows the electrons to move to the earth. This movement of electrons causes the deflection on the galvanometer. [1]

(b) Draw on the above diagram, the electric field set up between the sphere and the plate when the sphere was brought near. [1]

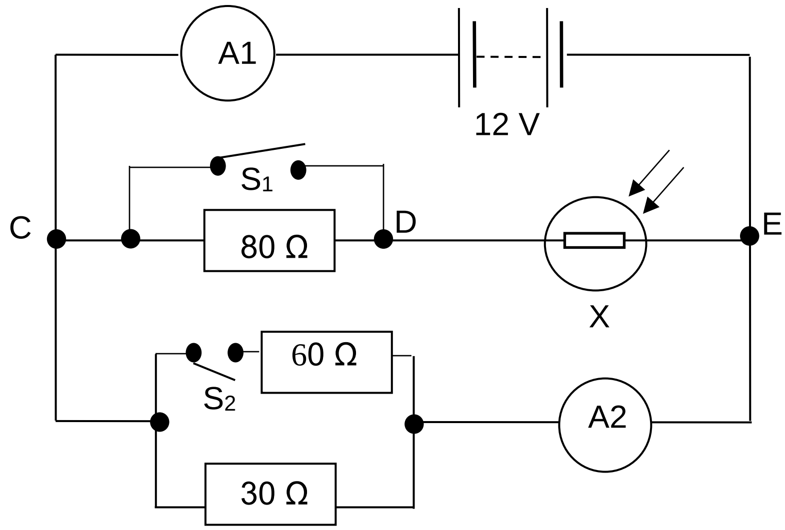
(c) Describe what would be observed if the charged sphere was held in hand and moved towards the metal plate. Explain your observation.

There will be no deflection. [1]

The charged sphere will be discharged when held in hand as the sphere is being earthed through the hand. [1]

[Total: 5]

6 The diagram shows an electrical circuit with different electrical components. The resistance of X is 2000 Ω and 400 Ω in dark and bright conditions respectively.



(a) State the name of component X light dependent resistor [1]

(b) When S_1 and S_2 are opened in a bright room, calculate

(i) the effective resistance of the circuit,

total resistance = $[1/(80 + 400) + 1/30]^{-1}$ [1]
= $[1/480 + 1/80]^{-1}$
= 28.2353
= 28.2 Ω [1]

(ii) the charge flowing through the battery in 2 minutes.

Q = It
= (12/28.2353) x (2 x 60) [1]
= 50.9671
= 51.0 C [1]

(c) When S_1 and S_2 are closed in a dark room,

(i) calculate the power dissipated in X.

power = V^2/R
= $12^2/2000$ [1]
= 144/2000
= 0.0720 W [1]

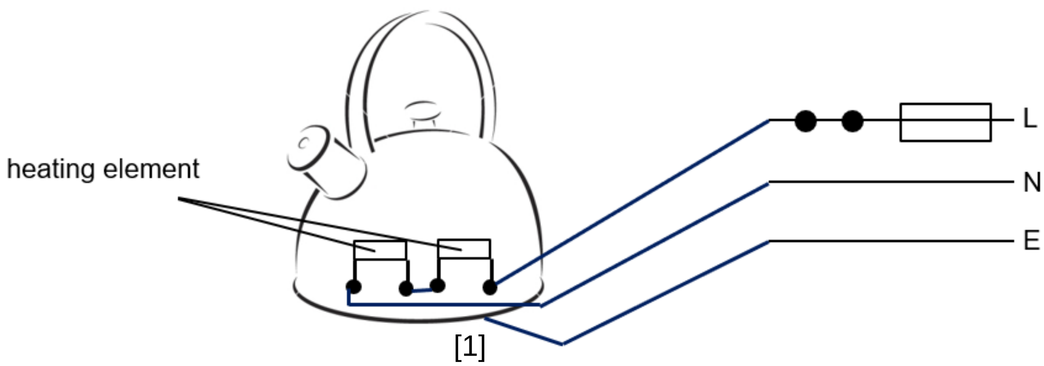
(ii) describe what measurements are taken and how they are used to find the energy produced by the 30 Ω in 2 minutes.

Measure the current flowing through the 30 Ω, the potential difference across it and the time taken [1]

Energy produced can be found using the formula E = IVt. [1]

[Total 9]

7 An electric kettle consists of two heating elements as shown in the diagram below. The heating elements can be connected to the electrical mains supply of 240 V in various ways so that the heating power can be varied.



[1] – connection in series

(a) Complete the circuit so that the heating power is the maximum and the kettle is safe to use. [2]

(b) The maximum heating power of the electric kettle is 550 W.
Determine the fuse rating for the kettle.

$$P = IV$$
$$550 = I \times 240$$
$$I = 550/240$$
$$= 2.292 \text{ A}$$
$$= 2.29 \text{ A}$$

Thus fuse rating = 3.0 A [1]

(c) Draw, on the above diagram, the correct position for the fuse and switch. Explain your answer.

[The fuse and the switch should be placed in the live wire] [1]

In the event the fuse blow or the switch is opened. The appliance will be disconnected from the live wire. [1]

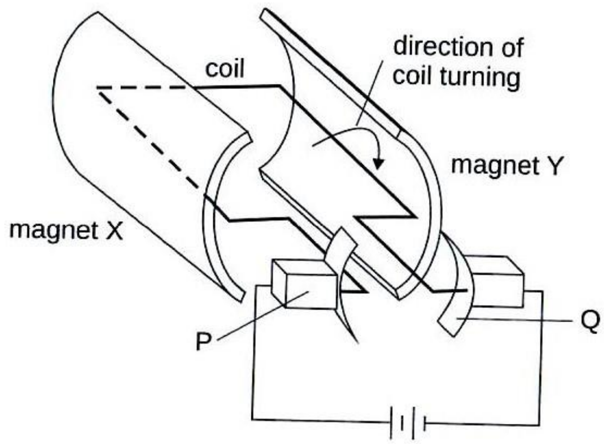
(d) Electrical energy costs $0.27 per kWh. Calculate the cost of using the kettle when switched on for 40 minutes every day in one month (i.e. 30 days).

total kWh = 550/1000 x 40/60 x 30
= 0.55 x 2/3 x 30
= 11 kWh [1]

total cost = 11 x 0.27
= $ 2.97 [1]

[Total: 7]

8 (a) The diagram shows a mechanical device.



(i) State the name and function of part Q.

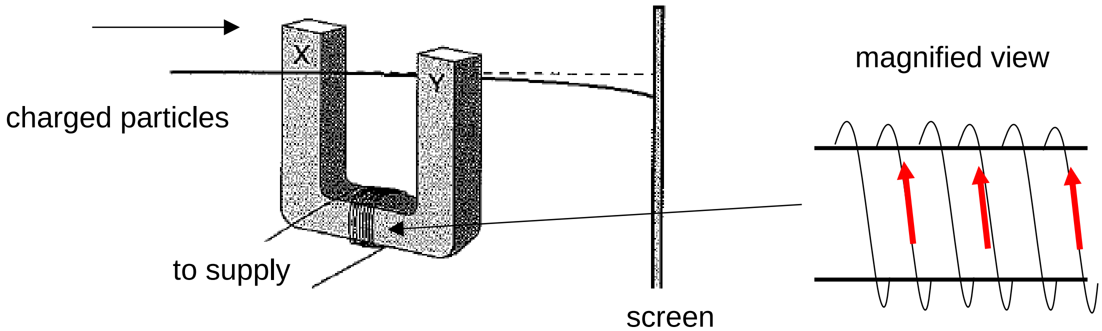
Split-ring commutator. [1]

It is used to reverse the direction of current in the coil every half rotation so that the coil continues to turn in the same direction. [1]

(ii) Suggest one modification to the above set-up so that coil will rotate faster in the opposite direction.

Use a stronger magnet with pole reversed or use a stronger current with battery connection reversed. [1]

(b) The diagram shows a beam of positively-charge particles passing between the poles of a powerful U-shaped electromagnet.



[1]

Fig. 8.1

(i) State the polarity of the magnet at X and Y.

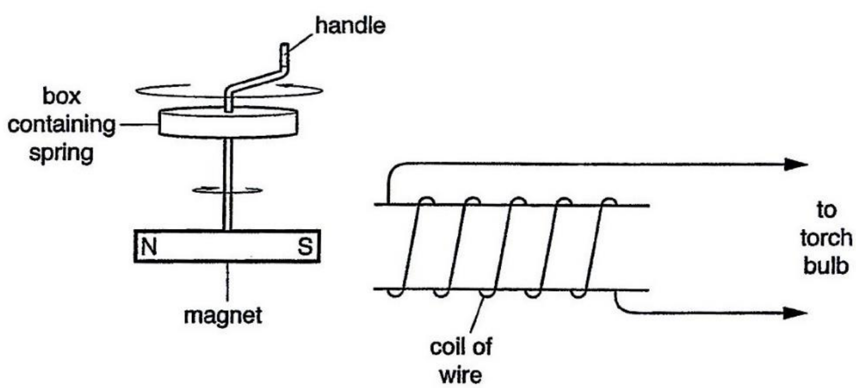
X: North pole Y: South pole [1]

(ii) State the type of current provided by the supply and show the direction of the current flowing in the solenoid using Fig. 8.1.

Direct current. [1]

[Total: 6]

9 A 'wind-up' torch does not have batteries. It uses the energy stored in a wound-up spring to generate the electricity needed. The diagram shows a simplified version of the arrangement.



(a) Explain why an e.m.f. is induced in the coil.

When the magnet rotates, it creates a changing magnetic field that is cutting the coil. [1]

According to Faraday's law, this changing magnetic field passing through the coil will induced an e.m.f. in the coil. [1]

(b) As the spring unwinds, the force in the spring decreases. Explain what happens to the light emitted by the torch.

The light emitted will be less as the magnet now turns slower. [1]
As the magnetic fields lines cutting the coil is now reduced, the current induced in the coil will be lower. [1]

[Total: 4]

10 The nuclide ${}^{184}_{78}\mathrm{Pt}$ emits an alpha α-particle and decays to another nuclide Osmium, Symbol Os.

(a) Write an equation which represents the decay of the ${}^{184}_{78}\mathrm{Pt}$ nucleus.

$${}^{184}_{78}\mathrm{Pt} \rightarrow {}^{180}_{76}\mathrm{Os} + {}^{4}_{2}He$$

[1]

(b) A sample of ${}^{184}_{78}\mathrm{Pt}$ emitting α-particle produced the following results when its emission was measured at a fixed distance from it.

count rate/minutes	510 (410)	330 (310)	210 (190)	138 (118)	102 (82)
time/minute	0	15	30	45	60

(i) The count rate from background radiation was taken and found to be 20 per minute. Taking the background radiation into consideration, plot a graph of the count rate due to α-emission against time.

[3]

(ii) Using the graph, determine the half-life of the sample.

half-life = <u>21.5 to 22.5 min</u> [2]

(iii) Suggest the origin of the background radiation.

Artificial source: building materials or
Natural source: rocks, radon gas in the air [1]

(iv) State one safety precaution which should be taken when handling radioactive materials.

Wearing of lead-lined gloves and suits or
Use long tongs or remote controlled devices to handle radioactive material. [1]

[Total: 8]

11 Fig. 11.1 shows two of the towers that support a single cable of total length 5.0 km, which links a factory to the electrical grid.

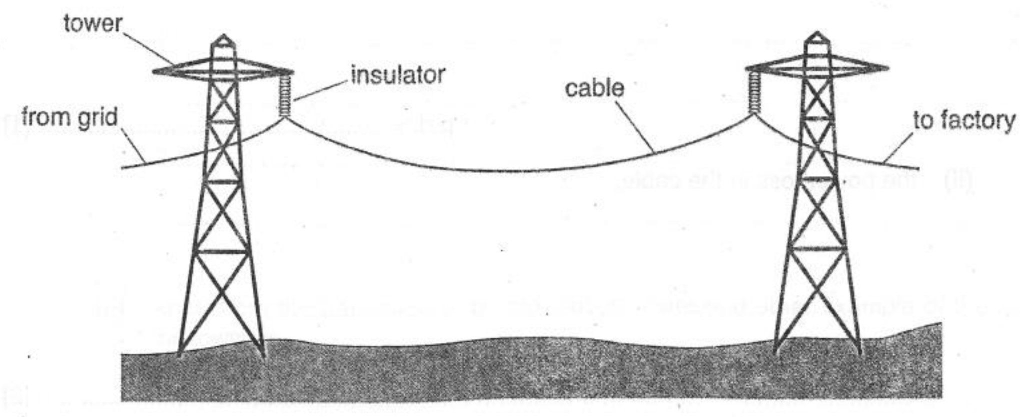


Fig. 11.1

If the weight of the cable between two towers is larger than a given force *F*, then the cable breaks. The value of *F* depends on the material from which the cable is made. The table gives the value of *F* and other data for three cables made from different materials.

cable	material	F / N	$\frac{\text{cross-sectional area}}{\text{m}^2}$	$\frac{\text{density}}{\text{kg/m}^3}$	$\frac{\text{resistance of 1 km}}{\Omega}$
1	*X*	6 000	3.0×10^{-4}	2 700	0.075
2	*Y*	9 000	3.0×10^{-4}	8 900	0.050
3	*Z*	27 000	3.0×10^{-4}	7 800	210

(a) Assuming that g is 10 N/kg, calculate

(i) the mass of a cable made of material *Y* with a length 5.0 km,

volume of cable Y = $3 \times 10^{-4} \times 5000$
= 1.5 m^3 [1]

mass = density x volume = 1.5 x 8900
= 13350 kg
= 13400 kg [1]

(ii) the minimum number of towers needed the grid and the factory to support this cable.

no required = (13400 x 10)/9000 [1]
= 14.8
= 15 [1]

(b) The cable used is actually made from material *X* and the current in it is 500 A.

For this cable, calculate

(i) the potential difference (p.d.) between the grid and the factory,

$v = IR$
$= 500 \times (0.075 \times 5)$
$= 187.5$
$= 188$ V [1]

(ii) the power loss in the cable,

$P_{loss} = I^2R$
$= 500^2 \times 0.375$ [1]
$= 93\,750$W
$= 93\,800$ W [1]

(c) Using data from the table, explain why

(i) *X* is a more suitable material than *Y* for the cable,

X has the smallest density among the 3 materials and hence the lowest mass. [1]

Value of F for X is smallest and hence it requires the least number of towers to support it. [1]

(ii) *Z* is an unsuitable material for the cable.

Z has the highest resistance among the 3 materials and thus power loss is the greatest. [1]

(d) State and explain the type of transformer to be connected between the tower and the factory.

Type: Step-down transformer [1]

The voltage transmitted over the power line is very high and they need to be step down to lower voltage suitable for the factory. [1]

[Total: 12]

Section B

12 Fig. 12.1 shows an experimental setup to determine the specific heat capacity of liquid X.

Liquid X in a glass cup is heated by an immersion heater. The energy transferred from the heater to liquid X is measured by a joulemeter.

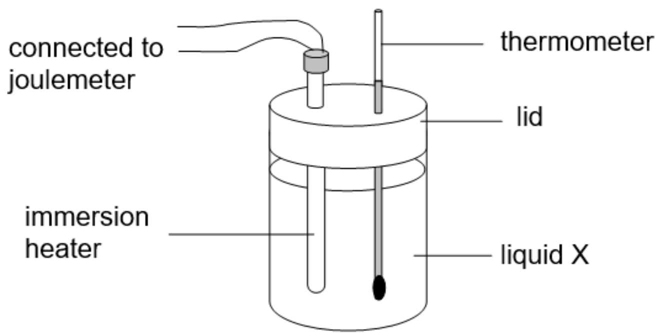


Fig. 12.1

The heater is switched on for a period of time. Table 12.2 shows the information about the experiment. Fig. 12.3 shows how the temperature of liquid X varies with time.

Table 12.2

mass of liquid X	250 g
initial reading on joulemeter	56 300 J
duration of time when heater is switched on	400 s
final reading on joulemeter	66 050 J

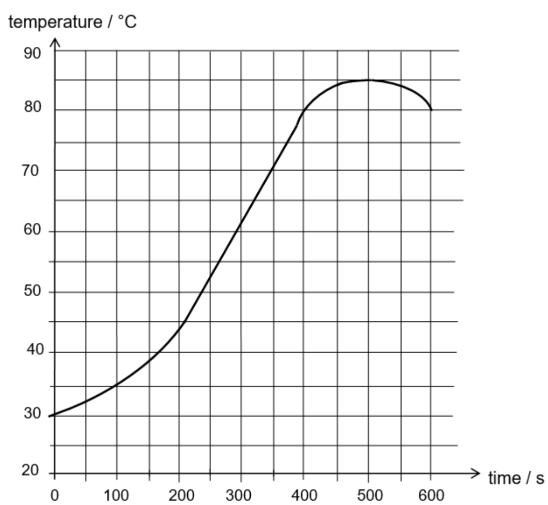


Fig. 12.3

(a) After the heater is switched off, the temperature of liquid X continues to rise, remains constant momentarily and then it starts to drop.

Suggest and explain this observation.

When the heater is switched off, the temperature of the heater is still higher than the temperature of liquid X. Hence energy continues to be transferred from the heater to liquid X, causing the temperature of liquid X to continue rising. [1]

Temperature of liquid X starts to drop when energy it transfers to the surroundings is more than the energy transferred to it. [1]

(b) (i) With reference to Table 12.2 and Fig. 12.3, determine the specific heat capacity, *c*, of liquid X.

$$Q = mc\Delta\theta$$

$$66\,050 - 56\,300 = 250/1000 \times c \times (80 - 30) \quad [1]$$

$$c = 780 \text{ J/(kg °C)} \quad [1]$$

(ii) State and explain how the calculated value of *c* would differ, if any, from the actual value of *c*.

The calculated value of c would be higher than the actual value of c. [1]

In reality, some of the energy supplied by the heater will be transferred to the surroundings of liquid X. [1] Hence using energy supplied by the heater to determine c would be higher than the actual energy transferred to liquid X.

(iii) Suggest one precaution that can be taken to improve the accuracy of the experiment.

wrap the glass cup with an insulating material. [1]

(c) Explain, using kinetic theory of matter, why a kettle of liquid X with a steady supply of energy takes a much longer time to boil off at boiling point than to heat it up close to its boiling point.

Large amount of heat energy is needed to overcome the atmospheric pressure acting on the boiling water [1] and also to overcome the force of attraction between the liquid molecules. [1]

To increase the temperature of water, heat energy is used to make the water molecules move faster.

[Total: 10]

13 Fig. 13.1 shows a tuning fork held a distance away from a microphone. When the tuning fork was struck, the microphone was able to detect the sound and displays a signal on the oscilloscope.

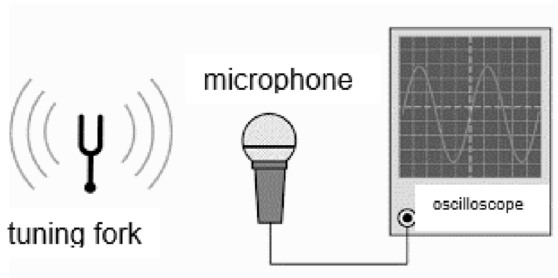


Fig. 13.1

(a) Using ideas about molecules, describe how sound travels from the tuning fork to the microphone.

<u>Vibration of tuning fork will cause the air molecules around it to vibrate.</u>

<u>Air molecules will be moving parallel to the direction of vibration as sound is a longitudinal wave. [1]</u>

<u>This creates a series of compression and rarefaction and in the process the sound energy is being transmitted from the tuning fork to microphone.</u> [1]

(b) Fig. 13.2 shows the positions of 11 air particles, at t = 0 ms, before the tuning fork is struck. After the tuning fork is struck, at t = 10 ms, the positions of the air particles change.

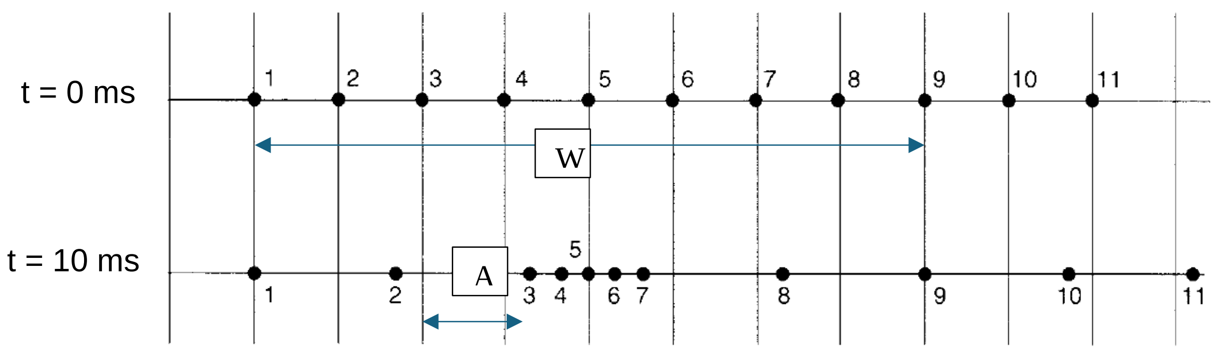


Fig. 13.2

On Fig. 13.2, mark out the amplitude and wavelength of the wave. Label them A and W respectively.

(c) (i) Given that 10 ms is equivalent to 1/4 of a period, determine the frequency of the sound.

$f = 1/T$
$= 1/(4 \times 0.01)$
$= 25$ Hz [1]

(ii) The speed of sound in air is 330 m/s. Calculate the wavelength of the sound wave.

$v = f\lambda$
$330 = 25\lambda$ [1]
$\lambda = 13.2$ m [1]

[1]

(e) The tuning fork was struck harder producing a louder sound. State and explain how the speed, amplitude A and wavelength W would change.

<u>The speed & wavelength of the wave remains the same since the frequency of the wave is unaffected.</u> [1]

<u>Amplitude would be larger as loudness is affected by amplitude of the wave.</u> [1]

(f) State one similarity and difference between the sound produced by the tuning fork and ultrasound.

Similarity: <u>both are longitudinal wave</u> [1]
Difference: <u>ultrasound cannot be heard by human.</u> [1]

[Total: 10]