For Examiner's Use

Section A

Answer **all** the questions in this section.

1 Fig. 1.1 shows the speed-time graph for a small balloon initially at rest, then falling vertically through the air and then attaining constant speed.

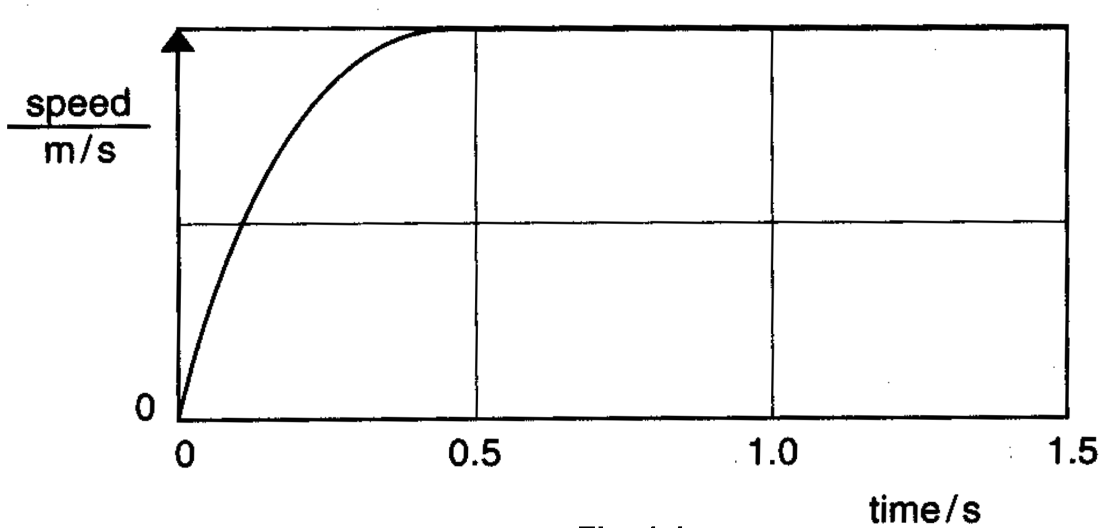

Fig. 1.1

(a)(i) Use Fig. 1.1 to determine the time interval over which the balloon is accelerating.

0.4 s [1] ***[note: 0.5 is also acceptable for this diagram]***

(ii) Is the acceleration constant? Explain your answer.

No. Since the gradient of the graph is decreasing, the acceleration decreases too. Hence, the acceleration is not constant. **[2]**

(b) Explain, using the forces acting, the motion of the balloon for the first second after release.

As the ballon falls from rest, the air resistance increases gradually and the resultant force decreases. This would result in a decreasing acceleration of the balloon. As the balloon continue falling, the air resistance increases until it balances the weight of the balloon. There is no resultant force and thus no acceleration, which will make the balloon to fall a constant speed. **[2]**

(c) The mass of the balloon is 60 g. The gravitational field strength is 10 N/kg.

(i) Calculate the weight of the balloon,

W = mg
= (60/1000) (10)
= 0.6 N

weight =……………………. [1]

(ii) State the value of the air resistance on the balloon 1.0 s after release. Explain your answer. [2]

<u>0.6 N</u>. Since the balloon is moving with constanct speed after 1.0 s of release, the <u>forces are balanced</u> (i.e. there is no resultant force). Hence, the <u>air resistance has the same magnitude as the weight of balloon.</u>

2 A cyclist, together with his bicycle, has a total mass of 90 kg and is travelling with a constant speed of 15 m/s on a flat road at A, as shown in Fig. 2.1. He then goes down a small slope to B so descending 4.0 m.

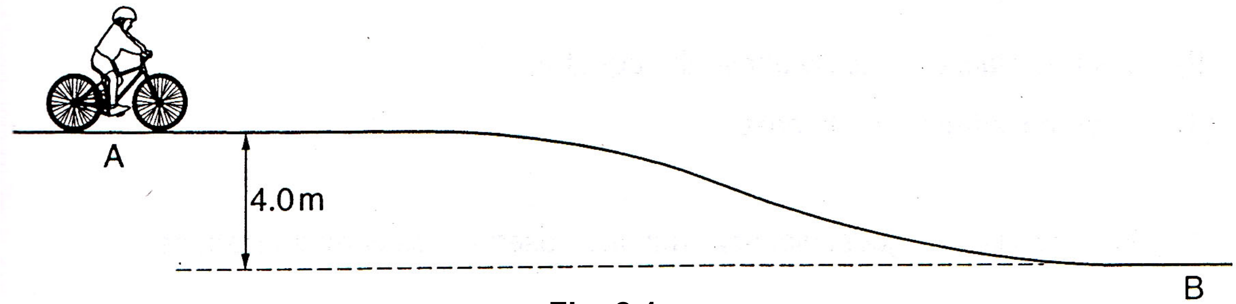

Fig. 2.1

Calculate

(a) the kinetic energy at A,

$E_k = \frac{1}{2} mv^2$
$= \frac{1}{2} (90)(15)^2$
$= 10125$ J

kinetic energy =…………………… [1]

(b) the loss of potential energy between A and B,

$E_p = mgh$
$= (90)(10)(4)$
$= 3600$ J

loss of potential energy =…………………… [1]

(c) the speed at B, assuming that all the lost potential energy is transformed into kinetic energy of the cyclist and bicycle.

Using conservation of energy,

Energy at the bottom of slope = Energy at the top of slope

$\frac{1}{2} (m)(v)^2 = \frac{1}{2} (m)(v)^2 + mgh$
$\frac{1}{2} (90)(v)^2 = 10125 + 3600$ [2]
$v^2 = (2)(13725) / 90$
$v^2 = 305$
$v = 17.5$ m/s [1]

speed =…………………… [3]

3 Sebastian holds the loose end of a long rope which is fixed to a post. He moves it up and down at a rate of 20 times every 5 seconds. Each time he moves the rope 15 cm up and 15 cm down from its original rest position. Fig. 3.1 shows the wave moving along the rope.

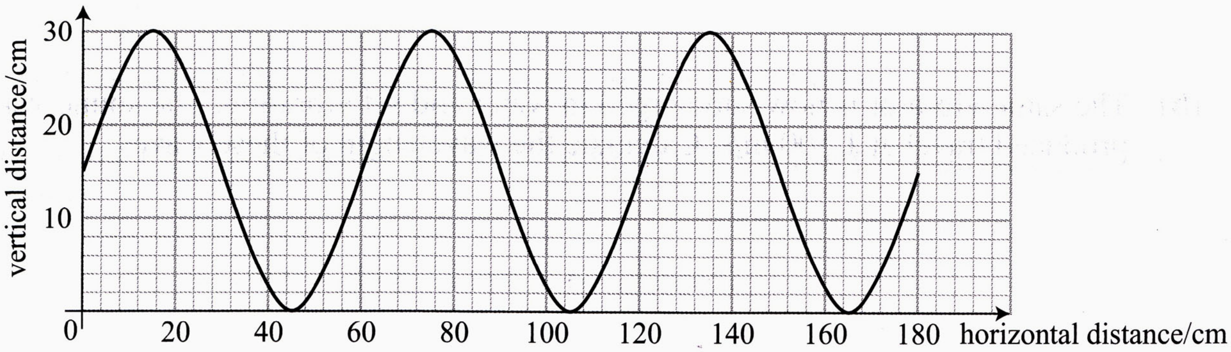

Fig. 3.1

(a) Why is the wave that travels along the rope called *transverse wave*?

The direction of vibration of the rope is perpendicular to the direction of travel of the wave. [1]

(b) State two other examples of transverse wave.

Water wave and radio wave (or any 2 other eletromagnetic waves) [1]

(c) State the value of the amplitude of the wave.

A = 30/2
= 15 cm

amplitude =…………………… [1]

(d) Calculate the frequency of the wave.

f = 20/5
= 4 Hz

frequency =…………………… [1]

(e) State the value of the wavelength of the wave.

λ = 60 cm

wavelength =…………………… [1]

(f) Calculate the speed of the wave.

v = fλ
= (4)(0.6)
= 2.4 m/s [or 240 cm/s]

Speed =…………………… [1]

4 Fig. 4.1 shows the virtual image I formed by a converging lens L.

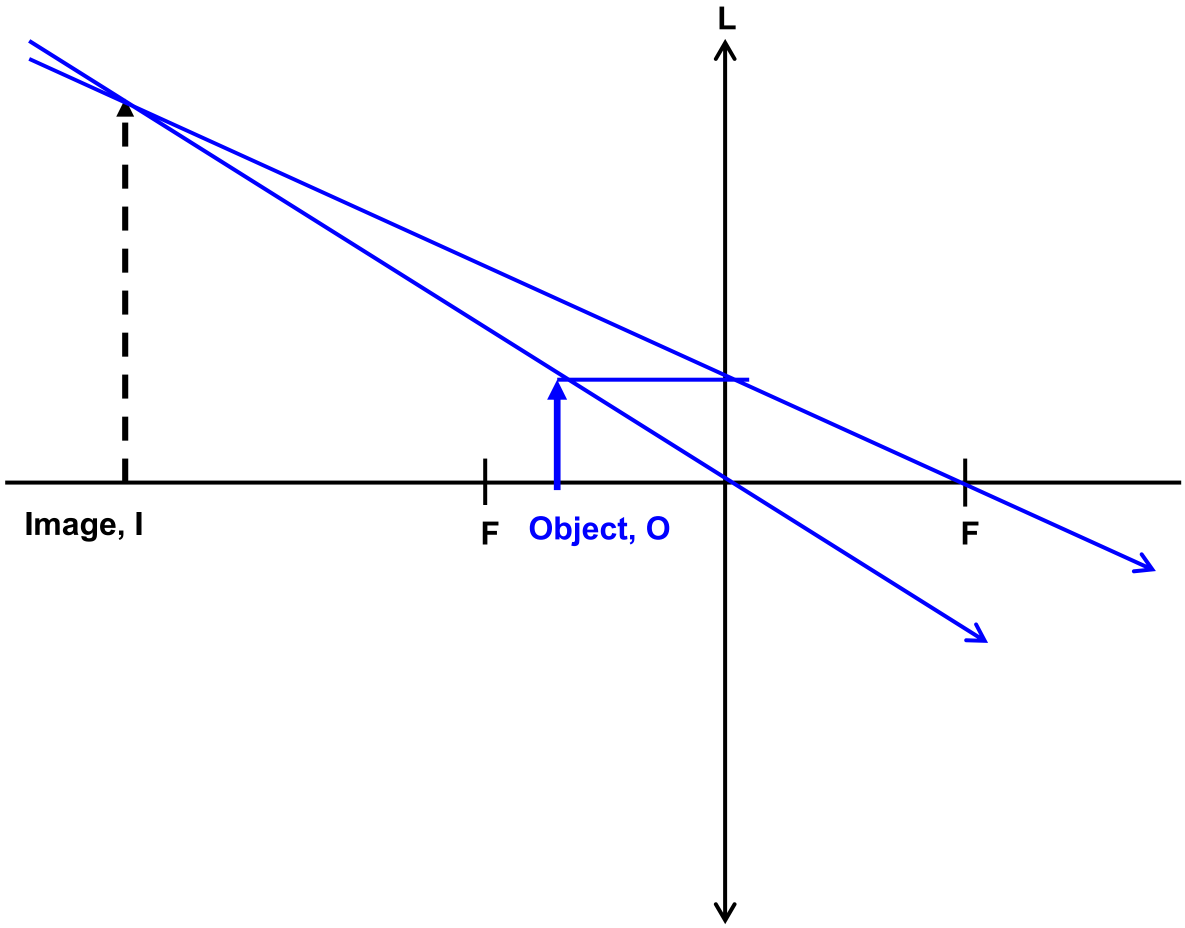

Fig. 4.1

(a) By means of a ray diagram, mark and label on Fig. 4.1 the position of the object, O. [3]

(b) What happens to the height of the image if the distance of the object from the lens is decreased? [1]

The height will decrease.

(c) Define the term *focal length*. [1]

The distance from the principal focus (focal point) to the optical center of a lens.

(d) Name three characteristics of the image formed if the distance of the object from the lens is equal to 1.7 times the focal length of the lens. [2]

Inverted, real and magnified. [1 correct ½ mark, 2 correct 1 mark, 3 correct 2 marks]

5 An electrically positively charged sphere C is brought near a small uncharged conducting sphere S suspended as shown in Fig. 5.1.

S is first attracted towards C until it touches the surface of C and then repelled to the position shown in Fig. 5.2.

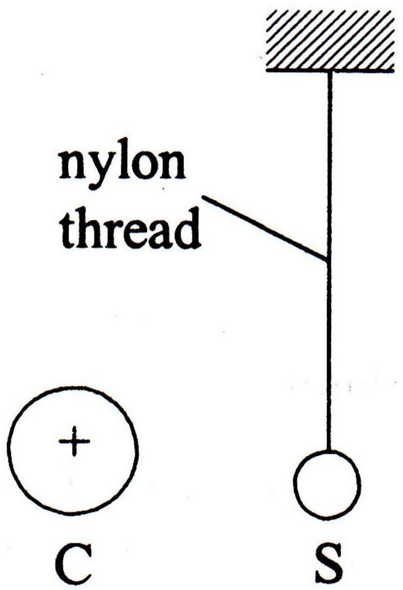

Fig. 5.1

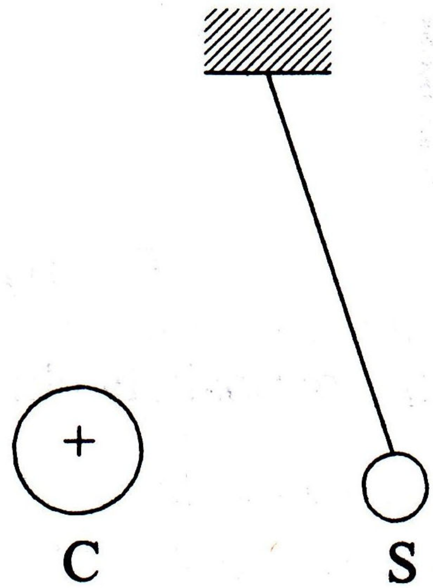

Fig. 5.2

(a) On Fig. 5.1 draw the charges induced on sphere S. [1]

(b) Explain carefully why S is first attracted towards C. [2]

Since C is positively charged, it will induce negative charges on the nearer side of S facing C and positive charges on the further side. Since induced negative charges in S are nearer to C, the force of attraction is greater than force of repulsion. Hence, there is a net attractive force.

(c) Explain why S is repelled after touching the surface of C.

After touching, electrons from S moves to neutralise some of the positive charges on C. S aquires a net positive charge. C is still positively charged but less in magnitude since it is much bigger than S. As like charges repel, S is repelled from C. **[2]**

For Examiner's Use

6 Fig. 6.1 shows a schematic diagram of the lighting circuit for street lamps. All 60 lamps are connected in parallel to a 240 V a.c. supply. The resistance of each lamp is 50.0 Ω. The wires connecting the lamps have negligible resistance.

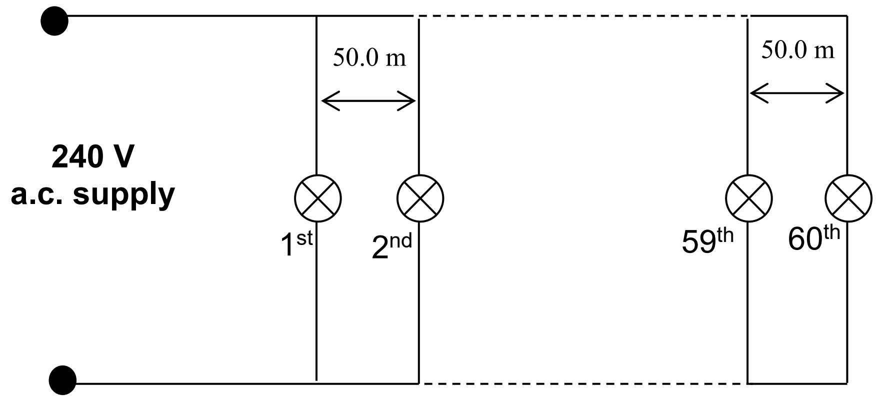

Fig. 6.1

(a) Calculate the effective resistance of the 60 lamps.

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots + \frac{1}{R_{60}} \qquad = \frac{1}{R} \times 60$$

$$= \frac{1}{50.0} \times 60$$

$$= 1.20$$

R = 0.833 Ω

effective resistance =……………………. [2]

(b) Calculate the current flowing through one lamp. State the formula you use.

V =IR

240 = I x 50.0

I = 4.8 A (2 or 3 s.f.)

current =……………………. [2]

(c) Calculate the total current flowing out from the power source.

Total I = 4.8 x 60

= 288 A

total current =……………………. [1]

(d) Calculate the power dissipated by one lamp. State the formula you use.

P $= V^2 / R$

$= 240^2 / 50.0$

= 1 152 W

power =……………………. [2]

7 A potential divider circuit is designed with a thermistor and a fixed resistor as shown in Fig. 7.1. The thermistor has a resistance of 4 kΩ and 6 kΩ when the temperature of the surrounding is 20 °C and 0 °C respectively. This thermistor has resistance that varies linearly with temperature. The alarm sounds when the output voltage (V_{out}) is 1.0 V or less.

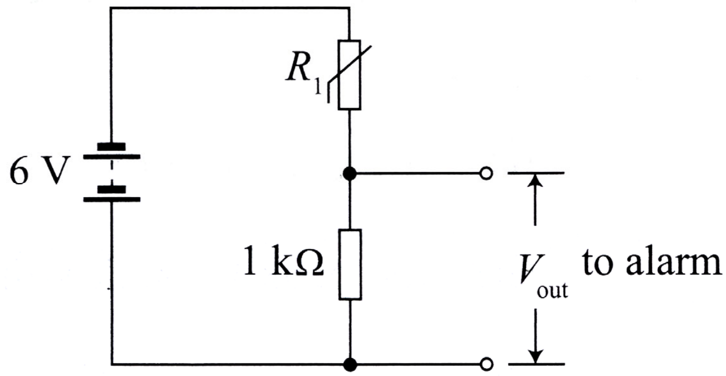

Fig. 7.1

(a) Will the alarm sound when the temperature is at 20 °C? Justify your answer by showing clearly the proper calculations.

$$V_{out} = 1/(1+4) \times 6$$
$$= 1.2 \text{ V}$$

The alarm will not sound since output voltage is more than 1.0 V. [3]

(b) Calculate the resistance of the thermistor at which the alarm is activated.

Let R be resistance of the thermistor

$$V_{out} = 1/(1+R) \times 6$$
$$1 = 1/(1+R) \times 6$$
$$(1+R) = 6$$
$$R = 5 \text{ k}\Omega$$

resistance =……………………. [2]

(c) Write down the temperature at which the alarm will be activated. Explain your conclusion. [2]

When the temperature reaches <u>10°C</u>, the alarm will be activated. Since the resistance <u>changes linearly with temperature, 5 kΩ will correspond to 10°C</u>.

For Examiner's Use

8 **(a)** A student activated a Geiger Muller (GM) tube in a classroom. It was observed that the counter on the GM tube gave a reading even though there was no known source of radioactive emission. The reading also changed from time to time.

Explain his observations.

The reading is due to <u>background radiation</u> that is present at the surroundings. The reading is changing because radioactive emission is a <u>random process</u>.

(b) Uranium-234 (^{234}U) is a radioactive element. Fig. 8.1 shows the number of protons and neutrons in the nuclei of the elements formed when Uranium-234 decays.

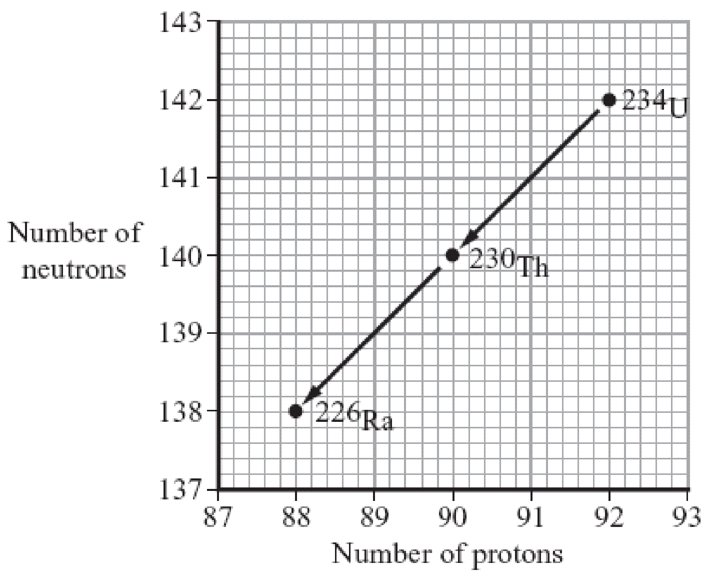

Fig. 8.1

(i) How does Fig. 8.1 show that uranium-234 (^{234}U) and thorium-230 (^{230}Th) emit alpha particles?

Alpha particle comprises 2 protons and 2 neutrons. Since both uranium-234 (^{234}U) and thorium-230 (^{230}Th) <u>lose 2 protons and 2 neutrons</u>, they emit alpha particles. [1]

(ii) What makes uranium and thorium different elements?

Uranium and thorium have <u>different number of protons</u> in their nucleus which makes them different elements. [1]

(iii) Radioactive decay may also produce gamma radiation. Why does the emission of gamma radiation not cause a new element to be formed?

Gamma radition is <u>a wave, not a particle</u>. Hence, there is <u>no change in the number of protons in the nucleus</u>. [1]

For Examiner's Use

Section B

Answer **all** the questions in this section. **Q11** has a choice of section to answer.
For **Q11** use lined pages provided and, if necessary, continue on the separate sheets available from the Supervisor.

9 (a) Fig. 9.1 shows a simple manometer (not drawn to scale). It contains two liquids, water and mercury. Both ends of the manometer are open to the atmosphere. The density of water is 1000 kg/m^3, while that of the mercury is 13600 kg/m^3. Take the pressure of atmosphere as 100 kPa and the acceleration due to gravity, g as 10 m/s^2.

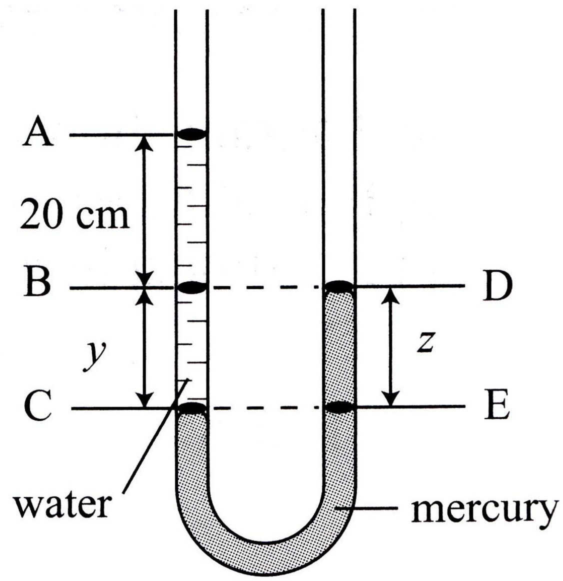

Fig. 9.1

(i) State the pair(s) of points that experience(s) the same pressure. [1]

AD and CE

(ii) Calculate the height y of the water column.

$$\rho_{water}\, g\, h_{water} = \rho_{mercury}\, g\, h_{mercury}$$

$$(1000)(\cancel{10})(20+y) = (13600)(\cancel{10})(y)$$

$$20+y = 13.6y$$

$$13.6y - y = 20$$

$$12.6y = 20$$

$$y = 20/12.6$$

$$= 1.59 \text{ cm}$$

height =…………………… [2]

For Examiner's Use

(iii) Write down the pressure at point E?

$$\mathbf{P = \rho_{mercury}\, g\, h_{mercury} + P_{atm}}$$
$$\mathbf{= (13600)(10)(1.59/100) + 100000}$$
$$\mathbf{= 102162.4\ Pa}$$

pressure =……………………. [2]

(b) A barometer reads 75.5 cm of mercury at the foot of a mountain and 65.5 cm of mercury at the top of the mountain.

Calculate the height of the mountain, in metres, assuming the density of mercury is 13600 kg/m^3 and the density of air is 1.25 kg/m^3.

Pressure difference = 75.5 – 65.5
= 10 cm hg

$$\mathbf{\rho_{mercury}\, g\, h_{mercury} = \rho_{air}\, g\, h_{air}}$$

$$\mathbf{(13600)(10)\cancel{(10)} = (1.25)\cancel{(10)}(h_{air})}$$
$$\mathbf{h_{air} = (13600)(10) / 1.25}$$
$$\mathbf{= 108800\ cm}$$
$$\mathbf{= 1088\ m}$$

height =……………………. [2]

(c) A bubble of air rises from the bottom of a pond to the surface. Just before the bubble breaks as it reaches the surface, the volume was triple its original volume.

Calculate the depth of the pond, assuming that atmospheric pressure is 1 x 10^5 Pa and density of water is 1000 kg m^{-3}.

$$\mathbf{P_1 V_1 = P_2 V_2}$$
$$\mathbf{(\rho_{water}\, g\, h_{water} + P_{atm})(V) = (1 \times 10^5)(3V)}$$
$$\mathbf{[(1000)(10)(h) + 1 \times 10^5](V) = (1 \times 10^5)(3V)}$$
$$\mathbf{(1000)(10)(h) = 2 \times 10^5}$$
$$\mathbf{h = 2 \times 10^5/10000}$$
$$\mathbf{= 20\ m}$$

depth =……………………. [3]

For Examiner's Use

10 Fig. 10.1 shows a cookware sales promoter holding a saucepan. He said this,
"Come look at this fabulous special saucepan XYZ. What makes it special is its very high heat capacity. A high heat capacity means that the saucepan can reach very high temperature with very little heat. So you can start cooking very quickly and what is more, it saves you money since little heat is needed!"

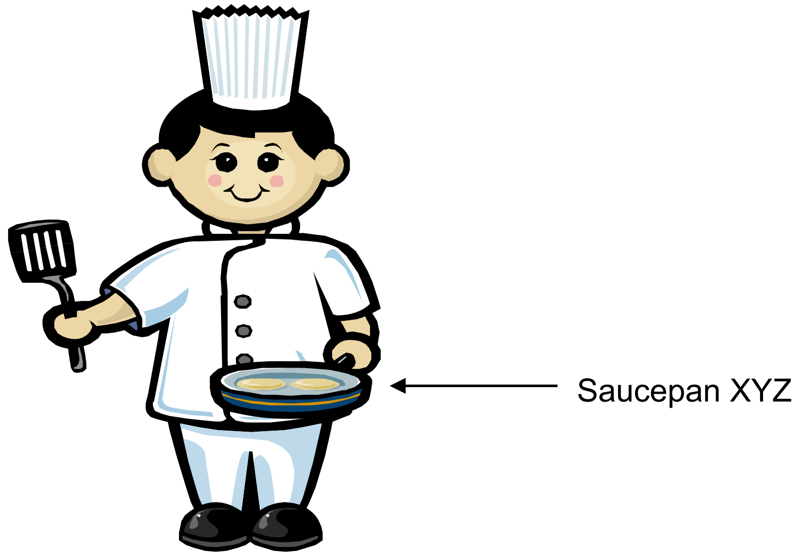

Fig. 10.1

(a) Is the statement said by the sales promoter correct? Explain.

No. The promotor does not understand the meaning of heat capacity. High heat capacity means that a material <u>needs a greater amount thermal energy to incease its temperature by 1°C</u>. This will delay the cooking and cost more. He should say low heat capacity instead of high heat capacity. **[2]**

(b) The saucepan containing 600 g of water is placed on top of a gas stove. It takes 2.0 min for the temperature of the water to rise from 30.0 °C to 50.0 °C.
The specific heat capacity of water is 4 200 J/kgK.

(i) Calculate the power supplied by the gas stove.

$$\mathbf{Pt = mc\theta}$$

$$\mathbf{P(2.0 \times 60) = (0.600)(4200)(50.0 - 30.0)} \quad \textbf{[1]}$$

$$\mathbf{P = 420\ W\ (2s.f.)} \quad \textbf{[1]}$$

power =……………………. [2]

(ii) Find the time required to make the water boil from 50.0 °C.

$Pt = mc\theta$

$420t = (0.600)(4200)(100.0 - 50.0)$

$t = 300$ s

time =……………………. [1]

(iii) When the water reaches 100.0 °C, it takes an additional 9.0 min to boil away all the water. Calculate the specific latent heat of vaporisation of water.

$Pt = ml_v$

$420(9.0 \times 60) = 0.600 \times l_v$

$l_v = 378\ 000$ J/kg

specific latent heat of vaporisation =……………………. [2]

(iv) State what is meant by *specific latent heat of vaporisation of water*. [1]

It is the amount of heat energy required to <u>change a unit mass of water</u> from it <u>liquid state to vapour state</u> <u>without any change in temperature</u>.

(v) Explain whether the value calculated in **b(iii)** is higher or lower than the actual latent heat of vaporisation. [1]

Value in b(iii) is higher than actual. There is <u>energy loss to surrounding</u>; hence <u>not all the heat supplied is used to boil the water</u>.

(vi) Explain why the value of specific latent heat of vaporisation of water is much greater than that of specific heat capacity of water. [1]

The thermal energy required during change of state to <u>overcome the force of attraction between the water molecules</u> and to <u>separate them</u> is <u>much greater than to increase their kinetic energy</u>.

For Examiner's Use

EITHER

(a) Q is South Pole and R is North Pole.

(b) Force acts upwards on AB and downwards on CD.

(c) Coil rotate in clockwise direction

(d) Split ring commutator. It allows the coil to keep rotating continuously in one direction by reversing the direction of the current in the coil every time the coil passes its vertical position.

(e) The coil continues to rotate in the same direction, i.e. clockwise direction. When the polarities of the battery are switched, the direction of current flow in the coil is reversed and at the same time the magnetic poles at Q and R are switches. Using, Fleming's Left hand rule, the direction of the forces on the coil remain unchanged and hence the direction of rotation remain unchanged too.

(f) Decrease the magnetic field strength between the solenoid by decreasing the number of turns on the solenoid.

Reduce the magnitude of the current in the coil by replacing the battery with a battery with a lower e.m.f.

For Examiner's Use

OR

(a)

(i) Peak voltage = 3 x 2.5

= 7.5 V

(ii) period, $T = 8 \times 5 \times 10^{-3}$ s

$f = 1/T$

$= 1/(8 \times 5 \times 10^{-3})$

= 25 Hz

(iii) $v = f\lambda$

= (25)(0.5)

= 12.5 m/s

(iv) I would observe 2½ complete waves shown on the screen