1 Which list contains only scalar quantities?

A area, length, displacement
B kinetic energy, speed, power
C potential energy, torque, time
D velocity, distance, temperature

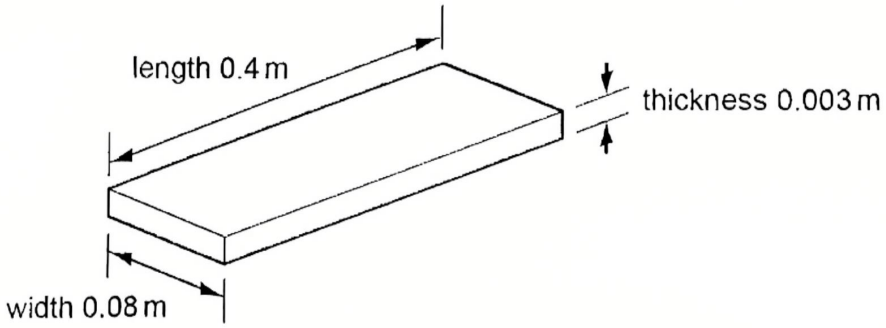
2 Which unit can be expressed in SI base units as kg m^2 s^{-2}?

A joule
B newton
C pascal
D watt

3 What is the best estimate of the mass of a single sheet of A4 paper?

A 0.04 g **B** 0.4 g **C** 4 g **D** 40 g

4 A manufacturer needs to measure accurately the dimensions of a wooden floor tile. The approximate dimensions of the tile are shown.



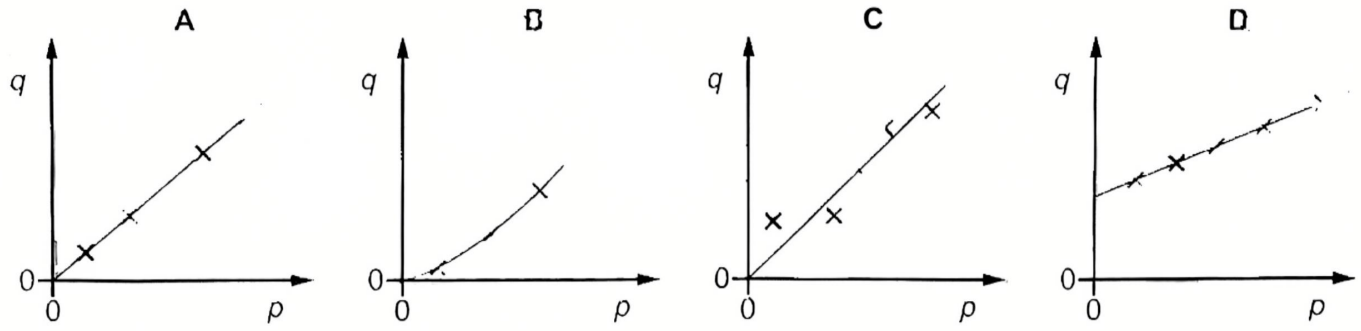
Which instruments measure each of these dimensions accurately?

	length	thickness	width
A	metre rule	digital micrometer	digital calipers
B	metre rule	digital calipers	digital micrometer
C	digital micrometer	metre rule	digital calipers
D	digital calipers	digital micrometer	metre rule

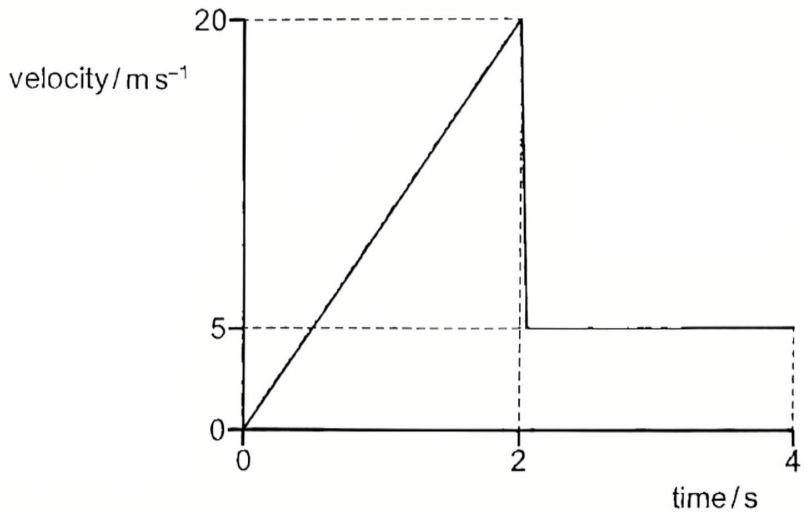
5 Two quantities p and q are directly proportional to each other.

Experimental results are plotted in a graph of q against p.

Which graph shows there were random errors in the measurements of p and q?



6 A stone is dropped from a height of 20 m above water. The graph shows the variation with time of the velocity of the stone.



Which statement describes the approximate position of the stone four seconds after it is dropped?

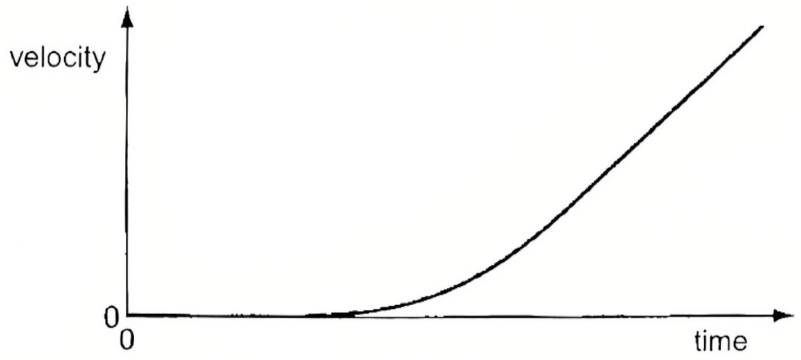
A It is at a distance of 10 m above the surface of the water.

B It is at a distance of 10 m below the surface of the water.

C It is at a distance of 20 m below the surface of the water.

D It is at a distance of 30 m below the surface of the water.

7 A racing car is fitted with an electronic monitoring system. Data from the car is used to plot a velocity-time graph for part of the race. The graph is displayed on a computer screen.



The graph covers a period of time when the car is first at rest, then

A moving with uniform speed and then moving with uniform acceleration.

B moving with uniform speed and then moving with non-uniform acceleration.

C moving with uniform acceleration and then moving with non-uniform acceleration.

D moving with non-uniform acceleration and then moving with uniform acceleration.

8 An object has an initial velocity u and an acceleration a. The object moves in a straight line through a displacement s and has a final velocity v.

The above quantities are related by the equation shown.

$$v^2 = u^2 + 2as$$

Which condition must be satisfied for this equation to apply to the motion of the object?

A The direction of a is constant and the direction of a is the same as the direction of s.

B The direction of a is constant and the direction of a is the same as the direction of u.

C The magnitude of a is constant and the direction of a is the same as the direction of v.

D The magnitude of a is constant and the direction of a is constant.

9 In which situation is the resultant force on the body equal to zero?

A a rock falling freely on the Moon

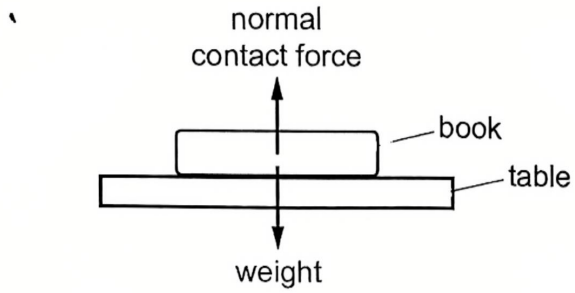
B a car turning a corner at constant speed

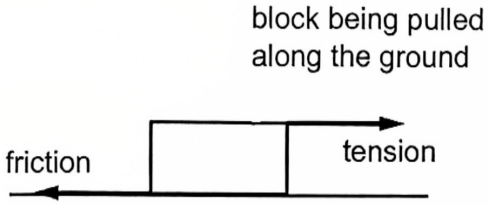
C an aircraft accelerating along a runway in a straight line

D a train going up a straight hill at constant speed in a straight line

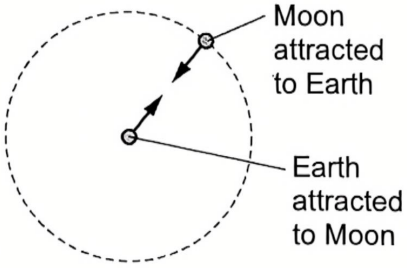
10 Each diagram shows two forces that are equal in magnitude.

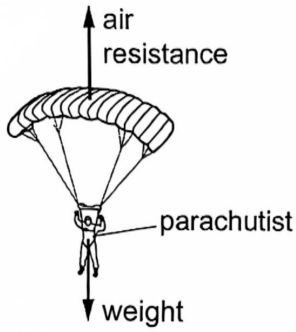
Which diagram shows two forces that are Newton's third law pair of forces?



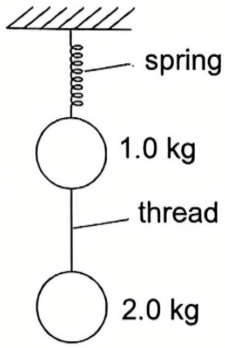


C





11 The diagram shows a stationary object of mass 1.0 kg suspended vertically from a spring. It is connected to another stationary object of mass 2.0 kg by a massless thread. The gravitational field strength g is 10 N kg^{-1}.

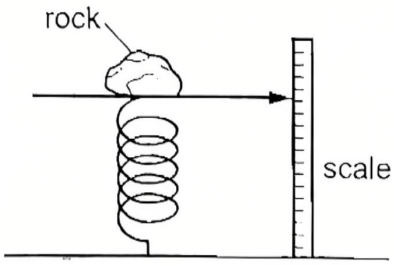


The thread is then cut.

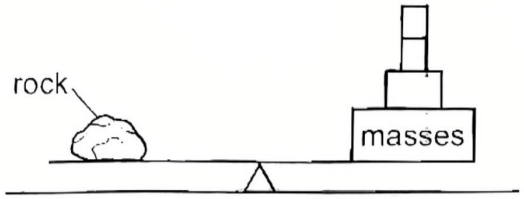
What are the magnitudes of accelerations of the two objects immediately after the thread is cut?

	acceleration of 1.0 kg object / m s^{-2}	acceleration of 2.0 kg object / m s^{-2}
A	20	10
	20	20
	30	10
	30	20

12 A physicist places a rock on a spring balance. She then places the same rock on a beam balance and balances it using known masses.



spring balance



beam balance

She repeats the experiment at the North Pole and at the Equator. The gravitational field strength is greater at the North Pole than at the Equator.

How do the readings at the North Pole compare with those at the Equator?

	scale reading on spring balance	masses needed on beam balance
A	different at North Pole	different at North Pole
B	different at North Pole	same at North Pole
C	same at North Pole	different at North Pole
D	same at North Pole	same at North Pole

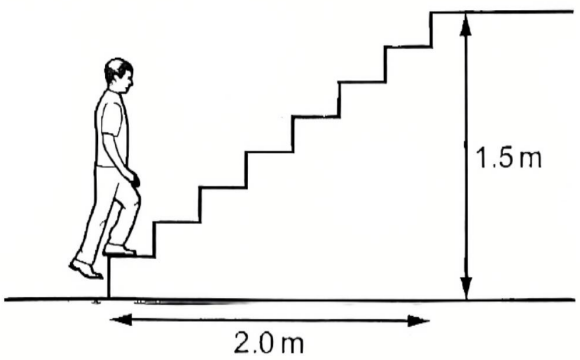
13 A student finds that the mass of a rock is 91 g.

She pours 40 cm^3 of water into a measuring cylinder. She then places the rock in the water so that the water covers the rock completely. The water level rises to 73 cm^3.

What is the density of the rock?

A 0.36 g cm^{-3} **B** 1.2 g cm^{-3} **C** 2.3 g cm^{-3} **D** 2.8 g cm^{-3}

14 A student of mass 60 kg climbs some steps. He travels a horizontal distance of 2.0 m and a vertical distance of 1.5 m. The gravitational field strength g is 10 N kg^{-1}.



(not to scale)

What is the work done against the force of gravity?

A 90 J **B** 120 J **C** 900 J **D** 1200 J

15 A man climbs slowly at a constant speed to the top of a ladder.

What is the principal energy transfer taking place as he climbs?

A chemical potential store to gravitational potential store

B chemical potential store to kinetic store

C internal store to kinetic store

D kinetic store to gravitational potential store

16 The table shows the output power of a solar panel, with a 30% efficiency, under different conditions.

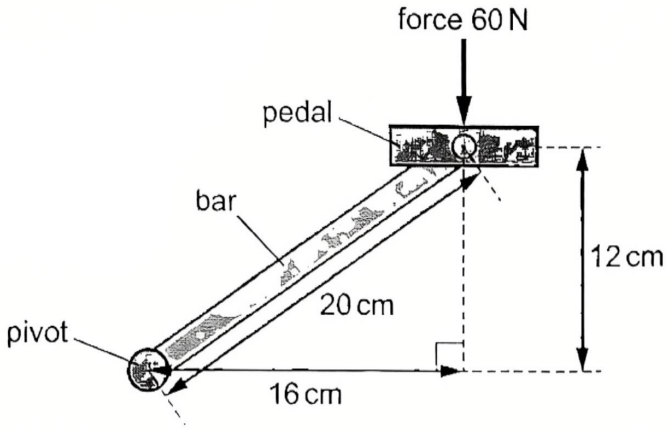
condition	output power / kW
sunny day	1.20
cloudy day	0.72

The solar panel contains several solar cells connected together. On a sunny day, each solar cell receives 1.0 kW of power from the Sun.

How much power from the Sun does each solar cell receive on a cloudy day?

A 0.40 kW **B** 0.60 kW **C** 0.80 kW **D** 1.0 kW

17 A bicycle pedal is connected to a pivot by a metal bar, as shown.

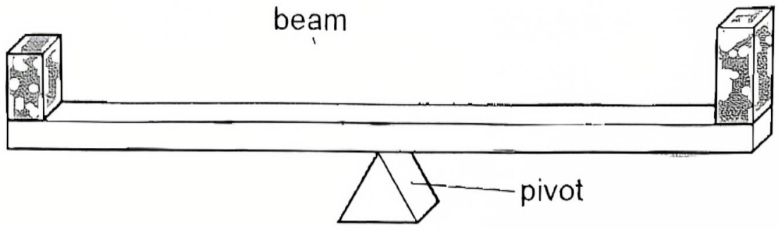


The force on the pedal is 60 N downwards.

What is the moment of this force about the pivot?

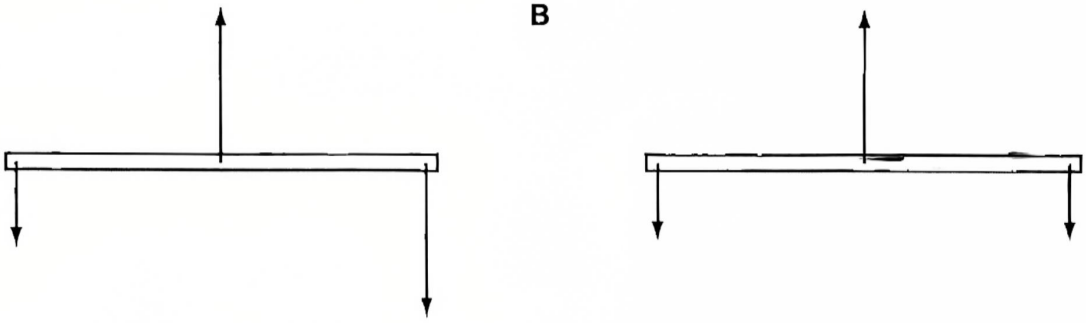
A 7.2 Nm **B** 9.6 Nm **C** 12 Nm **D** 960 Nm

18 Two blocks are placed on a beam which balances on a pivot at its centre. The weight of the beam is negligible.

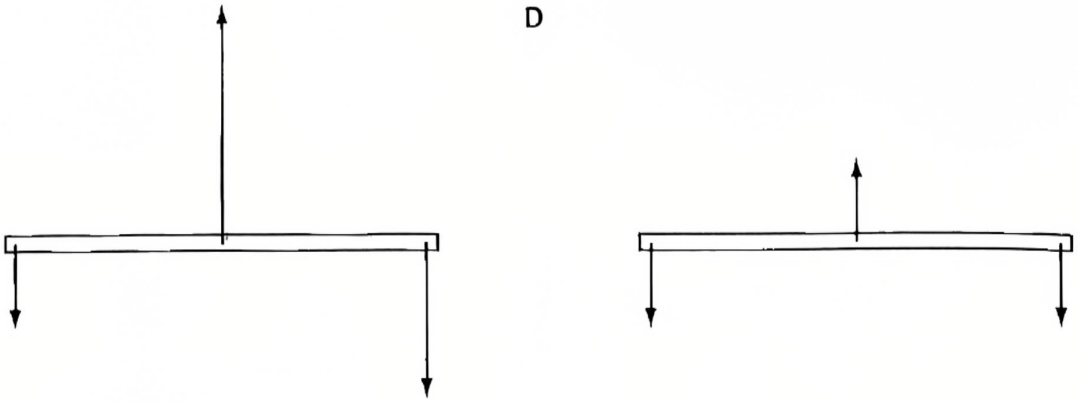


Which diagram shows the forces acting on the beam?
(The length of each arrow represents the size of a force.)

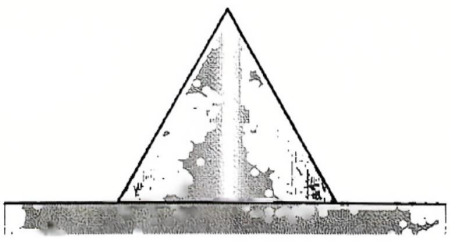
B



D



19 A metal cone with a circular base is placed on a flat surface.



The stability of the cone depends on

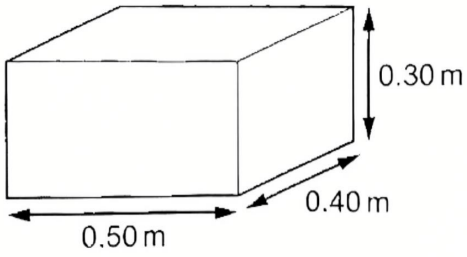
A its weight only.

B the diameter of its base only.

C the position of its centre of gravity only.

D the diameter of its base and the position of its centre of gravity.

20 A block of weight 900 N has rectangular faces. The diagram shows the lengths of the sides.



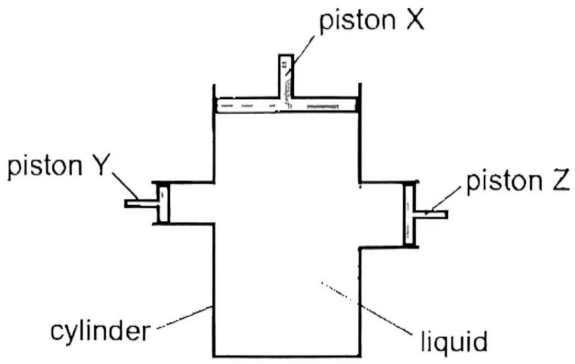
The block can rest on any of its faces.

What is the maximum pressure that the block can exert on the ground when resting on one of its faces?

A 4500 Pa **B** 6000 Pa **C** 7500 Pa **D** 15 000 Pa

21 Piston X is pushed into a horizontal hydraulic cylinder, producing a pressure P_X in the liquid.

The diagram shows the cylinder viewed from above.



view from above

There are two other pistons, Y and Z, in the cylinder. The pressures on piston Y and Z are P_Y and P_Z respectively.

What is the relationship between P_X, P_Y and P_Z?

A $P_X = P_Y + P_Z$

B $P_X > P_Z > P_Y$

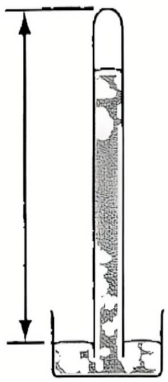
C $P_X < P_Z < P_Y$

D $P_X = P_Y = P_Z$

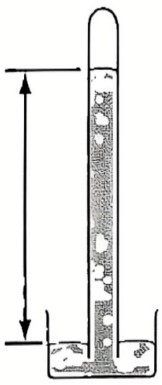
22 The diagrams show a simple mercury barometer.

Which diagram shows the distance to be measured to find atmospheric pressure?

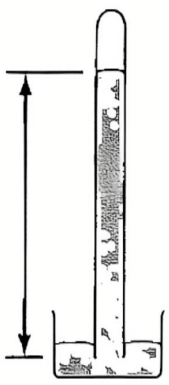
A



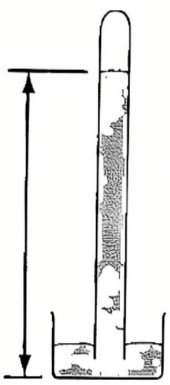
B



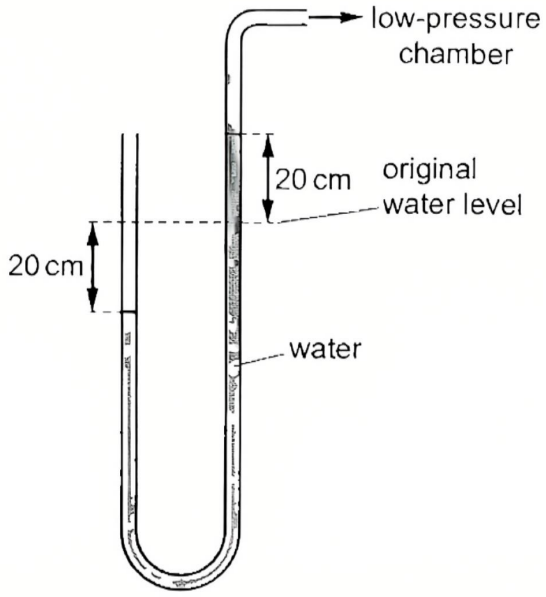
C



D



23 A U-tube containing water is used as a manometer.



When one end of the manometer is connected to a low-pressure chamber, both water levels in the manometer change by 20 cm. The gravitational field strength g is 10 N kg^{-1}.

The density of water is 1000 kg m^{-3}.

How far below atmospheric pressure is the pressure in this chamber?

A 2000 Pa **B** 4000 Pa **C** 200 000 Pa **D** 400 000 Pa

24 What describes the shape and volume of a gas or liquid at constant temperature?

	state	shape	volume
A	gas	not fixed	fixed
B	gas	not fixed	not fixed
C	liquid	fixed	fixed
D	liquid	fixed	not fixed

25 When fine pollen grains suspended in water are viewed under a microscope, they are seen to be making small, erratic movements.

Why is this?

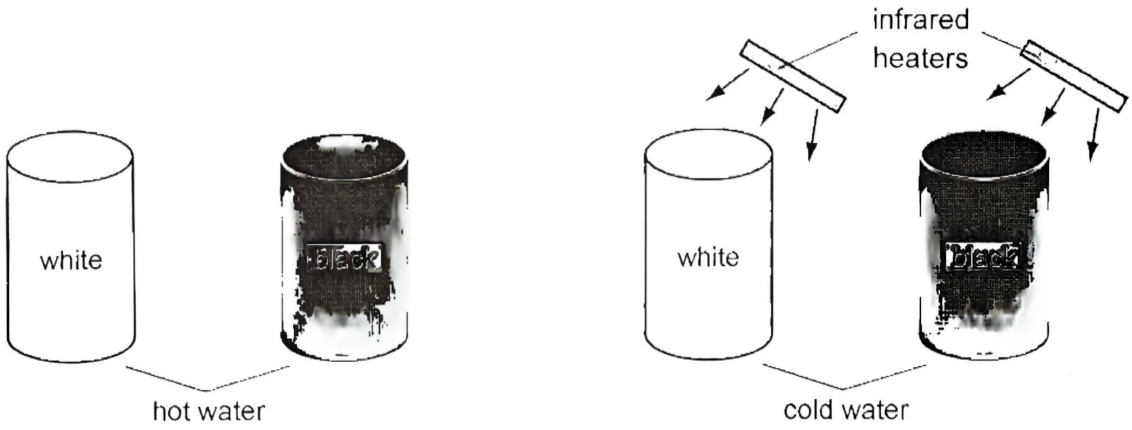
A There are convection currents in the water.

B They are being hit by water molecules.

C They are moving and colliding with one another.

D They are living organisms and so they move around.

26 The diagrams show four cans in a cool room. They are painted as shown. One pair is filled with hot water and left to cool down. The other pair is filled with cold water and placed under infrared heaters.

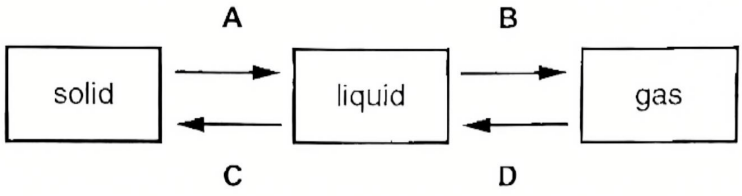


The hot water in the black can cools more quickly than the hot water in the white can. The cold water in the black can heats up more quickly than the cold water in the white can.

Which row shows the reasons for this?

	better emitter of infrared	better absorber of infrared
A	black	black
B	black	white
C	white	black
D	white	white

27 Which arrow shows condensation?



28 In an experiment, 1700 J of heat is supplied to 8.0 g of ice at 0 °C. Assume that water from the melted ice stays at 0 °C. The specific latent heat of fusion of ice is 340 J g^{-1}.

How much ice remains?

A 0 g **B** 3.0 g **C** 5.0 g **D** 7.8 g

29 A swimmer climbs out of a pool on a warm, dry day and almost immediately begins to feel cold.

Why is this so?

A The water on his skin is a good conductor of heat.

B The water prevents infrared radiation from reaching his body.

C The water takes latent heat from his body in order to evaporate.

D The water allows a convection current to remove energy from his skin.

30 A metal block of mass 1.0 kg, specific heat capacity c and temperature 80 °C is placed in good thermal contact with a second metal block of mass 2.0 kg, specific heat capacity $2c$ and temperature 30 °C. Assume no energy losses to the surroundings.

What is the final temperature of both blocks?

A 30 °C **B** 40 °C **C** 55 °C **D** 70 °C

--- End of Paper ---

Section A

Answer **all** questions.

1 A cruise ship departs from a jetty and sails 12.0 km due north in 8.0 minutes. It then changes direction and sails due east at a constant speed of 40.0 m s^{-1} for 10.0 minutes.

(a) Show that the average speed of the ship for the entire journey is 33 m s^{-1}.

[3]

(b) **(i)** Fig. 1.1 shows the displacement of the ship in the northerly direction drawn to scale.

Scale: 1.0 cm represents 4000 m

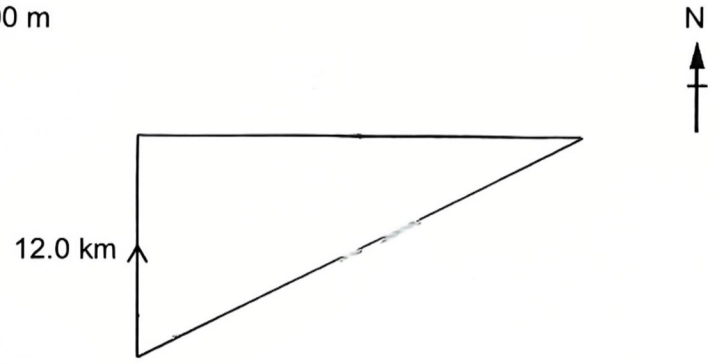


Fig. 1.1

On Fig. 1.1, complete the scale drawing to show the displacement in the easterly direction and the resultant displacement of the ship.

Use your drawing or otherwise, determine the magnitude of the resultant displacement and the angle between the resultant displacement and north.

resultant displacement = ...

angle = ... [3]

(ii) Calculate the magnitude of the average velocity of the ship for the entire journey.

average velocity = ... [1]

[Total: 7]

2 Fig. 2.1 is the displacement–time graph for a skydiver who jumps from a balloon at time $t = 0$.

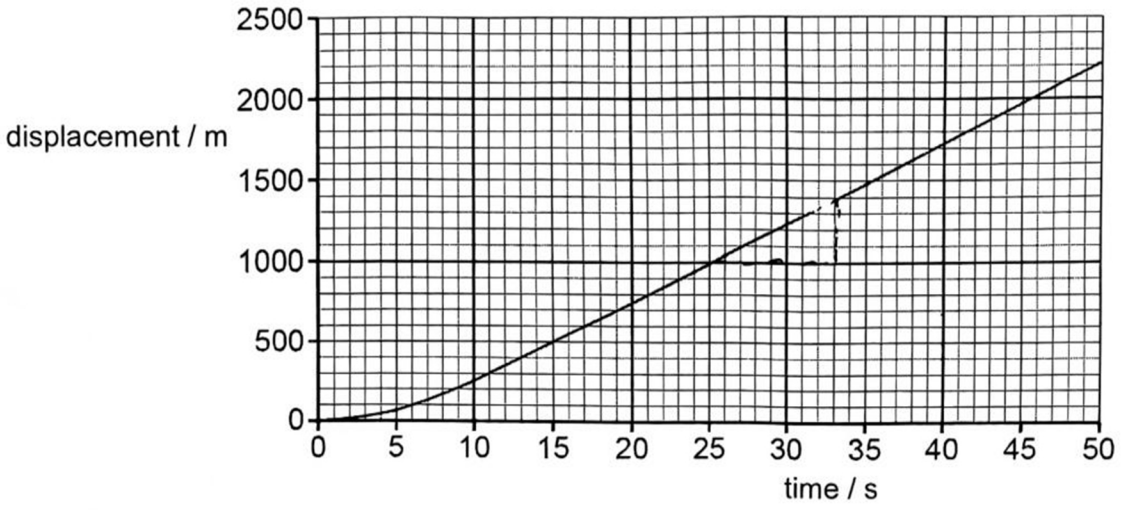


Fig. 2.1

(a) The first part of the graph shows the motion of the skydiver from when he jumps until he reaches terminal velocity.

(i) Describe the motion of the skydiver between $t = 0$ and $t = 15$ s.

.....

..... [1]

(ii) Explain the motion of the skydiver between $t = 0$ and $t = 15$ s in terms of the forces acting on him.

.....

.....

.....

.....

.....

..... [3]

(b) Using Fig. 2.1, determine the terminal speed of the skydiver.

terminal speed = ... [2]

[Total: 6]

(a) Ketchup does not flow easily. Shaking the glass bottle when tilted helps to get ketchup out, as shown in Fig. 3.1.

Fig. 3.1

Explain, using Newton's first law, how shaking the bottle helps to get ketchup out.

.....

.....

.....

..... [2]

(b) Evaporated milk in a tin can flows out slowly through a small hole in the lid, as shown in Fig. 3.2. When a second hole is punched, air can enter the can more easily, causing the milk to flow out more quickly.

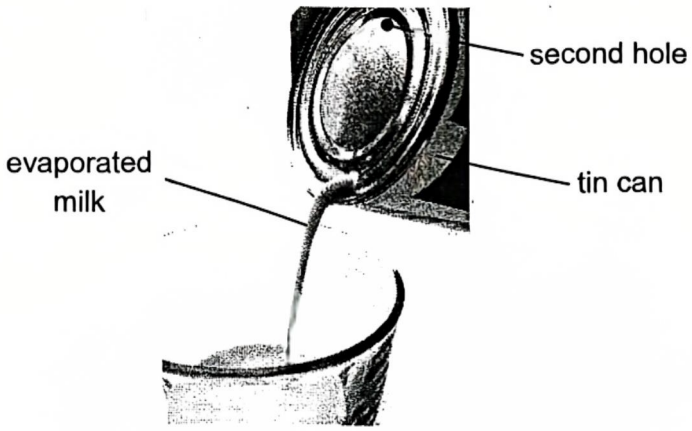


Fig 3.2

Using ideas of pressure, explain why evaporated milk flows out of a tin can more easily when there are two holes in the lid.

.....

..... [1]

[Total: 3]

4 A stone of mass 0.30 kg is thrown horizontally at a speed of 8.0 m s^{-1} from the top of a cliff height 45 m. The stone follows along a parabolic path and reaches point P, which is 32 m above the ground, as shown in Fig. 4.1.

Air resistance is negligible. The gravitational field strength g is 10 N kg^{-1}.

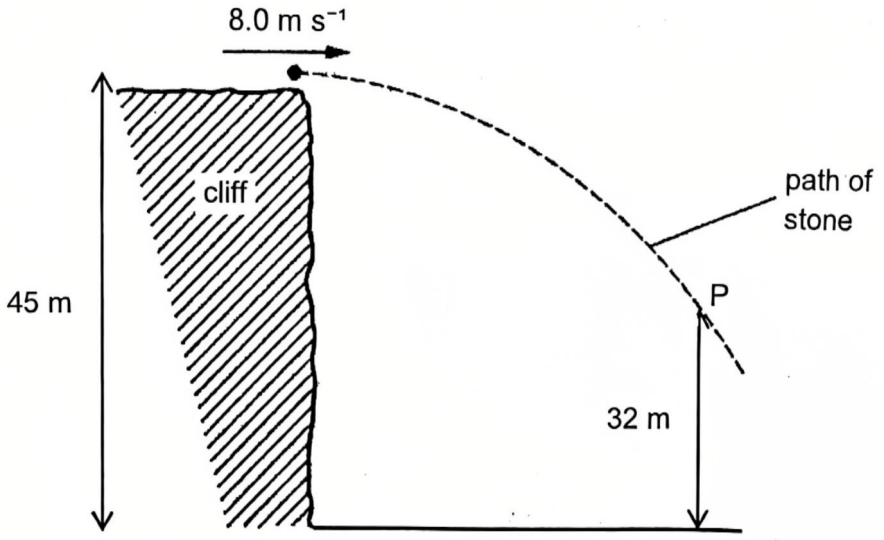


Fig. 4.1 (not to scale)

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

.....

.....

..... [2]

(b) **(i)** Calculate the kinetic energy of the stone at the top of the cliff.

kinetic energy = ... [2]

(ii) Calculate the loss in gravitational potential energy of the stone as it moves from the top of the cliff to point P.

loss in potential energy = ... [1]

(iii) Determine the speed of the stone at point P.

speed = ... [2]

[Total: 7]

5 Fig. 5.1 shows a laboratory freezer.

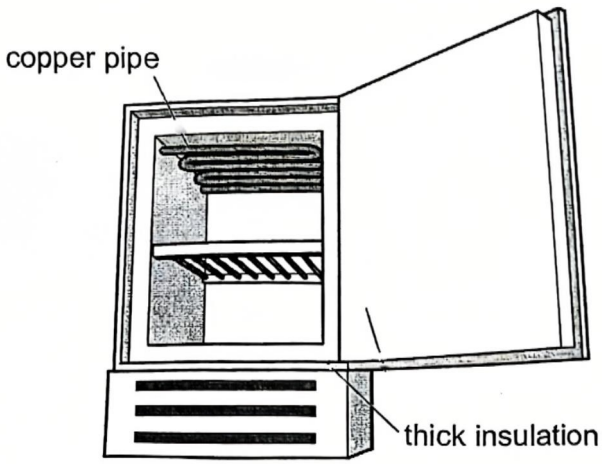


Fig. 5.1

The door is closed and the freezer is switched on.

A cold liquid is pumped through the copper pipe at the top of the freezer.

The temperature of the air next to the copper pipe decreases quickly.

(a) Explain how the temperature of the rest of the air in the freezer decreases.

.....

.....

.....

.....

.....

..... [3]

(b) The thick insulation shown in Fig. 5.1 is made from a plastic material.

(i) The plastic material in the insulation is a poor thermal conductor.

Using ideas about particles, describe how energy is transferred through the plastic material.

.....

.....

.....

..... [2]

(ii) The plastic material also contains a large number of small air bubbles.

Explain how the air bubbles reduce the transfer of thermal energy through the insulation.

.....

.....

.....

..... [1]

[Total: 6]

Fig. 6.1 shows a sealed cylinder with a piston of area 2.0 cm² that contains air.

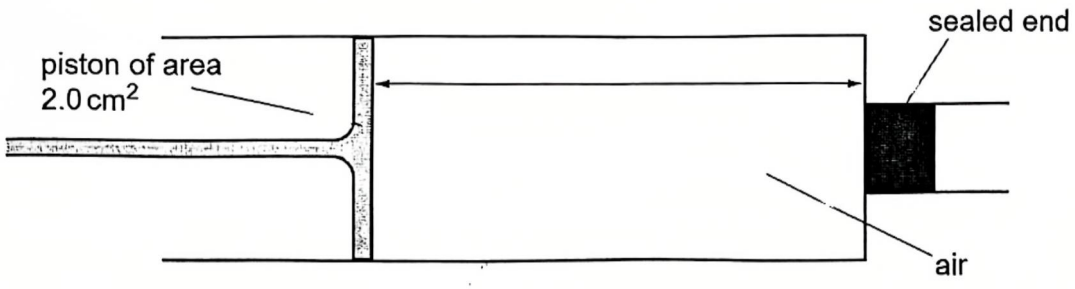


Fig. 6.1

When a force is applied to the piston, the length *d* changes from 6.0 cm to 4.0 cm. The pressure of the air increases but the temperature stays constant.

(a) Describe how the molecules of the air exert a pressure.

.....

.....

.....

..... [2]

(b) Using ideas about molecules, explain why the pressure increases even though the temperature remains constant.

.....

.....

.....

..... [2]

(c) The initial pressure of the air is 1.0×10^5 Pa.

Calculate the final pressure of the air.

final pressure = ... [2]

[Total: 6]

7 Fig. 7.1 shows a wind turbine with a blade radius of 50.0 m. When the wind blows directly towards the turbine at a speed of 15.0 m s^{-1}, the blades spin and the generator connected to the blades generates electrical power.

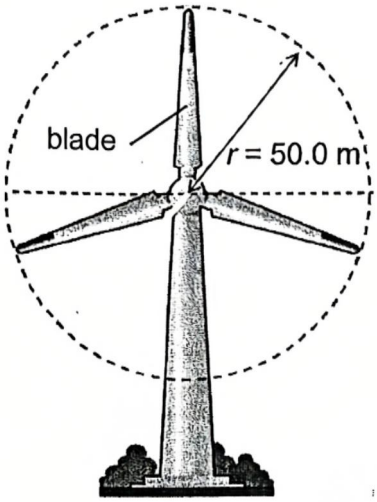


Fig. 7.1

(a) Wind energy is a renewable energy resource.

Name one other renewable energy resource.

.....

[1]

(b) The kinetic energy E of the wind blowing at a wind turbine for time t is given by the equation

$$E = \frac{1}{2}\pi r^2 v^3 \rho t$$

where r is the blade radius, v is the wind speed and ρ is the density of air. Take π = 3.142.

(i) The density of air is 1.25 kg m^{-3}.

Calculate the kinetic power P of the wind.

P = ...

[2]

(ii) The average electrical power generated by the turbine is 3.03 MW.

Calculate the efficiency of the turbine.

efficiency = ... [2]

[Total: 5]

8 A student investigates the specific heat capacity of water using the apparatus shown in Fig. 8.1

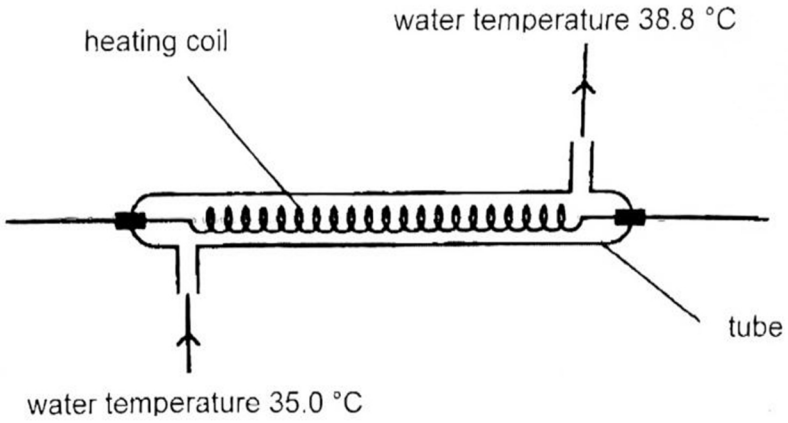


Fig. 8.1

Water enters the thin glass tube at a constant temperature of 35.0 °C. The power of a heating coil and the mass flow rate, which is the mass of water flowing through the tube per unit time, are varied such that the output temperature is always 38.8 °C.

Fig. 8.2 shows how the mass flow rate $\frac{\Delta m}{\Delta t}$ of water varies with the power P of the heating coil.

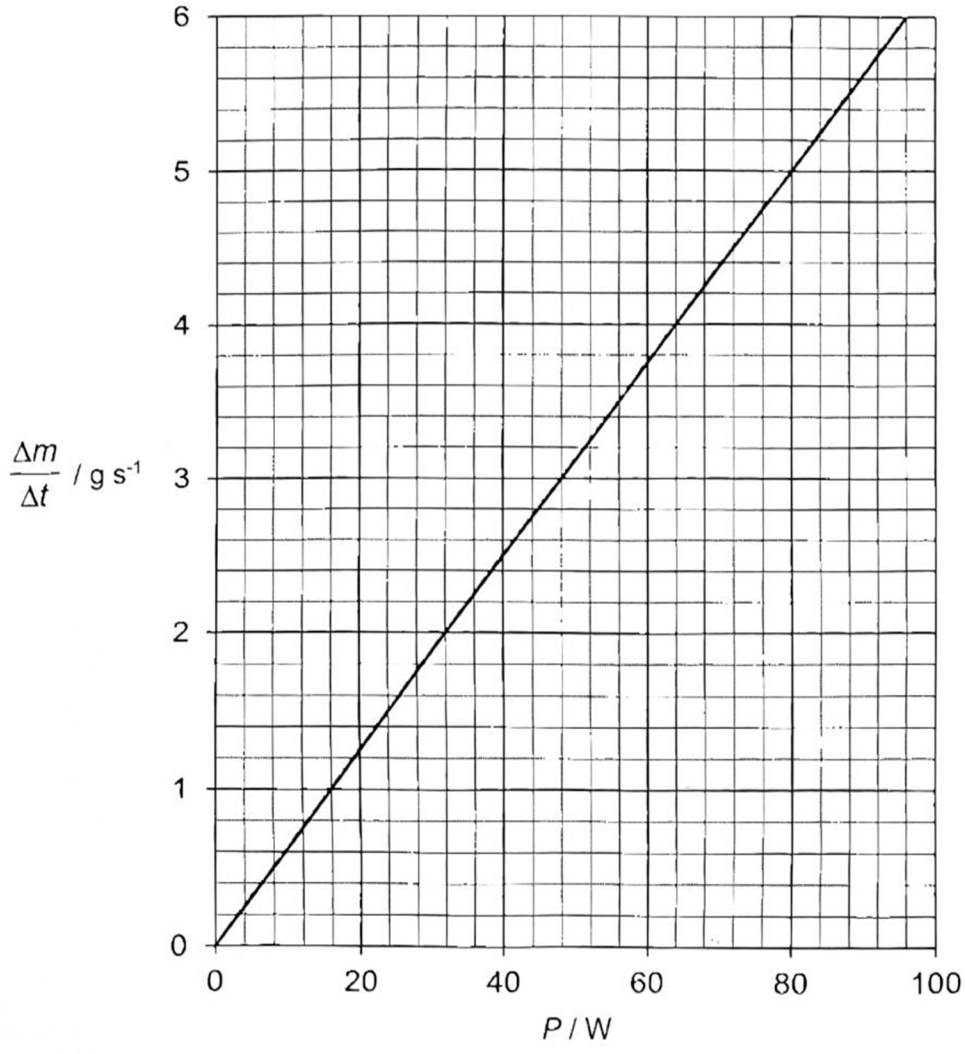


Fig. 8.2

(a) **(i)** Define *specific heat capacity*.

.....

.....

[2]

(ii) Using Fig. 8.2, determine the power of the heating coil when the mass flow rate of water is 4.0 g s^{-1}.

= ..... [1]

(iii) Assuming no energy is lost to the surroundings, use your answer to **(a)(ii)** to determine the specific heat capacity of water. Give your answer in $J g^{-1} K^{-1}$.

specific heat capacity = ... $J g^{-1} K^{-1}$ [2]

(iv) The tube is surrounded by insulation (not shown on Fig. 8.1) to reduce energy loss to the surroundings.

On Fig. 8.2, sketch a graph to show the variation of mass flow rate $\frac{\Delta m}{\Delta t}$ with power P when the insulation is removed. [2]

(b) Now, water at 100 °C enters the tube and begins to boil.

(i) Describe the change in the spacing between the water molecules during boiling.

..... [1]

(ii) The volume flow rate is the volume of water flowing through the tube per unit time.

Explain why the volume flow rate of water is much smaller than the volume flow rate of steam if both water and steam have the same mass flow rate.

.....

..... [1]

(iii) Explain why the apparatus shown in Fig. 8.1 is not suitable for boiling water.

.....

..... [1]

[Total: 10]

9 Fig. 9.1 shows a stationary lift of 2000 kg supported by a cable that is connected to a motor.

Fig. 9.2 shows a man of mass 72.8 kg standing inside the lift.

The gravitational field strength g is 10 N kg^{-1}.

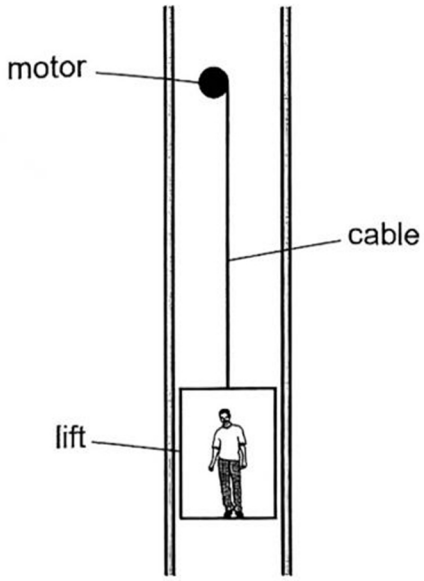


Fig. 9.1 (not to scale)

Fig. 9.2

(a) On Fig. 9.2, draw and label the forces acting on the man inside the lift. [2]

(b) When the motor is switched on, both the lift and the man accelerate upwards uniformly at 1.20 m s^{-2}.

(i) Calculate the resultant force acting on the man.

resultant force = ... [2]

(ii) Calculate the magnitude of the force exerted by the lift on the man.

force = ... [3]

(iii) Calculate the distance travelled by the lift in the first 5.0 s.

distance = ... [2]

(c) After the man exits the lift, the lift accelerates downwards at 10 m s^{-2}.

State the tension in the cable.

tension = ... [1]

[Total: 10]

Section B

Answer **one** question from this section.

10 Fig. 10.1 shows a student of weight 584 N at rest in a push-up position on the ground. The centre of gravity (CG) of the student is 0.840 m from his feet and 0.410 m from his hands.

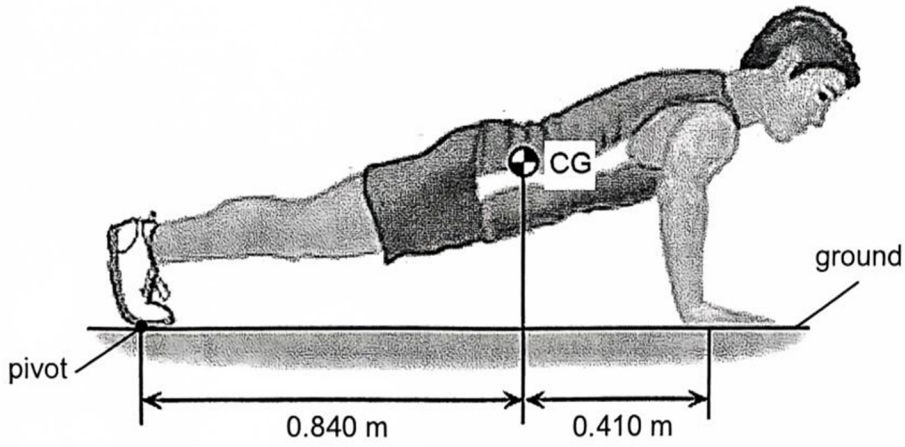


Fig. 10.1 (not to scale)

(a) State what is meant by the *centre of gravity*.

.....

..... [1]

(b) **(i)** State two conditions required for the person to be in equilibrium.

1. .....

.....

2. .....

..... [2]

(ii) By taking moment about the pivot, determine the total normal force F_h exerted by the ground on the student's hands.

= ..... [2]

(iii) Determine the total normal force F_f exerted by the ground on the student's feet.

F_f = ... [1]

(iv) The student shifts his CG slightly forward and closer to his hands without moving his hands and feet on the ground. He remains at rest in the new push-up position.

State and explain what happens to F_h and F_f.

.....

.....

.....

..... [2]

(c) The student does 20 push-ups. For each push-up, the student applies an average force of 600 N as he pushes up a distance of 0.50 m.

Calculate the total work done by the force.

total work done = ... [2]

[Total: 10]

11 A small glass measuring cylinder of oil is placed inside a freezer where the temperature is –18°C.

Fig. 11.1 shows how the temperature of the oil varies with time *t*.

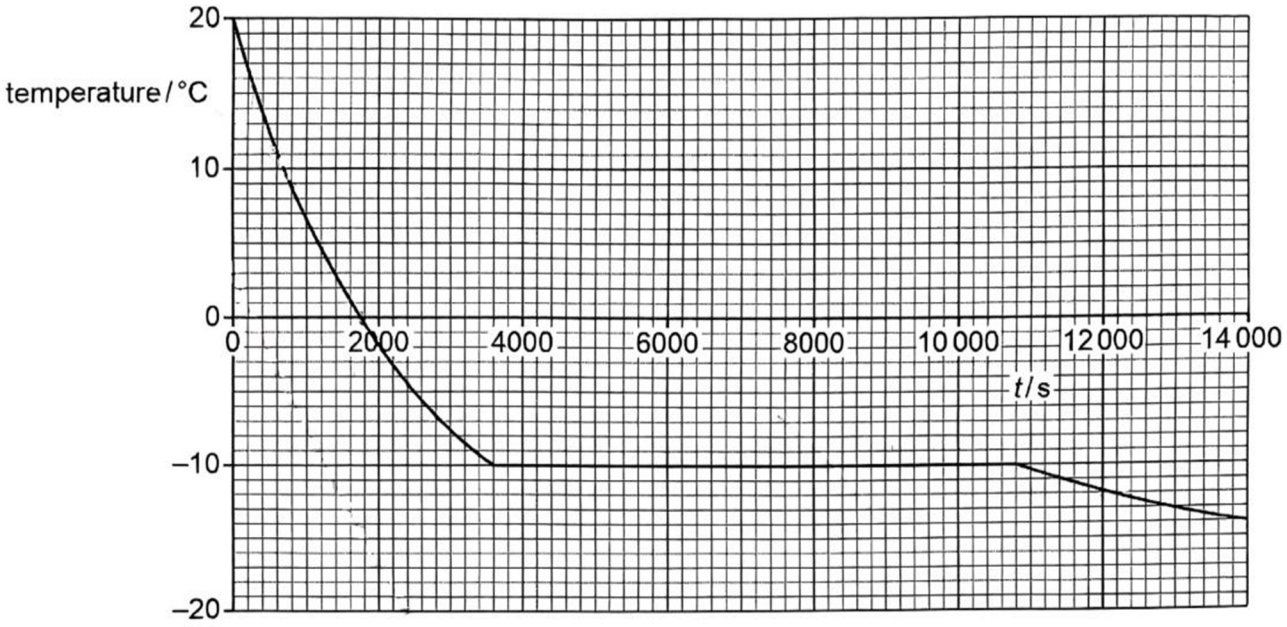


Fig. 11.1

Fig. 11.1 shows that it takes 700 s for the temperature to decrease from 20 °C to 10 °C but that it takes 1900 s to decrease from 0 °C to –10 °C.

(a) Explain why these times are different.

.....

.....

.....

..... [2]

(b) Explain what happens to the molecules of the oil and what happens to the level of the oil in the glass measuring cylinder as the temperature decreases from 20 °C to 0 °C.

.....

.....

.....

.....

.....

..... [3]

(c) Using ideas about molecules, explain why the temperature does not change between $t = 3600$ s and $t = 10\,800$ s, even though energy is lost by the oil.

.....

.....

.....

..... [2]

(d) There is 45 g of oil in the glass measuring cylinder and the specific latent heat of fusion of the oil is 5.7×10^4 $J kg^{-1}$.

Calculate the energy transferred from the oil between $t = 3600$ s and $t = 10\,800$ s.

energy = ... [2]

(e) After $t = 20\,000$ s, the temperature of the oil remains constant.

Explain why.

..... [1]

[Total: 10]

--- End of Paper ---