Name:...................................... Register/Index Number: .... Class: ....

PRESBYTERIAN HIGH SCHOOL

PHYSICS **6091/2**

Paper 2

22 August 2024 **Thursday** **1 hour 45 minutes**

2024 SECONDARY FOUR EXPRESS PRELIMINARY EXAMINATION

INSTRUCTIONS TO CANDIDATES

DO NOT OPEN THIS QUESTION PAPER UNTIL YOU ARE TOLD TO DO SO

Write your class, register number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glues or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer **one** question in this section.

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

For Examiner's Use	
Section A	
Section B	
Total	

Section A

Answer **all** the questions in the spaces provided.

1 Fig. 1.1 shows a cricket ball as it comes into contact with a cricket bat.

Fig. 1.1

The cricket ball has a mass of 0.16 kg and it hits the bat with a speed of 25 m/s.

After being in contact with the bat for 0.013 s, the ball rebounds with a speed of 22 m/s in the **direction** exactly **opposite** to its original direction.

(a) State one difference between speed and velocity.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………….. [1]

(b) Calculate the acceleration experienced by the cricket ball when it is struck by the bat.

acceleration = ……………… [2]

(c) Hence, determine the resultant force exerted on the ball by the bat.

resultant force = ……………… [1]

2 Fig. 2.1 shows a uniform rectangular concrete slab that is 4.0 m in length, 3.0 m in width and 0.10 m in thickness. It rests on a brick wall and is the roof of a bus shelter.
The density of the concrete slab is 1750 kg/m^3.

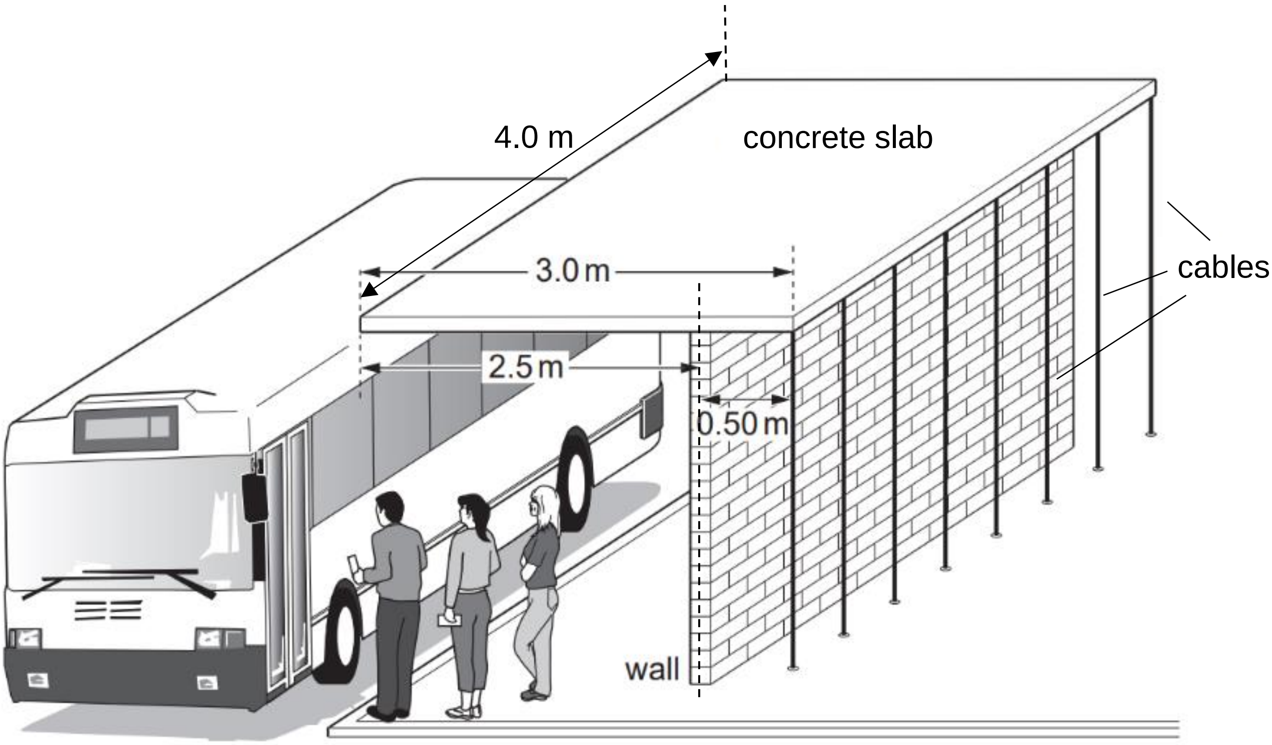

Fig. 2.1

(a) The gravitational field strength, g is 10 N/kg.
Calculate the weight of the rectangular concrete slab.

weight = ……………… [2]

(b) Using principle of moments, determine the total downward force exerted by the cables on the slab.

total downward force = ……………… [2]

(c) Hence, determine the upward force exerted by the brick wall on the concrete slab.

upward force = ……………… [2]

3 Fig. 3.1 shows a skier of mass 85 kg skiing down a very steep smooth slope.
The gravitational field strength, *g* is 10 N/kg.

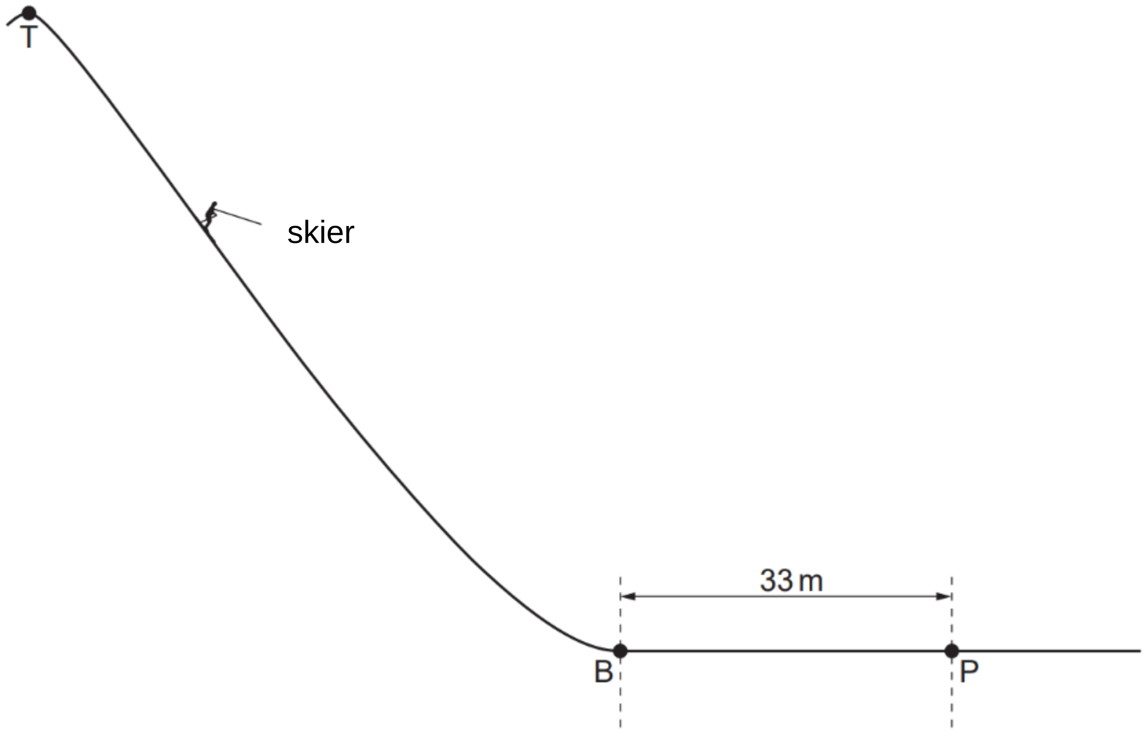

Fig. 3.1 (not to scale)

The skier starts moving from the top T of the slope with an initial speed of 2 m/s.
The force of gravity accelerates him down the slope.
When he reaches the bottom B of the slope, his speed is 30 m/s.

(a) **(i)** Calculate the difference in height between T and B.

difference in height = ……………… [2]

(ii) State one assumption you have made regarding the energy transfer for your calculation in **(a) (i)**.

....

....

.... [1]

(b) At **B**, the skier digs his skis into the snow and stops at the point P after travelling 33 m horizontally.

Calculate the average braking force that acts on the skier between B and P.

average braking force = ... [2]

4 A student uses a pump to inflate a bicycle tyre.

Fig. 4.1 shows the pump and the tyre.

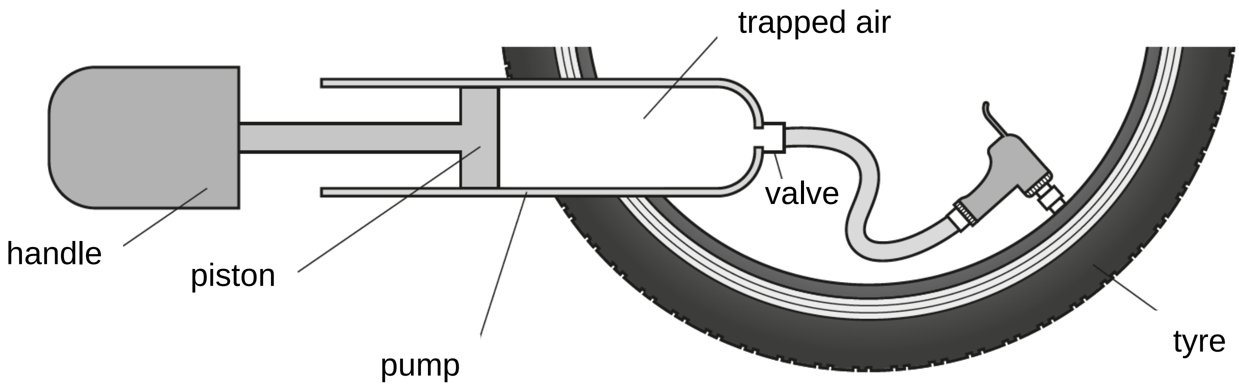

Fig. 4.1 (not scale)

(a) The pressure of the trapped air in the pump is 3.8×10^5 Pa and the cross-sectional area of the piston is 6.1 cm^2.

(i) Calculate the force exerted on the piston by the trapped air in the pump.

force = ……………… [2]

(ii) The student pushes the handle to the right and the piston forces the trapped air into the tyre.
The force exerted by the student is less than the value in **(a)(i)**.

Suggest one reason why.

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………… [1]

(b) Under the hot sun, the temperature of the trapped air in the pump increases.

Explain, in terms of its molecules, why the student needs to use a larger force to push the handle of the pump.

……………………………………………………………………………………………

……………………………………………………………………………………………

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………………………………………………………………………………………….. [2]

5 A wave travels along a rope from left to right. Two points on the rope, A and B, have vertical displacement d_A and d_B respectively. The variation of d_A and d_B over the same time interval *t* is shown in Fig. 5.1.

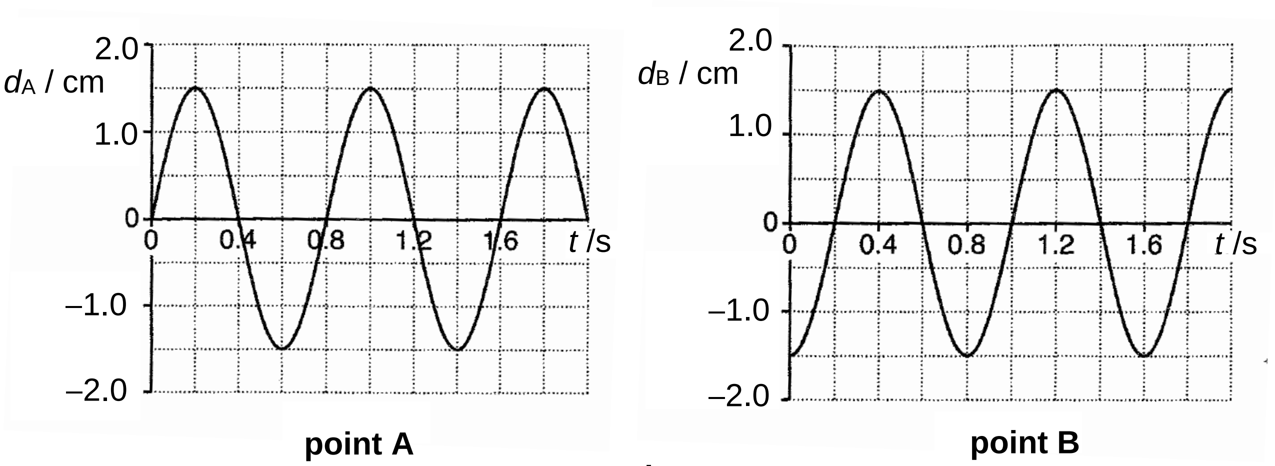

Fig. 5.1

(a) State the amplitude of the wave.

amplitude = ……………… [1]

(b) Point B is 38 cm to the right of point A.

(i) There are several possible values for the speed of the wave on the rope. Show that one possible value for the speed of the wave is about 200 cm/s. Show your working clearly. [2]

(ii) Explain why there are **other** possible values for the speed of the wave.

……………………………………………………………………………………

…………………………………………………………………………………… [1]

[Turn over

6 Ultrasound is used in medical imaging.

(a) Describe what happens to ultrasound waves as they meet the boundary between **two** different materials.

....

....

....

.... [2]

(b) To produce an image of an unborn child, an ultrasound emitter and receiver are placed close together on the mother's skin.

Fig. 6.1 shows pulses detected by the receiver.

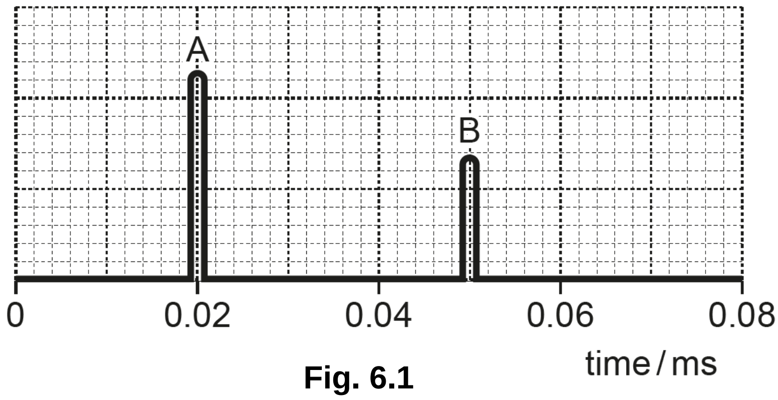

Fig. 6.1

Pulse A is the emitted pulse and pulse B is the first pulse that returns from the unborn child.

The average speed of ultrasound in human tissue is 1500 m/s.

Calculate the distance between the emitter and the child.

distance = ... [2]

[Turn over

7 Fig. 7.1 shows a ray of blue light, travelling in air, strikes the side of a glass block and continues in the same direction as it enters the glass block.

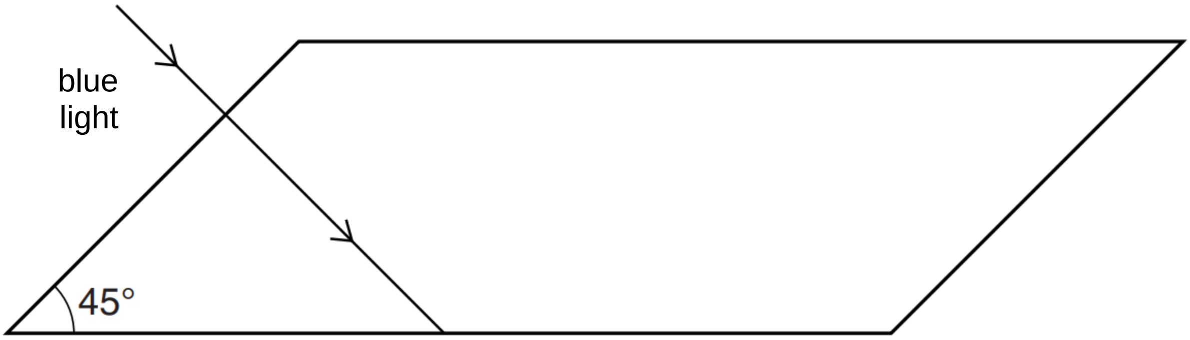

Fig. 7.1

The refractive index of glass for blue light is 1.5.

(a) Explain why the light continues in the same direction as it enters the glass block.

....

....

.... [1]

(b) On Fig. 7.1, complete the path of the light until it leaves the glass. Clearly indicate all workings in the space provided and label the various angles on the diagram. [3]

8 Fig. 8.1 shows a negatively charged rod close to an uncharged metal sphere that is mounted on an insulating stand.

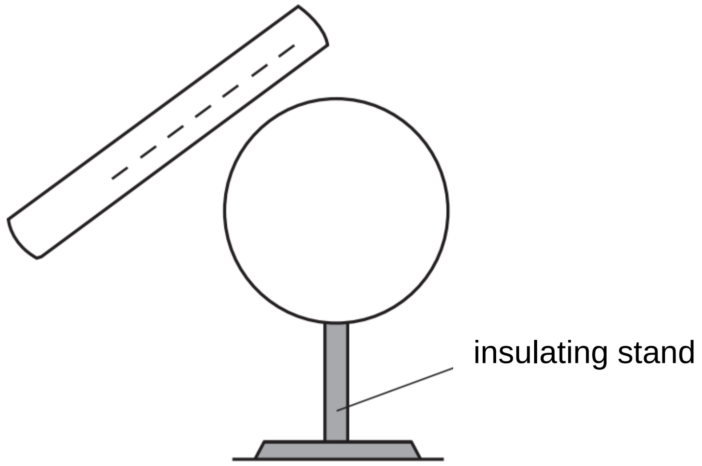

Fig. 8.1

(a) A metal wire connected to earth is touched against the sphere.

Explain what happens to the charge on the sphere.

....

....

.... [2]

(b) The earth wire remains in contact with the sphere.

Describe what happens in the wire as the rod is moved away.

....

....

.... [1]

9 Fig. 9.1 shows a circuit containing a 230 V a.c. supply connected to a television and two lamps.

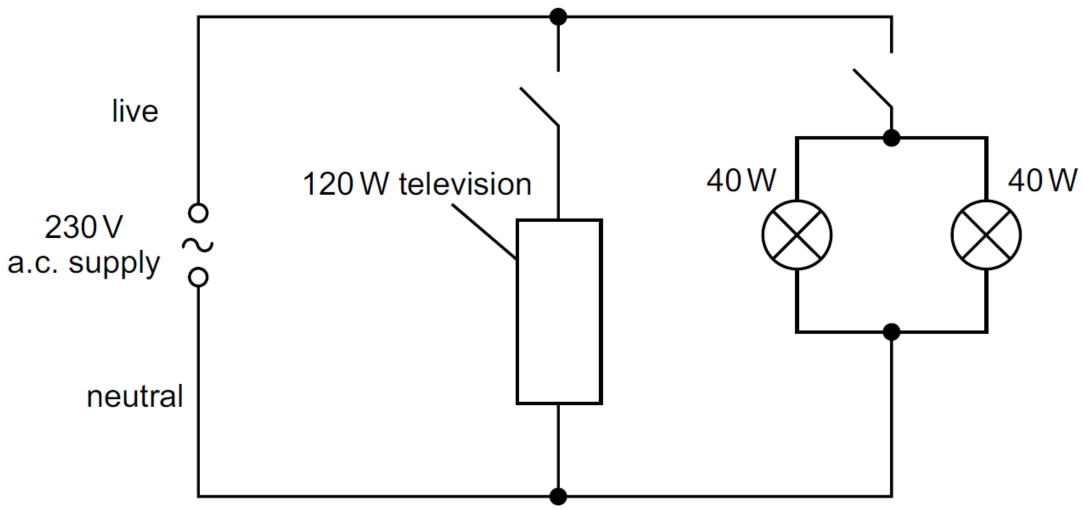

Fig. 9.1

In normal operation, both switches are closed. The power supplied to each lamp is 40 W and the power supplied to the television is 120 W.

(a) The circuit is in normal operation for 1 full day.
The cost of one unit of electricity is $ 0.30.

Calculate the total cost of operating the circuit for a day.

total cost = ... [2]

(b) Determine the total current in the circuit.

total current = ... [1]

(c) Suggest an appropriate fuse rating for the circuit.

fuse rating = ... [1]

(d) Explain why the switches are placed in the live wire and **not** in the neutral wire.

....

....

....

....

.... [2]

10 Fig. 10.1 shows a loose wire connected in a circuit with a d.c. (direct current) power supply and a switch. The length of the wire between the two supports is in the magnetic field of a horseshoe magnet.

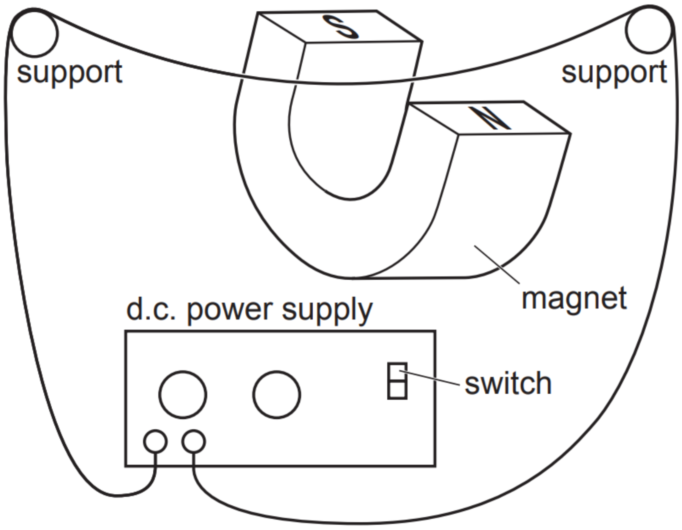

Fig. 10.1

(a) Explain why the wire moves down when the power is switched on.

....

....

....

.... [2]

(b) On Fig. 10.1, draw an arrow on the wire between the two supports to show the direction of the current. [1]

11 Electrical energy distribution takes place in a country through a network of transmission cables, as shown in Fig. 11.1.
A power station generates 100 MW of power at a voltage of 25 kV.

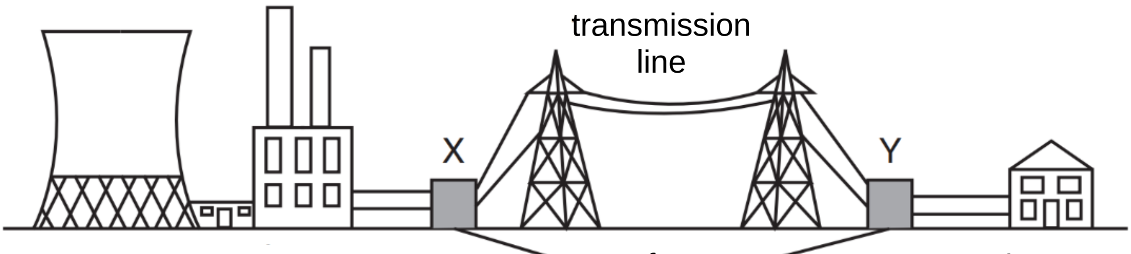

Fig. 11.1

Transformer X**,** which links the power station to the transmission cables, has 4000 turns in the primary coil and 44000 turns in the secondary coil.

(a) Calculate the current in the secondary coil of transformer X.

current = ……………… [2]

(b) Electricity is transmitted at high voltages.
State and explain why electricity is transmitted in this way.

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………….. [2]

(c) After transmission through the cables, only 80% of the original power generated at the power station is transferred to transformer Y.

Determine the total resistance of the transmission cables.

total resistance = ……………… [2]

12 A company makes insulating bowls to keep food cold. It undertakes a scientific test to find out the best material for making the bowls and whether it is worth supplying a lid. Bowls made with polystyrene and paper cardboard are filled with 200 g of ice and the mass of water collected is recorded every 5 minutes. The results are shown in Fig. 12.1

	bowl made from polystyrene		**bowl made from paper cardboard**	
	without lid	with lid	without lid	with lid
time / min	mass / g	mass / g	mass / g	mass / g
0	0	0	0	0
5	2	0	12	5
10	9	5	25	14
15	13	9	44	30
20	20	14	58	45
25	30	23	79	63

Fig. 12.1

(a) State two variables that should be kept constant to ensure a fair test.

....

....

.... [1]

(b) Using the data from the table 12.1, suggest which material is better for insulation and explain your choice.

....

....

....

....

....

....

.... [2]

(c) For both materials, give two reasons for the difference in the mass of water collected with and without lid.

1 …………………………………………………………………………………………...

…………………………………………………………………………………………………

…………………………………………………………………………………………………

2 …………………………………………………………………………………………...

…………………………………………………………………………………………………

……………………………………………………………………………………………….. [2]

(d) State and explain whether the colour of the insulation bowl should be white or black.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………….. [2]

(e) An ice maker is used to produce ice. Water at a temperature of 25.0 °C enters the machine and emerges as ice cubes at a temperature of – 3.0 °C.
The melting point of ice is 0 °C.

The following information is known:

specific heat capacity of liquid water	=	4.2×10^3 J/(kg°C)
specific latent heat of fusion of water	=	3.4×10^5 J/kg
specific heat capacity of ice	=	2.1×10^3 J/(kg°C)

Calculate the total amount of energy removed as 0.50 kg of water at 25.0 °C is cooled to form ice at – 3.0 °C.

total energy removed = ……………… [3]

13 Fig. 13.1 shows the proton number and the nucleon number of the nuclei of five neutral atoms.

	neutral atom 1	neutral atom 2	neutral atom 3	neutral atom 4	neutral atom 5
proton number	16	17	18	18	19
nucleon number	35	35	38	40	39

Fig. 13.1

(a) State the **two** atoms in Fig. 13.1 that

(i) are different isotopes of the same element,

....[1]

(ii) contain the same number of neutrons.

....[1]

(b) The nucleus of atom 1 is radioactive and when it decays, it emits a beta-particle.

State how the composition of the daughter nucleus produced differs from the parent nucleus.

....

....

.... [1]

(c) A sample contains a large number of radioactive nuclei that emit beta-particles. The sample is placed near to a radiation detector in a laboratory and the count rate is recorded over a long period of time.

Fig. 13.2 shows the count rate recorded by the detector during this period.

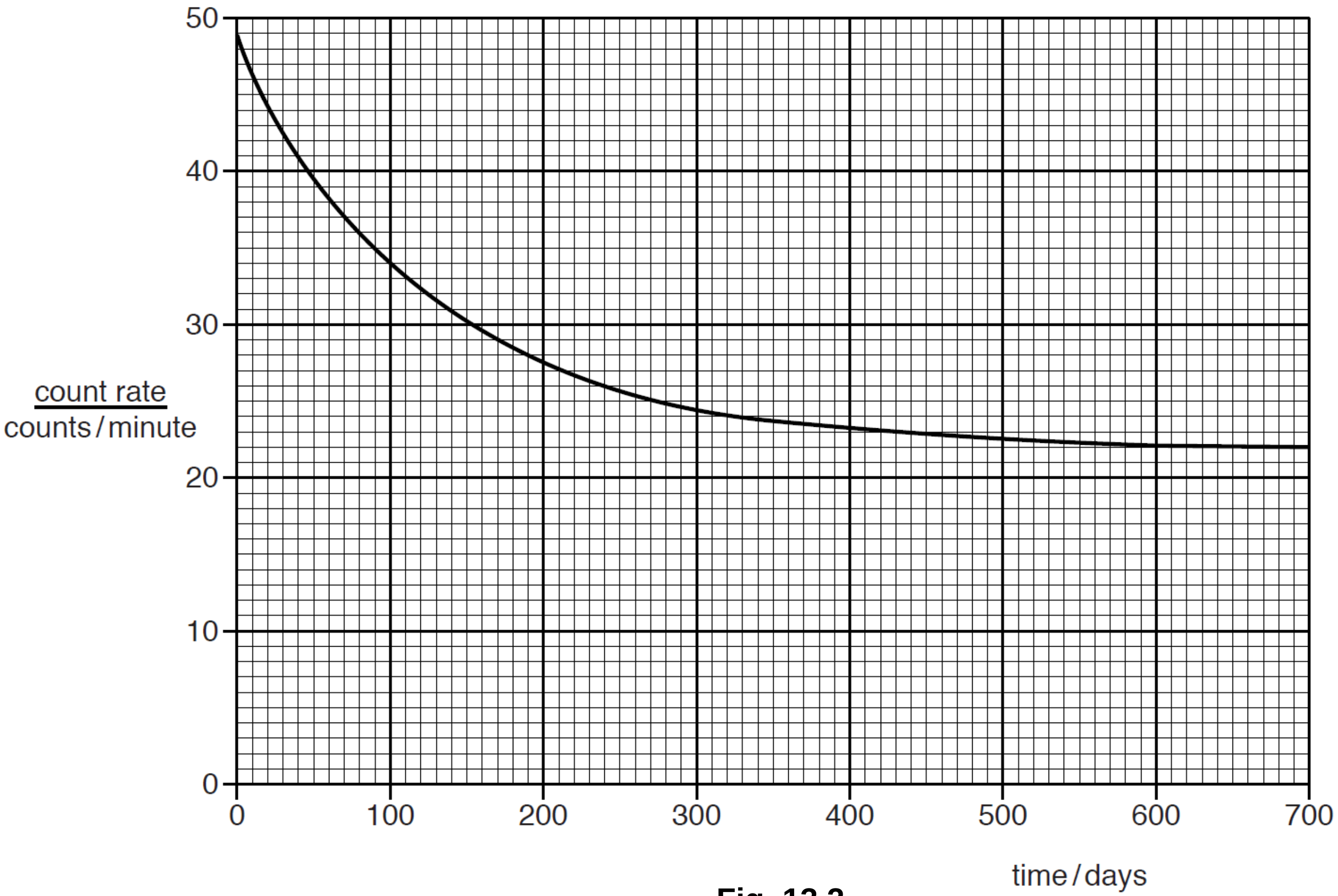

Fig. 13.2

(i) Suggest **two** different origins for the background count.

....

....[1]

(ii) Explain what is meant by *radioactive half-life*.

....

....

....[1]

(iii) Using Fig. 13.2,

1. determine the count rate, at time = 0, due to the sample on its own,

count rate of sample = ……………… [1]

2. estimate the half-life of the radioactive atoms in the sample.

half-life = ……………… [2]

(d) A student suggests a change to the experiment in **(c)**. He proposes completely encasing the radiation detector in lead a few mm thick before placing the sample that emits beta particles near it. This way, the effect of background radiation on the count rate can be ignored.

(i) Describe and explain the effect on the background count rate recorded by the detector of completely encasing the radiation detector in lead.

………………………………………………………………………………………

……………………………………………………………………………………..[1]

(ii) State and explain whether the student's suggestion is a sensible one.

………………………………………………………………………………………

……………………………………………………………………………………..[1]

Section B

Answer **one** question from this section.

14 During a game of cricket, a player hits a ball with a bat. The ball then travels vertically upwards, as shown in Fig. 14.1.

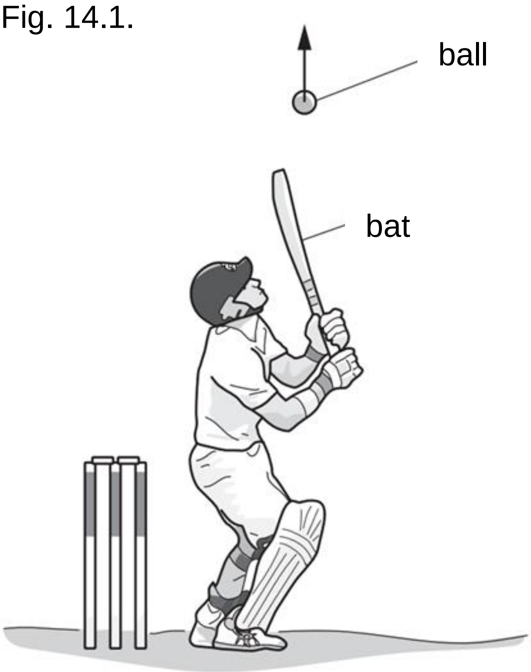

Fig. 14.1

The speed of the ball as it leaves the bat is 8.8 m/s.
The mass of the ball is 160 g.

(a) Calculate the kinetic energy of the ball as it leaves the bat.

kinetic energy = ... [1]

(b) Fig. 14.2 is the velocity-time graph for the ball.

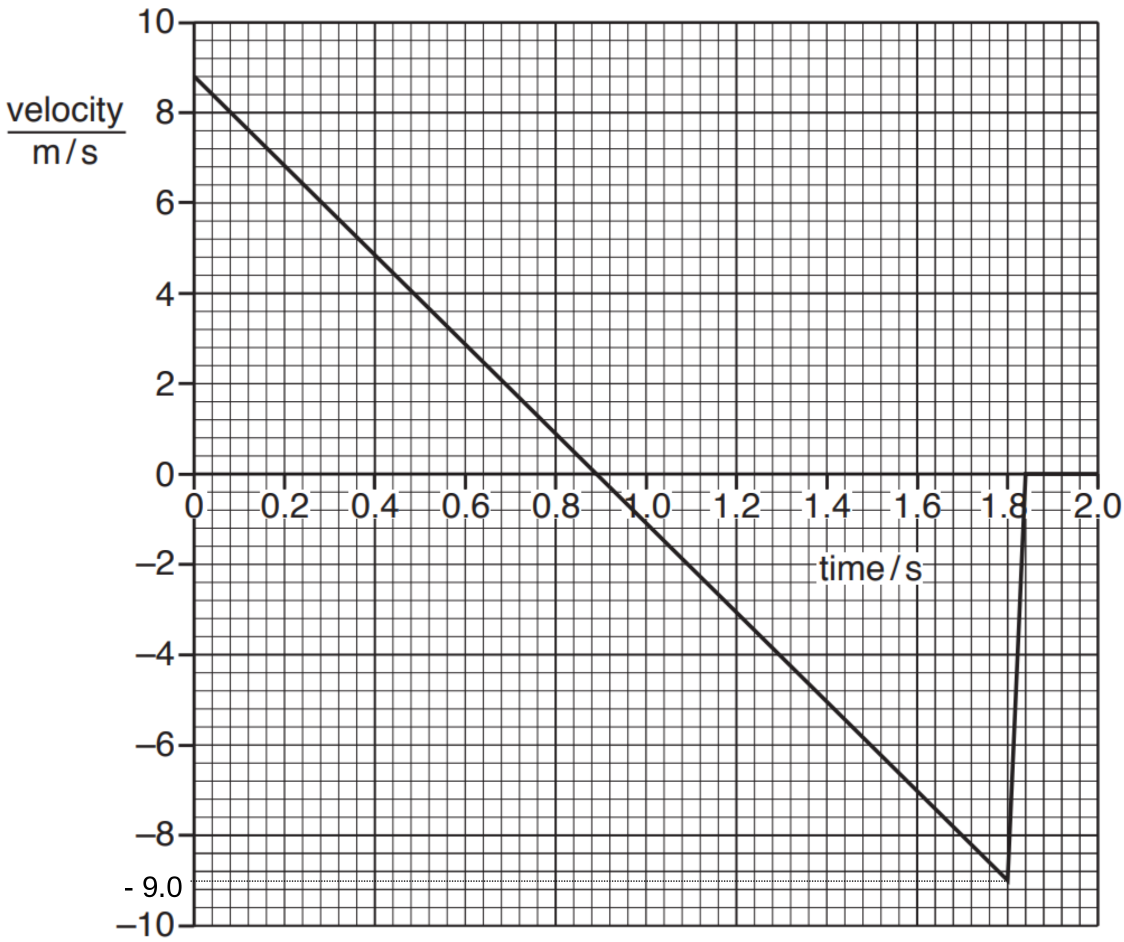

Fig. 14.2

(i) Determine the time at which the ball stops moving upwards.

time = ... [1]

(ii) Calculate the distance travelled before the ball stops moving upwards.

distance travelled = ... [2]

[Turn over

(c) Fig. 14.2 shows that the ball hit the ground after a time of 1.80 s and remains stationary after a time of 1.84 s.

(i) Describe the energy transfer that is occurring at this time interval.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………..[2]

(ii) Determine the resultant force acting on the ball when it landed on the ground.

resultant force = ……………… [2]

(d) For this ball moving in the way shown, the effect of air resistance is negligible. When a ball with a much smaller mass is hit vertically upwards at the same speed, air resistance produces a noticeable effect on its motion.

Suggest **two** ways in which the velocity-time graph for the ball with a smaller mass differs from Fig. 14.2.

1. ………………………………………………………………………………………

………………………………………………………………………………………

2. ………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………… [2]

15 A student sets up a circuit as shown in Fig. 15.1 by connecting a battery of electromotive force (e.m.f.) 9.0 V, a resistor P and a cylinder made of modelling clay. The modelling clay is an electrical conductor as shown in Fig. 15.2.

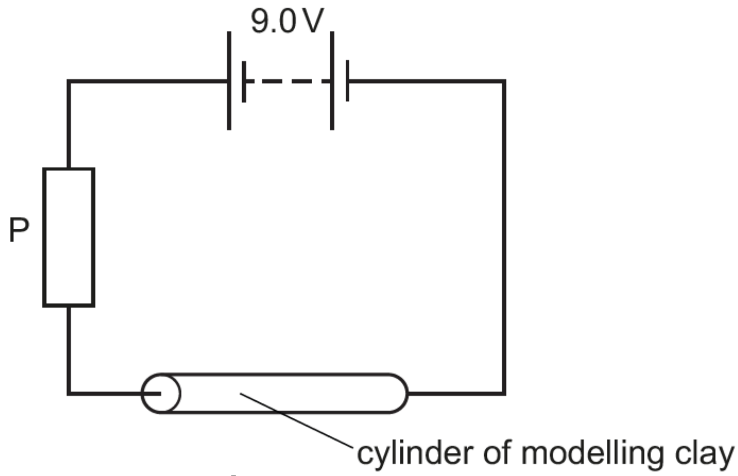

Fig. 15.1

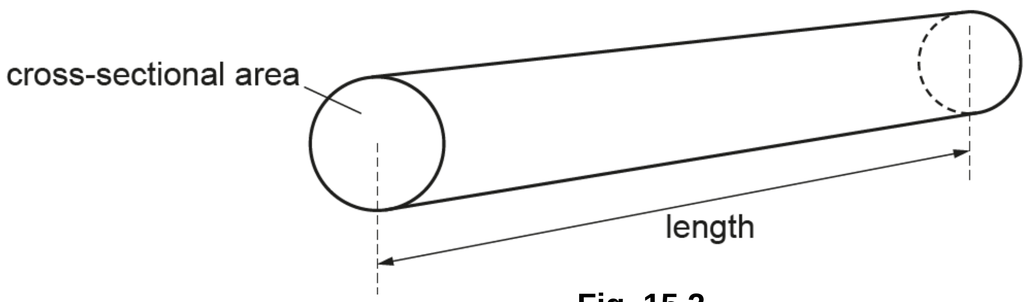

Fig. 15.2

(a) Explain what is meant by *electromotive force of 9.0 V*.

…………………………………………………………………………………………..

………………………………………………………………………………………….

…………………………………………………………………………………………...[1]

(b) The resistance of P is 4.0 Ω. The current in P is 1.5 A.

(i) Calculate the magnitude X of the charge that flows through P in 600 s.

charge through P = ……………… [1]

(ii) Determine the resistance of the cylinder of modelling clay.

resistance of cylinder = ……………… [2]

(c) The cylinder is removed from the circuit and replaced with a new cylinder made of the same modelling clay and having the **same volume**.

The new cylinder is twice the length of the original cylinder.

Calculate the time that it now takes for a charge of magnitude X to flow through resistor P.

time = ……………… [3]

(d) The student sets up a second circuit using a variable d.c. power supply, an ammeter and a 12 V metal filament lamp.

The circuit is shown in Fig. 15.3.

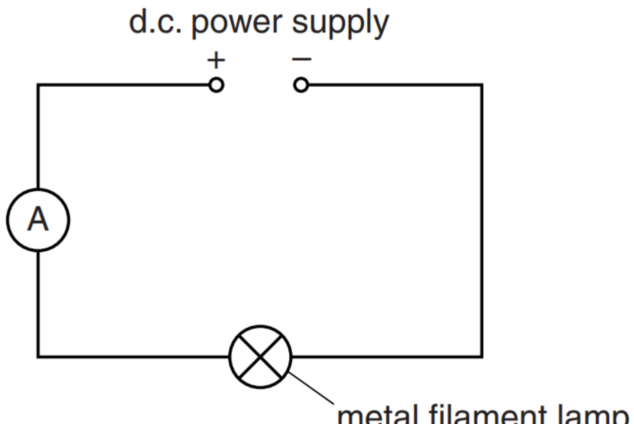

Fig. 15.3

The d.c. power supply is set to 12 V and the ammeter reading is 1.5 A. The student changes the e.m.f. of the d.c. power supply to 6.0 V.

The lamp dims and the ammeter reading changes.

(i) State and explain what happens to the resistance of the metal filament of the lamp.

....

....

....

....

....[2]

(ii) State whether the new ammeter reading is less than, equal to or greater than 0.75 A.

....[1]

END OF PAPER