O	BARTLEY SECONDARY SCHOOL PRELIMINARY EXAMINATION

CANDIDATE NAME			
CLASS		INDEX NUMBER	

PHYSICS 6091

Secondary 4
Paper 2

23 Aug 2024
1 h 45 mins

READ THESE INSTRUCTIONS FIRST

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, glue or correction fluid.

Section A
Answer **all** questions.
Write your answers in the spaces provided.

Section B
Answer **one** question.
Write your answers in the spaces provided.

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, as more marks are awarded for sound use of Physics than for correct answers.

The number of marks is given in brackets [ ] at the end of each question or part question.
At the end of the examination, submit this question paper.

For Examiner's Use	
Section A	
Section B	
Total	
Parent Signature:	

This document consists of **21** printed pages and **3** blank pages.

Set By: QSR

SECTION A

Answer **all** questions.

1 An aircraft flies at a constant height. The force from the aircraft's engines produces a force on the aircraft of 36 kN due north, as shown in Fig. 1.1. The wind produces a force of 12 kN towards the east.

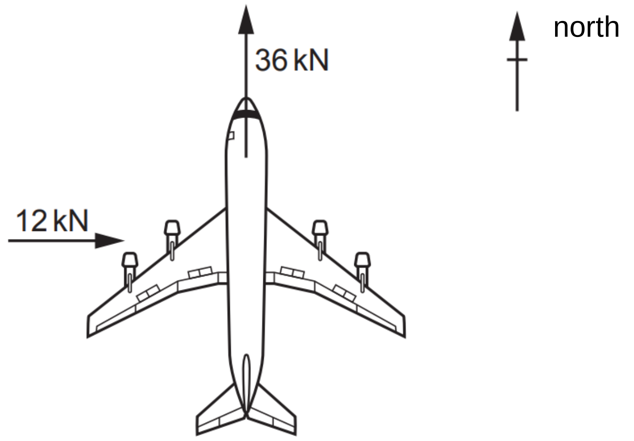


Fig. 1.1
(not to scale)

Draw a scale drawing to show the resultant force acting on the aircraft. Use your drawing to determine the magnitude and direction of the resultant force.

scale: ....

size of resultant force = ...

direction = ... [3]

2 Fig. 2.1 shows the path of a ray of blue light as it passes through a glass prism.

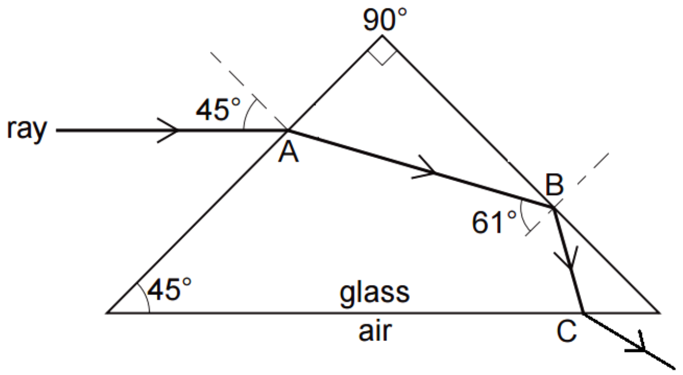


Fig. 2.1

(a) Determine the refractive index of the prism. Show your working.

refractive index = ... [2]

(b) Explain why the ray does not emerge into the air at **B**.

....

....

....

.... [2]

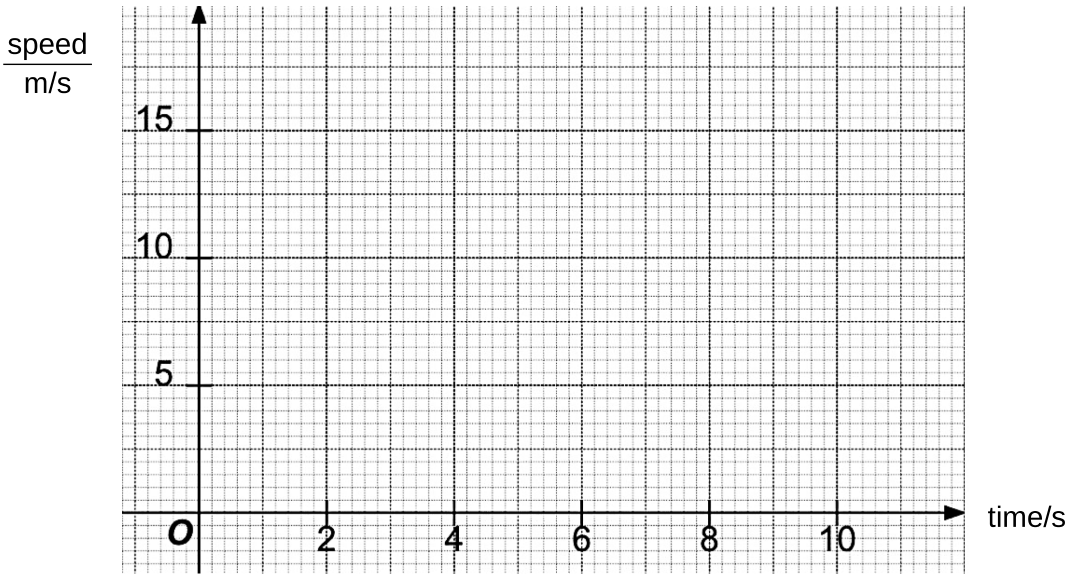
3 Fig. 3.1 shows a rider on a Personal Mobility Aid (PMA).

Fig. 3.1

The PMA contains a battery and a motor to drive the back wheel.

(a) The PMA accelerates from rest to 15.0 m/s for 3.0 s with decreasing acceleration.
It continues to move for the next 60 m with the same speed.
It then decelerates uniformly to rest in the next 2.0 s.

On the grid below, plot the speed–time graph for the motion of the PMA. [3]



(b) **(i)** State the name of the energy store in the battery.

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

(ii) Describe, in terms of work done, the stages of energy transfer from the energy store in the battery to the kinetic store of energy of the PMA.

……………………………………………………………………………………………….

……………………………………………………………………………………………….

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

(c) The total mass of the scooter and the rider is 80 kg.

Calculate the total kinetic energy of the rider and scooter when the scooter has a speed of 5.0 m/s.

kinetic energy = …………………………… [2]

(d) The battery is marked ‘energy capacity 0.35 kilowatt-hour (kW h)’.

The scooter stops working because the battery is totally discharged (flat). This means that there is no more energy stored in the battery. The battery is then recharged using a 70 W power supply.

Calculate the time taken to fully recharge the battery in seconds.

time = …………………………… s [2]

4 Fig. 4.1 shows a model of the human arm. The rubber band represents the muscle that moves part of the arm XY up.

A mass is suspended from section XY, as shown in Fig. 4.2. The weight of section XY is negligible and the model is at rest.

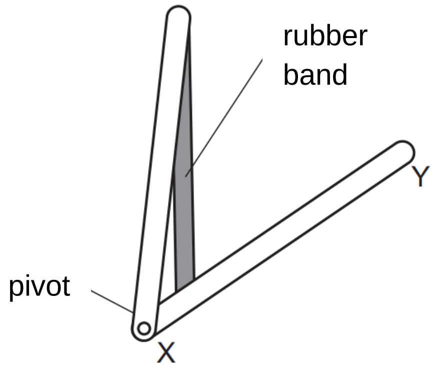


Fig. 4.1

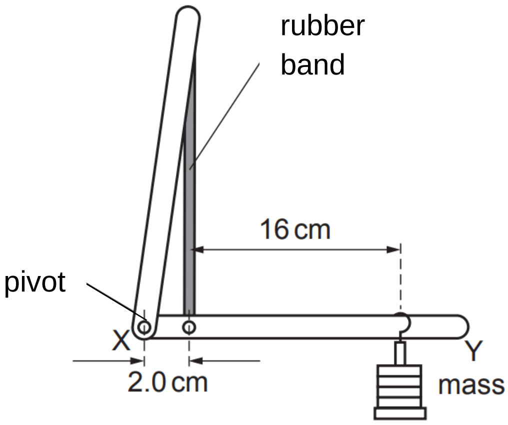


Fig. 4.2 (not to scale)

(a) State the *principle of moments*.

....

....

.... [1]

(b) Explain why the force that the rubber band exerts on section XY is larger than the weight of the mass in Fig. 4.2.

....

....

....

.... [2]

(c) The mass suspended from section XY in Fig. 4.2 has a weight of 5.0 N.

Calculate the force that the rubber band exerts on section XY.

force = ... N [2]

(d) Explain how your answer to **(c)** is different if the weight of section XY is **not** negligible.

……………………………………………………………………………………………………...

……………………………………………………………………………………………………...

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

5 Fig. 5.1 shows a 40 kg mass is initially at rest on a rough table and a 20 kg mass is attached to it via an inextensible and light string. The string goes over a smooth pulley with negligible friction.

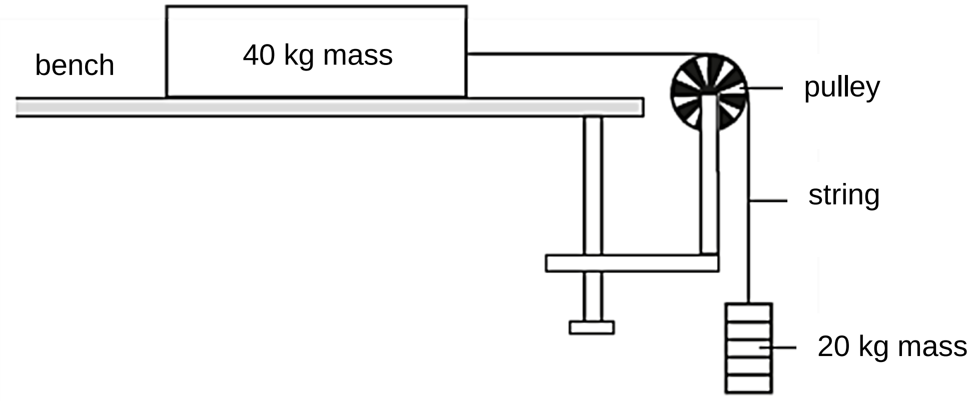


Fig. 5.1

When the 20 kg mass is released from rest, the two masses start to move together.
The friction between the 40 kg mass and the bench is 20 N. Take g = 10 N/kg

(a) Considering both masses as a system, calculate the acceleration of the masses when the masses start to move.

acceleration = …………………………… [2]

(b) Hence, calculate the tension in the string.

tension = …………………………… [2]

6 Most of the energy emitted by the Sun is in three regions of the electromagnetic spectrum. The name of one of these three regions is the ultraviolet region.

(a) State the names of all three regions in order of increasing frequency.

……………………………… , ……………………………… , ……………………………… [2]

(b) Some of the ultraviolet radiation emitted by the Sun reaches the surface of the Earth.

Give one possible harmful effect of excessive exposure to ultraviolet radiation and the property of ultraviolet radiation that causes this damage.

damaging effect ……………………………………………………………………..……………...

…………………………………………………………………………………………….........

property ……………………………………………………………………………………….........

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

(c) The ultraviolet radiation produced has a frequency of 8.8×10^{14} Hz.

Calculate the wavelength of this ultraviolet radiation in vacuum.

wavelength = …………………………… [2]

7 A student rubbed a plastic rod with a cloth.
The rod became negatively charged and the cloth became positively charged.

(a) Explain why the cloth became positively charged.

……………………………………………………………………………………………………..........

……………………………………………………………………………………………………..........

……………………………………………………………………………………………………..........

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

(b) In Fig. 7.1, the negatively charged rod is placed on a balance.

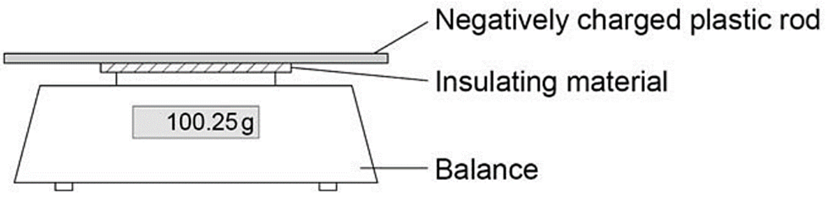


Fig. 7.1

Fig. 7.2 shows another similar charged rod being held stationary above the rod on the balance.

The rods do not touch each other.

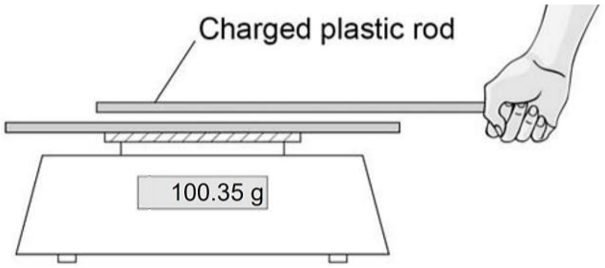


Fig. 7.2

Using Newton's Law of Motion, explain why the reading on the balance increases.

……………………………………………………………………………………………………..........

……………………………………………………………………………………………………..........

……………………………………………………………………………………………………..........

……………………………………………………………………………………………………..........

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

8 Fig. 8.1 shows a step-down transformer used to operate an electric bell.

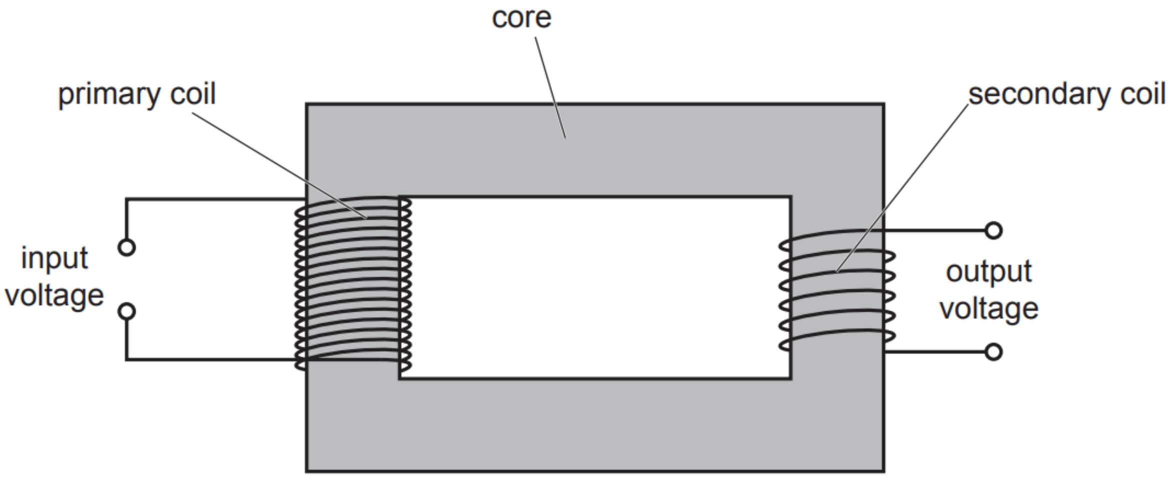


Fig. 8.1

(a) State and explain the material used for the core of the transformer.

....

.... [2]

(b) A current in the primary coil produces a magnetic field in the core.

Explain how an alternating voltage is produced in the secondary coil.

....

....

....

.... [2]

(c) The transformer has 4600 turns on the primary coil which is connected to a mains supply of 230 V. An output of 5.0 V is used to operate the bell.

Calculate the number of turns needed on the secondary coil.

number of turns = ... [2]

(d) State one change that can be made to the transformer shown in Fig. 8.1 so that it can be used as a step-up transformer.

.... [1]

9 The isotope iodine-131 emits two types of nuclear radiation. Gamma radiation is one of the types emitted.

A sample of iodine-131 produces a narrow beam of radiation which passes into a magnetic field. Fig. 9.1 shows some of the paths taken in the magnetic field by the radiation emitted from the sample.

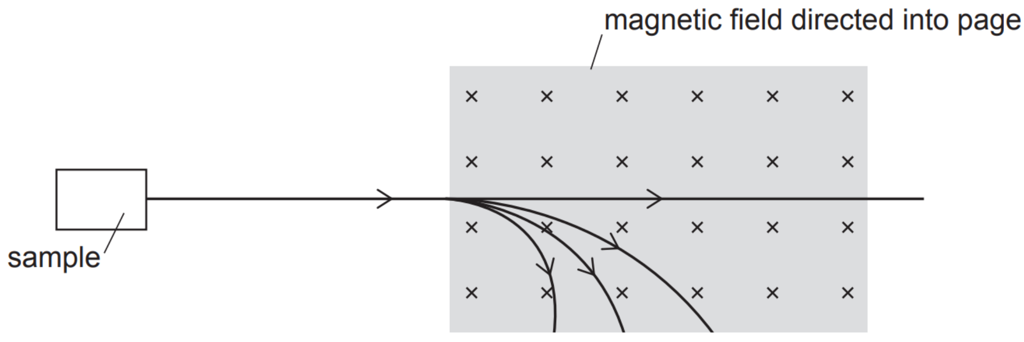


Fig. 9.1

(a) The direction of the magnetic field is into the page.

(i) On Fig. 9.1, mark with a gamma symbol (γ) any of the paths taken by the gamma radiation. [1]

(ii) Determine the other type of radiation emitted by iodine-131.

Explain how you obtain your answer.

type of radiation ……………………………………………………………………………….

explanation ..………………………………………..……………………………………….

..………………………………………………………………………………………………….

………………………………………...……………………………………………… [3]

(b) A sample contains 180 mg of iodine-131. The half-life of iodine-131 is 8.0 days.

Calculate the mass of iodine-131 remaining in the sample after 24.0 days.

mass of iodine-131 remaining = ... [2]

10 The power supply in a circuit is made from several cells, each with the same electromotive force.

Fig. 10.1 shows a circuit powered by a 12 V supply that automatically activates an alarm when there is a sufficient output voltage.

The voltmeter in parallel with the resistor measures the output voltage to the alarm.

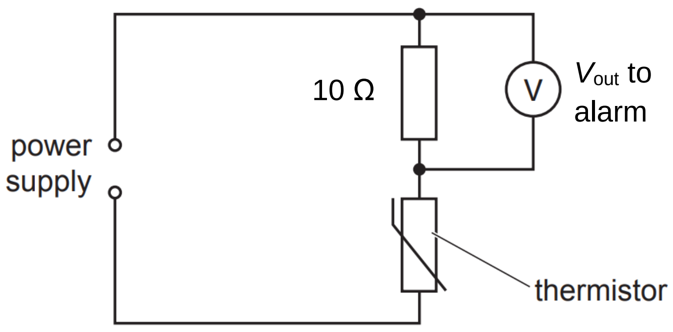


Fig. 10.1

Fig 10.2 shows how the resistance across the thermistor varies as temperature changes.

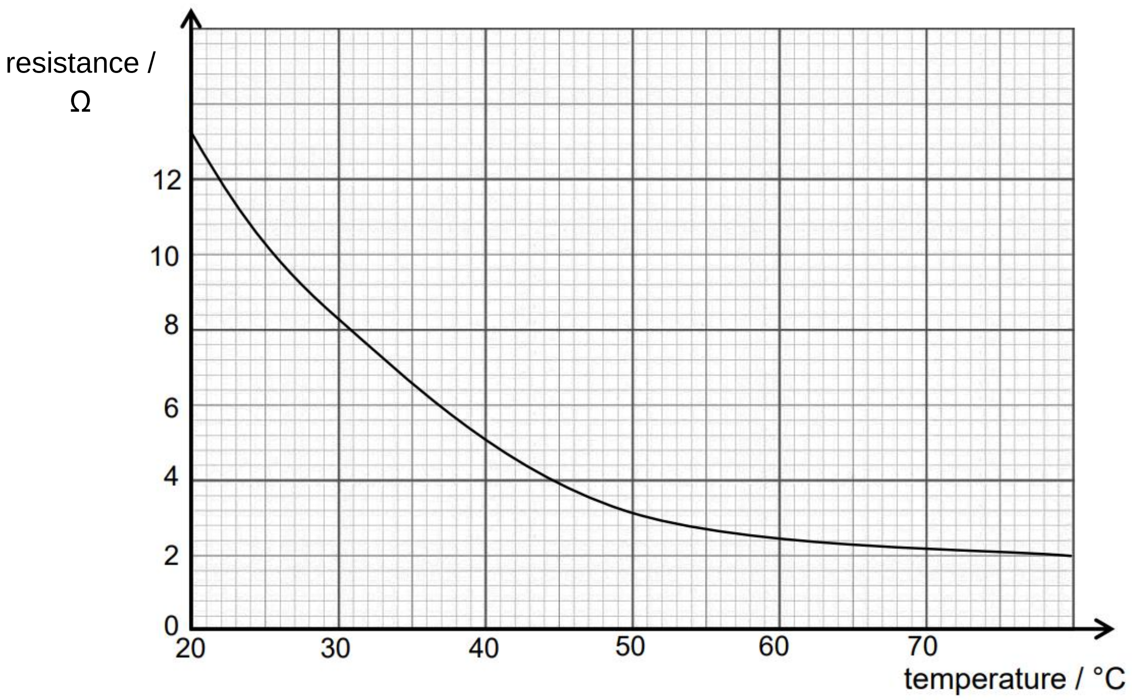


Fig. 10.2

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

....

....

....

.... [2]

(b) The minimum output voltage V_{out} for the alarm to work is 8.0 V.

Use Fig. 10.1 and Fig. 10.2 to calculate the minimum temperature required.

minimum temperature = …………………………… [3]

(c) The manufacturer wants to add light signal to the alarm. An LED light is now connected in parallel with the 10 Ω resistor.

State and explain how this will affect your answer in **(b)**.

……………………………………………………………………………………………........

……………………………………………………………………………………………........

……………………………………………………………………………………………........

……………………………………………………………………………………………........

……………………………………………………………………………………………........

……………………………………………………………………………………………........

………………………………………………………………………………………….... [3]

11 Fig. 11.1 shows a thermos flask that can be used to maintain the temperature of hot water.

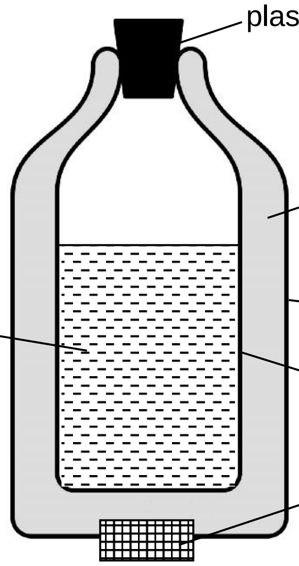


Fig. 11.1

In an experiment, six different thermos flasks are each filled with the same amount of hot water at 100°C. They are immediately stoppered and left in a room where the room temperature is kept constant at 30°C.

The effectiveness of the thermos flasks is determined by measuring the time taken for T-difference, t_d to decrease by half.

T-difference is the temperature difference between the hot water and the room.

Table 11.1 shows the characteristics of each of the thermos flask.

Table 11.1

thermos flask	space between inner and outer walls	inner wall		t_d / h
		thermal conductivity / $Wm^{-1}K^{-1}$	coating	
K	vacuum	1.1	silver paint	3.2
L	vacuum	1.3	black paint	2.8
M	vacuum	15	black paint	2.4
N	air	1.1	black paint	1.5
O	air	15	silver paint	1.6
P	air	15	black paint	1.3

(a) **(i)** State the T-difference at the start of the experiment.

T-difference = ……………….....…….. [1]

(ii) Determine the temperature of the hot water in flask L, 2.8 h after it is filled and stoppered with hot water.

temperature = ……………….....…….. [1]

(iii) Calculate the amount of thermal energy lost by the hot water in flask L after 2.8 h. The heat capacity of water is 2940 J/°C.

thermal energy lost = ……………….....…….. [2]

(iv) Calculate the average rate of heat loss by the hot water in flask L.

Express your answer in watts (W).

average rate of heat lost = ……………….....……. W [1]

(b) **(i)** Using Table 11.1. state the thermos flask that is the most efficient.

thermos flask ………………..…….. [1]

(ii) Explain how the characteristics of thermos flask in **b(i)** allow it to be the most efficient in maintaining the temperature of hot water for a long time.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [3]

(c) **(i)** Using the information provided in Table 11.1, suggest the relationship between thermal conductivity and the rate of heat loss by conduction.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(ii) State the assumptions made for the proposed relationship in **c(i)**.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(d) Describe the change in the motion of the molecules in the liquid as it cools down.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

SECTION B

Answer **one** question from this section.

12 The circuit in Fig. 12.1 includes three resistors and two open switches, S_1 and S_2.

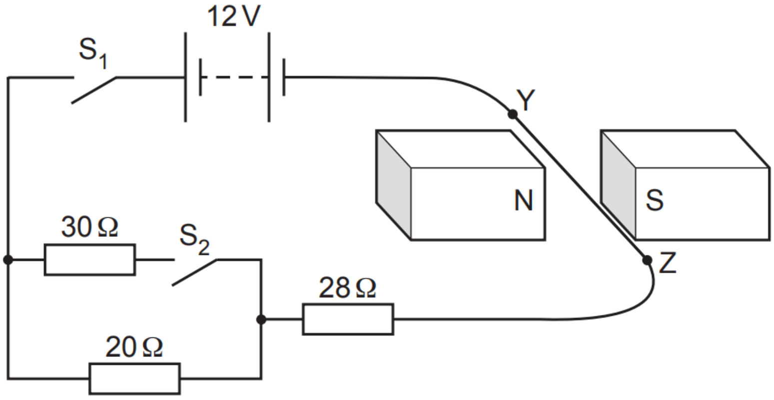


Fig. 12.1

YZ is a straight, horizontal section of connecting wire that lies between two magnets.

S_1 is now closed.

(a) Calculate the current in YZ.

current = ………………...……... [2]

(b) **(i)** In Fig. 12.1, draw the direction of the force on YZ. [1]

(ii) Explain how the direction of the force on YZ is determined.

....

....

....

.... [2]

(c) Switch S_2 in the circuit is now also closed.

(i) Calculate the total resistance of the circuit.

resistance = ……………….……….. [2]

(ii) Explain what happens to the force on YZ as switch S_2 is closed.

...……………………………………………………………………………………………….

...……………………………………………………………………………………………….

……………………………………………………………………………………… [2]

(iii) The current in the 20 Ω resistor is I_{20}. The current in the 30 Ω resistor is I_{30}.

Calculate I_{20} / I_{30}.

I_{20} / I_{30} = ……………….……….. [1]

13 Fig. 13.1 shows a long vertical tube, sealed at the base and open at the other end.

The tube is 1.0 m long. The cross-sectional area of the tube is 4.0×10^{-4} m^2. It is filled with a liquid of density 1.4×10^4 kg/m^3.

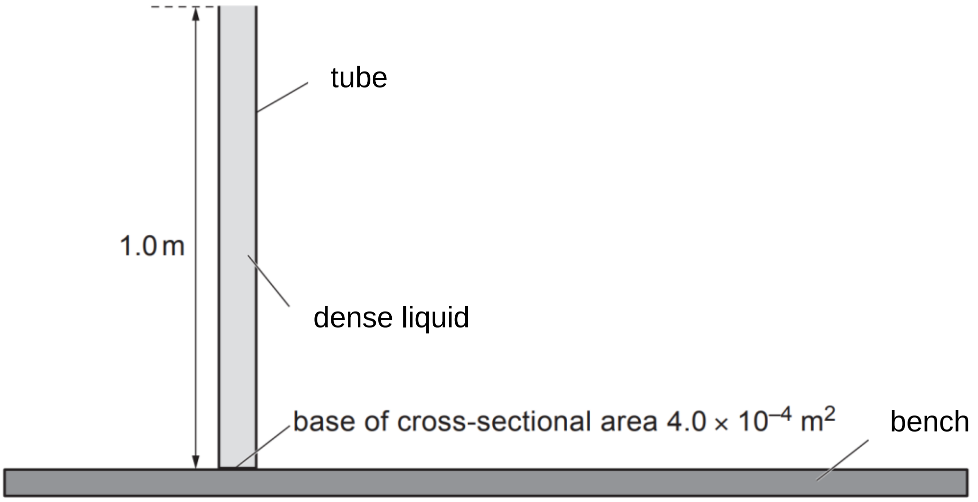


Fig. 13.1
(not to scale)

The atmospheric pressure is 1.0×10^5 Pa. Take g = 10 N/kg.

(a) Calculate:

(i) the total pressure in the liquid at the bottom of the tube,

total pressure = …………………..……… [3]

(ii) the force exerted on the inside surface of the bottom of the tube.

force = …………………..……… [2]

(b) A small sheet of glass is placed over the open end of the tube.

In Fig. 13.2, the tube is then inverted in a container of the dense liquid. The open end of the tube and the sheet of glass are a short distance below the surface of the liquid.

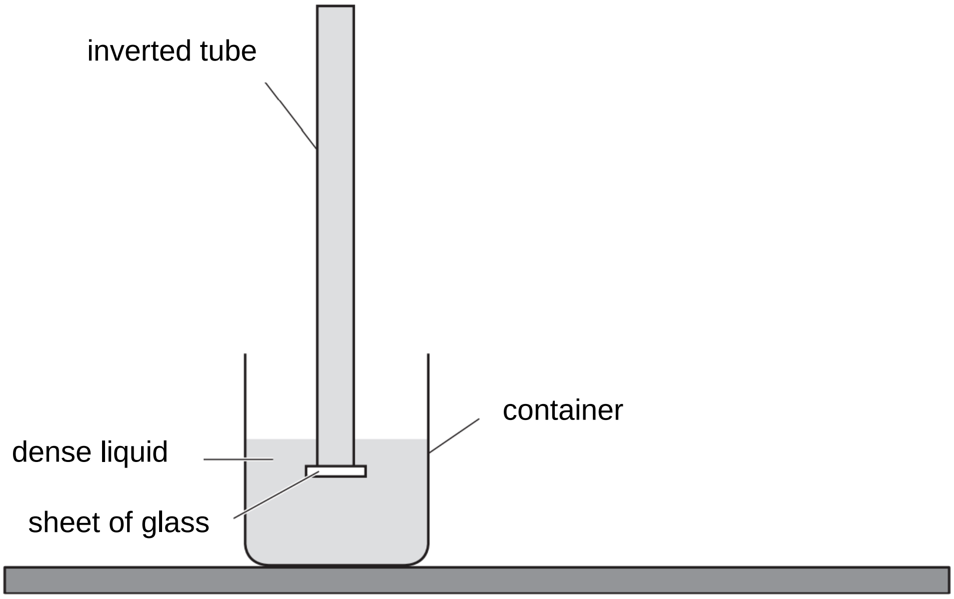


Fig. 13.2
(not to scale)

The sheet of glass seals the open end of the inverted tube.

(i) Describe what happens in the inverted tube when the sheet of glass is removed.

....

....

....

....

....

.... [3]

(ii) This equipment is used to make a measurement that is used to calculate atmospheric pressure.

Describe the measurement made and how it is then used in the calculation of atmospheric pressure.

You may draw a diagram to help your description.

....

....

....

....

.... [2]

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