



Cambridge IGCSE™

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PHYSICS

0625/31

Paper 3 Theory (Core)

May/June 2020

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.
- Take the weight of 1.0 kg to be 10 N (acceleration of free fall = 10 m/s^2).

INFORMATION

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [].

This document has **16** pages. Blank pages are indicated.

1 Fig. 1.1 shows a coil of wire.

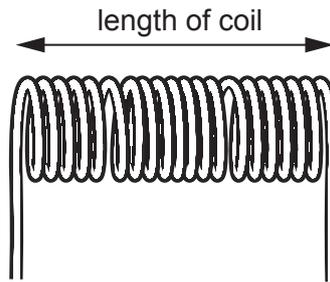


Fig. 1.1 (not to scale)

(a) A student measures the length of the coil using a ruler. His measurement is 3.8 cm.

There are 20 turns of wire in the coil. The student uses his measurement to calculate the average thickness of the wire.

(i) Show that the average thickness of the wire is about 0.2 cm.

average thickness of wire = cm [2]

(ii) The student's measurement of 3.8 cm is inaccurate.

Suggest **one** reason why the measurement is inaccurate.

.....
 [1]

(b) The volume of the wire in the coil is 16.6 cm^3 and its mass is 148 g.

Calculate the density of the metal used for the wire in the coil.

density = g/cm^3 [3]

(c) The student has a measuring cylinder and a beaker of water, as shown in Fig. 1.2.

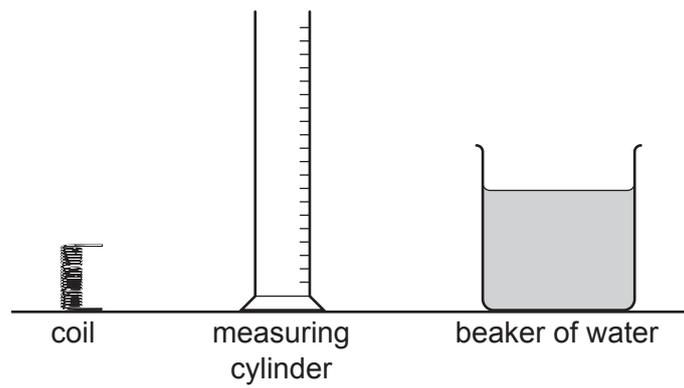


Fig. 1.2

Describe how the student can determine the volume of the coil by using the equipment shown in Fig. 1.2.

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 10]

Question no. 1

(a)(i) Average thickness of the wire

The coil has a **total measured length of 3.8 cm** and contains **20 turns of wire**. If the turns are placed side by side, the **average thickness of one turn of wire** can be found by dividing the total length by the number of turns.

$$\begin{aligned}\text{Average thickness of wire} \\ &= \text{total length} \div \text{number of turns} \\ &= 3.8 \text{ cm} \div 20 \\ &= \mathbf{0.19 \text{ cm}}\end{aligned}$$

Since 0.19 cm rounds to one significant figure as **0.2 cm**, this shows that the **average thickness of the wire is about 0.2 cm**, as required.

(a)(ii) Reason why the measurement is inaccurate

The measurement of 3.8 cm is inaccurate because **the turns of the wire may not be touching each other exactly**, leaving small gaps between turns. This would make the measured length larger than the true combined thickness of the wire alone.

(Other valid reasons include overlapping turns, stretched wire, or parallax error when reading the ruler.)

(b) Density of the metal

Density is defined as **mass per unit volume**.

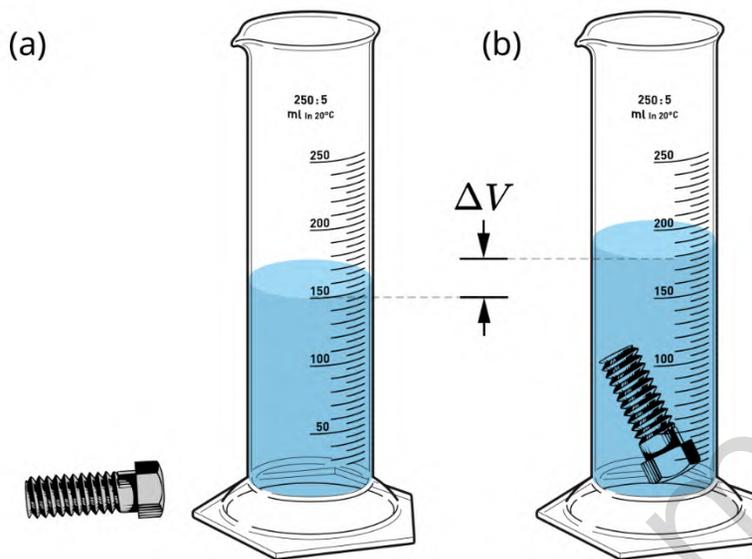
$$\text{Density} = \text{mass} \div \text{volume}$$

The mass of the wire is **148 g** and its volume is **16.6 cm³**.

$$\begin{aligned}\text{Density} \\ &= 148 \text{ g} \div 16.6 \text{ cm}^3 \\ &= \mathbf{8.9 \text{ g/cm}^3}\end{aligned}$$

So, the **density of the metal used for the wire is 8.9 g/cm³**.

(c) Determining the volume of the coil



To determine the volume of the coil, the student uses the **water displacement method**.

First, the measuring cylinder is **partially filled with water**, and the **initial water level is recorded**, ensuring the reading is taken at eye level to avoid parallax error.

Next, the coil is **carefully lowered into the measuring cylinder**, making sure it is **completely submerged** and that no air bubbles are trapped between the turns of the wire.

The **new water level is then recorded**.

The **increase in water level** (final volume minus initial volume) is equal to the **volume of the coil**, because the volume of water displaced is the same as the volume of the submerged object.

This method allows the volume of an irregular object such as a coil to be measured accurately.

- 2 (a) A student stretches a spring by adding different loads to it. She measures the length of the spring for each load. She plots a graph of the results.

Fig. 2.1 shows the graph of her results.

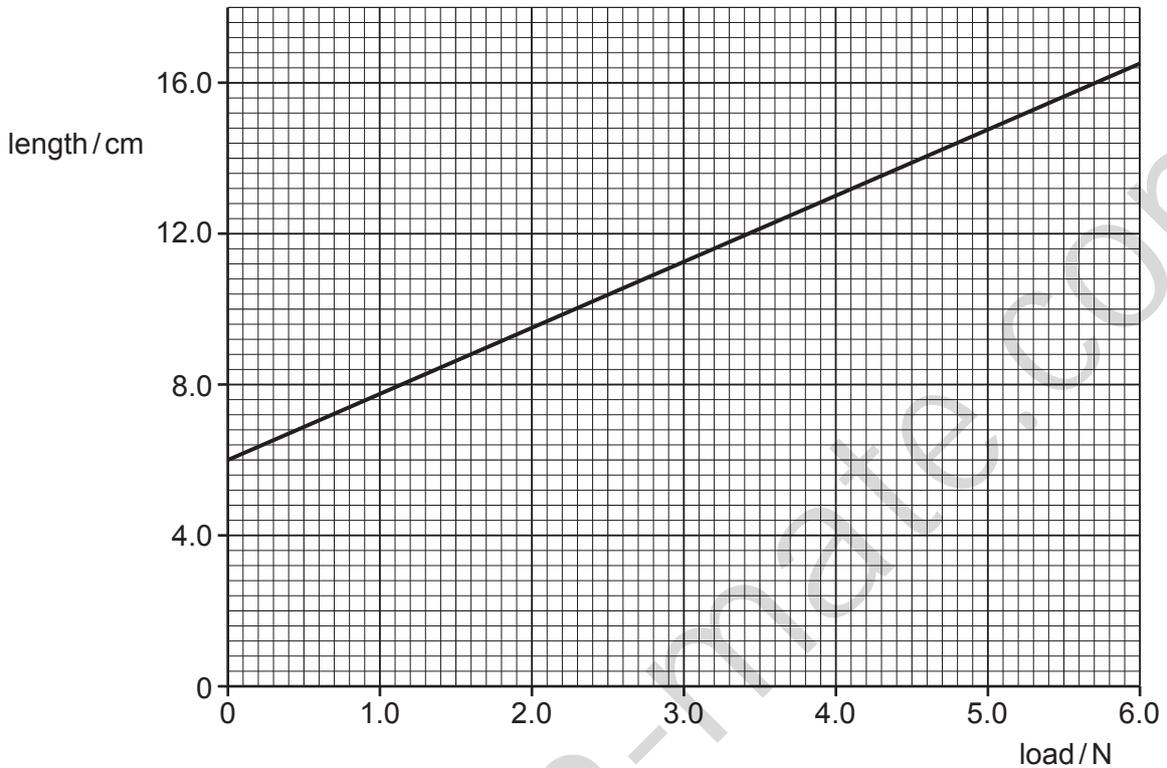


Fig. 2.1

Use the graph to determine:

- (i) the length of the spring without a load

length = cm [1]

- (ii) the length of the spring with a load of 4.0 N

length = cm [1]

- (iii) the extension due to a 4.0 N load.

extension = cm [1]

- (b) Complete the sentence about effects of forces. Choose words from the box.

colour	friction	pressure	shape	size	speed
--------	----------	----------	-------	------	-------

Stretching a spring with a load is an example of how a force can change the

..... and the of an object.

[2]

[Total: 5]

Question no. 2

(a)

From the graph, the vertical axis shows the **length of the spring in centimetres**, while the horizontal axis shows the **load in newtons**. The straight-line relationship indicates that the spring obeys **Hooke's law** over the range shown, so values can be read directly from the graph.

(a)(i) Length of the spring without a load

When there is **no load applied**, the load is **0 N**. Reading the value of the length at **0 N** from the graph, the line intersects the vertical axis at **6.0 cm**.

Therefore, the **natural (unstretched) length of the spring is 6.0 cm**.

Length = 6.0 cm

(a)(ii) Length of the spring with a load of 4.0 N

To find the length at **4.0 N**, a vertical line is taken up from **4.0 N on the horizontal axis** until it meets the straight line, and then a horizontal line is read across to the vertical axis. This gives a length of **13.0 cm**.

Length = 13.0 cm

(a)(iii) Extension due to a 4.0 N load

The **extension** of the spring is defined as the **increase in length compared to its original length**. This is found by subtracting the length with no load from the length with the load applied.

Extension = (length at 4.0 N) – (length at 0 N)

Extension = **13.0 cm – 6.0 cm = 7.0 cm**

Extension = 7.0 cm

(b)

Stretching a spring with a load is an example of how a force can change the **shape** and the **size** of an object.

A force causes the spring to **deform**, altering its shape, and at the same time increases its overall length, which means its size changes.

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- 3 Some gas molecules are in a box at room temperature. Fig. 3.1 shows the position of some of the molecules and the direction of movement of each molecule.

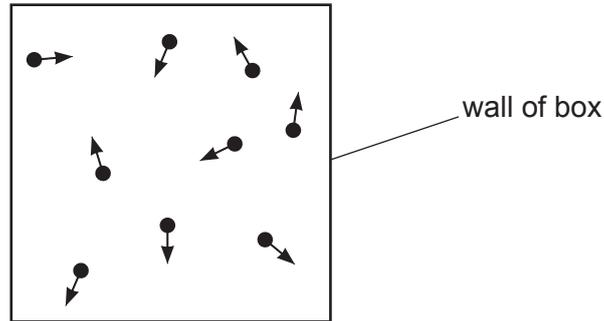


Fig. 3.1

- (a) (i) Describe the movement of the gas molecules.

.....

 [2]

- (ii) Describe how the molecules exert a pressure on the walls of the box.

.....

 [2]

- (b) The gas in Fig. 3.1 is cooled. The gas turns into a liquid then into a solid.

State how the average separation of molecules in the gas is different from the average separation of molecules in the solid.

.....
 [1]

[Total: 5]

Question no. 3

(a)(i) Description of the movement of the gas molecules

The gas molecules are in **constant motion** and are moving at **high speed**. As shown by the arrows in Fig. 3.1, the molecules do **not move in straight lines in one fixed direction**, but instead travel in **random directions**, continually changing direction as a result of collisions. This random, rapid motion is characteristic of gas molecules at **room temperature**, where they possess significant kinetic energy.

(a)(ii) How the molecules exert a pressure on the walls of the box

Gas pressure is produced because the molecules are in continuous motion and **collide with the walls of the box**. Each time a molecule hits the wall, it **changes momentum**, and this change in momentum means a **force is exerted on the wall**. As very large numbers of molecules collide with the walls every second, the combined effect of these tiny forces results in a **steady pressure acting on the walls of the container**.

(b) Difference in average separation of molecules in the gas and in the solid

In the gas, the molecules are **widely separated**, with large spaces between them. In contrast, in the solid, the molecules are **very close together or touching**, with only small vibrations about fixed positions.

4 (a) During part of a race, a skier travels a distance of 200 m in a time of 6.4 s.

Calculate the average speed of the skier.

average speed = m/s [3]

(b) Fig. 4.1 shows a speed–time graph for the skier in another part of the race.

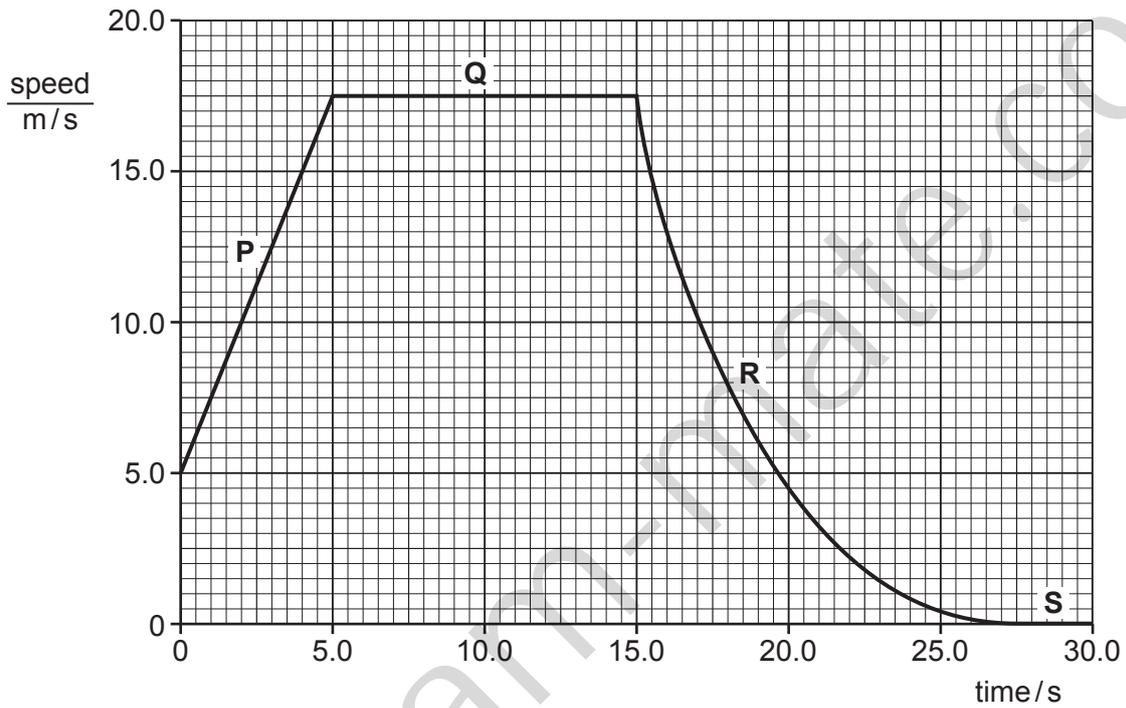


Fig. 4.1

Describe the motion of the skier at each point **P**, **Q**, **R** and **S** on the graph.

- P**
 - Q**
 - R**
 - S**
- [4]

(c) Skis are strapped to a skier’s feet and are longer and wider than the skier’s feet.

Explain how the skis prevent the skier from sinking into soft snow.

-
 -
 -
- [2]

[Total: 9]

Question no. 4

(a)

The **average speed** is found by dividing the **distance travelled** by the **time taken**.

So, average speed = $200 \text{ m} \div 6.4 \text{ s} = 31.25 \text{ m/s}$, which rounds to **31 m/s** (to 2 significant figures).

average speed = 31 m/s

(b) (From the speed–time graph)

P: At P the skier's speed is **increasing in a straight-line way**, so the skier is **accelerating at a constant rate** (starting from about **5 m/s**).

Q: At Q the line is **horizontal**, so the skier is moving at a **constant speed** (about **17.5 m/s**) with **no acceleration**.

R: At R the curve slopes downward, and the slope is changing, so the skier is **decelerating (slowing down)** but the deceleration is **not constant** (the speed decreases from about **17.5 m/s** towards **0 m/s**).

S: At S the speed is **zero**, so the skier is **stationary / at rest**.

(c)

The skier's **weight (force)** stays the same, but the skis are **longer and wider**, so they provide a **larger contact area** with the snow. Since **pressure = force \div area**, increasing the area **reduces the pressure** on the soft snow. With **less pressure**, the snow is less likely to compress, so the skier **does not sink as much**.

- 5 A metre rule is balanced on a pivot by three vertical forces, as shown in Fig. 5.1.

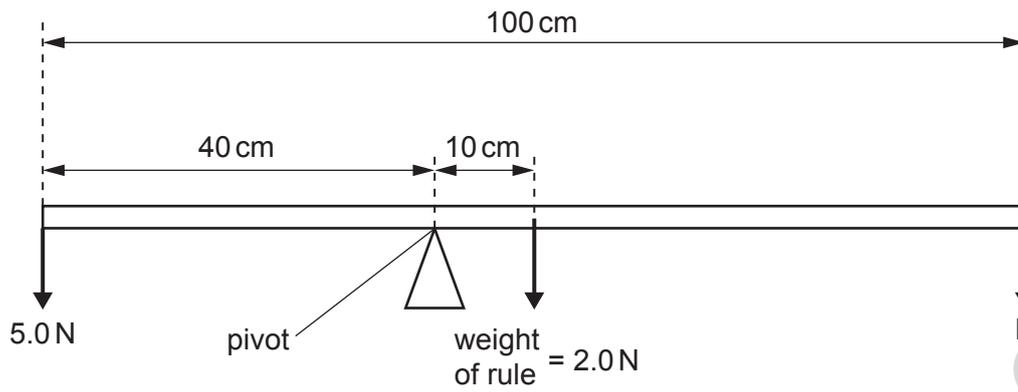


Fig. 5.1 (not to scale)

- (a) Show that the moment of the 5.0 N force about the pivot is 200 N cm.

[2]

- (b) Calculate the size of force F.

F = N [4]

[Total: 6]

Question no. 5

(a) Moment of the 5.0 N force about the pivot

The **moment of a force about a pivot** is defined as the **product of the force and the perpendicular distance from the pivot to the line of action of the force**.

In the diagram, the **5.0 N force acts vertically downward at the left end of the metre rule**. The distance from this force to the pivot is clearly shown as **40 cm**.

Therefore, the moment of the 5.0 N force about the pivot is calculated as:

$$\text{moment} = \text{force} \times \text{distance from pivot}$$

Substituting the given values:

$$\text{moment} = 5.0 \text{ N} \times 40 \text{ cm} = 200 \text{ N cm}$$

This shows that the **moment of the 5.0 N force about the pivot is 200 N cm**, acting in the **anticlockwise direction**.

(b) Calculation of the size of force F

Since the metre rule is **balanced and in equilibrium**, the **sum of the clockwise moments about the pivot must equal the sum of the anticlockwise moments about the pivot**.

From part (a), the **anticlockwise moment** due to the 5.0 N force is **200 N cm**.

There are two **clockwise moments** acting about the pivot:

1. The **weight of the rule**, which is **2.0 N**, acts **10 cm to the right of the pivot**.
 - Moment due to the weight = **2.0 N × 10 cm = 20 N cm**
2. The force **F** acts downward at the right end of the rule.
The distance from the pivot to this force is **60 cm**.

Applying the principle of moments:

$$\text{sum of anticlockwise moments} = \text{sum of clockwise moments}$$

So,

$$200 = (2.0 \times 10) + (F \times 60)$$

Simplifying:

$$200 = 20 + 60F$$

$$180 = 60F$$

Dividing both sides by 60:

$$F = 3.0 \text{ N}$$

Final Answer

The size of force F is 3.0 N.

6 Fig. 6.1 shows a liquid-in-glass thermometer.

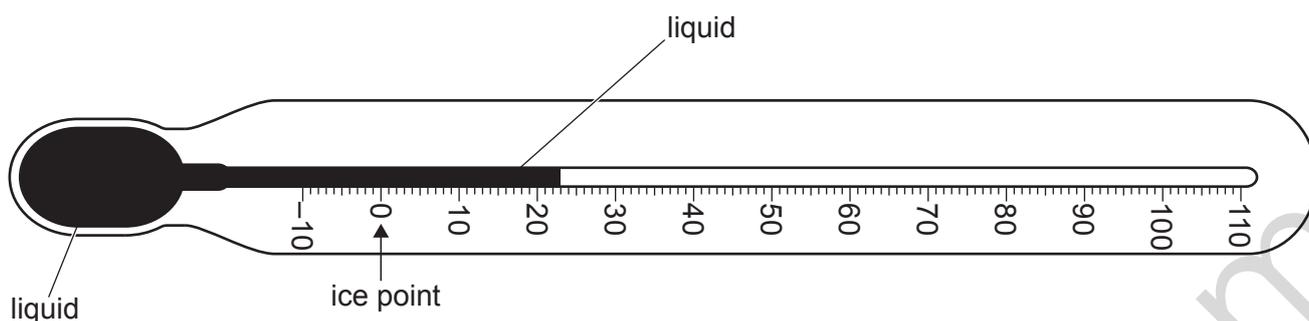


Fig. 6.1

(a) (i) This thermometer is used for measuring temperatures in science experiments.

State the unit for measuring temperature.

..... [1]

(ii) On Fig. 6.1, an arrow points to the temperature reading when the thermometer is placed in pure melting ice. This is labelled **ice point**.

On Fig. 6.1, draw an arrow pointing to the temperature reading when the thermometer is at the upper fixed point. Label this arrow **steam point**. [1]

(b) A liquid-in-glass thermometer uses the property of expansion of a liquid to measure temperature.

State **one** other application or consequence of thermal expansion.

.....
 [1]

(c) A student is testing how different surfaces absorb radiant heat.

The student puts two metal plates in holders and places them on either side of a radiant heater as shown in Fig. 6.2. One plate has a shiny metal side facing towards the heater and the other plate has a dull black side facing towards the heater.

A metal disc is attached to each plate using wax.

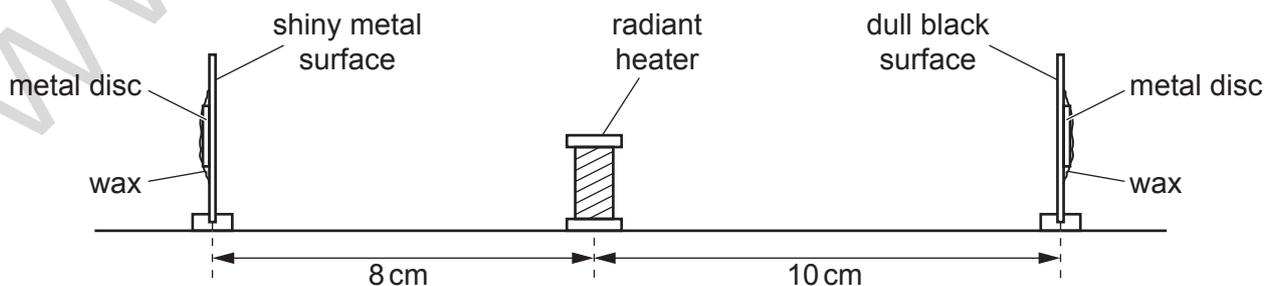


Fig. 6.2

- (i) The student turns on the radiant heater and starts a stop-clock. The wax on the plate with a dull black side melts and the metal disc falls off the plate 53 seconds after the stop-clock is started.

The metal disc on the plate with a shiny metal side remains attached for another 32 seconds after the metal disc on the first plate falls.

Explain why the metal disc on the plate with a dull black side falls before the metal disc on the plate with a shiny metal side.

.....

.....

.....

.....

..... [2]

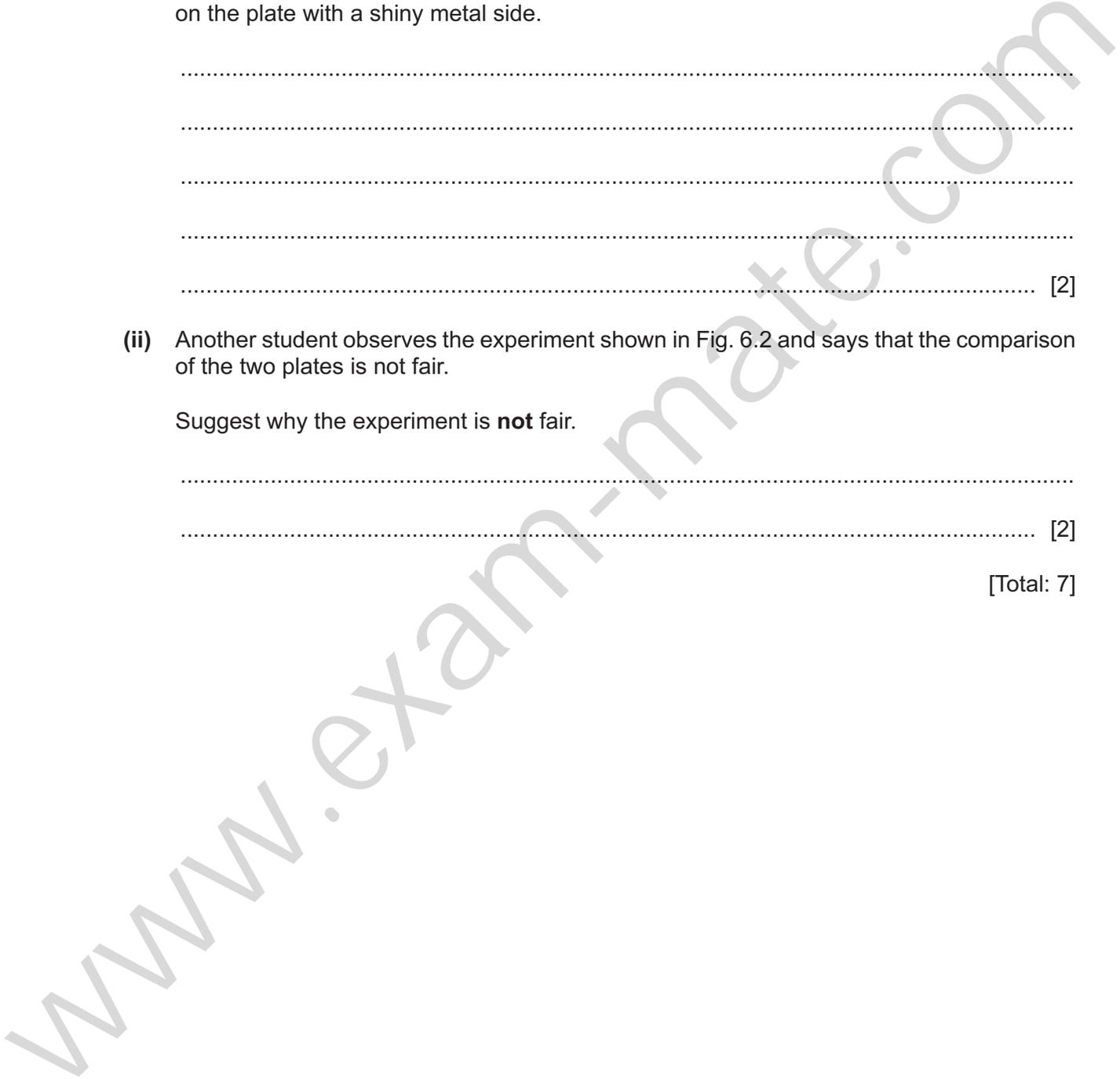
- (ii) Another student observes the experiment shown in Fig. 6.2 and says that the comparison of the two plates is not fair.

Suggest why the experiment is **not** fair.

.....

..... [2]

[Total: 7]



Question no. 6

(a)(i)

The unit used for measuring temperature on this thermometer scale is **degrees Celsius** ($^{\circ}\text{C}$).

(a)(ii)

The **steam point** (upper fixed point) is **100 $^{\circ}\text{C}$** , so the arrow should point to **100** on the scale and be labelled **steam point**.

Here is the diagram with the **steam point** arrow added (as requested):

(b)

One other application/consequence of thermal expansion is that **gaps are left between sections of railway track (or bridge expansion joints)** so that when the metal expands on heating, it **does not buckle or crack**.

(c)(i)

The plate with the **dull black surface** makes the metal disc fall first because a **dull black surface is a much better absorber of thermal (infrared) radiation** than a shiny metal surface. So, when the radiant heater is turned on, the black plate **absorbs more radiation per second**, its temperature rises faster, and heat is conducted to the wax more quickly. As a result, the **wax reaches its melting temperature sooner**, melts earlier, and the disc drops off before the disc on the shiny plate (which reflects more radiation and heats up more slowly).

(c)(ii)

The comparison is **not fair** because the two plates are **not the same distance from the heater** (one is **8 cm** away and the other is **10 cm** away). Since the amount of radiation received depends on distance, they do **not** receive the same intensity of radiant energy, so you cannot fairly conclude that any difference in melting time is only due to surface type. For a valid test, **all variables except the surface finish should be kept the same**, especially the **distance from the heater**.

7 (a) Fig. 7.1 shows a ray of light striking a plane mirror at point P.

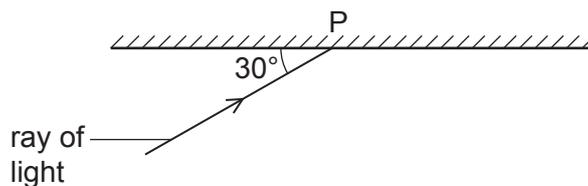


Fig. 7.1 (not to scale)

(i) Determine the value of the angle of incidence for the ray of light at point P.

angle of incidence = ° [1]

(ii) On Fig. 7.1,

- draw a normal at point P
- draw the ray reflected at point P
- determine the angle of reflection at point P.

angle of reflection = ° [3]

(b) Fig. 7.2 shows an object OB positioned 20 cm from a thin converging lens. Both principal foci of the lens are labelled F.

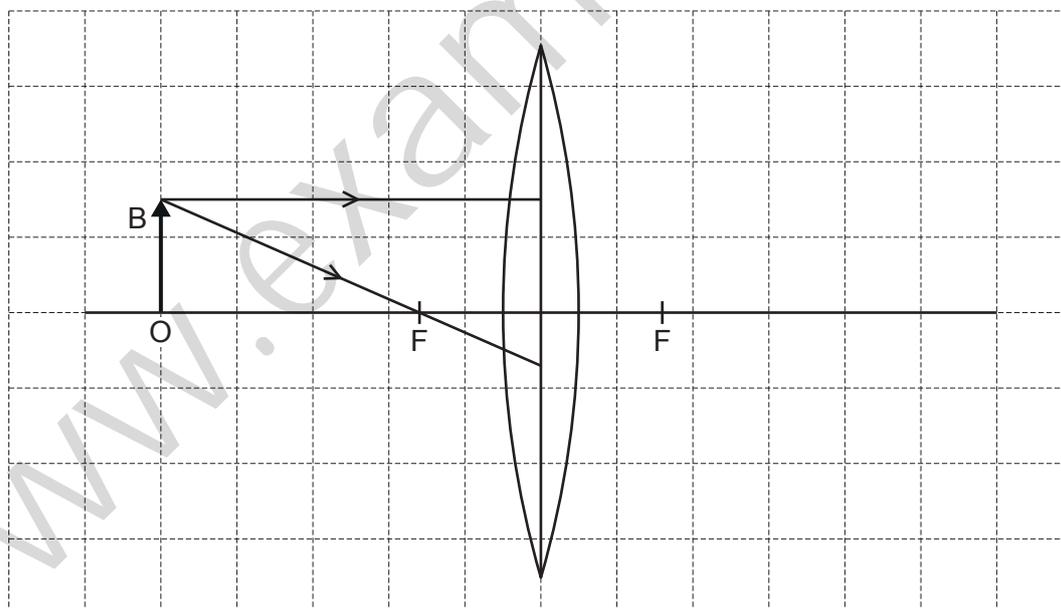


Fig. 7.2

Two rays from the tip B of the object are incident on the lens, as shown in Fig. 7.2.

On Fig. 7.2, continue the paths of these two rays to show the position of the image of OB formed by the lens. Draw an arrow to show the size, position and orientation of the image of OB. [4]

[Total: 8]

Question no. 7

(a)(i) Angle of incidence at P

In Fig. 7.1 the 30° shown is the angle **between the incident ray and the surface of the mirror**.

But the **angle of incidence** is defined as the angle **between the incident ray and the normal** (the normal is **perpendicular** to the mirror).

So,

- the normal makes 90° to the mirror surface
- therefore the angle between the ray and the normal is $90^\circ - 30^\circ = 60^\circ$

So the **angle of incidence** = 60° .

(a)(ii) Normal, reflected ray, and angle of reflection

At point **P**, you draw the **normal** as a straight line **perpendicular to the mirror**.

Then apply the law of reflection:

- **angle of incidence = angle of reflection**
- so the reflected ray must make the **same angle (60°)** with the normal, but on the opposite side.

Therefore, the **angle of reflection** = 60° .

Annotated diagram (normal + reflected ray + angles):

(b) Completing the rays and locating the image

For a **thin converging lens**, the two standard rules used here are:

1. A ray from the top of the object that is **parallel to the principal axis** refracts through the **principal focus on the far side** of the lens.
So the horizontal ray from **B** should be continued after the lens so that it passes through the **right-hand focus F**.

2. A ray that passes through the **principal focus on the object side** of the lens emerges **parallel to the principal axis** after refraction.
So the ray from **B** that goes through the **left-hand focus F** should be continued after the lens as a **straight line parallel to the axis**.

Where these two refracted rays intersect gives the position of the image tip **B'**.
Because the rays actually meet on the far side of the lens, the image is:

- **real** (formed by actual convergence of rays)
- **inverted** (so the image arrow points downward)
- and in this diagram it comes out at the intersection shown (so you draw the image as an inverted arrow with base on the axis at **O'** and tip at **B'**).

This has been drawn on the same annotated figure above (you can see the completed rays and the inverted image arrow labelled **O'** and **B'**).

8 Fig. 8.1 represents the pressure at one instant along part of a sound wave.

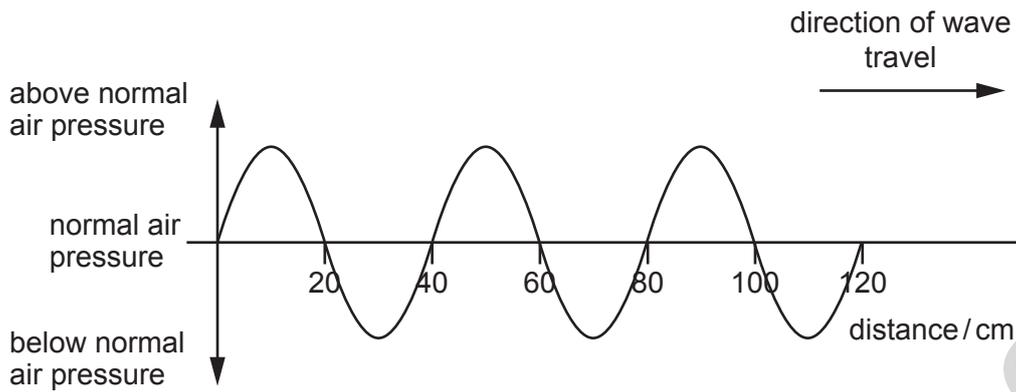


Fig. 8.1

(a) (i) Determine the wavelength of the sound wave.

wavelength of the sound wave = cm [1]

(ii) On Fig. 8.1, draw a wave representing a louder sound of the same wavelength. [1]

(b) State the range of audible frequencies for a healthy human ear. Include the unit.

..... [2]

[Total: 4]

Question no. 8

(a)(i) Determining the wavelength

From Fig. 8.1, the graph shows **pressure variation with distance at a single instant**. The **wavelength** of a sound wave is defined as the **distance between two successive points that are in the same phase**, for example **from one compression (maximum pressure) to the next compression**, or **from one rarefaction to the next rarefaction**.

By reading the horizontal distance between two adjacent peaks on the graph, we see that one peak occurs at about **20 cm** and the next at about **60 cm**.

The separation between these two points is:

$$\text{wavelength} = 60 - 20 = 40 \text{ cm}$$

So, the **wavelength of the sound wave is 40 cm**.

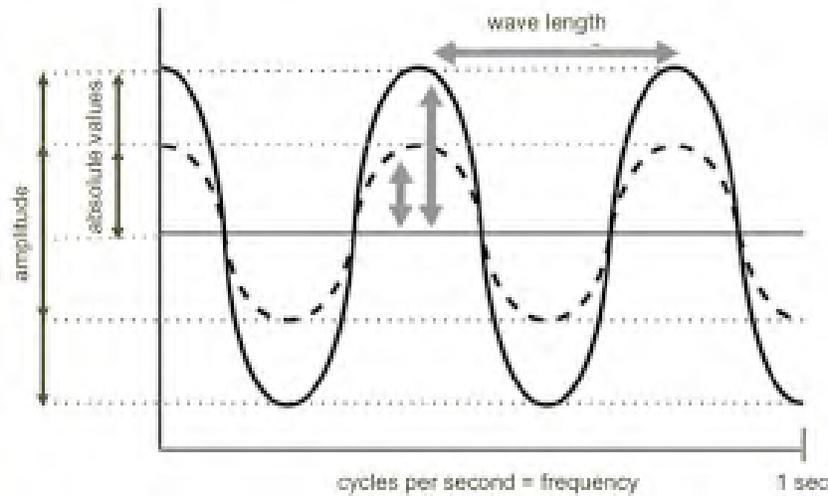
(a)(ii) Louder sound of the same wavelength

A **louder sound** corresponds to a **greater amplitude of pressure variation**, while the **wavelength remains unchanged**.

Therefore, on Fig. 8.1, the correct wave should be drawn with:

- **The same spacing between peaks and troughs (same wavelength)**
- **Larger maximum and minimum pressure deviations from the normal air pressure line (greater amplitude)**

In other words, the wave should be **taller**, but **not stretched horizontally**.



(b) Range of audible frequencies

For a healthy human ear, the audible range of sound frequencies extends from **low-frequency sounds at about 20 hertz** to **high-frequency sounds at about 20 000 hertz**.

Hence, the **range of audible frequencies is from 20 Hz to 20 000 Hz**.

This range defines the limits within which sound waves can stimu

9 (a) Fig. 9.1 shows the magnetic field pattern around a bar magnet.

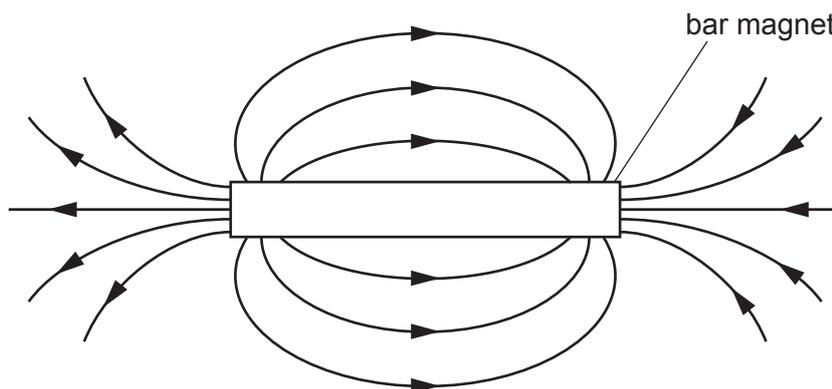


Fig. 9.1

(i) On Fig. 9.1, write the letters N and S to indicate the north and south poles of the magnet. [1]

(ii) Fig. 9.2 shows a soft-iron bar placed close to a permanent magnet.

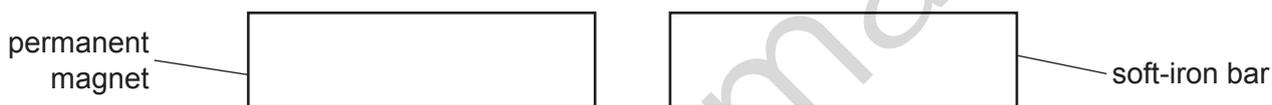


Fig. 9.2

State and explain what happens to the soft-iron bar. You may draw on Fig. 9.2.

.....

.....

..... [3]

(b) Three balls P, Q and R are electrically charged. The balls are suspended by threads of insulating material. Fig. 9.3 shows the arrangement.

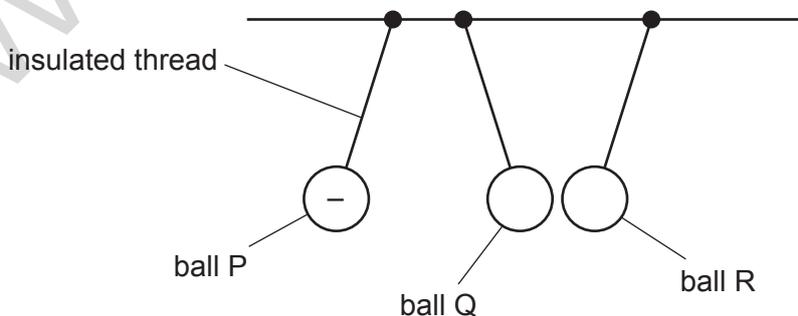


Fig. 9.3

Ball P is negatively charged.

(i) State the charge on ball Q and the charge on ball R.

ball Q

ball R

[2]

(ii) Explain your answer for part (i) for the charge on ball Q.

.....

.....

..... [2]

[Total: 8]

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Question no. 9

(a)(i)

Magnetic field lines outside a bar magnet go from **north to south**. In Fig. 9.1 the arrows show the field leaving the **left** end and entering the **right** end, so the **left end is N** and the **right end is S**.

(a)(ii)

When the **soft-iron bar** is placed close to the permanent magnet, it becomes **magnetised by induction**. This happens because the magnet's field causes the magnetic domains in the soft iron to **line up**, so the soft iron behaves like a **temporary (induced) magnet**.

As a result, the end of the soft iron nearest the magnet becomes the **opposite pole** to the pole of the permanent magnet facing it. This guarantees an **attractive force** between them (unlike poles attract), so the soft-iron bar is **pulled towards the magnet**. The far end of the soft iron becomes the **same pole** as the nearby pole of the permanent magnet.

A labelled diagram showing the correct idea (opposite pole nearest the magnet) is below:

(b)(i)

Ball Q is negatively charged.
Ball R is positively charged.

(b)(ii)

Ball P is given as **negatively charged**. From the diagram, ball Q is pushed away from P, meaning Q is **repelled** by P. Since **repulsion only happens between like charges**, Q must have the **same type of charge as P**, so **Q is negative**.

10 (a) A student investigates the electrical resistance of some components.

Fig. 10.1 shows an incomplete diagram of the circuit used by the student.

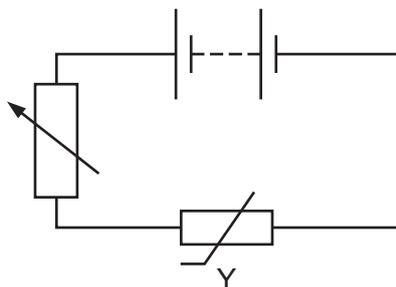


Fig. 10.1

- (i) State the term used for component Y. [1]
- (ii) The student uses the circuit to measure the resistance of component Y.

Complete the diagram in Fig. 10.1 by adding electrical symbols to show an ammeter and a voltmeter correctly connected to determine the resistance of component Y. [3]

(b) Fig. 10.2 shows two resistors A and B.



Fig. 10.2

- (i) Resistor A and resistor B are connected in series.
State the value of their combined resistance.
..... Ω [1]

- (ii) Resistor A and resistor B are connected in parallel.
Compare the combined resistance when in parallel with the resistance of resistor A alone.
..... [1]

[Total: 6]

Question no. 10

(a)(i)

Component **Y** is a **thermistor**.

A **thermistor** is a resistor whose **resistance changes with temperature** (so it is used as a temperature sensor).

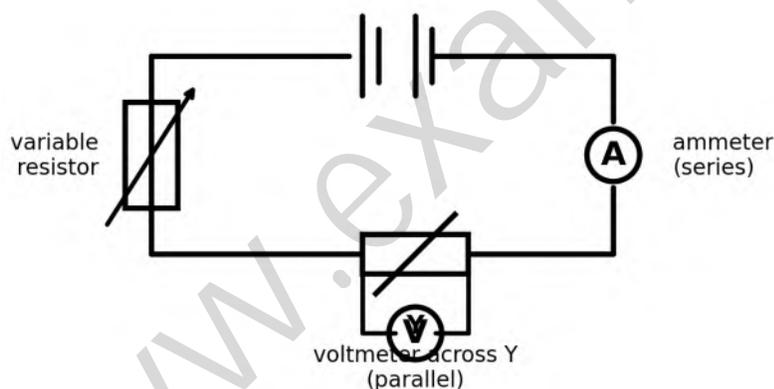
(a)(ii)

To determine the resistance of Y, the student must measure the **current through Y** and the **potential difference (voltage) across Y**, then use $R = V / I$.

So, in the circuit:

- The **ammeter** must be connected **in series** with component **Y** (so it measures the **same current** that flows through Y).
- The **voltmeter** must be connected **in parallel across Y** (so it measures the **potential difference across Y only**).

Here is the **completed circuit diagram** showing both meters correctly placed:



(b)(i)

When resistors are in **series**, their resistances **add** because the same current passes through each one.

So the combined resistance is:

$$5.0 \, \Omega + 7.0 \, \Omega = 12.0 \, \Omega$$

Therefore, the combined resistance is **12 Ω** .

(b)(ii)

When resistors are in **parallel**, the combined resistance is **smaller than the smallest individual resistance**, because adding a parallel branch provides **more paths for current** (so the total current increases for the same voltage, meaning the equivalent resistance must decrease).

Since resistor A alone is **5.0 Ω** , the combined resistance in parallel must be **smaller than 5.0 Ω** .

So, the combined resistance is **smaller than the resistance of resistor A alone**.

11 A teacher uses a power supply in a metal case. The circuit for the power supply includes a fuse.

(a) (i) Draw the electrical symbol for a fuse. [1]

(ii) The metal case of the power supply is earthed. A fault occurs and a live wire touches the metal case.

Explain how earthing the metal case protects the teacher.

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

(b) The power supply circuit includes a transformer. Its input voltage is 240V. There are 960 turns on the input coil and 64 turns on the output coil.

Calculate the output voltage of the transformer.

output voltage = V [3]

[Total: 7]

Question no. 11

(a)(i)

Here is the **electrical symbol for a fuse** (drawn as it would appear **in series** in a circuit):

(a)(ii)

When the **metal case is earthed**, the earth wire provides a **low-resistance path to the ground**. If a fault happens and the **live wire touches the metal case**, the case would otherwise become **live** and could give a shock.

Because of the earth connection, a **large current flows to earth** through the earth wire (rather than through the teacher). This large fault current flows in the **live wire through the fuse** (the fuse is **in the live wire**), so the fuse wire **heats up** rapidly. Since the fuse contains a **thin wire with a low melting point**, it **melts (blows)**, which **breaks the circuit** and disconnects the power supply from the mains. As a result, the metal case is no longer live, so the teacher is protected from an electric shock.

(b)

For an ideal transformer, the voltage ratio equals the turns ratio:

output voltage / input voltage = turns on output / turns on input

So,

$$\text{output voltage} = 240 \times (64 / 960)$$

First simplify $64 / 960 = 1 / 15$, so:

$$\text{output voltage} = 240 \times (1 / 15) = \mathbf{16 \text{ V}}$$

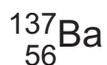
Output voltage = 16 V

12 Radioactive sources emit α -(alpha), β -(beta) and γ -(gamma) radiations.

(a) State which of these types of radiation can pass through paper.

..... [1]

(b) Barium-137 is a radioactive isotope. The nuclide notation for barium-137 is



Determine the number of neutrons in a nucleus of barium-137.

number of neutrons = [1]

(c) An isotope of barium-137 has a half-life of 3 minutes.

A radioactive source contains 36 mg of this isotope.

Calculate the mass of the isotope that remains in the source after 9 minutes.

mass of the isotope remaining = mg [3]

[Total: 5]

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Question no. 12

(a)

Among the three types of radiation emitted by radioactive sources, **both beta (β) radiation and gamma (γ) radiation can pass through paper.**

This is because **alpha (α) particles are highly ionising but have very low penetrating power**, so they are stopped by a sheet of paper or even a few centimetres of air. In contrast, **beta particles are smaller and faster-moving electrons**, so they are able to pass through paper, although they are eventually stopped by thin metal such as aluminium. **Gamma radiation consists of high-energy electromagnetic waves**, which have **very high penetrating power** and can easily pass through paper.

(b)

The nuclide notation for barium-137 shows that the **mass number is 137** and the **proton (atomic) number is 56**.

The number of neutrons in a nucleus is found by **subtracting the proton number from the mass number**, since the mass number represents the total number of protons and neutrons.

So, the number of neutrons in a nucleus of barium-137 is:

$$137 - 56 = 81$$

Therefore, **the nucleus of barium-137 contains 81 neutrons**.

(c)

The half-life of the isotope is **3 minutes**, which means that **the mass of the radioactive isotope halves every 3 minutes**.

After **9 minutes**, the isotope will have undergone:

$$9 \div 3 = 3 \text{ half-lives}$$

Starting with an initial mass of **36 mg**, the mass remaining after each half-life is:

- After 1 half-life: **36 mg** → **18 mg**
- After 2 half-lives: **18 mg** → **9 mg**
- After 3 half-lives: **9 mg** → **4.5 mg**

Therefore, **the mass of the isotope remaining after 9 minutes is 4.5 mg.**

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