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PHYSICS

0625/42

Paper 4 Theory (Extended)

May/June 2021

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.

- 1 (a) Fig. 1.1 shows a sealed weather balloon which is stationary in still air.

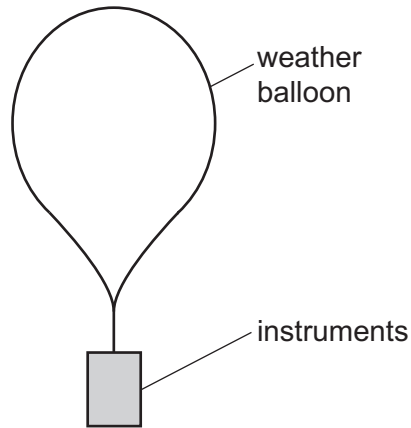


Fig. 1.1

State whether the overall density of the balloon and its instruments is greater than, less than, or the same as the density of the surrounding air.

It is same as density of surrounding air.

[1]

- (b) At night, the gas inside the balloon cools. The pressure of the air outside the balloon remains the same.

- (i) State whether the balloon rises, falls or remains stationary.

It falls

[1]

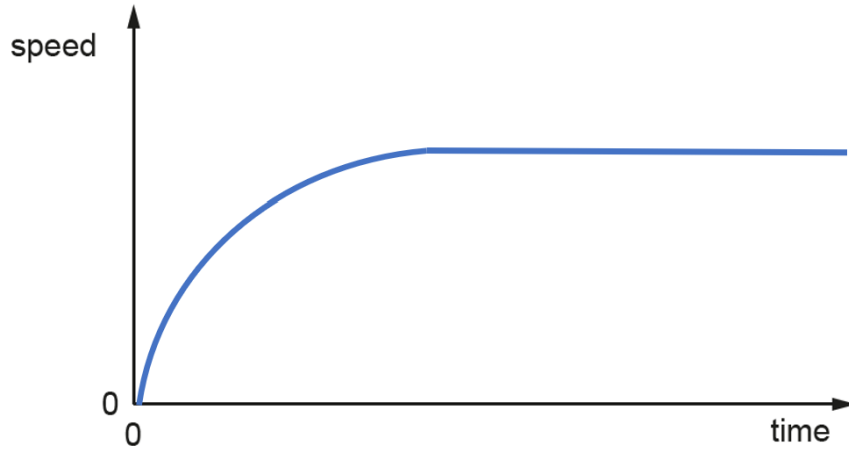
- (ii) Explain your answer.

**The volume of the balloon decreases and hence the density increases.
As a result the balloon falls.**

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

(c) An object is released from the balloon. It starts at rest and eventually reaches a constant speed.

(i) On the axes of Fig. 1.2, sketch a speed–time graph to show this motion.



[3]

(ii) State the values of the initial acceleration and the final acceleration of the object.

initial acceleration $10 \text{ m / s}^2 \text{ down}$

final acceleration 0

[2]

[Total: 9]

- 2 (a) Define the *moment* of a force.

Moment of a force is equal to force \times perpendicular distance from pivot [1]

- (b) Fig. 2.1 shows an object of negligible weight. The object is in equilibrium.

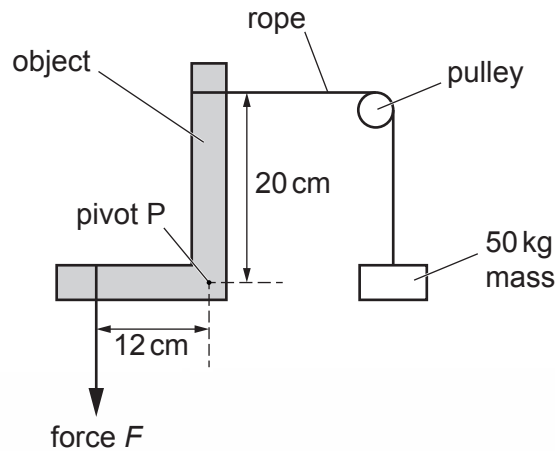


Fig. 2.1

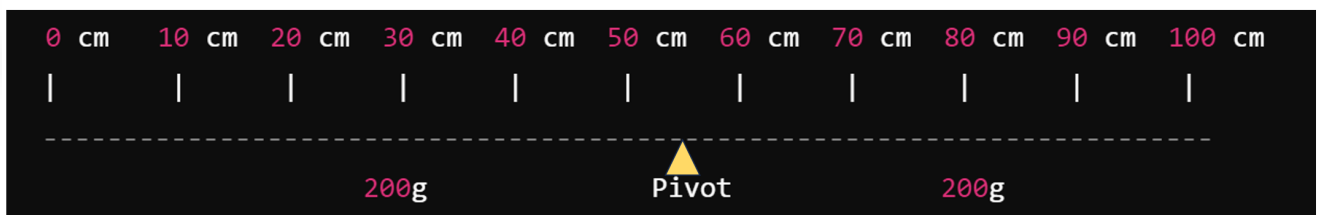
The object is free to rotate about its pivot P.

Calculate the value of force F .

$$\begin{aligned} (F_1d_1 = F_2d_2 \Rightarrow) & 500 \times 20 = F \times 12 \\ F &= 10\,000 / 12 \\ &= 830 \text{ N} \end{aligned}$$

$$F = \text{.....} \mathbf{830 \text{ N}} \quad [2]$$

- (c) Describe an experiment involving vertical forces to show that there is no net moment on an object in equilibrium. You may draw a diagram in the space provided.



Materials Needed

- A uniform meter ruler
- A pivot (such as a knife edge or a fulcrum)
- Weights (masses with known values)
- A clamp stand (optional, for stability)

Procedure

Set Up the Ruler on the Pivot:

Place the meter ruler horizontally on the pivot at its center (50 cm mark). Ensure that the ruler is balanced and level.

Add Weights to Create Forces:

Place weights at known distances from the pivot on both sides of the ruler. For example, place a 200g weight at the 30 cm mark on one side and another 200g weight at the 70 cm mark on the other side.

You can use multiple weights to create different force scenarios.

[3]

[Total: 6]

Ensure Equilibrium:

Adjust the position of the weights if necessary to ensure the ruler remains horizontal and balanced.

Verify the Net Moment:

Measure the distances of the weights from the pivot.

Calculate the moments (force \times distance) for each weight about the pivot.

Sum the moments on both sides of the pivot.

Calculations and Analysis

Assume the weight of the ruler is negligible or uniform.

Calculate the moments on either side of the pivot:

Moment on left side = $200\text{g} \times (50\text{ cm} - 30\text{ cm}) = 200\text{g} \times 20\text{ cm}$

Moment on right side = $200\text{g} \times (70\text{ cm} - 50\text{ cm}) = 200\text{g} \times 20\text{ cm}$

The moments are equal and opposite, ensuring there is no net moment, and the ruler remains in equilibrium.

Conclusion

When the ruler is balanced, it shows that the sum of the clockwise moments equals the sum of the counterclockwise moments.

This demonstrates that there is no net moment on the object, confirming the condition for rotational equilibrium.



- 3 Fig. 3.1 shows water flowing at very slow speed over a cliff edge.

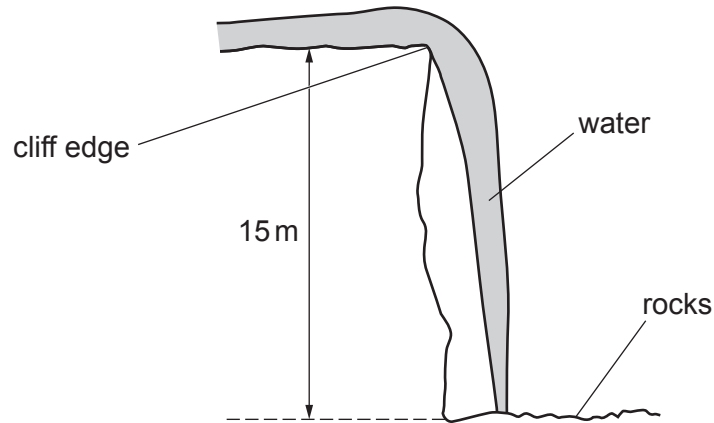


Fig. 3.1

The water falls 15 m onto the rocks below.

- (a) Show that the velocity of the water when it strikes the rocks is 17 m/s.

$$P.E = K.E$$

$$mgh = \frac{1}{2} m v^2 \quad [m \text{ gets cancelled from both sides}]$$

$$2gh = v^2$$

$$v^2 = 2 \times 10 \times 15$$

$$v^2 = 300$$

$$v = \sqrt{300}$$

$$v = 17.32 \text{ m/s}$$

[4]

- (b) 30 kg of water flows over the cliff edge every second.

Calculate the force exerted by the rocks on the falling water. Ignore any splashing.

$$F = \text{change of } p / \text{change of time}$$

$$F = 30 \times 17.32 / 1 \quad [\text{note : momentum} = \text{mass} \times \text{velocity}]$$

$$F = 520 \text{ N}$$

520 N

force = [3]

[Total: 7]

4 (a) Pollen particles are mixed into a liquid. They are seen to move when observed through a microscope.

(i) Describe this movement.

This movement can be describes as random [or / haphazard / zig-

[1]

(ii) Explain this movement in terms of the molecules of the liquid and the pollen particles.

The liquid water molecules move fast and collide with more massive pollen particles. This causes the random movement of the liquid

[3]

(b) (i) Medical professionals sometimes rub ethanol over the skin of a patient. Ethanol evaporates readily at room temperature and has a high specific latent heat of vapourisation.

State whether the patient experiences heating, cooling or neither at the site where the ethanol is applied. Explain your answer.

statement

explanation **The thermal energy needed to evaporate ethanol is taken from skin. As a result, most energetic liquid molecules escape, leaving least energetic molecules behind. Hence evaporation causes cooling**

[3]

(ii) State any effect on the rate of evaporation of ethanol when a fan blows air over the patient's skin.

Rate of evaporation increases

[1]

[Total: 8]

- 5 (a) A machine delivers a hot drink in a plastic cup, which is uncomfortably hot to hold.

Fig. 5.1 shows the cup with the hot drink.

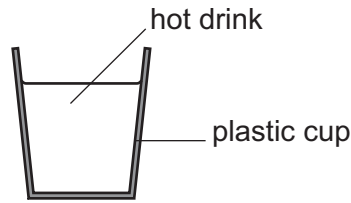


Fig. 5.1

Fig. 5.2a shows the cup with the hot drink and a holder for the sides of the cup.

Fig. 5.2b shows a cross-section through the holder. The holder is made from two strong paper cylinders separated by a wavy piece of strong paper to make air gaps.

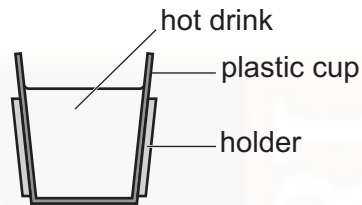


Fig. 5.2a

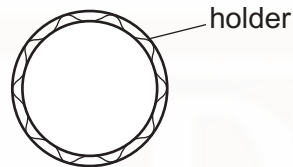


Fig. 5.2b

Explain how using the holder makes it more comfortable to hold the cup.

Air is a poor conductor. It reduces conduction. As a result, the temperature of outside of holder is lower than cup and hence less thermal energy is conducted to the hand.

.....
 [3]

- (b) A student carries out experiments on the cooling of the hot drink described in (a), with and without the holder in place. He finds that the holder only reduces the rate of cooling slightly.

Suggest and explain another action that reduces the rate of cooling more effectively.

suggestion **put a lid on the cup**

explanation **Because the convection from the surface is less when lid is present**

.....
 [3]

- (c) State the method of thermal energy transfer from a star through the vacuum of space.

radiation

..... [1]

[Total: 7]

- 6 (a) Fig. 6.1 shows a ray of green light passing through a prism.

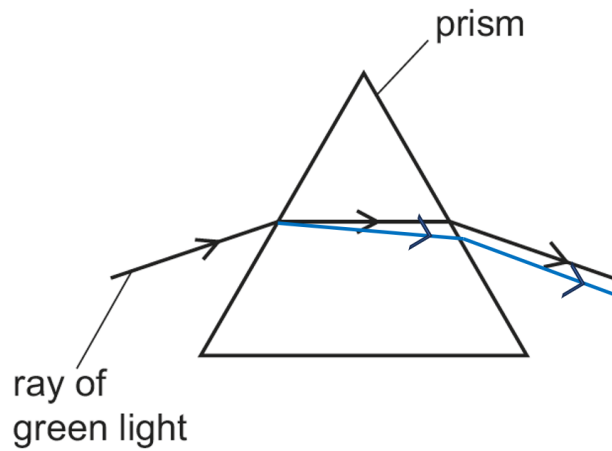


Fig. 6.1

A ray of blue light is directed towards the prism on the same path as the ray of green light.

On Fig. 6.1, draw the path of the blue light through and out of the prism. [3]

- (b) The wavelength of the blue light in air is 4.8×10^{-7} m.

Calculate the frequency of the blue light.

$$v = f\lambda$$

Hence:

$$f = v / \lambda$$

$$= 3 \times 10^8 \div 4.8 \times 10^{-7}$$

$$= 6.3 \times 10^{14} \text{ Hz}$$

frequency = 6.3×10^{14} [3]

[Total: 6]

- 7 (a) Fig. 7.1 shows two magnets and the gap between the N pole of one magnet and the S pole of the other magnet.

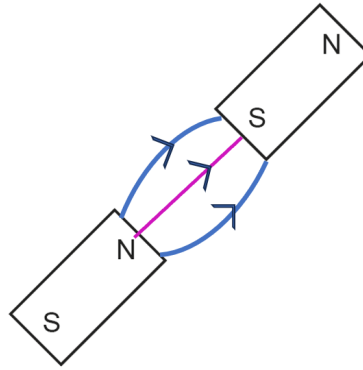
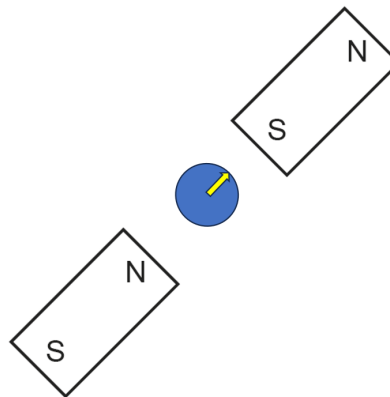


Fig. 7.1

On Fig. 7.1, draw **three** lines to show the pattern and direction of the magnetic field in the gap. [2]

- (b) (i) Fig. 7.2 is a repeat of Fig. 7.1 showing the two magnets.

On Fig. 7.2, draw the position of a plotting compass needle when it comes to rest in the gap between the N pole and the S pole.



[1]

- (ii) Explain why the needle comes to rest in this position.

This is because the compass aligns with the field. N pole of the needle is attracted to the S pole of the magnet

.....
 [2]

- (c) Describe a method of demagnetising a bar magnet.

Hammer the magnet , with the magnet lying in the magnetically E-W direction

.....
 [2]

8 (a) Two identical radioactive sources emit α -particles and γ -rays into two vacuum tubes.

(i) Fig. 8.1 shows two electrically charged plates on either side of one of the vacuum tubes.

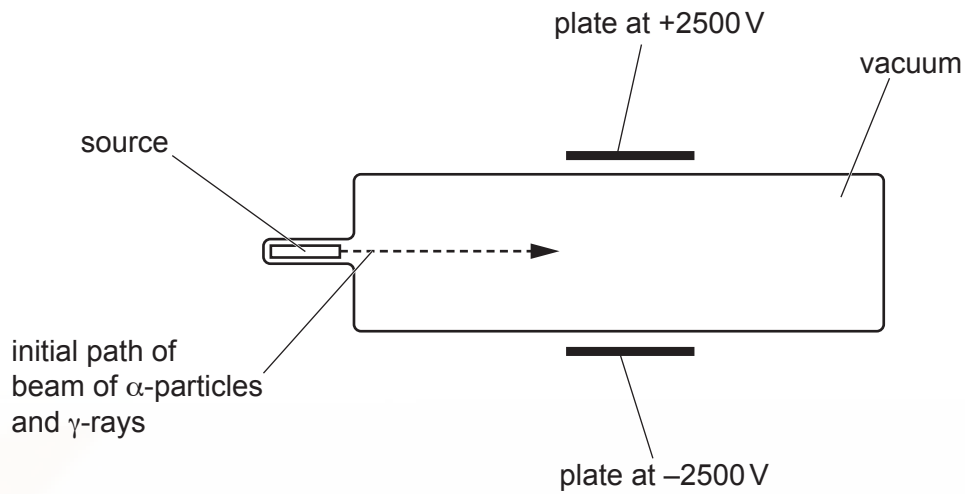


Fig. 8.1

Write the symbol α **once** in Table 8.1 to indicate any deflection of the α -particles.

Write the symbol γ **once** in Table 8.1 to indicate any deflection of the γ -rays.

Table 8.1

into page	out of page	no deflection	towards bottom of page	towards top of page
		γ	α	

[2]

- (ii) Fig. 8.2 shows the poles of a very strong magnet on either side of the other vacuum tube.

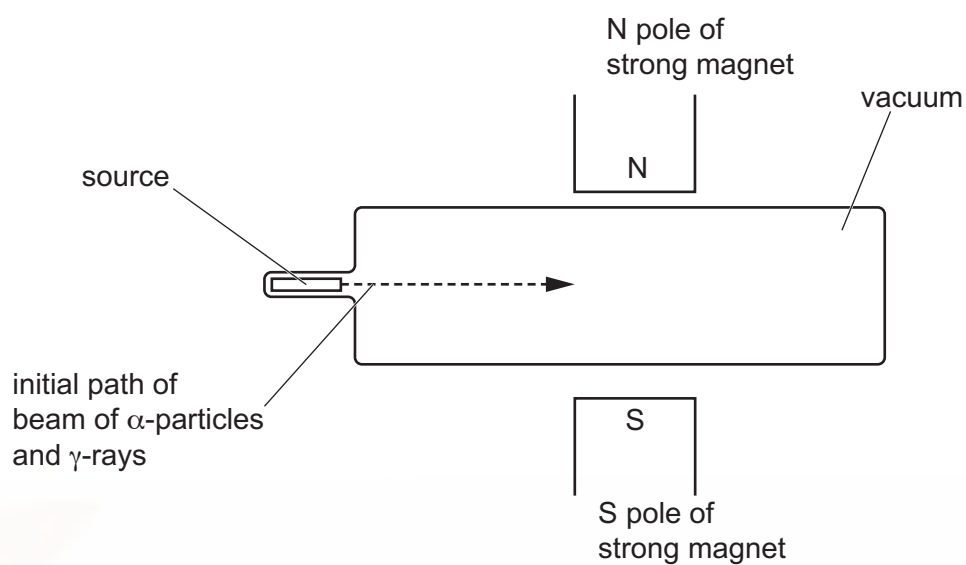


Fig. 8.2

Write the symbol α **once** in Table 8.2 to indicate any deflection of the α -particles.

Write the symbol γ **once** in Table 8.2 to indicate any deflection of the γ -rays.

Table 8.2

into page	out of page	no deflection	towards bottom of page	towards top of page
α		γ		

[2]

(b) Fig. 8.3 shows a simple direct current (d.c.) electric motor with a split-ring commutator.

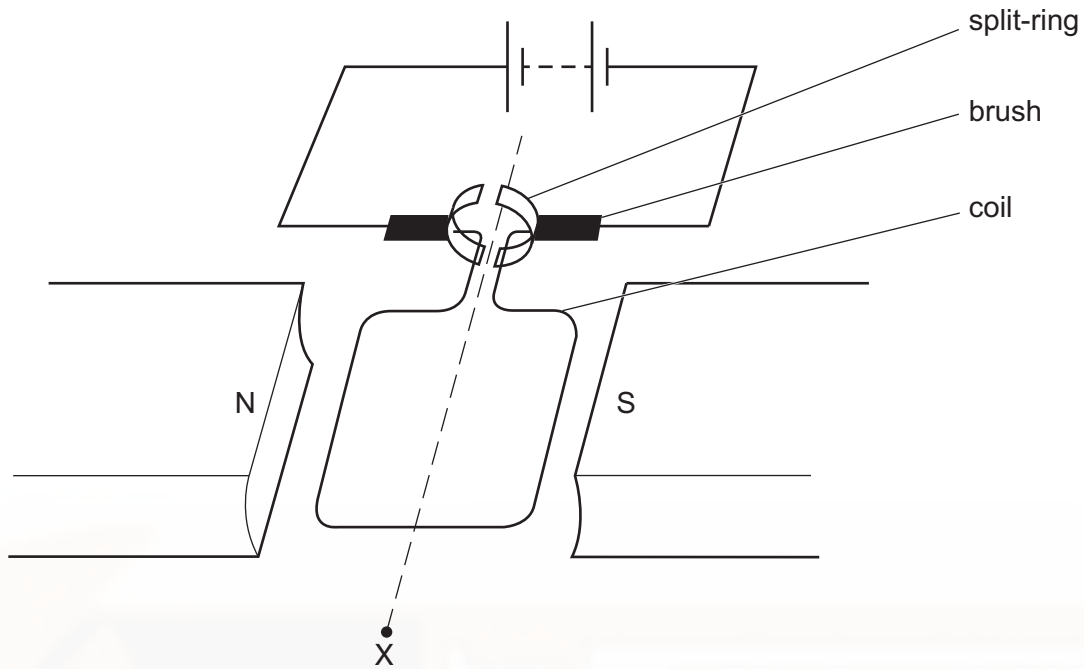


Fig. 8.3

(i) State and explain the direction of rotation of the coil as seen from point X.

statement **clockwise**

explanation **Because there is a force on L wire up and force on RH wire down**

..... [3]

(ii) The coil rotates through 90° from the position shown.

State what happens to the moment in this position.

There is zero moment

..... [1]

(iii) The coil is rotated through 180° from the position shown. By considering the forces on the coil, explain how the split-ring commutator enables the motor to turn continuously.

The current in coil changes direction , but the forces on the wires still acts up on L and down on R

..... [2]

[Total: 10]

- 9 (a) Fig. 9.1 shows a circuit.

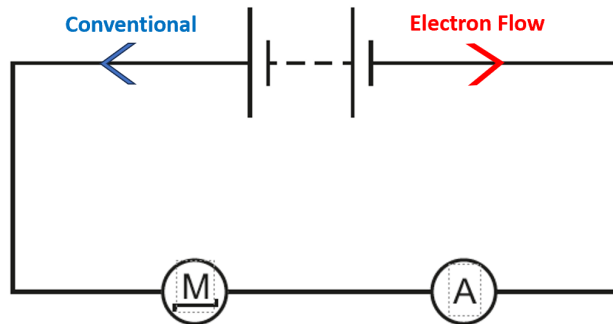


Fig. 9.1

On Fig. 9.1, draw **two** clearly labelled arrows to show the direction of the electron flow and the direction of the conventional current in the circuit. [2]

- (b) The current in the motor is 13A. The charge on an electron is 1.6×10^{-19} C.

Calculate the number of electrons that pass through the motor every second.

$$Q=It$$

$$\text{Hence: } Q= It=13 \times 1= 13\text{C}$$

Also;

$$Q= n \times e$$

Hence

$$n= Q/e$$

$$n=13/1.6 \times 10^{-19}\text{C}$$

$$n= 8.1 \times 10^{19}$$

$$8.1 \times 10^{19}$$

number of electrons = [3]

[Total: 5]

10 (a) Fig. 10.1 shows the potential difference–current graph for a circuit component K.

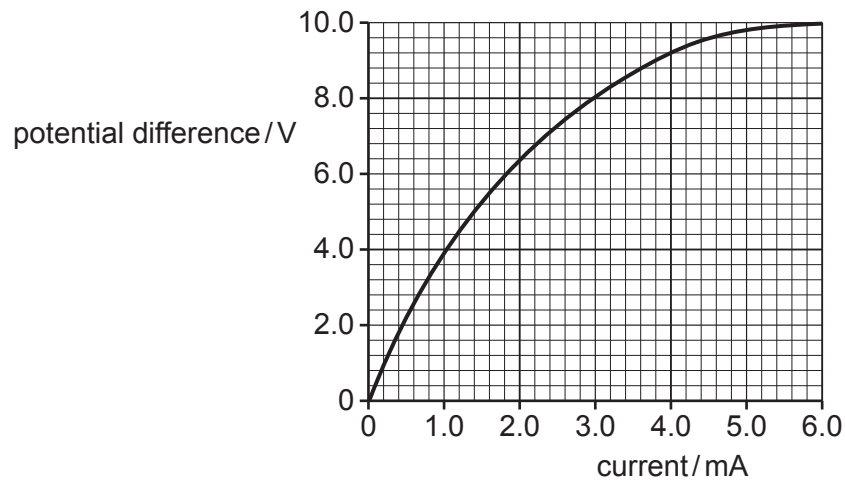


Fig. 10.1

Calculate the resistance of component K when the current in it is 4.0 mA.

From The Graph:

At $I = 4.0\text{mA} = 0.004\text{A}$, $V = 9.2\text{V}$

$V = IR$

Hence;

$R = V/I$

$= 9.2 / 0.004 = 2300\Omega$

2300 Ω

resistance = [2]

(b) Fig. 10.2 shows a circuit containing component K.

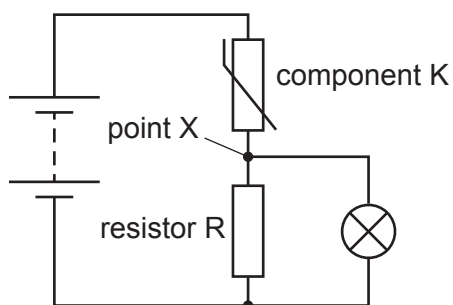


Fig. 10.2

At low temperature, component K has a much greater resistance than resistor R.

At high temperature, component K has a much smaller resistance than resistor R.

State and explain the effect on the lamp when the temperature changes from very low to very high.

Refer to the voltage at point X in your explanation.

statement **There is a much greater current in lamp**

explanation **The resistance of thermistor is reduced. Hence the pd across R increases and there is a larger current in the lamp**

..... [4]

(c) State the name of component K.

thermistor

..... [1]

[Total: 7]

- 11 (a) A student investigates a radioactive substance in a laboratory.

Fig. 11.1 is a graph showing the count rate detected as the substance decays for 7.5 minutes.

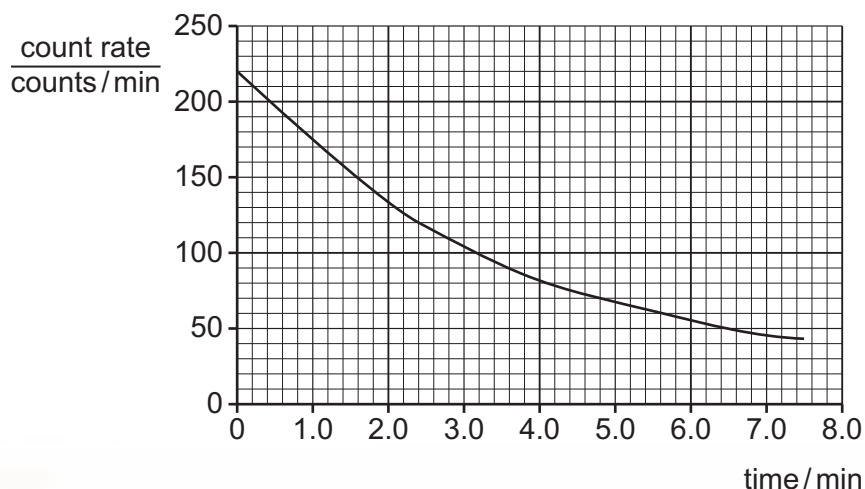


Fig. 11.1

The background radiation is 20 counts/min.

- (i) Determine the half-life of the substance.

Initial count rate adjusted for background radiation = $220 - 20 = 200$

After 1 half-life count rate adjusted for background radiation = 100

Hence Half life = 2.4 min

half-life = [3]

- (ii) Calculate the count rate detected at time = 9.6 minutes.

Note 9.6 mins = 4 half lives

(13 + 20 =) 32

33

count rate =counts/min [2]

- (b) The substance emits α -particles and γ -rays. The student suggests that it is safe to store the substance in a plastic container of thickness 2 mm.

State and explain whether the student's suggestion is correct.

statement **incorrect**

explanation **The container is 2mm plastic and does not absorb γ and hence is penetrated by γ**

[3]

[Total: 8]

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