BEATTY SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2025
SECONDARY FOUR EXPRESS / FIVE NORMAL (ACADEMIC) / G3

CANDIDATE NAME	

CLASS		REGISTER NUMBER	

SCIENCE (PHYSICS, CHEMISTRY) 5086/02

Paper 2 Physics **29 August 2025**
Setter: Mrs Seah **1 hour 15 minutes**

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

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

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

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

For Examiner's Use	
A	**55**
B…..	**10**
Total	**65**

Section A

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

1 **(a)** A student compares microwaves and ultraviolet radiation in a vacuum.

Complete the sentences with only the phrases provided

higher than	less than	the same as

The frequency of ultraviolet radiation is **higher than** the frequency of microwaves. [1]

The speed of microwaves in a vacuum is **the same as** the speed of ultraviolet radiation in a vacuum. [1]

(b) State the region of the electromagnetic spectrum that is used for sun-tanning beds.

Ultraviolet radiation [1]

2 Fig. 2.1 shows how the speed of a vehicle changes with time.

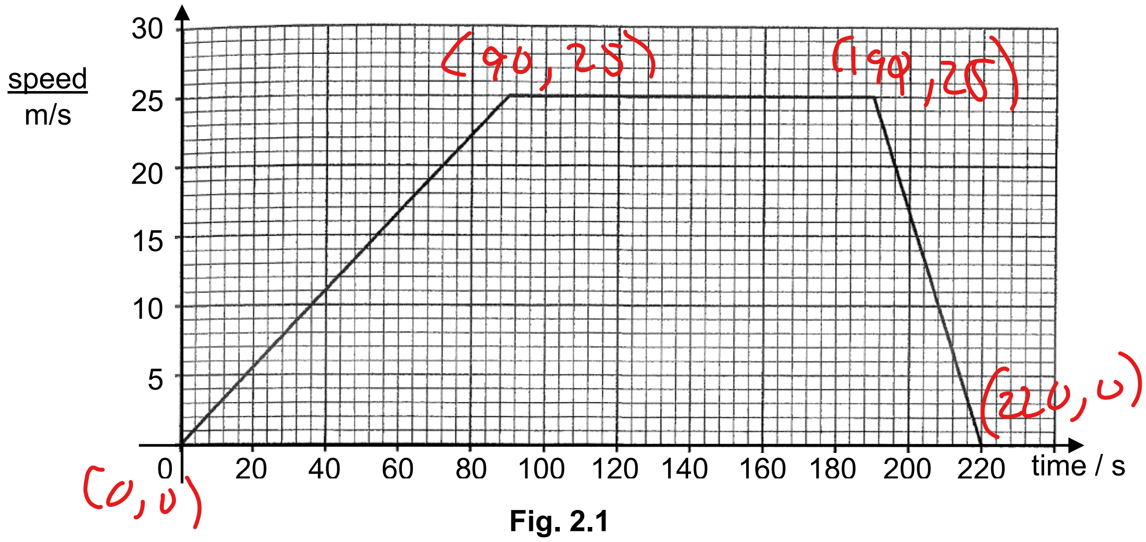


Fig. 2.1

(a) Describe the motion of the vehicle from t = 200 s to t = 220 s.

Uniform/constant deceleration

.... [1]

(b) Calculate

(i) the acceleration of the vehicle in the first 70 s.

$a = \frac{v-u}{t}$

$= \frac{25.0}{90}$ or $\left(\frac{19.5}{70}\right)$

= 0.278 or = 0.279 = 0.28 m / s^2 (2sf or 3sf)

acceleration = ... m/s^2 [1]

(ii) the distance travelled for the whole journey.

Total distance

= area under graph (trapezium) area of

$= \frac{1}{2}[(190 - 90) + 220) \times 25.0$ $\frac{1}{2}$ (Sum of // side) x ht

= 4000 m

distance travelled = ... m [2]

3 A cylindrical beaker with a base area of 30.0 cm^2 contains a mixture of two immiscible liquids, A and B. The mass of the beaker is 50.00 g. The beaker is placed on an electronic beam balance as shown in Fig. 3.1.

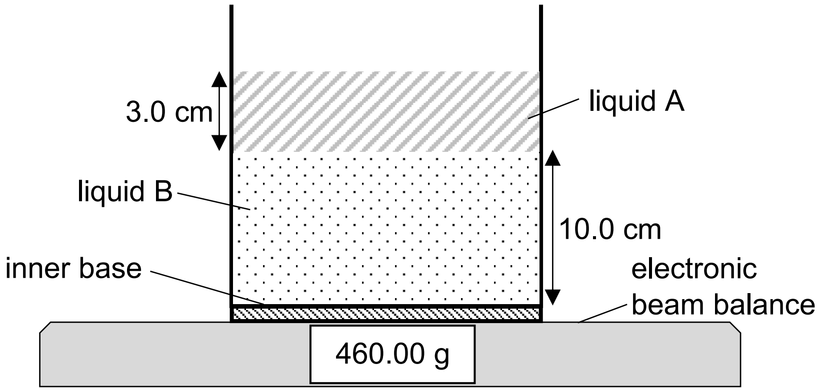


Fig. 3.1

(a) Calculate the average density of the mixture. $D = \frac{m}{V}$

volume = 13 x 30.0 = 390 cm^3

average density = (460 – 50) / 390

= 1.05 g / cm^3

average density = ... g / m^3 [2]

(b) The density of liquid A is known to be 1.00 g/cm^3.

Calculate the density of liquid B.

mass of A = density of A x volume of A

= 1.00 x (3 x 30.0)

= 90.0 g

density of B = mass of B / volume of B

= (410 – 90.0) / (390 – 90.0)

= 1.07 g / cm^3

density = ... g /cm^3 [2]

$1 cm^2 = 1 cm \times 1 cm$
$= 0.01 \times 0.01 cm^2$

$30 cm^2$ = divide 100 twice

(c) Calculate the pressure exerted on the inner base of the beaker due to the mixture.

Inner base area = 30/(100 x 100)

= 0.003 m² or 3 x 10^{-3} m²

$P = \frac{F}{\text{Area of contact}}$

pressure

= weight acting on inner base / cross-sectional area

= $((\frac{410}{1000})x10)\div(0.003)$

= 1370 Pa

pressure = ……………….. Pa [3]

4 Fig. 4.1 shows a ball of mass 0.50 kg sliding down a rough slope from position A which is 7.5 m above the ground with an initial speed of *v* m/s. Friction along the slope produces 10.7 J of thermal energy. The initial speed *v* m/s decreases as the ball rolls down the slope to position B. The ball leaves the slope at position B moving vertically upward and reaches a height of 13.0 m above the ground at position C.

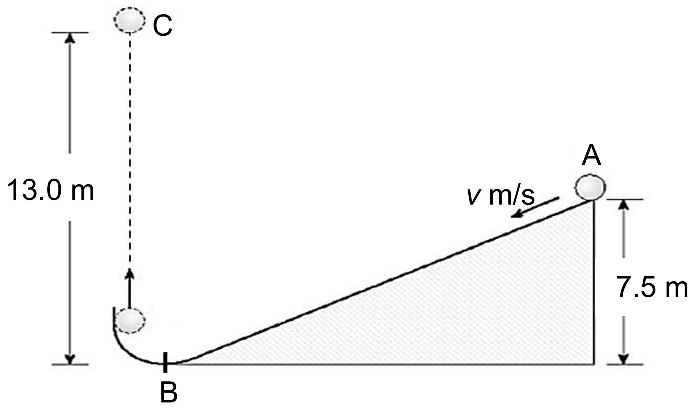


Fig. 4.1

(a) Explain why the speed of the ball decreases as it travels from position A to position B with the relevant energy transfers between the different energy stores.

From point A to before point B, the energy in the ball is transferred from the **gravitational potential store** and **kinetic store** to the **internal store (of surrounding air and ball).**

Work is done against friction or to overcome friction along the slope and the speed of the ball decreases as **thermal energy is dissipated to surroundings.**

by mechanically

From point A to before point B, the energy transferred is **by heating** from the gravitational potential store and kinetic store of ball to the internal store (of surrounding air and ball).

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

(b) Calculate the

(i) gravitational potential store of the ball at position C,

GPE = mgh

= 0.50 x 10 x 13

= 65 J

gravitational potential store = ……………….. J [1]

(ii) initial speed *v*, at position A.

Assuming there is no energy loss,

$E_A = E_B + WD_{frictn}$

GPE at C + WD against friction = total energy at A (GPE + KE)

$E_B = E_C$

65 + 10.7 = ($\frac{1}{2}$ x 0.50 x v²) + (0.50 x 10 x 7.5)

v = 12.4 m/s

initial speed = ……………….. m/s [2]

5 A solid substance at 30.0 °C is heated for 20 min until it melts at 150 °C. It takes 10 min for the substance to melt completely.

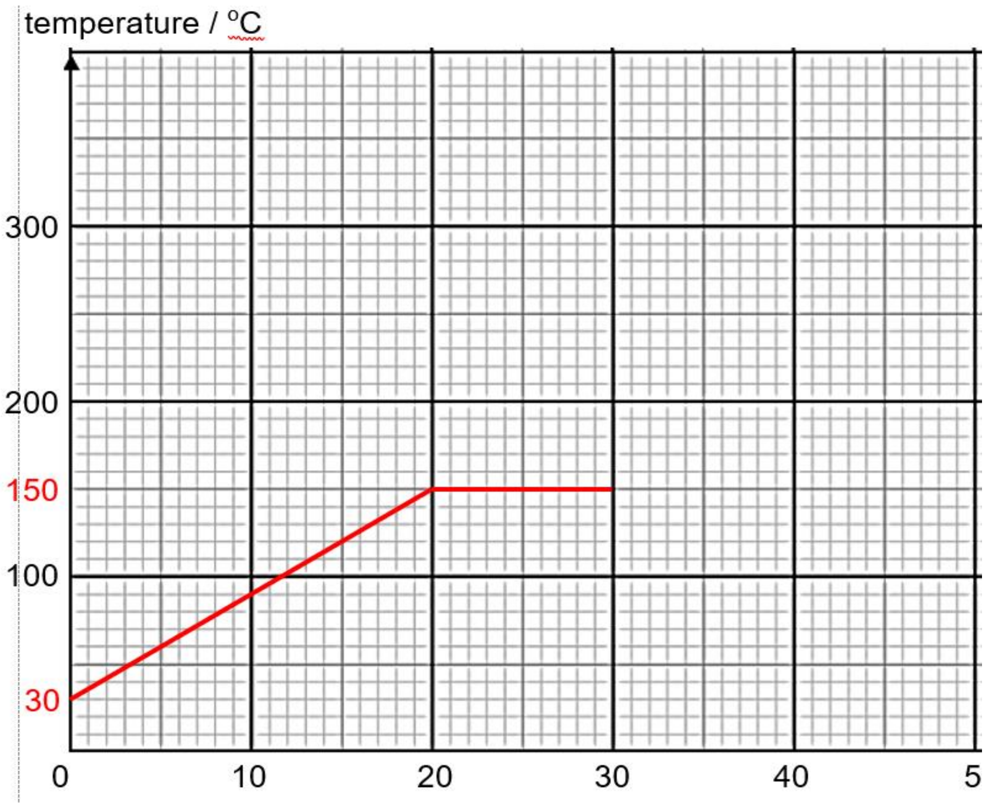


Fig. 5.1

(a) Sketch on Fig. 5.1 the variation in temperature of the substance with time until it melts completely.

[2]

(b) State and explain what happens to the average energy in the kinetic store of the molecules as the substance is cooled until room temperature.

The average kinetic energy **decreases**.

Energy in the **internal store (kinetic energy) of the substance** is **transferred** to the **internal store of the surroundings** by the **propagation of infrared waves**.
…………………………………………………………………………………………….. [2]

6 Fig. 6.1 shows a metal pipe being used as a simple heat exchanger by a student in an investigation. Heat is transferred from the hot water inside the metal pipe to the cold water outside the metal pipe in the basin.

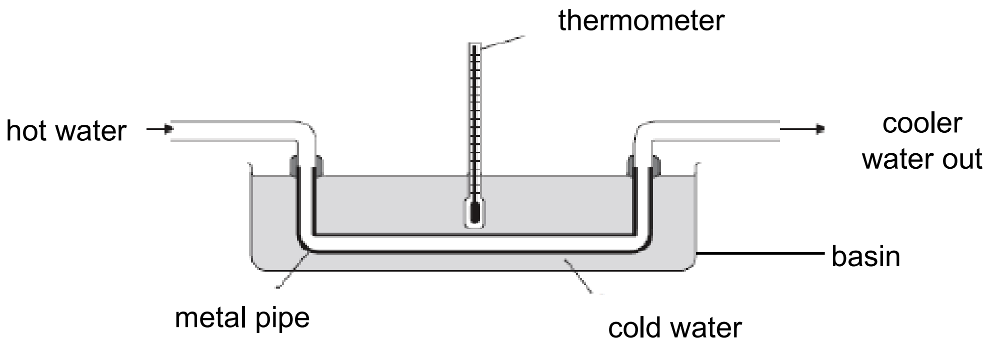


Fig. 6.1

Name and describe the process in which all the cold water in the basin is heated.

Convection

The **heated water expands**, becomes **less dense and rises**. The **surrounding water being denser, sinks to be heated**.

The movement of water due to a difference in density sets up convection currents.

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

7 An instrument produces sound waves in air. The pressure of the sound wave is measured as shown in Fig. 7.1.

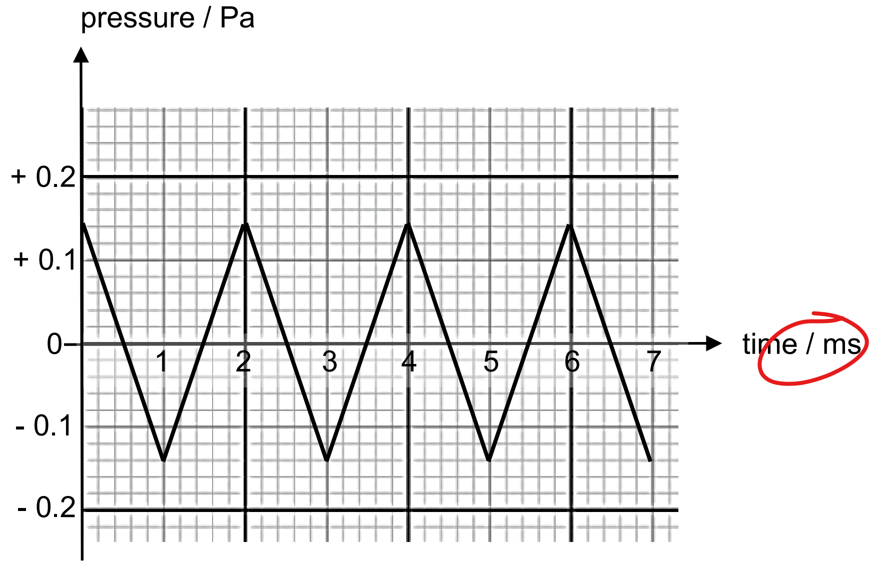


Fig. 7.1

The speed of sound in air is 320 m/s.

Calculate the wavelength of the sound wave produced.

$f = \frac{1}{T}$

$= \frac{1}{2x10^{-3}}$

$= 500$ Hz

$v = f\lambda$

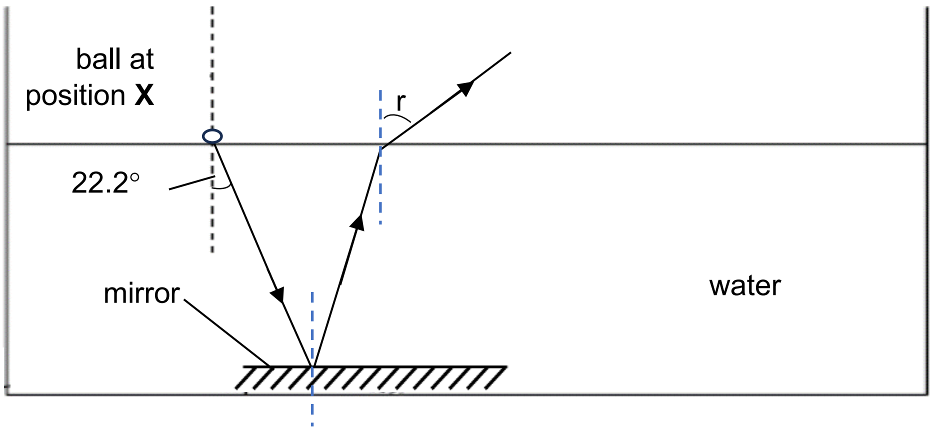
$\lambda = \frac{320}{500}$

$= 0.64$ m

= 64 cm (allow e.c.f)

wavelength = ………………… cm [2]

8 Fig. 8.1 shows a rectangular tank containing a ball floating in water at position **X**. A ray of light from the ball strikes the plane mirror at the bottom of the tank, making an angle of 22.2° with the normal at the water surface. The ray will be reflected from the surface of the mirror and emerge at a point on the surface of the water.



(a) On Fig. 8.1, draw the path of the ray of light through the water.

Label the angle of refraction, ∠*r,* after the ray of light has emerged from the water surface. [1]

(b) If the refractive index of water is 1.33, calculate the angle of refraction for the ray as it emerges from the water.

$n = \frac{\sin i}{\sin r}$ (OLD → OMD)

$$\frac{\sin r°}{\sin 22.2} = 1.33$$

r = 30.2°

$n = \frac{\sin \text{big} \angle}{\sin \text{small} \angle}$

angle of refraction = ………………… ° [2]

9 Fig. 9.1 shows a method of producing sandpaper using static electricity.

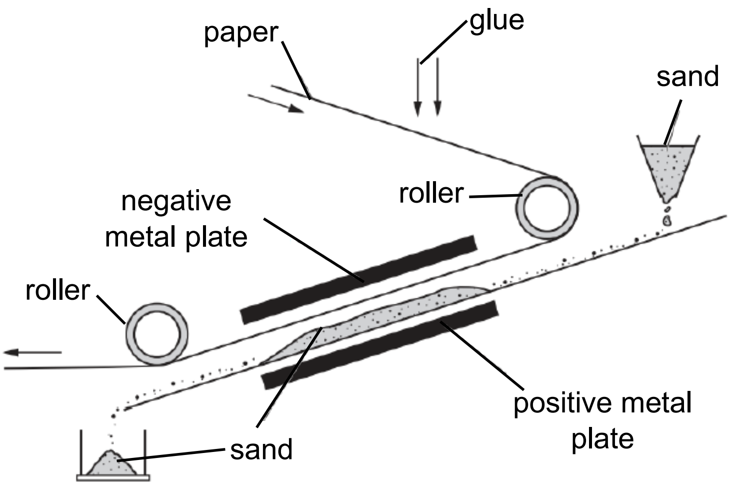


Fig. 9.1

Glue is sprayed onto the moving paper, forming a layer of sticky paper. This sticky paper then passes between two metal plates. One plate is positively charged and the other is negatively charged, creating an electric field between them.

Grains of sand are placed just below this sticky paper between the charged plates, where each grain is given a charge. As the rollers continue to move the sticky paper away from the plates, sandpaper is produced.

(a) State and explain whether the sand grains are positively or negatively charged.

Sand grains are **positively charges** as **unlike charges attract**. In order for the sand to be **attracted to the glued papers, which are placed at the negative plate.**

.... [2]

(b) A man accidentally touches the exposed part of the positive plate. The potential difference between the hand and the metal is 1500 V and the charge transferred is 4.0×10^{-4} C.

energy

Calculate the energy transferred when the charges pass through him.

E=QV

$V = J/C$

charge

$=4.0 \times 10^{-4} \times 1500$

= 0.60 J

energy = ……………….. J [1]

10 Fig. 10.1 shows a lamp from a car headlight. It contains two metal filaments.

Fig. 10.1

Fig. 10.2 shows the current-p.d. (*potential difference*) graph for the two filaments.

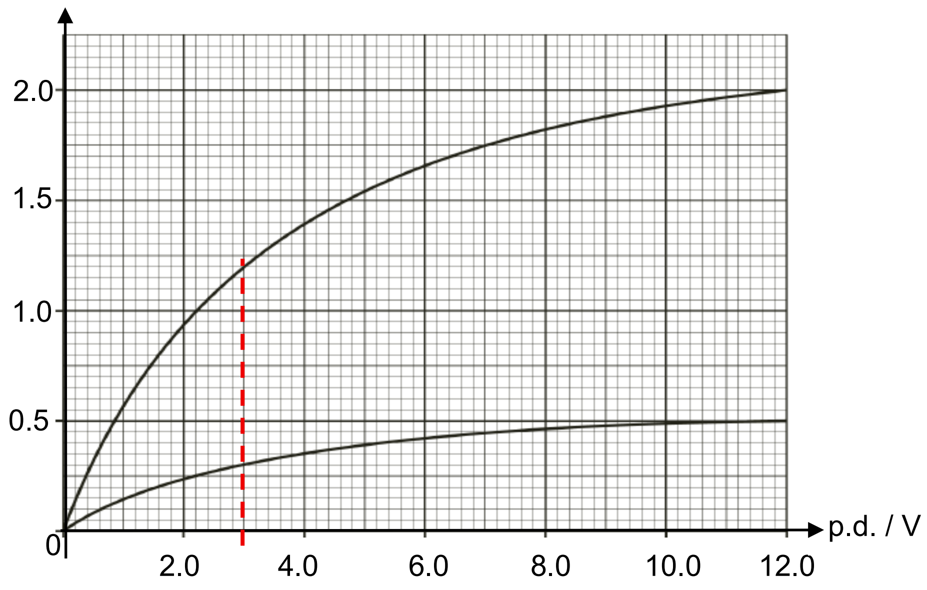


Fig. 10.2

In one of the tests, the two filaments are connected in parallel to a dry cell with 3.0 V.

(a) From the graph, determine the total current flowing through the lamp.

From graph,

Current = 1.2 + 0.3

= 1.5 A

electric current = ………………… A [1]

(b) Hence, calculate the total resistance of the two filaments.

$$R = \frac{V}{I}$$

$$= \frac{3}{1.5}$$

= 2 Ω (allow e.c.f from (a))

total resistance = ………………… Ω [1]

(c) Calculate the amount of charge flowing through the lamp in one minute.

Q=It

= 1.5 x 60

= 90 C (allow e.c.f from (a))

charge = ……………….. C [1]

11 Fig. 11.1 shows the electrical wiring in a water heater. It consists of a heater coil rated '240 V, 2500 W' and an exhaust fan rated '240 V, 300 W'. The mains supply 240 V to the water heater.

always find I (P=IV)

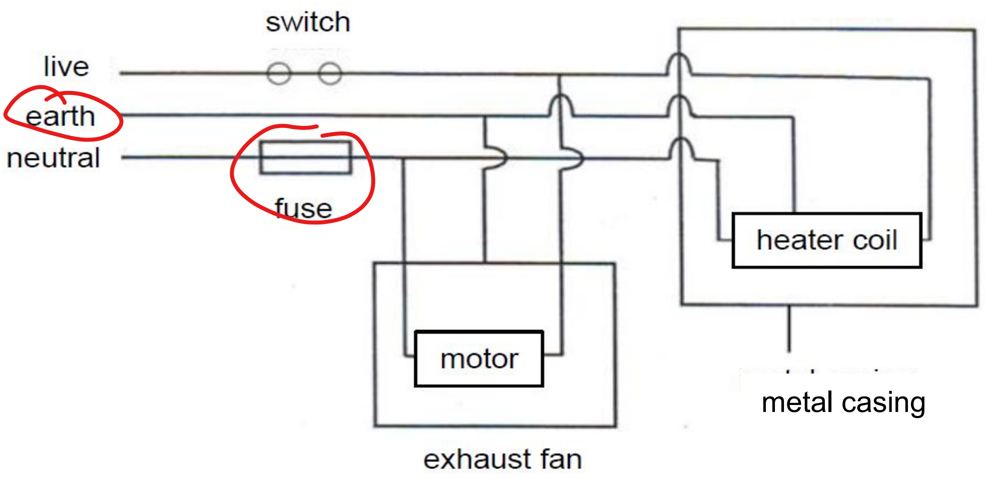


Fig. 11.1

(a) Identify **two** mistakes in the wiring of the circuit in Fig. 11.1 and describe how they should be corrected.

1. The **earth wire is connected to the heater coil**. It should be connected to the **metal casing**.
2. The **fuse is connected to the neutral wire**. It should be connected to the **live wire**.

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

(b) State and explain, with the help of calculations, whether a fuse rating of 11 A is suitable in this circuit.

Calculations:

P = VI

Total current = $\frac{2500}{240} + \frac{300}{240}$

= 11.7 A

The fuse is unsuitable because the fuse rating is lower than the current required for both appliances to function normally.

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

(c) Both appliances are used for 25 minutes each day. Each kWh of electrical energy costs 26 cents.

Calculate the total cost of electrical energy consumption for 30 days.

(1) kW (total)
(2) kWh (individual app.)
(3) kWh x unit cost

Energy = Pt

$$= \left(\frac{2500}{1000} + \frac{300}{1000}\right) \times \left(\frac{25}{60}\right) \times 30$$

= 35 kWh

Cost = 35 x 0.26

= $9.10

total cost = $ .... [2]

12 **(a)** Fig. 12.1 shows the inside of a smoke detector.
When there is no smoke, the alarm stays off since the radioactive source reaches the radiation detector. When there is smoke, the alarm will be triggered when smoke particles block the radioactive source and absorbs alpha radiation. This results in a change in the count rate detected by the radiation detector.

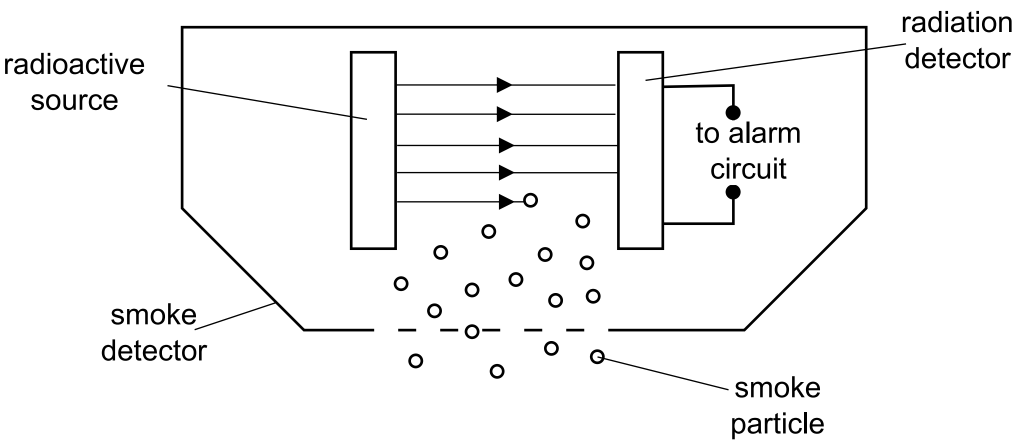


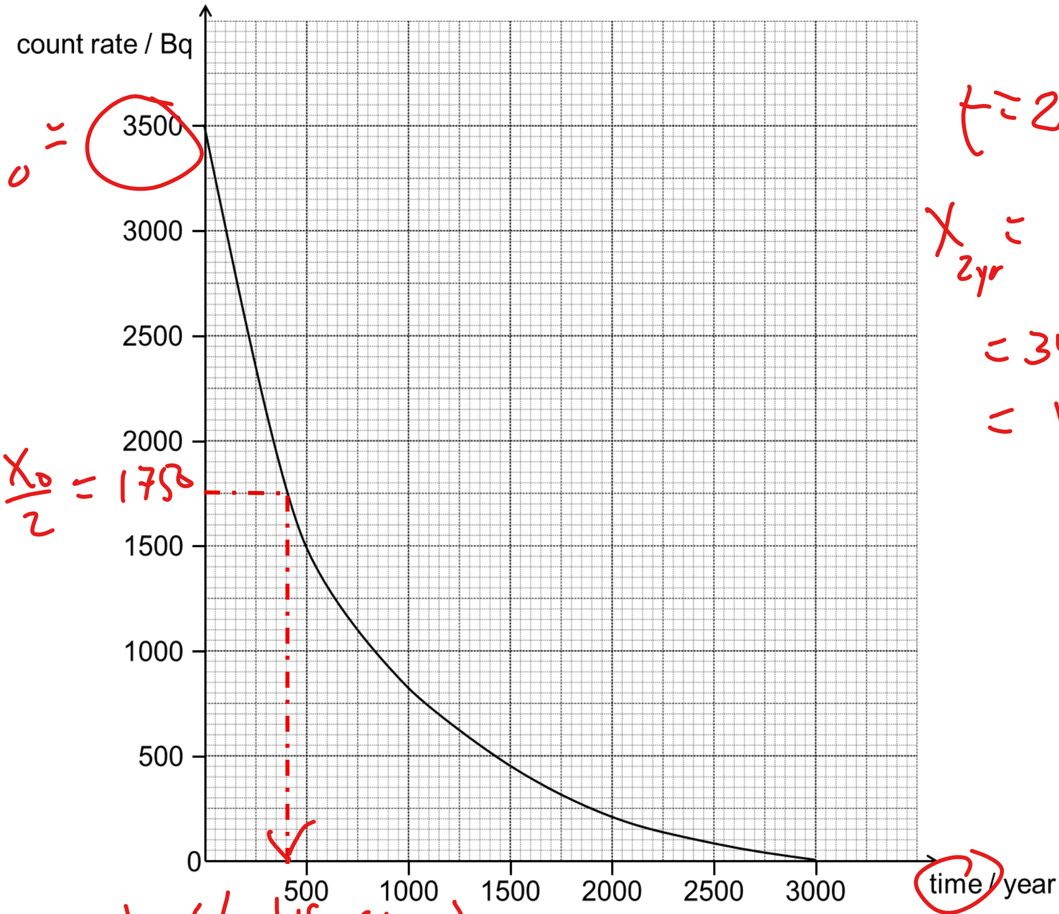
Fig. 12.1

(i) Explain why the smoke alarm will **not** work if the alpha radiation source is replaced by a beta or gamma radiation source.

Both beta and gamma radiation will be **able to penetrate through the smoke.**

There will be **no change in the count rate** detetcted and **alarm will not be triggered.**
.... [2]

(ii) Fig. 12.2 shows how the count rate of the alpha radiation source in the smoke alarm varies with time.



$X_0 = 3500$

$\frac{X_0}{2} = 1750$

half-life (time)

$t = 2000\,yr$

$X_{2yr} = 3500\left(\frac{1}{2}\right)^{2000/400}$

$= 3500\left(\frac{1}{2}\right)^{5}$

$= 109.4\,Bq$

Fig. 12.2

Determine the half-life of the alpha radiation source in the smoke alarm.

Show on Fig. 12.2 how you arrive at your answer.

Red line should be shown on the graph to get full credit

half of 3500 = 1750 Bq

half life = 400 years

half life = ... years [2]

(b) Fig.12.3 shows a radioactive source used to measure and control the thickness of cardboard during manufacture. Strontium-90 is an isotope used in this radioactive source. A nucleus of strontium-90 emits a beta-particle as it decays.

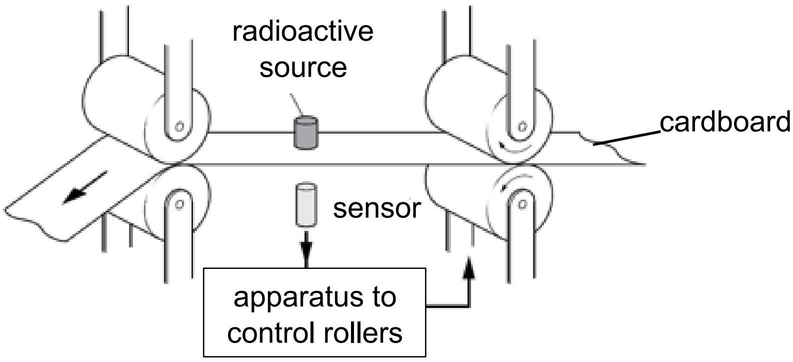


Fig. 12.3

(i) The count rate detected by the sensor is observed to fluctuate even when the thickness of the cardboard remains constant.

Explain why this happens.

Radioactive decay is <u>spontaneous</u> and <u>random</u>.

.... [1]

(ii) In nuclide notation, strontium-90 is written as ${}^{90}_{38}Sr$. The decay equation of strontium-90 to an isotope of yttrium (Y) is written as shown in Fig. 12.4.

$$ {}^{90}_{38}Sr \rightarrow {}^{90}_{39}Y + {}^{0}_{-1}\beta $$

Fig. 12.4

Using Fig. 12.4, explain how the composition of the nuclei of the strontium and yttrium isotopes illustrates that Beta decay can be considered as the decay of a neutron to a proton and an electron.

When a Stronium nucleus undergoes beta decay, one of its neutrons decays into a proton and **<u>an electron, as an beta particle</u>**.

The resulting daughter nuclide, yttrium-90, has one less neutron, **<u>one more proton</u>**, 39, and the **<u>same mass number</u>**.
.... [2]

(iii) The half-life of strontium-90 is 29 years. A pure source of strontium-90 emits 1.6×10^5 beta particles per second.

Calculate the number of beta particles emitted per second by the source after 87 years.

$\frac{87}{29}$ = 3 half-lives

$(1.6 \times 10^5) \div 2^3 =$ **0.2×10^5** particles per second

OR

$1.6 \times 10^5 \rightarrow 0.8 \times 10^5 \rightarrow 0.4 \times 10^5 \rightarrow$ **0.2×10^5** $\rightarrow$ **2.0×10^4**

$$X_{87} = X_0 \left(\frac{1}{2}\right)^{87/29}$$
$$= X_0 \left(\frac{1}{2}\right)^3$$
$$= \frac{1.6 \times 10^5}{8} = 20000$$

number of particles per second = ……………….. [2]

(iv) Suggest why a radioactive source with a half-life of millions of years is unsuitable for use in the apparatus shown in Fig.12.3.

The radioactive source will be **dangerous** **even** **after a long time** or after the apparatus is scrapped / not in use

…………………………………………………………………………………………

……………………………………………………………………………………… [1]

Section B

Answer only **one** question in this section.

Write your answers in the spaces provided.

13 Every year during Singapore's National Day, there will be a performance by the Red Lions. Fig. 13.1 shows a wing suit worn by one of the parachutists.

parachute material

Fig. 13.1

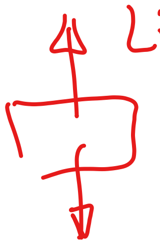
(a) The wing suits allow the parachutists to "fly" and use their body positions to navigate and adjust the speed before the parachute is opened.

Explain how the design of this suit allows the parachutist to adjust his speed.

By **closing** and **opening** the wing suit, parachutist **can decrease and increase the surface area of the wing suit respectively.**

The **larger the surface area, the larger the air resistance** on the parachutist and the parachutist will fly with **lower speed** and vice versa.

.... [2]



Lift changes depend whether parachute open or not

W (fix.)

(b) Fig. 13.2 shows the velocity-time graph of a parachutist as he jumps from a helicopter. He opens his parachute at X.

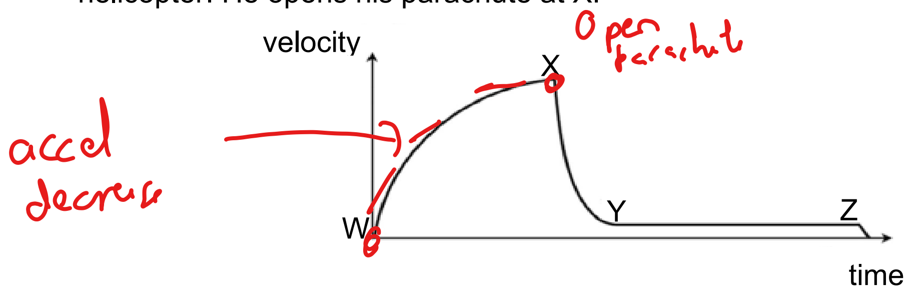


Fig. 13.2

Explain, in terms of forces, the motion of the parachutist as he moves from W to Y.

At W, **only weight** acts on the parachutist, he accelerates downwards at 10 m/s^2.

From W to X, he falls with increasing velocity**, air resistance increases**. **Downward resultant force decrease**, hence his acceleration decreases.

From X to Y, his velocity decreases due to the **increase in air resistance** from opening the parachute and is now higher than weight. **Resultant force is negative and upwards.** upward lift > wt (decrease speed.

.... [3]

(c) Fig. 13.3 shows the vertical forces acting on the parachutist a few seconds after he jumps off the plane.

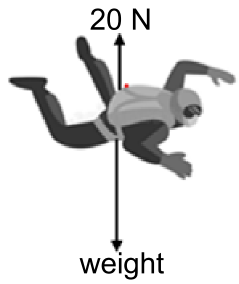


Fig. 13.3

The parachutist weighs 70 kg and experiences an upward force of 20 N.

(i) Given that the gravitational field strength is 10 N/kg, determine the weight of the parachutist.

W = mg = 70 x 10 = **700 N**

weight = ... N [1]

(ii) Calculate the vertical acceleration of the parachutist.

$F_{resultant}$ = ma

(700 – 20) = 70 x a

a = 9.71 m/s^2

acceleration = ... m/s^2 [2]

(iii) The weight of the parachutist is one of two forces that form an action-reaction pair of forces.

State the name, direction and magnitude of the other force of this action-reaction pair when the parachutist is experiencing zero resultant force.

Force on Earth by the parachutist.

The force is **equal in magnitude of 700 N** or weight of parachutist but **opposite in direction or upwards**, towards the parachutist.

.... [2]

$F_{AB} = F_{BA}$

earth parachut

14 For a Science project, a student designs a device to measure current in place of an ammeter. Fig. 14.1 shows the device inside the plastic box.

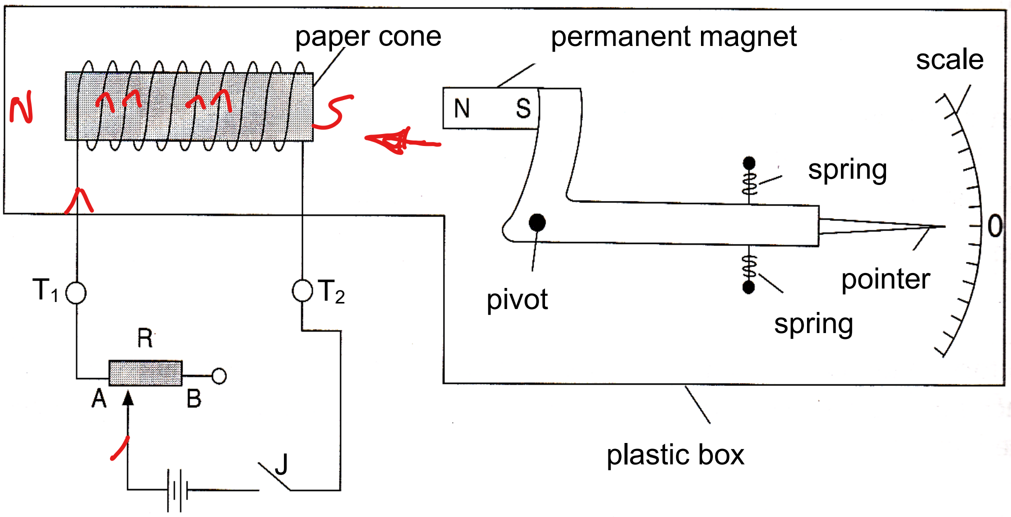


Fig. 14.1

(a) T_1 and T_2 are terminals to which the external circuit is connected. The pointer on the right indicates the magnitude of the current by pointing to a calibrated scale.

(i) State and explain which direction (up or down) the pointer will deflect when the switch J is closed.

1 **Upwards**

2a

When current passes through the **solenoid**, it **becomes an electromagnet or a weak magnet.**

2b

Right hand side of the solenoid is the **South pole.**

ACW moment

It **attracts the permanent magnet and pointer deflects upwards.**

about pivot .... [3]

(ii) Briefly explain how this device can also be used to indicate the direction of current flow.

When the current now flows in **opposite direction**, from T_2 to T_1, the **right-hand side** of the solenoid will be induced to be **North pole**.

It **repels** the permanent magnet and pointer **deflects downwards.**
.... [2]

(b) Another student is inspired to create an automatic cutter for his Science project. Fig. 14.2 shows the project which consists of a circuit including three resistors and two open switches S_1 and S_2.

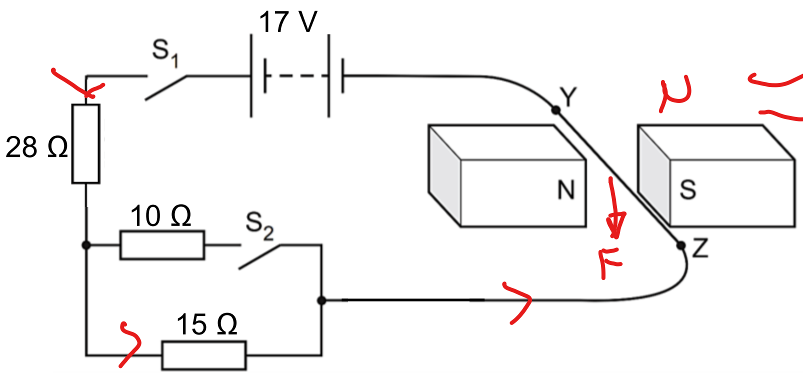


Fig. 14.2

The power supply in the electric circuit is a battery of electromotive force (e.m.f.) 17 V. YZ is a straight, horizontal section of conducting wire, placed between two magnets. When heated sufficiently, the wire can then be used as a cutter to cut through styrofoam. When S_1 is closed, the current flows through YZ and it experiences a force.

(i) Explain why wire YZ experiences this force.

S_2 open $R_T = 28 + 15 = 43\,\Omega$

In the presence of the **magnetic field due to the current** and the **magnetic field of the permanent magnets**, an **uneven magnetic field will occur**.

A **stronger resultant field** will be set up **above the wire** with a weaker **resultant field** set up **below the wire /** this causes an uneven / unbalanced magnetic field. Hence YZ experiences a **downward force** from **stronger to weaker field.**

.... [2]

(ii) Calculate the current that is passing through the 15 Ω resistor after both switches, S_1 and S_2 are closed.

$R_{Initial} = 28 + 15 = 43\,\Omega$

Effective R = $28 + [\frac{1}{15} + \frac{1}{10}]^{-1} = 28 + 6 = 34\ \Omega$

1 $I = \frac{17}{34} = 0.5$ A

2 $Pd_{28} = 0.5 \times 28 = 14$ V

3 $Pd_{15} = 17 - 14\text{ V} = 3$ V

4 $I_{15} = \frac{3}{15} = 0.2$ A

current = ………………... A [3]

END OF PAPER

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