Name:	Class:	Index No.:

Anglo-Chinese School
(Barker Road)

PRELIMINARY EXAMINATION 2024

SECONDARY FOUR EXPRESS

PHYSICS 6091

PAPER 2

TIME: 1 HOUR 45 MINUTES

READ THESE INSTRUCTIONS FIRST

Write your name, class & index number in the box provided at the top of this page.
Write in dark blue or black pen.
You may use a pencil for any diagrams or graphs.
Do not use glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer **one** question only. Question **15** has a choice of parts to answer.

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 the sound use of Physics than correct answers.

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

For Examiner's Use	
Section A	**/ 70**
Section B	**/ 10**
Total	**/ 80**

*This question paper consists of **24** printed pages.*

SECTION A (70 marks)

Answer **all** the questions in this section.

1 Fig. 1.1 is the speed-time graph for a rocket from the moment that the fuel starts to burn at time $t = 0$.

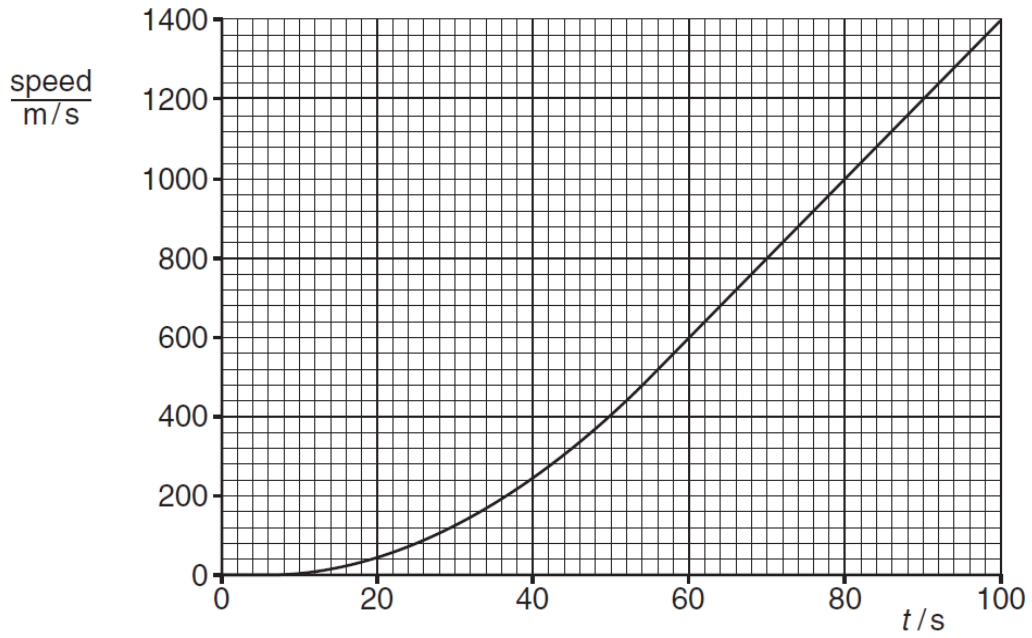


Fig. 1.1

(a) State the magnitude of the acceleration of the rocket at $t = 0$.

acceleration = …….. [1]

(b) Describe the motion of the rocket between $t = 5$ s and $t = 80$ s.

……

…… [2]

(c) Calculate the acceleration of the rocket at $t = 90$ s.

acceleration = …….. [2]

2 A rock climber, of total weight 620 N, holds herself in equilibrium against a vertical cliff. She pulls on a rope that is fixed at the top of the cliff and presses her feet against the cliff.

Fig. 2.1 shows her position.

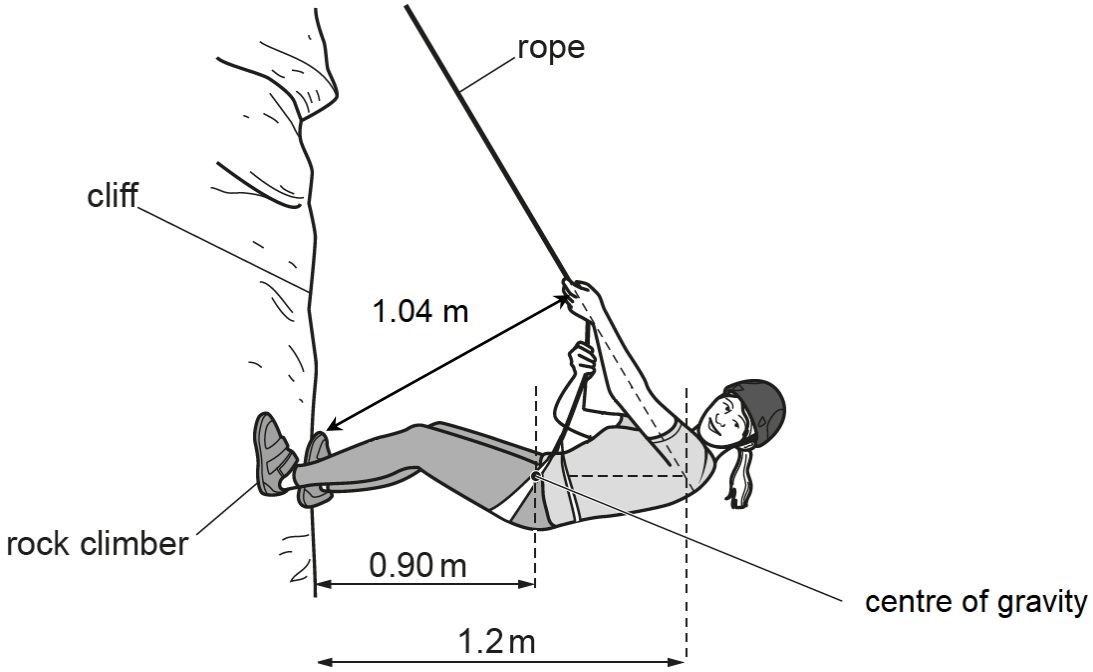


Fig. 2.1

The climber's centre of gravity is 0.90 m from the cliff.

(a) Calculate the moment due to her weight about her feet.

moment = …….. [1]

(b) The rope is at an angle to the horizontal and the distances are as shown in Fig. 2.1.

Determine the tension in the rope.

tension = …….. [2]

3 Fig. 3.1 shows a mercury manometer. The left arm of the manometer contains some trapped gas. The density of mercury is 13 600 kg/m^3. The gravitational field strength g is 10 N/kg.

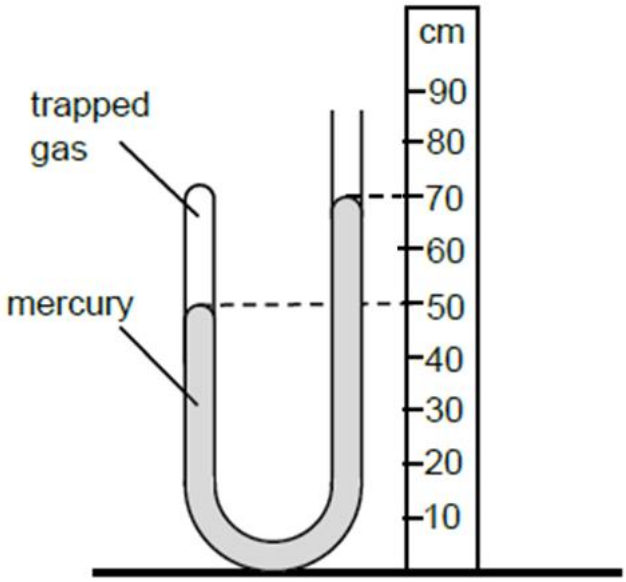


Fig. 3.1

(a) **(i)** The atmospheric pressure is 76.0 cm Hg.

Calculate this pressure in Pascals.

pressure = …….. [1]

(ii) Calculate the pressure of the trapped gas.

Calculate this pressure in Pascals.

pressure = …….. [2]

(b) A small hole is discovered in the left arm of the manometer such that the trapped gas can escape to the surroundings.

By drawing on Fig. 3.2, indicate the new mercury levels in both arms of the manometer. [1]

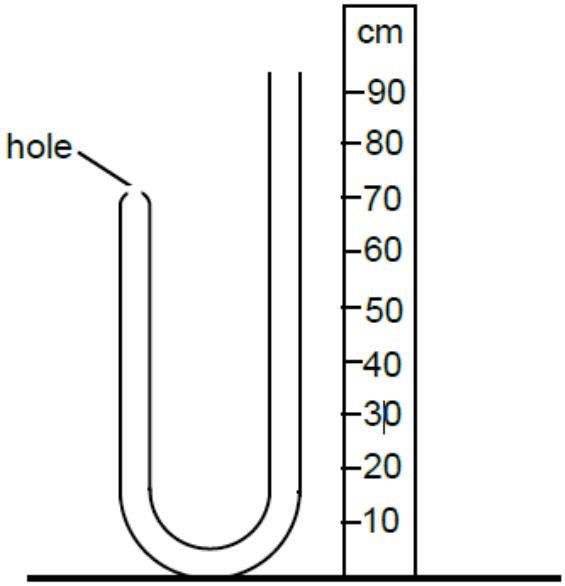


Fig. 3.2

4 A plastic tray has fifteen sections as shown in the Figure 4.1 below.

Fig. 4.1

When it is filled with water and placed in the freezer compartment of a refrigerator, the water freezes to form ice cubes.

(a) Describe the change(s), if any, that occur(s) to the arrangement and to the motion of the molecules as the water becomes ice.

arrangement: ……

……

……

motion: ……

……

…… [2]

(b) Each section contains a mass of 20 g of water that is initially at a temperature of 28 °C. The specific latent heat of fusion of ice is 330 J/g and the specific heat capacity of water is 4200 J/(kg°C).

(i) Define *specific heat capacity*.

……

…… [1]

(ii) Calculate the total amount of energy released from the water for all the water in the tray to become ice at 0 °C.

energy = …….. [3]

(iii) The freezer compartment takes energy from the water at a rate of 30 W.

Calculate the time taken for all the water in the tray to become ice.

time taken = …….. [2]

5 Fig. 5.1 shows the horizontal forces as a cyclist travels forward.

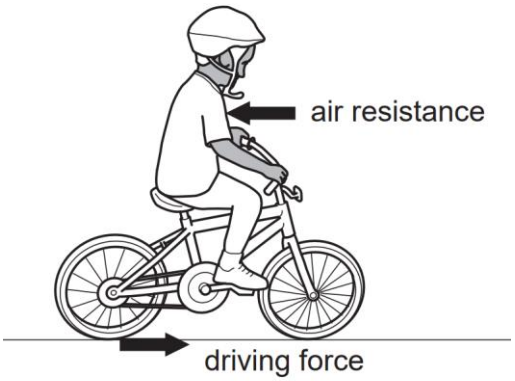


Fig. 5.1

The cyclist produces the driving force that acts on the back wheel.

As the bicycle moves, energy is transmitted from the pedals to the back wheel. Fig. 5.2 shows what happens to the energy input to the pedals.

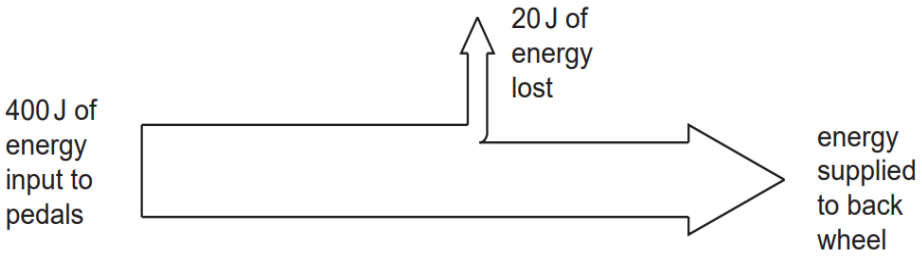


Fig. 5.2

(a) State the *principle of conservation of energy*.

……

…… [2]

(b) Calculate the efficiency of the bicycle in transmitting energy from the pedals to the back wheel.

efficiency = …….. [2]

6 Two identical metal saucepans, pan **A** and **B**, contain the same mass of hot water at the same initial temperature.

One of the saucepans is painted black, while the other is painted white. Both saucepans are not covered and they are cooled under the same conditions.

The cooling curves for the water in the two saucepans are shown in Fig. 6.1.

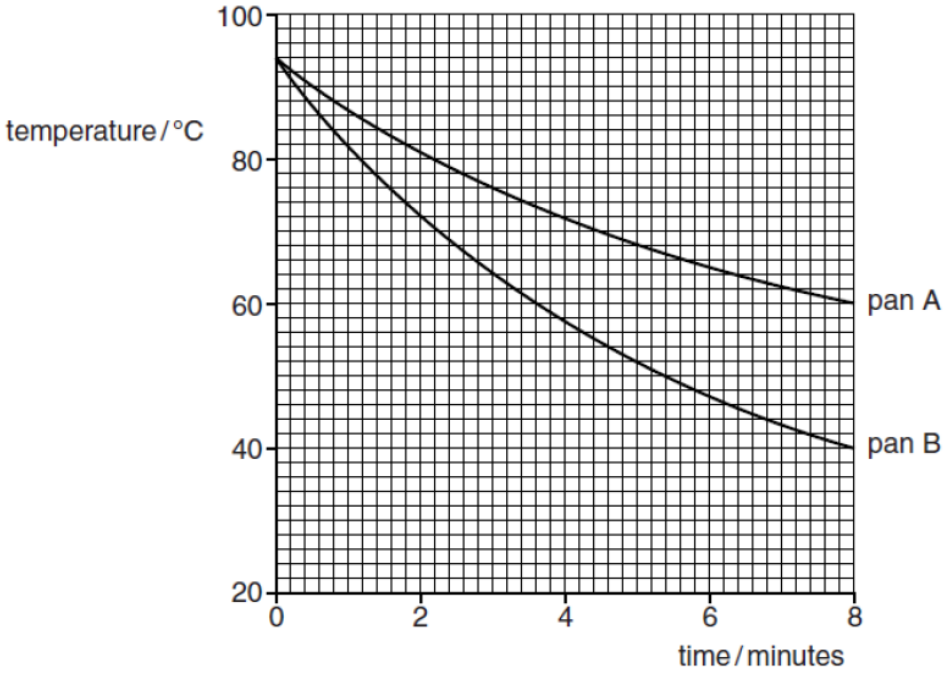


Fig. 6.1

(a) State and explain, with reference to Fig. 6.1, which of the pans (**A** or **B**) was painted black.

……

……

……

……

…… [3]

(b) Describe and explain, using the concept of thermal energy transfer, how Fig. 6.1 will be different if the experiment is repeated with both pans each covered with a lid.

……

……

……

…… [2]

7 Fig. 7.1 shows a straight dipper vibrating near the water surface of a ripple tank.

Water waves forming crests and troughs, are observed as a series of wavefronts moving away from the dipper.

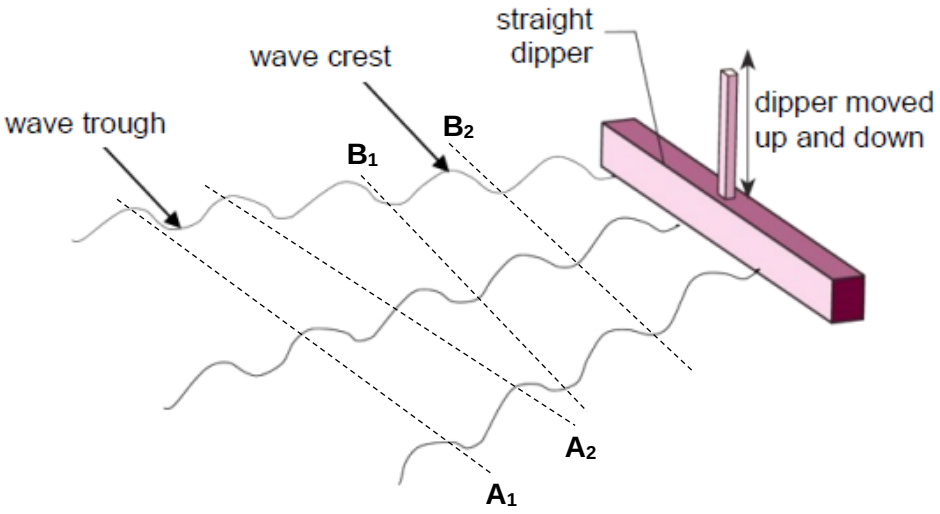


Fig. 7.1

(a) **(i)** Explain what is meant by a *wavefront*.

……

…… [1]

(ii) Tick one of the boxes to show the correct pair of dotted lines that show two consecutive wavefronts. [1]

A_1 and A_2	☐	A_1 and B_1	☐
A_2 and B_2	☐	B_1 and B_2	☐

(b) Two students conduct an experiment using the ripple tank in Fig. 7.1 to measure the speed of water waves. The measurements are recorded as follows:

average number of wave crests passing a point in 10 seconds = 5
average distance between two consecutive wave crests = 8.0 cm
average distance from the crest to the trough of the wave = 4.0 cm

Determine the speed of the water waves.

speed = …….. [2]

8 Fig. 8.1 shows the various regions of the electromagnetic spectrum arranged in order of increasing frequency.

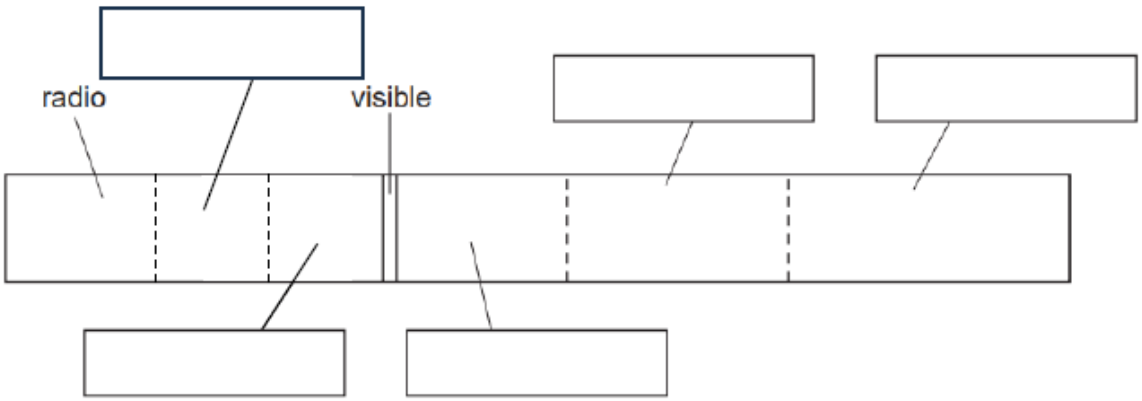


Fig. 8.1

Two of the regions have been labelled.

(a) In the boxes provided in Fig. 8.1, write the names of the other regions. [2]

(b) Some components of the electromagnetic spectrum cause ionisation. They are known as ionising radiation.

State what is meant by *ionisation* and state one region in **(a)** that is **not** an ionising radiation.

……

……

…… [2]

9 Fig. 9.1 shows the path of a ray of blue light as it passes through a glass prism.

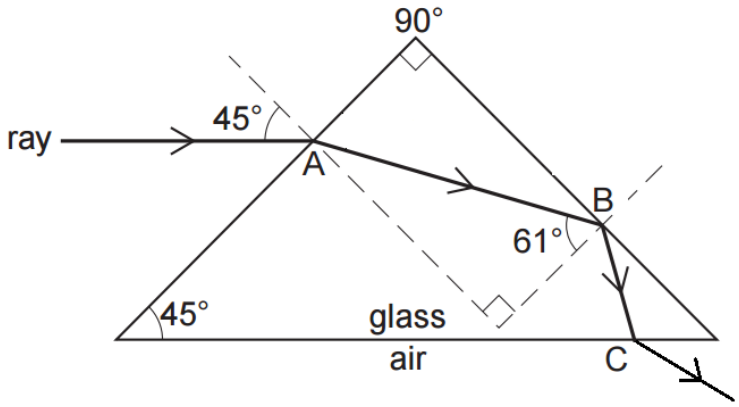


Fig. 9.1

(a) Explain why the ray changes direction at **A**.

……

…… [1]

(b) Determine the angle of refraction at **A** and hence, the refractive index of the glass.

angle of refraction at **A** = ……..

refractive index = …… [3]

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

……

……

…… [2]

10 Fig. 10.1 shows a method of producing sandpaper using static electricity.

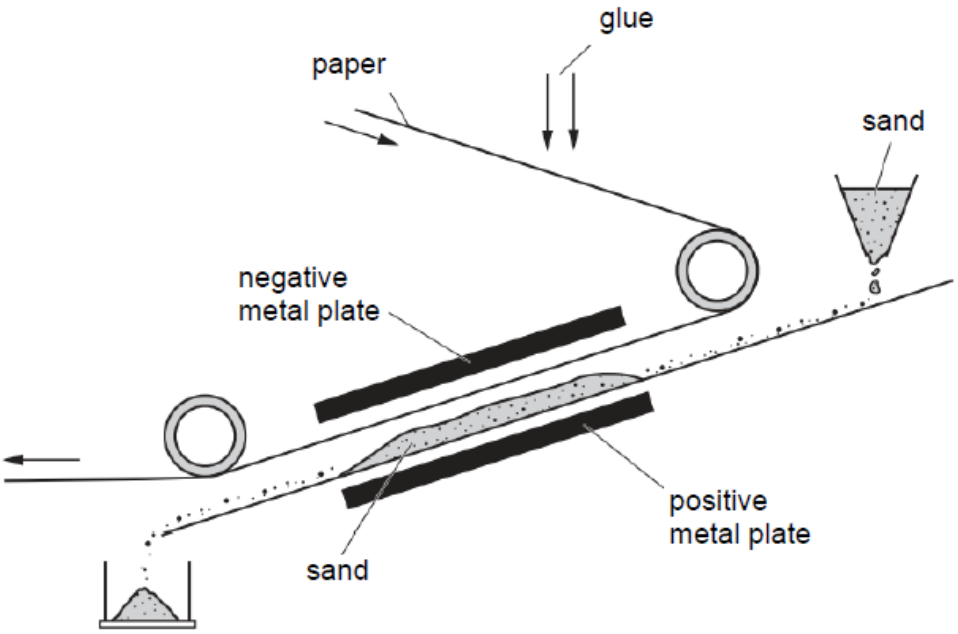


Fig. 10.1

Glue is sprayed on to moving paper. The sticky paper then passes between two metal plates. One of the plates is positively charged and the other plate is negatively charged. There is an electric field between the plates.

(a) On Fig. 10.2, draw and show the direction of the electric field between the two metal plates. [2]

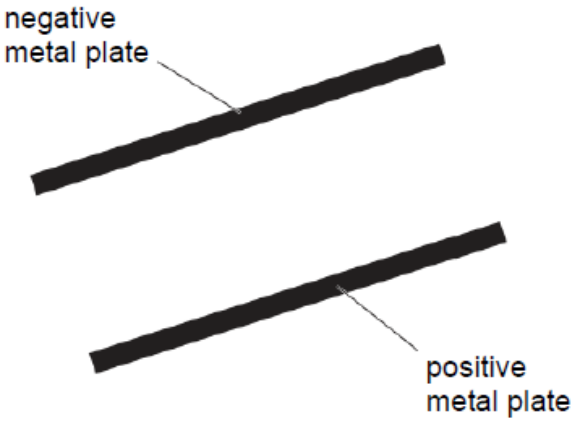


Fig. 10.2

(b) Grains of sand are present just below the sticky paper. Each grain of sand is given a charge. Fig. 10.3 shows two layers of sand grains in the space between the two plates.

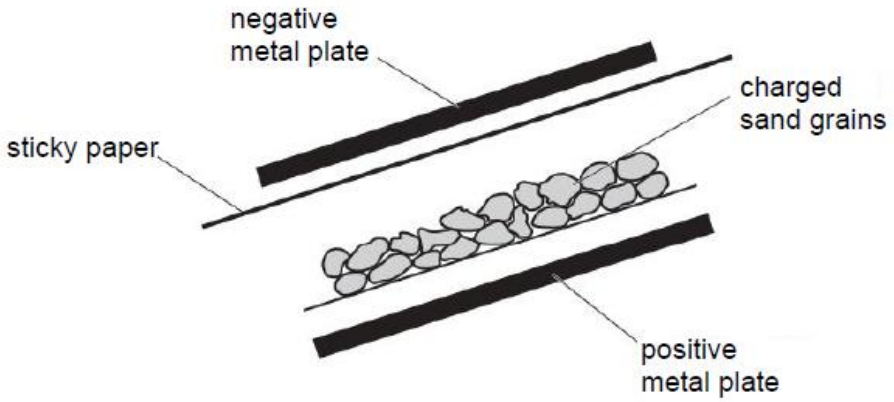


Fig. 10.3

Sand grains are attracted to the negative metal plate.

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

……

……

…… [2]

(c) 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.

Calculate the energy transferred when the charges pass through him.

energy = …… [2]

11 The primary coil of a simple soft iron-cored transformer is connected to the a.c. mains supply.

Fig. 11.1 is a diagram of the arrangement.

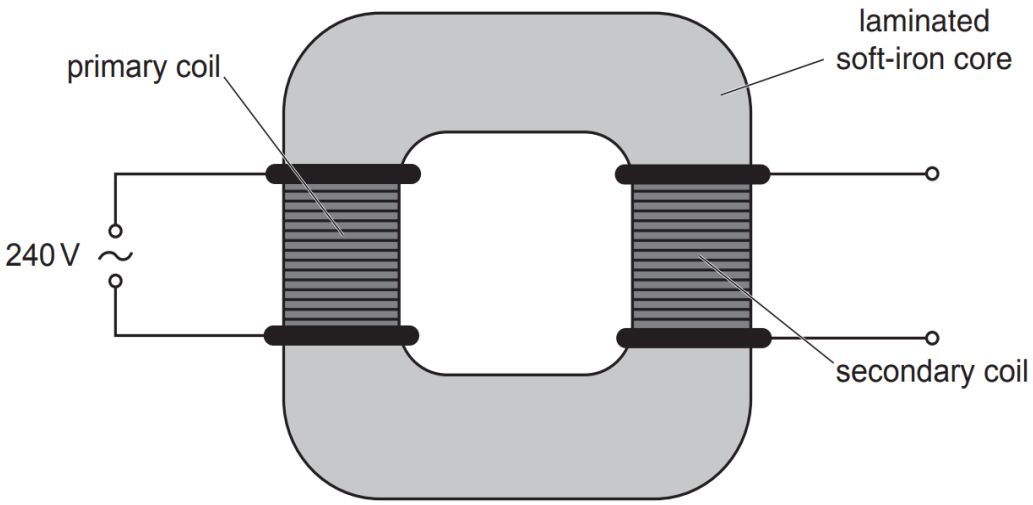


Fig. 11.1

(a) Suggest why the core is laminated.

……

…… [1]

(b) Using Faraday's law of electromagnetic induction, explain why a transformer will not operate using a direct current input.

……

……

……

……

…… [2]

12 The count rate from a sample of radioactive material is measured every 20 seconds for 2 minutes. The results which has been corrected for background radiation, are shown in Fig 12.1.

time / s	0	20	40	60	80	100	120
count rate / count/s	280	210	164	122	88	72	54

Fig. 12.1

(a) Suggest one possible source for the background radiation.

……. [1]

(b) From the table, without attempting a graph, estimate the half-life of the radioactive material.

half-life = …….. [1]

(c) The radioactive material emits only α-particles.

Describe an experiment to prove that no β-particles or γ-radiation are emitted from the radioactive material. Draw a labelled diagram of the set-up of the experiment to be conducted.

…….

…….

…….

…….

…….

……. [2]

(d) State one precaution that should be taken for safe handling of the radioactive material.

…….

……. [1]

13 Fig 13.1 represents the radioactive decay of a $^{238}_{92}U$ nucleus.

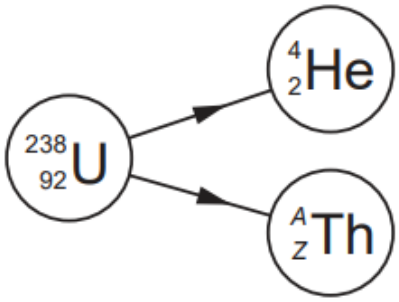


Fig. 13.1

In the space below, write the nuclear equation for this decay, including the numerical values of A and Z.

[2]

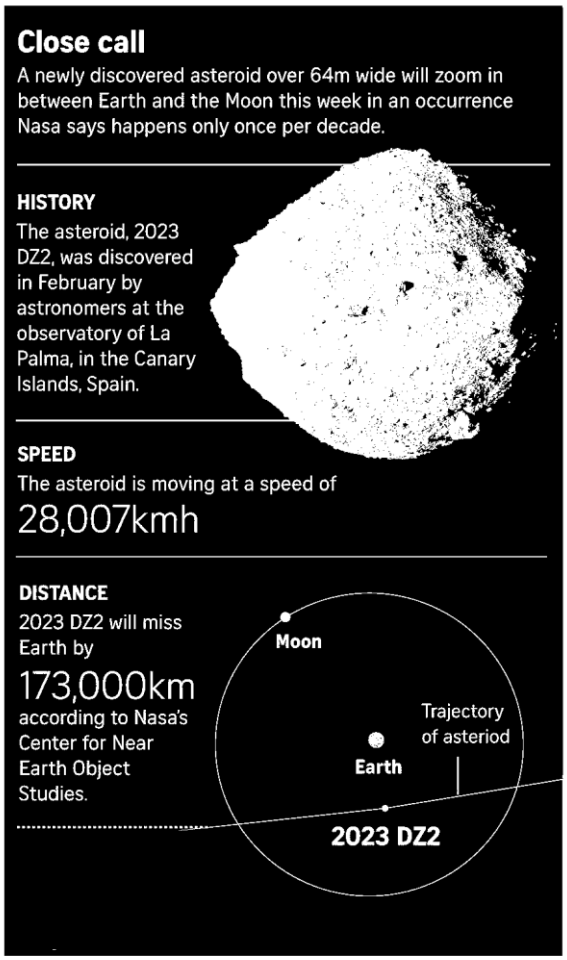
14 The following excerpt is adapted from
'City killer' asteroid to pass between Earth and Moon harmlessly on March 25 weekend.
[26 Mar 2023, The Straits Times]

A newly discovered asteroid big enough to wipe out a city will pass harmlessly between Earth and the Moon's orbit this weekend, offering astronomers the opportunity to study the space rock closely.

Estimated to be between 40m and 90m in diameter, the asteroid named 2023 DZ2 will be within 515,000 km of the Moon on Saturday and, several hours later, fly past the Earth at about 28,000 kmh.
It will miss Earth by about 173,000 km, a little less than half the distance to the Moon.

The Virtual Telescope Project said the significant size of the asteroid will make it easy for people to observe with good binoculars and small telescopes a few hours before the fly-by.

"Astronomers with the International Asteroid Warning Network are using this close approach to learn as much as possible about 2023 DZ2 in a short time period – good practice for #PlanetaryDefence in the future if a potential asteroid threat were ever discovered," Nasa tweeted.



(Not drawn to scale)

(a) Based on the data given, estimate the distance between the Earth and the moon in metres.

distance = …….. m [1]

(b) In the text as well as the graphics in this news article, the speed of the asteroid when it fly past the Earth is given as about "28,000 kmh".

(i) State the error in representation of this speed.

…….. [1]

(ii) Using the correct representation of the speed, calculate the speed of the asteroid in metres per second and express this in standard form.

speed = …….. m/s [2]

(c) Scientist use a method called mathematical modelling to give estimates and predictions of physical phenomenon. It involves the conversion of physical situations into mathematics with some assumptions as parameters to aid in the modelling.

(i) Using a simple model of the asteroid as a sphere of diameter 64 m, calculate the volume of the asteroid.

volume of sphere, $V = \frac{4}{3}\pi r^3$,where r = radius of sphere.

volume = …….. [2]

(ii) Assume the average density of this asteroid is 2700 kg/m^3.

Calculate the mass of this asteroid.

mass = …….. [1]

(iii) Hence, estimate the kinetic energy of this asteroid at the given speed in **(b)(ii)**.

kinetic energy = …… [1]

(d) The following excerpt is adapted from
Asia: Biographies and Personal Stories Part II
[Fall 2015, Education About Asia Magazine]

On August 6, 1945, the US dropped an atomic bomb on Hiroshima, Japan. The nuclear bomb exploded over the center of the city, completely devastating it. The area within 1.2 miles of the hypocenter was entirely leveled and burned. According to the city of Hiroshima, approximately 140,000 people had died by the end of December 1945. The atomic bomb "Little Boy", an enriched Uranium nuclear fission bomb released the equivalent energy of 15 kilotons of TNT.	

The power of nuclear explosion is expressed in terms of its relationship to TNT (a type of explosive material) due to the enormous power possessed by a single weapon. The explosive energy available is equivalent to thousand of tons (kilotons) or millions of tons (megatons) of TNT.

Use the information contained in the excerpt to answer the following questions.

(i) State what is meant by *nuclear fission*.

……...

……... [1]

(ii) If asteroid 2023 DZ2 were to hit Earth, calculate the energy equivalent of the number of bombs dropped on Hiroshima.

1 kiloton of TNT = 4.2×10^{12} J

number of bombs = …….. [2]

SECTION B (10 marks)

Answer only one of the two alternative questions in **Question 15**.

15 EITHER

The power supply in an electric circuit is a battery of electromotive force (e.m.f.) 12 V.

(a) State **two** ways in which the e.m.f. of a battery differs from that of an alternating current (a.c.) power supply.

1 ……..

2 …… [2]

(b) The circuit includes three resistors and two open switches, S_1 and S_2.

Fig. 15.1 shows the circuit.

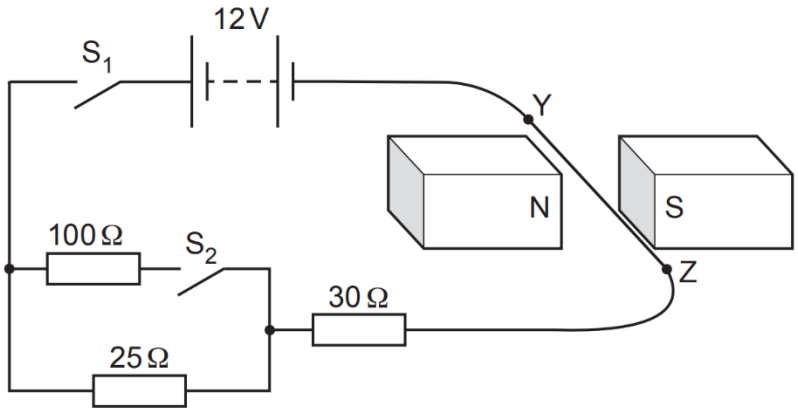


Fig. 15.1

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

S_1 is now closed.

(i) Explain why YZ experiences a force.

……

……

…… [2]

(ii) Tick the box which describes the direction of the force on YZ.

towards N	☐	towards Z	☐
towards S	☐	downwards	☐
towards Y	☐	upwards	☐

[1]

(c) Switch S_2 in the circuit in Fig. 15.1 is now 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 25 Ω resistor is I_{25}. The current in the 100 Ω resistor is I_{100}. State a value for the ratio of I_{100} to I_{25}.

ratio = ……. [1]

15 OR

Fig.15.2 below shows a drone. It can hover and travel through the air.

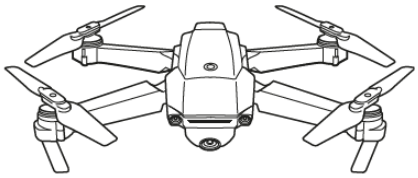


Fig. 15.2

A student flies the drone on a journey from **A** to **B** to **C** to **D** at a constant height.

Fig. 15.3 shows the path of the drone, viewed from above.

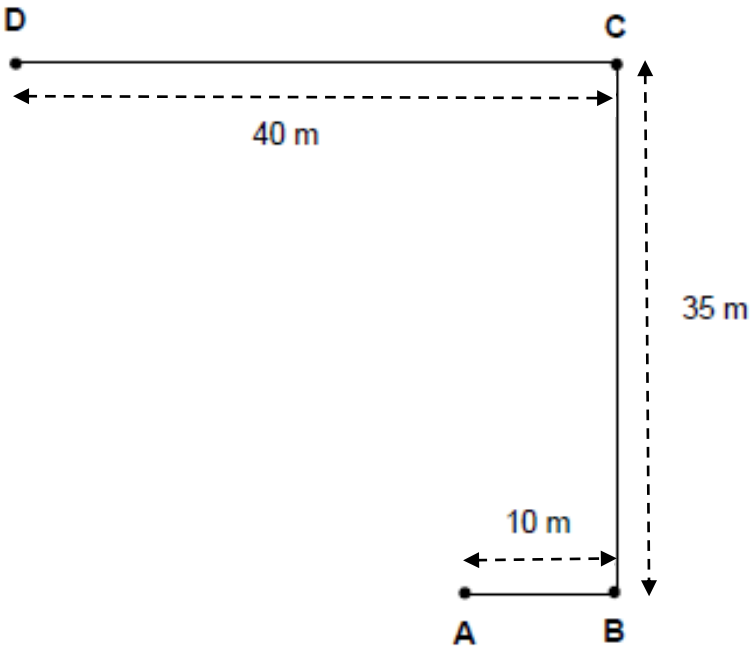


Fig 15.3

(a) (i) Determine the total distance travelled by the toy drone.

distance = ……. [1]

(ii) Determine the scale used to construct Fig 15.3.

1 cm on the diagram represents …….. on the path. [1]

(iii) Hence, determine the magnitude of the displacement of the drone.

Show your working in the space below.

displacement = ……. [2]

(b) The mass of the drone is 5.50 kg. It is hovering at a constant height above the ground.

The gravitational field strength g is 10 N/kg.

(i) State the upward force produced by the drone.

upward force = …… [1]

(ii) The upward force is now increases to 100 N.

Calculate the acceleration of the drone.

acceleration = …… [2]

(iii) When the drone hovers at **D**, its motor fails, and it falls. It reaches uniform velocity as it falls.

Explain, in terms of the forces and acceleration, what happens as the drone falls and reaches terminal velocity.

……

……

……

…… [3]

END OF PAPER