Name: ……. Index no. ……. Class…….

Bukit Batok Secondary School

GCE O LEVEL PRELIMINARY EXAMINATION 2024

SECONDARY 4 EXPRESS

PHYSICS **6091/02**

Paper 2 Structured and Free Response 23 Aug 2024

1 hour 45 minutes

1050 – 1235 h

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

READ THESE INSTRUCTIONS FIRST

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

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

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

Candidates are reminded that **all** quantitative answers should include appropriate units.
The use of an approved scientific calculator is expected, were appropriate.
Candidates are advised to show all their working in a clear and orderly manner, as more marks are awarded for sound use of Physics than for correct answers.

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

For Examiner's Use	
Section A	
Section B	
Total	

Section A

Answer **all** the questions.

1 In a fireworks display, a 4.0 kg rocket is launched vertically upwards from the ground into the air. The rocket runs out of fuel when moving with a velocity of 64 m/s.
Fig. 1.1 shows how the velocity of the rocket varies with time until it reaches ground.

Assume that air resistance can be neglected.

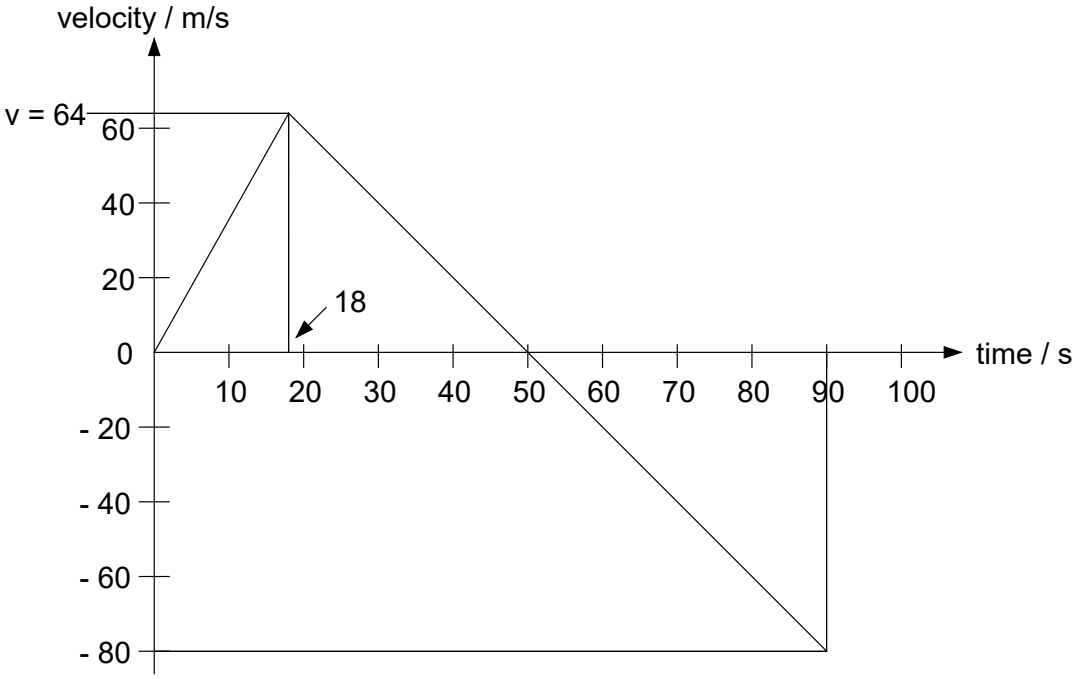

Fig. 1.1

(a) Describe the direction of motion and acceleration of the rocket from time t = 0 s to t = 50 s.

……

……

……

…… [2]

(b) State the time at which the rocket reaches its highest point.

time = …… [1]

(c) Using Fig. 1.1, calculate the maximum height reached by the rocket

maximum height = …… [2]

2 Fig. 2.1 shows the vertical forces acting on a skydiver a few seconds after he jumps off the plane.

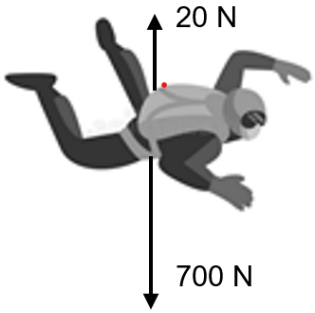

Fig. 2.1

The skydiver experiences an upward force of 20 N.
The weight of the skydiver is 700 N.

(a) Define gravitational field strength.

……

…… [1]

(b) Determine the mass of the skydiver.
The gravitational field strength *g* is 10 N/kg.

mass = …… [1]

(c) Calculate the vertical acceleration of the skydiver in Fig 2.1.

acceleration = …… [2]

(d) Use Newton's laws of motion to explain why the skydiver accelerates at first and then reaches terminal velocity.

……

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……

……

…… [2]

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

State and describe the other force of this pair when the air resistance reaches 700 N.

……

…… [2]

3 Fig 3.1 shows an air cushion connected to a mercury manometer. Before the 50 kg mass is placed on the air cushion, the air pressure inside the air cushion is the same as the atmospheric pressure.

When a 50 kg mass is placed on the air cushion, the manometer shows the heights difference between the two columns. The atmospheric pressure is 76 cmHg.

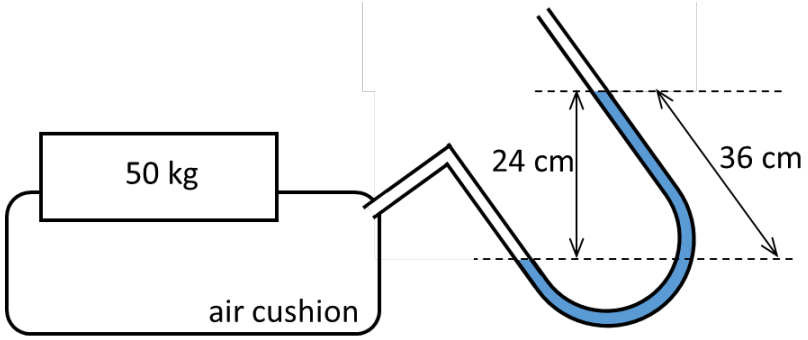

Fig. 3.1

(a) Calculate the pressure (in cmHg) of the air cushion.

pressure = …….....cmHg [2]

(b) The density of mercury is 13 600 kg/m^3.

Calculate the contact area between the 50 kg mass and the air cushion.
The gravitational field strength *g* is 10 N/kg.

area = …… [3]

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

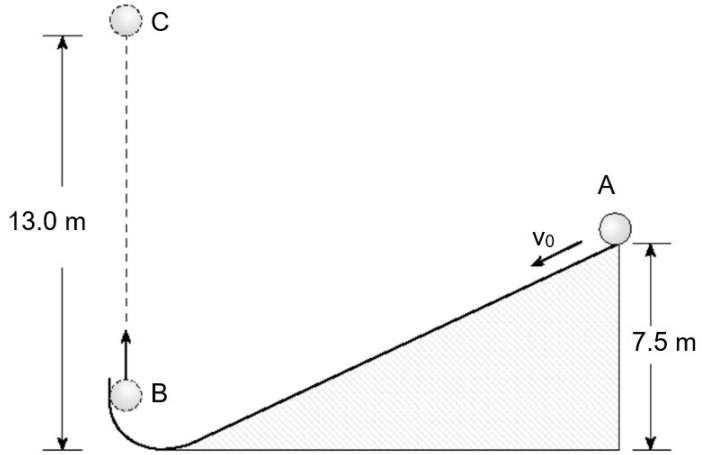

Fig. 4.1

(a) Using the concept of **energy stores and transfers**, explain the changes in the energy within the ball and its effects on the ball as it rolls down from position A to B.

……

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……

……

……

……

……

……

…… [4]

(b) **(i)** Calculate the gravitational potential store of the ball at position C.

gravitational potential store = …… [1]

(ii) Calculate the initial speed v_0, at position A.

v_0 = ... [2]

(c) State one assumption for your calculations in **(b)(ii)**.

.....

..... [1]

5 In a bicycle shop, two wheels hang in equilibrium from a horizontal uniform rod AC, as shown in Fig. 5.1.

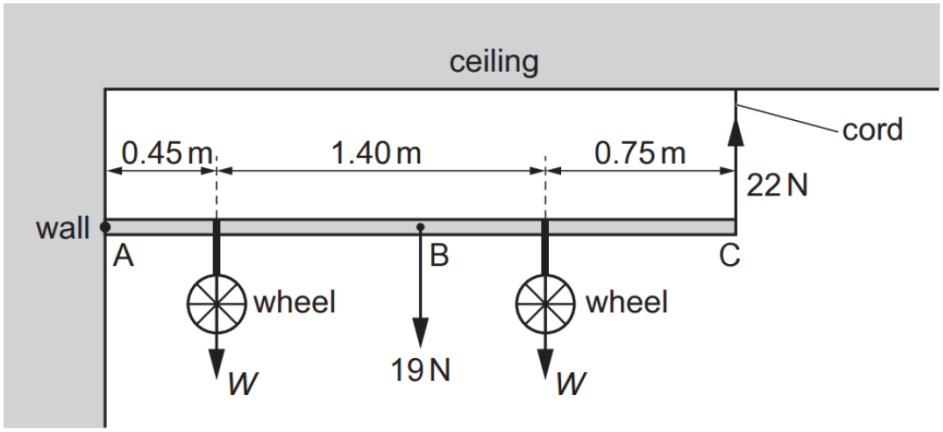

Fig. 5.1

The rod has weight 19 N and is freely hinged to a wall at end A. The other end C of the rod is attached by a vertical elastic cord to the ceiling. The centre of gravity of the rod is at point B.

The weight of each wheel is W and the tension in the cord is 22 N.

(a) State the principle of moments.

……

…… [2]

(b) By taking moments about end A,
show that the weight W of each wheel is 14 N.

[2]

(c) Determine the magnitude and the direction of the force acting on the rod at end A.

magnitude = ……

direction = …… [1]

6 A student compares two electric heaters that are used at home.
Fig. 6.1 shows the design of electric heater X while Fig.6.2 shows the design of electric heater Y.

Each heater consists of an identical tank to contain the same volume of water and an identical electrical heating element at the bottom of the heater.

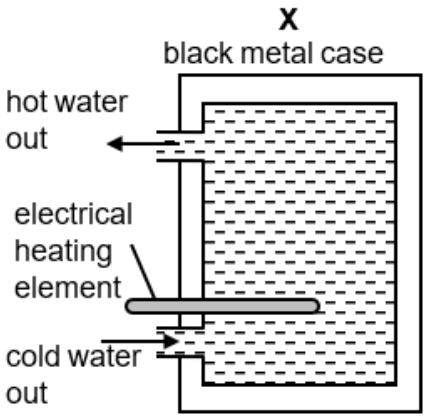

Fig. 6.1

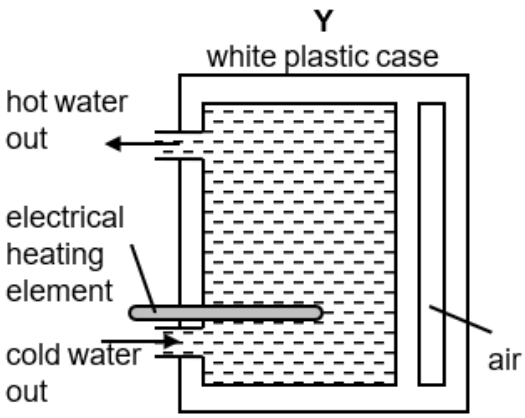

Fig. 6.2

(a) State with explanation based on 2 reasons, which electric heater is more effective in reducing heat loss to the surroundings.

……

……

……

…… [2]

(b) A student poured 0.25 kg of hot water into a container.
At time t = 0 min, he measured the temperature of the hot water.
After a certain time, ice cubes were added to the hot water.

Fig. 6.3 shows the temperature-time graph obtained.

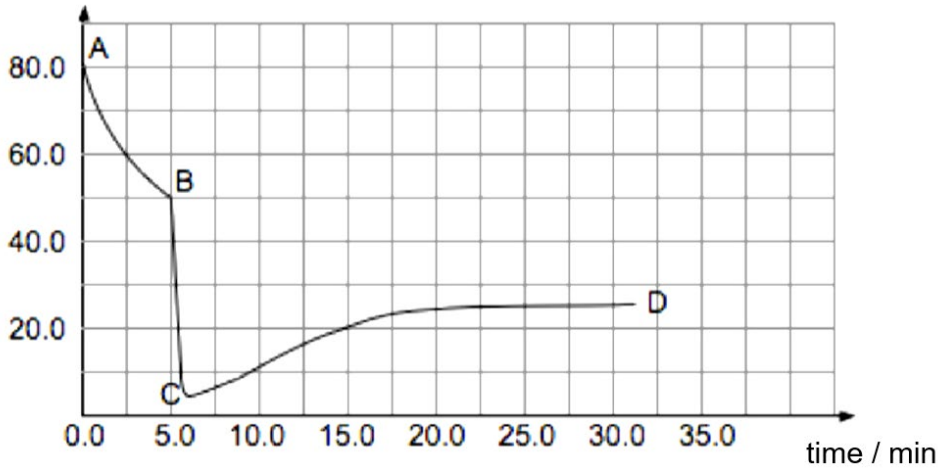

Fig. 6.3

The following information is provided.

specific latent heat of fusion of ice	336 kJ/kg
specific latent heat of vaporisation of water	2260 kJ/kg
specific heat capacity of ice	2100 J/(kgK)
specific heat capacity of water	4200 J/(kgK)

(i) Define specific heat capacity.

……

…… [1]

(ii) Using Fig. 6.3, calculate the loss of thermal energy of the hot water from B to C.

[2]

loss in thermal energy = ……

(iii) From B to C, the ice cubes melt completely and reach a temperature of 5 ºC at that instant.

Calculate the mass of the ice cubes added to the hot water.

mass = …… [3]

7 Fig. 7.1 shows a machine producing sandpaper using static electricity. As the paper is rolled along the conveyor belt, glue is sprayed onto the moving paper from the glue spray gun.

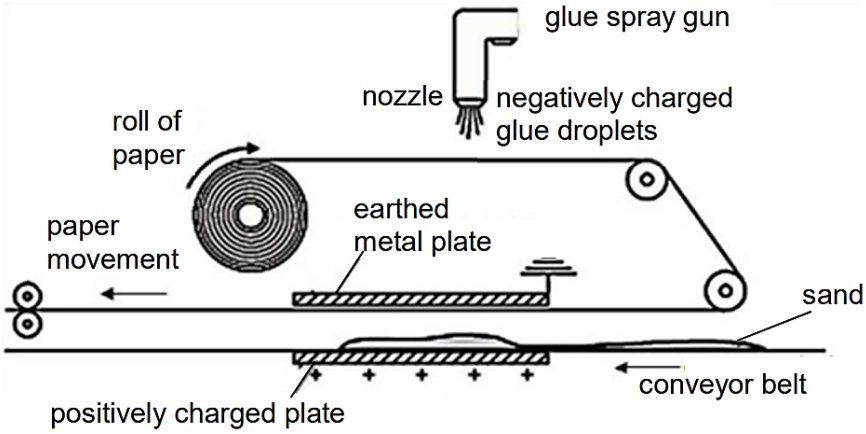

Fig. 7.1

As glue is forced out of the nozzle, it breaks up into small negatively charged droplets and spread out evenly on the paper.

(a) Explain, in terms of the particles involved, how the glue becomes negatively charged after passing through the nozzle of the spray gun.

……

…… [1]

(b) Explain why glue droplets spread out evenly after leaving the nozzle.

……

…… [1]

(c) As the paper passes between the metal plates, electrostatically charged sand moving on a conveyor belt also passes between the metal plates.

Explain why the sand move upwards and stick onto the paper as they pass through the metal plates.

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…… [2]

8 Fig. 8.1 shows a lamp from a car headlight. It contains two metal filaments.

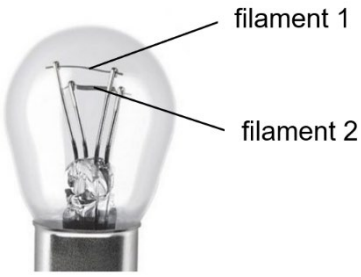

Fig. 8.1

Fig. 8.2 shows the current–voltage graph for the two filaments.

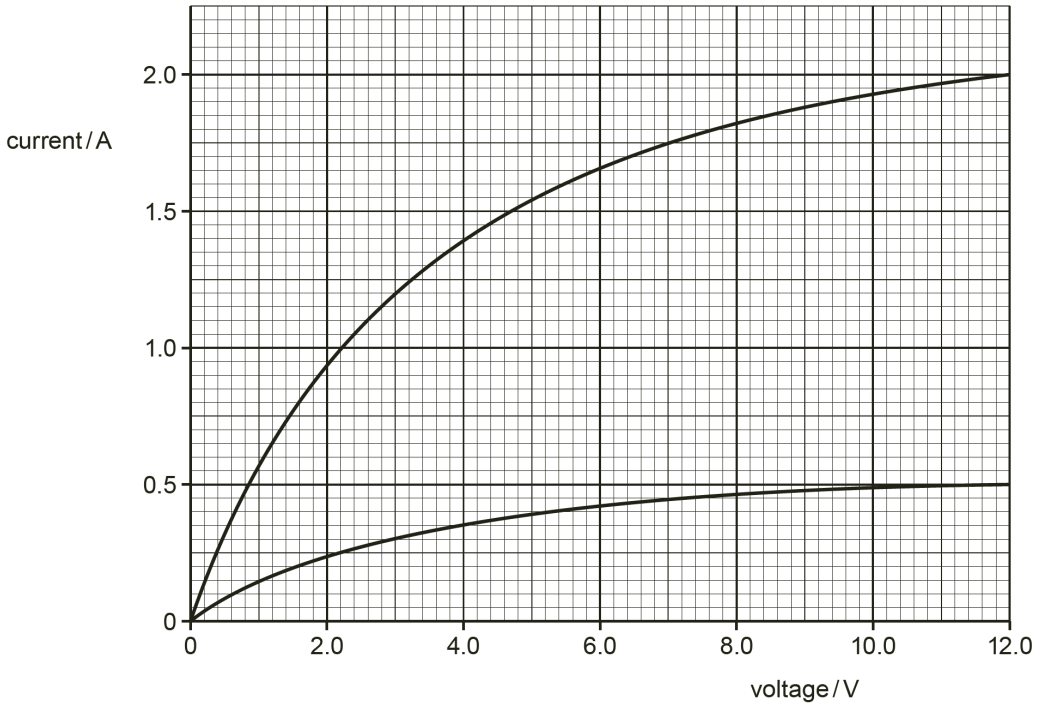

Fig. 8.2

The two filaments are connected in parallel to a voltage of 4.0 V.

(a) From the graph, determine the total current flowing through the lamp with a voltage of 4.0 V.

total current = ... [1]

(b) Hence, calculate the total resistance of the two filaments when they are connected in parallel to a voltage of 4.0 V.

total resistance = ... [1]

(c) The two filaments are made from the same type of metal and have the same length, when uncoiled. They both operate at the same temperature.

Explain why one filament could have a resistance that is greater than that of the other filament.

……

…… [1]

(d) Calculate the amount of charge flowing through the lamp in one minute given that the working p.d. of the lamp is 4.0 V.

charge = …… [1]

(e) Hence, calculate the work done across the car lamp.

work done = …… [1]

9 In Fig. 9.1, a potential divider is made from a light-dependent resistor (LDR) and a 6.0 kΩ fixed resistor. The potential divider is connected in series with a 12 V d.c. power supply and a voltmeter is connected across the 6.0 kΩ resistor.

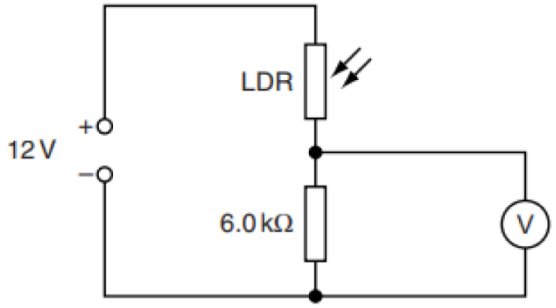

Fig. 9.1

(a) The circuit is placed on a rooftop at sunrise and left there until 12 noon on a clear sunny day.

Explain why the reading on the voltmeter changes.

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[2]

A buzzer, which produces a sound when the potential difference across it goes above 4.5 V, is placed in parallel to the 6.0 kΩ resistor as shown in Fig. 9.2.

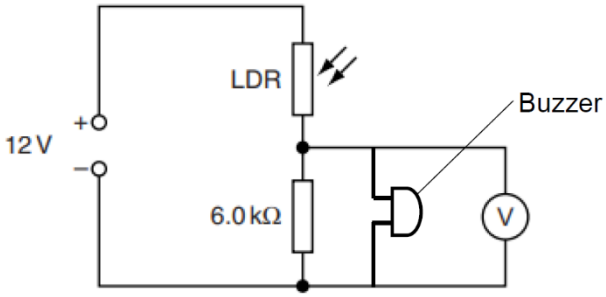

Fig. 9.2

(b) The buzzer has a resistance of 1440 Ω.

Determine the minimum resistance of the LDR before the buzzer sounds.

Minimum resistance = ... [2]

10 Fig. 10.1 shows the coil of a d.c. motor placed between the poles of a magnet. Current flows from the external circuit into the coil.

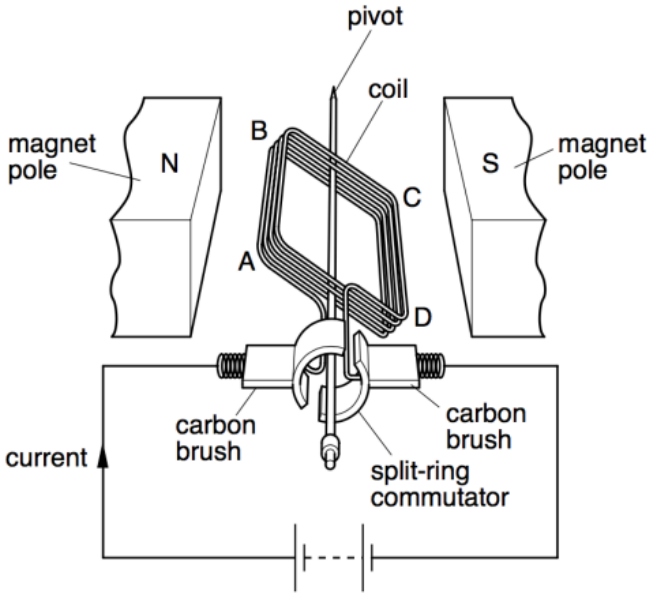

Fig. 10.1

The current in the coil causes a force to act on each side of the coil.

(a) **(i)** On Fig 10.1, draw the forces that act on side AB and CD of the coil [1]

(ii) Describe how you determined the direction of the forces on the side AB of the coil.

……

……

……

……

…… [2]

(iii) The coil begins to rotate around the axle and a split-ring commutator ensures that the coil continues to rotate.

With reference to side AB of the coil, explain how the split-ring commutator ensures that the rotation continues.

……

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…… [2]

(b) Fig. 10.2 shows the structure of a transformer which is used in the transmission of electrical power through the cables.

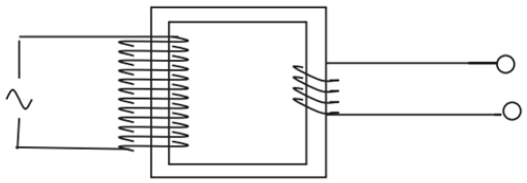

Fig. 10.2

coil	number of turns
J	50
K	100
L	1 000
M	1 500

Table. 10.3

An engineer is assigned to build a step-down transformer for stepping down the voltage from 3.3 kV to 220 V in the substation of a housing estate. He has the choice of using four types of coils with different number of turns as shown in Table 10.3 above.

(i) Based on Table 10.3, select the most suitable pair of coils for making the primary coil and secondary coil of the transformer. Justify your answer with appropriate workings.

Explain your choice.

……

……

……

……

……

…… [2]

(ii) State why the power produced at output is **not** 100% efficient.

……

……

…… [1]

(c) Explain why a step-up transformer is used for high voltage transmission in cables.

……

……

……

…… [2]

11 The decay of a nucleus of radium $^{226}_{88}Ra$ leads to the emission of an α-particle and leaves behind a nucleus of radon (Rn).

(a) Write an equation involving nuclide notation to show this decay.

…… [1]

(b) In a laboratory at a nuclear power station, a radiation detector is connected to a computer. The readings recorded are displayed on the computer screen.

The detector is switched on. Ten minutes later, at time t = 10 minutes, a small sample of radioactive material is removed from a nuclear reactor and placed near to the detector. Readings are recorded for a further 40 minutes.

The graph displayed on the computer screen is shown in Fig. 11.1

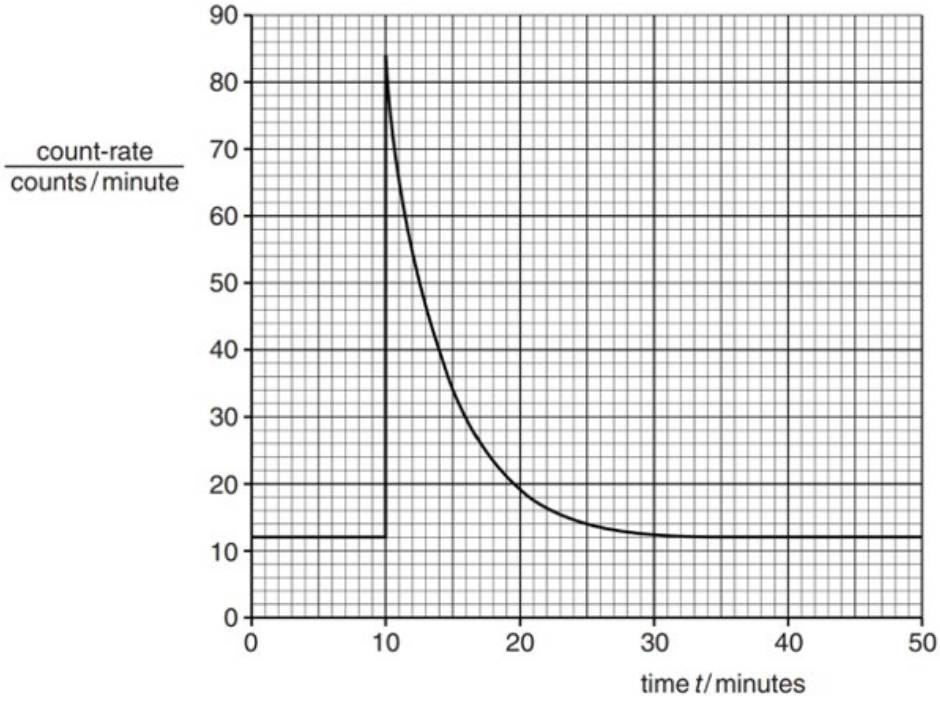

Fig. 11.1

(i) Use the graph to determine the background count rate in the laboratory

count rate = …… [1]

(ii) Suggest one source of this background radiation

…… [1]

(iii) Use the graph to determine the count rate due to only the radioactive sample at the following times at t = 10 minutes and t = 19 minutes

count rate at t = 10 minutes = ……

count rate at t = 19 minutes = …… [1]

(iv) Using your answers in part **(iii)**, calculate the half-life of the radioactive sample.

half-life = …… [2]

(c) State one use and one hazard of radioactivity based on penetrating abilities and ionising effect of beta particles.

One use:

……

…… [1]

One hazard:

……

…… [1]

Section B

Answer **one** question from this section.

12 Fig. 12.1 shows the internal components of a speaker. It consists mainly of a permanent magnet and an electromagnet connected to an a.c. power supply.

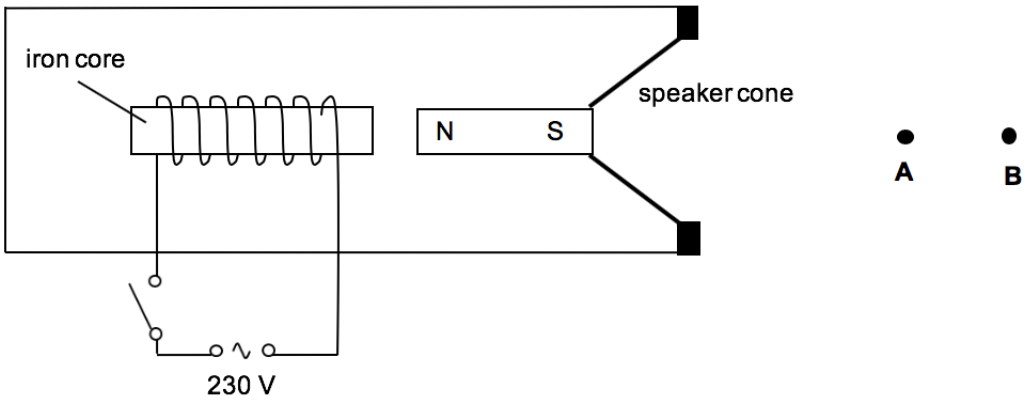

Fig. 12.1

(a) The speaker cone vibrates when it is turned on. Describe how this takes place and how sound waves are produced as a result.

.....

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.....

..... [3]

(b) Two identical microphones were placed at points A and B. Both microphones were connected to the same computer display and the waveforms for the sound at A and B are shown in Fig. 12.2. One division on the horizontal axis represents a time interval of 10 ms.

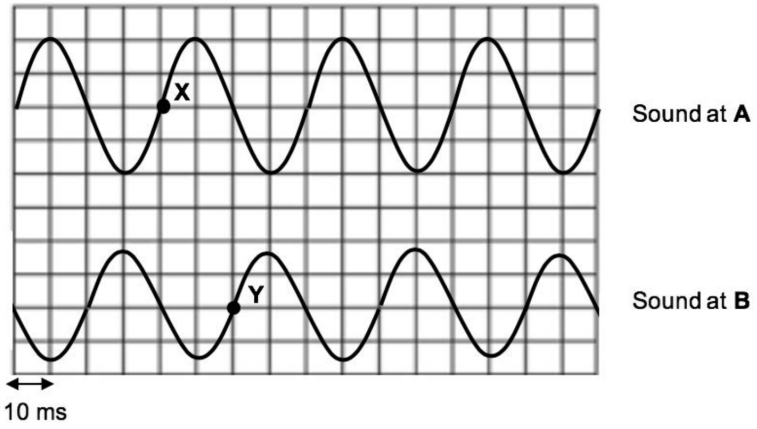


Fig. 12.2

Given that the speed of sound is 330 m/s, calculate

(i) the frequency of sound produced by the speaker,

frequency = …… [1]

(ii) the distance between points A and B given that points X and Y belong to the same wavefront.

distance = …… [1]

(iii) Compare the pitch and loudness of the sound heard at A and B.

……

…… [1]

(c) Fig.12.3 shows a simple a.c generator which has a frequency of 100 Hz and peak voltage 12 V.

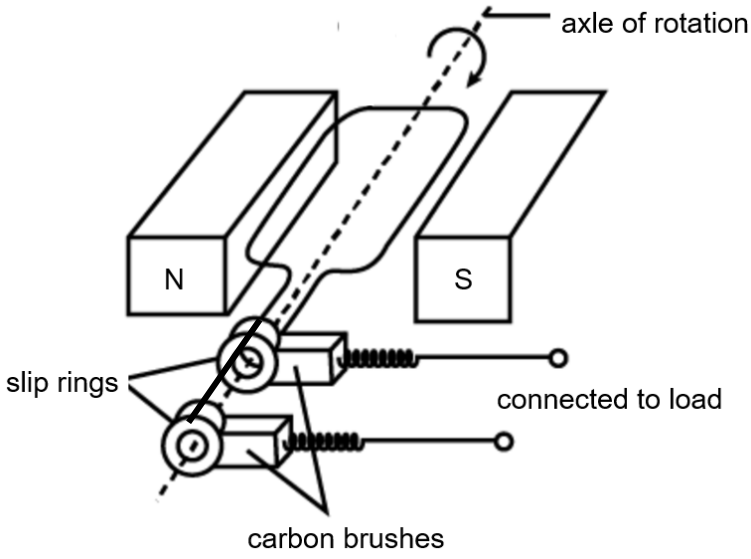
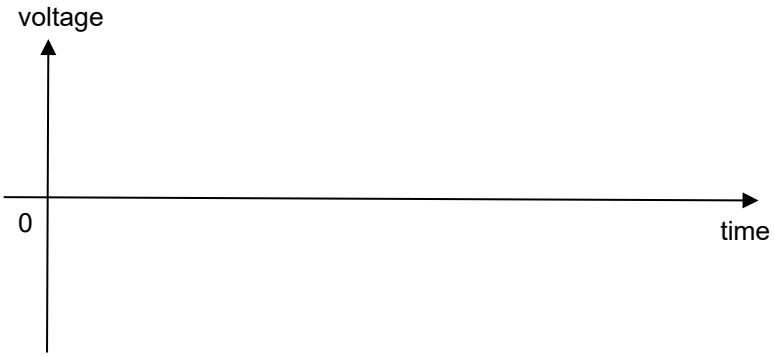


Fig. 12.3

(i) Sketch the graph of the voltage produced against time for two complete cycles below. Include relevant data on both axes.
The position of the coil at time = 0 s is as shown in Fig. 12.3.



[2]

(ii) If the speed of rotation of the coil is reduced, sketch the new graph of the voltage produced on the same axis above.

Label this new graph as **(ii)**. [1]

(iii) Explain the difference in amplitude between the graphs for **b(i)** and **b(ii)**.

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……

……

…… [1]

13 **(a)** Fig. 13.1 shows an object **O** placed on the principal axis that passes through the centre of a converging lens. The lens is perpendicular to the principal axis but is not shown.

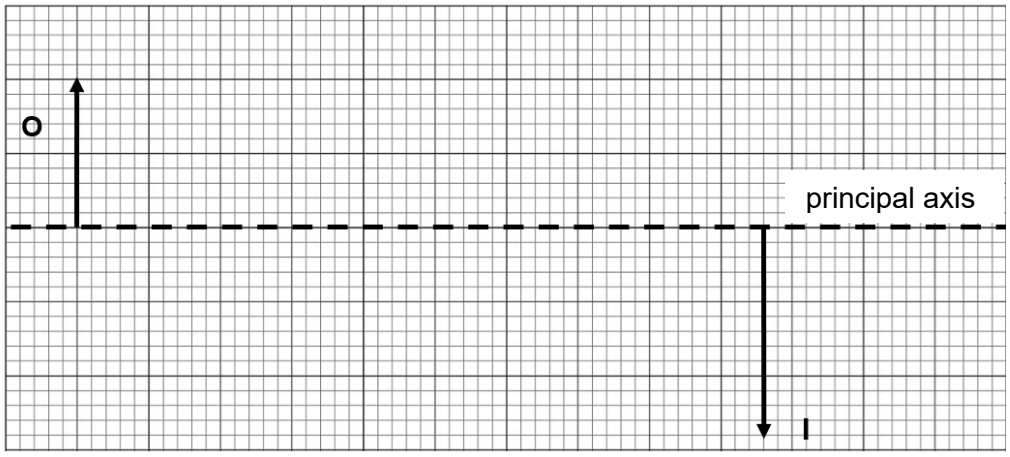

Fig. 13.1

(i) The image I produced by the lens is shown above.

On Fig. 13.1, draw a ray of light to determine the position of the lens and label the lens **L** in a suitable position. [1]

(ii) Draw another ray of light to determine the focal point of the lens and label the focal point **F** in a suitable position. [1]

(iii) Describe the image formed.

……

…… [1]

(iv) The lens in Fig. 13.1 is replaced with an identical lens with a higher refractive index. State the change, if any, to the focal length of the new lens.

……

…… [1]

(v) State one example of visible light in medical application other than for illumination.

…… [1]

(b) Fig. 13.2 shows the inside parts of an a.c. generator.

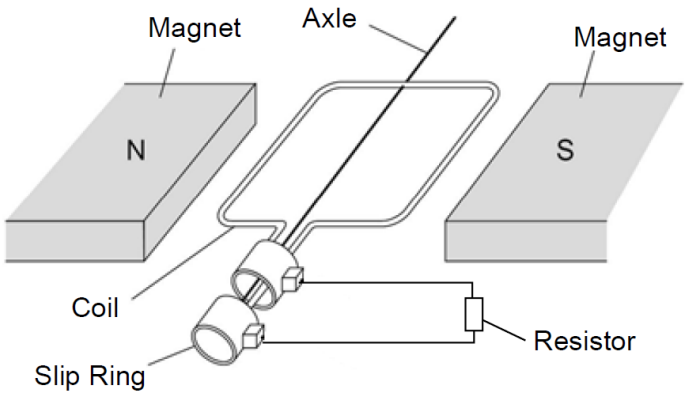

Fig. 13.2

(i) The handle of the a.c. generator is turned, causing the coil to rotate.

Using appropriate laws, explain how an alternating current is induced and the direction of the alternating current produced in the coil.

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..... [3]

(ii) If the rate of turning the handle doubles, explain the changes in the voltage output for the a.c. generator

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.....

..... [2]

END OF PAPER