CHRIST CHURCH SECONDARY SCHOOL
2024 PRELIMINARY EXAMINATION
FOUR EXPRESS

CANDIDATE NAME		CLASS	
CENTRE NUMBER	S	INDEX NUMBER	

PHYSICS **6091/02**
Paper 2 **20 Aug 2024**
1 hour 45 minutes

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

READ THESE INSTRUCTIONS FIRST
Write your name, class register number and class in the spaces provided at the top of this paper and all the work you hand in.
You may use an HB pencil for any diagrams, graphs.
Do not use staples, paper clips, highlighters, 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.

Students are reminded that **all** quantitative answers should include appropriate units.
The use of approved scientific calculator is expected where appropriate.
Students 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.

Section A

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

1 Fig. 1.1 shows a CHRian stationary on a Zipline.

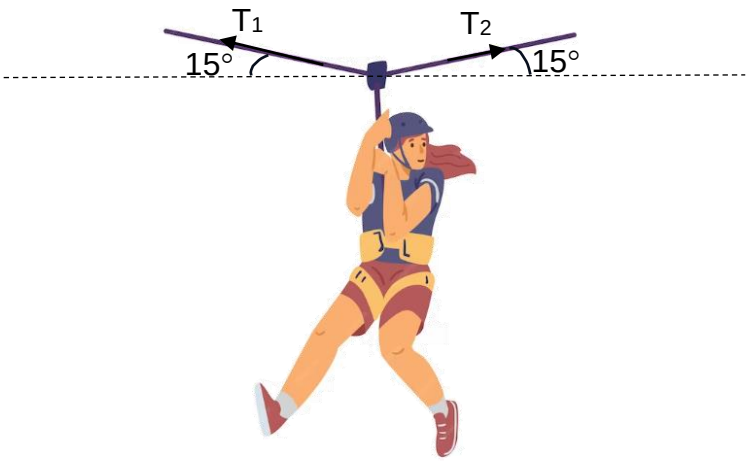

Fig. 1.1 (not to scale)

Two contact forces, tensions, T_1 and T_2 are acting on the rope as shown.
To keep stationary, a third, non-contact force is acting on this CHRian by the *gravitational field* of the earth.

(a) State what is meant by the *gravitational field*.

……..

……..[1]

(b) Given that T_1 and T_2 are each 850 N and tilted at an angle of 15° from the horizontal, Use a vector diagram, determine the resultant force from these two tensions.
State clearly the scale used.

scale:……[1]

resultant force =……[2]

(c) Explain, by applying Newton's Law, how the answer to **(b)** can be used to determine the magnitude and direction of the non-contact force.

……..

……..

……..

……..[2]

[Total: 6]

2 Fig. 2.1 shows a wind turbine used to generate electricity.

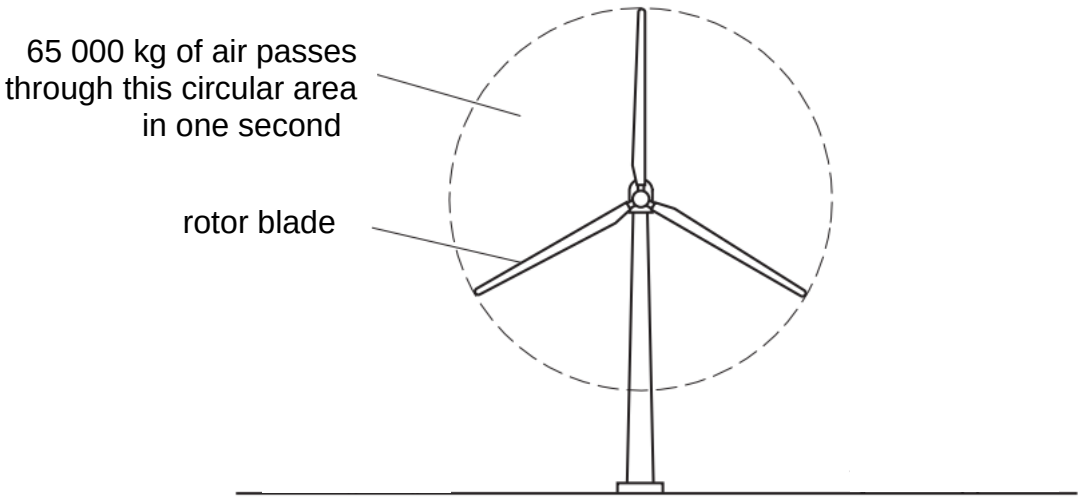

Fig. 2.1

(a) The wind blows directly towards the turbine with a speed of 12 m/s.
In one second, 65 000 kg of air passes through the circular area swept out by the rotor blades.

Calculate the energy in the kinetic store of this mass of air in one second.

energy in the kinetic store = ……[2]

(b) Given that the efficiency of this wind turbine is 72%.

Calculate the amount of electrical power generated.

electrical power = ……..[1]

(c) Using the principle of conservation of energy and energy stores, describe how energy transfer takes place in the wind turbine.

……..

……..

……..

…….[2]

(d) The potential difference between the electrical turbine is 3.5 MV.

Calculate the electric current produced.

current = ……..[2]

[Total: 7]

3 Fig. 3.1 shows a toy water rocket.

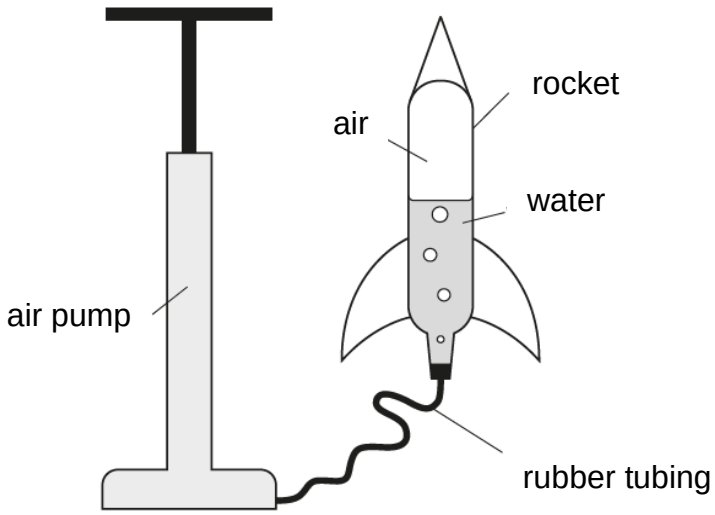

Fig. 3.1

The rocket is half-filled with water and connected by rubber tubing to a pump. Air is then pumped into the rocket so that the pressure in the rocket increases.

(a) Explain, using ideas about molecules, why pumping air in the rocket increases the pressure in the rocket.

……..

……..

……..

……..[2]

(b) State and explain, using ideas about molecules, how the pressure of the air in the rocket would change when the temperature of the air in the rocket is increased.

……..

……..

……..

……..[2]

[Total:4]

4 Fig. 4.1 shows a tank with a base area of 5.0 m^2 connected at the bottom via a horizontal pipe to a vertical tube of cross-sectional area 0.10 m^2.
Both the tank and the vertical tube are exposed to the atmosphere.

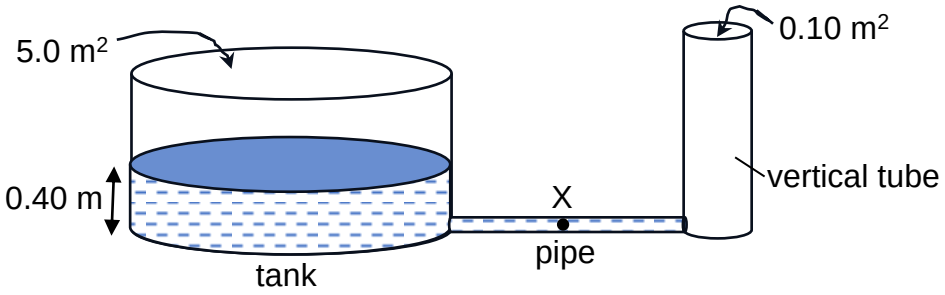

Fig. 4.1 (not draw to scale)

A liquid of density 900 kg/m^3 is poured into the tank to a depth of 0.40 m.

(a) On Fig. 4.1, clearly show the depth of liquid in the vertical tube. [1]

(b) Calculate the mass of liquid in the tank only. (You may ignore the volume of pipe).

mass of liquid in the tank = ……..[2]

(c) Calculate the total pressure at point X indicated on Fig. 4.1.
Given that the atmospheric pressure is 100 kPa. Take g = 10 N/kg.

total pressure = ……..[3]

[Total: 6]

5 Fig. 5.1 shows a geothermal reservoir.

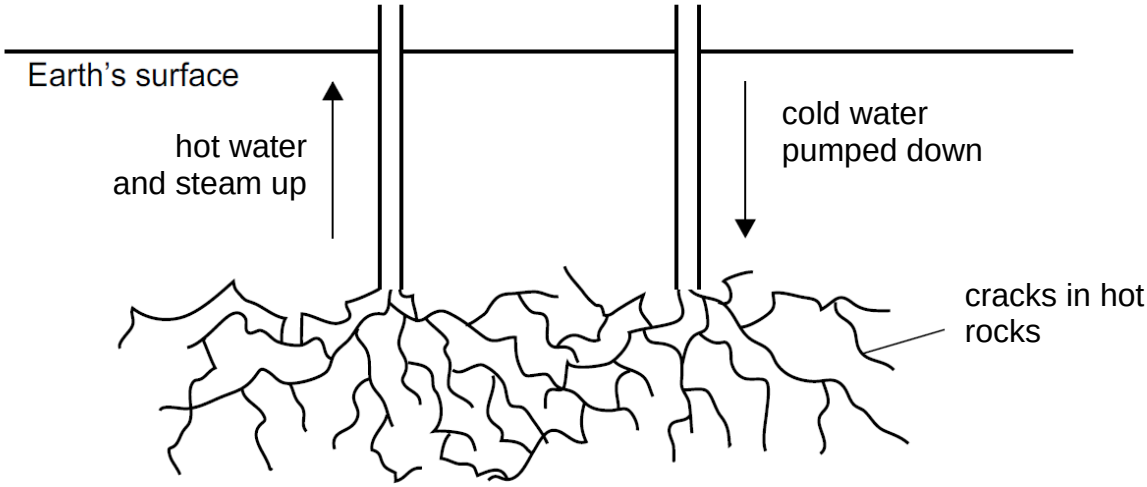

Fig. 5.1

(a) 1500 kg of cold water at a temperature of 25 °C is pumped down to the hot rocks. The water rises back up as 50% hot water and 50% steam.

Both the steam and the hot water are both at a temperature of 100 °C.
The specific heat capacity of water is 4200 J / (kg °C) and the latent heat of vaporisation of water is 2260 kJ/kg.

Calculate the total energy required to turn 1500 kg of water from 25 °C to 50% water and 50% steam at 100°C.

total energy = …….. [3]

(b) Explain why the pipe carrying the cold water is usually made of metal and painted black.

……

……

……

……[2]

[Total: 5]

6 Echolocation is used in nature by some animals to locate distant objects (such as a prey) by means of high-pitched sound waves.

Fig 6.1 shows a bat flying at a speed of 6.0 m/s towards a stationary moth.

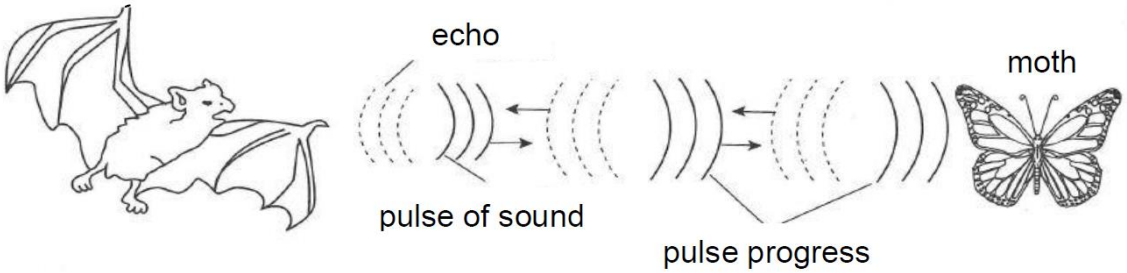

Fig. 6.1 (not to scale)

(a) Describe how sound waves produced by the bat travel through the air, reached the moth and eventually return to the bat.

……..

……..

……..

……[2]

(b) Fig. 6.2 shows the initial position of the bat at A. After sending a high-pitched sound wave, it flew for 0.50 s. The echo is received by the bat at position B.

Fig. 6.2

Given that the speed of sound in air is 330 m/s, calculate the initial distance between the bat and the stationary moth.

Show your working clearly.

distance = ……[2]

(c) Radar, a system similar to echolocation, is used for communication purposes.

Radar makes use of radio waves that are transmitted and the reflected radio waves are detected by sensors.

(i) State **two** differences between radio waves and sound waves.

……..……..……..

……..…….

……..……..……..

……..[2]

(ii) A radar signal of frequency 1.5 GHz is sent to long range air traffic communication.

Calculate the wavelength of this radar.
State clearly any constant used.

wavelength = ……..[2]

[Total: 8]

7 Fig. 7.1 shows two parallel rays of light, one red and one blue, entering a glass prism. The blue ray is also shown incident on a different side of the prism after passing through the prism.

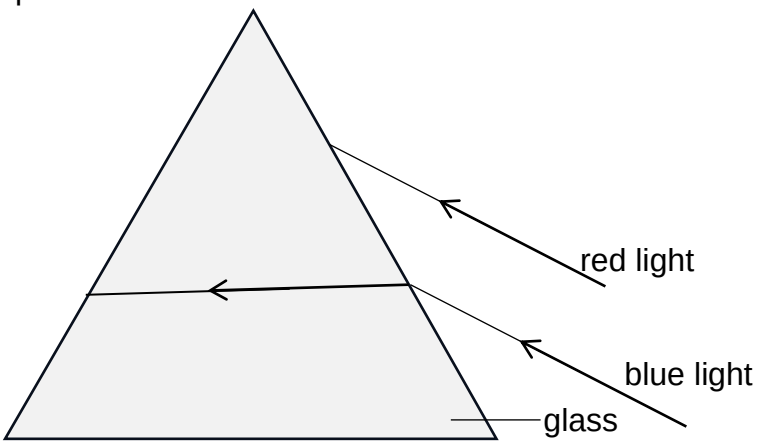

Fig. 7.1 (not to scale)

The ray of blue light strikes the left side of the prism at an angle equal to its critical angle c which is equal to 42°.

(a) On Fig. 7.1, draw and label the incident and refracted angles for the blue light ray. [1]

(b) With reference to the blue light ray, state what is meant by critical angle. You may draw on Fig. 7.1 to support your answer.

……..

……..

…….[2]

(c) Calculate the refractive index for the blue light.

refractive index = …….[2]

(d) The refractive index of glass for red light is smaller than the refractive index for blue light.

On Fig. 7.1, draw the path of the red light as it travels in the prism and after it strikes the left side of the prism. [2]

[Total:7]

8 Fig. 8.1 shows a circuit consisting of a 9.0 V cell, two resistors R_1 and R_2 of 120 Ω each, a light dependent resistor (LDR), and a thermistor.

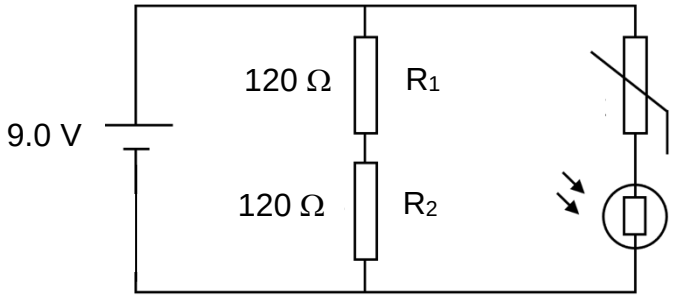

Fig. 8.1

Table 8.2 shows the range of resistance values for the LDR and the thermistor. The resistance of the thermistor varies linearly with temperature.

device	temperature /°C	light intensity	resistance /Ω
thermistor	20		200
	35		50
LDR		bright noon day	100
		night	200

Table 8.2

(a) Calculate the effective resistance of this circuit when it is during the night with a temperature of 20 °C.

effective resistance = ……[2]

(b) The output voltage V_{out} across the LDR is connected to a fan that will be switched on when the output voltage Vout ≥ 6.0 V.

Using Table 8.2, state under what conditions (temperature and light intensity) will the fan be switched on. Show your working on the space given below.

……..

……[2]

[Total:4]

9 Fig. 9.1 shows a simple d.c. motor used in a toy car.

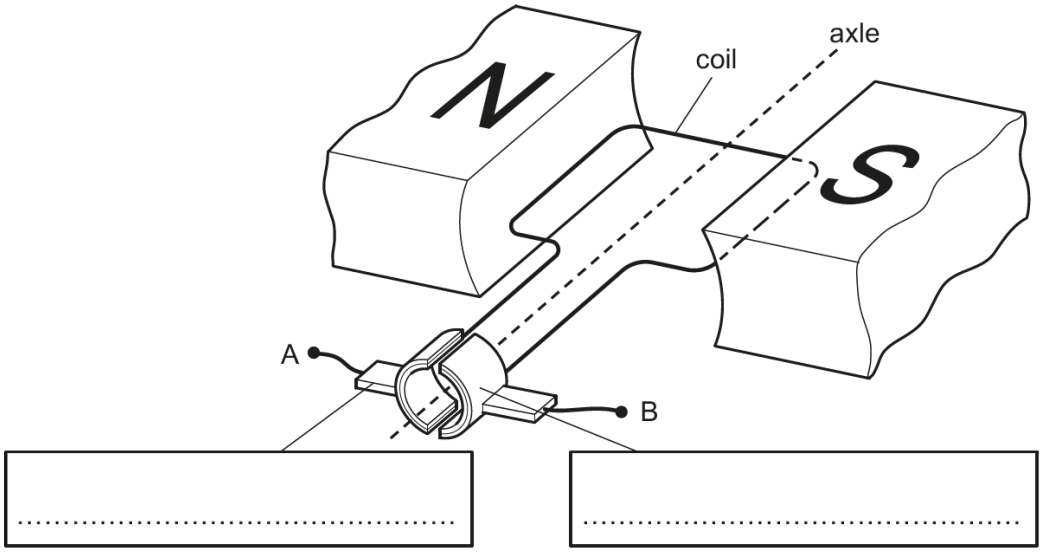

Fig. 9.1

Terminals A and B are connected to a battery and the motor rotates.

(a) On Fig. 9.1, name to parts of the motor inside the boxes provided. [2]

(b) State the effect of switching the positions of the North and South poles and increasing the number of turns of the coil.

……..

……..

……..

……[2]

(c) The power supply to the motor is switched on and off at a steady rate.

Fig. 9.2 shows how the speed of the toy car varies with time as a result of the power supply being switched on and off.

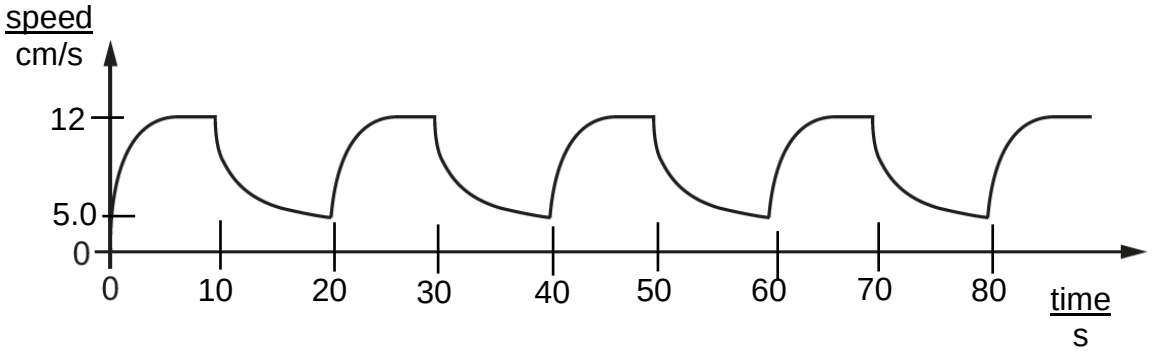

Fig. 9.2

Describe the motion of the toy car.

……

……

……

……[2]

[Total:6]

10 A radioactive isotope, Uranium emits alpha (α)-particles and gamma (γ) rays.

(a) A uranium $^{238}_{92}U$ atom emits an α-particle and γ rays to form Thorium, *Th*.

Write a nuclide equation to represent this decay.

……[1]

(b) Describe how you verify that only α-particles and γ rays are emitted. Use the space provided to describe your answer.

……

……

……

……

……

……

……

……

……

……

[3]

(c) An experiment was conducted to find the range of α-particles in air.
Table 10.1 shows the results of the experiment.

distance from the source to the detector / cm	count rate / counts per minute
1.0	731
2.0	688
3.0	604
4.0	545
5.0	24
6.0	26
7.0	25
8.0	24
9.0	26

Table 10.1

(i) Estimate the background radiation count rate.

……[1]

(ii) Based on your answer in **(i)**, estimate the count rate of the radioactive source when the source is at a distance of 3.0 cm from the detector.

count rate = ……[1]

(iii) State and explain the maximum distance that α-particles can travel from the source.

……

……

……[1]

(d) Thorium, *Th* is an isotope which further emits β-particles and γ-rays to become Protactinium, *Pa.*

(i) Define the term isotope.

……

……[1]

(ii) Write a nuclei equation and state the atomic number of protactinium.

……

……[1]

(iii) Fig. 10.2 shows the percentage activtiy decay curve of a sample of the unstable thorium nuclei *isotope* that decays per second.

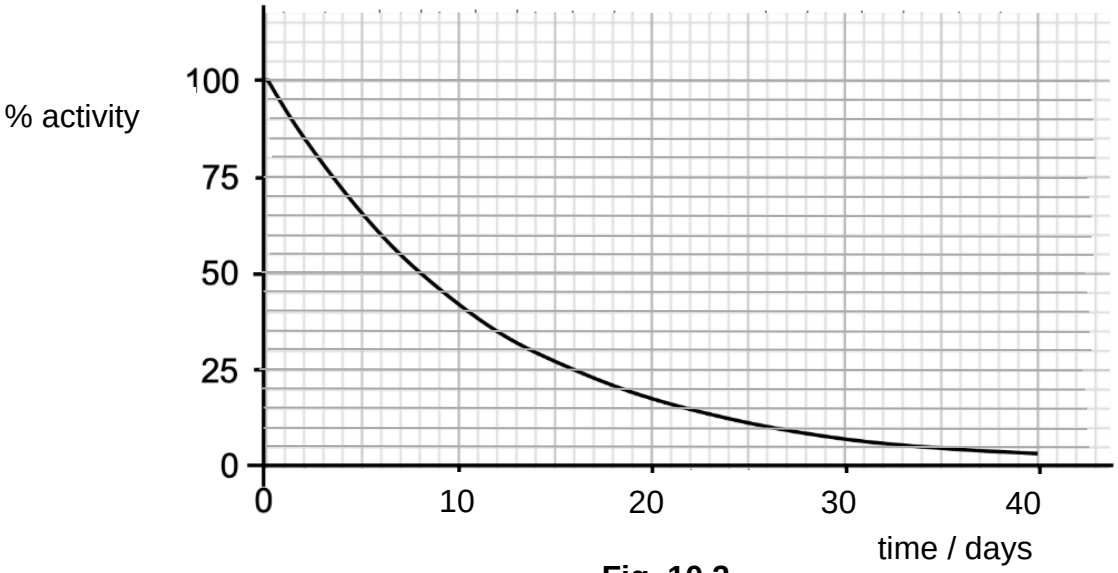

Fig. 10.2

Using Fig. 10.2, determine the half-life of this thorium isotope.
Show your working clearly.

half-life of Th isotope = ……[2]

(e) State an application of radioactivity in the medical or industrial uses.

…..……

……[1]

[Total:12]

11 Fig. 11.1 shows an electrostatic precipitator with the key components.

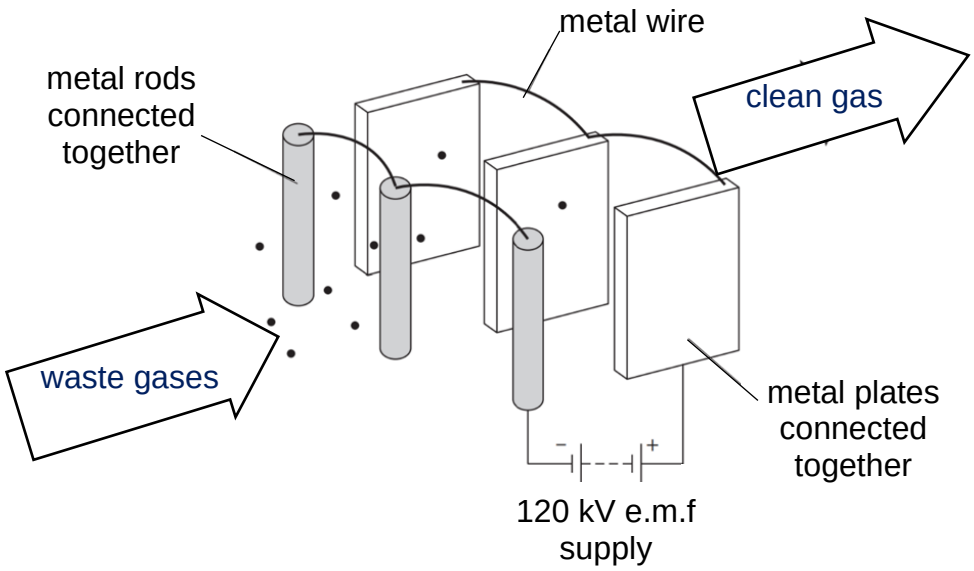

Fig. 11.1

(a) Using the law of electrostatic, explain how the waste gases (initially uncharged) passing through the metal rods get charged and eventually are removed, leaving the metal plates as clean gas.

……

……

……

……

……

……[2]

(b) Fig. 11.2 shows a single isolated negatively charged particle.
On Fig. 11.2, draw the electric field on this negatively charge particle.

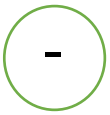

Fig 11.2

[1]

(c) The discharge current from the 120 kV e.m.f. supply is 1.5 mA in 2.0 s.

Calculate the amount of energy of this discharge.

energy = ……[2]

[Total: 5]

Section B

Answer **one** question from this section.

12 (a) A simple iron-cored transformer has an input voltage of 120 turns and is connected to an alternating current power supply of 25 V.

Describe the set-up of this transformer that can be used to step up the voltage to 200 V. In your account, you should:

- include a diagram to show the structure of this transformer
- state the key information essential for this step-up transformer to work
- state any assumption(s) made.

……

……

……

……[4]

(b) Fig. 12.1 shows a solenoid is held in a vertical position. The solenoid is connected to a sensitive, centre-zero galvanometer. A vertical bar magnet is held stationary at position X just above the solenoid.

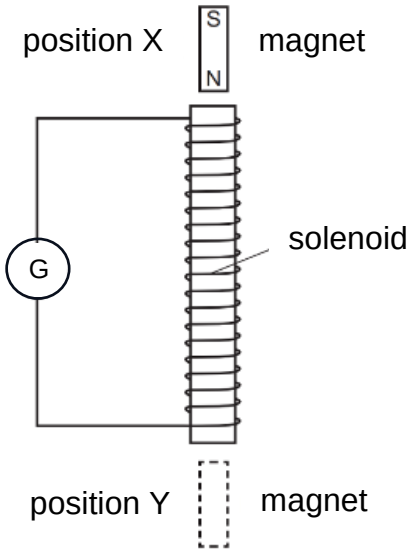

Fig. 12.1

The magnet is released and it drops through the solenoid.

During the initial stage of the drop, the sensitive galvanometer shows a small deflection to the left.

Explain why the galvanometer shows a deflection.

……..

……..

……..

……..

……[2]

(c) The magnet passes the middle point of the solenoid and continues to drop.

It reaches position Y as shown in Fig. 12.1.

Describe and explain what is observed on the galvanometer as the magnet falls from the middle point of the solenoid to position Y.

……..

……..

……..

……..

……[2]

(d) Fig. 12.2 shows the voltage output against time from a simple alternating current generator.

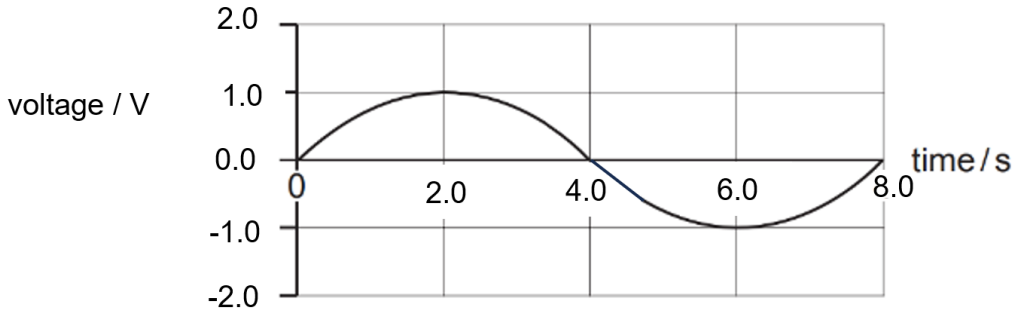

Fig. 12.2

On Fig. 12.2, draw the voltage output against time if the generator rotates at twice the original speed. [2]

[Total: 10]

13 Fig. 13.1 shows an electric oven with two heating elements arranged at the top and bottom to provide a uniform heating to food placed in the oven.

A 230 V alternating current (a.c.) power supply is used as a source.

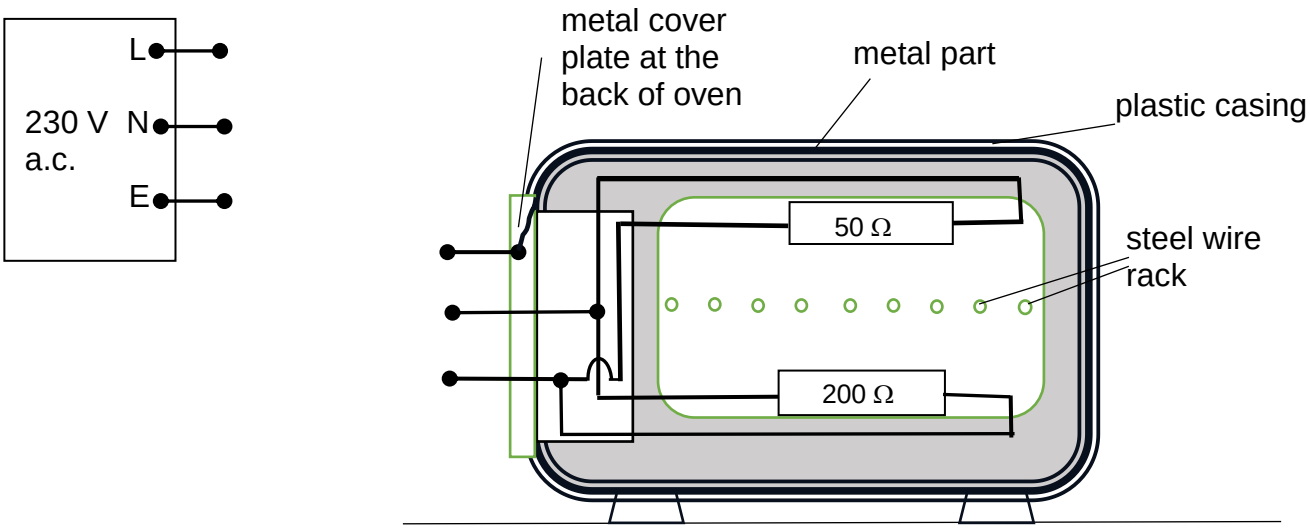

Fig. 13.1

(a) On Fig. 13.1, draw lines to complete the circuit diagram to show how the live, neutral and earth wires should be connected to the 230 V a.c. supply.

Include a fuse and a switch in your circuit diagram. [2]

(b) Determine the current based on the arrangement of the heating elements when connected to the a.c. supply and switched on.

current = ……[2]

(c) Suggest a suitable fuse rating given the choice of 3 A, 5 A, 7A, 9 A and 13 A. Explain your answer how you arrive at your choice.

……..

……..

……[1]

(d) A restaurant uses five electric ovens daily for 3.0 hours.

Table 13.2 shows the cost of electricity supplied by two energy retailers.

energy retailer	monthly price plan	
	type	electricity rate
X	fixed price	30 cents/kWh
Y	fixed price with rebate	32 cents/kwh ($15 rebate for consumption more than 500 kWh)

Table 13.2

Based on Table 13.2, explain which energy retailer would be more provide lesser cost. Show your working clearly on the space given below.

energy retailer …… would provide a lesser cost [3]

(e) Fig. 13.3 shows the same electric oven with the heating elements only.

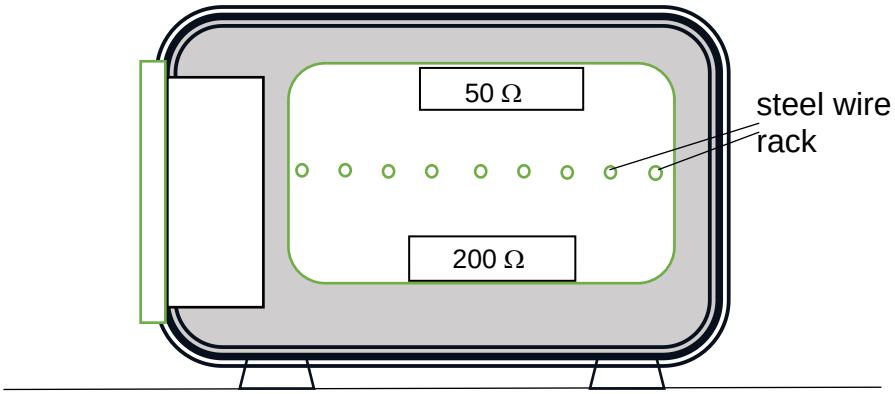

Fig. 13.3

Explain how this arrangement of the heating elements increase the temperature of the air in the oven to allow the food to be eventually uniformly cooked.

You may draw on Fig. 13.3 to explain.

……..

……..

……..

……..

……..

…….[2]

[Total: 10]