O

ANDERSON SECONDARY SCHOOL
Preliminary Examination 2025
Secondary Four Express

CANDIDATE NAME:

CLASS: / INDEX NUMBER:

PHYSICS **6091/02**

Paper 2 Structured and Free Response **20 August 2025**

1 hour 45 minutes

Candidates answer on the Question Paper. **1145-1330 h**

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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

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, where 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 [70]	
Section B [10]	
Total [80]	

Section A

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

1 An aircraft flies at a constant height. Air drag and the force from the aircraft's engine together produce a force on the aircraft of 50 kN due north. The wind produces a force of 20 kN at an angle of 30º to the horizontal, as shown in Fig. 1.1.

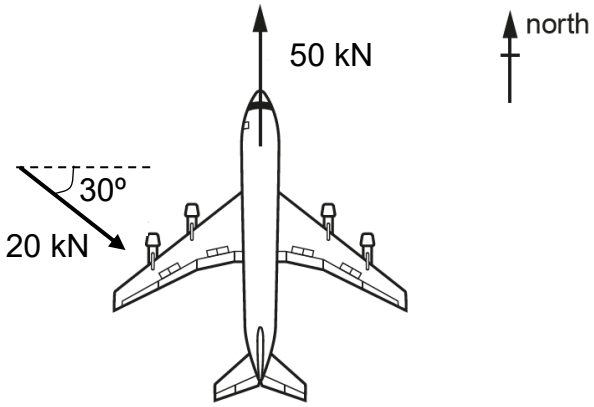

Fig. 1.1

Draw a scale drawing in the space below to show the resultant force acting on the aircraft.

Use your drawing to determine the size of the resultant force and the angle between the resultant force and north.

resultant force = ……

angle = ……

[3]

[Total: 3]

2 Fig. 2.1 shows a mobile bird sculpture that has been created by an artist.

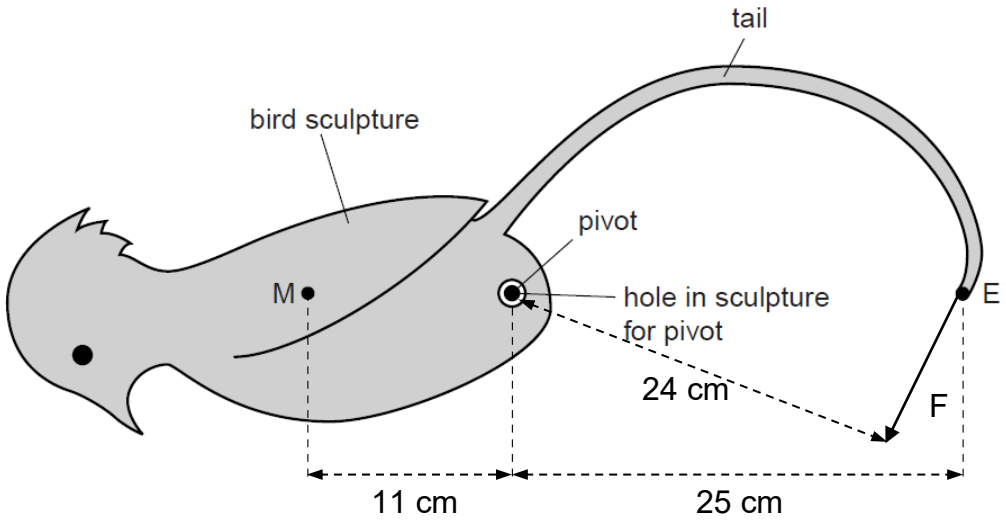

Fig. 2.1

M is the centre of gravity of the bird sculpture, including its tail. The bird sculpture is placed on a pivot. A force F is added at the end E of the tail so that the bird remains stationary in the position shown.

The mass of the bird and tail is 2.2 kg. The gravitational field strength g = 10 N/kg.

(a) Calculate F.

F = ...[2]

(b) A counter-weight is added at E. The centre of gravity of the sculpture with counter-weight is at the pivot.

The sculpture is rotated clockwise to the position shown in Fig. 2.2. It is held still, then carefully released.

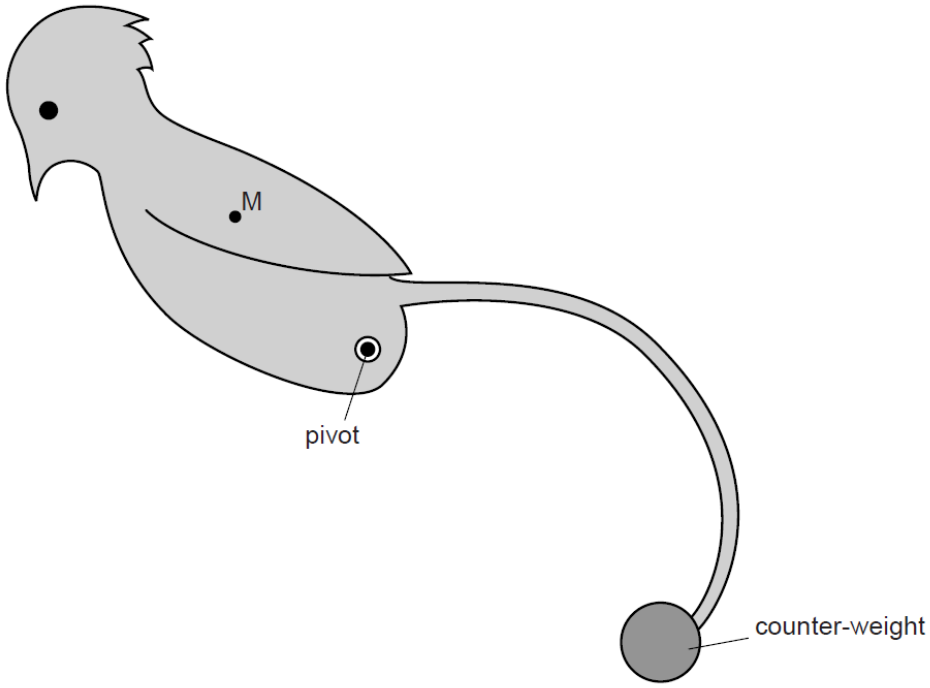

Fig. 2.2

State and explain why the sculpture will stay in that position.

……

……

……

……

……[2]

[Total: 4]

3 Fig. 3.1 shows a long vertical tube, sealed at the base and open at the other end. The tube is 1.0 m long. The cross-sectional area of the tube is 4.0×10^{-4} m^2. It is filled with a liquid of density 1.6×10^4 kg/m^3. The gravitational field strength is 10 N/kg.

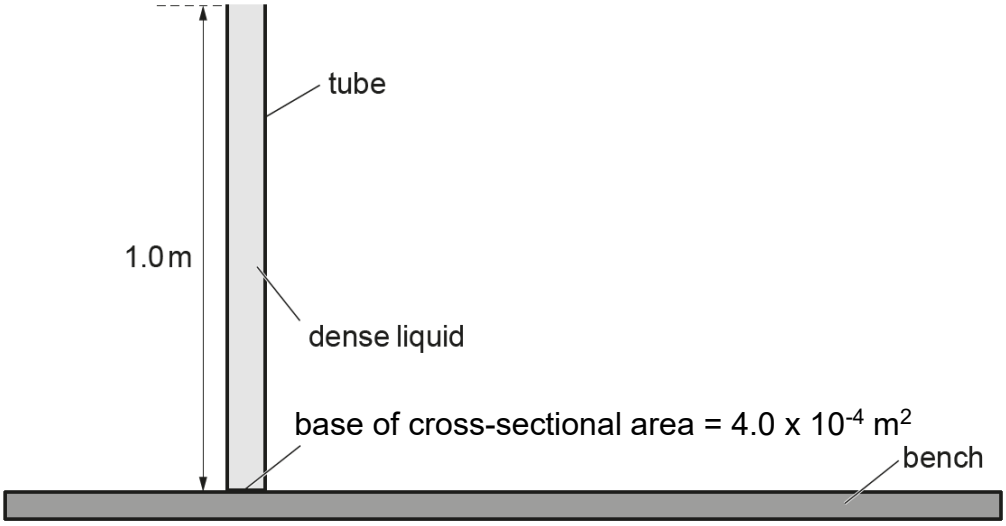

Fig. 3.1

The atmospheric pressure is 1.0×10^5 Pa.

(a) (i) Calculate the total pressure in the liquid at the bottom of the tube.

pressure = ……[2]

(ii) Calculate the force exerted on the inside surface of the bottom of the tube.

force = ……[1]

(b) A small sheet of glass is placed over the open end of the tube. The tube is inverted in a container of a dense liquid. The open end of the tube and the sheet of glass are just below the surface of the liquid as shown in Fig. 3.2.

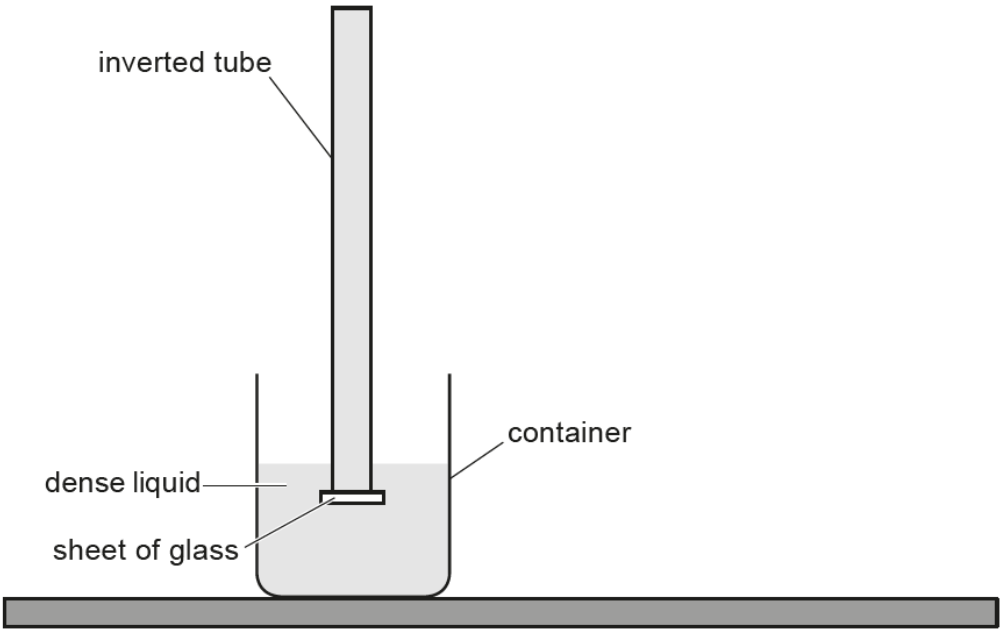

Fig. 3.2

The sheet of glass seals the open end of the inverted tube.

Describe and explain what happens to the level of liquid in the inverted tube when the sheet of glass is removed.

……

……

……

……

……[3]

[Total: 6]

4 Fig. 4.1 shows a conveyor belt transporting a package to a raised platform. The belt is driven by a motor. The mass of the package is 16 kg. The gravitational field strength is 10 N/kg.

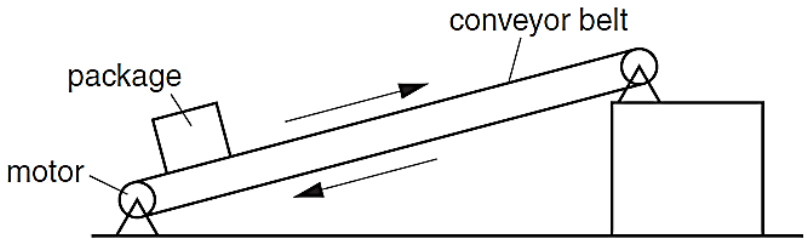

Fig. 4.1

(a) Calculate the increase in energy in the gravitational potential store of the package when it is raised through a vertical height of 1.8 m.

energy = ……[1]

(b) The package is raised through the vertical height of 1.8 m in 4.5 s.

Calculate the power needed to raise the package.

power = ……[1]

(c) The electrical power supplied to the motor is much greater than the answer to **(b)**.

Explain how the principle of conservation of energy applies to this system.

……

……

……

……[2]

[Total: 4]

5 Fig. 5.1 shows the components of the electromagnetic spectrum in order of increasing wavelength.

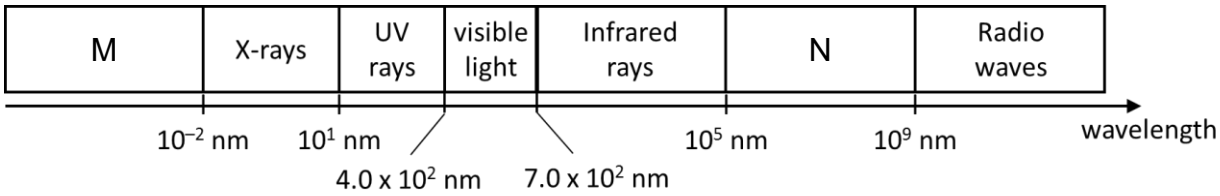

Fig. 5.1

(a) Name the components M and N and state one use of each component you have named.

……

……

……[2]

(b) X-rays are used in the medical field to produce images of organs (e.g. bones and lungs) inside the patient's body.

However, the amount of X-rays a person is exposed to must be monitored as over-exposure may affect the health of the person.

(i) State a possible effect on a person's health due to over-exposure to X-rays.

……

……[1]

(ii) Explain why over-exposure to X-rays may have the effect stated in part **b(i)**.

……

……[1]

[Total: 4]

6 Fig. 6.1 shows the path of a light ray in a diamond.

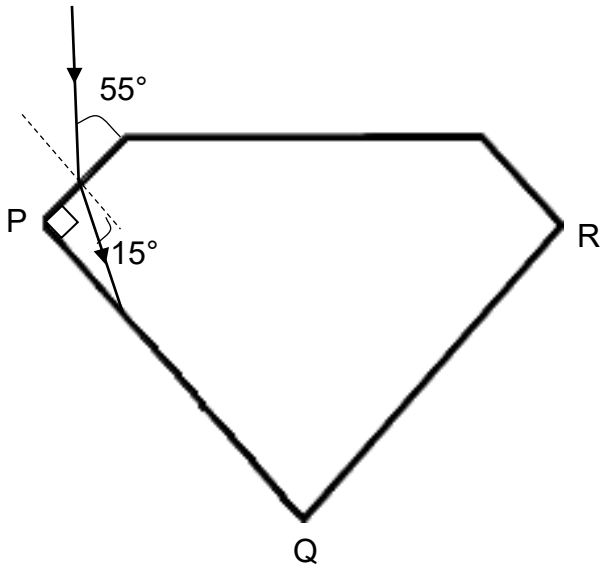

Fig. 6.1

(a) State the meaning of the critical angle of a diamond.

.....

.....[1]

(b) **(i)** Calculate the refractive index of diamond.

refractive index = ...[2]

(ii) Calculate the critical angle of diamond.

critical angle = ...[1]

(c) **(i)** Determine the angle of incidence at boundary PQ.

angle of incidence = ……..……..[1]

(ii) Explain how the ray will behave at boundary PQ.

.....

.....

…….....[2]

[Total: 7]

7 In a waste management plant, a thermistor circuit as show in Fig. 7.1 is used to detect the temperature of certain waste materials, such as heated food containers or metallic items that may retain heat.

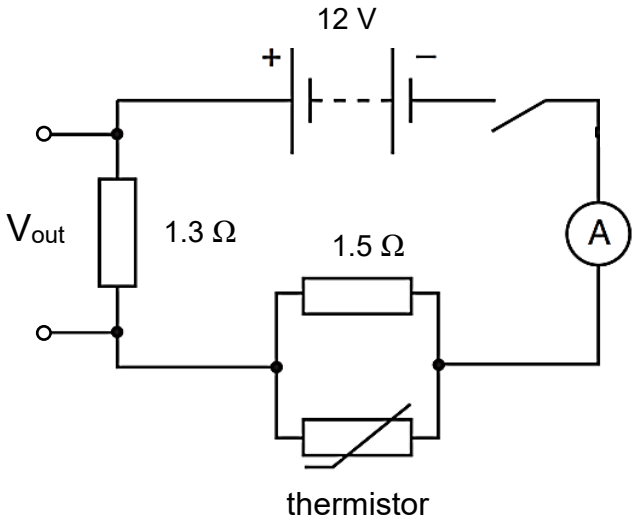

Fig. 7.1

(a) The electromotive force (e.m.f.) of the battery is 12 V. The switch is closed. The thermistor has a resistance of 6.0 Ω at room temperature.

Calculate the current measured by the ammeter at room temperature.

current = ……[2]

(b) State and explain what will happen to the reading of V_{out}, when the temperature of the waste material near thermistor is high.

……

……

……[2]

(c) Fig. 7.2 shows a permanent magnet being used to separate materials in another section of the waste management plant.

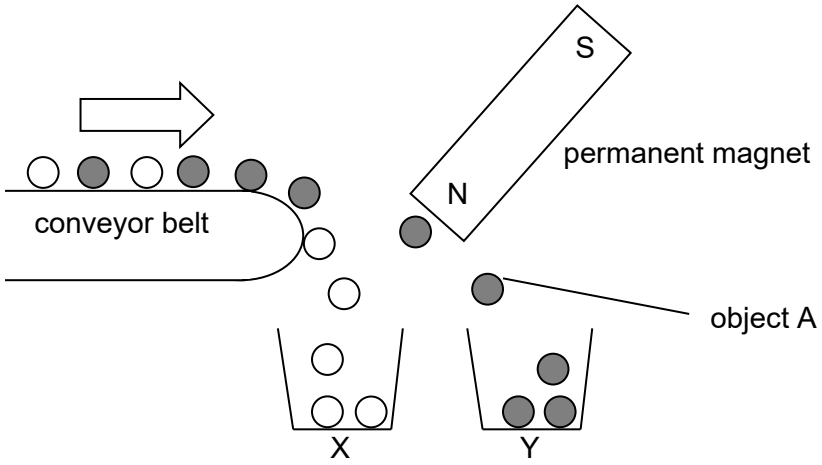

Fig. 7.2

(i) Explain why object A can be collected in container Y.

……

……

……[2]

(ii) Suggest a material for the permanent magnet. Explain your answer.

……

……[1]

[Total: 7]

8 Fig. 8.1 shows part of a simple d.c. motor. The motor is connected to a battery with the positive terminal of the battery connected to terminal A.

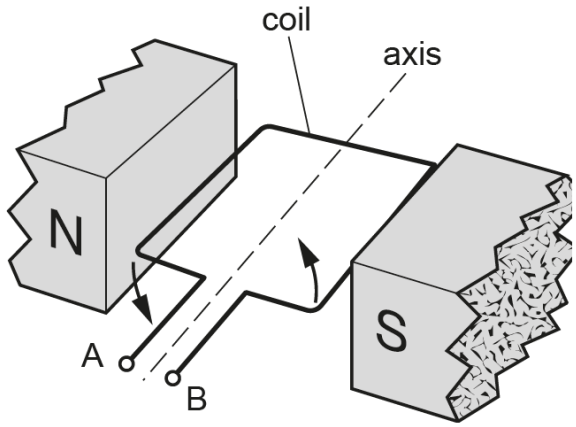

Fig. 8.1

(a) Explain why the coil turns in the direction shown.

……..……..

……..……..

……..……..

……..……..

……..……..

……..……..[3]

(b) The turning effect is increased when the coil is wound around a soft-iron cylinder.

Explain why this happens.

……..……..

……..……..[1]

(c) The motor has a power rating of 1200 W, and is now connected to a 230 V mains supply. Fuses of 5 A, 8 A and 13 A are available.

(i) Calculate the current in the motor.

current = …….. [2]

(ii) Suggest which of the three fuses is the best to use in the plug and explain why the other fuses are less suitable.

.....

.....

.....

.....[2]

[Total: 8]

9 **(a)** Surgical instruments in sealed plastic bags are placed in thin plastic boxes. A conveyor belt takes the boxes close to a cobalt-60 source which sterilises the instruments. This is shown in Fig. 9.1.

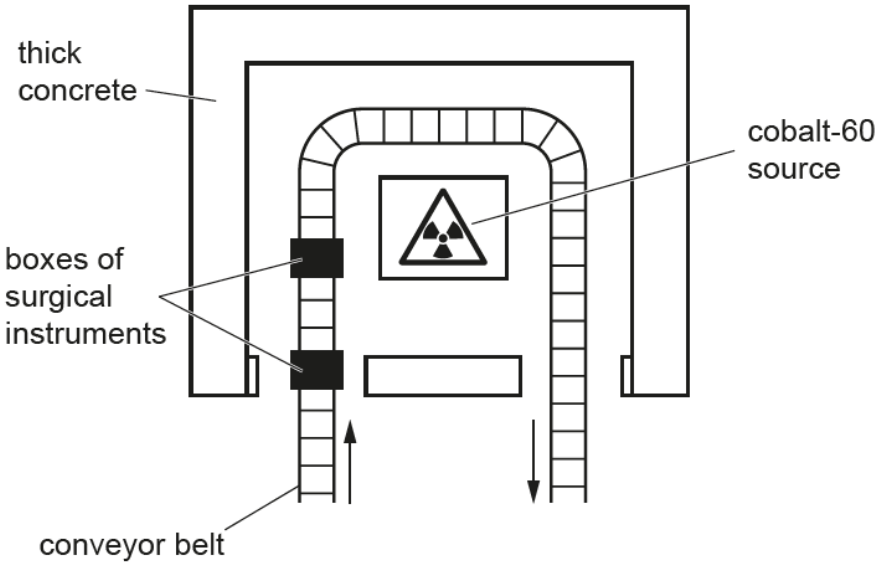

Fig. 9.1 (viewed from above)

The cobalt-60 source is a radioactive isotope of cobalt that emits gamma-radiation.

(i) Suggest one safety measure when handling radioactive materials.

…...……...[1]

(ii) Suggest why the thick concrete in Fig. 9.1 is used.

……

...……...[1]

(iii) A nucleus of cobalt-60 ($^{60}_{27}\mathrm{Co}$) decays to a nucleus of Ni by a beta (β) and gamma (γ) emission.

$$^{60}_{27}\mathrm{Co} \rightarrow {}^{60}_{28}\mathrm{Ni} + \ldots\ldots\ldots\ldots\ \beta + \ldots\ldots\ldots\ldots\ \gamma$$

In the space provided, complete the equation above to show the missing proton and nucleon numbers. [2]

(b) A teacher places a radiation detector on a bench in a school laboratory and switches it on.

(i) The teacher measures and records the background radiation count rate.

Describe what is meant by 'background radiation'

……

...……..[1]

(ii) The teacher moves a sample of protactinium-234 so that it is next to the detector. The count rate is measured every 20 s with the sample present, and then corrected for background radiation.

Fig. 9.2 shows a graph of the corrected count rate against time for the protactinium-234 sample.

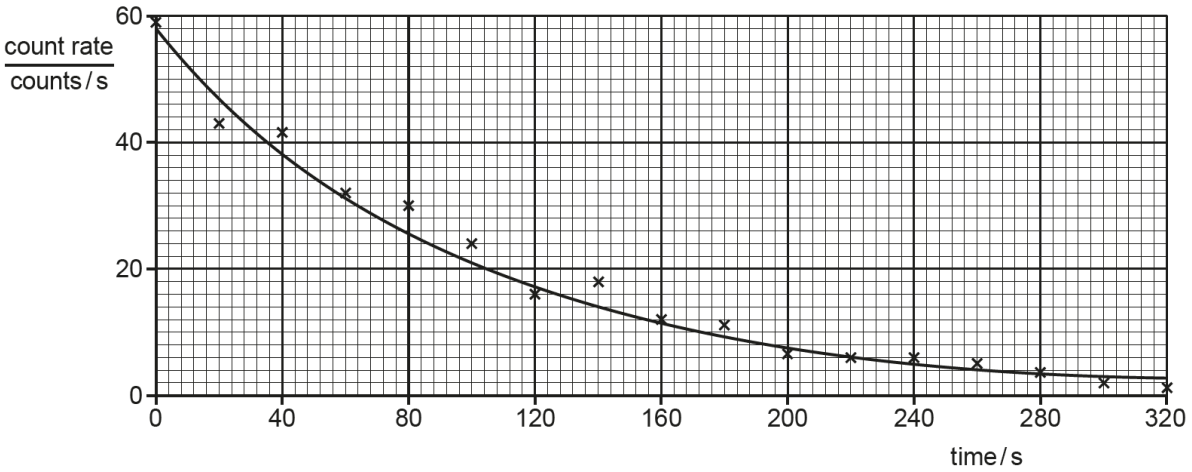

Fig. 9.2

Using Fig. 9.2, determine the half-life of protactinium-234.

Show your working.

half-life = ……...[2]

[Total: 7]

10 **(a)** An iron bar has many turns of wire wrapped around it, as shown in Fig. 10.1. The wire is connected to an alternating current supply. Some more wire is made into a flat coil and connected across a low voltage lamp.

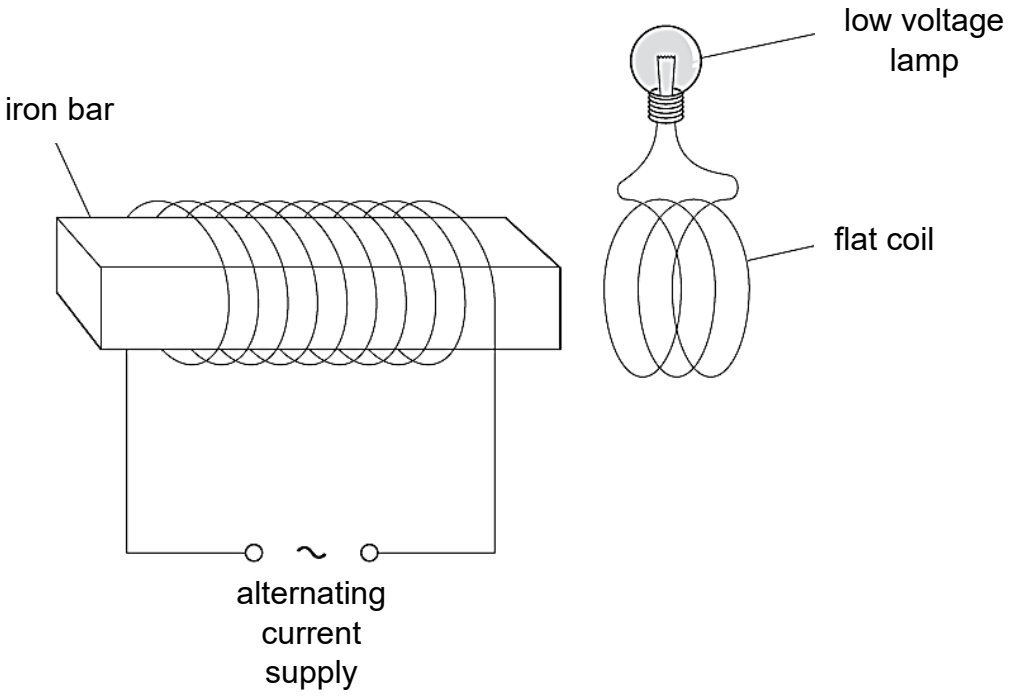

Fig. 10.1

When the flat coil is held close to the end of the iron bar, the lamp glows.

(i) Explain why this happens.

.....

.....

.....

.....[2]

(ii) Explain why increasing the frequency of the alternating current supply also increases the brightness of the lamp.

.....

.....[1]

(b) Fig. 10.2 shows the mains power supply of 240 V connected to the primary coil of a transformer. The primary coil consists of 800 turns.

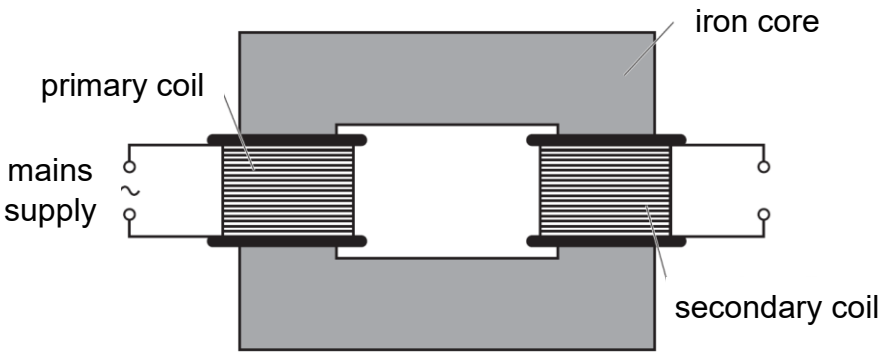

Fig.10.2

(i) The core of the transformer is made from iron.

Explain why iron is a suitable material for the core of the transformer.

.....

.....[1]

(ii) There are 50 turns on the secondary coil.

Calculate the maximum value of the voltage across the secondary coil.

maximum voltage = ... [2]

(iii) The current in the primary coil and secondary coil is 0.22 A and 3.2 A respectively.

Calculate the efficiency of the transformer.

efficiency = ... [2]

(iv) Transformers are used to step up the voltage at the power station before sending electricity through transmission lines.

Explain why electricity is transmitted at high voltage.

.....

.....

.....[2]

[Total: 10]

11 A cafe is studying how different containers affect the cooling of hot coffee. Each cup is filled with 200 g of coffee at 90 °C. The room temperature is 25 °C and the humidity is 60 %. A fan in the café circulates air gently around the tables.

Three types of containers are used:

- Takeaway Cup: double-walled, made of thin cardboard with a corrugated sleeve

Fig. 11.1

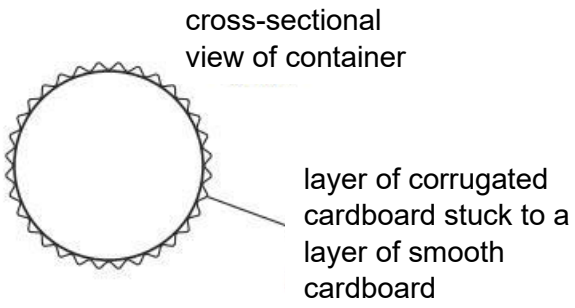

Fig. 11.2

- Mug M: ceramic, high heat capacity
- Mug N: plastic, low heat capacity
- Vacuum flask: double-walled glass with a vacuum gap, silvered inner surfaces, and a tight stopper

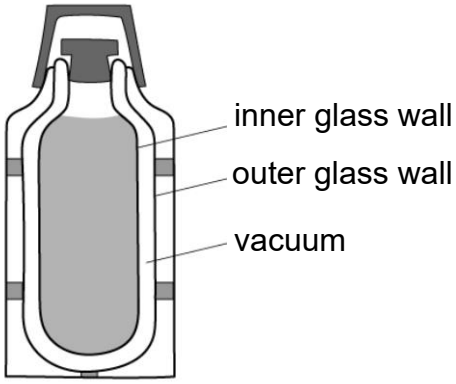

Fig. 11.3

In another experiment, liquid nitrogen is explored for “nitro ice cream” or “nitro coffee”. Liquid nitrogen is nitrogen gas at an extremely low temperature. It has a boiling point of -196 °C. When the liquid nitrogen reaches its boiling point, a small piece of 40 g metal at 25 °C is slowly lowered into it. The metal cools to -196 °C.

The table below shows more details of the materials used in the experiments.

Table 11.4

specific heat capacity of water	4200 J / kg°C
specific heat capacity of ceramic	850 J / kg°C
specific heat capacity of the metal	0.39 J / g°C
specific latent heat of vaporisation of nitrogen	200 J / g

(a) Explain why the design of the takeaway cup allows a customer to hold the container of hot coffee comfortably.

...……..……..

...……..……[1]

(b) Hot coffee is poured into mugs, M and N. Both mugs are of the same size.

State and explain which mug will cause the coffee to cool down less.

...……..……

...……..……

……..……..…..[2]

(c) State and explain the advantage of having a vacuum between the two glass walls of a flask.

...……..……

...……..……

……..……..…..[2]

(d) In the vacuum flask, there is a small space containing gas above the liquid. As the liquid cools, the temperature of the trapped gas decreases.

Explain, in terms of the particles of the gas, why the pressure the gas exerts on the inner walls of the container decreases as the temperature decreases.

...

...

...

.....[2]

(e) In the nitro experiment, energy is transferred away from the metal as it cools.

Calculate

(i) the energy transferred away from the metal as it cools,

energy = ... [2]

(ii) the mass of nitrogen that boils away.

mass = ... [1]

[Total: 10]

Section B

Answer **one** question from this section.
Answer either **Question 12** or **Question 13**.

12 Fig. 12.1 shows a stationary space rocket being launched at sea level. The space rocket has main engines that will help it to blast off from the Earth. The rocket must reach a breaking speed in order to escape from Earth. Table 12.1 shows information about the launch. After the rocket enters outer space, the rocket's exhaust will be propelling the rocket to move.

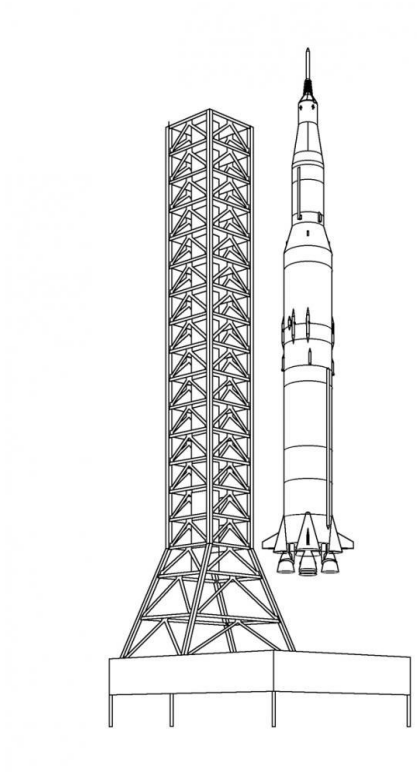

Fig. 12.1

Table 12.1

altitude (height) of the rocket at the escape speed just before it hits the outer space (assuming uniform acceleration)	830 km
mass of space rocket (assumed to remain the same throughout the launch)	22 000 kg
breaking speed	11 000 m/s

(a) The acceleration is assumed to remain constant throughout the launch.

Using the information provided in Table 12.1,

(i) determine the time taken for the rocket to reach breaking speed,

time taken = ……[2]

(ii) determine the vertical acceleration of the rocket,

acceleration = ……[2]

(iii) calculate the upward thrust of the rocket, given the gravitational field strength is 10 N/kg.

upward thrust = ……[2]

(b) "*After the rocket enters outer space, the rocket's exhaust will be propelling the rocket to move*."

The statement means that the rocket pushes against the exhaust it releases in space. This is one force in an action-reaction pair.

Describe the other force in the pair.

……..…….

……..…….

……..……...[2]

(c) In reality, during launching, the space rocket will burn solid fuel that is inside the fuel compartment. Once the compartment is empty, the compartment will be detached from the main body. The rocket continues to burn fuel stored inside the rocket, keeping the upward thrust the same.

Explain how this affects the acceleration of the rocket.

……..…….

……..…….

……...[2]

[Total: 10]

13 A technician uses pulses of ultrasound to detect imperfections in a sample of steel. The speed of ultrasound in steel is 5200 m/s.

Fig. 13.1 shows the pulses of ultrasound transmitted into steel when the ultrasound transmitter and receiver is placed at position X, Y and Z.

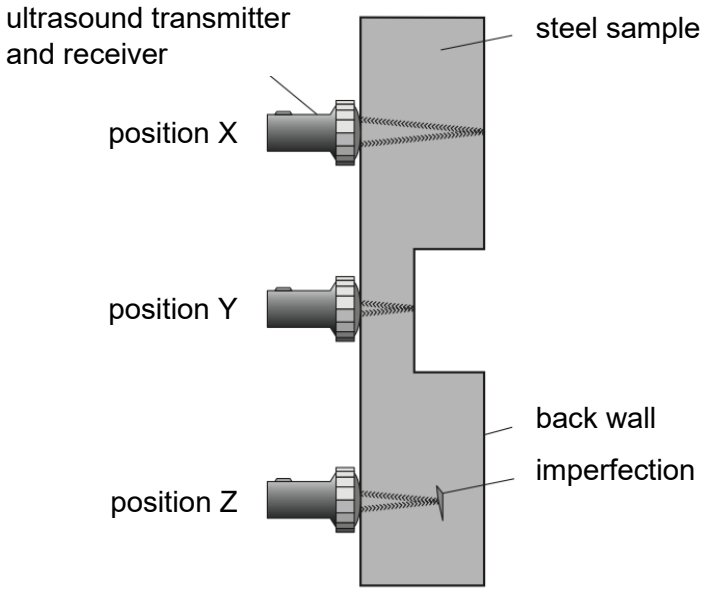

Fig. 13.1

(a) Explain how sound energy is transferred through the steel sample.

……

……

……...[2]

(b) Explain the meaning of lower amplitude of the sound pulse.

……

……...[1]

(c) Fig. 13.2 shows the time between the pulses being transmitted and received. The pulse is transmitted at t = 0 s. The pulse being received when at position X and at position Y are both drawn on the same graph on Fig. 13.2.

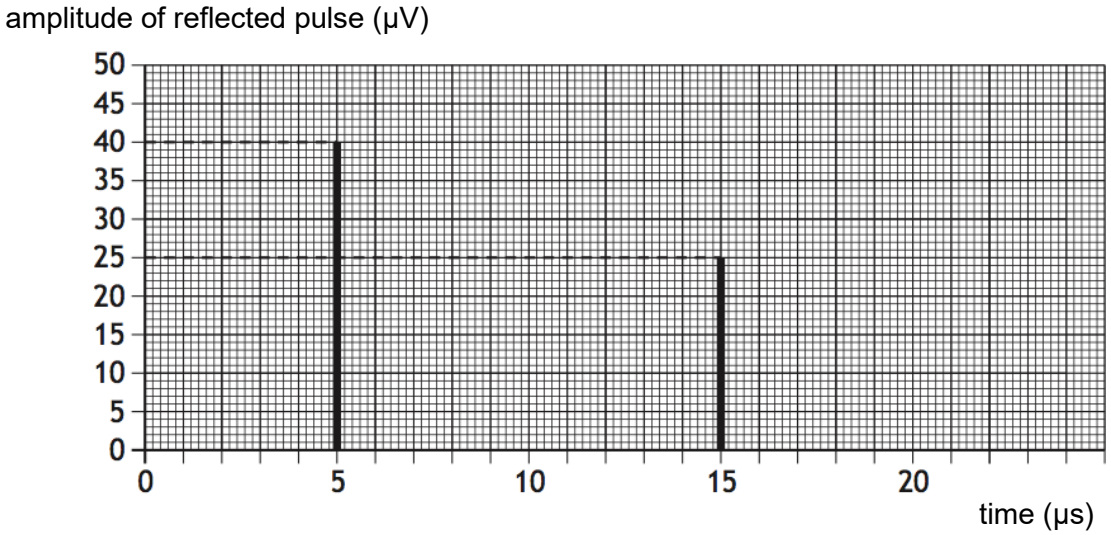

Fig. 13.2

(i) From Fig. 13.2, state the time taken between the pulse being transmitted and received at position X. Explain your answer.

.....

.....[1]

(ii) Calculate the thickness of the steel sample at position X.

thickness = ... [2]

(iii) Explain why both the received pulses in Fig. 13.2 have different amplitudes even though the transmitted pulse at both positions has the same amplitude at the start.

...

.....[1]

(iv) On Fig. 13.2, draw a line to show the reflected pulse at position Z. [1]

(d) Another application of ultrasound is to determine the depth of the sea.

Explain the difference in the speed of sound in steel and in seawater.

……

……

……..[2]

[Total: 10]