SYDNEY GRAMMAR SCHOOL

# 2002
## HIGHER SCHOOL CERTIFICATE TRIAL EXAMINATION

# Physics

### General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board-approved calculators may be used
- Write using blue or black pen
- Draw diagrams using pencil
- A data sheet, formula sheet and Periodic Table are provided at the back of this paper
- Write your Student Number at the top of each page starting at page 8.

**Total Marks - 100**

**Section I** Pages 2 – 19

**75 marks**

This section has two parts, Part A and Part B

Part A – 15 marks
- Attempt Questions 1 - 15
- Allow about 30 minutes for this part

Part B – 60 marks
- Attempt Questions 16 - 28
- Allow about 1 hour and 45 minutes for this part

**Section II** Pages 20 – 22

**25 marks**

- Attempt ONE Question from Questions 29 - 33
- Allow about 45 minutes for this section

AWW/MRW/AGY/SRW

| Each boy should have the following: | |
|---|---|
| 1 Question Paper | |
| 1 Multiple-choice Answer Sheet | |
| 1 4-page Writing Booklet | |

## Section I
**75 marks**

**Part A – 15**
**Attempt Questions 1 - 15**
**Allow about 20 minutes for this part**

Use the multiple-choice Answer Sheet.

Select the alternative A, B, C or D that best answers the question. Fill the response oval completely.

**Sample** 2 + 4 =

(A) 2 (B) 6 (C) 8 (D) 9

Ⓐ ● Ⓒ Ⓓ

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

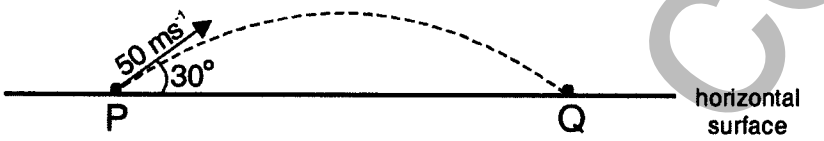
● ⊗ Ⓒ Ⓓ

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows.

1 A space probe orbits the planet Saturn with a period of 12 hours and at a distance of 121 511 km from the centre of the planet.
What is the mass of Saturn?

(A) $5.7 \times 10^{26}$ kg
(B) $6.0 \times 10^{24}$ kg
(C) $1.8 \times 10^{24}$ kg
(D) $5.7 \times 10^{17}$ kg

2 A ball is thrown from P to Q and follows a parabolic path. The initial velocity at P is 50 $ms^{-1}$ at 30° above the horizontal and the time of flight is 5.1 s.



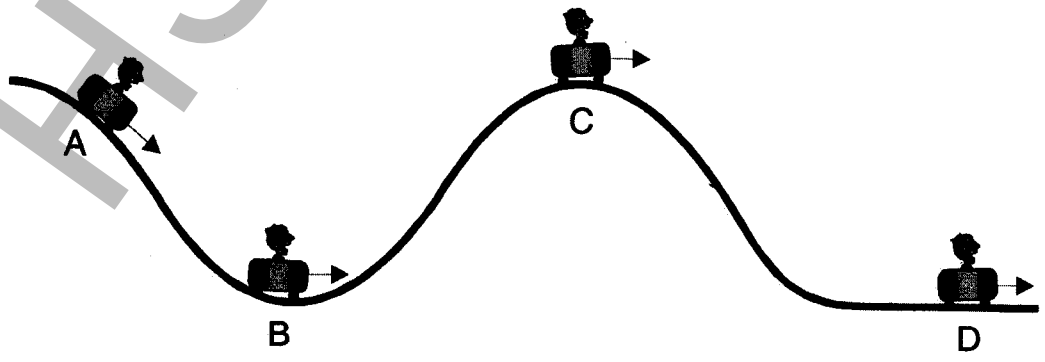

What is the magnitude of the displacement from P to Q?

(A) 127.5 m
(B) 221 m
(C) 255 m
(D) 348.5 m

3 An astronaut of mass 80 kg experiences a force of 1176 N from his seat during launch when the rocket is just above the launch pad. What is the acceleration of the rocket?

(A) 2.0 g
(B) 1.5 g
(C) 1.0 g
(D) 0.5 g

4 In which of the following roller coaster cars would the rider be most likely to experience similar forces to those experienced by an astronaut in a stable orbit?



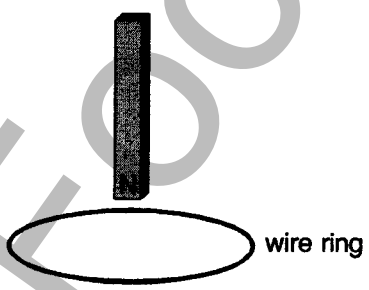
**5** What is the potential energy of a 1.0 kg mass at the surface of the Earth assuming the radius of the Earth is 6380 km?

(A) $+9.83$ J
(B) $-9.83$ J
(C) $+6.27 \times 10^7$ J
(D) $-6.27 \times 10^7$ J

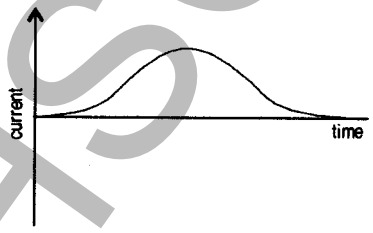
**6** An electric motor driven from a constant voltage supply is used to raise a load. If the load is decreased which one of the following sets of changes occurs?

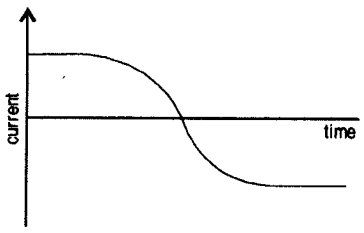
| | *speed of rotation* | *back emf* | *current in coil* |
|---|---|---|---|
| (A) | decreases | decreases | increases |
| (B) | increases | increases | decreases |
| (C) | decreases | decreases | decreases |
| (D) | increases | decreases | increases |

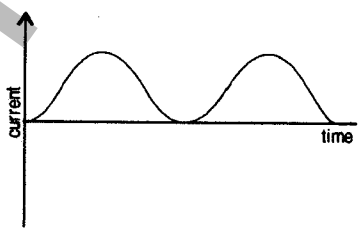
**7** A bar magnet is lowered at constant speed through a wire ring, as shown in the diagram.

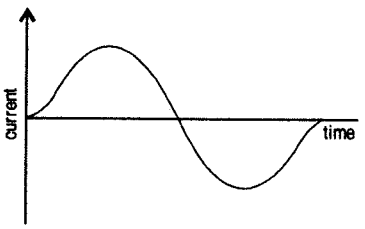



Which graph best represents the variation of current induced in the ring with time?

(A)



(B)


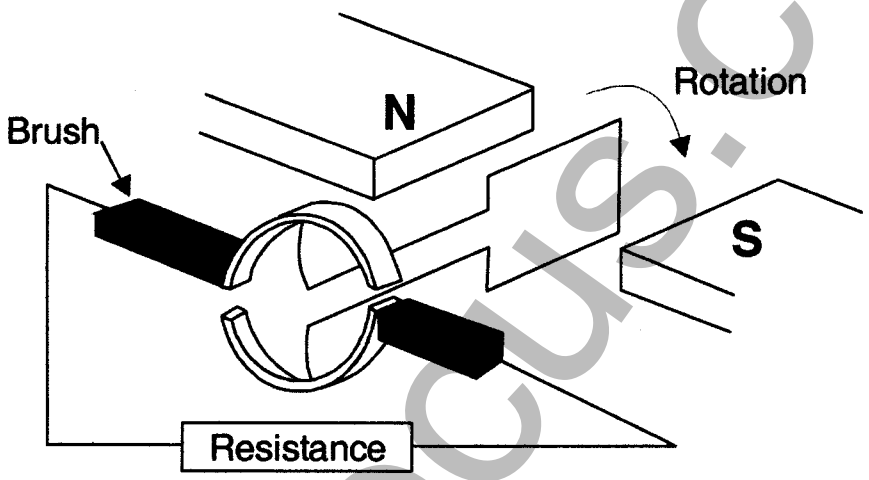

(C)



(D)


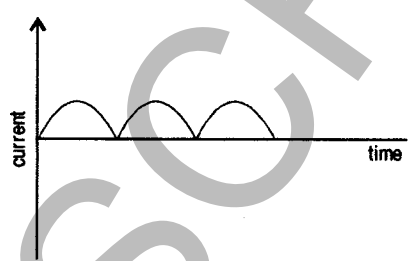
**8** An ideal transformer has a primary coil with 2000 turns and a secondary coil with 850 turns. If the primary voltage is 240 V, what is the secondary voltage?

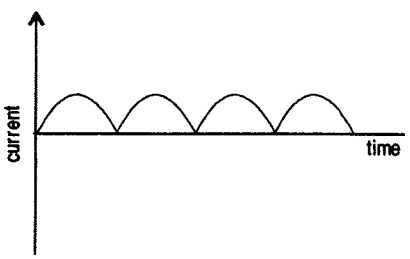
(A) $6.86 \times 10^{-4}$ V
(B) $3.65 \times 10^{-4}$ V
(C) $1.02 \times 10^{2}$ V
(D) $2.74 \times 10^{3}$ V

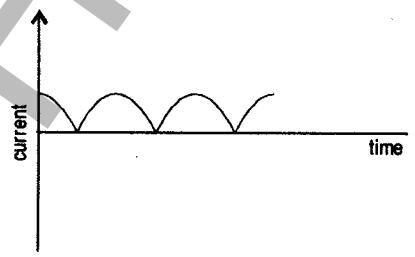
**9** One type of generator is shown in the diagram below.

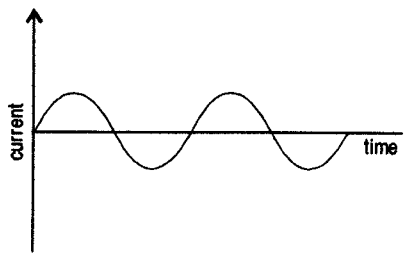



Which graph shows the output current that flows in the resistor as the generator makes two full rotations of the coil from the starting position shown in the diagram?

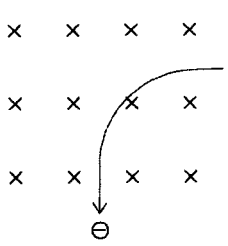
(A)


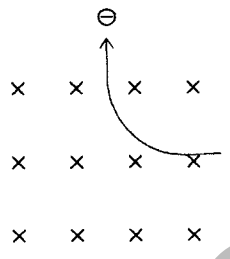

(B)


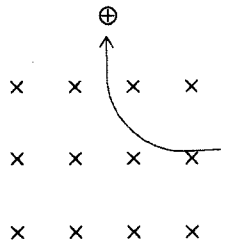

(C)


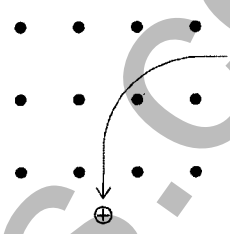

(D)


**10** Which of the following diagrams shows the correct path of the charged particle in a magnetic field?

(A) 

(B) 

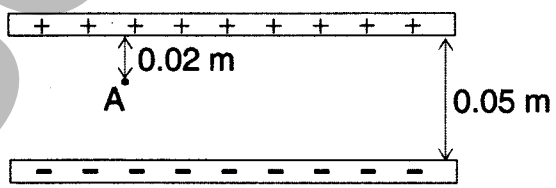
(C) 

(D) 

**11** Which of the following groups of properties are all properties of cathode rays?

(A) Travel in straight lines, deflected by electric fields, behaviour is independent of the cathode material.
(B) Travel in straight lines, deflected by magnetic fields only, behaviour is independent of the cathode material.
(C) Deflected by electric fields and magnetic fields, cause fluorescence on glass that depends on cathode material.
(D) Always travel in a curved path, deflected by electric and magnetic fields, cause fluorescence on glass.

**12** In the following diagram two parallel, charged metal plates are used to create an electric field. The plates are 0.05 m apart and point A is 0.02 m from the positive plate.



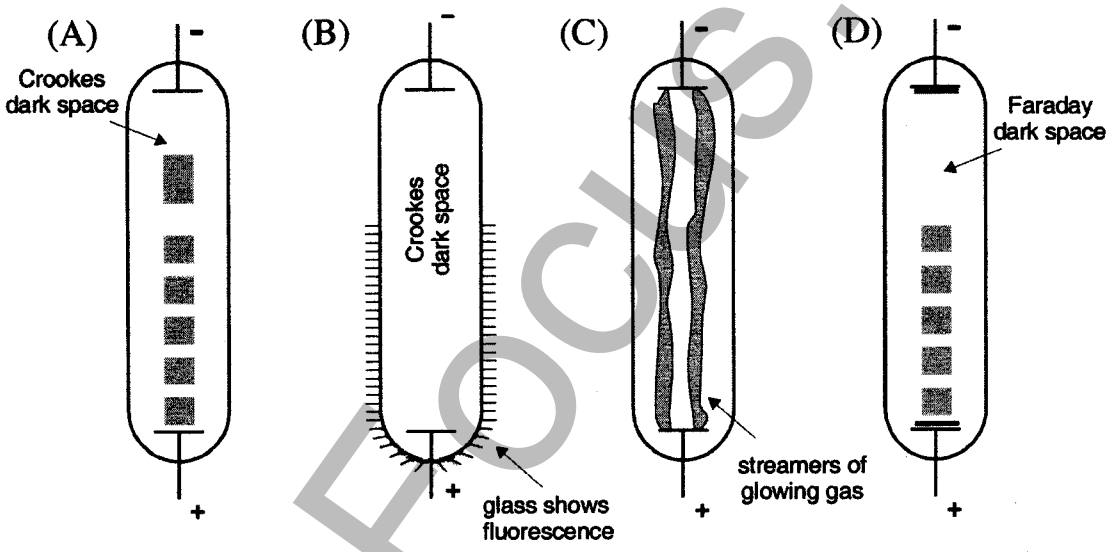

If the potential difference between the positive plate and point A is 40 V, what is the electric field strength between the plates?

(A) 40 $Vm^{-1}$
(B) 100 $Vm^{-1}$
(C) 2000 $Vm^{-1}$
(D) 8000 $Vm^{-1}$

**13** Which of the following statements correctly describes the electric field strength in the region around an isolated electron in space?

(A) The field is directed radially towards the electron and gets weaker near the electron.
(B) The field is directed radially towards the electron and gets stronger closer to the electron.
(C) The field is directed radially away from the electron and gets stronger closer to the electron.
(D) The field is directed radially towards the electron and is uniform at all distances.

**14** In the following gas discharge tubes, the glowing striations occur when a high D.C. voltage is applied between the electrodes. Which tube has the lowest gas pressure?




**15** Induction motors are a common form of electric motor. They are used in domestic appliances such as washing machines or fans. Which of the following is one of the main advantages of induction motors?

(A) They are quiet and do not produce sparks.
(B) They can run on A.C. and D.C.
(C) Their commutator allows them to have universal applications.
(D) They allow speed to be varied easily.

Student Number

## Section I (continued)

**Part B – 60 marks**
**Attempt Questions 16 - 28**
**Allow about 1 hour and 55 minutes for this part**

Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations.

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**Marks**

**Question 16** (5 marks)

A communication satellite is often placed in a geostationary orbit around the Earth so that it has an orbital period of 24 hours ($8.64 \times 10^4$ s).

(a) Explain the main advantage of a geostationary orbit. **1**

(b) Calculate the radius of a geostationary orbit. **1**

(c) Discuss the impact of the Earth's rotational motion on the launch of a rocket. **3**

Student Number

**Marks**

**Question 17** (3 marks)

Describe Galileo's analysis of projectile motion. **3**

**Question 18** (6 marks)

Discuss the difficulties associated with effective and reliable communications between satellites and Earth. **6**

Student Number

**Marks**

**Question 19** (5 marks)

The Voyager 2 space probe, launched by NASA in 1977 was designed to tour the planets of the solar system. It reached Jupiter in 1979 and left Saturn in 1981. This space probe has a mass of 750 kg and is now $9.8 \times 10^9$ km from the Sun after 25 years. The current velocity of Voyager 2 is about 16 $kms^{-1}$.

(a) Calculate the gravitational force on Voyager 2 in its present position. The mass of the Sun is $2.0 \times 10^{30}$ kg and the mass of other planets may be ignored. **2**

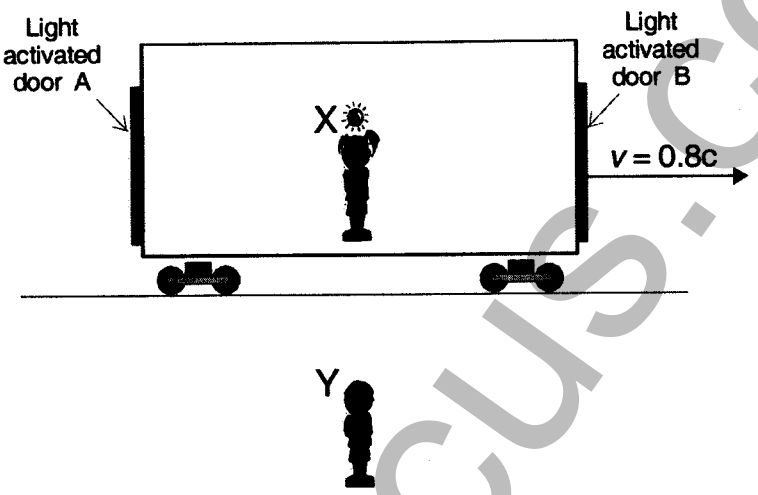
(b) Describe how a slingshot effect around Jupiter was used to accelerate the space probe. **3**

Student Number

**Marks**

**Question 20** (4 marks)

In this thought experiment to demonstrate relativity, an observer (X) on a train travelling at 0.8 c makes a light flash, in the centre of the carriage, to open the light activated doors (A and B) at each end of the carriage. Observer Y is observing this from a stationary platform outside the train. **4**



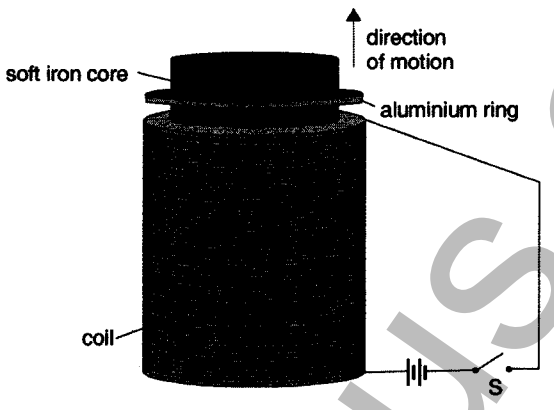

Explain how this thought experiment can show the relativity of simultaneity of events for observer X and observer Y.

Student Number

**Marks**

**Question 21** (4 marks)

An aluminium ring rests over the end of a coil of wire so that their vertical axes coincide as shown in the diagram below. Just after switch S is closed the aluminium ring moves upwards.



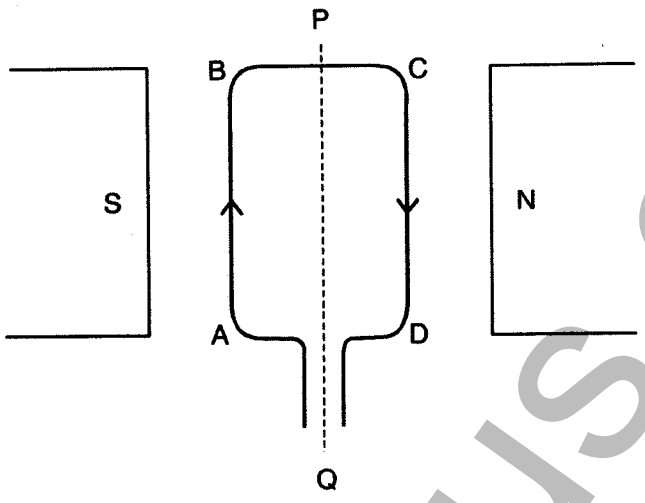

Explain how Faraday's Law and Lenz's Law are applied to explain the movement of the aluminium ring. **4**

Student Number

**Marks**

**Question 22** (5 marks)

The following diagram shows a rectangular loop in a uniform magnetic field of 0.085 T. The loop is free to rotate on the axis PQ.




not drawn to scale

The length of side AB is 25 cm and side BC is 20 cm.

(a) Calculate the torque on the loop. **1**

(b) Describe the net result of the forces on the loop. **2**

(c) Discuss the importance of the invention of the commutator to the development of the electric motor. **2**

Student Number

**Marks**

**Question 23** (3 marks)

Describe how you carried out an investigation to demonstrate the principle behind the operation of an induction motor. **3**

**Question 24** (3 marks)

Describe the operation of an A.C. generator. **3**

Student Number

**Marks**

**Question 25** (8 marks)

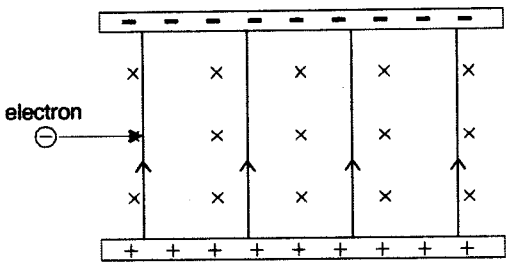
Analyse the impact of the development of transformers on society. **8**

Student Number

**Marks**

**Question 26** (5 marks)

An electron moves at a velocity of $5.7 \times 10^3$ ms$^{-1}$ into the region between two charged parallel plates, as shown in the diagram. Between the plates there is also a uniform magnetic field of $7.5 \times 10^{-2}$ T at right angles to the electric field.




KEY

electric field E = 250 Vm$^{-1}$

magnetic field $B_{in}$ = 7.5 x 10$^{-2}$ T

(a) Calculate the force on the electron due to the magnetic field. **1**

(b) Calculate the net force on the electron. **2**

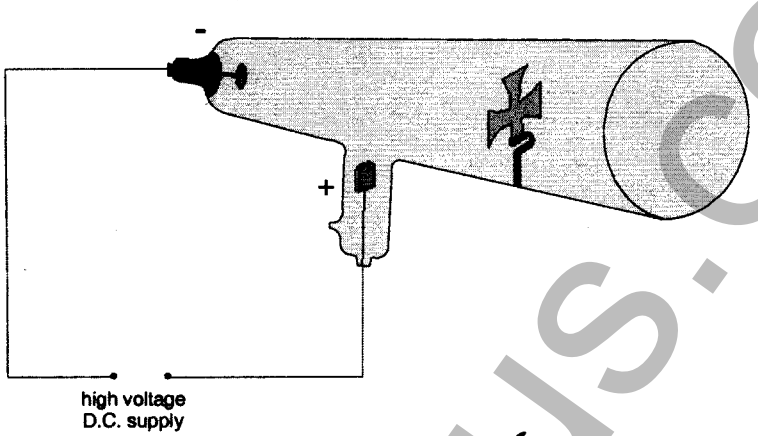
(c) Describe one application of electrically charged parallel plates. **2**

Student Number

**Marks**

**Question 27** (5 marks)

The following diagram shows one of the cathode ray tubes used to identify the properties of cathode rays. In this tube, a metal target in the shape of a Maltese Cross, can be placed in the path of the cathode rays.




(a) Describe the observation made when the metal target was upright in the path of the cathode rays. **1**

(b) Identify the property of cathode rays that is revealed by the observation you have described in part (a). **1**

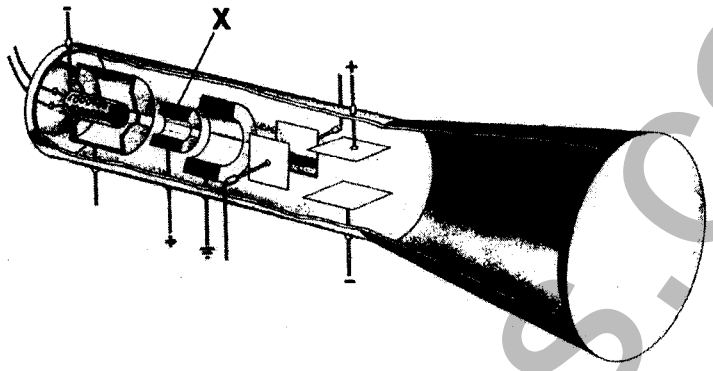
(c) Explain why the apparent inconsistent behaviour of cathode rays caused a debate as to whether they were charged particles or electromagnetic waves. **3**

Student Number

**Marks**

**Question 28** (4 marks)

The following diagram shows the main parts of a cathode ray tube, in an oscilloscope. Some parts of the diagram have been shown as a cut-away cross section.




(a) Identify X. **1**

(b) Outline the role of the electrodes in the electron gun. **1**

(c) Discuss the impact of the development of the oscilloscope on experimental physics. **2**

## Section II

**25 marks**
**Attempt ONE question from Questions 29 - 33**
**Allow about 45 minutes for this section.**

Answer the question in a writing booklet. Extra writing booklets are available.
Show all relevant working in questions involving calculations.

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**Pages**


| | | |
|---|---|---|
| **Question 29** | **Geophysics** | |
| **Question 30** | **Medical Physics** | |
| **Question 31** | **Astrophysics** | |
| **Question 32** | **From Quanta to Quarks** | **21 - 22** |
| **Question 33** | **The Age of Silicon** | |

**Marks**

**Question 32 - From Quanta to Quarks** (25 marks)

(a) (i) Calculate the De Broglie wavelength of an electron with a velocity of $4.55 \times 10^6$ ms$^{-1}$. **1**

(ii) Explain the stability of electron orbits in the Bohr atom using De Broglie's hypothesis. **2**

(iii) The electron microscope is a very useful tool in many areas of scientific study. Outline the reason why it has a greater resolving power than the light microscope. **1**

(b) Natural transmutation occurs when one radioactive element decays into another element. Write a balanced nuclear equation illustrating the alpha decay of Bismuth 214 into another element. **1**

(c) Prior to Chadwick's discovery of the neutron it was thought that the nucleus was composed of protons and electrons. Describe how the use of conservation laws assisted Chadwick in his discovery of the neutron. **3**

(d) Use the following nuclear fission transmutation and the table of atomic masses to calculate the mass defect and energy released during the fission of one atom of ${}^{235}_{92}U$. **3**

$$ {}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{148}_{57}La + {}^{85}_{35}Br + 3{}^{1}_{0}n $$

| Particle | Mass of Particle (kg) |
|---|---|
| ${}^{235}_{92}U$ | $3.90173 \times 10^{-25}$ |
| ${}^{148}_{57}La$ | $2.45539 \times 10^{-25}$ |
| ${}^{85}_{35}Br$ | $1.40952 \times 10^{-25}$ |
| ${}^{1}_{0}n$ | $1.675 \times 10^{-27}$ |

**Question 32 continues on page 22**

**Marks**

Question 32 (continued)

(e) Discuss and assess the contributions of Heisenberg and Pauli to the development of atomic theory. **6**

(f) Describe how Bohr's postulates led to the development of a mathematical model of the hydrogen atom to account for the existence of the hydrogen spectrum and discuss the limitations of this model. **8**

**End of Question 32**