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 =

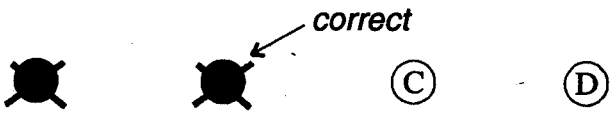
(A) 2 (B) 6 (C) 8 (D) 9

Ⓐ ● Ⓒ Ⓓ

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

● ✕ Ⓒ Ⓓ

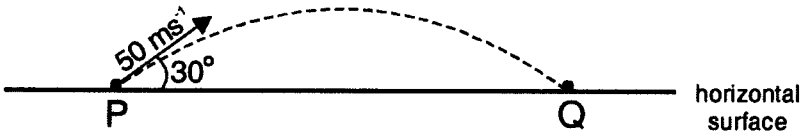
If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows.



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.



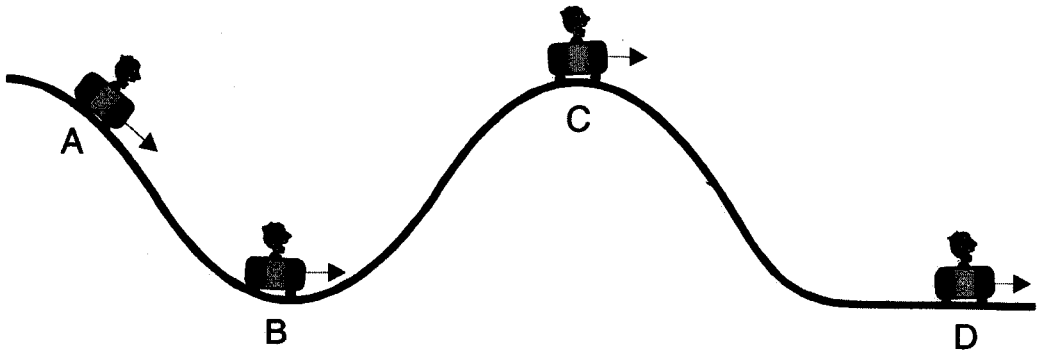

What is the magnitude of the displacement from P to Q?

(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?



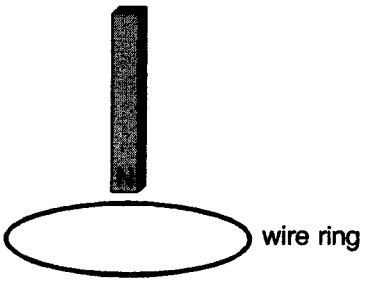
**5** What is the potential energy of a 1.0 kg mass at the surface of the Earth assuming the radius of the Earth is 6380 km?

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

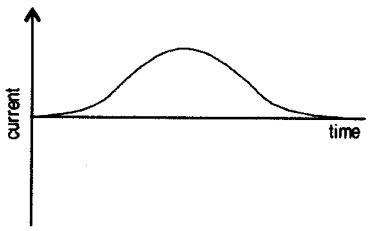
**6** An electric motor driven from a constant voltage supply is used to raise a load. If the load is decreased which one of the following sets of changes occurs?

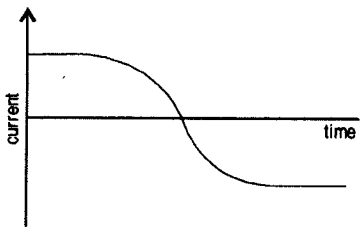
| | *speed of rotation* | *back emf* | *current in coil* |
|---|---|---|---|
| (A) | decreases | decreases | increases |
| (B) | increases | increases | decreases |
| (C) | decreases | decreases | decreases |
| (D) | increases | decreases | increases |

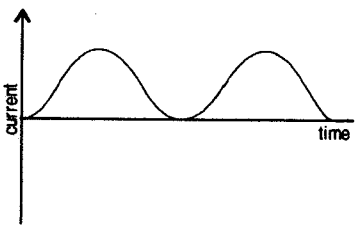
**7** A bar magnet is lowered at constant speed through a wire ring, as shown in the diagram.

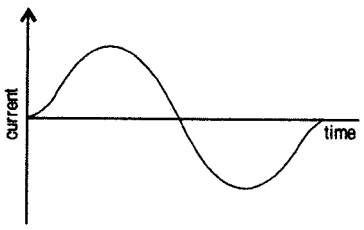



Which graph best represents the variation of current induced in the ring with time?

(A)



(B)


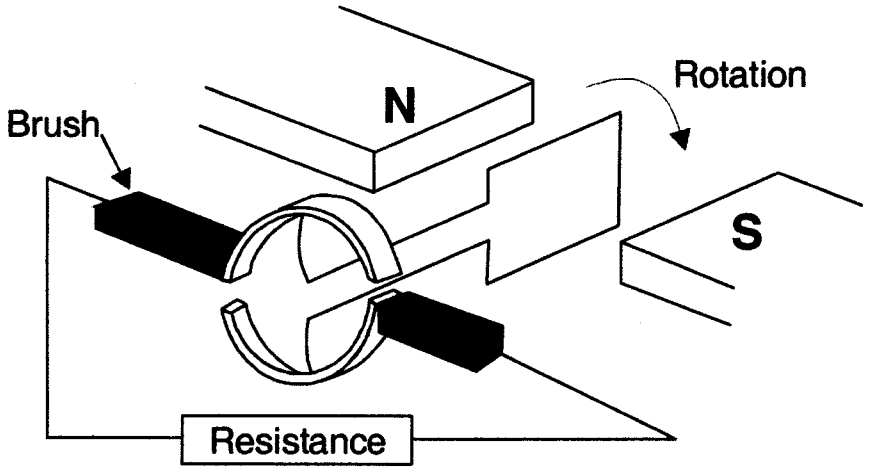

(C)



(D)


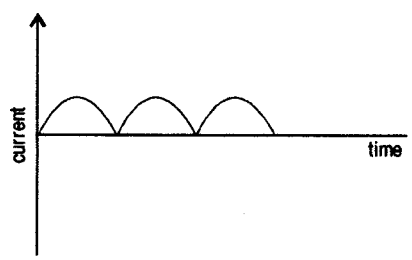
**8** An ideal transformer has a primary coil with 2000 turns and a secondary coil with 850 turns. If the primary voltage is 240 V, what is the secondary voltage?

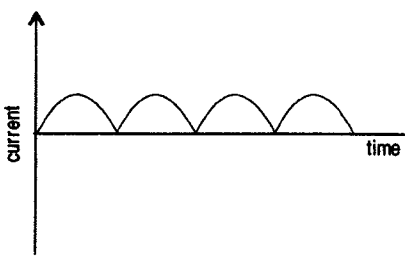
(A) $6.86 \times 10^{-4}$ V
(B) $3.65 \times 10^{-4}$ V
(C) $1.02 \times 10^{2}$ V
(D) $2.74 \times 10^{3}$ V

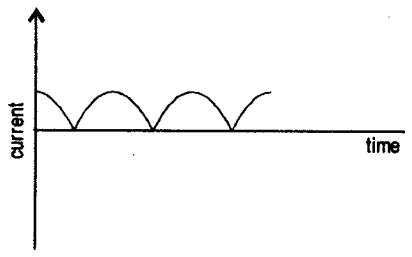
**9** One type of generator is shown in the diagram below.

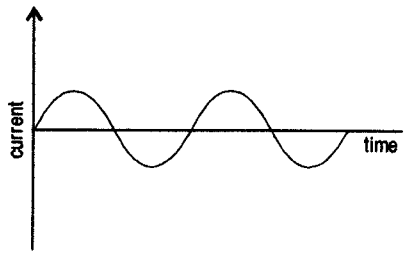



Which graph shows the output current that flows in the resistor as the generator makes two full rotations of the coil from the starting position shown in the diagram?

(A)


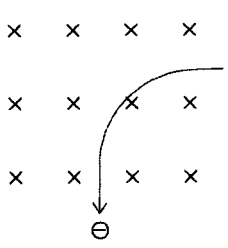

(B)



(C)


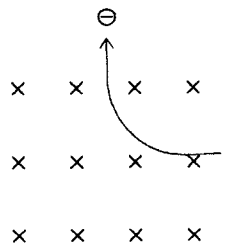

(D)


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

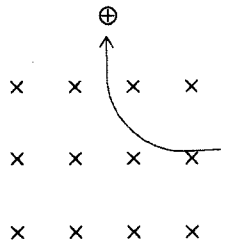
(A)



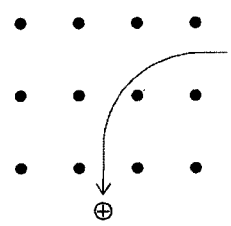
(B)



(C)



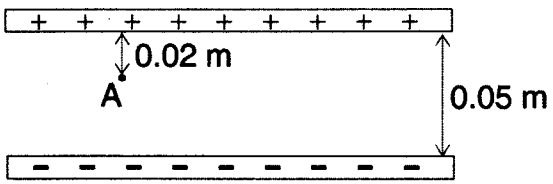
(D)



**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.



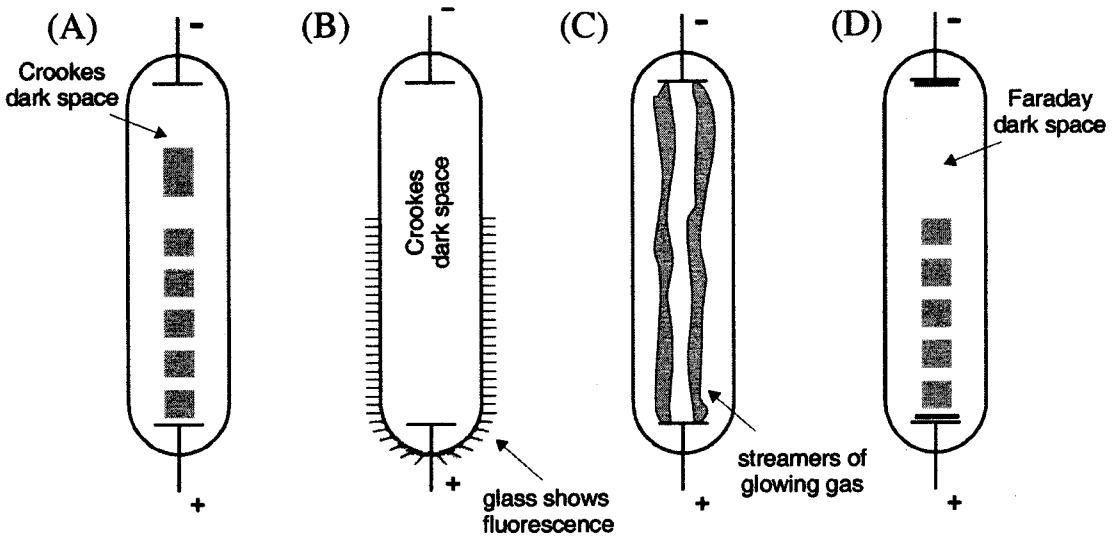

If the potential difference between the positive plate and point A is 40 V, what is the electric field strength between the plates?

(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**

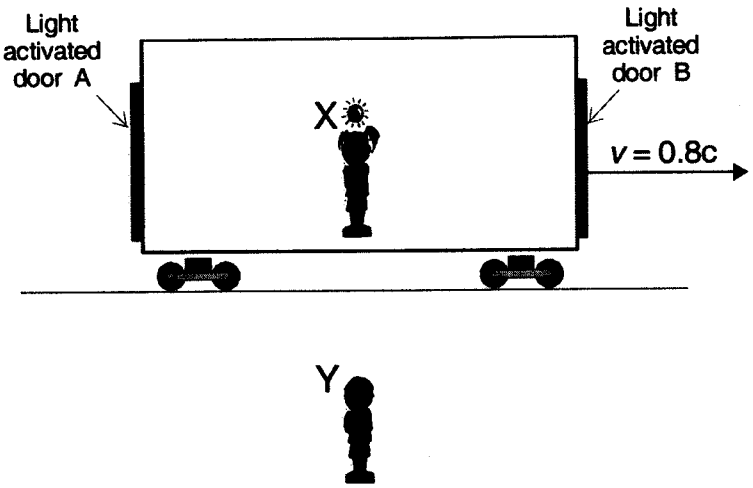
(b) Describe how a slingshot effect around Jupiter was used to accelerate the space probe. **3**

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**



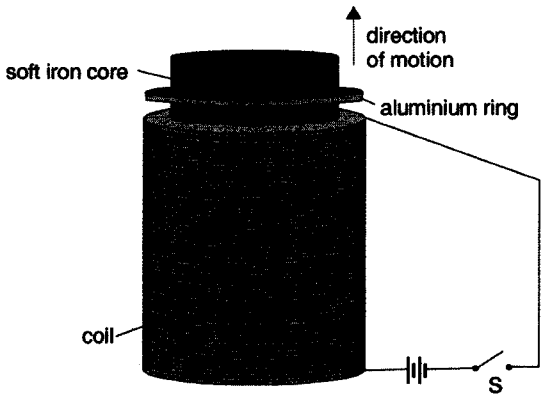

Explain how this thought experiment can show the relativity of simultaneity of events for observer X and observer Y.

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.



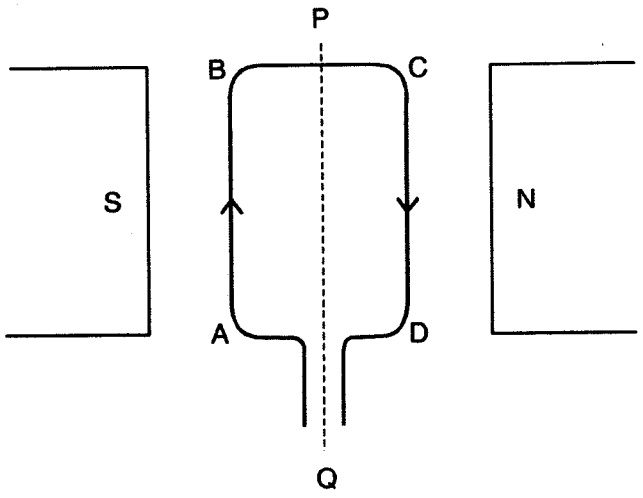

Explain how Faraday's Law and Lenz's Law are applied to explain the movement of the aluminium ring. **4**

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)

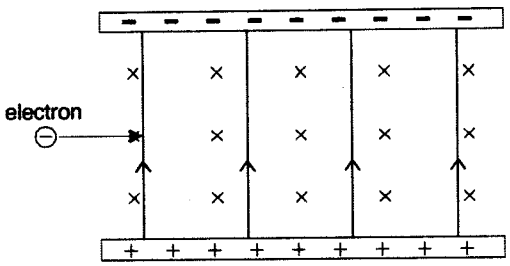
Analyse the impact of the development of transformers on society. **8**

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**

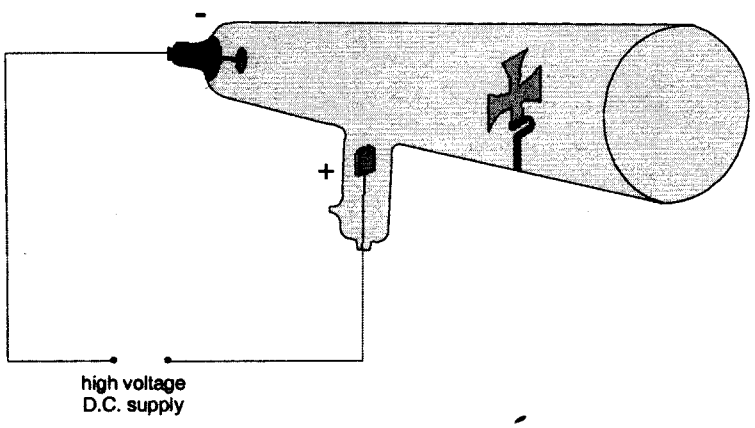
(c) Describe one application of electrically charged parallel plates. **2**

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**

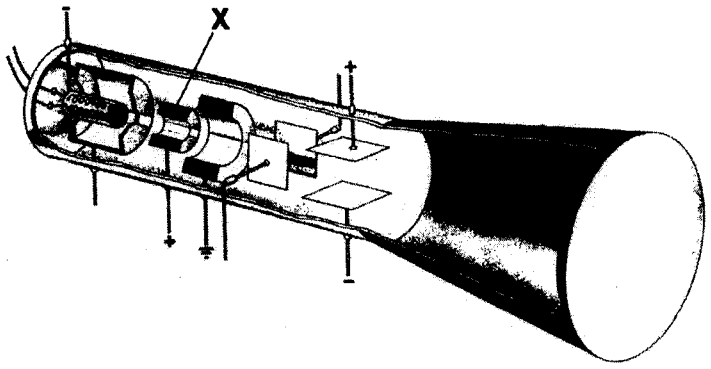
(c) Explain why the apparent inconsistent behaviour of cathode rays caused a debate as to whether they were charged particles or electromagnetic waves. **3**

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**

**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**

2 4M RJJF

SYDNEY GRAMMAR SCHOOL

Class

Student Number

# Physics

## Part A

## ANSWER SHEET

**2002**

**FORM VI**

**HIGHER SCHOOL CERTIFICATE**

**TRIAL EXAMINATION**

### General Instructions

- Write your class and student number in the space provided.
- Attempt all questions 1 – 15
- Use a blue or black pen
- Select the alternative A, B, C, or D that best answers the question.
- Fill in the response oval completely.

| | | | | |
|---|---|---|---|---|
| 1. | ● | B | C | D |
| 2. | A | ● | C | D |
| 3. | A | B | C | ● |
| 4. | A | B | ● | D |
| 5. | A | B | C | ● |
| 6. | A | ● | C | D |
| 7. | A | B | C | ● |
| 8. | A | B | ● | D |
| 9. | A | ● | C | D |
| 10. | A | ● | C | D |
| 11. | ● | B | C | D |
| 12. | A | B | ● | D |
| 13. | A | ● | C | D |
| 14. | A | ● | C | D |
| 15. | ● | B | C | D |

| Examiners use only | |
|---|---|
| Marks for Part A: | |

## Section I (continued) Marking Scheme AWW

## (Masters only)

**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.

**Maintains a constant geographical position (stays over one point on the Earth's surface**
**AND**
**therefore a ground receiver can be aimed at a constant angle (OR allowing constant 24 hr contact between satellite and ground)** — **1**

(b) Calculate the radius of a geostationary orbit.

**Any calculation leading to radius = $4.2 \times 10^7$ metres (4240 km)** — **1**

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

- **Describe that rotation of Earth gives a surface velocity at the equator that adds an initial velocity to the space craft if it is launched in the direction of rotation.** — **1**
- **Recognise the energy advantage/disadvantage involve** — **1**
- **Recognises that a launch north-south adds no advantage** — **1**

**OR a launch to west gives a negative initial velocity**

**OR use good physics to show that the equator is better than other latitudes**

Marks

**Question 17** (3 marks)

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

| | |
|---|---|
| **Describes the proposal of two independent components of the motion** | **1** |
| **Describes BOTH components:**<br>• **Horizontal – constant velocity**<br>• **Vertical – accelerating at g, OR has a gravitational force acting** | **1** |
| **States that the final parabolic path is the result of both components acting simultaneously** | **1** |

**Question 18** (6 marks)

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

| | |
|---|---|
| • **States at least two causes of difficulties from:**<br>**Distance , van Allen Belts, Sun spot activity** | **1** |
| • **States any third cause of difficulty.**<br>**Examples: ionosphere, atmospheric absorption, line of sight occlusion, other EM communications on Earth or in space (noise)** | **1** |
| • **Discuss how each cause produces communication difficulties between Earth and satellite. (1 mark each)** | **3 (max)** |
| • **Shows an exceptional understanding of the physics of the causes OR shows the link between solar activity and van Allen Belts or ionosphere** | **1** |

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. **Total 2**

$$F = \frac{Gm_1m_2}{r^2} = \frac{6.7x10^{-11}\,x2.0x10^{30}\,x750}{(9.8x10^{12})^2}$$ **1**

**$= 1.05 \times 10^{-3}$ N includes unit** **1**

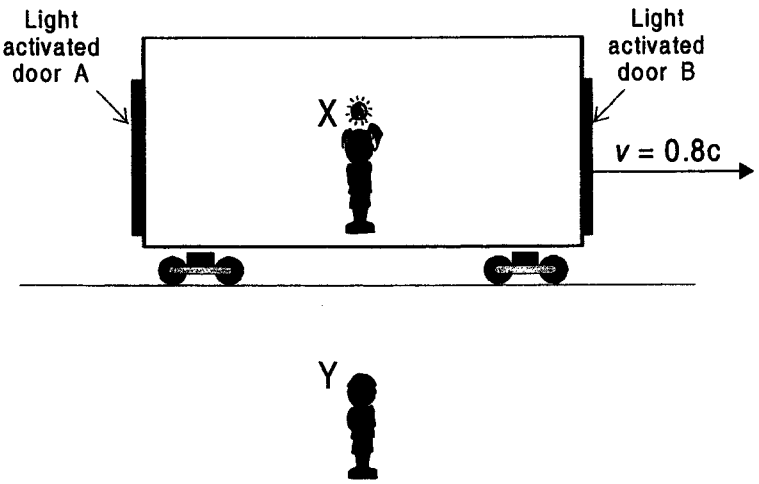
(b) Describe how a slingshot effect around Jupiter was used to accelerate the space probe. **Total 3**

- **Recognises that the orbital velocity of Jupiter adds to the probe velocity** **1**
- **Describes a mechanism in terms of momentum exchange during a non-contact elastic collision with Jupiter OR adds to the description by discussing velocity relative to the sun.** **1**
- **Shows an exeptional understanding of the process (eg by including a diagam or algebraic treatment including a vector addition of velocities)** **1**

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.

- **Shows a basic understanding of the concept of relativity of simultaneity** 1
- **Gives a basic description of what BOTH observers see including distance and/or time of travel for light 'rays'** 1
- **(X sees A & B open simultaneously: Y sees A open before B because it 'runs into the light)**

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- **Shows a good understanding of the reasons why the door openings A & B are not simultaneous for B but are simultaneous for A, in terms of train movement and light movement** 1

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- **Relates the reasons to the constancy of the velocity of light v =c, for BOTH observers.** 1

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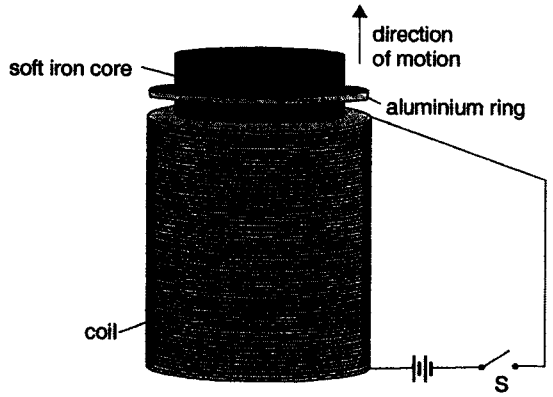
Question 21 (4 marks)

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

As current in coil increased, it produces a changing B inside the ring. This induces a current in the ring (Faraday). Current In the ring produces a B of its own. The direction of this B opposes the B of the coil (Lenz), therefore the ring jumps off.

4 for an answer which shows a thorough understanding of this
3 for an answer which misses a major point
2 for a general idea of the process
1 for a poor understanding
0 for an answer which contains no correct physics.

Question 32 (continued)

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

3 marks for each scientist, one mark for each of the following points:

Heisenberg:

- Uncertainty principle states that there are limits to our knowledge about the position and momentum of an object
- Mathematically: $\Delta x \, \Delta p \geq \hbar$ where $\Delta x$ = uncertainty of position,
  $\Delta p$ = uncertainty of momentum
  $\hbar = h/2\pi$
  or a good explanation as to why momentum and position can't be determined simultaneously
- This principle led to the development of our quantum mechanical model of the atom where we talk in terms of probabilities rather than definite and predictable values. Electrons exist in clouds

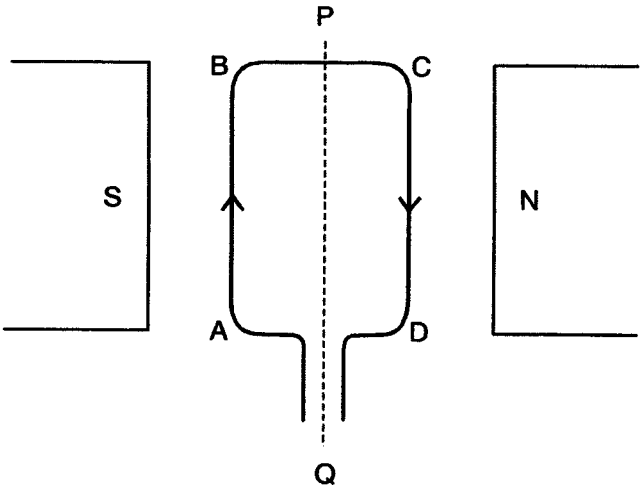
Pauli:

- Exclusion principle which states that no two electrons can have the same quantum state. (quantum numbers)
- This explained the periodic table by showing why the shells had a maximum number of electrons
- Postulated the existence of the neutrino which explained beta decay more fully.

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.

Calculate the torque on the loop. 1

Torque = nBIA = 1 x 0.085 x 4.5 x (0.25 x 0.2)

∴ T = 0.019 Nm (no, or incorrect units lost the mark)

Describe the net result of the forces on the loop. 2

The loop rotates about PQ (side CD goes down) - 1 mark

The loop (eventually) stops at $90^{o}$ - 1 mark

Discuss the importance of the invention of the commutator to the development of the electric motor. 2

Commutator reverses the direction of the current in the loop every half turn - 1 mark

So that the loop continues to rotate. - 1 mark

**Marks**

Question 23 (3 marks)

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

1 mark for a description of an experimental setup which will demonstrate the Motor effect or induction

1 mark for description of a result which was due to the above effect.

1 mark for an explanation of the result in terms of the effect under consideration or a link to the induction motor.

Question 24 (3 marks)

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

Loop rotates in B which induces a current in the loop - 1 mark

Loop's direction wrt field reverses each half turn, therefore the current Reverses as a consequence - 1 mark

Slip rings allow the current produced to be fed into an external circuit. - 1 mark

Marks

Question 25 (8 marks)

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

Transformers allow voltages to be changed to allow:

- Distribution at high voltages to reduce losses over long distances
- As P=IV, high V means low I
- Power generation away from population centres (less pollution, power for remote areas, urban sprawl)
- Stepped down at domestic end for safety
- Allows a wide range of applications which need various voltages
- Labour saving devices widespread domestically and industrially - unemployment
- More energy consumed - pollution and depletion of fossil fuels, carbon dioxide and global warming
- Some health risks may be associated with high tension power lines
- Less dependance on coal for heating led to an improvement of air quality in cities

1 mark for any reasonable point to a maximum of 8 marks

Note:

- it was difficult to get more than 6 marks unless some negative impacts were mentioned.
- many boys wasted time and effort describing the transformer itself, rather than its impact.
- Many answers were repetitive.

Crib form VI 2002 Physics exam

Quanta to Quarks

Q32a (i) $\lambda = h/p = h/(mv) = 1.5987 \times 10^{-10}$ m.( 1mark)

(ii) De Broglie proposed that electrons had wave properties and that the electron formed a non radiating standing wave around the nucleus. He stated that an integral number of electron wavelengths fit around the circumference of the orbit.( 2marks)

(iii) Resolving power is inversely dependent on wavelength. High speed electrons have a much smaller wavelength than visible light and hence have much great resolving power.( 1mark)

(b) ${}_{83}Bi^{214} \rightarrow {}_{2}He^{4} + {}_{81}Tl^{210}$ ( 1mark)

c) Chadwick repeated the experiment of Joliot and Curie of firing alpha particles into Be and then letting the neutral rays pass through paraffin and nitrogen gas. By measuring the momentum and kinetic energy of the protons released and nitrogen atoms he was able to demonstrate that the neutral radiation had a mass slightly larger than a proton. In particular he derived an equation using the laws of conservation of momentum and energy which connected the velocity of the proton or nitrogen to the mass of the neutron.

(3 marks for a superior description with diagram), (2 marks for good description but with details left out),(1 mark for some indication that the pupil knew of Chadwick's work)

d) $m_I = 3.91848 \times 10^{-25}$ kg (1 mark)
$m_F = 3.91516 \times 10^{-25}$ kg
mass defect $\Delta m = 3.32 \times 10^{-28}$ kg ( 1mark)
$E = \Delta mc^2 = 2.988 \times 10^{-11}$ kg ( 1mark)

(e) over page.

f) 3 marks for Bohr's postulates
i.e. angular momentum is quantized $mvr = nh/2\pi$
there exist stable electron orbits where electrons do not radiate e-m waves
Energy is emitted or absorbed when electrons move from one orbit to another. $\Delta E = hf$.

1 mark for connecting the energy emitted by an electron when it moves from one orbit to another as producing a photon which leads to the hydrogen spectral lines

2 marks for a description of limitation eg Zeeman effect(splitting of spectral lines in a magnetic field), Hyperfine splitting of spectral lines due to the interaction of the magnetic moment of the nucleus with the electron.

2 marks for either a description of the mathematics or the mathematics for how Bohr derived the Rydberg equation eg
*Bohr set the centripetal force = to the electrostatic force and then*
*Bohr used the quantization of angular momentum and the fact that the total energy of the electron was made up of electrical potential energy + the kinteic energy of the electron to shown that the Energy of the electrons depended on* $1/n^2$.

## Question 28 (a) (1 mark)

### Marking Guidelines

| Criteria | Marks |
|---|---|
| • anode. | 1 |

## Question 28 (b) (1 mark)

### Marking Guidelines

| Criteria | Marks |
|---|---|
| • outlines the correct role of the electrodes in the electron gun relating to: –<br>– accelerating the electron beam to high speed;<br>OR – focus the beam;<br>OR – producing the electrons. | 1 |

## Question 28 (c) (2 marks).

### Marking Guidelines

| Criteria | Marks |
|---|---|
| • Demonstrates a thorough understanding of the impact of the development of the oscilloscope on experimental physics by discussing in detail a range of reasons relating to: – viewing<br>– analysing<br>– measuring<br>plus example. | 2 |
| • Demonstrates some understanding of the impact of the development of the oscilloscope on experimental physics by discussing briefly a range of reasons relating to: – viewing<br>– analysing<br>– measuring<br>plus example. | 1 |

| Criteria | Marks |
|---|---|
| OR<br>• Clearly and correctly explains why the apparent inconsistent behaviour of cathode rays caused a debate, using a range of reasons relating to any two from the above list for either waves or particles and any one from the above list for the other.<br>e.g. 2 behaviours for waves, 1 behaviour for particles OR.<br>2 behaviours for particles, 1 behaviour for waves. | 2 |
| OR. • A well argued statement re inconsistent behaviour regarding cathode rays not deflected in electric fields but being deflected in magnetic fields.<br>clear, well explained physics required to obtain two marks. | 2 |
| • States at least two reasons but does not explain which relates to waves and which one is to particles. | 1 |
| OR • States at least one or two reasons for either waves or particles only<br><br>OR • States one reason for waves and reason for particles. | 1 |

Question 27 (c) (3 marks)

MARKING GUIDELINES

| Criteria | Marks |
|---|---|
| • Clearly and correctly explains why the apparent inconsistent behaviour of cathode rays caused a debate, using a range of reasons relating to at least <u>three</u> from:<br><u>Particle nature of cathode rays.</u><br>- push objects along (paddle wheel).<br>- deflected by magnetic fields<br>- deflected by electric field<br>- cathode rays deposited negative charges on impact with an object.<br>AND at least three from:<br><u>Electromagnetic radiation nature</u><br>(= light like characteristics)<br>- passed through the thin metal films because no particles had ever been observed to do this.<br>- not deflected by electric fields.<br>- travels in straight lines<br>- causes fluorescence.<br>- causes chemical reactions. | 3 |
| • Clearly and correctly explains why the apparent inconsistent behaviour of cathode rays caused a debate, using a range of reasons relating to any two from the above list for wave phenomena AND any two from the above list for particle phenomena. | 2 |

## Question 27 (a) (1 mark)

MARKING GUIDELINES

| Criteria | Marks |
|---|---|
| • Correctly describes the observation made when the metal target was upright in the path of the cathode rays. | 1 |

Sample answer:

A shadow of the metal target appeared in the midst of the green glow at the end of the tube.

## Question 27 (b) (1 mark)

MARKING GUIDELINES.

| Criteria | Marks |
|---|---|
| • Identifies a correct property of cathode rays revealed by the observation described in part (a). | 1 |

Sample answer:

Cathode rays travel in straight lines or cathode rays cannot pass through metal.

Question 26(c) continued.

Acceptable applications include:

- Cathode ray oscilloscopes – useful to control X- or/and Y- deflection
- Electron microscopes
- velocity selector
- determination of $q/m$ ratio for electrons.

Did not accept

Television

Lightning rods.

Maximum of 1 mark for use of electric fields in photocopier operation.

Sample Answer:

Electrically charged plates are used in cathode ray oscilloscopes, to direct the electron beam up, down, left or right before hitting the fluorescent screen. This enables the complex wave patterns to be analysed.

## Question 26 (a) (1 mark)

MARKING GUIDELINES

| Criteria | Marks |
|---|---|
| • Correct answer<br>$F_B = Bqv\sin\theta$<br>$= 7.5\times10^{-2}\times1.602\times10^{-19}\times5.7\times10^{3}\times1$<br>$= 6.85\times10^{-17}\,N$ | 1 |

## Question 26 (b) (2 marks)

MARKING GUIDELINES

| Criteria | Marks |
|---|---|
| • Uses the correct formulae for $F_E$, substitutes correct values into $F_E = qE$ and correctly adds vectorially $F_E$ and correct or incorrect $F_B$ from part (a) (i.e. Answer (a) + $1.602\times10^{-19}\times250$)<br>Sample Answer:<br>net force = $6.85\times10^{-17}\,N\downarrow + 1.602\times10^{-19}\times250$<br>$= 1.086\times10^{-16}\,N$ (down) | 2 |
| • Correct addition vectorially of incorrect $F_E$ with $F_B$ | 1 |

## Question 26 (c) (2 marks)

MARKING GUIDELINES

| Criteria | Marks |
|---|---|
| • States an example in which the application of electrically charged parallel plates is useful.<br>AND<br>• A purpose for this use. | 2 |
| EITHER<br>• States an example in which the application of electrically charged parallel plates is useful.<br>OR<br>• A purpose for this use. | 1 |