SYDNEY GRAMMAR SCHOOL

2007
FORM VI
TRIAL HSC EXAMINATION

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using blue or black pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A data sheet, formulae sheets and Periodic Table are provided at the back of this paper
- Write your candidate number at the top of each page in Part B
- Hand in the paper in ONE bundle at the end of the exam.

Check List

Each candidate must have

- Question paper
- Multiple choice answer sheet
- Five-page booklet

Total marks (100)

Section I Pages 2 - 28

(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 - 30
- Allow about 1 hour and 45 minutes for this part

Section II Pages 29 – 32

(25 marks)

- Use a separate writing booklet
- Attempt Question 34 only.
- Allow about 45 minutes for this section

Masters

AAH – Dr A. Haines

MRW – Dr M. Ward

AWW – Mr A. Woolnough

RJF – Mr J. Forbes

SRW – Mr S Williams

1 The weight of the Mars Exploration Rover (MER) on the Earth's surface is 1.77×10^3 N. Which of the following gives the correct weight of the MER on the planet Mars if the acceleration due to gravity is 3.71 ms^{-2} on the Martian surface?

(A) 1.8×10^2 N
(B) 4.8×10^2 N
(C) 6.7×10^2 N
(D) 6.6×10^3 N

2 Mars has a mass 6.42×10^{23} kg and the escape velocity from the surface of Mars is 5.03×10^3 ms^{-1}. What is the radius of Mars?

(A) 1.7×10^6 m
(B) 3.4×10^6 m
(C) 8.5×10^9 m
(D) 1.7×10^{10} m

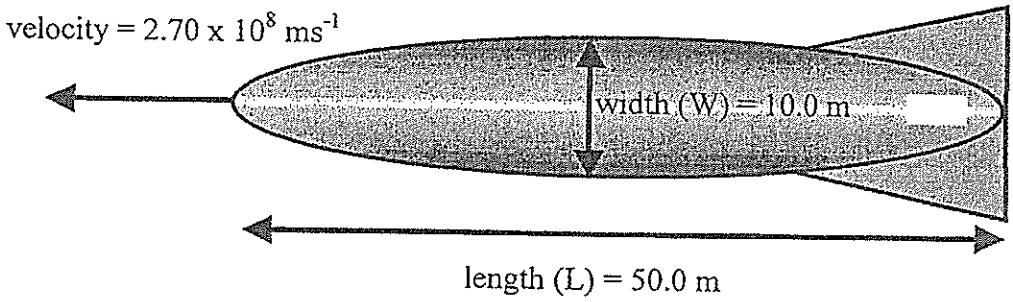
3. On December 2, 2006, contact with the Earth Probe spacecraft was lost. It is orbiting at an altitude of 730 km. Since there is no more on-board fuel, it is not possible to do a controlled re-entry. What is the type of orbit and the most likely outcome for this spacecraft?

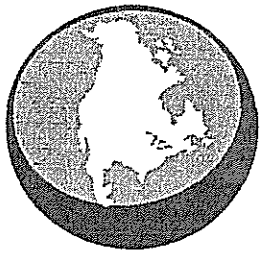
(A) Low Earth orbit suffering orbital decay and will burn up on re-entry.
(B) Stable geostationary orbit but will rapidly fall into the sun.
(C) Low Earth orbit, and will fly off into space.
(D) Geostationary orbit, but will soon re-enter the atmosphere and burn up.

4. Galileo discovered four moons of Jupiter. One moon - Io - which he measured to be 4.2 units from the centre of Jupiter and to have an orbital period of 1.8 earth days. A second moon, Ganymede, he found to be 10.7 units from the centre of Jupiter. What is the orbital period of Ganymede?

(A) 4.6 earth days
(B) 7.3 earth days
(C) 9.01 earth days
(D) 10.7 earth days

5 A spacecraft is moving with a constant velocity of 2.70×10^8 ms^{-1}. The dimensions of the spacecraft, shown in the following diagram, are measured by an observer on the spacecraft.





stationary planet

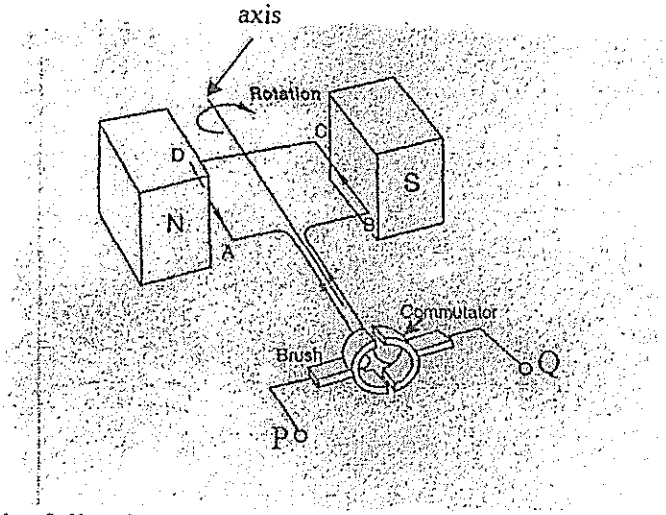
What are the correct dimensions of the moving spacecraft as observed by a stationary observer on the planet?

	Length (L) observed from planet	Width (W) observed from planet
A	115	22.9
B	115	10.0
C	50.0	4.36
D	21.8	10.0

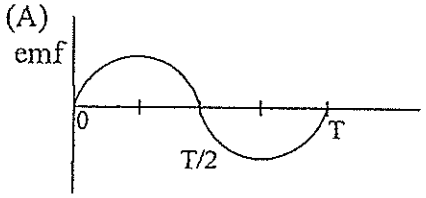
6 A DC electric motor connected to a constant voltage supply is used to raise a load at a constant rate.
When the load is then removed, the speed of rotation of the coil increases.
Which of the following quantities also increases?

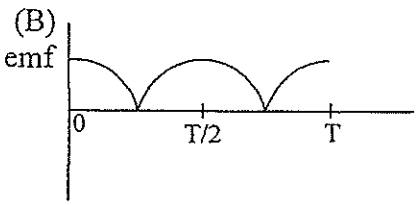
(A) back emf
(B) net voltage
(C) current
(D) resistance of the coil

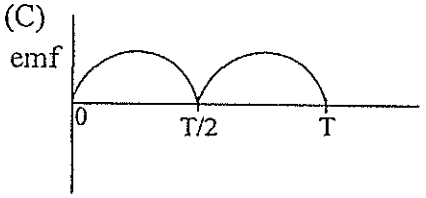
7 The following diagram shows a single rectangular loop in a generator that rotates with constant rotational speed about the axis shown. The magnetic field is uniform and constant. At time, t = 0, the magnetic flux through the coil is 0 Wb.

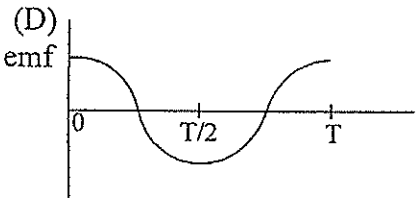


Which of the following graphs shows the resultant induced emf at terminals PQ for one complete rotation? (Note: T = period of rotation).

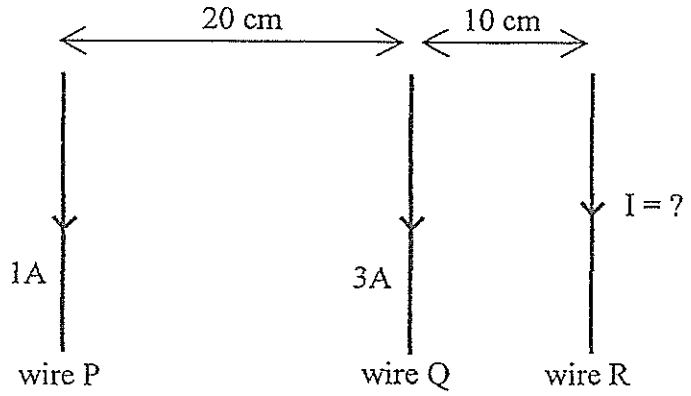
(A)


(B)


(C)


(D)


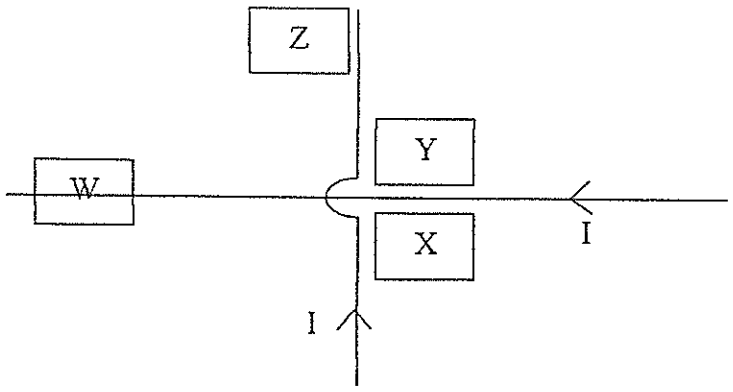
8 Three parallel wires of equal length carry steady currents as shown in the diagram.



What current must flow in wire R so that the net magnetic force on wire Q is zero?

(A) 0.25A
(B) 0.50A
(C) 1.0A
(D) 2.0A

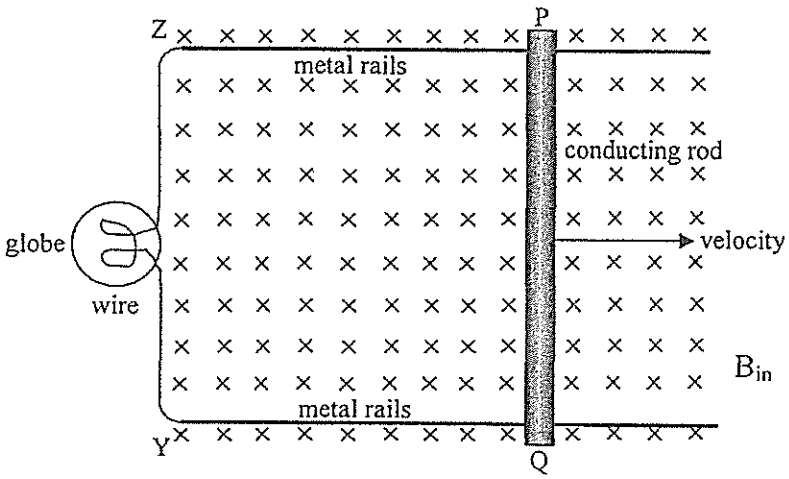
9 Two straight wires, each carrying identical currents, are arranged at right angles to each other and lie in a horizontal plane. The wires are not connected to each other.



The diagram above shows four identical areas, labelled W, X, Y and Z, each of which lies in the same horizontal plane as the two wires.
Which area has the greatest magnetic flux?

(A) W
(B) X
(C) Y
(D) Z

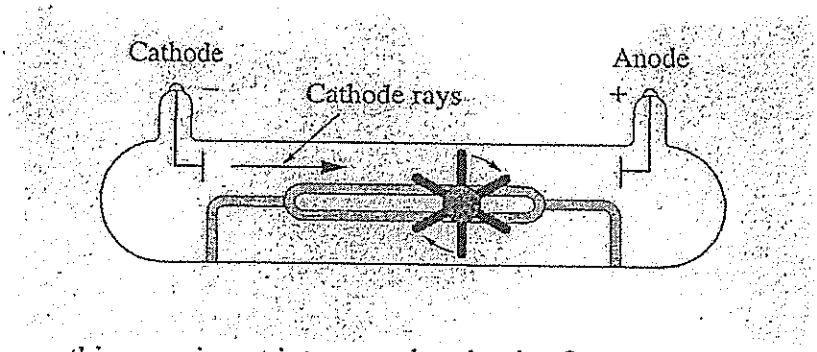
10 A horizontal conducting rod PQ makes contact with horizontal metal rails ZP and YQ. The apparatus is in a uniform magnetic field directed down into the page.



The conducting rod, while still in contact with the rails, is moved at constant velocity to the right, through the magnetic field. Which statement about the current through the globe is correct?

(A) No current flows.
(B) An alternating current flows between Y and Z.
(C) A direct current flows from Y to Z.
(D) A direct current flows from Z to Y.

11 The diagram below shows the famous 'paddle-wheel' experiment performed to investigate the properties of cathode rays. When the electron beam is turned on, the wheel is seen to rotate from the cathode to the anode.

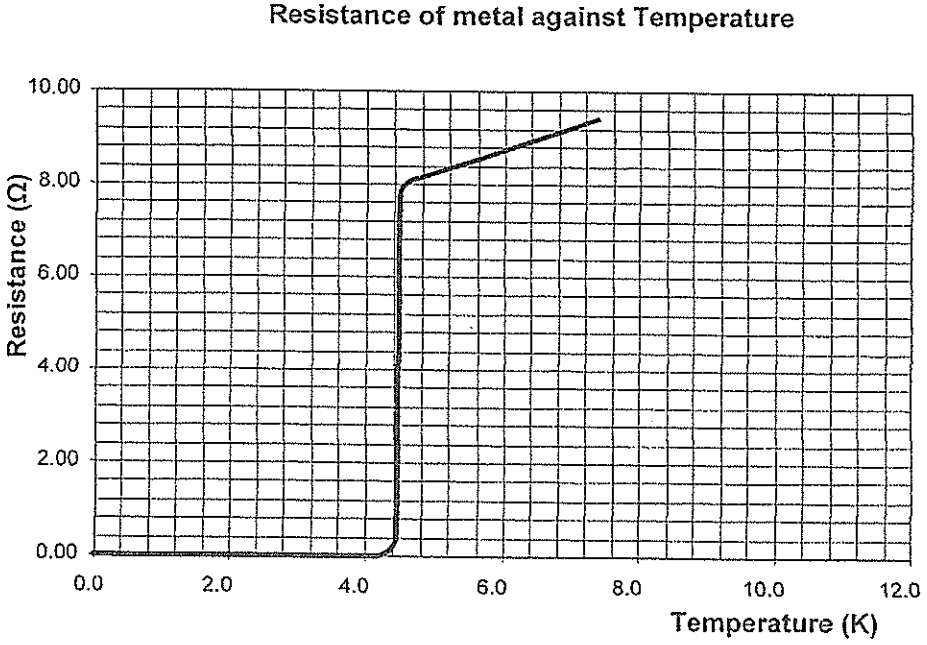


How was this experiment interpreted at the time?

(A) Cathode rays are undeflected by magnetic fields.
(B) Cathode rays are negatively charged.
(C) Cathode rays pass through solid matter.
(D) Cathode rays have momentum.

12 The table below lists the critical temperature of four common metals, and the graph shows how the resistance of a sample of one of those metals varies with temperature.

Metal	Critical Temperature (K)
Lead	7.2
Tin	3.7
Mercury	4.2
Zinc	0.9



Identify the metal used in the graph.

(A) Lead
(B) Tin
(C) Mercury
(D) Zinc

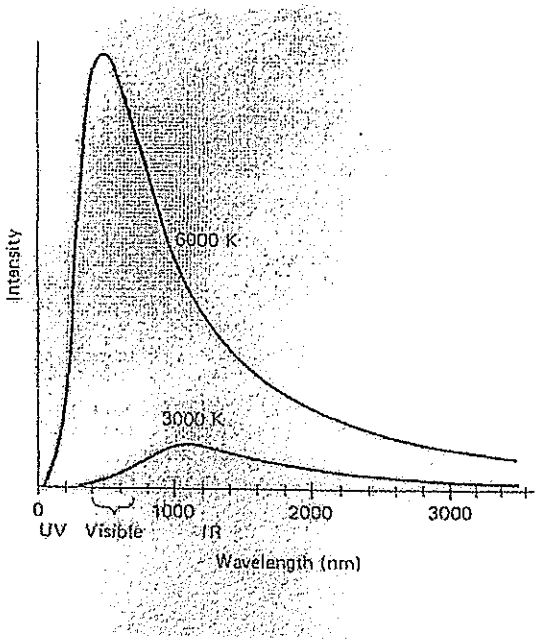
13 Identify the physicist who first proposed that the energy emitted and absorbed by the walls of a black body cavity is quantised.

(A) Planck
(B) Hertz
(C) Einstein
(D) Bohr

14 Calculate the energy of a photon of light of wavelength 4.8×10^{-9}m.

(A) 4.1×10^{-17} J
(B) 1.3×10^{-25} J
(C) 9.4×10^{-34} J
(D) 3.2×10^{-42} J

15 The diagram below shows the radiation curves for a black body at two different temperatures.



At, 3000 K, What is the wavelength of light at which the intensity of emission is a maximum?

(A) 300 nm
(B) 500 nm
(C) 1100 nm
(D) 3000 nm

Class

Candidate Number

Part B

Total marks - 60
Attempt Questions 16 - 30
Allow about 1 hour and 45 minutes for this Part

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

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Question 16 (5 marks) **Marks**

a) Calculate the change in gravitational potential energy of a satellite with a mass of 1.50×10^2 kg that results from lifting it from the surface of the Earth to a position 4.17×10^7 m from the centre of the Earth. 3

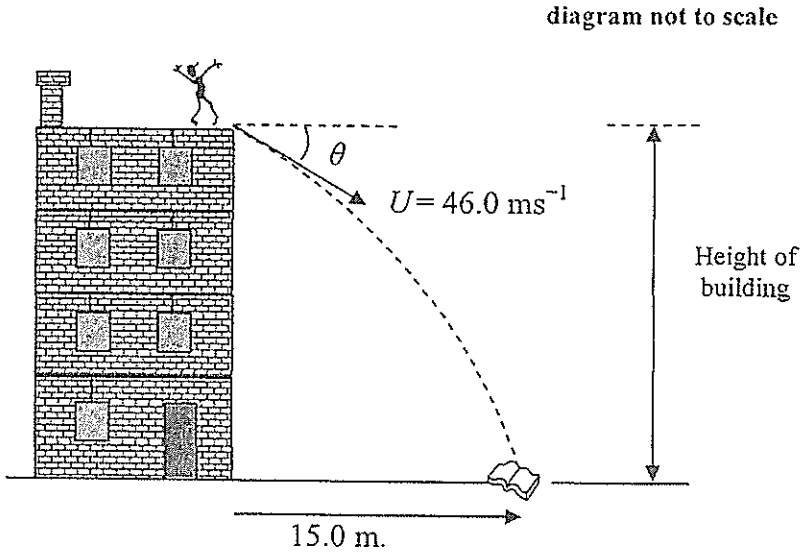
b) Identify two reasons why the total energy required to launch a 150 kg satellite into an orbit 4.17×10^7 m from the centre of the Earth is much greater than the value you have calculated in part a) 2

Class

Candidate Number

Question 17 (6 marks) **Marks**

A student stands on the top of a building and throws his physics book downwards, at angle θ, with an initial velocity, $U = 46.0\ ms^{-1}$.
This is shown in the following diagram:



The book is observed to hit the ground 15.0 m from the base of the building, taking 0.420 seconds to hit the ground. Ignore any effects of air resistance.

a) Calculate the horizontal component of the initial velocity. **1**

b) Determine the angle θ. **1**

Question 17 continued on next page.

Class

Candidate Number

Question 17 (continued) **Marks**

c) Calculate the height of the building. 2

d) Calculate the magnitude of the final velocity of the book just before it hits the ground. 2

Class

Candidate Number

Question 18 (3 marks)

Marks

A satellite of mass 1.75×10^3 kg orbits the Earth at a distance of 7.88×10^6 m from the centre of the Earth, in a stable circular orbit.

a) Calculate the centripetal force acting on the satellite. **1**

b) Determine the period of the orbit of the satellite. **2**

Class

Candidate Number

Question 19 (2 marks)

Marks

An astronaut of mass 80.0 kg stands on the horizontal floor of a spaceship moving vertically with an upwards acceleration of 8.0 ms^{-2}. Assume that the acceleration due to gravity at the position of the spaceship is g = 9.8 ms^{-2}.
Calculate the magnitude of the force exerted by the spaceship on the astronaut.

2

Question 20 (4 marks)

Identify and discuss TWO of the issues associated with the safety of astronauts during re-entry of a space shuttle into the Earth's atmosphere.

4

Class

Candidate Number

Question 21 (3 marks)

Marks

Compare and contrast the structure and function of a step-up transformer with that of a step-down transformer.

3

Class

Candidate Number

Question 22 (6 marks) **Marks**

Assess the effects of the development of AC generators on society and the environment.

6

Class

Candidate Number

Question 23 (3 marks) **Marks**

Describe a first hand investigation you have done to demonstrate the principle of the AC induction motor and explain the result of the investigation.

3

Class

Candidate Number

Question 24 (5 marks)

Marks

Using a diagram to illustrate your answer, describe the application of the motor effect to the operation of the loud speaker.

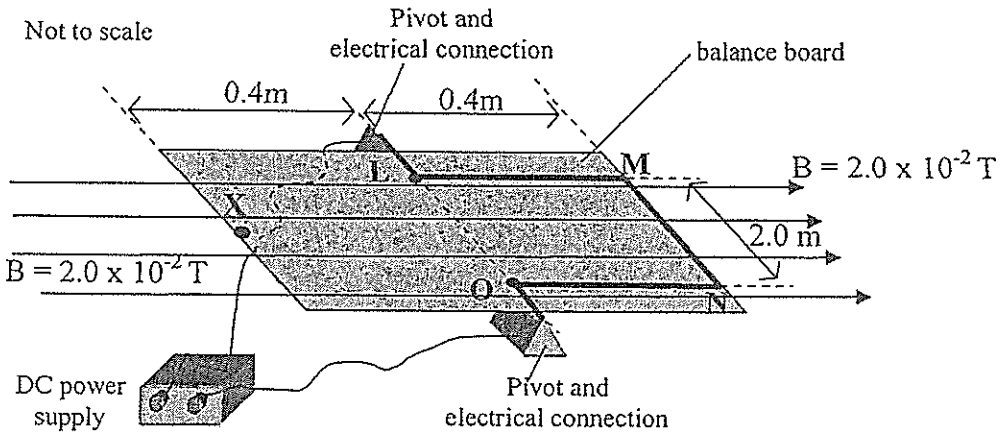
5

Class

Candidate Number

Question 25 (3 marks) **Marks**

The following apparatus was used to measure the current flowing through a wire.



A single conductor, following the path LMNO, is attached to a balance board as shown. The board is balanced on pivot points and is free to rotate on the axis LO. The whole apparatus is in a uniform magnetic field of 2.0×10^{-2} T. The pivot points provide an electrical connection to a DC power supply allowing current to flow in the conductor LMNO. When no current flows, the board and conductor are in balance and are level. When the current is turned on a mass of 5.0×10^{-3} kg is needed at point X to bring the board back into balance. Calculate the magnitude and direction of the current in the conductor.

NOTE:

- MN is 2.0 metres long.
- Point X and segment MN are equidistant from the axis.

3

Class

Candidate Number

Question 26 (4 marks) **Marks**

Compare the operation of:

(i) the electron gun, and
(ii) the deflection systems

in a **television** with their operation in a **cathode ray oscilloscope.**

4

Question 27 (3 marks)

Describe the BCS theory which explains the phenomenon of superconductivity in metals.

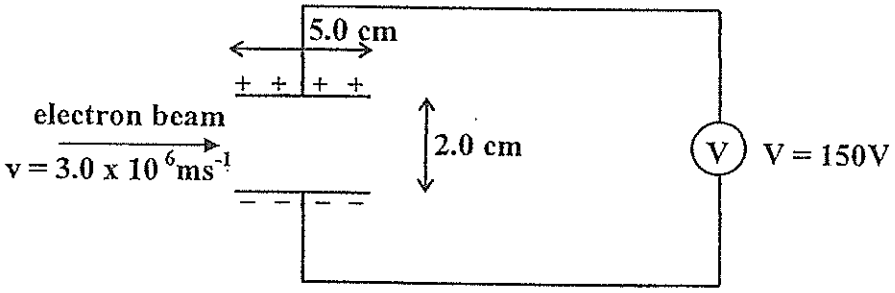
3

Class

Candidate Number

Question 28 (4 marks) **Marks**

The apparatus shown below represents a set-up similar to J.J.Thomson's experiment to measure the charge to mass ratio of the electron.



(a) Calculate the magnitude of electric field strength between the plates.

2

(b) Calculate the magnitude and direction of the magnetic field that would need to be applied between the plates to allow the electron beam to pass between them without being deflected.

2

Class

Candidate Number

Question 29 (4 marks)

Marks

Describe Heinrich Hertz's experiment to determine the velocity of radio waves.

4

Class

Candidate Number

Question 30 (5 marks)

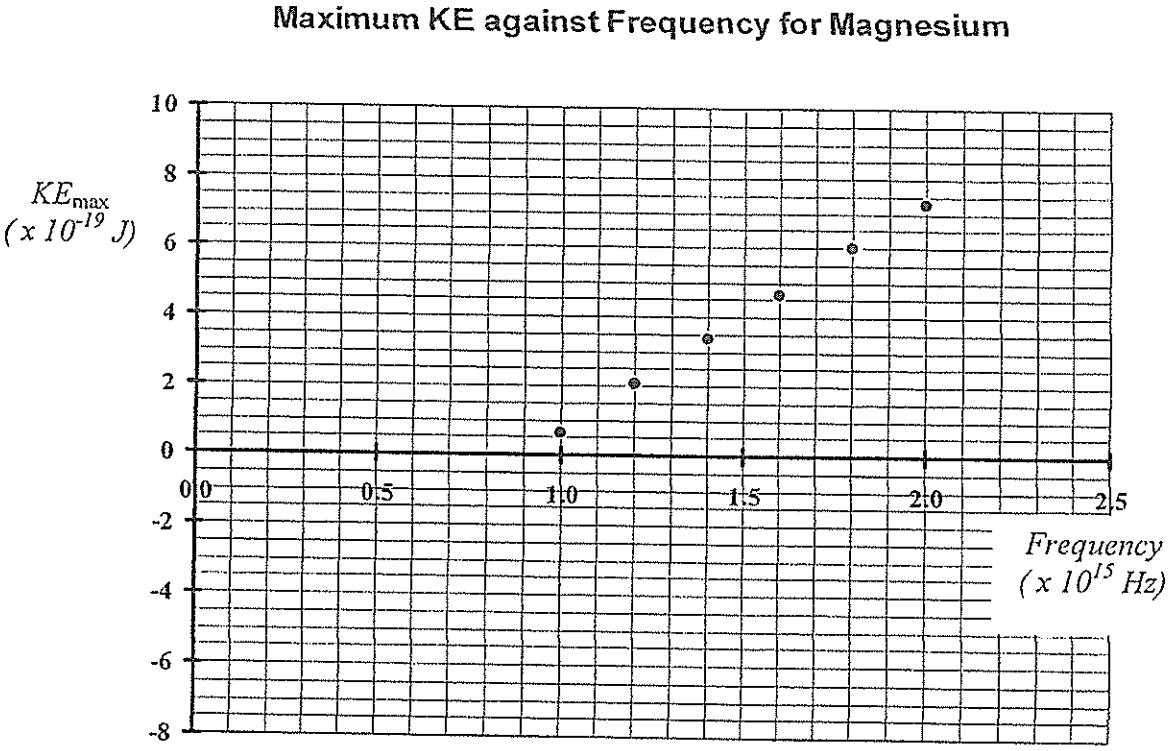
When light of sufficient frequency is incident on the surface of a metal, it liberates electrons. This is known as the photoelectric effect.

Einstein was able to explain the photo-electric effect through his photon model of light. One aspect of his explanation concerns the maximum kinetic energy of the electrons emitted, which is given by the equation:

$$KE_{max} = hf - \varphi$$

In this equation, f is the frequency of the light, φ is the work-function of the metal (i.e. the minimum energy required to release the electrons from the metal) and h is Planck's constant.

The graph below shows the results of an experimental investigation into the photoelectric effect when light is incident on the surface of magnesium.



Question 30 continued on next page.

Class

Candidate Number

Question 30 (continued) **Marks**

(a) Estimate the minimum frequency of light for which photo-emission of electrons occurs in magnesium (i.e. the threshold frequency). 1

(b) Determine the work-function, φ, of magnesium. 2

(c) Sodium has a work-function of 3.68×10^{-19} J. Add to the graph a line representing the relationship between maximum kinetic energy, KE_{max}, and frequency, f, for sodium. 2

Question 34 - From Quanta to Quarks (25 marks) **Marks**

(a) Describe one application of a radio-isotope commonly used in medicine and outline why it is used in the application you have chosen. 2

(b)

"Any model of the atom will only be accepted by the scientific community if it can be used to predict or explain observed phenomena."

Discuss this statement as it applies to both the Rutherford model of the atom and the Bohr model which replaced it. 7

(c) Calculate the wavelength of a photon emitted by a hydrogen atom when an electron makes a transition from quantum level 6 to quantum level 3. 2

(d)

(i) Calculate the velocity of an electron that has a de Broglie wavelength of 2.70×10^{-8} metres. 1

(ii) Explain the stability of the electron orbits in the Bohr model of the hydrogen atom using de Broglie's Hypothesis. Use a diagram to illustrate your answer. 4

(e) Assess the contribution of Wolfgang Pauli to the development of atomic theory. 4

(f) Assess the impact of the Manhattan Project on society. 5

END OF PAPER