STUDENT NUMBER: | | | | |

PYMBLE LADIES' COLLEGE

2004

TRIAL EXAMINATION

Physics

General Instructions
- Reading time - 5 minutes
- Working time - 3 hours
- Write using black or blue pen
- Draw diagrams in pencil
- Board-approved calculators may be used
- A data sheet, formulae sheets and Periodic Table are provided
- Write your Student Number at the top of this page and other pages where indicated, including the multiple choice answer sheet

Total marks – 100

Section I
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
25 marks
- Attempt all sections of Question 31
- Allow about 45 minutes for this section

Section I
75 marks

Part A Multiple choice 15 marks
Attempt Questions 1–15.
Allow about 30 minutes for this part

Use the multiple-choice answer sheet.

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

Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

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

A ● B ⊗ C ○ D ○

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

Question 1

The radius of the Earth is 6.38×10^3 km.

How much work must be done on a rocket of mass 1000 tonnes on the Earth's surface if it is to completely escape the Earth's gravitational influence? (Ignore other influences).

(A) 9.8×10^6 J

(B) 6.3×10^{10} J

(C) 6.3×10^{13} J

(D) 6.3×10^{16} J

Question 2

The following data compare Earth and Jupiter.

Planet	radius (km)	mass (kg)	orbital period (years)
Earth	6.4×10^3	6.4×10^{24}	1
Jupiter	7.0×10^4	1.9×10^{27}	12

The acceleration due to gravity at the surface of the Earth is $g = 9.8\ m.s^{-2}$.

Which of the following is closest to the acceleration due to gravity at the surface of Jupiter?

(A) $9.8\ m.s^{-2}$

(B) $25.9\ m.s^{-2}$

(C) $117.6\ m.s^{-2}$

(D) $2.59 \times 10^6\ m.s^{-2}$

Question 3

The Earth, with a radius of 6.38×10^6 m, has many artificial satellites. One satellite orbits at an altitude of 300 km, has a mass of 200 kg and orbits with a velocity of 2800 $km.h^{-1}$.

What is the centripetal force acting on this orbiting satellite?

(A) 1.8×10^{-3} N

(B) 2.3×10^{-1} N

(C) 1.8×10^{1} N

(D) 2.3×10^{3} N

Question 4

During the launch of a spacecraft, an astronaut experiences a vertical acceleration of 29.4 ms^{-2}.

What is the 'g-force' experienced by the astronaut?

(A) 1

(B) 2

(C) 3

(D) 4

Question 5

Assume that the Moon has an orbital radius around the Earth of R_M, and that it takes approximately 28 days to orbit the Earth. If an artificial satellite takes one day to orbit the Earth, what must be its orbital radius relative to that of the Moon's?

(A) $0.25\ R_M$

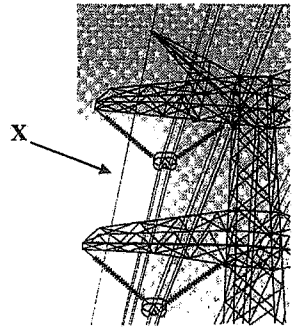
(B) $0.11\ R_M$

(C) $3.6 \times 10^{-2}\ R_M$

(D) $1.27 \times 10^{-3}\ R_M$

Question 6

The diagram shows part of a transmission tower with various wires and insulators.



What is the purpose of the wire labelled X?

(A) to transmit electrical current

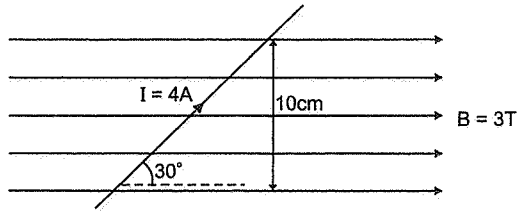
(B) to act as a shield from lightning

(C) to "earth" the transmission tower

(D) to act as a "neutral" wire

Question 7

The diagram below shows a current carrying wire in an external magnetic field.



What is the force on the wire?

(A) 0.6 N out of the page

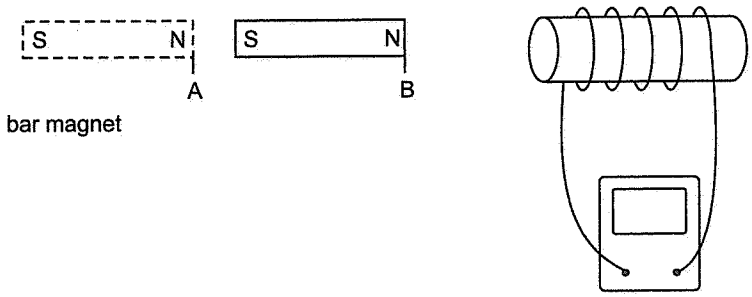
(B) 1.2 N out of the page

(C) 0.6 N into the page

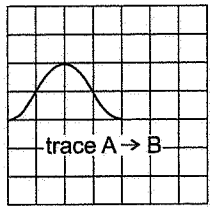
(D) 1.2 N into the page

Question 8

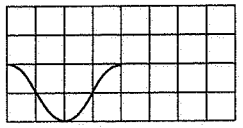
This question refers to the following diagram.

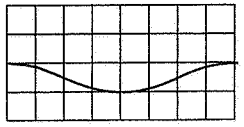


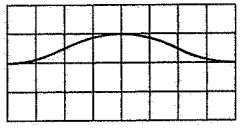
The ends of a solenoid are connected to the terminals of a cathode ray oscilloscope as shown. The cathode ray oscilloscope acts as a voltmeter, producing a trace of voltage (on the vertical scale) against time. A magnet is moved from A to B towards the solenoid. A trace appears on the oscilloscope screen as shown.

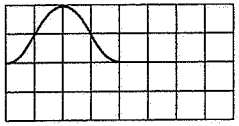


Which of the following traces would appear on the oscilloscope screen when the north pole of the magnet is moved backwards from B to A taking twice the original time?

(A) 

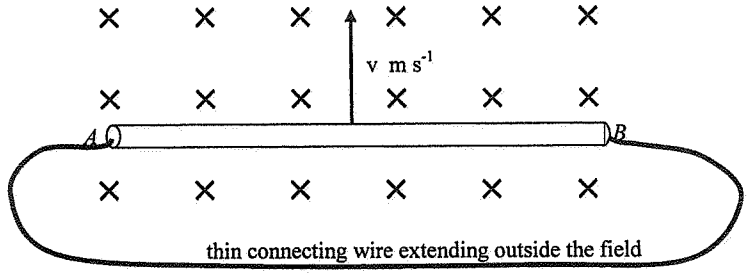
(B) 

(C) 

(D) 

Question 9

A straight conductor AB is moved at a speed of v m s^{-1} at 90° to the lines of a magnetic field directed into the page. The ends of the conductor are connected to a thin wire that lies outside the field as shown.



Which of the following statements is true?

(A) no current will flow in the coil because there is no potential difference in the circuit

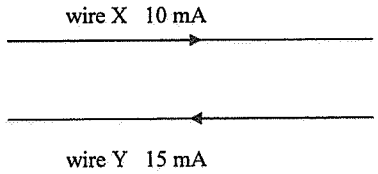
(B) electrons will flow from B to A through the rod

(C) conventional current flows from A to B through the external connecting wire

(D) conventional current flows from B to A through the external connecting wire

Question 10

The diagram below shows two parallel current carrying wires 1.5 m long, separated by a distance of 0.1 m. The current in wire X is 10 mA; the current in wire Y is 15 mA.



What is the force on wire X?

(A) 4.5×10^{-4} down

(B) 4.5×10^{-4} up

(C) 4.5×10^{-10} down

(D) 4.5×10^{-10} up

Question 11

What is the energy of a photon of blue light with $\lambda = 450.0$ nm?

(A) 6.6×10^{14} J

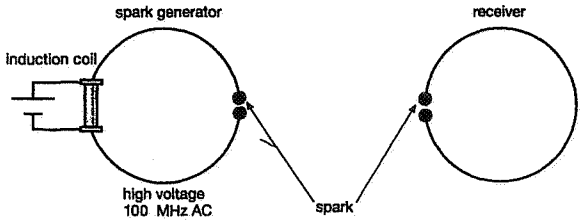
(B) 1.5×10^{-15} J

(C) 4.4×10^{-19} J

(D) 9.9×10^{-49} J

Question 12

Heinrich Hertz performed an experiment using equipment similar to that shown below. He observed that when a spark was produced by the spark generator, another spark could be produced in the loop of wire that was acting as a receiver.



What did Hertz deduce from results of this experiment?

(A) that invisible electromagnetic waves travel at the speed of light

(B) that electrons have wave properties

(C) that light behaves like a wave

(D) that light behaves as if it is absorbed in packets of energy

Question 13

Germanium was used in early transistors because

(A) it has a relatively low melting point and was therefore easier to shape

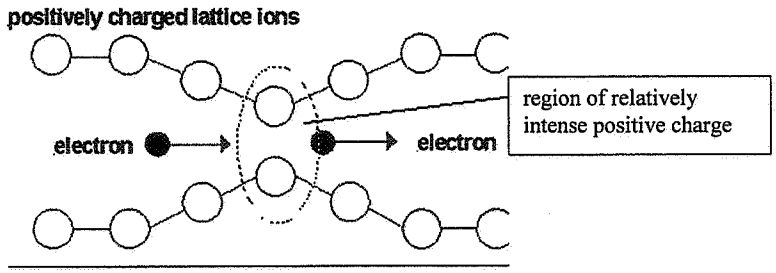
(B) suitable alternative semiconductors could not be purified at the time

(C) it is more easily doped than other semiconductors

(D) it is less volatile than other semiconductors

Question 14

The following diagram shows a pair of electrons moving through a lattice of positive ions. One electron attracts positive ions towards it and this region of enhanced positive charge attracts the second electron.



The diagram illustrates

(A) semiconductivity

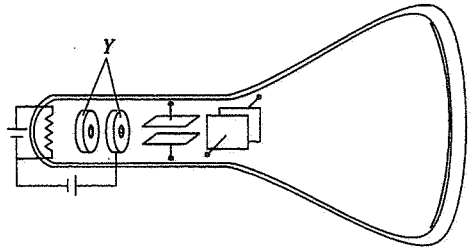
(B) the Meissner effect

(C) the photoelectric effect

(D) the BCS theory

Question 15

The diagram below shows a simple cathode ray tube from an oscilloscope.



What is the function of the parts labelled Y?

(A) producing electrons.

(B) showing the position of the beam.

(C) deflecting the beam horizontally.

(D) accelerating the electrons.

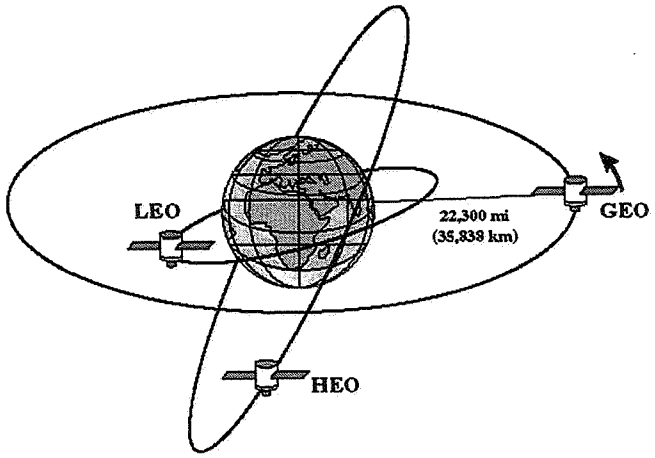
Section 1 (Continued)

Part B Extended Answers - 60 marks
Attempt Questions 16–27
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.

Question 16 (4 marks) **Marks**



(a) Explain why satellites in stable Low Earth Orbits (LEO) require a greater orbital velocity than satellites in stable Geostationary Orbits (GEO). **2**

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(b) Calculate the speed of a Geostationary satellite at a radius of 35,838 km. **2**

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Question 17 (7 marks) **Marks**

(a) One of Einstein's thought experiments involves him sitting on a train travelling at the speed of light and looking at a mirror. He asked the question as to whether he would be able to see his own reflection. Einstein thought that he should be able to see his reflection.

(i) Outline the reasoning he would have used **1**

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(ii) Explain why this experiment cannot be done in reality. **2**

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(b) Explain how knowledge of the results of the Michelson-Morley experiment may have assisted the acceptance of Einstein's special theory of relativity by other physicists. **2**

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(c) An astronaut travelling at 0.7 c measures the distance from Earth to a nearby star to be 12 light years. Calculate the distance an observer on Earth would measure for the trip. **2**

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Question 18 (3 marks) **Marks**

(a) Discuss the application of the Law of Conservation of Momentum during the launch of the Space Shuttle. **2**

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(b) Explain why NASA has chosen Cape Canaveral for its space launches. **1**
Cape Canaveral is one of the closest sites of the USA mainland to the equator, at a latitude of 28°.

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Question 19 (5 marks) **Marks**

(a) A cannon ball is fired from a cliff 50 m high with a horizontal velocity of 100 ms^{-1}. **3**
Calculate how far the cannon ball lands from the base of the cliff.

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(b) Outline Newton's concept of escape velocity. **2**

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Question 20 (5 marks) **Marks**

A transformer has 2,700 loops in its primary coil and steps down an input voltage of 6.0×10^3 V to 240 V. The input current is 2.4 A. Assume that the transformer is 100% efficient.

(a) Calculate the number of loops in the secondary coil. 1

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(b) Calculate the output current. 1

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(c) Explain why voltage transformations are related to the Law of Conservation of Energy. 1

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(d) Explain why some electrical appliances in the home that are connected to the mains domestic power supply use a transformer. 2

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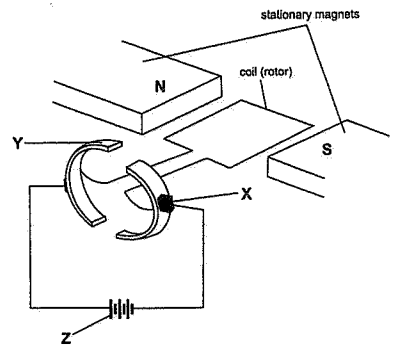
Question 21 (8 marks) **Marks**

(a) Examine the diagram of a DC motor shown below. Identify the parts labelled X,Y,Z and outline their function in the spaces provided.



X 2

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Y 2

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Z 2

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Continued on next page.

(b) Describe the changes you would need to make to the above setup to convert the DC motor to a DC generator. 2

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Question 22 (4 marks) **Marks**

Large electric motors can take up to a minute to reach their normal operating speeds after being switched on.

A particular motor has a resistance of 0.80 Ω and draws 10.0 A at normal operating speeds when connected to a 100 V DC supply.

To prevent the motor from burning out when first turned on, a starting resistance is placed in series with the motor.

(a) Calculate the starting resistance that is needed if the current in the motor is not to exceed 20.0 A. 1

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(b) Deduce the magnitude of the back emf of the motor when it is operating at normal speeds. 1

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(c) Explain the cause of the back emf that occurs when the motor coil is rotating. 2

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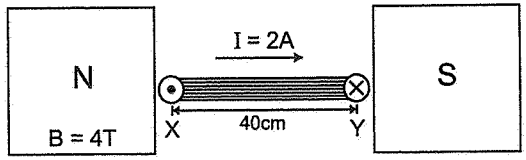
Question 23 (3 marks) **Marks**

A 50 turn coil of dimensions 40 cm x 60 cm is placed in a 4 T magnetic field as shown below. A current of 2 A flows through the coil.



(a) Calculate the magnitude of the torque acting on the coil. 1

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(b) Forces of equal magnitude are applied to X and Y which just prevent the coil from turning. 1

Calculate the magnitude of each force.

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(c) The forces are now removed. Identify the direction in which the coil will turn. 1

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Question 24 (6 marks) **Marks**

(a) Assess Einstein's contribution to quantum theory. Include some reference to the photoelectric effect in your answer. **3**

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(b) Summarise the use of the photoelectric effect in solar cells. **3**

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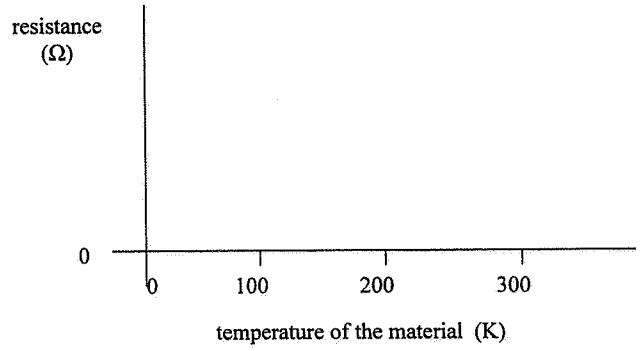
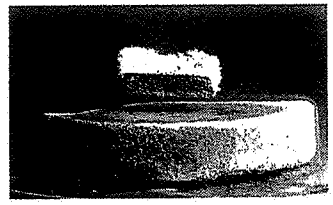
Question 25 (6 marks) **Marks**

(a) On the axes below, sketch a graph that illustrates the typical trend of electrical resistance of a superconductor as temperature changes. Sketch a second graph on the same set of axes showing a typical non-superconducting metallic conductor. **2**



The photograph below shows a magnet hovering above a superconducting material below its critical temperature. .



(b) Explain why a magnet is able to hover above a superconducting material that has reached the temperature at which it is superconducting (as a result of the Meissner effect). **3**

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(c) Explain why the Meissner effect is not simply an example of Lenz's Law. 1

Question 26 (9 marks) **Marks**

(a) With reference to valence and conduction bands account for the relative difference in resistivity between insulators, semiconductors and conductors. 3

(b) Assess the impact of the invention of transistors on society with particular reference to their use in microchips and microprocessors. 6

Section II - From Quanta to Quarks (25 marks)

Answer Question 27 - Sections (a) – (m)
Allow about 45 minutes for this section

Answer the question on the writing paper provided. Extra writing paper is available.

Write your student number on every piece of writing paper.

Show all relevant working in questions involving calculations.

Marks

(a) Outline the structure of the Rutherford model of the atom. **2**

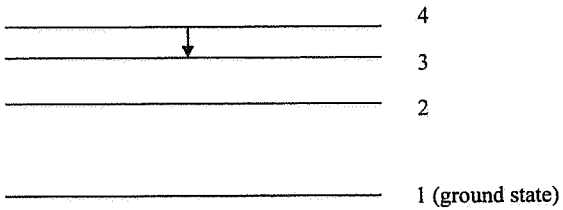
(b) During your studies you have performed a first-hand investigation to observe the visible components of the hydrogen spectrum. Describe how you observed the hydrogen spectrum. Include a diagram in your answer. **4**

(c) Define Bohr's postulates on which he based his model of the atom. **3**

(d) Analyse the significance of the hydrogen spectrum in the development of Bohr's model of the atom. **3**

(e) Identify four difficulties with the Rutherford-Bohr model. **2**

The diagram below represents the first four energy levels in the hydrogen atom.



(f) Calculate the wavelength of the emission spectral line due to the transition shown in the diagram (between the energy levels 4 and 3). **1**

(g) Calculate the energy gap between the energy levels 4 and 3. **1**

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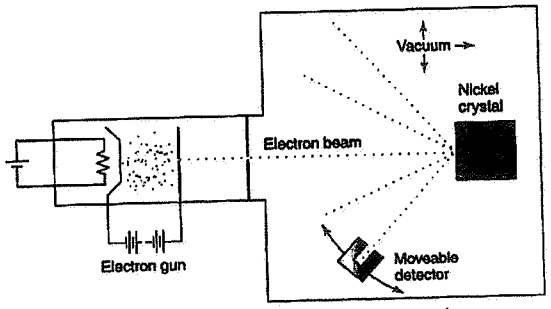
de Broglie proposed that particles have both wave and particle properties.

Davisson and Germer performed an experiment which confirmed de Broglie's proposal. The diagram below shows their experimental setup.



They fired electrons of known kinetic energy at a nickel crystal and used a movable detector to measure the scattering intensity at different angles.

(h) Identify the method used by Davisson and Germer to control the kinetic energy (and thus the speed) of the electrons. **1**

(i) Calculate the de Broglie wavelength of electrons which have a speed of 4.2×10^6 ms^{-1}. **1**

(j) Davisson and Germer knew the spacing of the atoms in the nickel crystal using an independent method. Identify the method used to determine the spacing. **1**

(k) Explain why Davisson and Germer concluded that the results of their experiments supported de Broglie's proposal for the wave nature of electrons. **2**

(l) Identify contributions to the development of atomic theory made by Heisenberg and Pauli. **2**

(m) Outline how de Broglie's idea of matter waves was used to explain the stability of the stationary states in the Bohr model of the atom. Include a diagram in your answer. **2**

End of Question 27

End of Paper