PETRUS KY COLLEGE
NEW SOUTH WALES

in partnership with

VIETNAMESE COMMUNITY IN AUSTRALIA
NSW CHAPTER

JULY 2006

PHYSICS

PRE-TRIAL TEST

HIGHER SCHOOL CERTIFICATE (HSC)

Student Number: | | | | |

Student Name: _____

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue 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 Centre Number and Student Number at the top of pages 1 and 8

TOTAL MARKS: 100

Section I

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 16–27

• Allow about 1 hour and 45 minutes for this part

Section II (Optional)

25 marks

• Attempt ONE question from Questions 28–32

• Allow about 45 minutes for this section

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Part A – 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.

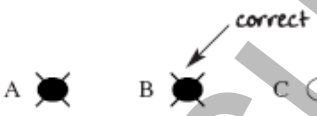
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

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.

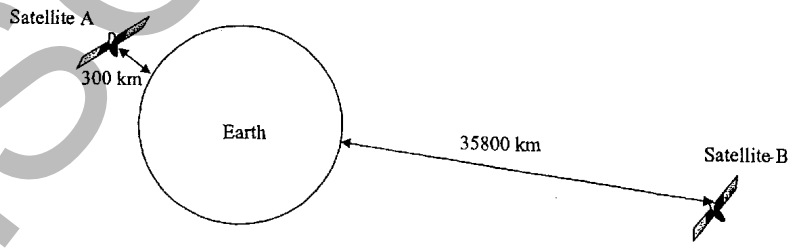


Question

1 The force on an object due to a gravitational field is known as its

(A) mass
(B) gravitational potential energy
(C) weight
(D) acceleration

2 The diagram below shows two satellites of the same mass and the altitude at which they are orbiting above the Earth. The diagram is not drawn to scale.



Choose the most correct statement from the following.

(A) Satellite B completes one orbit of the Earth in less time than Satellite A
(B) Satellite A experiences a greater centripetal force than Satellite B
(C) Satellite B moves at a faster speed than Satellite A
(D) Satellite A is likely to remain at a fixed position in the sky

3 When a space craft re-enters the earth's atmosphere the re-entry angle is important. In the statements below take a steep angle to be one greater than 15 degrees and a shallow one to be less than this. Which statement is the best description of re-entry?

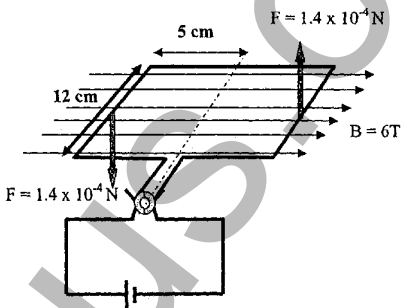
(A) It should enter at a steep angle so that it travels less distance through the atmosphere.

(B) It should enter at a steep angle so that at does not bounce off the atmosphere.

(C) It should enter at a shallow angle so that it does not bounce off the atmosphere.

(D) It should enter at a shallow angle so that it slows at a lower rate.

4 One turn of wire with dimensions shown is in a uniform magnetic field of strength 6 T. A current travels through the wire, producing a force F=1.4 x 10^{-4} N on each side of the turn of wire as shown.



Determine the total torque on the turn of wire.

(A) 1.4 x 10^{-5} N.m

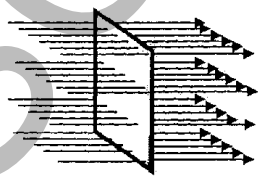
(B) 7.0 x 10^{-6} N.m

(C) 7.2 x 10^{-2} N.m

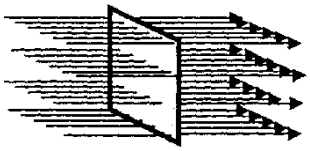
(D) 1.008 x 10^{-5} N.m

5 The following diagrams are all drawn to the same scale and show separate loops of wire that have a magnetic field cutting through them so that the field lines run perpendicular to the surface of the loop. Choose the diagram with the strongest magnetic field.

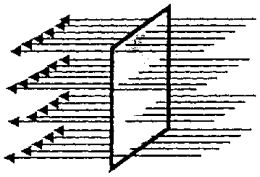
(A)



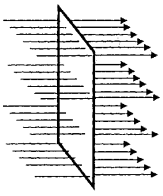
(B)



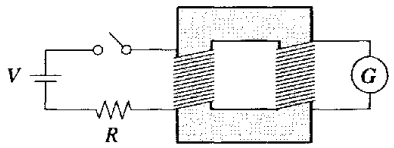
(C)



(D)

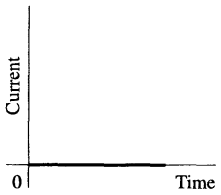


6 The primary coil of a transformer is connected to a battery, a resistor and a switch. The secondary coil is connected to a galvanometer.

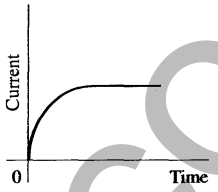


Which of the following graphs best shows the current flow in the galvanometer when the switch is closed?

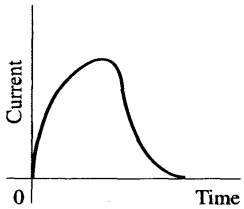
(A)



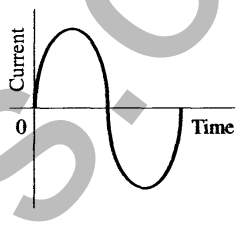
(B)



(C)

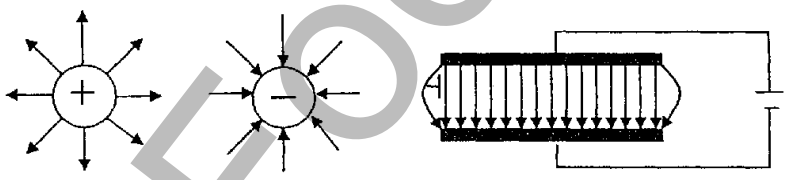


(D)

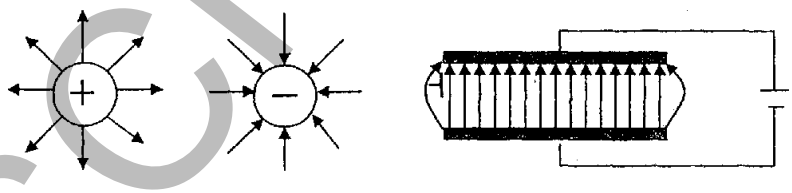


7 Which of the following shows three correct diagrams representing electric field lines?

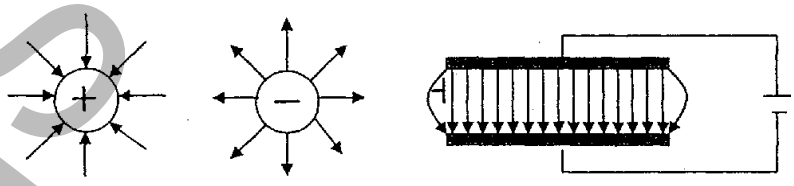
(A)



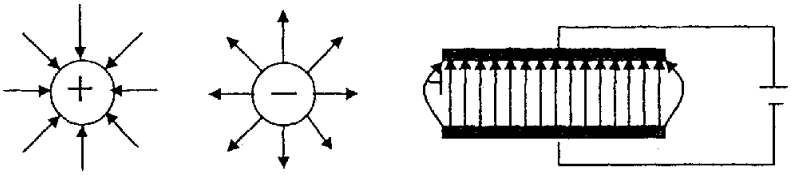
(B)



(C)



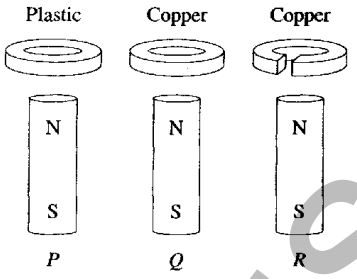
(D)



8 In the cathode ray tube of a conventional TV display or oscilloscope, which components focus the beam, control brightness and accelerate electrons along the tube?

(A) Heating filament
(B) Electrodes in the electron gun
(C) Deflection plates or coils
(D) Fluorescent screen

9 Three rings are dropped at the same time over identical magnets as shown below.



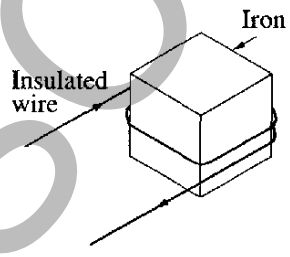
Which of the following describes the order in which the rings P. Q and R reach the bottom of the magnets?

(A) They arrive in the order P, Q, R.
(B) They arrive in the order P, R, Q.
(C) Rings P and R arrive simultaneously, followed by Q.
(D) Rings Q and R arrive simultaneously, followed by P.

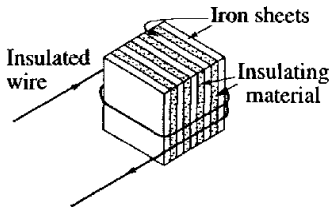
10 A transformer is to be designed so that it is efficient, with heating by eddy currents minimised. The designer has some iron and insulating material available to build the transformer core. The windings are to be made with insulated copper wire.

Which of the following designs minimises the energy losses in the core?

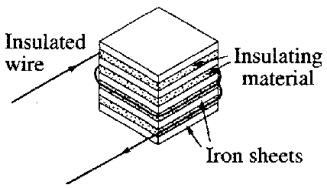
(A)



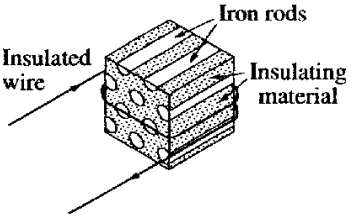
(B)



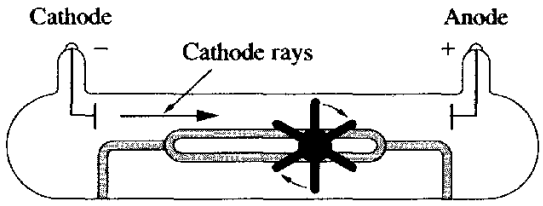
(C)



(D)



11 The discharge tube shown below contains a rotating paddle wheel that is free to move. The tube's electrodes are connected to a high-voltage source.



Which of the following statements about cathode rays does this apparatus provide evidence for?

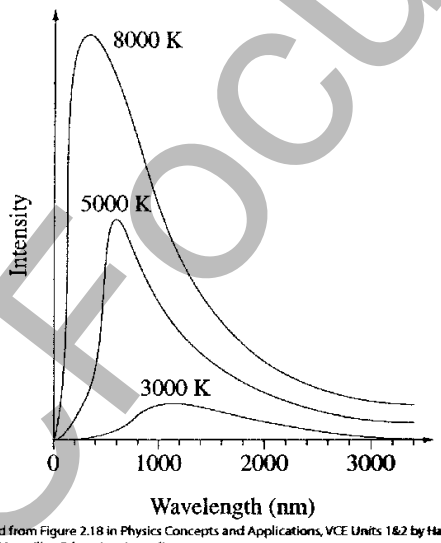
(A) Cathode rays travel in straight lines.

(B) Cathode rays are particles that have momentum.

(C) Cathode rays can only be produced in vacuum tubes.

(D) Cathode rays are waves of high frequency and short wavelength

12 The family of curves below shows the relationship between the intensity of black body radiation and its wavelength for various Kelvin temperatures.



This diagram has been adapted from Figure 2.18 in Physics Concepts and Applications, VCE Units 1&2 by Harding et al, Macmillan Education Australia, 1997. Reproduced by permission of Macmillan Education Australia.

Who was the first to correctly explain this relationship?

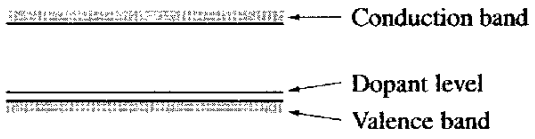
(A) Planck, in 1900, when he suggested energy at the atomic level was quantised

(B) Einstein, in 1905, when he suggested light was a stream of particles called photons

(C) Rutherford, in 1911, when he suggested the nuclear model of the atom

(D) Bohr, in 1913, when he suggested electrons exist in stationary states

13 A doped silicon semiconductor has the following energy-level diagram.



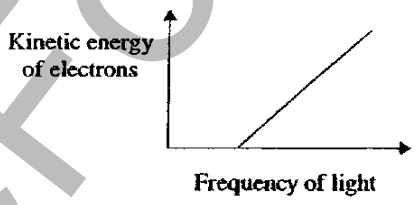
What element was most likely used to dope the silicon?

(A) Boron
(B) Germanium
(C) Phosphorus
(D) Sulfur

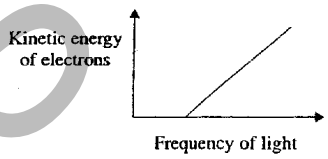
14 Shortly after cathode rays were discovered there was debate as to whether they were particles or waves. Which of the following was most important in leading some scientists to think they were waves?

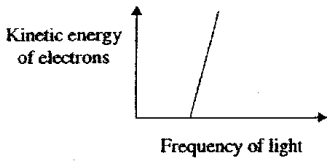
(A) They were not deflected by electric fields
(B) They moved in straight lines.
(C) They could be reflected.
(D) They were emitted from the anode.

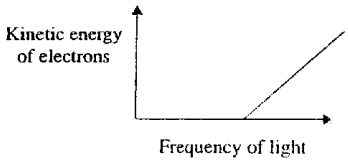
15 In a photoelectric effect experiment, the following graph was obtained using zinc metal.

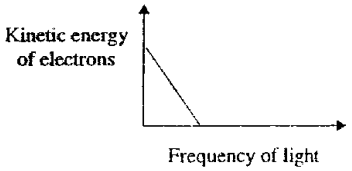


Which of the graphs below would be obtained with an identical experiment in which only the metal was changed?

(A)


(B)


(C)


(D)


Student Number: | | | | |

Section I (continued)

Part B — 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 **Marks**

16 A projectile is fired at a velocity of 50 ms^{-1} at an angle of 30° to the horizontal. **4**

Determine the range of the projectile.

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17 Einstein's 1905 theory of special relativity made several predictions that could not be verified for many years. **6**

(a) State ONE such prediction. 1

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(b) Describe an experiment to test this prediction 2

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(c) Explain how technological advances since 1905 have made it possible to carry out this experiment. 3

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18 The idea of a universal aether was first proposed to explain the transmission of light through space. Michelson and Morley attempted to measure the speed of Earth through the aether. **4**

Evaluate the impact of the result of the Michelson and Morley experiment on scientific thinking.

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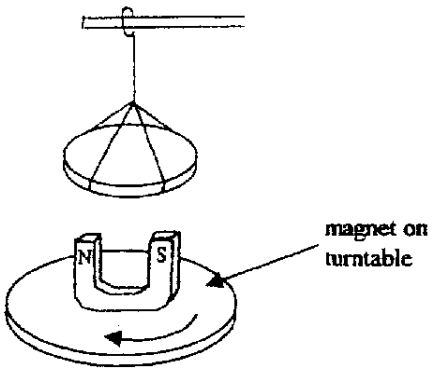
19 A thick aluminium disc is suspended over a strong magnet. The magnet is mounted on a turntable, which rotates as shown. **3**



(a) Describe what happens to the aluminium disc when the turntable rotates. 1

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(b) Use Lenz's law to explain this observation. 2

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20 In your course you had to gather information to explain how induction is used incertain applications. **6**

With reference to TWO applications, describe how you assessed the reliability of information you found.

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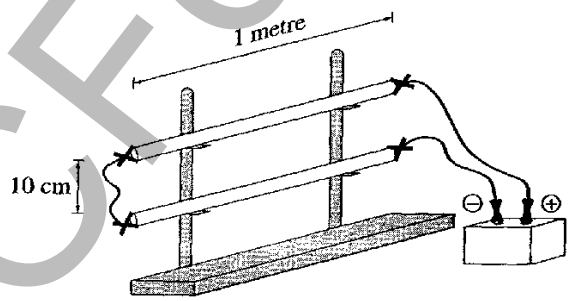
21 Two thin metal tubes one metre long were supported in a vertical wooden rack as shown in the diagram. **6**



The two ends were connected together, then the other two ends were connected briefly to a car battery as shown in the diagram. It was observed that one of the tubes jumped upward as the connection was made.

(a) Explain why only one tube jumped upward. 2

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(b) Each tube has a mass of 1 x 10^{-2} kg, and the tubes lie on the rack 10cm apart. What minimum current flows when one tube jumps? 3

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(c) What is the implication of this result for power distribution networks? 1

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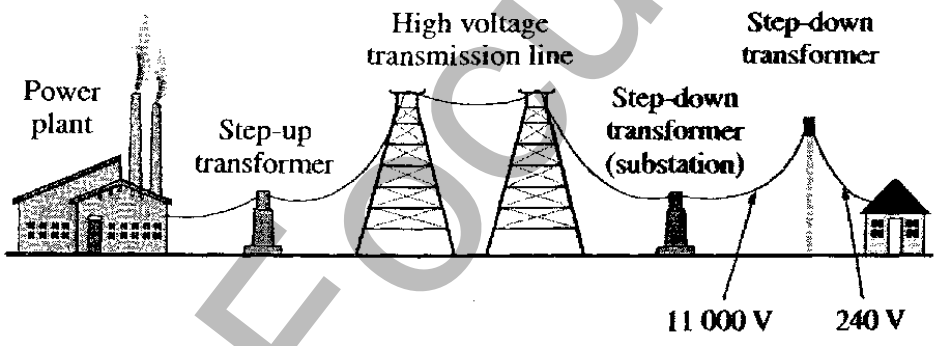
22 A schematic diagram of a system to supply electricity to a house is shown below. **5**



J D Cutnell & K W Johnson, 2001, *Physics*, 5th edn. Reprinted with permission of John Wiley & Sons, Inc.

The step-down transformer in the substation has a turns ratio of 30: 1.

(a) What is the voltage carried by the high voltage transmission line? 1

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(b) Identify the causes of the two main energy losses in the transmission of electricity between the power plant and the house. 2

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(c) Explain how the application of superconductivity could minimise energy loss in the system. 2

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23 Explain how an understanding of black body radiation changed the direction of scientific thinking in the early twentieth century. **3**

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24 Using labelled diagrams and text, explain how superconductivity occurs according to the BCS theory. **4**

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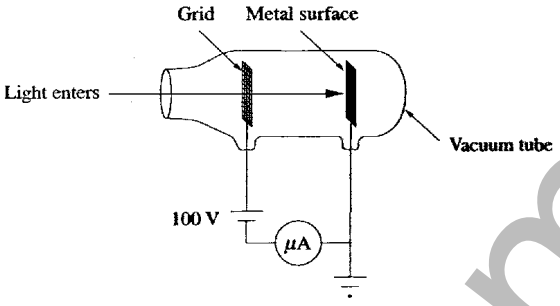
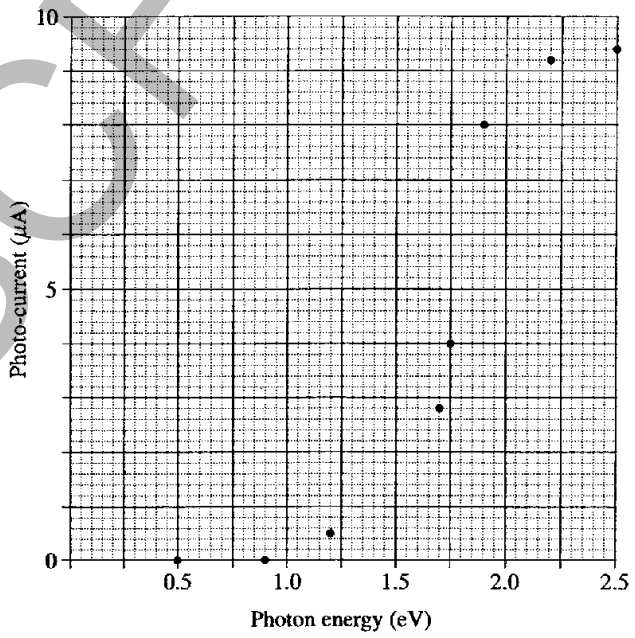
25 A student conducts an experiment using a photoelectric cell as shown in the diagram. **6**



Light is shone through a grid onto a metal surface. The metal is at earth potential and the grid is at 100 V. so that any electrons emitted from the surface produce a current in the external circuit.

The student shines light sources of different photon energies onto the metal surface and records the current flowing for each. The light sources are adjusted so that their intensities are equal. The results are recorded in the table and shown on the graph.

Photon energy (eV)	*Photo-current* (μA)
0.50	0
0.90	0
1.20	0.5
1.70	2.8
1.75	4.0
1.90	8.0
2.20	9.2
2.50	9.4



(a) On the grid provided, draw the straight line of best fit in the region where the photo-current varies greatest with photon energy. 1

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(b) From the line drawn on your graph, estimate the minimum energy (work function) for photoelectric emission. 1

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(c) The experiment is repeated, but the intensities of the light sources are doubled. Predict the results of this new experiment by drawing a second line on the graph. 2

(d) Justify the line you have drawn in part (c). 2

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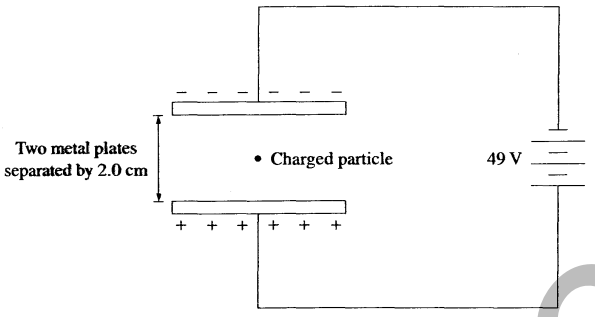
26 The diagram shows two parallel horizontal metal plates connected to a DC source of electricity. Suspended between the plates is a charged particle of mass 9.6×10^{-6} kg. **5**



(a) Using conventional symbols, draw the electric field between the metal plates on the diagram above. 1

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(b) Determine the magnitude of the electric field between the plates. 1

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(c) Determine the sign and magnitude of the charge on the particle if it is suspended motionless between the plates. 3

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27 The Braggs developed the equation $n\lambda = d\sin\theta$ to use in the work on X-ray diffraction. **8**

(a) What is the quantity θ in the Bragg's experiments? 1

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(b) What did the Braggs use this equation to find ? 1

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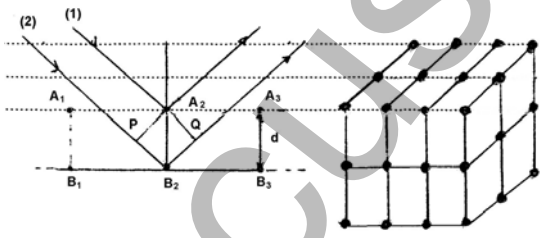
(c) How did this work improve our understanding of conductivity in metals? 2



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(d) Describe the behaviour of superconductors in relation to temperature and magnetic fields. 4

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Physics

Section II (Optional)
25 marks

- **Attempt ONE question from Questions 28-32**
- **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.**

Question 28 — Geophysics (25 marks)

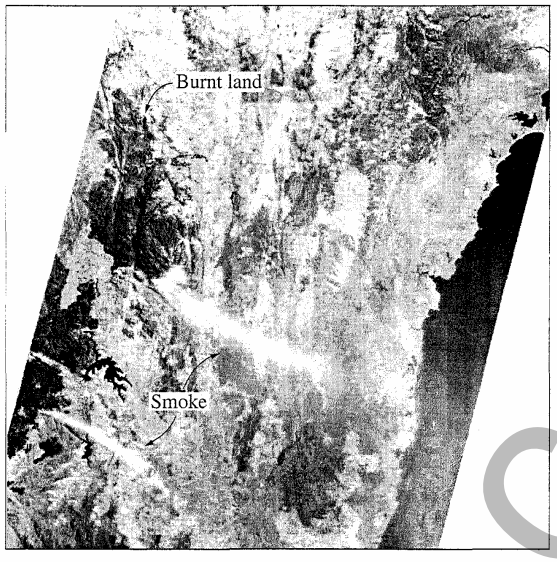
a) (i) Identify THREE principal methods used by geophysicists to investigate the structure of Earth and the properties of Earth materials. 1

(ii) Describe the role that geophysicists play in the monitoring of nuclear test-ban treaties. 2

b) Summarise the geophysical evidence that supports the theory of plate tectonics. 3

c) (i) Describe how absorption and reflection of radiation can provide information about a reflecting surface. 2

(ii) The picture below shows a satellite image of a bushfire burning in a forested area. Images such as the one below can be used as a part of the process of monitoring changes in vegetation. 3



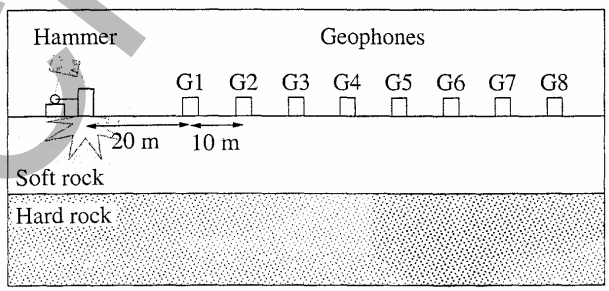
Explain how remote-sensing techniques can be used to monitor the spread of a bushfire, and the regrowth of vegetation in regions affected by a bushfire.

d) (i) Outline the structure and function of a geophone. 2

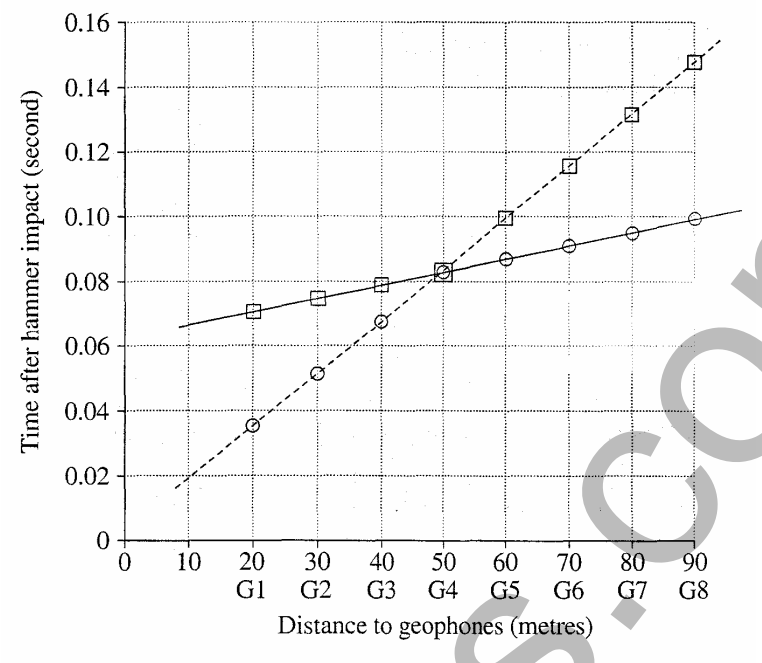
(ii) The method of seismic refraction is depicted in the diagram below. A series of eight geophones, G1 to G8, are arranged in a straight line along level ground. They are each separated by a distance of 10 m.

At a distance of 20 m from the first geophone, a hammer is used to strike the ground to produce seismic waves.

The geophones are attached to a seismograph that records the time of arrival of the waves after the hammer strikes the ground.



The data from the geophones are analysed and the arrival times of the direct and refracted waves that reach each geophone are recorded. These data are shown in the graph on page 33. On the graph, a circle represents the arrival of the first wave to reach a geophone, and a square represents the arrival time of the second wave to reach a geophone. The points on the graph associated with the direct seismic wave and the refracted seismic wave are shown.



Legend

○ Time of arrival of first wave at geophone

□ Time of arrival of second wave at geophone

_____ Refracted wave

--------- Direct wave

(i) Explain why the line for the refracted wave crosses the line for the direct wave on the graph. 2

(ii) From the graph, calculate the speed of the direct wave in the soft rock layer. 2

e) Outline the application of Newton's theory of universal gravitation to the field of geophysics, and discuss how information obtained from gravity surveys has led to a greater understanding of the structure of Earth. 8

Question 29: Medical Physics (25 marks)

a) (i) Briefly describe how an endoscope works. 1

(b) Explain how a computed axial tomography (CAT) scan is produced. 3

b) The table shows information relating to the transmission of sound through some types of body tissue.

Tissue	Acoustic impedance ($x10^6$ kg m^{-2} s^{-1})	Density (kg m^{-3})	Velocity of sound (m s^{-1})
Muscle	1.70	1040	1630
Fat	1.38	945	1460
Bone	7.80	2560	3050

(i) Identify ONE property of ultrasound. 1

(ii) Justify why, in an ultrasound scan, a boundary between muscle and bone would show up more clearly than would a boundary between muscle and fat. 3

c) Position emission tomography (PET) is an extremely valuable diagnostic tool. It is often underestimated when compared with other diagnostic tools, because it produces a scan of low resolution and requires the injection of a radioisotope. Evaluation the use of PET as a diagnostic tool. 6

d) A researcher wishes to use two techniques to exam the bones of a certain patient; conventional X-ray and isotopic bone scan. 5

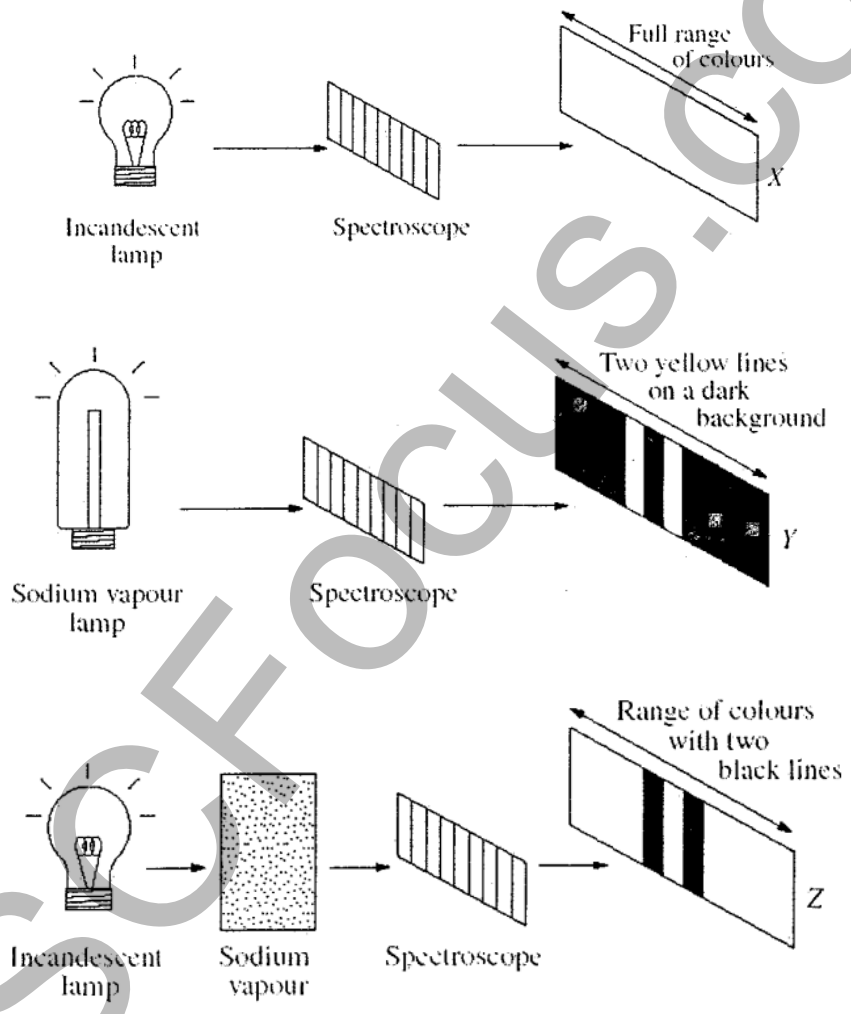
Compare the imaging radiation used and the usefulness of the final image from these two techniques.

e) Asses the impact of the use of new imaging techniques such as MRI and PET has had on society. 6

Question 30: Astrophysics (25 marks)

a) Discuss how the development of adaptive optics and at least one other development have improved resolution and sensitivity of ground based astronomy. 6

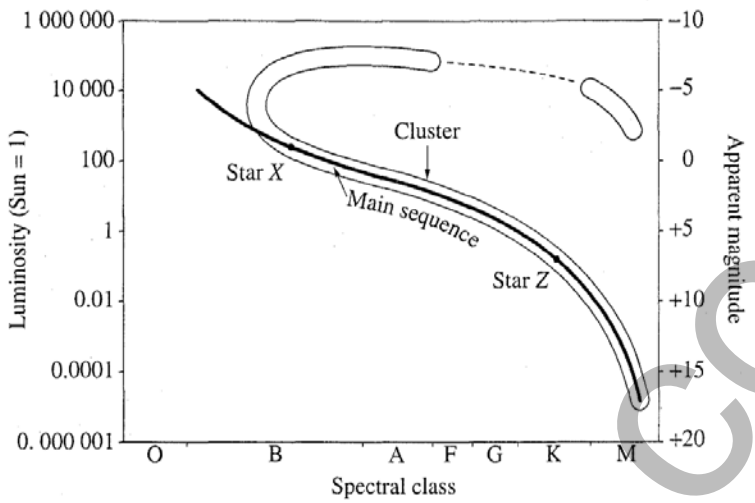
b) A student carried out an experiment to examine the spectra of various light sources through spectroscopes as shown in the diagram. The student observed three different spectra. 4



Account for the differences in the three observed spectra.

c) Evaluate the importance of the Hertzsprung-Russell diagram in our understanding of the evolution and life of stars. 6

d) The H-R diagram for a cluster is shown below.



(i) Why is the cluster considered young? 1

(ii) Stars X and Z are both part of the same cluster but have different main sequence nuclear reactions and different evolutionary pathways.

(1) Contrast the fusion reactions in star X and star Z 2

(2) Predict TWO possible evolutionary pathways for star X. 3

e) Evaluate the impact of studying the visible spectrum of light on our understanding of celestial objects. 8

Question 31: From Quanta to Quarks (25 marks)

a) (i) Reproduce the table below in your answer booklet, complete with the integer (whole number) values in the appropriate places, for the components of the nucleus of an atom. 2

	Charge	Mass	Contribution to Mass Number	Contribution to Atomic Number
Proton				
Neutron				

(ii) Strontium-90 (^{90}Sr) is radioactive and is known to produce β-particles. Outline the process of the production of a β-particle from a ^{90}Sr atom and 2

write a balanced equation for the process.

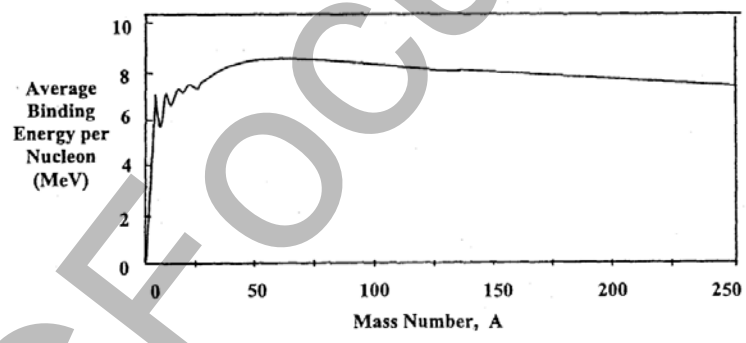
b) Describe a first hand investigation you conducted to observe the emission spectrum of a gas such as hydrogen. 3

c) Explain the stability of the electron orbit in the Bohr model of the atom with particular reference to the deBroglie hypothesis. 3

d) Assess the impact of the Manhattan Project of the I 940s upon today's society. 7

e) (i) The mass of the oxygen-16 atom is 15.994915 amu. Calculate the mass defect for this atom. 2

(ii) Use the following graph of binding energy per nucleon vs. mass number of atoms to explain the significance of the position of Iron-56 (^{56}Fe). 2



f) Analyse the ability of the Rutherford-Bohr model of the atom to completely explain observed spectral characteristics. 4

DATA SHEET

Charge on electron, q_e	-1.602×10^{-19} C
Mass of electron, m_e	9.109×10^{-31} kg
Mass of neutron, m_n	1.675×10^{-27} kg
Mass of proton, m_p	1.673×10^{-27} kg
Speed of sound in air	340 m s^{-1}
Earth's gravitational acceleration, g	9.8 m s^{-2}
Speed of light, c	3.00×10^8 m s^{-1}
Magnetic force constant, $\left(k \equiv \frac{\mu_0}{2\pi}\right)$	2.0×10^{-7} N A^{-2}
Universal gravitational constant, G	6.67×10^{-11} N m^2 kg^{-2}
Mass of Earth	6.0×10^{24} kg
Planck constant, h	6.626×10^{-34} J s
Rydberg constant, R (hydrogen)	1.097×10^7 m^{-1}
Atomic mass unit, u	1.661×10^{-27} kg 931.5 MeV/c^2
1 eV	1.602×10^{-19} J
Density of water, ρ	1.00×10^3 kg m^{-3}
Specific heat capacity of water	4.18×10^3 J kg^{-1} K^{-1}

FORMULAE SHEET

$$v = f\lambda$$

$$I \propto \frac{1}{d^2}$$

$$\frac{v_1}{v_2} = \frac{\sin\ i}{\sin\ r}$$

$$E = \frac{F}{q}$$

$$R = \frac{V}{I}$$

$$P = VI$$

$$\text{Energy} = VIt$$

$$v_{av} = \frac{\Delta r}{\Delta t}$$

$$a_{av} = \frac{\Delta v}{\Delta t} \text{ therefore } a_{av} = \frac{v-u}{t}$$

$$\Sigma F = ma$$

$$F = \frac{mv^2}{r}$$

$$E_k = \frac{1}{2}mv^2$$

$$W = Fs$$

$$p = mv$$

$$\text{Impulse} = Ft$$

$$E_p = -G\frac{m_1 m_2}{r}$$

$$F = mg$$

$$v_x^{\ 2} = u_x^{\ 2}$$

$$v = u + at$$

$$v_y^{\ 2} = u_y^{\ 2} + 2a_y\Delta y$$

$$\Delta x = u_x t$$

$$\Delta y = u_y t + \frac{1}{2}a_y t^2$$

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

$$F = \frac{Gm_1 m_2}{d^2}$$

$$E = mc^2$$

$$l_v = l_0\sqrt{1-\frac{v^2}{c^2}}$$

$$t_v = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$m_v = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

FORMULAE SHEET

$$\frac{F}{l} = k\frac{I_1 I_2}{d}$$

$$F = BIl\sin\theta$$

$$\tau = Fd$$

$$\tau = nBIA\cos\theta$$

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

$$d = \frac{1}{p}$$

$$M = m - 5\log\left(\frac{d}{10}\right)$$

$$\frac{I_A}{I_B} = 100^{(m_B - m_A)/5}$$

$$m_1 + m_2 = \frac{4\pi^2 r^3}{GT^2}$$

$$F = qvB\sin\theta$$

$$E = \frac{V}{d}$$

$$E = hf$$

$$c = f\lambda$$

$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\lambda = \frac{h}{mv}$$

$$Z = \rho v$$

$$\frac{I_r}{I_0} = \frac{\left[Z_2 - Z_1\right]^2}{\left[Z_2 + Z_1\right]^2}$$

$$A_0 = \frac{V_{\text{out}}}{V_{\text{in}}}$$

$$\frac{V_{\text{out}}}{V_{\text{in}}} = -\frac{R_{\text{f}}}{R_{\text{i}}}$$

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number 79 — Symbol of element: Au
Atomic Weight 197.0 — Name of element: Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.41 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [97.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanides	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [209.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223.0] Francium	88 Ra [226.0] Radium	89–103 Actinides	104 Rf [261.1] Rutherfordium	105 Db [262.1] Dubnium	106 Sg [266.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [277] Hassium	109 Mt [268] Meitnerium	110 Ds [271] Darmstadtium	111 Rg [272] Roentgenium							

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [144.9] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinides

89 Ac [227.0] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237.0] Neptunium	94 Pu [244.1] Plutonium	95 Am [243.1] Americium	96 Cm [247.1] Curium	97 Bk [247.1] Berkelium	98 Cf [251.1] Californium	99 Es [252.1] Einsteinium	100 Fm [257.1] Fermium	101 Md [258.1] Mendelevium	102 No [259.1] Nobelium	103 Lr [262.1] Lawrencium

Where the atomic weight is not known, the relative atomic mass of the most common radioactive isotope is shown in brackets.
The atomic weights of Np and Tc are given for the isotopes ^{237}Np and ^{99}Tc.