JAMES RUSE AGRICULTURAL HIGH SCHOOL

Student ID: .....

PHYSICS

HIGHER SCHOOL CERTIFICATE

2004 TRIAL EXAMINATION

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, Formulae Sheets and a Periodic Table are provided.
Write your Student Number in the space provided.

Section I	Theory Section:	Total Marks (75)	Contains Part A and Part B
	Part A	15 marks,	allow about 30 mins
	Part B	60 marks,	allow about 1 hour 45 min
Section II	Option Section:	Total marks (25),	allow about 45 mins

Section I **Part A:** **Answer Space.** Place a cross in the correct space.

	A	B	C	D
1				
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Section I **Part A:** Answer all questions in the multiple choice answer space.

1. A satellite of the earth (radius 6×10^6 m) takes 96 minutes to orbit the earth at an altitude of 200 km above the earth's surface. Using this data, the mass of the earth is closest to:-

a) 6.0×10^{24} kg
b) 5.8×10^{24} kg
c) 5.2×10^{24} kg
d) 4.3×10^{24} kg

2. The velocity of a particle 2 seconds after it has been projected horizontally at 30 ms^{-1} in the earth's field is approximately:-

a) 20 ms^{-1}
b) 30 ms^{-1}
c) 36 ms^{-1}
d) 42 ms^{-1}

3. If g(moon)= 1.6ms^{-2} and g(mars) = 3.7ms^{-2} the ratio of the forces experienced by a 30 kg object when taken to the moon then mars is closest to:-

a) 1.6 : 3.7
b) 48 : 3.7
c) 1.6 : 117
d) 1 : 1

4. The gravitational attraction between two 5 gram masses separated by a distance of 15 cm is closest to:-

a) $G \div 9$
b) $G \times 10^{-2} \div 9$
c) $G \times 10^{-6} \div 9$
d) $G \times 10^{-1} \div 45$, where "G" is the universal gravitational constant.

5. The period "T" of a simple pendulum is given by $T = 2\pi\sqrt{l} \div \sqrt{g}$, where "l" is the length and "g" is the earth's gravity constant. Which of the following would produce a straight line graph passing through the origin?

a) T vs $\sqrt{l}$
b) T vs l
c) T vs $\sqrt{g}$
d) T vs g

6. Torque may be described as:-

a) the turning moment of a force
b) force times distance (perpendicular to the force)
c) force times distance (parallel to the force)
d) two of the above

7. Energy losses occur as energy is fed through transmission lines from the generator to the consumer. These losses are minimised in practice by:-

a) using transmission lines of the lowest possible resistance value.
b) sending the energy in high current/low voltage form
c) sending the energy in high voltage/low current form
d) two of the above

8. A rectangular loop of wire conductor is rotated inside a uniform magnetic in the usual orientation to produce an emf. The emf is proportional to:-

a) the rate of change of magnetic field strength
b) the rate of change of area as the loop rotates
c) the rate of change of flux
d) two of the above

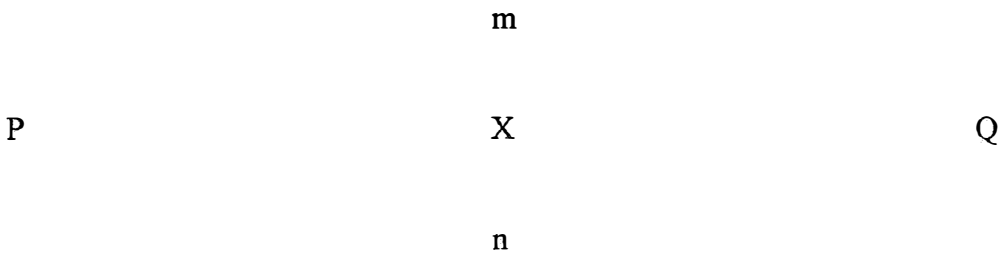
9. An "ideal" transformer has 200 turns in the primary winding and 40 000turns in the secondary. If a current of 2 mA flows in the secondary and the power output is 100 watts the primary voltage is:-

a) 200 V
b) 250 V
c) 400 V
d) 50 000 V

10. In an electric meter in which the magnetic pole pieces are curved to produce a radial magnetic field:-

a) the scale is always linear
b) the rectangular conducting loop is always parallel to the magnetic field
c) the rectangular conducting loop is always perpendicular to the magnetic field
d) two of the above

11. Oppositely charged objects P and Q are separated as in the diagram below.



A third charge X is placed and held half way between P and Q. To place X in a region of higher electric field intensity X could be moved towards:-

a) m or n
b) P or Q
c) P only
d) Q only

12. Á charged particle may be able to move in a straight line through a region containing an electric and a magnetic field if it enters:-

a) the magnetic field before the electric field
b) the electric field before the magnetic field
c) a region where the magnetic and electric fields are perpendicular to each other.
d) a region where the magnetic and electric fields are parallel with each other

13. A photon of wavelength 400 nm would have energy of approximately:-

a) 3.1 eV
b) 4.9 eV
c) 2.4×10^{-40} J
d) 9.0×10^{-19} J

14. A monochromatic light source is causing electrons to be emitted from a metal surface. Greatly increasing the intensity of the light source will result in:-

a) electrons being emitted with greater energy
b) many more electrons being emitted
c) slightly more electrons being emitted
d) no change in the number of emitted electrons

15. The number of free electrons that can drift from atom to atom is least in:-

a) insulators
b) p type semiconductors
c) n type semiconductors
d) conductors

End Section 1 Part Á multiple choice

Student ID: .....

Section I Part B:Questions 16-29 Answer all questions in the space provided.
Show all relevant working .

16. At lift-off a rocket has a mass of 35,000 kg, of which 80% is fuel. The rocket takes off vertically and has a thrust of 400,000 N. Just before the fuel runs out the rocket is accelerating vertically. Assuming that the thrust is constant find:-

a) the acceleration at lift-off. (2 marks)

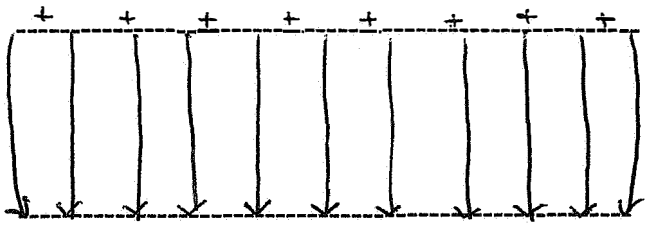
b) the g-force on the rocket just before the fuel runs out. (2 marks)

17. Compare qualitatively low earth and geo-stationary orbits. (4 marks)

18. Explain how the production and reception of radio waves may be demonstrated in the school laboratory. (4 marks)

Student ID: .....

19. A pair of parallel conducting plates is separated by a distance of 20mm,as in the diagram below. The potential difference across the plates is 4000 volts. The upper plate is positive.



a) Draw the electric field lines on the diagram using all the usual conventions.

(1 mark)

b) A charge of + 1.6×10^{-19} C is placed 5mm from the negative plate. Find the force acting on the charge.(disregard gravity) (2 marks)

c) The charge is now moved to a position 5mm from the positive plate. What force now acts on the charge? Give a reason for your answer. (2 marks)

20. Describe how "doping" a semiconductor can change its electrical properties. (3 marks)

Student ID: .....

21. a) Identify a practising male or female Australian scientist. (1 mark)

b) In what area is he/she currently working? (1 mark)

c) Give information about his/her research. (2 marks)

22. What is the nature of an inertial frame of reference? (2 marks)

23. a) Spaceship "Interstellar" is travelling through space at a speed at which the time passed on the spaceship in one earth day appears to take only 10 hours. At what fraction of the speed of light is the spaceship travelling? (3 marks)

b) If the "Interstellar" is 25m long with respect to an observer who is onboard, what will an observer who is stationary with respect to the spaceship measure its length to be as it passes at the speed in a) above? (2 marks)

Student ID: .....

24. The table below shows the radius of orbit for a number of planets in our solar system. For this question assume that the orbits are circular and the planets move at a constant speed.

Planet:	Mercury	Venus	Earth	Jupiter	Saturn
radius of orbit (x 10^6 km)	58.5	109	150	780	1430

a) Calculate the time for Jupiter to complete one orbit in terms of earth years (2 marks)

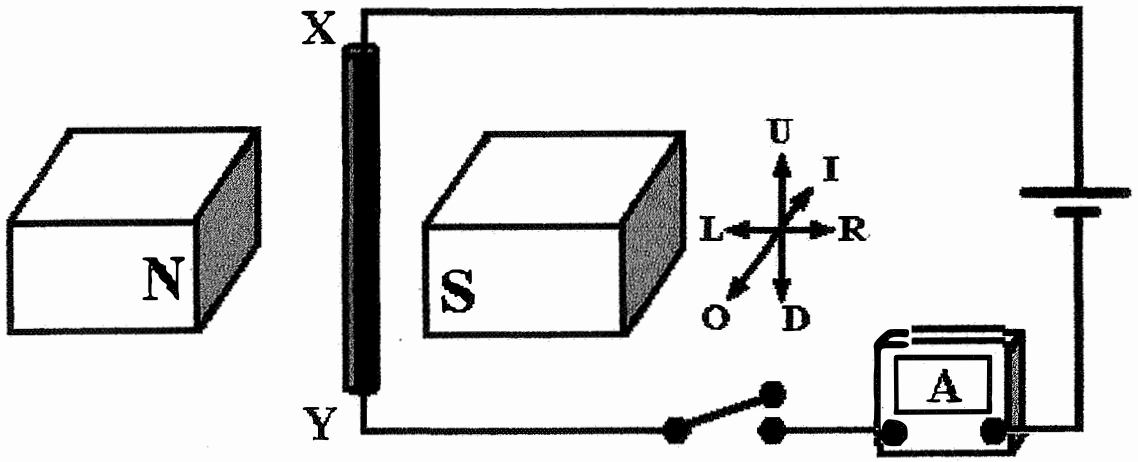
b) Calculate the orbital speed of Jupiter in ms^{-1}. (2 marks)

c) If the mass of Jupiter is 1.9×10^{27} kg find the force the sun exerts on it to keep it in orbit.

(2 marks)

Student ID: .....

25. In the diagram below two bar magnets are producing a uniform magnetic field of 0.4 Tesla. The conductor X-Y is 5.0 cm long and has a total resistance of 10.0 ohms, distributed evenly along the conductor. Only 3.0 cm of the conductor is actually inside the magnetic field. The battery voltage is 100.0 volts.



A perpendicular axis system is shown in the diagram, labelled: up (U), down (D), left (L), right (R), into page (I) and out of page (O). The conductor is free to move in any of these directions.

a) Calculate the current flowing in the circuit just as the switch is closed, before the conductor starts to move. (1 mark)

b) Calculate the magnitude of the magnetic force exerted on the conductor after the switch is closed. (1 mark)

c) State the direction: U, D, R, L, I or O, in which the conductor will start to move.

(1 mark)

Student ID: .....

25 cont. d) As the conductor starts to move in response to this magnetic force, the reading on the ammeter will change. State how the reading will change and explain the reasoning behind your answer. (3 marks)

26. A particle of charge 3.2×10^{-19}C and mass 4 atomic mass units (u) enters a uniform magnetic field of strength 0.2 Tesla with a velocity of 4×10^{6} ms^{-1} whereupon it moves in a circular path. Assuming it completes a semicircle, then leaves the field, determine the time it spends in the field. (4 marks)

Student ID: .....

27. Explain the particle theory of light in terms of photons with particular energy and frequency. (5 marks)

28 a) Explain the role of transformers in electricity substations (3 marks)

28 cont.

b) Why do some electrical appliances in the home use a transformer? Give an example. (3 marks)

29 Discuss the effect on the magnitude of the force on a current-carrying conductor when the angle between the direction of the external magnetic field and the direction of the length of the conductor is varied. (2 marks)

End of PART B

Student ID: .....

Section II Option: Quanta to Quarks. Answer all questions in the writing booklet provided. Show all working.

1 What is meant by the term "transmutation". (1 mark)

2 Outline how you performed a first hand investigation to observe the hydrogen spectrum. (4 marks)

3 Account for the need for the strong nuclear force and describe its properties. (4)

4. One atom of U 235 can fission to produce La 139 and Mo 95 and two neutrons as in the equation below:- (do not consider electrons in any calculations)

$$^{235}U + {}^{1}n \rightarrow {}^{139}La + {}^{95}Mo + 2({}^{1}n)$$

where La 139 = 138.8061 amu
Mo 95 = 94.9057 amu
U 235 = 235.0439 amu
n = 1.0087 amu

a) Using the information above calculate the mass defect of U 235 in amu. (2 marks)

b) How many joules is this equivalent to? (2 marks)

c) If235 grams of U contains 6×10^{23} atoms how many joules of energy would be released by the complete conversion of one kg of U 235 into energy? (3 marks)

5. Protons in the nucleus attract each other gravitationally and repel electrically. Evaluate the relative contributions of the two forces. (Numerical answer required.). Given the electrical force is $kQq \div R^2$, where k is the coulomb constant 9×10^9 SI units, and charges Q and q coulombs are separated by R metres.

(3 marks)

.6 Explain the concept of mass defect and indicate how this relates to the release of energy in a fission reaction. (6 marks)

End of Section II Option

---------- **END OF TEST** ----------

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PHYSICS

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2004 TRIAL EXAMINATION SOLUTIONS

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Section I **Part A:** **Answer Space.** Place a cross in the correct space.

	A	B	C	D
1				X
2			X	
3	X			
4		X		
5	X			
6				X
7			X	
8		•		X
9		X		
10				X
11		X		
12			X	
13	X			
14		X		
15	X			

Student ID: .....

Section I **Part B:Questions 16-29** Answer all questions in the space provided.
Show all relevant working .

16. At lift-off a rocket has a mass of 35,000 kg, of which 80% is fuel. The rocket takes off vertically and has a thrust of 400,000 N. Just before the fuel runs out the rocket is accelerating vertically. Assuming that the thrust is constant find:-

a) the acceleration at lift-off. (2 marks)

$T - mg = ma$

mass of rocket = 35000 − 7000 kg

$T = 400{,}000$

$a = \frac{T - mg}{m} = \frac{400000}{35000} = 11.4\ ms^{-2}$ 1.62

b) the g-force on the rocket just before the fuel runs out. (2 marks)

after fuel burn, mass of rocket = 35000 − 7000 = 7000 kg

$T = 400{,}000$ $m = 7000$ $a = \frac{T}{m} = 47.1\ ms^{-2}$

$a = \frac{T - mg}{m}$

$= \frac{400000 - (7000}{7000}$

$= 47.34$

$g = \frac{47.1 + 9.8}{9.8} = 5.8\ g$

17. Compare qualitatively low earth and geo-stationary orbits. (4 marks)

Low earth	Geostationary
• lies on outer rim of atmosphere	• lies near upper edge of V.A. belts
• about 250 − 1000 km high	• altitude 35800 km
• period of 90 minutes	• period about 24 hours
• orbital vel. of 28000 km h^{-1}	• orbital speed is 11000 km h^{-1}
• subjected to friction	• not subjected to friction

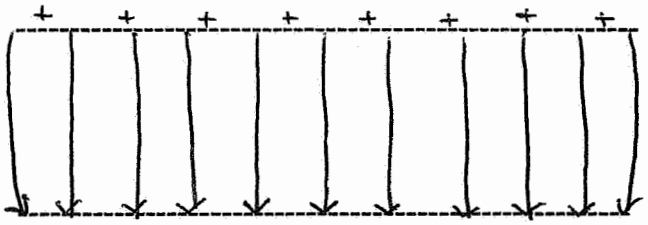
18. Explain how the production and reception of radio waves may be demonstrated in the school laboratory. (4 marks)

Equipment : high voltage source (induction coil), small portable rad
Adjust induction coil to produce at a 5 mm spark
the AM dial
Scan across to pick up the radio waves produced by sparking

or Set up CRO with unbeadable wires attached to input
Place CRO 1.5 m in front of induction coil
and observe pattern of wave on screen

Student ID: .....

19. A pair of parallel conducting plates is separated by a distance of 20mm,as in the diagram below. The potential difference across the plates is 4000 volts. The upper plate is positive.



a) Draw the electric field lines on the diagram using all the usual conventions. (1 mark)

b) A charge of + 1.6×10^{-19} C is placed 5mm from the negative plate. Find the force acting on the charge.(disregard gravity) (2 marks)

$E = \frac{V}{d} = \frac{4000}{20 \times 10^{-3}} = 200\,000$ V

$F = Eq$

$= 3.2 \times 10^{-14}$ N downwards or toward − plate

c) The charge is now moved to a position 5mm from the positive plate. What force now acts on the charge? Give a reason for your answer. (2 marks)

Same force (3.2×10^{-14} N)

Electric field is uniform.

20. Describe how "doping" a semiconductor can change its electrical properties. (3 marks)

Doping is the addition of an impurity to a semiconductor. Doping increases the electrical conductivity of the semiconductor.

N-type semiconductors : gp. 5 element used for doping. The extra e^- is in the conduction band and is mobile, increasing the conductivity (eg. P or As)

p-type semiconductor : gp. 3 element (eg. B or Ga) used for doping. As there are only 3 valence e^-, a hole is incorporated, which can be filled by an e^-. The hole facilitates the movement of e^-, i.e. increasing its conductivity.

Student ID: .....

21. a) Identify a practising male or female Australian scientist. (1 mark)

.....

b) In what area is he/she currently working? (1 mark)

.....

c) Give information about his/her research. (2 marks)

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22. What is the nature of an inertial frame of reference? (2 marks)

It is a non-accelerating frame of reference (is at rest or moving at constant velocity)
: a frame of reference where all the laws of motion are valid

23. a) Spaceship "Interstellar" is travelling through space at a speed at which the time passed on the spaceship in one earth day appears to take only 10 hours. At what fraction of the speed of light is the spaceship travelling? (3 marks)

$t_v = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$ $t_0 = 10$ $t_v =$

$\sqrt{1-\left(\frac{v}{c}\right)^2} = \frac{t_0}{t_v}$

$\frac{v}{c} = \sqrt{1-\left(\frac{10}{24}\right)^2}$

$\frac{v}{c} = 0.9091$ $v = 0.9091\,c$ or $0.91\,c$

b) If the "Interstellar" is 25m long with respect to an observer who is onboard, what will an observer who is stationary with respect to the spaceship measure its length to be as it passes at the speed in a) above? (2 marks)

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

$= 25\sqrt{1-\left(\frac{v}{c}\right)^2}$

$= 10.42$ m

Student ID: .....

24. The table below shows the radius of orbit for a number of planets in our solar system. For this question assume that the orbits are circular and the planets move at a constant speed.

Planet:	Mercury	Venus	Earth	Jupiter	Saturn
radius of orbit (x 10^6 km)	58.5	109	150	780	1430

a) Calculate the time for Jupiter to complete one orbit in terms of earth years (2 marks)

$\frac{R^3}{T^2} = \frac{R^3}{T^2}$

$T = 11.86$ Earth Years

b) Calculate the orbital speed of Jupiter in ms^{-1}. (2 marks)

$v = \frac{2\pi r}{T}$

$v = 13105.78\ ms^{-1}$ or $1.31 \times 10^4\ ms^{-1}$

c) If the mass of Jupiter is 1.9×10^{27} kg find the force the sun exerts on it to keep it in orbit.

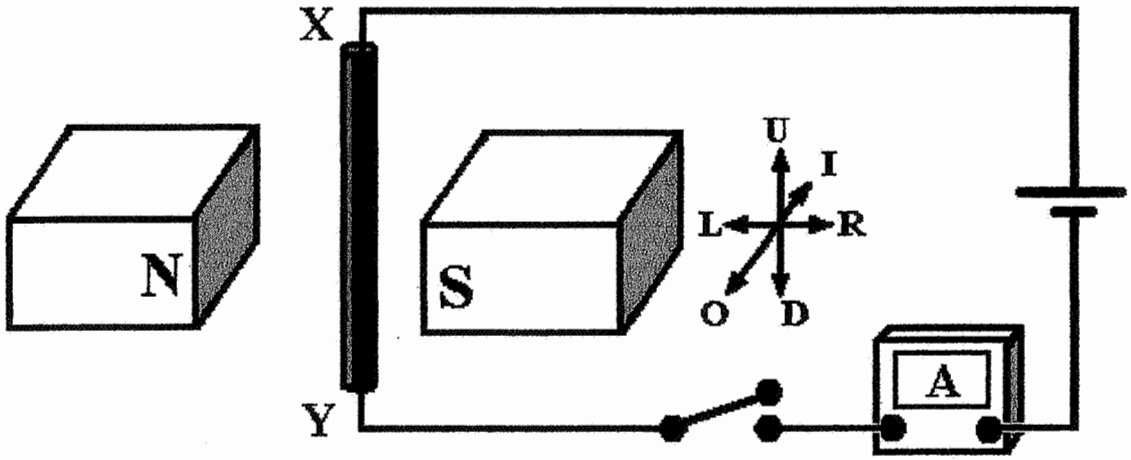
(2 marks)

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

$= \frac{(1.9 \times 10^{27})(13105.78)^2}{7.80 \times 10^9}$

$= 4.18 \times 10^{23}$ N toward Sun

25. In the diagram below two bar magnets are producing a uniform magnetic field of 0.4 Tesla. The conductor X-Y is 5.0 cm long and has a total resistance of 10.0 ohms, distributed evenly along the conductor. Only 3.0 cm of the conductor is actually inside the magnetic field. The battery voltage is 100.0 volts.



A perpendicular axis system is shown in the diagram, labelled: up (U), down (D), left (L), right (R), into page (I) and out of page (O). The conductor is free to move in any of these directions.

a) Calculate the current flowing in the circuit just as the switch is closed, before the conductor starts to move. (1 mark)

$I = \frac{V}{R} = \frac{100}{10} = 10\ A$

b) Calculate the magnitude of the magnetic force exerted on the conductor after the switch is closed. (1 mark)

$F = BIl$
$= 0.4 \times 10 \times 3 \times 10^{-2}$
$= 1.2 \times 10^{-1}$ $F = 0.12\ N$

c) State the direction: U, D, R, L, I or O, in which the conductor will start to move.

(1 mark)

O

25 cont. d) As the conductor starts to move in response to this magnetic force, the reading on the ammeter will change. State how the reading will change and explain the reasoning behind your answer. (3 marks)

Current will decrease because as the conductor moves towards O the force on the charges in XY will be upwards (U) direction, opposing the original current

∴ current in direction X to Y will decrease

(This is an eg of back emf.)

26. A particle of charge 3.2×10^{-19} C and mass 4 atomic mass units (u) enters a uniform magnetic field of strength 0.2 Tesla with a velocity of 4×10^{6} ms^{-1} whereupon it moves in a circular path. Assuming it completes a semicircle, then leaves the field, determine the time it spends in the field. (4 marks)

$F_B = qvB$ $F_c = \frac{mv^2}{r}$ $T = \frac{2\pi r}{v}$

$\frac{mv^2}{r} = qvB$ $v = \frac{2\pi r}{T}$

$qB = \frac{m.2\pi r}{T}$

$T = \frac{m.2\pi r}{qB} = 650 \times 10^{-9}$ s

or $\frac{1}{2}T = 325$ ns

Student ID: .....

27. Explain the particle theory of light in terms of photons with particular energy and frequency. (5 marks)

Light can be considered to be packets of energy.

A photon is the smallest amount of energy a particular frequency of light can have.

The energy of a photon is given by $E = hf$

Energy can be transfered to matter from light in photons.

However, a photon cannot transfer parts of its energy, but all or none of it.

The intensity of light is dependent on the number of photons in a given area.

All photons, regardless of their frequency, have zero rest mass and travel at the speed of light.

28. a) Explain the role of transformers in electricity substations (3 marks)

In transmission substations transformers increase the voltage & reduce the current when trasmitting power for a large distance from ~~where~~ power station to where consumers are located.

Because current is reduced, energy loss is reduced $P = I^2R$

In suburban powerstations and in city areas, the voltage is stepped down, so to be safely used at homes, offices etc

28 cont.

b) Why do some electrical appliances in the home use a transformer? Give an example. (3 marks)

Homes are provided with 240 V. most electronic circuits are designed to operate between 3 – 12 V. ∴ step down transformers are used eg. CD players. Other devices, T.V. & monitors require high voltage to operate CRT, ∴ step-up transformers are built in.

29 Discuss the effect on the magnitude of the force on a current-carrying conductor when the angle between the direction of the external magnetic field and the direction of the length of the conductor is varied. (2 marks)

When conductor is perpendicular to $\vec{B}$, the force is max. When cond. is parallel to $\vec{B}$, the force is zero. When conductor is at θ to $\vec{B}$, the force is proportional to $\sin\theta$.

End of PART B

Student ID: .....

Section II **Option: Quanta to Quarks.** Answer all questions in the writing booklet provided. Show all working.

a RA element emitting α or β, producing a new element.

1 What is meant by the term "transmutation". (1 mark)

H spectral tube, high V source, spectroscope, in the dark

2 Outline how you performed a first hand investigation to observe the hydrogen spectrum. (4 marks)

F_g not strong

3 Account for the need for the strong nuclear force and describe its properties. 4 prop (4 marks)

F_{el} repulsion, weaker. 3 " − 1 m "

4. One atom of U 235 can fission to produce La 139 and Mo 95 and two neutrons as in the equation below:- (do not consider electrons in any calculations)

$$^{235}U + {}^{1}n \rightarrow {}^{139}La + {}^{95}Mo + 2({}^{1}n)$$

where La 139 = 138.8061 amu
Mo 95 = 94.9057 amu
U 235 = 235.0439 amu
n = 1.0087 amu

0.3234 amu

a) Using the information above calculate the mass defect of U 235 in amu. (2 marks)

b) How many joules is this equivalent to? 4.8×10^{-11} J (2 marks)

c) If 235 grams of U contains 6×10^{23} atoms how many joules of energy would be released by the complete conversion of one kg of U 235 into energy? 1.2×10^{14} J or 9×10^{16} J (3 marks)

5. Protons in the nucleus attract each other gravitationally and repel electrically. Evaluate the relative contributions of the two forces. (Numerical answer required.). Given the electrical force is $kQq \div R^2$, where k is the coulomb constant 9×10^9 SI units, and charges Q and q coulombs are separated by R metres. F_{el} = 1.4×10^{36} times the F_g

All working to be shown. (3 marks)

.6 Explain the concept of mass defect and indicate how this relates to the release of energy in a fission reaction. (6 marks)

mass defect – definition.

$E = mc^2$.

Fission example.

---------- end section II Option ----------

---------- **END OF TEST** ----------