Physics
2013 Task 4
Trial HSC

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
  Black pen is preferred
- 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

Total marks – 100

Section I

75 marks

This section has two parts, Part A and Part B

Part A – 20 marks
- Attempt Questions 1–20
- Choose the most correct answer

Part B – 55 marks
- Attempt Questions 21–30

Section II- Option:Quanta to Quarks

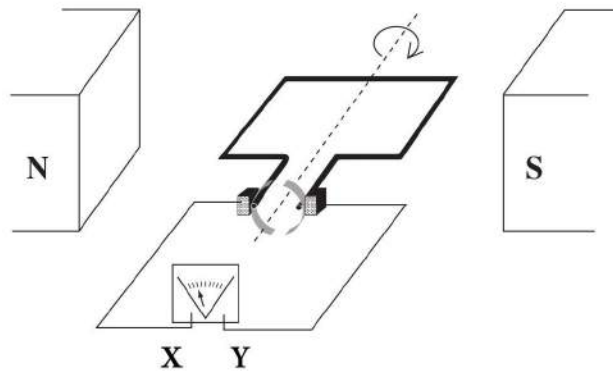**25 marks**

Section I
75 marks

Part A – 20 marks
Attempt Questions 1–20
Allow about 35 minutes for this part

Use the multiple-choice answer sheet for Questions 1–20.

___

1   The diagram shows a device connected to a meter.

The coil is rotating in a magnetic field as shown. The polarity of the terminal labelled X will be:

(A)   North

(B)   Negative

(C)   South

(D)   Positive

2   In 1983 the definition for the standard metre was changed. This was done because:

(A)   Prior to 1983 there was no international agreement

(B)   The definition needed to be based on a universal constant independent of the frame of reference

(C)   The wavelength of light from a krypton lamp could be reproduced in any laboratory

(D)   The distance between two lines on a platinum iridium bar was considered to be reliable in all inertial frames of reference

3 The heated filament in a cathode ray tube would normally be found near the:

(A) Cathode

(B) Anode

(C) Electric field plates

(D) Helmholtz coils

4 The graph shows how the gravitational potential energy (E_p) of a satellite changes with its altitude.
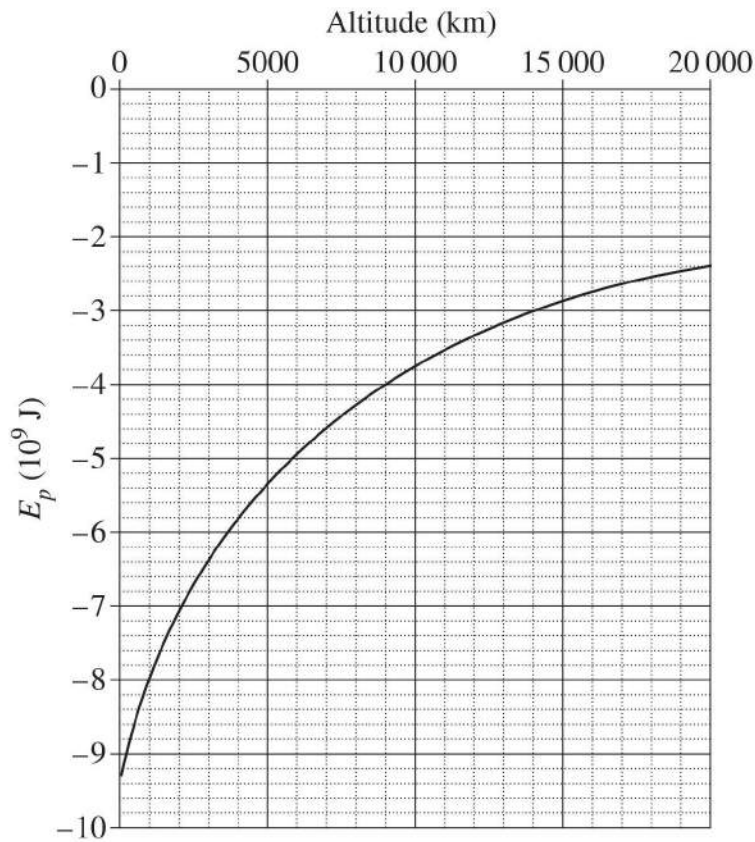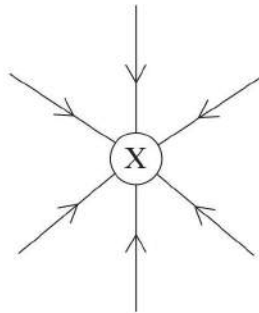

What is the work done when a satellite's altitude is changed from 9 000 km to 13000 km?

(A) -8.0×10^2 MJ

(B) $+8.0 \times 10^9$ J
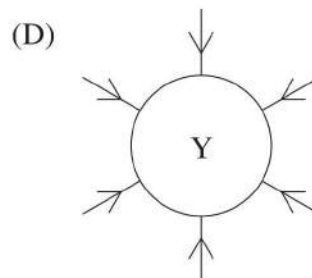
(C) -0.8×10^9 J

(D) $+8.0 \times 10^2$ MJ

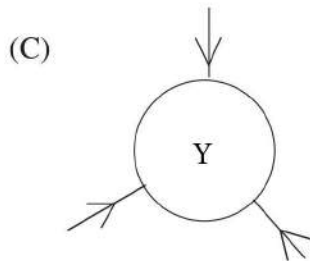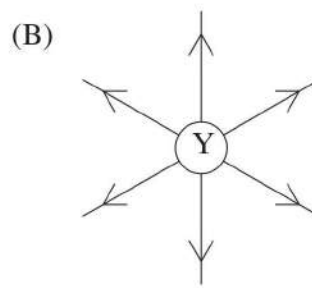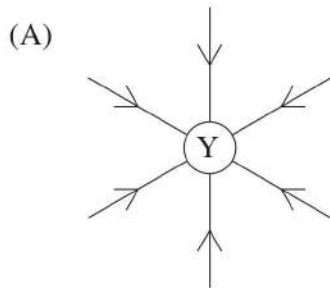**5**   Which of the following could be added to a crystal of silicon to create an n-type semiconductor?

(A)   Carbon

(B)   Boron

(C)   Indium

(D)   Arsenic

**6**   The diagram represents the gravitational field around planet X.

If planet Y has the same mass but half the density, which diagram would best represent its gravitational field?

(A)

(B)

(C)

(D)

7 In moving-coil galvanometers, the coil experiences a torque because of the current flowing through it and this causes a pointer to move across a linear scale.

What factor does not contribute to the scale being linear?

(A) A spring which provides proportionality between its angular displacement and

the applied torque

(B) A constant relationship between the plane of the coil and the magnetic field

(C) A DC input which is proportional to voltage

(D) A constant cross-sectional area of the moving coil

8 A wire carrying a current of 1.3 amperes passes through a region of uniform magnetic field, magnitude 0.05 T, and as a result experiences a force of magnitude 0.02 N.
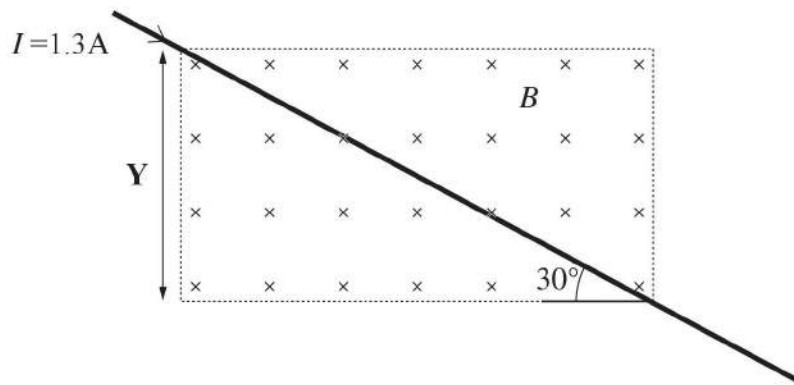
What is the length of the dimension Y?

(A) 0.3 m

(B) 0.5 m

(C) 0.4 m

(D) 0.2 m

9 Compared to a low earth orbit satellite, which row of the table correctly describes the relative properties of a geostationary satellite of the same mass?

	Orbital velocity (m/s)	E_P (J)
(A)	Higher	Higher
(B)	Higher	Lower
(C)	Lower	Higher
(D)	Lower	Lower

10   If the transformers below are 90% efficient at stepping up voltage, which one would be best to convert 10 volts AC to an output voltage of 22 volts AC?

(A)

10 turns | | 4 turns

(B)

10 turns | | 22 turns

(C)

2 turns | | 10 turns

(D)

22 turns | | 10 turns
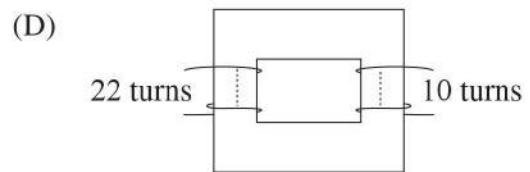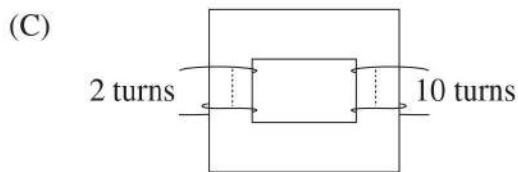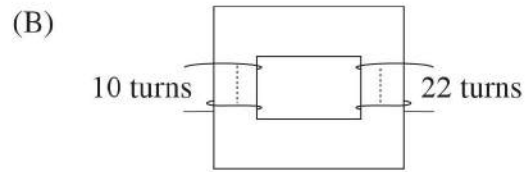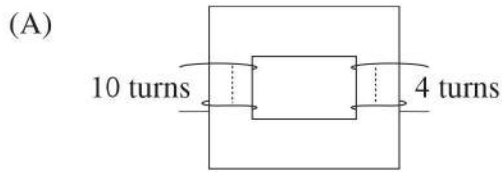
11   Which of the following statements is correct regarding the physics of a rocket launch?

(A)   Equal and opposite forces act on the rocket. This enables it to continue to accelerate even in the vacuum of space

(B)   The change in momentum of the expelled gases is equal in magnitude to the change in momentum of the rocket

(C)   The change in momentum of the expelled gases and the rocket ship must remain equal at all times

(D) The expelled gases exert a force against the launch pad. The launch pad then exerts an equal and opposite force on the rocket causing it to accelerate

Use the data below to answer Questions 12 and 13.

Orbital period of the Moon around Earth	2.36×10^6 s
Mean orbital radius of the Moon	3.83×10^8 m
Mass of Earth	6.0×10^{24} kg
Mass of the Moon	7.35×10^{22} kg

12   What is the gravitational force exerted on the Earth by the Moon ?

(A) 7.6×10^{20} N

(B) 1.6×10^{22} N

(C) 4.7×10^{26} N

(D) 2.0×10^{20} N

13   What is the orbital period of an Earth satellite having an orbital radius one third that of the Moon?

(A) 4.53×10^5 s

(B) 2.06×10^4 s

(C) 4.53×10^6 s

(D) 2.06×10^3 s

14 The graph shows variation in magnetic flux through a generator coil with time.
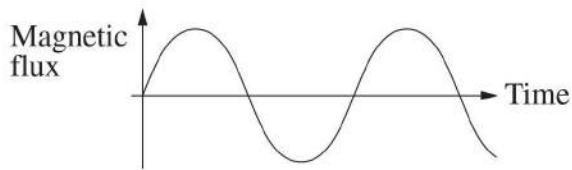
Which graph best represents the corresponding induced back emf in the coil?

(A) Back emf

(B) Back emf

(C) Back emf

(D) Back emf
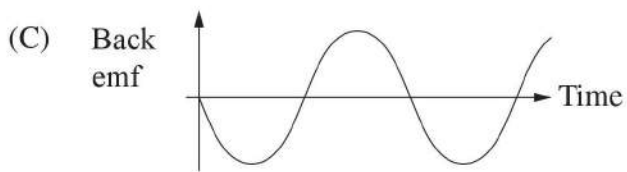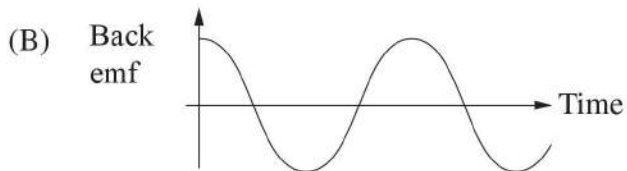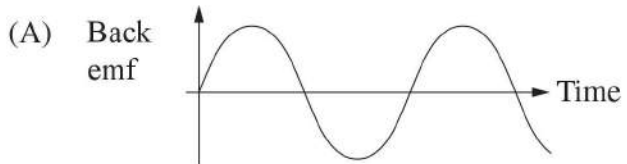
15 A sample of pure silicon is doped with boron. How do the electrical properties of the doped silicon change ?

(A) An increased number of electrons, lower resistance and a band gap less than 1.2 eV

(B) An increased number of electrons, better conductivity and a band gap of 1.2 eV

(C) An increased number of holes, better conductivity and a band gap less than 1.2 eV

(D) An increased number of holes, lower resistance and a band gap greater than 1.2 eV

16 A 12V electric generator is connected in series with a switch, an ammeter, a voltmeter and a light bulb. With the switch open, both the ammeter and voltmeter give a zero reading.

Which of the following correctly describes what happens when the switch is closed?

(A) If the applied voltage exceeds the back emf the light will turn on

(B) The ammeter will read zero, the voltmeter will read 12 and the lamp will be off

(C) The ammeter will give a non zero reading, the voltmeter will read zero and the lamp will be off

(D) The lamp will turn on and the voltmeter will read slightly less than 12 volts

17 The following equipment is attached to a DC power supply.
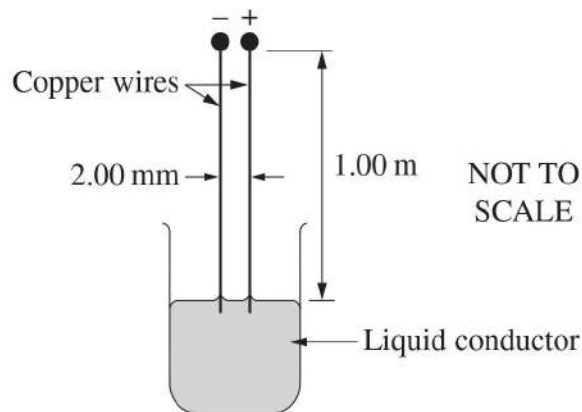
What current must be flowing through the wires to result in a force of 15.6 mN between them?

(A) 0.224 A

(B) 5.00 A

(C) 12.5 A

(D) 25.0 A

18 Two satellites are in orbit around the Earth at the radii shown. Satellite Y has twice the mass of satellite X. If the orbital velocity of X and Y is V_X and V_Y respectively,

Earth

X   Y

THIS DIAGRAM IS
DRAWN TO SCALE
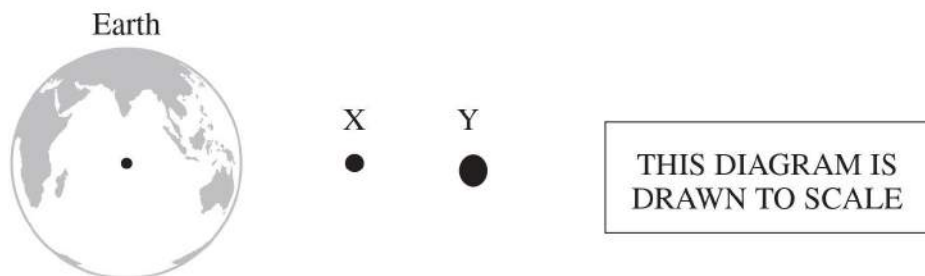
What is the value of $\dfrac{V_Y}{V_X}$?

(A) 0.8

(B) 0.7

(C) 1.4

(D) 0.5

19 The diagram represents an induction cooking system.

Base of the cooking pot

Ceramic cooktop

AC voltage source
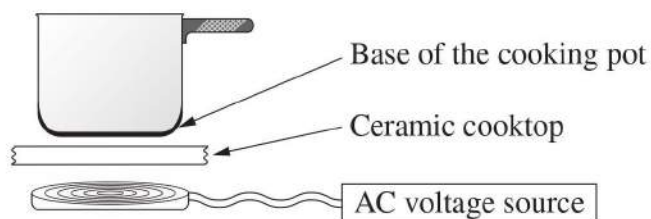
Which row in the following table shows the set of conditions that would result in the slowest heating of the base of the cooking pot?

	AC voltage frequency	Electrical resistance of pot base
(A)	Low	Low
(B)	Low	High
(C)	High	Low
(D)	High	High

20 An intergalactic security company wishes to develop a semiconductor sensor to detect thermal radiation from Klingons. The sensor will work on the same principle as a solar cell.

Typical Klingon Blackbody Radiation Curve
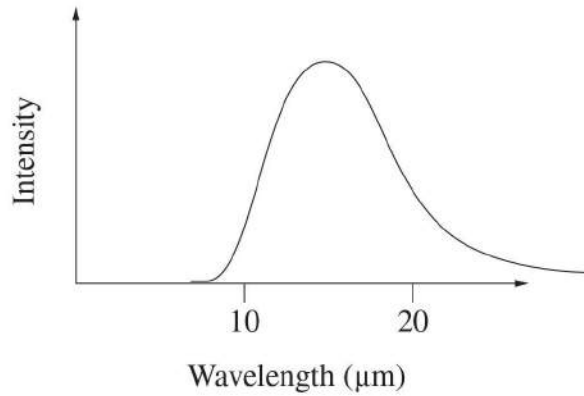
Semiconductor	Band gap (eV)
HgCdTeq	0.03
InSbGz	1.25
GeCdAx	1.33
GaNj	0.08

Using the information provided, which semiconductor would be most suitable for this purpose?

(A) HgCdTeq

(B) InSbGz

(C) GeCdAx

(D) GaNj

Section I (continued)

Part B – 55 marks
Attempt Questions 21–30
Allow about 1 hour and 40 minutes for this part

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Marks are allocated to working in questions involving calculations. Show all working.

Question 21 (6 marks)

(a)   Outline a first-hand investigation that could be performed to distinguish   **3**
between non-inertial and inertial frames of reference.

(b)   Six students in the same class each built a pendulum and measured the time for one   **3**
swing. Each student's pendulum was a different length. Each student used their own
period and length measurement to calculate a value for "g".

Without changing the length of each student's pendulum or the equipment used,
describe a procedure that could be used to achieve a more reliable result for "g".

(c)

Question 22 (6 marks)

A bar magnet is placed on a sensitive electronic balance as shown in the diagram. A hollow solenoid is held stationary, such that the magnet is partly within the solenoid.

The solenoid is then lifted straight up without touching the magnet.

(a)   Explain the changes would you expect to observe on the electronic balance?   **2**

(b)   A voltmeter and an ammeter were then connected in series between points X and Y and the experiment was repeated. Explain what would be observed on the two meters.   **4**

Question 23 (4 marks)

Consider the following thought experiment.

Two towers are built on Earth's surface. The top of each of the towers is 350 km above the surface of the Earth . Tower A is built at the Earth's North Pole and Tower B is built at the equator.

NOT TO SCALE
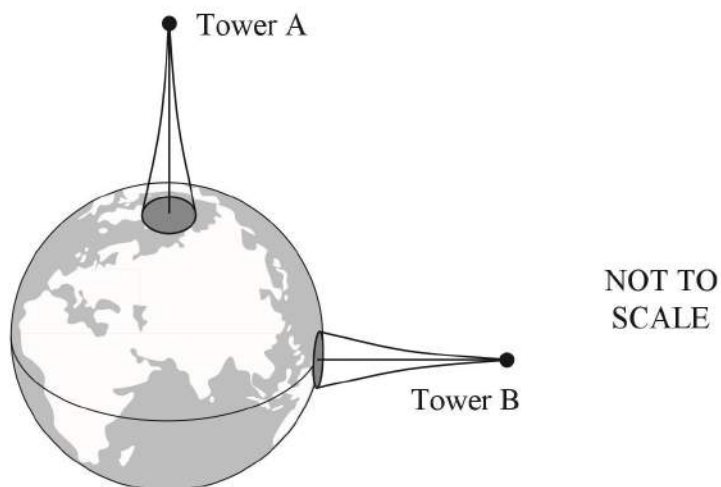
a) Identical masses are simultaneously released from rest from the top of each tower. Compare the motion of each of the masses after their release. **3**

b) Calculate the gravitational potential of a 2.0 kg mass placed at the top of Tower B. The radius of the earth at the equator is 6378 km. **1**
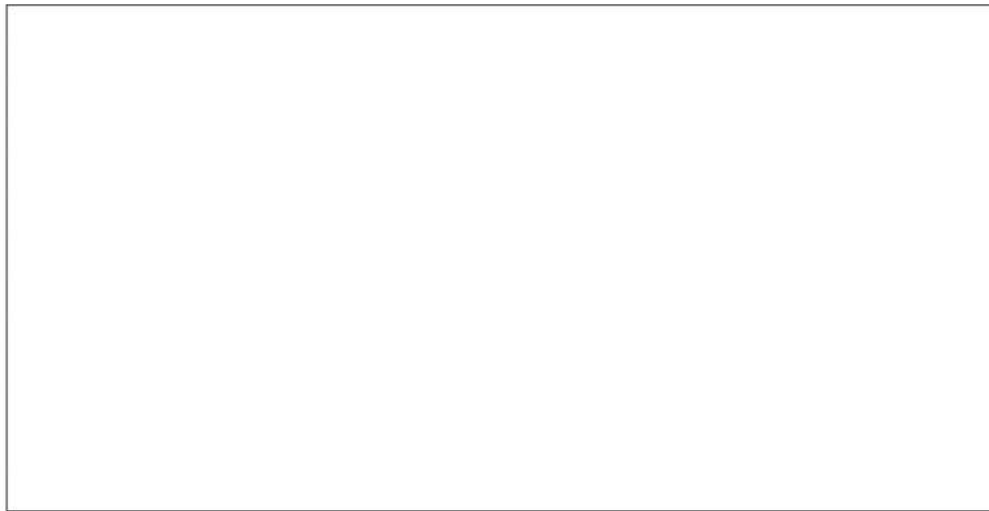
Student Number

Question 24 (5 marks)

(a) Using a labelled diagram, show the differences in the energy bands between P type and N type semiconductors.   **3**

(b) Contrast the effect of heat on the electrical properties of metals and semiconductors.   **2**

2013 SBHS Physics Trial.

Section I – Part B (continued)

Student Number

Question 25 (7 marks)

(a)   The diode valve has largely been replaced by the PN junction.   **4**

Draw labelled diagrams of a diode valve and a PN junction.

(b)   Assess the impact of the use of solid state devices on communication.   **3**

Question 26 (6 marks) .

A transmission line is to be used to supply 100 MW of power from a power station to a substation 100 km away. Two possible designs are shown below.

Design A – Low voltage

| Power station 1_{10} MW output | Substation 100 MW input 33 kV input |

100 km

Design B – High voltage

40 W total line resistance

| Power station with step-up transformer, 5_{10} kV output | Substation 100 MW input 500 kV input |

100 km
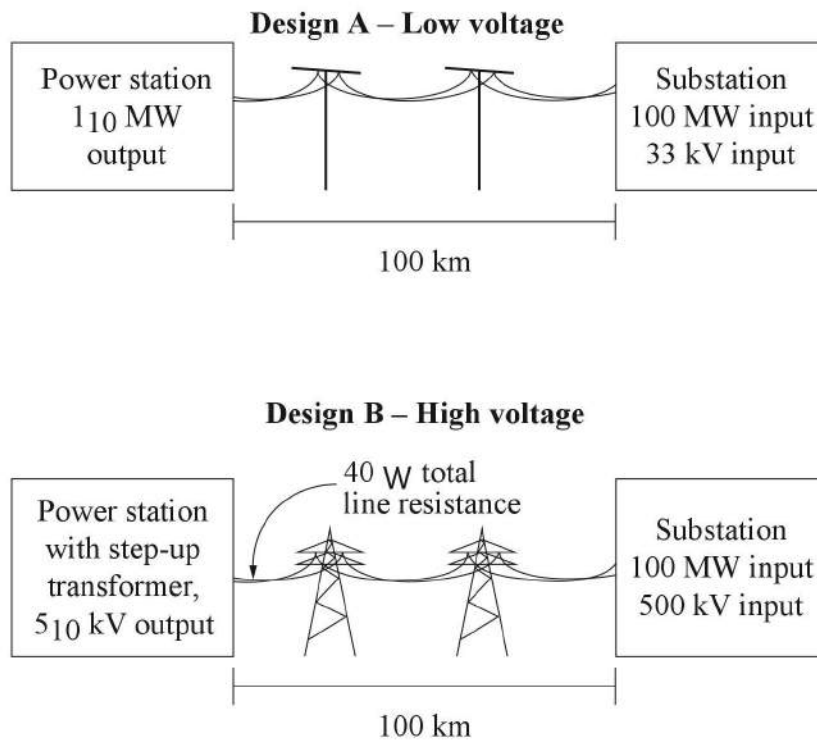
a) Using appropriate calculations, evaluate the relative efficiency of each design in supplying electrical energy to the substation. **4**

b) Account for the differences in efficiency of each design. **2**

Question 27 (4 marks)

A projectile is launched at 60° to the horizontal from the top of a 34 metre cliff.

4

The target is positioned 55 m away from the base of the cliff.
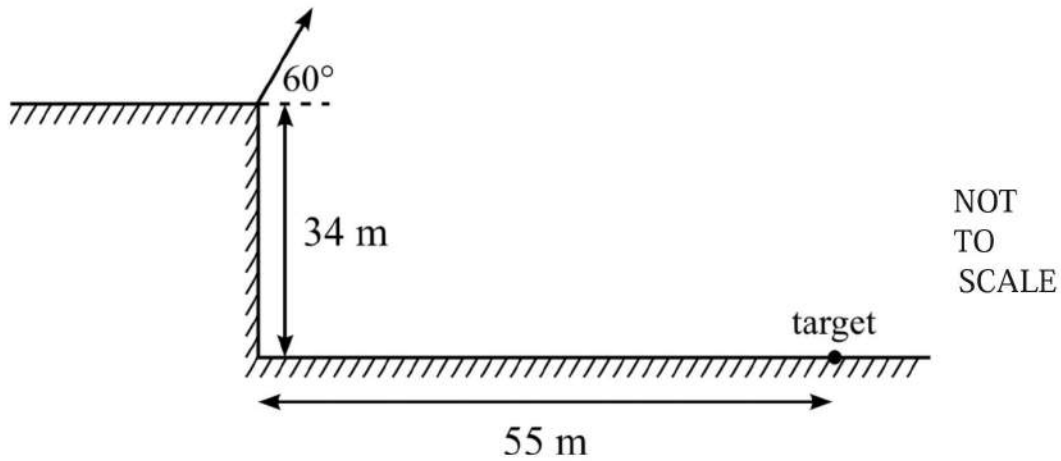
Calculate the magnitude of the required launch velocity such that the projectile strikes the target 34 m below the launch height.

Question 28 (7 marks)

(a)   Outline ONE piece of evidence supporting Einstein's theory of relativity.   **2**

(b)   What criteria are used to test and validate a theory?   **3**

(c)   The distance between the cathode and screen in a cathode ray tube is 40 cm.   **2**

   If an electron travels through the tube at 3.0×10^7 m s^{-1}, what is the apparent distance from the cathode to the screen in the electron's frame of reference?
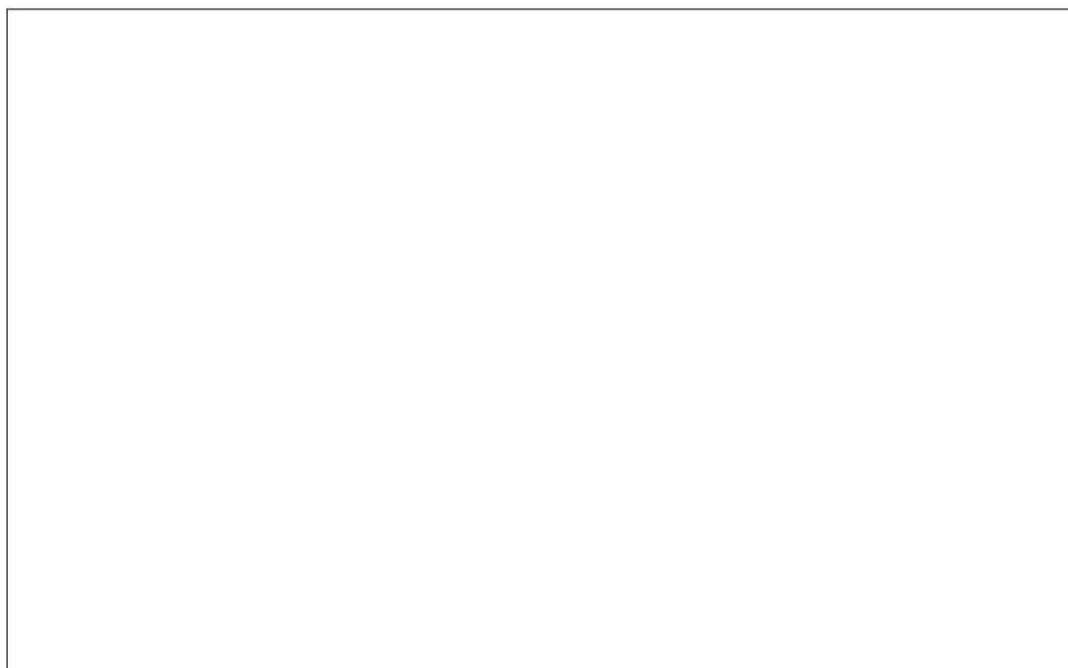
Question 29 (5 marks)

With the aid of a labelled diagram, explain how the galvanometer maintains a linear   **5**

relationship between input current and displacement of the pointer.

Question 30 (5 marks)

The diagram shows the paths taken by an alpha and beta particle when they enter a region of uniform magnetic field.

(a) Why are the paths circular ?   **1**

(b) Which path does the beta particle follow? Justify your answer.   **2**

(c) The alpha particle enters the field at a velocity of 5500 m/s. Calculate the radius   **2**
     of curvature of it's path while in the field. (Alpha particle mass = 4.001 amu)

2013 SBHS Physics Trial

Section II - The Options

25 marks

This paper only includes the Quanta to Quarks Option.

ANSWERS GO IN THE SEPARATE ANSWER BOOKLET

Show all relevant working in questions involving calculations.

From Quanta to Quarks (25 marks)

Answer in the Answer Booklet provided.

(a)   (i)   Why was the Bohr model of the atom an improvement on the model   **2**
                  proposed by Rutherford ?

        (ii)   Use the Rydberg equation to calculate the wavelength of the highest   **2**
                  freqency visible line in the Balmer series.

       (iii)   Outline the contribution of the Pauli Exclusion Principle in clarifying
                  2 shortcomings of the Bohr model of the atom.   **2**

(b)   (i)   What are the requirements for a controlled nuclear chain reaction?   **2**

        (ii) $^{235}U_{92} + {}^{1}n_0 \text{ ------- } {}^{140}Ba_{56} + {}^{92}Kr_{36} + 4\,{}^{1}n_0$

                  Calculate the energy released in MeV in this reaction.   **4**

         $^{235}U = 235.1170$ amu, $^{1}n_0 = 1.008665$ amu, $^{140}Ba = 140.9139$ amu

         $^{92}Kr = 91.8973$ amu.

(c)   (i)   Describe the use of a particular isotope in medicine.   **2**

        (ii)   Outline the key features and components of the standard model of   **4**
                  matter, including quarks and leptons.

(d)   (i)   How can neutrons be used to probe the positions of nucleii within the   **4**
                  structure of a metallic crystal? Make reference to the work of
                  Louis de Broglie and Davisson and Germer in your answer.

e)   Describe the role of conservation laws in the discovery of the neutrino.   **3**

SYDNEY BOYS HIGH SCHOOL

Physics

HSC TRIAL EXAMINATION

2013
MULTIPLE CHOICE ANSWERS

1	2	3	4	5	6	7	8	9	10
B	B	A	D	D	D	C	D	C	A

11	12	13	14	15	16	17	18	19	20
B	D	A	D	C	B	C	A	B	D

2013 SBHS Physics Trial

Section I (continued)

Student Number

Part B – 55 marks
Attempt Questions 21–30
Allow about 1 hour and 40 minutes for this part

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Marks are allocated to working in questions involving calculations. Show all working.

Question 21 (6 marks)

(a) Outline a first-hand investigation that could be performed to distinguish between non-inertial and inertial frames of reference. **3**

> *3 MARKS -*
> *. correctly describe equipment and how it will be set up + appropriate labelled diagram.*
> *. describes how equipment is used to demonstrate a non-inertial frame*
> *. describes how equipment is used to demonstrate an inertial frame*
>
> *SUBTRACT 1 MARK FOR EACH MISSING PART*

(b) Six students in the same class each built a pendulum and measured the time for one swing. Each student's pendulum was a different length. Each student used their own period and length measurement to calculate a value for "g". **3**

Without changing the length of each student's pendulum or the equipment used, describe a procedure that could be used to achieve a more reliable result for "g".

> *3 MARKS -*
> *. measurement is taken for multiple of swings(eg 10) then divided to give T*
> *. previous step is repeated (say 3 times) then averaged.*
> *. a graph of T² v L is made and gradient measured.*
> *. show how "g" is related to gradient.*
> *SUBTRACT 1 MARK IF PROCEDURE IS POORLY SEQUENCED*
> *SUBTRACT 1 MARK FOR EACH MISSING PART.*

Question 22 (6 marks)

A bar magnet is placed on a sensitive electronic balance as shown in the diagram. A hollow solenoid is held stationary, such that the magnet is partly within the solenoid.
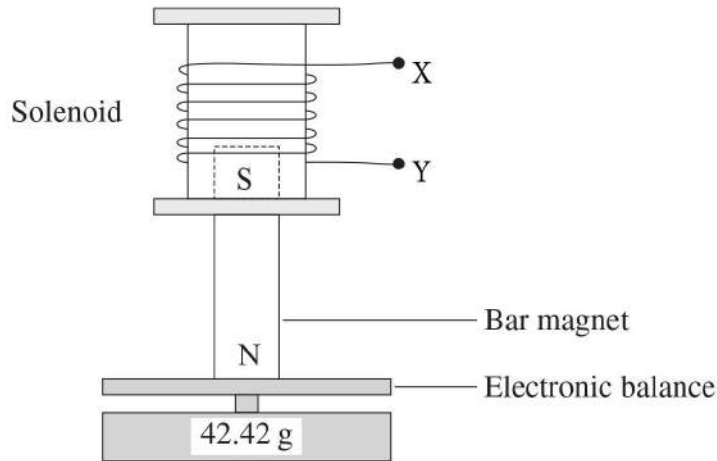
The solenoid is then lifted straight up without touching the magnet.

(a)   Explain the changes would you expect to observe on the electronic balance?   **2**

> *. states that no change would be observed on the balance*
> *. explains <u>why</u> there is no change with reference to- Faraday's Law and the open circuit*
> ***SUBTRACT ONE MARK FOR EACH MISSING PART***

(b)   A voltmeter and an ammeter were then connected in series between points
       X and Yand the experiment was repeated. Explain what would be
   observed on the two meters.

                                                                                        4

> *. student demonstrates some understanding of using meters*
> *. states that the voltmeter would register a reading*
> *. states that the ammeter would <u>not</u> register a reading*
> *. explains that the voltmeter is connected incorrectly (in series) and that the circuit is still open- so while a voltage can be detected, no current will flow through the ammeter*
>
> ***SUBTRACT ONE MARK FOR EACH MISSING PART.***

Question 23 (4 marks)

Consider the following thought experiment.

Two towers are built on Earth's surface. The top of each of the towers is 350 km above the surface of the Earth. Tower A is built at the Earth's North Pole and Tower B is built at the equator.

NOT TO SCALE
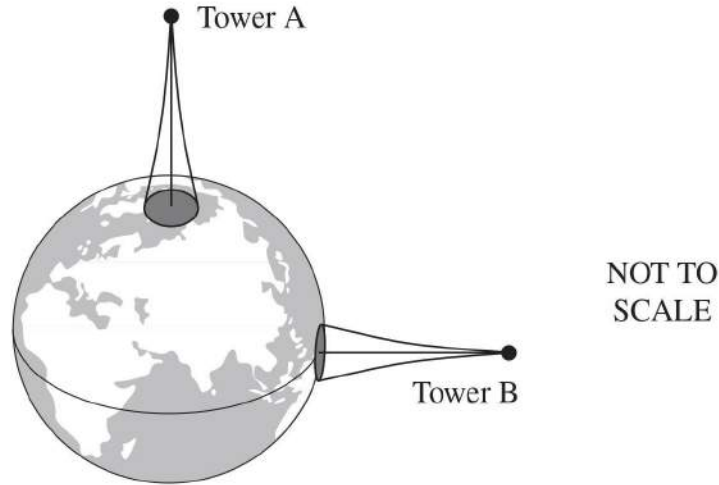
a) Identical masses are simultaneously released from rest from the top of each tower. Compare the motion of each of the masses after their release.

3

> *FOR 3 MARKS: The answer must state explicitly at least 2 similarities*
> *AND 1 difference(or vice versa).*
> *The differences and similarities stated must be correct.*
>
> *FOR 2 MARKS: Only 1 similarity and difference is given (or correct).*
>
> *FOR 1 MARK: A correct similarity or difference is given*

b) Calculate the gravitational potential of a 2.0 kg mass placed at the top of Tower B.

The radius of the earth at the equator is 6378 km.

1

> *1 MARK - correct equation*
> *1 MARK - correct answer with correct unit (-17.7 J)*

Student Number

Question 24 (5 marks)

(a) Using a labelled diagram, show the differences in the energy bands   **3**
between P type and N type semiconductors.

> *FOR 3 MARKS - Correct diagram inlcuding*
> *.Labelled axis*
> *.Correct Conduction and Valence bands*
> *.Correct Dopant levels (acceptor for P type and donor for N)*
> *.Labels for Conduction Band, Acceptor Level,Donor Level, (Small)Forbidden Energy Gap.*
>
>
> *or FOR 2 MARKS - Missing one part from above*
>
>
> *or FOR 1 MARK- Missing 2 parts from above*

(b) Contrast the effect of heat on the electrical properties of metals and   **2**
semiconductors.

2 MARKS - states a particular property and how it is different in metals and semi conductors.

Eg. Heat affects the conductivity of metals and semiconductors in opposite ways. Increasing the temperature of a metal reduces it's conductivity whereas increasing the temperature of a semiconductor increases it's conductivity.

(The answer could also be written in terms of changes to R)

Section I – Part B (continued)

Question 25 (7 marks)

(a) The diode valve has largely been replaced by the PN juncion. **4**

i) Draw labelled diagrams of a diode valve and a PN junction.

Each diagram is marked out of 2.

For the DIODE - correct apparatus, labels thermionic cathode, vacuum, anode, glass.

For the PN JUNCTION - ruler and pencil, correct apparatus, labels P layer, N layer, deplection zone (or layer)

SUBTRACT ONE MARK FOR EACH PART MISSING OR INCORRECT.

(b) Assess the impact of the use of solid state devices on communication. **3**

FOR 3 MARKS - the response must be a clearly stated assessment. ie it m ust present a JUDGEMENT of the value or size of THE IMPACT .

AND...The judgement must be supported with justification....................................

or FOR 2 MARKS - The judgement is not stated strongly(clearly) or is not well supported

or FOR 1 MARK - A judgement is made but not supported or the support is not valid

Question 26 (6 marks) .

A transmission line is to be used to supply 100 MW of power from a power station

to a substation 100 km away. Two possible designs are shown below.

Design A – Low voltage
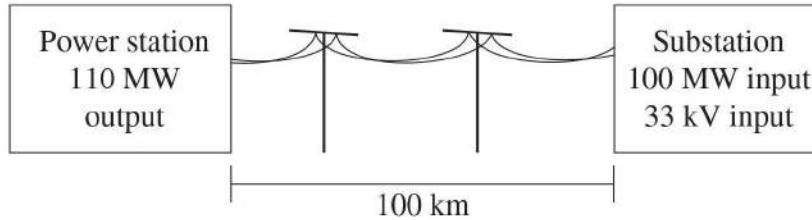
Design B – High voltage
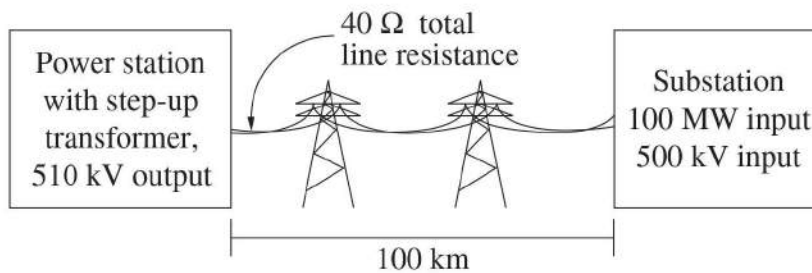
a) Using appropriate calculations, evaluate the relative efficiency of each design   4
   in supplying electrical energy to the substation.

   2 MARKS - for the correct calculation of efficiency.   A-91%, B 98%
   ....

   ....
   2 MARKS - for a correct evaluation statement relating to the calculated values
   ....*for A and B.*..

   ....

b) Account for the differences in efficiency of each design.   2

   1 MARK - for identifying that design A is more inefficient because it loses more
   ....*heat*...

   ....*THE SECOND MARK for relating the extra heat loss in A to the higher current*
   in A compared to B
   ....

   .due to the lower operating voltages
   ....

   .refers to I= P/V

Question 27 (4 marks)

A projectile is launched at 60° to the horizontal from the top of a 34 metre cliff.

The target is positioned 55 m away from the base of the cliff.

4

NOT TO
SCALE
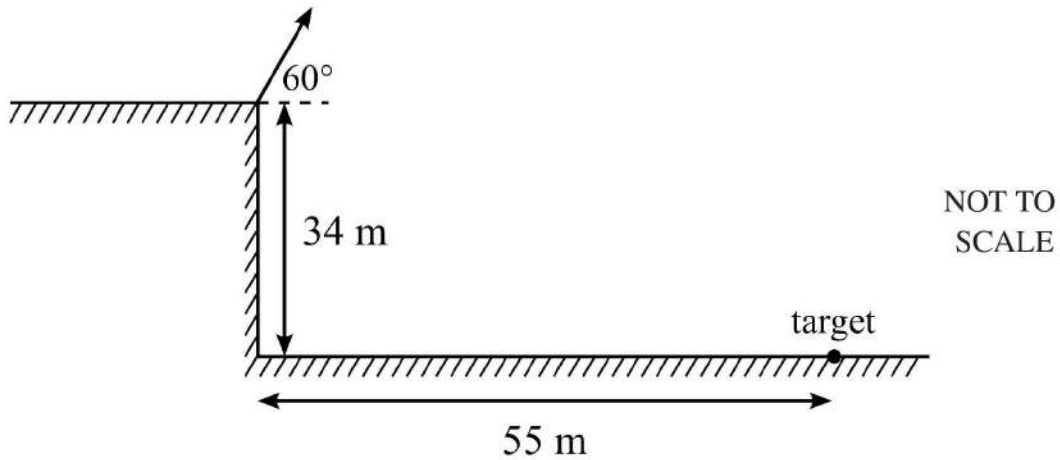
Calculate the magnitude of the required launch velocity such that the projectile strikes the target 34 m below the launch height.

4 MARKS for correct answer with units and 2 s.f. showing working.

OR

1 MARK - writes expressions for the initial X and Y velocity components ....
1 MARK - correct value   v= 21m/s
.....1MARK - Correct units and 2 sig figs...

Student Number

Question 28 (7 marks)

(a)   Outline ONE piece of evidence supporting Einstein's theory of relativity.   **2**

   1 MARK - correct piece of evidence (egs- muon life dilation, radioisotope decay dilation)

   1MARK - outlines how it provided evidence
   ....

(b)   What criteria are used to test and validate a theory?   **3**

   ....
      1 MARK EACH -
   ....
      -The theory must be able to make testable predictions
   ......-The predictions must agree with observations...............................
      -The predictions must be supported by controlled experiments and peer review
   ....

   ....

   ....

(c)   The distance between the cathode and screen in a cathode ray tube is 40 cm.   **2**

   If an electron travels through the tube at 3.0×10^7 m s^{-1}, what is the apparent
   distance from the cathode to the screen in the electron's frame of reference?

   ....
      1 MARK - correct calculation of correction factor. cf
      = .866...
      1 MARK - correct answer 43cm
      - ....
   ....

Question 29 (5 marks)

With the aid of a labelled diagram, explain how the galvanometer maintains a linear

relationship between input current and displacement of the pointer.

5

....

First 2 MARKS - appropriate diagram labeling the radial magnetic field, radial spring and pointer

....

Next 3 MARKS - *clearly shows relationships and cause and effect between-*

- *Input <u>current</u> and resulting <u>torque</u>*
- *A radial B field means angle of plane of the coil relative to B field lines is always zero.*

-*Because of previous point Torque and therefore pointer movement is proportional to I.*
-*Algaebraic support of previous statement*
- *correct reference to the reaction torque provided by the radial spring*

....
....

Question 30 (5 marks)

The diagram shows the paths taken by an alpha and beta particle when they enter a region of uniform magnetic field.
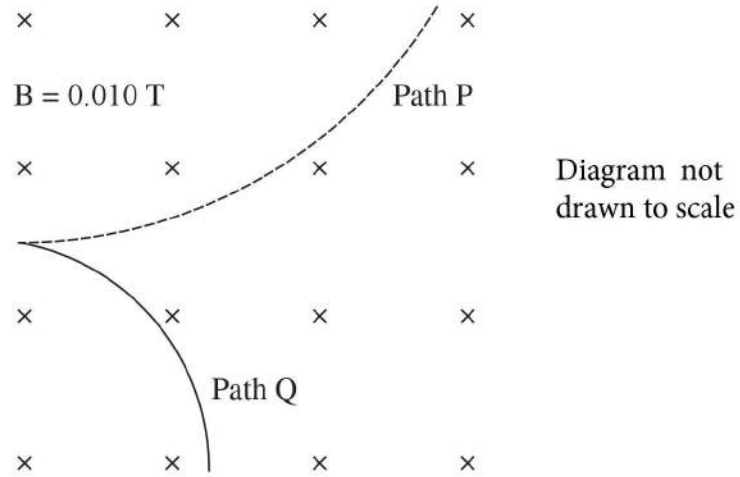
(a) Why are the paths circular ?   1

Correct statement stating that the magnetic force(qvB) remains perpendicular to particle velocity so is centripetal in nature -this gives circular path. (desirable - Answer should provide algabraic support)

(b) Which path does the beta particle follow? Justify your answer.   2

2 MARKS - Path Q
*   -Right hand palm rule predicts a downward force for the negative beta particle.*
OR   - If v was constant for both P and Q, could justify using the proportionality relationship between radius and m/q ratio.

(c) The alpha particle enters the field at a velocity of 5500 m/s. Calculate the radius   2
of curvature of it's path while in the field. (Alpha particle mass = 4.001 amu)

2 marks for correct answer and unit - r = 0.011 m

OR

1 mark if correct formula but answer not complete

2013 SBHS Physics Trial

Section II - The Options

25 marks

This paper only includes the Quanta to Quarks Option.

ANSWERS GO IN THE SEPARATE ANSWER BOOKLET

Show all relevant working in questions involving calculations.

(a) (i) For 2 MARKS -
-describes at least one piece of empirical evidence that Rutherford couldn't explain.
-<u>describes at least one improvement Bohr made to the model</u> to explain the problem.
(ii)   Wavelength = 410 x 10⁻⁹ m 2 marks for correct answer and unit (or 1 mk for correct subst.)
(iii) States the P.E.P. and Gives 2 correct shortcomings (subtract 1 mk for each missing part)(eg-Zeeman Eff. Hyperfine splitting, Electron Config (not intensity variation)

(b)Markers comment-the level of student understanding in this question was innadequate.(i) Requirements for controlled nuclear reaction-

. Fissionable source of CRITICAL MASS
. Cooling system to transfer /remove heat from reaction chamber
. A shielding system around the containment vessel to prevent radiation leakage
. A moderator to slow the neutrons
. Control rods (eg Cd) to remove neutrons.

2 MARKS -at least 4 of the 5 points.   1 MARK- at least 3 of the 5 points.
(ii) E released = 268.7 MeV (= 43 pJ)
4 MARKS FOR CORRECT WORKING AND CORRECT ANSWER IN MeV
OR
2 MARKS FOR calculating correct mass defect (0.29 amu)   (= 4.8 x 10⁻²⁸ kg)
OR
1 MARK FOR correct working.

(c)
(i) Names a particular and correct isotope (1MARK). Gives <u>specific</u> info about <u>application and use</u> (1 MARK)

(ii)
.Shows that all matter is made of QUARKS, LEPTONS, BOSONS
.Gives egs and describes nature of leptons
.Gives egs and describes nature of bosons
.Gives the 6 types of quarks and Leptons.
.Outlines the composite particles(Hadrons) made from quarks with egs.
SUBTRACT ONE MARK FOR EACH MISSING PART.

(d) FOR 4 MARKS -

THE FOLLOWING 3 POINTS ARE REQUIRED...

-De Broglie proposed that orbiting electrons had a wave nature with <u>wavelength =h/mv</u>

- Davisson and Germer 's empirical evidence that <u>electrons*</u> can be diffracted off nickel crystals confirming their wave nature. (*many students incorrectly said neutrons)

-neutrons will <u>diffract</u> off metallic crystals to form an <u>interference</u> pattern .(*Correct terminology is required*)

PLUS AT LEAST ONE OF THESE

- neutrons are not deflected by protons and electrons and so have higher penetrative property .

- <u>neutrons allow better resolution</u> than electrons due to their relativily high momentum (mv) and short De Broglie wavelength.

(e) 3 MARKS - subtract a mark for each missing point.
(many students mistakenly wrote about Chadwick's discovery of the neutron)

- <u>State Law of Conservation of Energy</u> and explain there were <u>unexplained variations in kinetic energy during Beta decay</u>.

- Pauli proposed an undetected particle must exist that was carrying off the missing energy.

-The Law of Conservation of Charge was upheld during beta decay so the proposed mystery particle could not have any charge.