Student Number | | | | | | |

Newington College

Physics

Trial HSC Examination

2016

General Instructions

- Reading time: 5 minutes
- Working time: 3 hours
- Board approved calculators may be used
- Write using black or blue pen only
- Draw diagrams using a sharp pencil and ruler
- A Data Sheet, Formula Sheet and Periodic Table is provided at the back of this paper
- Write your Student Number at the top of each page

Total Marks: 100

Section I
80 marks

This section has two parts, Part A and Part B

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

Part B – 60 marks
- Attempt Questions 21 – 32
- Allow about 1 hour and 40 minutes for this part

Section II
20 marks
- Attempt ALL parts of the question
- Allow about 45 minutes for this section

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Section I
80 marks

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

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

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

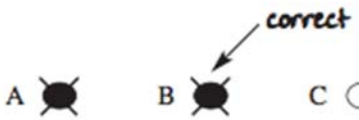
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

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.



1 A satellite orbits the Moon with an orbital radius of 10,000 km.

Compared to the same satellite with an identical orbital radius orbiting Earth, the satellite orbiting the Moon will:

(A) be moving faster.

(B) have the same centripetal force acting on it.

(C) have greater kinetic energy.

(D) have a longer orbital period:

2 The formula $E = mc^2$ would most appropriately be used to determine the:

(A) mass of a neutron.

(B) mass of an atom.

(C) energy of a photon of light.

(D) energy of a proton at rest.

3 Which of the following correctly describes an earth geostationary orbit?

	Orbital Period (hours)	**Orbital Decay**
(A)	Approximately 1-3	Significant
(B)	Approximately 1-3	Insignificant
(C)	24	Significant
(D)	24	Insignificant

4 A newly discovered planet has both a mass and radius that is double that of the Earth. What is the acceleration due to gravity on this planet?

(A) 4.9 m/s^2

(B) 9.8 m/s^2

(C) 19.8 m/s^2

(D) 39.6 m/s^2

5 A student performed a first-hand investigation. It was later asserted that the procedure followed was not valid.

The student may have correctly made this assertion because:

(A) the investigation was not repeated.

(B) the investigation failed to account for all the variables involved.

(C) one result was significantly different to the other ten made.

(D) an unexpected result was obtained.

6 A field of magnetic flux density 4T could be formed by a magnetic flux of 2 Wb passing through a circular coil of radius:

(A) 0.2 m

(B) 0.4 m

(C) 0.8 m

(D) 1.0 m

7 In semiconductors, electrons and holes both help to carry current.

Holes are understood to:

(A) be positively charged particles.

(B) be neutral particles.

(C) move in the direction of the applied electric field lines.

(D) move in the same direction as the electrons.

8 A critical characteristic of cathode rays that enabled JJ Thomson to determine the charge to mass ratio of electrons was that:

(A) moving electrons can be deflected by magnetic and electric fields.

(B) electrons have a small mass.

(C) cathode rays are waves.

(D) electrons have both a wave and a particle nature.

9 A spaceship travels through space at 2×10^8m/s for 16 days as measured by an astronaut on the ship. How much time has passed on Earth?

(A) 5.3 days

(B) 11.9 days

(C) 21.5 days

(D) 48.0 days

10 An induction cooker produces a rapidly changing magnetic field that:

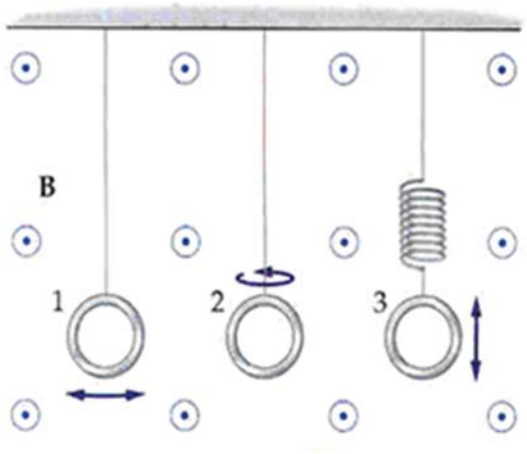
(A) Produces eddy currents in the ceramic cooktop to warm food.

(B) Produces eddy currents in a saucepan to warm food.

(C) Produces eddy currents in the food that dissipate as heat, warming the food.

(D) Produces eddy currents in the cooktop, saucepan and food generating heat.

11 The three loops of wire shown in the diagram below are all in a region of space with a uniform, constant magnetic field. Loop 1 swings back and forth as the bob on a pendulum; loop 2 rotates about a vertical axis; and loop 3 oscillates vertically on the end of a spring.



Which loop or loops will have a current induced, due to their motion?

(A) 1 and 2 only

(B) 2 and 3 only

(C) 1, 2 and 3

(D) 2 only

12 An electric drill has a DC motor. When it is operated with a load on the motor that makes it turn more slowly, the coils in the motor quickly get very hot. With no load on the motor, the coils do not get as hot.

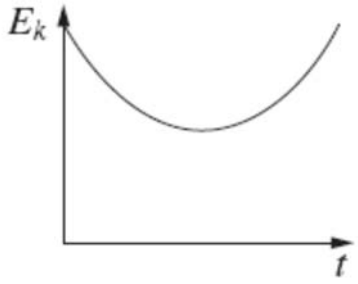
(A) a larger current flows through the coils when the drill is under load.

(B) more back EMF is present when the drill is under load.

(C) friction causes heat to be generated.

(D) a smaller current flows through the coils when the drill is under load.

13 The following graph shows the kinetic energy of a projectile over time..



Which is the most likely launch angle of the projectile?

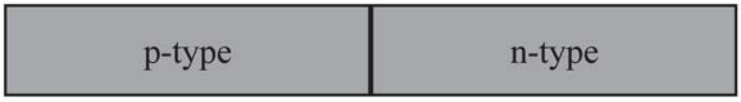
(A) Launched horizontally.

(B) Launched straight upwards.

(C) Launched 45^0 above the horizontal.

(D) Launched 45^0 below the horizontal.

14 A p-type piece of doped silicon is joined to an n-type piece of doped silicon, as shown below:



Which statement is correct?

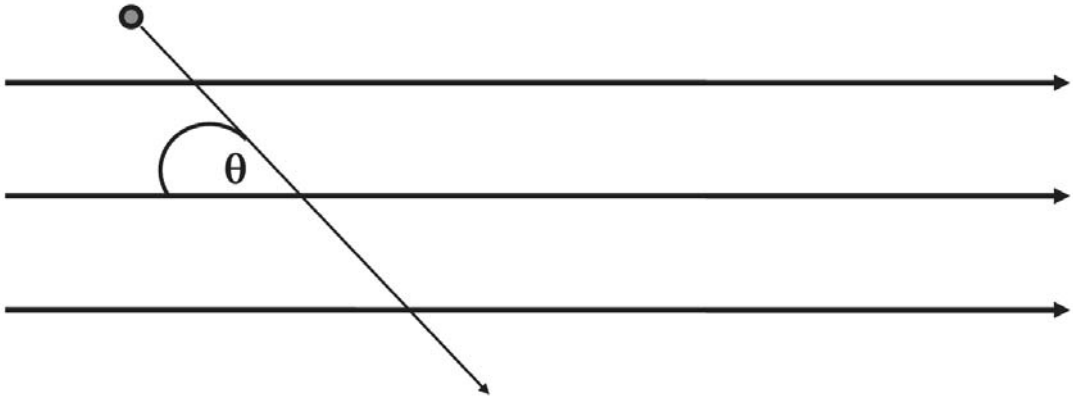
(A) Electrons will move into the n-type from the p-type.

(B) Electrons will move into the p-type from the n-type.

(C) Electrons will be ejected from the p-type silicon making it positive.

(D) Electrons will be absorbed by the n-type silicon making it negative.

15 A particle of charge +Q and mass m in travelling with speed v enters a uniform magnetic field of strength B at an angle θ to the direction of the field lines.



The radius of the circular path followed by the particle on entering the magnetic field is:

(A) $r = \dfrac{mv}{QBSin\theta}$

(B) $r = \dfrac{mvCos\theta}{QB}$

(C) $r = \dfrac{mv}{QBCos\theta}$

(D) $r = \dfrac{mvSin\theta}{QB}$

16 Superconductivity can be found:

(A) In all materials at a low enough temperature.

(B) In all metals at a low enough temperature.

(C) Only in some metals of a low enough temperature.

(D) In some metals and other compounds at a low enough temperature

17 An iPhone requires a 6V power source. If the mains power (240V) is to be used, what is the turns ratio ($N_{primary} : N_{secondary}$) that would be required in the adaptor of the transformer?

(A) 1 : 40

(B) 1: 4

(C) 4 : 1

(D) 40 : 1

18 Hertz used a high voltage source to produce an electric spark from a transmitter: this electrical energy could then be detected at a receiving coil.

He found that he could increase the intensity of the spark at the receiving coil by:

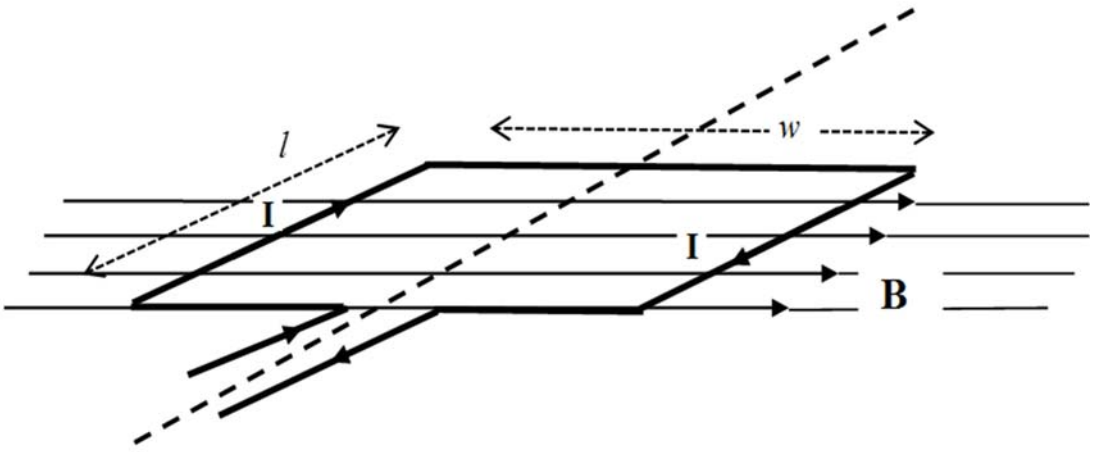
(A) placing a sheet of glass between the transmitter and the receiving coil.

(B) shining infrared light on the transmitter.

(C) shining ultraviolet light on the receiving coil.

(D) increasing the gap between the terminals of the receiving coils.

19 A single loop of wire is situated within a magnetic field **B** of 1.5 mT as shown. The plane of the loop is at an angle of $\theta = 0^{o}$ to the magnetic field.



A current **I** of 3.50 A flows through the loop. The loop is free to rotate about its axis.

Given that the width of the loop, w = 10.0 cm and the length of the loop, l = 20.0 cm, the maximum torque produced by this loop is closest to:

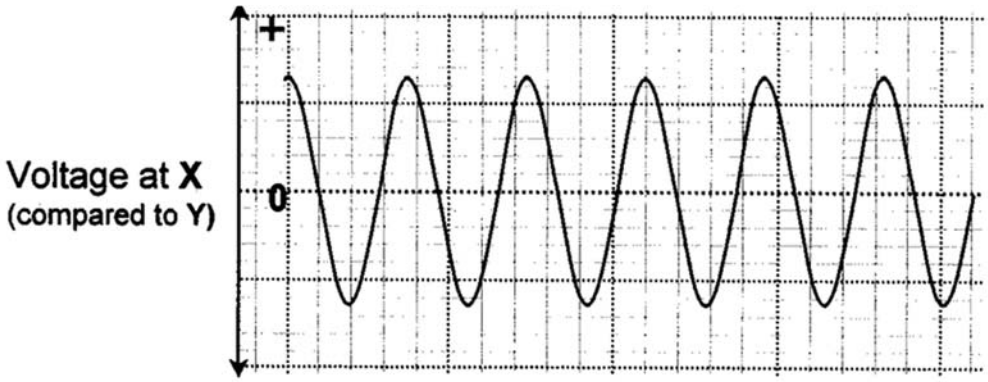
(A) 1.05×10^{-4} N m anticlockwise

(B) 1.05 N m anticlockwise

(C) 5.25×10^{-4} N m clockwise

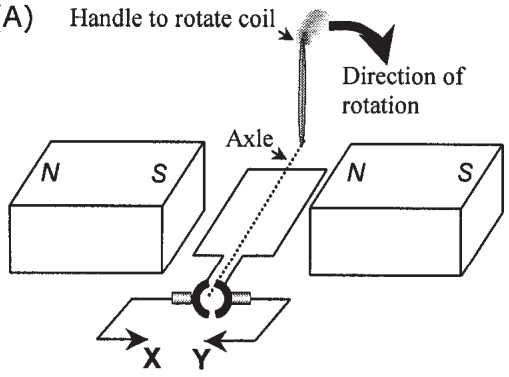
(D) zero

20 During an experiment a generator was attached to Cathode Ray Oscilloscope. The handle of the generator was rotated at a constant rate and a plot of the voltage produced at the contact **X**, compared to **Y**, was recorded. The following graph shows the result produced.

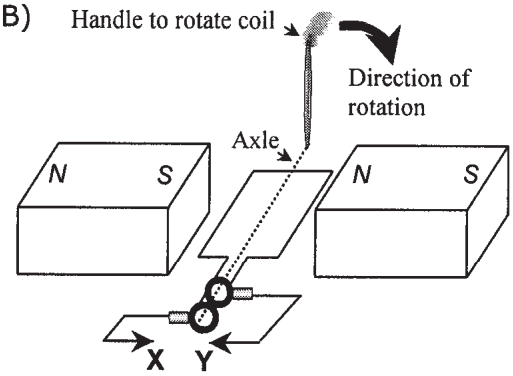


Considering that the graph begins with the generator in the position shown, which of the following would correctly represent the direction of rotation and the type of generator?

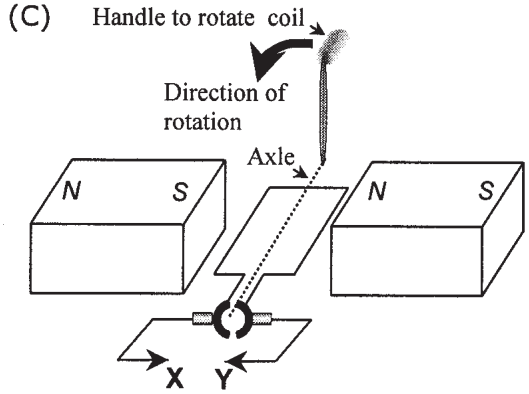
(A)



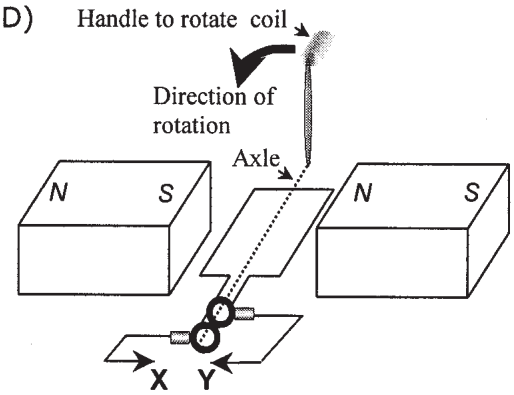
(B)



(C)



(D)



Section I (continued)

Part B – 60 marks
Attempt Questions 21-32
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.

Show ALL relevant working in questions involving calculations.

21. (3 marks) **Marks**

Using a diagram explain why and how transmission wires need to be insulated from supporting structures. **3**

22. (6 marks) **Marks**

The picture below shows the opening screen of an online activity aimed at teaching Year 8 students the difference between mass and weight.

(a) Assess the statement "Nothing on the International Space Station (ISS) has any weight". **3**

Question 22 is continued on the following page

Question 22 continued…

(b) Calculate the acceleration of a 5.00×10^2 kg space probe when it is 4.00×10^5 km away from the centre of a planet that has a mass of 2.50×10^{24} kg. **3**

23. (5 marks) **Marks**

On April 12, 1961, Yuri Gagarin made history as the first human to orbit the Earth, at an average altitude of 250km. The first stage of the rocket used to launch his *Vostok* spacecraft produced a total of 4.50×10^5 N. The total mass of the rocket at launch was 4.33×10^4 kg which includes 3.83×10^4 kg of first stage fuel.

(a) Assuming the thrust is kept constant during the first stage, calculate the final acceleration of the rocket immediately before the fuel for the first stage runs out. You may assume that the acceleration due to gravity at this time is 9.81 m/s^2. **3**

(b) Determine the g-force experienced by Gagarin immediately BEFORE the fuel for the first stage had been used. **2**

24. (7 marks) **Marks**

A local transformer has a primary coil connected to a 32 kV power cable and has a current of 12 A through it.

(a) Explain why AC is used in preference to DC for transformers. **2**

(b) Explain why this transformer needs to be cooled. Identify how this cooling may be achieved as part of your answer. **2**

(c) If the output from this transformer is 11.0 kV with an output current of 28.0 A, calculate the energy lost by this transformer in one day. **3**

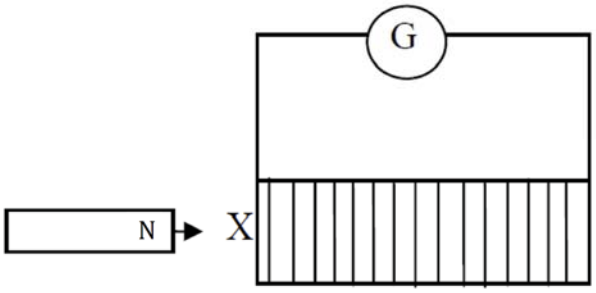
25. (4 marks) **Marks**

It has been stated that "a DC generator is simply a motor in reverse". **4**

Assess this statement with reference to the structure, function and energy transformations involving motors and generators. Include suitable diagrams showing energy transformations in your answer.

26. (4 marks) **Marks**

A student pushed the north pole of a bar magnet towards the end of a conducting coil that was connected to an external circuit. She measured a flow of current in the coil using a galvanometer.



Identify the magnetic pole induced at location 'X'. Account for your answer using Lenz's Law and the principle of conservation of energy. **4**

27. (4 marks) **Marks**

During the HSC course you will have observed the occurrence of different striation patterns in discharge tubes having different pressures.

(a) With the aid of suitable diagrams, describe the observations you made during this experiment in class. **3**

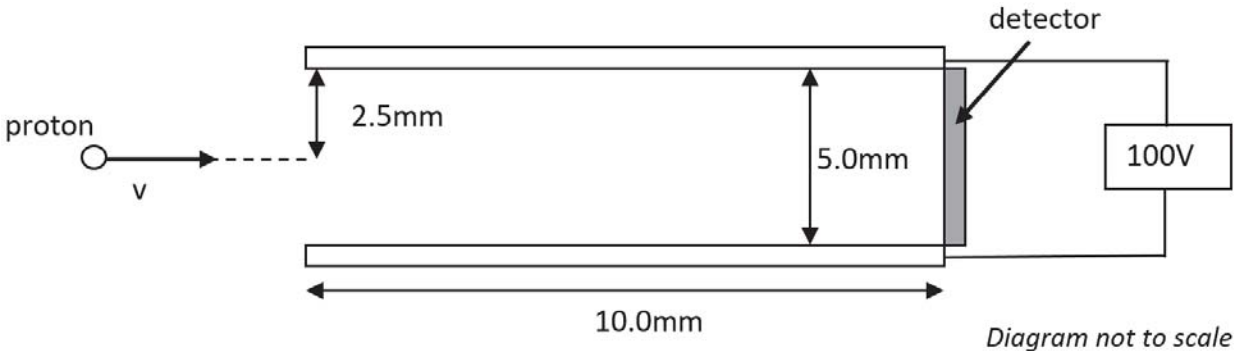
(b) Identify TWO hazards and corresponding safety measures when using discharge tubes. **1**

28. (4 marks) **Marks**

Evaluate Einstein's contribution to quantum theory and its relation to black body radiation. **4**

29. (8 marks) **Marks**

Two oppositely charged electric plates are connected as shown. The top plate has a negative charge.



(a) Draw in the electric field between the plates. **1**

(b) Calculate the electric field strength between the plates. **2**

Question 29 is continued overleaf.

Question 29 continued…

(c) A proton moving horizontally at a velocity of 1×10^5 m/s enters the region between the plates. Determine whether the proton reaches the detector. Use calculations to **justify** your answer. Include a sketch indicating the trajectory of the electron on the diagram provided. **5**

30. (6 marks) **Marks**

During the early part of the 20th century, devices such as triodes and valves led to significant developments in communication technology. However, these types of technology have since been superceded by their solid state counterparts.

(a) Contrast the relative electrical resistance of conductors, semi-conductors and insulators using suitable diagrams showing band structure. **3**

(b) Discuss the role of thermionic devices in developing solid state technologies such as the transistor. **3**

Additional writing space for Question 30 is provided overleaf.

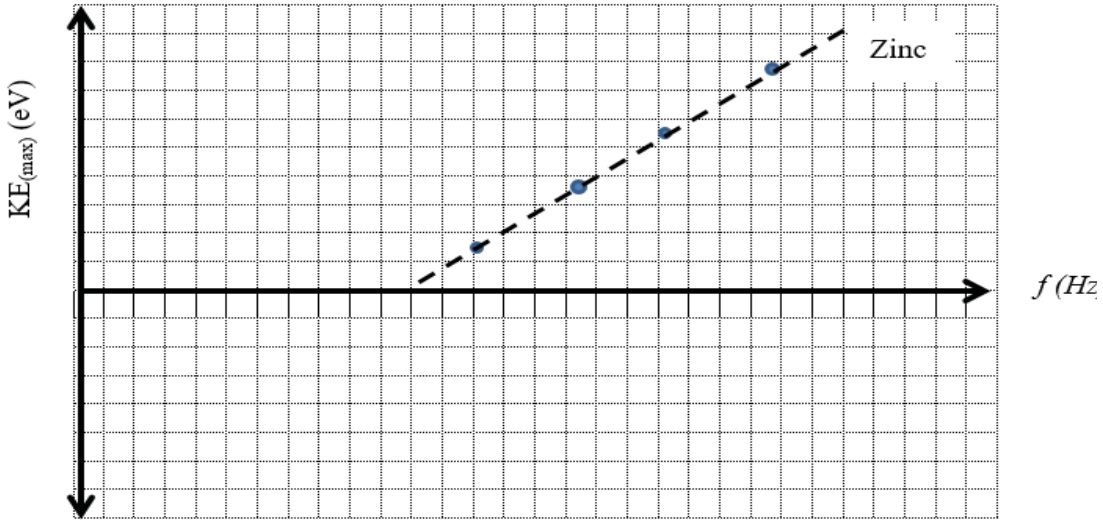
Question 30 continued…

31. (3 marks) **Marks**

Superconductivity is an area of active research. Discuss the use of superconducting materials for ONE potential application in the future. **3**

32. (6 marks) **Marks**

An investigation was conducted in which light was shone onto a metal surface and the maximum kinetic energy of emitted electrons was measured for incident light of various frequencies. The results are shown in the graph below.



(a) Explain the significance of the x-intercept and why it can never be zero. **2**

(b) The work function for zinc is 4.33 eV, calculate the frequency of light that is just capable of causing an electron to be emitted from the surface of the zinc. **2**

(c) On the axes above, draw the line of best fit that would result when the target metal is changed to platinum and the experiment repeated. Platinum has a work function of 6.35 V. **2**

Section II

20 marks
Attempt ALL parts of the question.
Allow about 45 minutes for this section.

Answer the question in a separate writing booklet.

Extra writing booklets are available.

Show all relevant working in questions involving calculations.

33. From Quanta to Quarks (20 marks) **Marks**

(a) During the course you will have viewed the emission spectra of hydrogen in the visible region of the electromagnetic spectrum. It includes a number of lines that come closer together at shorter wavelengths.

(i) Calculate the wavelength of visible light emitted for hydrogen gas when $n_i = 3$ using the Rydberg equation. **2**

(ii) Calculate the energy that would be associated with each photon at this wavelength? Give your answer in terms of eV. **2**

Question 33 is continued overleaf.

Question 33 continued…

(b) The Bohr model of the atom maybe described as a combination of classical physics and quantum physics. **6**

Analyse the statement above in terms of the development of physics in the early part of the 20^{th} century.

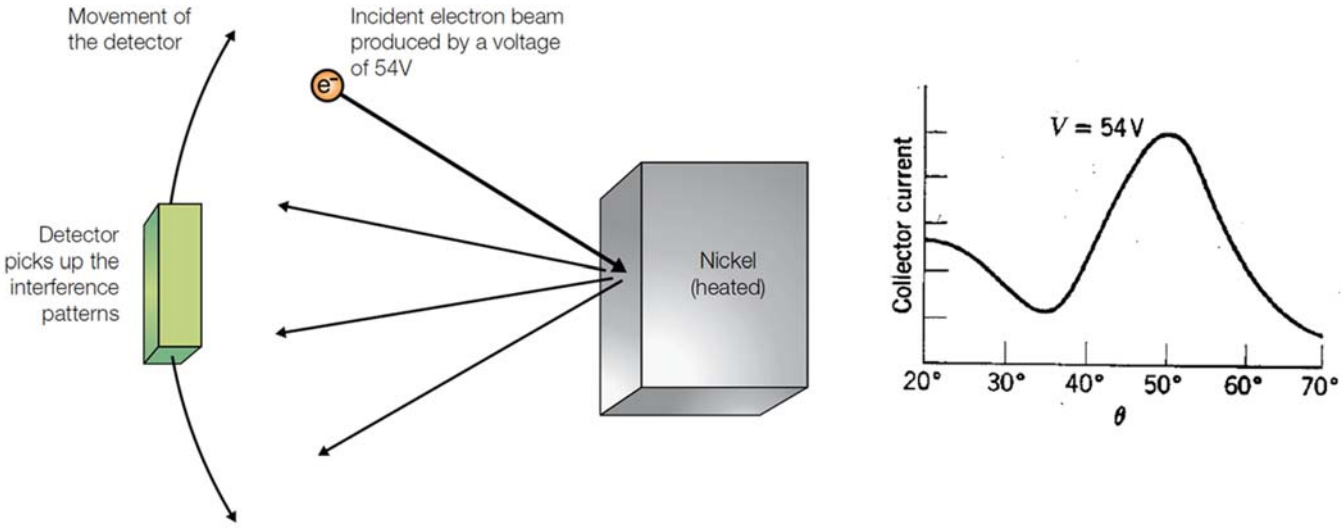
Question 33 is continued overleaf

Question 33 continued…

(c) Louis de Broglie proposed that any moving particle could be associated with certain wave properties.

(i) Calculate the wavelength of an electron moving at a speed of 2.0×10^7 m/s. **2**

(ii) Davisson and Germer performed an experiment, the key components of which are shown in the diagram below, together with a set of typical results. **4**



Discuss the significance of this experimental result in terms of de Broglie's postulate that all forms of matter have both wave and particle characteristics.

Question 33 is continued overleaf.

Question 33 continued…

Question 33 is continued overleaf.

Question 33 continued…

(d) In 1932, two English physicists, Cockcroft and Walton, carried out artificial transmutation by bombarding lithium with accelerated hydrogen nuclei, producing two helium nuclei:

$$ {}^{1}_{1}\mathrm{H} + {}^{7}_{3}\mathrm{Li} \rightarrow {}^{4}_{2}\mathrm{He} + {}^{4}_{2}\mathrm{He} $$

(i) Determine if energy is released or absorbed in this reaction. Justify your answer with suitable calculations. **2**

Useful data: H: 1.0073 amu Li: 7.0160 amu He: 4.0015 amu

(ii) Compare the process above to nuclear transmutations resulting from alpha decay. **2**

END OF EXAMINATION

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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

$$v = f\lambda$$

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

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

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

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

$$P = VI$$

$$\text{Energy} = VIt$$

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

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

$$\Sigma F = ma$$

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

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

$$W = Fs$$

$$p = mv$$

$$\text{Impulse} = Ft$$

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

$$F = mg$$

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

$$v = u + at$$

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

$$\Delta x = u_x t$$

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

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

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

$$E = mc^2$$

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

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

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

FORMULAE SHEET

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

$$F = BIl\sin\theta$$

$$\tau = Fd$$

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

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

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

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

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

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

$$F = qvB\sin\theta$$

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

$$E = hf$$

$$c = f\lambda$$

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

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

$$Z = \rho v$$

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

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

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

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number	79
Symbol	Au
Standard Atomic Weight	197.0
Name	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 65.38 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 87.61 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.96 Molybdenum	43 Tc 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 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.9 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 Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89–103 Actinoids	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium						

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm 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 173.1 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

Elements with atomic numbers 113 and above have been reported but not fully authenticated.

Standard atomic weights are abridged to four significant figures.

Elements with no reported values in the table have no stable nuclides.

The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of data. Some data may ha ve been modified.

Student Number | | | | | | |

Newington College

Physics

Trial HSC Examination

2016

MARKING GUIDE

General Instructions

- Reading time: 5 minutes
- Working time: 3 hours
- Board approved calculators may be used
- Write using black or blue pen only
- Draw diagrams using a sharp pencil and ruler
- A Data Sheet, Formula Sheet and Periodic Table is provided at the back of this paper
- Write your Student Number at the top of each page

Total Marks: 100

Section I
80 marks

This section has two parts, Part A and Part B

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

Part B – 60 marks
- Attempt Questions 21 – 32
- Allow about 1 hour and 40 minutes for this part

Section II
20 marks
- Attempt ALL parts of the question
- Allow about 45 minutes for this section

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Section I
80 marks

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

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

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

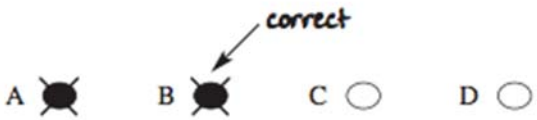
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

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.



1	A satellite orbits the Moon with an orbital radius of 10,000 km. Compared to the same satellite with an identical orbital radius orbiting Earth, the satellite orbiting the Moon will:	
	(A)	be moving faster.
	(B)	have the same centripetal force acting on it.
	(C)	have greater kinetic energy.
	(D)	have a longer orbital period.

2	The formula $E = mc^2$ would most appropriately be used to determine the:	
	(A)	mass of a neutron.
	(B)	mass of an atom.
	(C)	energy of a photon of light.
	(D)	energy of a proton at rest.

3	Which of the following correctly describes an earth geostationary orbit?		
		Orbital Period (hours)	**Orbital Decay**
	(A)	Approximately 1-3	Significant
	(B)	Approximately 1-3	Insignificant
	(C)	24	Significant
	(D)	24	Insignificant

4	A newly discovered planet has both a mass and radius that is double that of the Earth. What is the acceleration due to gravity on this planet?	
	(A)	4.9 m/s^2
	(B)	9.8 m/s^2
	(C)	19.8 m/s^2
	(D)	39.6 m/s^2

5	A student performed a first-hand investigation. It was later asserted that the procedure followed was not valid. The student may have correctly made this assertion because:	
	(A)	the investigation was not repeated.
	(B)	the investigation failed to account for all the variables involved.
	(C)	one result was significantly different to the other ten made.
	(D)	an unexpected result was obtained.

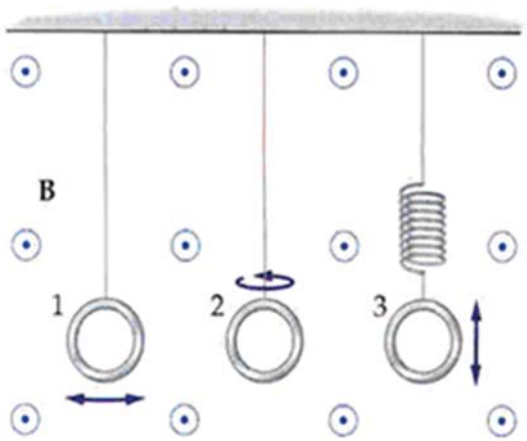
6	A field of magnetic flux density 4T could be formed by a magnetic flux of 2 Wb passing through a circular coil of radius:	
	(A)	0.2 m
	(B)	0.4 m
	(C)	0.8 m
	(D)	1.0 m

7	In semiconductors, electrons and holes both help to carry current. Holes are understood to:	
	(A)	be positively charged particles.
	(B)	be neutral particles.
	(C)	move in the direction of the applied electric field lines.
	(D)	move in the same direction as the electrons.

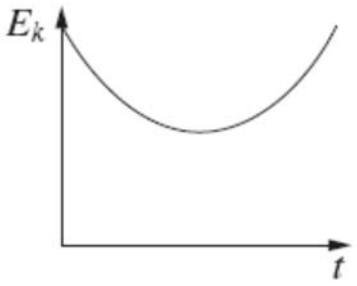
8	A critical characteristic of cathode rays that enabled JJ Thomson to determine the charge to mass ratio of electrons was that:	
	(A)	moving electrons can be deflected by magnetic and electric fields.
	(B)	electrons have a small mass.
	(C)	cathode rays are waves.
	(D)	electrons have both a wave and a particle nature.

9	A spaceship travels through space at 2 x 10^8m/s for 16 days as measured by an astronaut on the ship. How much time has passed on Earth?	
	(A)	5.3 days
	(B)	11.9 days
	(C)	21.5 days
	(D)	48.0 days

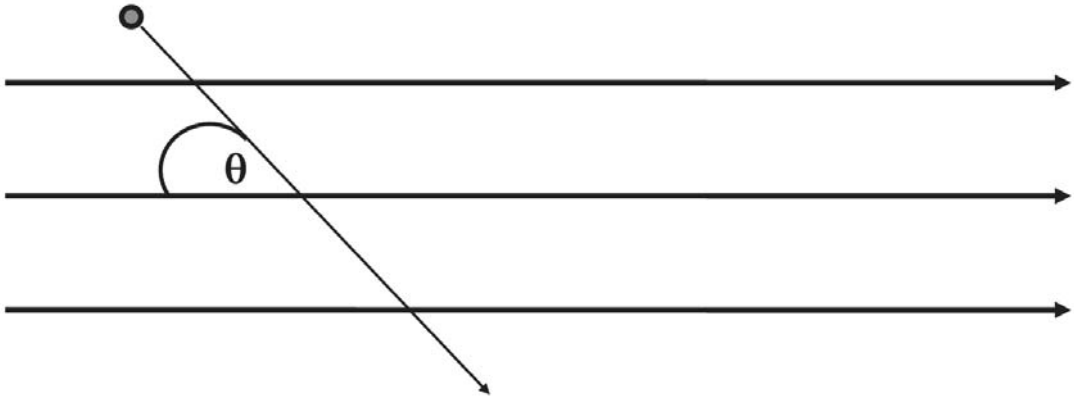
10	An induction cooker produces a rapidly changing magnetic field that:	
	(A)	Produces eddy currents in the ceramic cooktop to warm food.
	(B)	Produces eddy currents in a saucepan to warm food.
	(C)	Produces eddy currents in the food that dissipate as heat, warming the food.
	(D)	Produces eddy currents in the cooktop, saucepan and food generating heat.

11	The three loops of wire shown in the diagram below are all in a region of space with a uniform, constant magnetic field. Loop 1 swings back and forth as the bob on a pendulum; loop 2 rotates about a vertical axis; and loop 3 oscillates vertically on the end of a spring.  Which loop or loops will have a current induced, due to their motion?	
	(A)	1 and 2 only
	(B)	2 and 3 only
	(C)	1, 2 and 3
	(D)	2 only

12	An electric drill has a DC motor. When it is operated with a load on the motor that makes it turn more slowly, the coils in the motor quickly get very hot. With no load on the motor, the coils do not get as hot.	
	(A)	a larger current flows through the coils when the drill is under load.
	(B)	more back EMF is present when the drill is under load.
	(C)	friction causes heat to be generated.
	(D)	a smaller current flows through the coils when the drill is under load.

13	The following graph shows the kinetic energy of a projectile over time..  Which is the most likely launch angle of the projectile?	
	(A)	Launched horizontally.
	(B)	Launched straight upwards.
	(C)	Launched 45^0 above the horizontal.
	(D)	Launched 45^0 below the horizontal.

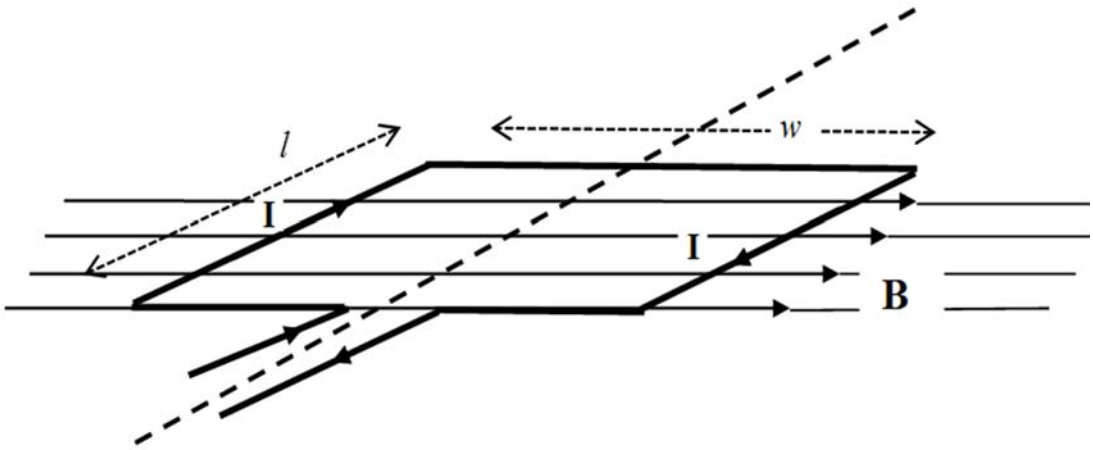
14	A p-type piece of doped silicon is joined to an n-type piece of doped silicon, as shown below:  Which statement is correct?	
	(A)	Electrons will move into the n-type from the p-type.
	(B)	Electrons will move into the p-type from the n-type.
	(C)	Electrons will be ejected from the p-type silicon making it positive.
	(D)	Electrons will be absorbed by the n-type silicon making it negative.

15	A particle of charge +Q and mass m in travelling with speed v enters a uniform magnetic field of strength B at an angle θ to the direction of the field lines.  The radius of the circular path followed by the particle on entering the magnetic field is:	
	(A)	$r = \frac{mv}{QBSin\theta}$
	(B)	$r = \frac{mvCos\theta}{QB}$
	(C)	$r = \frac{mv}{QBCos\theta}$
	(D)	$r = \frac{mvSin\theta}{QB}$

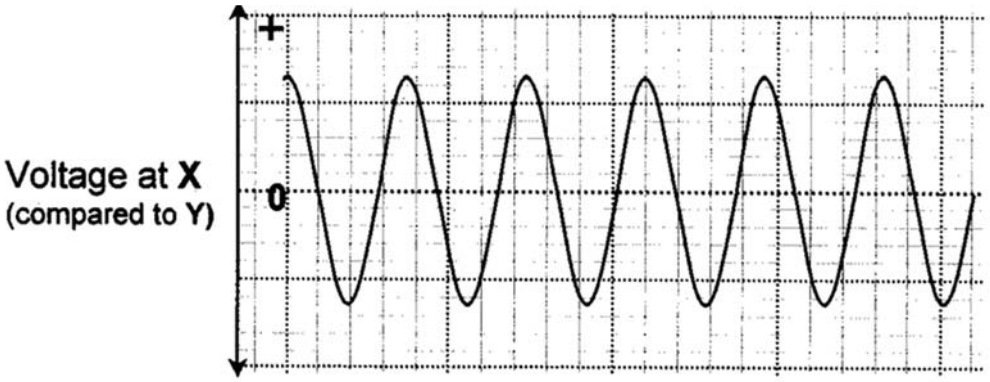
16	Superconductivity can be found:	
	(A)	In all materials at a low enough temperature.
	(B)	In all metals at a low enough temperature.
	(C)	Only in some metals of a low enough temperature.
	(D)	In some metals and other compounds at a low enough temperature

17	An iPhone requires a 6V power source. If the mains power (240V) is to be used, what is the turns ratio ($N_{primary}$: $N_{secondary}$) that would be required in the adaptor of the transformer?	
	(A)	1 : 40
	(B)	1: 4
	(C)	4 : 1
	(D)	40 : 1

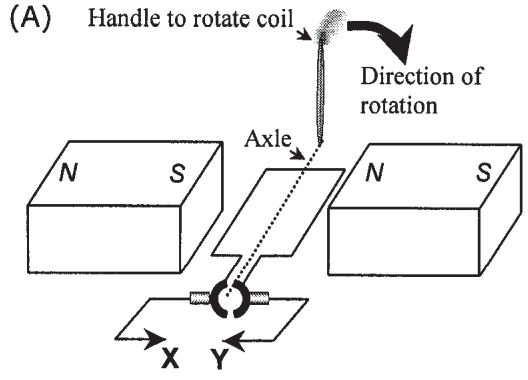
18	Hertz used a high voltage source to produce an electric spark from a transmitter: this electrical energy could then be detected at a receiving coil. He found that he could increase the intensity of the spark at the receiving coil by:	
	(A)	placing a sheet of glass between the transmitter and the receiving coil.
	(B)	shining infrared light on the transmitter.
	(C)	shining ultraviolet light on the receiving coil.
	(D)	increasing the gap between the terminals of the receiving coils.

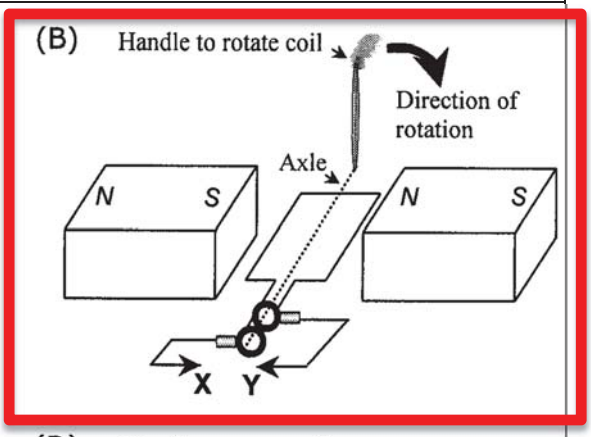
19	A single loop of wire is situated within a magnetic field **B** of 1.5 mT as shown. The plane of the loop is at an angle of $\theta = 0^o$ to the magnetic field.  A current **I** of 3.50 A flows through the loop. The loop is free to rotate about its axis. Given that the width of the loop, w = 10.0 cm and the length of the loop, l = 20.0 cm, the maximum torque produced by this loop is closest to:	
	(A)	1.05×10^{-4} N m anticlockwise
	(B)	1.05 N m anticlockwise
	(C)	5.25×10^{-4} N m clockwise
	(D)	zero

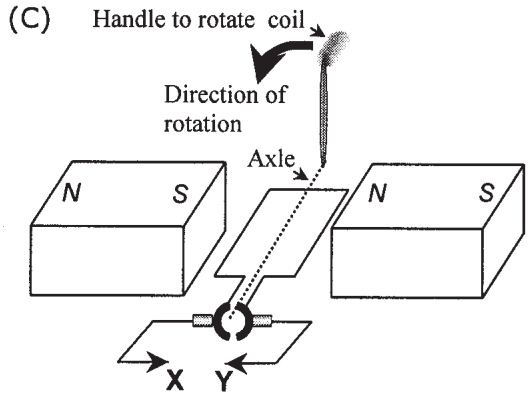
20 During an experiment a generator was attached to Cathode Ray Oscilloscope. The handle of the generator was rotated at a constant rate and a plot of the voltage produced at the contact **X**, compared to **Y**, was recorded. The following graph shows the result produced.

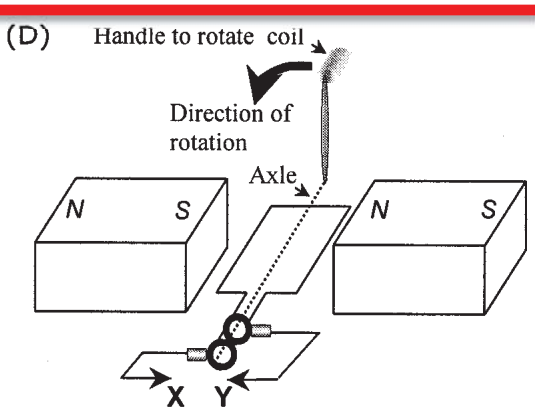


Considering that the graph begins with the generator in the position shown, which of the following would correctly represent the direction of rotation and the type of generator?





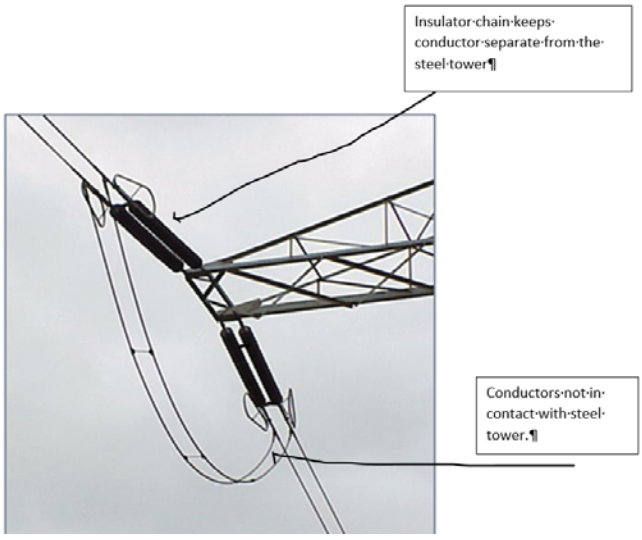




Question 21

Criteria	Marks
• An appropriate labelled diagram that shows insulation from structures (D=diagram) • Purpose of insulation (C=cause) • Structures related to consequences of not insulating the wires (E=effect)	3
• An appropriate diagram (not labelled) that shows appropriate insulation structures and describes consequences of not insulating the wires OR an appropriate labelled diagram that shows insulation structures but includes unclear reasoning	2
• Demonstrates some understanding of why the wires need to be insulated	1

Sample answer



Ceramic insulators ensure that sufficient distance is provided between transmission wires and supporting structures. Without them electrical energy could earth through the supporting structures to the ground below. This would present a danger of electrocution and would result in a considerable loss of energy making the transmission less efficient.

Question 22

(a)

Marking Criteria	Marks
• Identifies that the astronauts in the ISS are still within the gravitational field of the Earth, hence as they have mass they still have a weight. • Identifies that the astronauts will feel the senstation of being 'weightless' as they are in free fall around the Earth • Response includes a correct assessment of the validity, justified based on the reasoning presented	**3**
• Identifies that the astronauts in the ISS are still within the gravitational field of the Earth, hence as they have mass they still have a weight OR • Identifies that the astronauts will feel the senstation of being 'weightless' as they are in free fall around the Earth • Response includes a correct assessment of the validity, justified based on the reasoning presented	**2**
• Identifies that the astronauts in the ISS are still within the gravitational field of the Earth, hence as they have mass they still have a weight OR • Identifies that the astronauts will feel the senstation of being 'weightless' as they are in free fall around the Earth	**1**

Sample Answer

22 b.

Marking Criteria	Marks
• Correct answer with correct formula substitution and units	**3**
• Correct substation with convert km-→ m	**2**
• Answer provided with one error OR • Incorrect substition	**1**

$$F = G\frac{m_1 m_2}{d^2}$$

$$\frac{F}{m_1} = a = G\frac{m_{planet}}{d^2}$$

$$= 6.67\times10^{-11}\frac{2.50\times10^{24}}{(4.00\times10^{8})^2}$$

$$= 1.04\times10^{-3}\ \text{m s}^{-2}$$

Question 23a.

Marking Criteria	Marks
• Shows correct substitution for F= thrust – weight • Applies Newton's 2nd Law to determine acceleration, including calculation of net force a=f/m • Calculates acceleration with direction.	**3**
• Any TWO of the above	**2**
• Any ONE of the above	**1**

Sample Answer:

Launch mass = 4.33×10^4; Mass of fuel **used** in first stage = 3.83×10^4; Thrust = 4.50×10^5 N

Mass of rocket just before end of first stage = $4.33 \times 10^4 - 3.83 \times 10^4$

= 5.00×10^3 kg

Net force on rocket at end of first stage = T – W

= T – mg

= $4.50 \times 10^5 - 5.00 \times 10^3 \times 9.81$

= 4.01×10^5 N up

Acceleration at the end of first stage = F_{net}/m

= $(4.01 \times 10^5)/(5.00 \times 10^3)$

= 80.2 m/s^2 up

Question 23b.

Marking Criteria	Marks
• Substitution into correct formula • Correctly determines the value of g-force	**2**
• Attempt to calculate g-force as a ratio the acceleration to 'g'	**1**

Sample Answer:

g force = (g + a)/g

= (9.81 + 80.2)/ 9.81

= 9.2

Question 24 a.

Marking Criteria	Marks
• Change in flux due to AC in primary coil linked to E/M induction in secondary coil • Explanation of why DC cannot be used is clear	2
• AC causes changing flux in secondary coil OR • E/M induction requires changing flux	1

- AC in the primary coil of the transformer generates a continuously reversing magnetic field which results in changing flux through the secondary coil. As EMF = $-n\frac{d\Phi}{dt}$, thereby producing the secondary current and voltage. DC applied to the primary coil will produce a flux that is constant, therefore no induced EMF in secondary coil.

Question 24 b.

Marking Criteria	Marks
• Explanation described completely in terms of efficiency and power input, thus heat produced • May use a relevant equation used or quantitative reasoning • Identifies at least ONE method used to cool transformers	2
• Any one of the above	1

The power input of this transformer is P=VI=384 kW. Even a small inefficiency (1% = 3.8 kW) will result in heat being produced in the transformer. If this is not lost by cooling, the insulation on the coils will melt and the transformer will short circuit and be destroyed. As the coils have a finite resistance R and power loss is given by $P = I^2R$, the transformer's coils will generate heat.

Transformers can be cooled using by circulating oil through the device, heating fins etc.

Question 24 c.

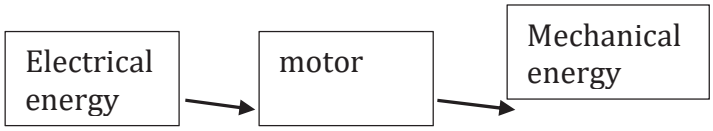
Marking Criteria	Marks
• Calculate input power AND calculate output power • Calculate power lost • Calculate energy lost	3
• Calculate input power AND calculate output power • Calculate power lost	2
• Calculate input power OR • Calculate output power	1

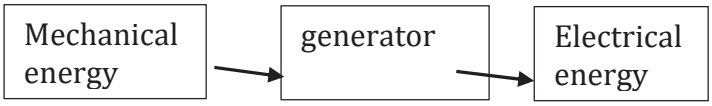
Power in = $V_{in}I_{in}$ = 32 000 x 12 = 384 kW
Power out = $V_{out}I_{out}$ = 11 000 x 28 = 308 kW
Power lost = 76 kW
Energy lost in 1 day = $(76 \times 10^3) \times 60 \times 60 \times 24 = 6.57 \times 10^9$ J or 6.57 GJ

Question 25

Marking Criteria	Marks
• (S)Structure and function of motors and generators compared • (E)Energy transformations in both compared/outlined • (D)Appropriate diagrams used to support/illustrate answer • (A)Assessment is clear and relates to the response provided	**4**
• As above but with an aspect omitted • An assessment made	**3**
• Several aspects of motors and generators compared	**2**
• An aspect of motors and generators is compared	**1**

The physical structure of a motor is the same as a generator, however their roles are reversed: a motor converts electrical energy into mechanical energy whilst a generator does the opposite:





Question 26

Marking Criteria	Marks
• State Lenz's Law AND states the principle of conservation of energy • Describes production of the current to oppose the change in flux AND • Links the production of a SOUTH pole to increasing KE without any work being done on the magnet, AND • States the increased KE in the absence of work input violates the aw of conservation of energy	**4**
• State Lenz's Law AND states the principle of conservation of energy • Describes production of the current to oppose the change in flux AND • Links the production of a SOUTH pole to increasing KE without any work being done on the magnet, OR • States the increased KE in the absence of work input violates the law of conservation of energy	**3**
• State Lenz's Law AND states the principle of conservation of energy • Describes production of the current to oppose the change in flux	**2**
• State Lenz's Law AND states the principle of conservation of energy	**1**

Sample Answer:

Lenz's Law states that an induced emf will form that creates a magnetic field to opposed the original change in flux.

The approaching north pole creates a change in flux in the coil. This induces an anti-clockwise current in the coil that creates a north pole to oppose the approaching magnet.

The principle of conservation of energy states that energy cannot be created nor destroyed. A north pole must be induced because if the opposite were true (i.e. a south pole was induced), then the south pole would attract the magnet and **increase** its energy without any input of work.

Creation of energy without work input would violate the law of conservation of energy

Question 27

(a) (3 marks)
Outcomes Assessed: H9-10, H11-14
Targeted Performance Bands: 2-3

Criteria	Marks
• Complete set of observations are made • Must talk about ribbons, striations and gap and green glow • Labelled diagrams are acceptable	3
• Omits ONE or TWO important observations	2
• Only states ONE accurate observation	1

Sample Answer

1. At normal air pressure nothing is observed inside the tube.
2. As the air is evacuated, purple streamers begin to appear that are continuous from the anode to the cathode.
3. Next striations appear, the colour is now dull pink and there is a gap between the cathode and the first striation.
4. The gap increase and the striations become dimmer.
5. Eventually no striations are seen anymore, only a green glow on the glass.

(b) (3 marks)
Outcomes Assessed: H9-10, H11-14
Targeted Performance Bands: 3-5

Criteria	Marks
• At least TWO risks and ONE appropriate precaution are identified	3
• ONE risk and matching precaution identified	2
• Risk and precaution identified but do not match • OR ONE missing	1

Sample Answer

The induction coil used in this experiment emits radiation. It is recommended to stand at least 1m away from the coil while it is being used so as not to be exposed to this radiation.
X-rays are emitted as high-energy electrons collide with things. As the electrons collide with the glass at the end of the tube, X-rays will be emitted. Stand clear of the end of the tube and a distance away.

BH: Complete set of observations?? I mainly looked for a through description with appropriate references to color, banding and also accepted Crooke's or Faraday's dark spots for full marks

Q 27 (b) the exam script said it was out of 1 while the marking criteria said it was out of 3. I therefore marked it out of 2. Question 27 overall was therefore out of 3+2=5

Question 28

Marking Criteria	Marks
• Shows thorough knowledge of appropriate aspects of quantum theory AND black body radiation • Provide specific example of Einstein's contribution e.g. his use of Planck's hypothesis ('quanta') to explain the photoelectric effect • Uses the above to evaluate the significance of Einstein's contribution e.g. terms of leading scientists to accept the idea of the quantisation of light, thus opening up new areas of physics	4
• Shows sound knowledge of quantum theory AND black body radiation • Provide specific example of Einstein's contribution e.g.his use of Planck's hypothesis ('quanta') to explain the photoelectric effect	3
• Shows basic knowledge of quantum theory AND • Shows basic knowledge of black body radiation	2
• Shows basic knowledge of quantum theory OR • Shows basic knowledge of black body radiation	1

Sample Answer:

Planck hypothesised that radiation in the black body cavity was absorbed and emitted in discrete amounts 'quanta', rather than continuous waves as suggested by classical physics.

Einstein's analysis and explanation of the photoelectric effect showed that light was quantised i.e. light can be considered to exist in discrete packets or bundles of energy known as a photon. A photon can only transfer all or none of its energy, not just part of it. This was a major departure from classical physics.

His theoretical explanation of the photoelectric effect was confirmed with empirical observations, and was able to explain aspects of the phenomenon that classical physics was unable to. This suggested that Planck's hypothesis was correct.

Hence Einstein's contribution was very significant as it explained the photoelectric effect, provide support for Planck's hypothesis and the physics black body radiation, thus leading scientists to accept the idea of the quantisation of light, opening up new areas of physics.

Question 29

(a)

Criteria	Marks
• Draws in electric field lines correctly between plates (directed up, parallel lines with even spacing → uniform electric field)	1

(b)

Criteria	Marks
• Correct variable substitution into appropriate formula • Correct calculation of the electric field strength including units	2
• Any ONE of the above	1

Sample Answer:

Data: V = 100V; d = 5mm = 0.005m; E=?

V = E x d

E = V / d

= 100 / 0.005

= 2×10^4 V/m up *(BH: I did not require up since it said strength of force)*

(c)

Criteria	Marks
• Correct calculation of force on proton • Correct calculation of acceleration of proton • Suitable analysis of the proton as projectile motion to confirm the range of the proton • Parabolic shape drawn for trajectory, showing proton colliding with upper plate.	5
• Correct calculation of force on proton • Correct calculation of acceleration of proton • Suitable analysis of the proton as projectile motion to confirm the range of the proton with ONE error • Parabolic shape drawn for trajectory, showing proton colliding with upper plate.	4
• Correct calculation of force on proton • Correct calculation of acceleration of proton • Parabolic shape drawn for trajectory, showing proton moving towards upper plate.	3
• Any TWO of the above	2
• Correct calculation of force on proton OR • Correct calculation of acceleration of proton OR • Parabolic shape drawn for trajectory, showing proton moving towards upper plate.	1

Sample Answer:

Data: $v = 1 \times 10^5$ m/s; $q_p = 1.6 \times 10^{-19}$C; $m_p = 1.673 \times 10^{-27}$ kg

$F_p = E \times q_p$
$= 2 \times 10^4 \times 1.6 \times 10^{-19}$
$= 3.2 \times 10^{-15}$ N up

$F_{net} = F_p$ (weight force is negligible ~10^{-26}N compared to $F_{elec} \sim 10^{-15}$ N)
$F_{net} = m_p \times a$ hence:
$F_p = m_p \times a$
$a = F_{net} / m_p$
$= (3.2 \times 10^{-15})/(1.673 \times 10^{-27})$
$= 1.91 \times 10^{12}$ m/s^2 up

Since acceleration is constant, we can treat this as a projectile motion problem. If the proton travels a vertical distance of 2.5mm towards the upper (negative) plate before it travels the full distnce between the plates, it will NOT hit the detector.

Let's check this by calculating the time taken for the proton to travel 2.5mm vertically, then compare this to the corresponding range for this time.

Part One: Time taken to travel vertically 2.5mm = ?.

Consider the vertical component of the proton's movement:
Data: $r = 2.5\text{mm} = 0.0025$ m; $a_p = 1.91 \times 10^{12}$ m/s^2; $u = 0$ m/s; $t = ?$

$r = ut + \frac{1}{2} \times a_p \times t^2$
$0.0025 = 0 \times t + 0.5 * 1.91 \times 10^{12} \times t^2$
$t^2 = 0.0025 / (0.5 \times 1.91 \times 10^{12})$

$t = [0.0025 / (0.5 \times 1.91 \times 10^{12})]^{0.5}$
$= 5.11 \times 10^8$ s

Part
Now, consider the horizontal component of the proton's motion:
Data: $u_x = 1 \times 10^5$ m/s; $t = 5.11 \times 10^8$ m/s

$r_x = u_x \times t$
$= 1 \times 10^5 \times 5.11 \times 10^8$
$= 5.11 \times 10^{-3}$ m

i.e. in the time taken for the proton to hit the upper (negative) plate, it travels 5.1 mm horizontally. Since the length of the parallel plates are 10mm, the proton does not reach the detector.

Question 30

(a)

Criteria	Marks
• Includes correctly drawn and labelled diagrams showing the band structure for a metal conductor, a semi-conductor and an insulator • Identifies differences in the band structure of each of the three types of materials (relevant to the conductivity/resistivity of the material) • Relates the above to corresponding differences in the relative electrical resistance of conductors, semi-conductors and insulators and heat	3
• Any TWO of the above	2
• Any ONE of the above	1

BH: (note students did not generally explicitly pick up on the fact that with metallic conductors as temperature increases whereas with thermal semiconductors the conductivity mechanism actually requires heat – very few students actually contrasted this).

(b)

Criteria	Marks
• Outlines the widespread use of thermionic devices in communication technologies (e.g. radio) and identifies the application of the transistor as a solid state replacement in equivalent modern day devices. • Identifies ONE advantage of the use of thermionic devices in communication devices • Identifies TWO disadvantages of thermionic devices used in communication technologies • Relates the disadvantages above to the need to undertake research into the electrical properties of solid state materials, leading to the development of the transistor.	3
• Outlines the widespread use of thermionic devices in communication technologies (e.g. radio) and identifies the application of the transistor as a solid state replacement in equivalent modern day devices. • Identifies ONE advantage of the use of thermionic devices used in communication technologies • Identifies TWO disadvantages of thermionic devices used in communication technologies	2
• Identifies ONE advantage of the use of thermionic devices in communication technologies OR • Identifies ONE disadvantage of thermionic devices used in communication technologies	1

Marker Comments:
Better responses would have communicated important understandings concerning switching (diodes) and amplification transistors and triodes

Sample Answer:
Thermionic devices such as valves and triodes were important components of early communications technologies such as radio. These thermionic devices consisted of a vacuum tube containing a cathode and at least one other electrode. The cathode is heated to high temperature allowing the emission of electrons. Diode valves function as switches within electrical circuits (allowing current to only flow in one direction), triodes allowed switching and amplification. Both of these functions are important for electrical circuits in communication technology and allowed devices such as radios to become widespread.
Whilst diode valves and triode valves allowed the development and uptake of communication technology, these types of devices have several disadvantages:
They are fragile, they consume a lot of electrical energy and are less efficient as they produce a lot of heat and the devices themselves are physically large.
These issues led to research into alternative technologies to address these limitations, research that ultimately led to the development of solid state electronics. The solid state diode replaced the diode valve and the solid state transistor replaced the triode valve. This research led to a greater understanding of electrical conductivity in solid materials, behaviour that can be explained by band theory. These solid state devices were much smaller, more durable and long lasting compared to their valve equivalents. They were also cheaper to produce and more energy efficient allowing a large range of electronic devices to be widely produced today including computers and mobile phone devices that rely on microprocessor technology.

Question 31

Criteria	Marks
• Outlines the use of superconducting materials in ONE potential future application (e.g. computers, generators and motors, transmission of electricity through power grids). • Identifies ONE or more advantages relevant to the use of superconducting materials for the named application AND • Identifies ONE or more disadvantages relevant to the use of superconducting materials for the named application • Well structured answer	3
• Outlines the use of superconducting materials in ONE potential future application (e.g. computers, generators and motors, transmission of electricity through power grids). • Identifies ONE advantage relevant to the use of superconducting materials for the named application OR • Identifies ONE disadvantage relevant to the use of superconducting materials for the named application	2
• Outlines the use of superconducting materials in ONE potential future application (e.g. computers, generators and motors, transmission of electricity through power grids. Note maglev trains were accepted).	1

Marker Comments:
Need to specifically link the properties of a superconductor to the features that make it suitable for the chosen application. For example, “no energy loss as there is no electrical resistance” rather than just “no energy loss”.

Question 32

(a)

Marking Criteria	Marks
• Correct and complete explanation provided • Threshold frequency described with reason why it cannot be zero	2
• A partial explanation is provided	1

Sample Answer:

Where the plotted line passes through the x-axis (frequency) is the value of the threshold frequency – the minimum frequency of incident light that will cause photo-electrons to be emitted from the metal surface. As E=hf, this cannot be zero as some energy must be given electrons so that they can leave the surface of the metal.

(b)

Marking Criteria	Marks
• Calculation performed correctly	2
• One error made	1

Sample Answer:

$$E = hf$$
$$f = \frac{E}{h}$$
$$= \frac{4.33 \times (1.6 \times 10^{-19})}{6.626 \times 10^{-34}}$$
$$= 1.05 \times 10^{15} \text{ Hz}$$

(c)

Marking Criteria	Marks
• Drawn line is parallel to line for zinc • Drawn line is to the right of line for zinc	2
• One of the above	1

Question 33

(a) (i)

Marking Criteria	Marks
• Substitution into correct formula • Correctly determines the wavelength	2
• Answer provided with one error	1

Sample Answer:

33(a)(i)

Visible light → Balmer series → $n_f = 2$; $n_i = 3$; $R_H = 1.097 \times 10^7\ m^{-1}$

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

$$= 1.097 \times 10^7 \times \left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

$$= 1.52 \times 10^6\ m^{-1}$$

$$\therefore \lambda = \left(1.52 \times 10^6\right)^{-1}$$

$$= 6.56 \times 10^{-7}\ m$$

$$= 656\ nm$$

(a) (ii)

Marking Criteria	Marks
• Substitution into correct formula • Correctly determines the energy of the photon in electron-volts.	2
• Answer provided with one error OR • Correct answer with no or wrong units	1

Sample Answer:

33(a)(ii) Data: $v = c = 3 \times 10^8$ m/s; $\lambda = 6.56 \times 10^{-7}$ m; $f = ?$; $E = ?$

$$v = c = f\lambda \rightarrow f = \frac{c}{\lambda}$$

$$E = hf \rightarrow E = \frac{hc}{\lambda}$$

$$= \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{6.56 \times 10^{-7}}$$

$$= 3.029 \times 10^{-19} \text{ J}$$

* $1 \text{ eV} = 1.602 \times 10^{-19}$ J

$$\therefore E = \frac{3.029 \times 10^{-19}}{1.602 \times 10^{-19}} \text{ eV}$$

$$= 1.89 \text{ eV}$$

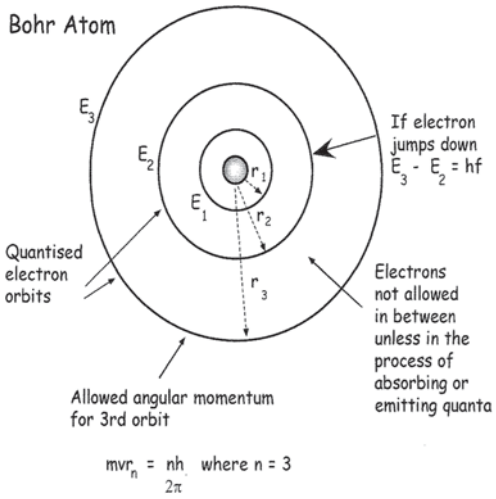
(b)

Identify components and the relationship between them; draw out and relate implications

Criteria	Marks
• Describes the structure of the Bohr model • Identifies ONE or more components of the Bohr model based on classical physics • Identifies ONE or more components of the Bohr model based on quantum ideas • • Relates the above points to the development of our understanding of the nature of physics using ONE relevant example • Well structured, logical answer that shows a thorough understanding or the relevant physics	5-6
• Describes the structure of the Bohr model • Identifies ONE component of the Bohr model based on classical physics • Identifies ONE component of the Bohr model based on quantum ideas • Shows basic understanding of relevant physics • Relates the above points to the development of our understanding of the nature of physics using ONE relevant example	3-4
• Describes the structure of the Bohr model • Identifies ONE component of the Bohr model based on classical physics OR • Identifies ONE component of the Bohr model based on quantum ideas e.g. quantised angular momentum and the concept that a photon will release a quantum of energy when moving from one energy state to another	2
• Any ONE of the above.	1

Sample Answer

The statement is appropriate as the Bohr model of the hydrogen atom employs a combination of both classical and quantum physics, ideas which came our understanding of physics in the early 20th century.



Key components of the Bohr model are shown in the diagram shown right include:

- Postulate 1: Electrons orbit the nucleus in quantised orbits (energy levels) outward from the nucleus. An electron in an orbit is in a stationary energy state and does not radiate energy.
- Postulate 2: When an electron moves from a lower to a higher orbit, or falls from a higher to a lower orbit, the electron will absorb or release a quantum of energy (EMR). The frequency of the quantum that is absorbed or emitted is related to the change in the electron's energy and is given by the Planck–Einstein formula: $E_{initial} - E_{final} = hf$
- Postulate 3: The angular momentum of the electron is quantised ($mvr_n = \frac{nh}{2\pi}$) where 'n' is the principal energy shell number.

In terms of classical physics, Bohr assumed that the electron moves in circular orbits about the proton under the influence of the Coulomb force of attraction. Using classical mechanics describing centripetal force and Coulomb's law, Bohr was able to calculate the total energy of the electron-proton system by summing the kinetic energy (E_k) and the electric potential energy.

By combining these ideas with quantum ideas presented in his 1st and 3rd postulates, he was then able to develop mathematical equations to describe quantitatively the radius as well as the energy change of the principal energy shells as they moved away from the nucleus.

His model also incorporated quantum physics. For example, his second postulate relied upon earlier work by Planck (and Einstein and assumed that an electron would absorb or emit a quantum of energy (as a photon) when jumping up to or falling down from different energy states. He also assumed that the energy state of an electron in a given energy shell is quantised and that the angular momentum of an electron is quantised.

His second postulate draws upon the idea of light as quanta, first proposed by Planck to account for the radiant energy being exchanged as discrete bundles (quanta) between the cavity walls and the internal energy field of a blackbody, from which he proposed that the energy of each quanta exchanged is given by E = hf. It also makes use of Einstein's work in understanding light as a particle to explain the photoelectric effect, for example, making use of the idea that a photon carries a discrete amount of energy and hence that an electron can only absorb or emit a discrete amount of energy to move between energy levels.

Hence, the Bohr model of the hydrogen atom is a combination of ideas from both classical and quantum physics that were accepted in the early part of the 20th century. His model could be used to predict and explain the observed spectra of hydrogen and hence provided further support for the idea of particle nature of light. de Broglie's subsequent postulate on the nature of matter waves provided a basis for Bohr's third postulate, and ultimately led to new ideas regarding wave-particle duality and more sophisticated, quantum-mechanics based models of the atom (including Heisenberg's matrix mechanics and Schrödinger wave equations).

(c) (i)

Marking Criteria	Marks
• Substitution into correct formula • Correctly determines the wavelength of the electron.	2
• Identifies correct formula OR • Correct numerical answer with no working)	1

Sample Answer:

33(c)(i)

Data: $h = 6.626 \times 10^{-34}$; $M = m_e = 9.109 \times 10^{-31}$ kg; $V = 2 \times 10^{7}$ m/s.

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

$$= \frac{6.626}{9.109 \times 10^{-31} \times 2 \times 10^{7}}$$

$$= 3.637 \times 10^{-11} \text{ m}$$

(c) (ii)

Marking Criteria	Marks
• Describes experimental result as evidence to support deBroglie's postulate. • Identifies the variation in the collector current at different angles as evidence of interference behaviour (constructive/destructive), consistent with similar experiments with x-rays undertaken by the Braggs • Relates these interference results to evidence of electrons having wave like properties, hence providing evidence of wave nature of electrons • Compares these results and/or de Broglie's postulate to previous experiments or ideas regarding the particle nature of electrons (e.g. Thomsons q/m ratio determination) • Well-structured answer that demonstrates the significance of Davisson-Germer results.	4
• Describes experimental result as evidence to support deBroglie's postulate. • Makes reference to electrons having wave-like properties • Identifies evidence of interference in the results to support the above point	3
• Describes experimental result as evidence to support deBroglie's postulate. • Makes reference to electrons having wave-like properties OR • Identifies evidence of interference in the results to support the above point	2
• Any ONE of the above	1

Sample Answer

de Broglie postulated that all forms of matter could exhibit both wave-like and particle-like properties, with the wavelength of a matter wave being given by the relationship $\lambda = h / mv$.

The diffraction of electrons from the surface of a crystal of nickel with scattering at the exact angles predicted by Bragg's equation and a wavelength predicted by the de Broglie equation $\lambda = h / mv$, was observed by Davisson and Germer.

The results showing a variation in collector current at different angles are characteristic of an interference pattern produced by the diffracted electrons, showing constructive and destructive interference. The maxima occurs around 50^o for the results shown. Such interference demonstrates that electrons have wave-like behaviour. This experiment was significant as it provided direct empirical evidence to support de Broglie's proposal.

In the context of the ground-breaking nature of de Broglie's proposal of matter waves, the results is also significant as all experimental evidence regarding the electron prior to this suggested that the electron was a particle (e.g. Thomson's experiment to measure the charge to mass ratio of the electron).

(d) (i)

Marking Criteria	Marks
• Correctly identifies energy is released • Supports answer with correct calculations based on mass defect	2
• Attempt at calculating mass defect	1

Sample Answer

Total Mass LHS = 1.0073 + 7.0160 = 8.0233 u | Mass on LHS > Mass on RHS

Total Mass RHS = 4.0015 + 4.0015 = 8.0030 u

$\Delta M = 8.0233 - 8.0030$

= 0.0203 u i.e. mass has been converted into energy

∴ energy is RELEASED.

(d) (ii)

Criteria	Marks
• Identifies ONE or more similarities between the artificial transmutation shown and alpha decay • Identifies ONE or more differences between the artificial transmutation shown and alpha decay	2
• Any ONE of the above	1

Sample Answer:
Compared to alpha decay, the process of nuclear transmutation shown above was initiated by bombarding the original lithium atom with a proton i.e. the process was artificially induced. This compares to the natural process of radioactive decay by alpha decay, in which an unstable radioactive atom spontaneously emits an alpha particle. Radioactivity is a naturally occurring process.
The artificial transmutation process shown and radioactive alpha decay are similar in that both processes release energy.