Student Number…….

SYDNEY BOYS HIGH SCHOOL

HSC TRIAL EXAMINATION 2006

PHYSICS

General Instructions Reading Time 5 minutes Working Time 3 hours Write using blue or black pen Draw diagrams using pencil. Board- approved calculators may be used. A data sheet, formulae sheets and Periodic Table are provided with this paper. Marks may be allocated to working Show all working	**Total marks – 100** **Section I** Pages 2 – 16 **Total marks 75** This section has two parts, Part A and Part B. Part A – 15 marks • Questions 1 – 15 • Allow about 30 minutes for this part Part B – 60 marks • Attempt Questions 16 – 30 • Allow about hour and 45 minutes for this part. **Section II** Page 15 **Total marks 25**

1. There are a number of reasons which contribute to variations in the value of the acceleration due to gravity at specific locations on the surface of the Earth.

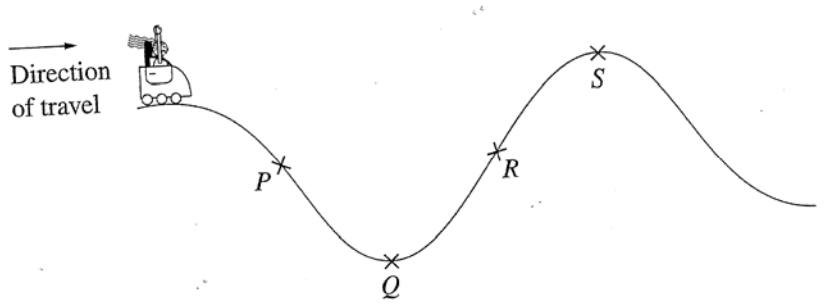
Which of the following pairs of reasons would **not** be responsible for such variations?

(A) Crustal variations and the shape of the Earth.
(B) The shape of the Earth and the height above sea level.
(C) Height above sea level and the Earth's spin.
(D) Crustal variations and the Earth's orbit around the Sun.

2. The Earth, of radius and mass, 6.38×10^6 m and 5.98×10^{24} kg respectively, has an artificial satellite. The satellite orbits at an altitude of 300 km, has a mass of 200kg and travels with a velocity of 20 000km h^{-1} The gravitational force acting on the satellite is;

(A) 1.8×10^{-3} N
(B) 2.3×10^{-1} N
(C) 1.8×10^{3} N
(D) 2.3×10^{3} N

3. The diagram shows four positions of a car on a roller coaster ride.



At which point during this ride would the occupant experience maximum 'g force'?

(A) P
(B) Q
(C) R
(D) S

4. The table contains information related to two planets orbiting a distant star.

Planets	Mass (kg)	Orbital radius (m)	Radius of planets (m)	Length of day (s)	Orbital period (s)
Alif	1.21×10^{25}	4.00×10^{11}	8.0×10^{6}	9.5×10^{4}	8.75×10^{7}
Ba	1.50×10^{24}	8.00×10^{11}	4.0×10^{6}	4.7×10^{4}	—

The orbital period of the planet Ba can be determined by using data selected from this table.

What is the orbital period of the planet Ba?

(A) 3.10×10^{7}s
(B) 5.51×10^{7}s
(C) 1.39×10^{8}s
(D) 2.47×10^{8}s

5. A radioactive particle used in a linear accelerator. Measured at rest relative to the laboratory it has a half life of 2.5μs. When measured at constant speed by an observer in the laboratory, its half life has increased to 10μs.

What is the speed of the particle relative to the laboratory?
(A) 1.68×10^8 ms $^{-1}$
(B) 2.10×10^8 ms $^{-1}$
(C) 290 000 000 ms $^{-1}$
(D) 2.60×10^8 ms $^{-1}$

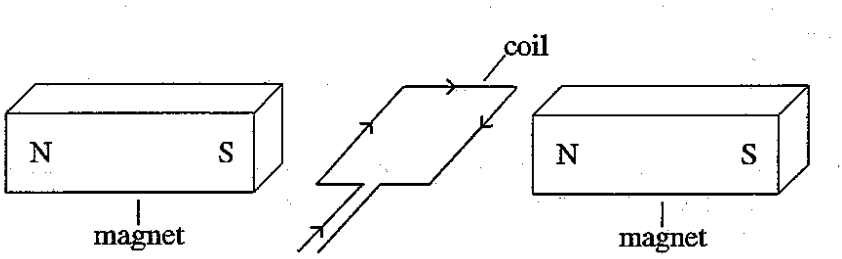
6. Identify which of the following is **not** a component of a DC generator.

(A) brushes
(B) coil
(C) magnetic field
(D) slip-rings

7. Two long parallel wires are carrying electrical currents. The direction of the current in one of the wires is reversed. How does this affect the force between the wires?

(A) The force does not change.
(B) The force changes direction.
(C) The force increases.
(D) The force decreases.

8. The following diagram shows a coil of wire between two magnets.



When a current passes through the coil in the direction shown, which is now free to move, the coil will:

(A) start rotating clockwise (viewed from the front)
(B) not move
(C) move vertically
(D) start rotating anticlockwise (viewed from front)

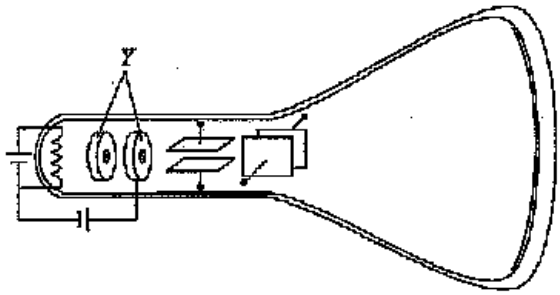
9. A piece of wire 1.0cm long is at right angles to a magnetic field whose magnetic flux density is 1.5T. A current of 2.0 A flows in the wire. What is the magnitude of the force on the wire?

(A) 3.0 N
(B) 0.3 N
(C) 0.03 N
(D) zero

10. A transformer is needed to convert an input voltage of 6000V to an output voltage of 240V.The **type of transformer** and the **ratio** of the number of turns in its secondary coil to the number of turns in its primary coil are

(A) step up, 25:1
(B) step up, 1:25
(C) step down, 25:1
(D) step down, 1:25

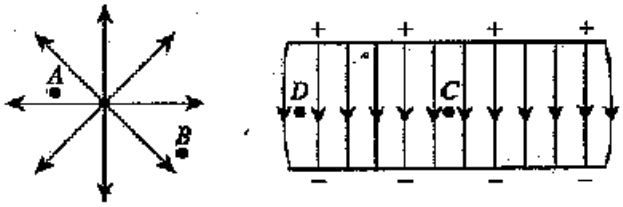
11. The following diagram shows a simple cathode ray tube from an oscilloscope.



The parts labelled Y have the function of

(A) producing electrons.
(B) showing the position of the beam.
(C) deflecting the beam horizontally.
(D) accelerating the electrons.

12. The following diagram shows the electric fields near a point charge and between parallel plates.



At which point is the magnitude of the electric field greatest?

(A) A
(B) B
(C) C
(D) D

13. Which of the following statements is correct?

(A) Einstein was the first person to observe the photoelectric effect.
(B) Planck hypothesised that energy was exchanged, in quanta amounts, by the atomic oscillators of a black body.
(C) Hertz performed experiments to measure the speed of light, using radio waves.
(D) Einstein predicted that for a black body, as the wavelength shortens, the radiation intensity will increase.

14. Solid state devices replaced thermionic devices because <u>thermionic</u> devices;

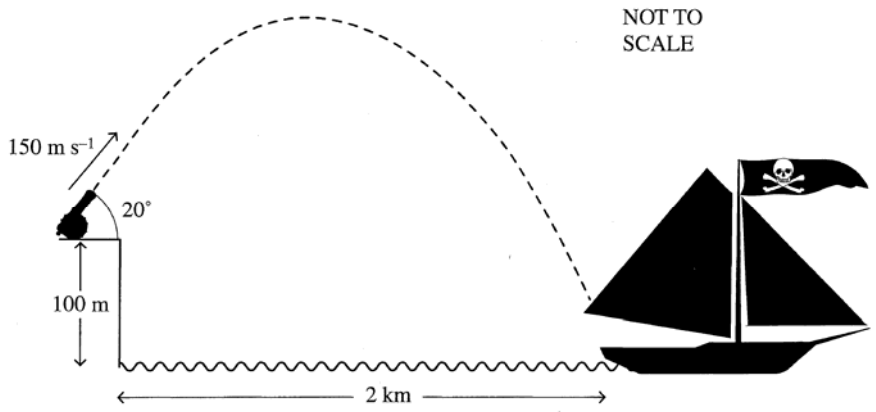
(A) were much smaller and required less current in their circuits.
(B) had a much longer life as they did not become warm at all.
(C) were less reliable and were easily broken.
(D) allowed the cathode coating to evaporate, helping current flow.

15. In metal conductors, the resistance

(A) increases as the amount of impurities increase.
(B) increases as the lattice vibrations decrease.
(C) decreases as more electrons are scattered by lattice vibrations.
(D) decreases as the temperature of the metal increases.

Section B (60 marks) Show all working **Marks**

16.



An enemy ship was sailing 2km from the coast. A cannon on a 100 metre-high cliff fired a projectile at an angle of 20^{O} to the horizontal, at a speed of 150 m/s.

(a) Determine the vertical and horizontal components of the initial velocity. **2**

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(b) Calculate the **time** taken for the cannon ball to reach the maximum height **and** the maximum **height** of the cannon ball above the water.

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(c) Calculate

(i) the range of the cannon ball **2**

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(ii) how far from the ship the cannon ball landed **1**

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(d) Describe an adjustment of the cannon that is necessary for a cannon ball to hit the ship. **1**

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17. Explain why all low earth orbit satellites will eventually fall to the Earth's surface. **2**

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18. A boy standing on train station platform observes a NLST (near light-speed transport) train pass through the station. He observes the clocks on the train to be running slower than normal. However, a girl on the train observes the boy's watch, and notices that his watch is running slower than the clocks on the train.

Account for the above situation with reference to the principle of relativity. **3**

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19. Michelson and Morley set up an experiment to measure the velocity of Earth relative to the aether. **Mark**

(a) Outline TWO features of the aether model for the transmission of light. **2**

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(b) Recount the Michelson and Morley experiment, which attempted to measure the relative velocity of Earth through the aether, and describe the results they anticipated. **4**

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20. In your course you performed an investigation to demonstrate the production of an alternating current. **Mark**

(a) Describe an experiment you did to produce alternating current, with particular reference to how you verified that alternating current was actually produced. **3**

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(b) Describe two advantages of using AC generators for large-scale electrical power production. **2**

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21. The photograph shows a small electrical motor from an electric drill. **3**

(a) Name the labelled parts A, B, and C **and**

(b) Describe the function Of each

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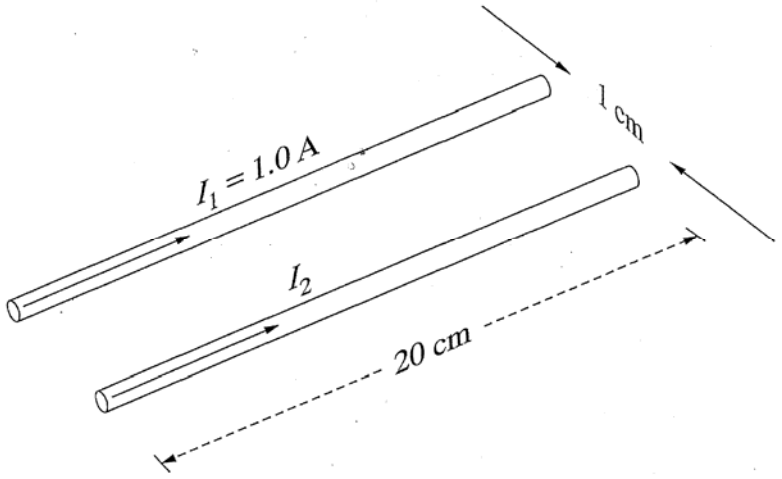
22. The diagram shows part of an experiment designed to measure the force between two parallel current-carrying conductors.

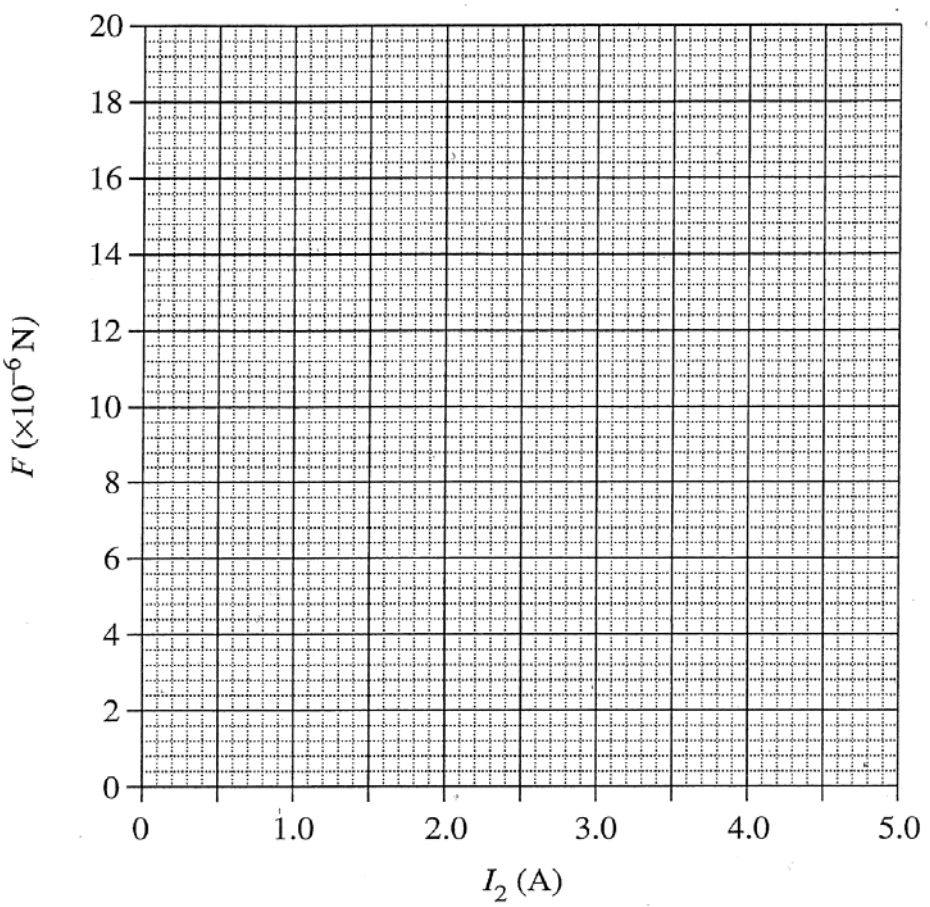


The experimental results are tabulated below.

I_2 (A)	Force ($\times 10^{-6}$ N)
0	0
2.0	7
3.0	11
4.0	14
5.0	18

Question 22 (continued) **Mark 3**

(a) Plot the data and draw the line of best fit.



(b) Calculate the gradient of the line of best fit for the graph. **1**

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(c) Write an expression for the magnetic force constant *k* in the terms of the gradient and other variables. **2**

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(d) Use this expression and the gradient calculated in part (b) to determine the value of the magnetic force constant *k*. **1**

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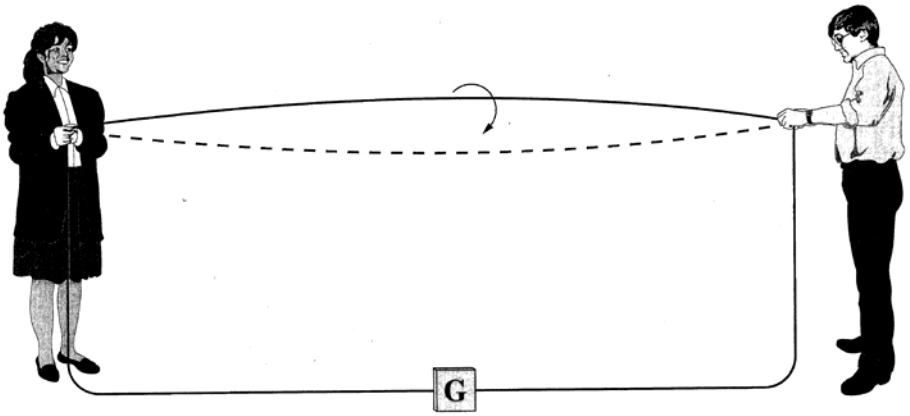
23. In a particular experiment a long length of copper wire of very resistance is rotated by two students. The ends of the wire are connected to a galvanometer G, and a current is detected.



Explain the effect of increasing the speed of rotation on the current measured by the galvanometer **4**

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24. Using silicon as an example of a semiconductor, describe how it carries a current and how doping effects the process. **2**

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25. During your course you carried out an investigation to model behaviour of semiconductors, including the concept of holes. **Marks 3**

Outline what you did in your investigation. Explain how the model showed conduction in semiconductors.

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26. In early studies, the observed characteristics of cathode rays led to the belief that they were electromagnetic waves. **3**

Describe the wave-like properties of cathode rays and explain how other evidence shows them to be particles.

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27. A physics student was conducting an investigation on the photoelectric effect. The student used an infrared laser with a wavelength of 1.55×10^{-6}m for this investigation.

(a) Calculate the energy of a photon from this laser. **2**

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(b) When the laser light was shone onto a photo-cell, no current was detected. The student increased the intensity of the light but still detected no current. **3**
Explain this observation.

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28. (a) Calculate the frequency of a photon of blue light of wavelength 460nm. **1**

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(b) Identify Planck's hypothesis that allowed him to successfully account for the black body radiation curve. **1**

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29. Outline how Hertz measured the speed of radio waves. **3**

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30. Describe how superconductors and magnetic levitation have played a part in the development of the maglev train. **2**

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SECTION II- Option

From Quanta to Quarks. (25 Marks) **Marks**

(a) Discuss Rutherford's model of the nuclear atom with orbiting electrons **4**

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(b) In refining the model of the atom, Bohr began with three postulates. **2**
State 2 of Bohr's postulates.

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(c) Identify experimental evidence that supported <u>one</u> of Bohr's postulates and explain how it provided this support. **2**

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(d) Define the term transmutation. **1**

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Marks

(e) As a result of the studying the electrons emitted during beta decay, Pauli suggested the existence of a then unknown particle. **Discuss** Pauli's suggestion, and relate this to the energy **4**

of the emitted electrons.

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(f) Calculate the mass of a particle that has a De Broglie wavelength of 2.5×10^{-12} m when moving with speed of $200 ms^{-1}$. **1**

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(g) Calculate the energy of the lowest frequency photon emitted in the Balmer series? **2**

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(h) Write the transmutation equation for the beta decay of $Bi\ ^{210}_{83.}$ **2**

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Marks

(i) Explain the significance of the conservation laws, in Chadwick's discovery of the neutron. **4**

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(j) Justify the existence of the strong nuclear force. **3**

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END OF EXAMINATION

Data sheet

Charge on the 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, $\left(k \equiv \frac{\mu_0}{2\pi}\right)$	2×10^{-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}

Student Number…….

Formulae sheet

$v = f\lambda$

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

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

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

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

$P = VI$

Energy = VIt

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

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

$\Sigma F = ma$

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

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

$W = Fs$

$p = mv$

Impulse = Ft

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

$F = mg$

$v_x^2 = u_x^2$

$v = u + at$

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

$\Delta x = u_x t$

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

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

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

$E = mc^2$

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

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

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

Formulae sheet

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

$$F = BIl\sin\theta$$

$$\tau = Fd$$

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

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

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

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

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

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

$$F = qvB\sin\theta$$

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

$$E = hf$$

$$c = f\lambda$$

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

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

$$Z = \rho v$$

$$\frac{I_r}{I_o} = \frac{[Z_2 - Z_1]^2}{[Z_2 + Z_1]^2}$$

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

$$\frac{V_{out}}{V_{in}} = -\frac{R_f}{R_i}$$

Periodic Table of the Elements

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 Phosphorous	16 **S** 32.07 Sulfur	17 **Cl** 35.45 Chlorine	18 **Ar** 39.95 Argon
19 **K** 39.10 Potassium	20 **Ca** 40.08 Calcium	21 **Sc** 44.96 Scandium	22 **Ti** 47.87 Titanium	23 **V** 50.94 Vanadium	24 **Cr** 52.00 Chromium	25 **Mn** 54.94 Manganese	26 **Fe** 55.85 Iron	27 **Co** 58.93 Cobalt	28 **Ni** 58.69 Nickel	29 **Cu** 63.55 Copper	30 **Zn** 65.41 Zinc	31 **Ga** 69.72 Gallium	32 **Ge** 72.64 Germanium	33 **As** 74.92 Arsenic	34 **Se** 78.96 Selenium	35 **Br** 79.90 Bromine	36 **Kr** 83.80 Krypton
37 **Rb** 85.47 Rubidium	38 **Sr** 87.62 Strontium	39 **Y** 88.91 Yttrium	40 **Zr** 91.22 Zirconium	41 **Nb** 92.91 Niobium	42 **Mo** 95.94 Molybdenum	43 **Tc** [98.91] Technetium	44 **Ru** 101.1 Ruthenium	45 **Rh** 102.9 Rhodium	46 **Pd** 106.4 Palladium	47 **Ag** 107.9 Silver	48 **Cd** 112.4 Cadmium	49 **In** 114.8 Indium	50 **Sn** 118.7 Tin	51 **Sb** 121.8 Antimony	52 **Te** 127.6 Tellurium	53 **I** 126.9 Iodine	54 **Xe** 131.3 Xenon
55 **Cs** 132.9 Caesium	56 **Ba** 137.3 Barium	57–71 Lanthanides	72 **Hf** 178.5 Hafnium	73 **Ta** 180.9 Tantalum	74 **W** 183.8 Tungsten	75 **Re** 186.2 Rhenium	76 **Os** 190.2 Osmium	77 **Ir** 192.2 Iridium	78 **Pt** 195.1 Platinum	79 **Au** 197.0 Gold	80 **Hg** 200.6 Mercury	81 **Tl** 204.4 Thallium	82 **Pb** 207.2 Lead	83 **Bi** 209.0 Bismuth	84 **Po** [209.0] Polonium	85 **At** [210.0] Astatine	86 **Rn** [222.0] Radon
87 **Fr** [223.0] Francium	88 **Ra** [226.0] Radium	89–103 Actinides	104 **Rf** [261.1] Rutherfordium	105 **Db** [262.1] Dubnium	106 **Sg** [266.1] Seaborgium	107 **Bh** [264.1] Bohrium	108 **Hs** [277] Hassium	109 **Mt** [268] Meitnerium	110 **Ds** [271] Darmstadtium	111 **Rg** [272] Roentgenium							

KEY

Atomic number
Atomic mass
79 **Au** 197.0 Gold — **Symbol of element**, Name of element

Lanthanides	57 **La** 138.9 Lanthanum	58 **Ce** 140.1 Cerium	59 **Pr** 140.9 Praseodymium	60 **Nd** 144.9 Neodymium	61 **Pm** [146.9] Promethium	62 **Sm** 150.4 Samarium	63 **Eu** 152.0 Europium	64 **Gd** 157.3 Gadolinium	65 **Tb** 158.9 Terbium	66 **Dy** 162.5 Dysprosium	67 **Ho** 164.9 Holmium	68 **Er** 167.3 Erbium	69 **Tm** 168.9 Thulium	70 **Yb** 173.0 Ytterbium	71 **Lu** 175.0 Lutetium
Actinides	89 **Ac** [227.0] Actinium	90 **Th** 232.0 Thorium	91 **Pa** 231.0 Protactinium	92 **U** 238.0 Uranium	93 **Np** [237.0] Neptunium	94 **Pu** [244.1] Plutonium	95 **Am** [243.1] Americium	96 **Cm** [247.1] Curium	97 **Bk** [247.1] Berkelium	98 **Cf** [251.1] Californium	99 **Es** [252.1] Einsteinium	100 **Fm** [257.1] Fermium	101 **Md** [258.1] Mendelevium	102 **No** [259.1] Nobelium	103 **Lr** [262.1] Lawrencium

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

Student Number.....

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SYDNEY BOYS HIGH SCHOOL
HSC PHYSICS TRIAL
MULTIPLE CHOICE ANSWER SHEET

Student number ……

	A	B	C	D
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11				
12				
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14				
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ANSWERS

Student Number.....

FINAL VERSION

SYDNEY BOYS HIGH SCHOOL
HSC PHYSICS TRIAL
MULTIPLE CHOICE ANSWER SHEET

Student number .....

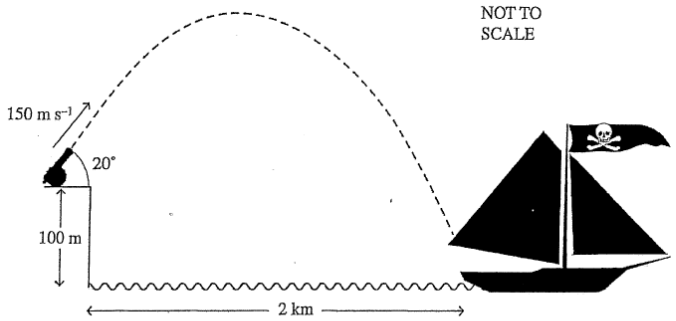
	A	B	C	D	
1				X	
2			X		
3		X			
4	~~X~~			X	Changes A→D
5			X	~~X~~	D→C
6				X	
7		X			
8	X				
9			X		
10				X	
11				X	
12			X		
13		X			
14			X		
15	X				

FINAL VERSION

Student Number.....

Section B (60 marks) Show all working **Marks**

16.



An enemy ship was sailing 2km from the coast. A cannon on a 100 metre-high cliff fired a canon ball at an angle of 20^{o} to the horizontal, at speed of 150 m/s.

(a) Determine the vertical and horizontal components of the initial velocity. 2

$\mu_x = 150 \cos 20 = 141$ m/s

$\mu_y = 150 \sin 20 = 51.3$ m/s

(b) Calculate the **time** taken for the cannon ball to reach the maximum height and hence the maximum **height** of the cannon ball above the water. 3

$v_y = 0$, $a = -9.8$, $\mu_y = 51.3$ m/s

$v = \mu + at$

$t = \frac{v_y - \mu_y}{a_y}$

$= \frac{0 - 51.3}{-9.8}$

$= 5.24$ s

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

$= 51.3 \times 5.24 + \frac{1}{2} \times -9.8 \times 5.24^2$

$= 134.27$ m

∴ Height above water

$= 134.27 + 100$

$= 234$ m

Student Number.....

(c) Calculate the range of the cannon ball and hence determine how far from the ship the cannon ball landed. **Marks** 3

Max ht = 234.27 m

time to fall from 234.27 m

$t = \sqrt{\frac{2 \times \Delta y}{a_y}}$

$= \sqrt{\frac{2 \times 234.27}{9.8}}$

$= 6.91$ s

∴ TOTAL TIME = 6.91 + 5.24

= 12.2 s

Range $\Delta x = u_x \cdot t$

$= 140.95 \times 12.15$

$= 1713.2$

$= 1713$ m

2 marks

Cannon ball landed 287 m short of the ship 1 mark

(d) Describe an adjustment of the cannon that is necessary for a cannon ball to the ship. 1

- Increase angle (to horizontal) of launch ("adjust" not good enough)

(or increase gunpowder to give more velocity)

17. Explain why all low –Earth satellites will eventually fall to the Earth's surface. 2

LEO Satellites (300–1500 km altitude) experience some atmospheric drag which slows them down. Fuel is carried to occasionally boost velocity. When fuel runs out – orbital decay + crashing to earth occurs.

18. A boy standing on train station platform observes a NLST (near light-speed transport) train pass through the station. He observes the clocks on the train to be running slower than normal. However, a girl on the train observes the boy's watch, and notices that his watch is running slower than the clocks on the train.

Account for the above situation with reference to the principle of relativity. 3

need this

Both observers see clocks in the other frame run slow. This is because moving clocks run slow, relative to stationary observers. Both the boy & girl's observations are consistent with Special Relativity as Einstein stated that all INERTIAL FRAMES are equal (both of these are inertial because neither are accelerating) Therefore both observers would see clocks in the other frame running slow.

17

Marking Criteria	Marks
Gives correct description of change to orbital speed with reason	2
Gives only a general description of the change in orbital speed	1

The satellite's orbital speed decreases with increasing altitude due to reduced centripetal force.

18

Marking Criteria	Marks
Clear, concise discussion, referring to the PoR and frames of reference both being correct as no inertial frame of reference is preferred over another inertial FoR	4
Discussion shows understanding of PoR and mentions frames of reference	3
Reference to PoR and frames of reference	2
Some reference to the PoR	1

Student Number.....

19. Michelson and Morley set up an experiment to measure the velocity of Earth relative to the aether. **Mark**

(a) Outline TWO features of the aether model for the transmission of light. 2

1 mark each - Any 2 of... filled space, transparent, permeated all matter, low density, high elasticity low viscosity, stationary - the absolute rest frame

(b) Recount the Michelson and Morley experiment, which attempted to measure the relative velocity of Earth through the aether, and describe the results they anticipated. 4

Describes the apparatus used - an interferometer with labels, The use of a coherent light source which would be split by a half silvered mirror then recombined to form an interference pattern. M+M expected the interf pattern to change as the interferometer was rotated due to the change in relative light speed. Despite good procedures and repetition no change was ever detected — 4

Describes experiment but poorly recounts - expected results or achieved results or apparatus used — 3-2

Has some understanding of the interferometer, or that light speed was expected to change or that no result was achieved. — 1

Student Number.....

20. In your course you performed an investigation to demonstrate the production of an alternating current. **Mark**

(a) Describe an experiment you did to produce alternating current, with particular reference to how you verified that alternating current was actually produced. 3

* A description and diagram showing how AC was produced and detected (e.g. oscillating needle) 3-2

* A description but omits some apparatus or procedural matter 2-1

* evidence of some knowledge of a suitable expt. 1

(b) Describe two advantages of using AC generators for large-scale electrical power production. 2

Any 2 reasonable advantages (but must have)

e.g. • allows voltage to be easily changed

• no commutator and ∴ better reliability

• turbines can be spun by a variety of methods (wind, water, steam, tidal or wave movement)

(1 mark each - ONLY FIRST TWO RESPONSES MARKED)

21. The photograph shows a small electrical motor from an electric drill. 3

(a) Name the labelled parts A, B, and C **and**

(b) Describe the function Of each

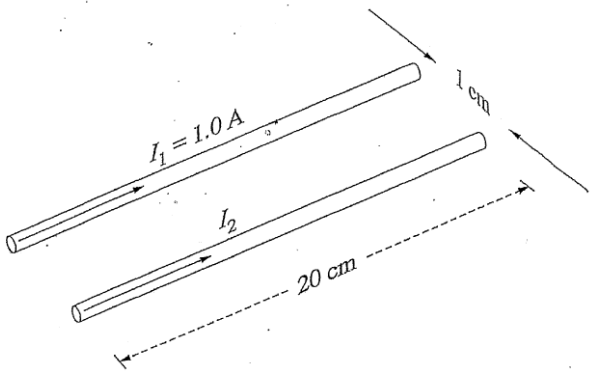
A - Electromagnetic windings - produce a magnetic field

B - Armature windings - carries current

C - Commutator - reverses current each $\frac{1}{2}$ turn

Student Number.....

22. The diagram shows part of an experiment designed to measure the force between two parallel current-carrying conductors. **Mark 7**



The experimental results are tabulated below.

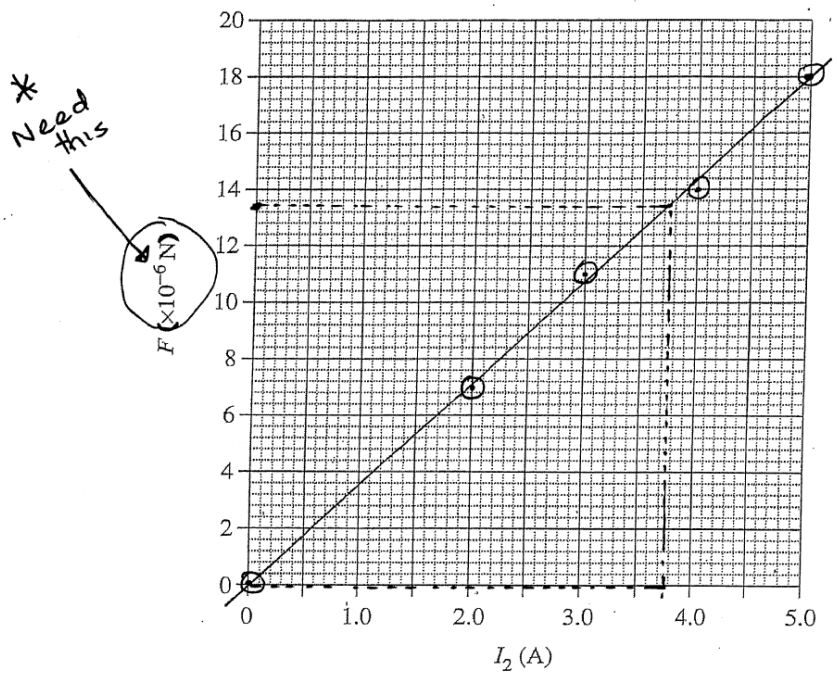
I_2 (A)	Force ($\times 10^{-6}$ N)
0	0
2.0	7
3.0	11
4.0	14
5.0	18

Question **22** (continued) **Mark**

Student Number.....

3

(a) Plot the data and draw the line of best fit.



* Need this

* There needed to be a clear line of B.Fit.

(b) Calculate the gradient of the line of best fit the graph. 1

rise $= \frac{(13.4 - 0) \times 10^{-6}}{3.75 - 0} = 3.57 \times 10^{-6}$

run

(GRADIENT CALCULATIONS MUST BE FROM THE LINE, NOT POINTS)

(c) Write an expression for the magnetic force constant k in the terms of the gradient and other variables. 2

$F = \frac{k I_1 I_2 l}{d}$ | $F = \frac{k I_1 l}{d} \cdot I_2$ | gradient $= \frac{k I_1 l}{d} =$ | $k = \frac{\text{grad} \cdot d}{I_1 \cdot l}$

$\therefore k = \text{grad} \times 0.05$

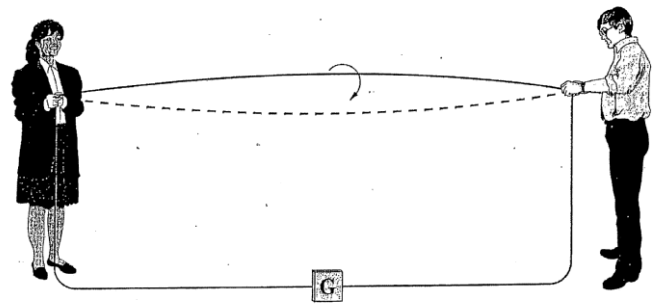
(* GRADIENT MUST APPEAR IN THE EXPRESSION)

(d) Use this expression and the gradient calculated in part (b) to determine the value of the magnetic force constant k. 1

$k = \text{gradient} \times 0.05 = 1.79 \times 10^{-7}$

Student Number.....

23. In a particular experiment a long length of copper wire of very resistance is rotated by two students. The ends of the wire are connected to a galvanometer G, and a current is detected. **Marks** 4



Explain the effect of increasing the speed of rotation on the current measured by the galvanometer

outline/identifies that more speed gives a greater rate of cutting field lines or greater rate of change of magnetic flux. States Faraday Law or that induced emf = $\frac{\Delta \text{FLUX}}{\Delta \text{TIME}} = \frac{B\Delta A}{t} = Blv$. Explains increased emf occurs and ∴ more current } 4 marks

Relates speed to flux change and ∴ greater current } 3–2

Identifies more current will be read on galvanometer] 1

24. Using silicon as an example of a semiconductor, describe how it carries a current and how doping affects the process. **2**

*BANDS AND HOLES MUST BE REFERRED TO.

- Describes the movement of electrons and holes in silicon and that doping increases the number of available electrons or holes OR that doping changes/reduces the energy required to make the semiconductor conductive OR that doping changes electrical properties } 2–3
- Describes charge movement OR doping OR a dodgy description of both } 1

thought experiments
not acceptable

Student Number.....

25. During your course you carried out an investigation to model behaviour of semiconductors, including the concept of holes. **Marks**

* NEED 3

Outline what you did in your investigation. Explain how the model showed conduction in semiconductors.

Gives apparatus used (or diagram) and how it shows holes/electrons being able to move with energy input to cross F.E. gap ie Valence band -> Conductio } 3-2

Describes apparatus with little procedural info OR doesn't refer to hole or electron movement (ie. HOW IT occurs) } 1

E.g. petri dish, marbles. Marble represent electrons, when shaken (E in) marbles jump up (conduction band) and leave a HOLE. Both the marble + hole can move

CONDUCTION BAND
VALENCE BAND

26. In early studies, the observed characteristics of cathode rays led to the belief that they were electromagnetic waves. 3

Describe the wave-like properties of cathode rays and explain how other evidence shows them to be particles.

EXPLANATION OF PROPERTIES REQUIRED A LIST IS NOT ENOUGH

Gives 2 wave-like props. (travels in straight lines, flouresces green light, not deflected by E fields in 1880) and at least 1 particles property e.g. - imparts momentum, stopped by thin metals, deflected by B fields PLUS EXPLANATION.] 3

Gives 1 wavelike + 1 particle property] 2

Gives only wave OR particle props.] 1

27. A physics student was conducting an investigation on the photoelectric effect. The student used an infrared laser with a wavelength of 1.55×10^{-6}m for this investigation.

NO UNIT = -1

(a) Calculate the energy of a photon from this laser. 2

$E = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{1.55 \times 10^{-6}} = 1.28 \times 10^{-19}$ J

(b) When the laser light was shone onto a photo-cell, no current was detected. The student 3

increased the intensity of the light but still detected no current. OR WORK FUNCTION
Explain this observation.

Clearly relates answer to threshold frequency, explaining that increasing intensity doesn't increase photon E so no photo electrons will eject. } 3 mks

Understands concept of threshold frequency to some degree } 2 - 1

28. (a) Calculate the frequency of a photon of blue light of wavelength 460nm. **1**

$f = \frac{c}{\lambda} = \frac{3 \times 10^8}{460 \times 10^{-9}} = 6.52 \times 10^{14}$ Hz (CALCULATION MUST BE CORRECT AND COMPLETE)

(b) Identify Planck's hypothesis that allowed him to successfully account for the black body radiation curve. **1**
* BOTH REQUIRED

Energy is absorbed and emitted by atomic oscillators in black body's in packets of energy called quanta.

29. Outline how Hertz measured the speed of radio waves. **3**

* Describes the apparatus with acceptable accuracy (1 mark)
* Outlines the connection of the transmitter + receiver with a wire (1 mark)
* demonstrate an understanding that an interference effect occurred from which Hertz used $c = f\lambda$ to determine 'c' (1 mark)

30. Describe how superconductors and magnetic levitation have played a part in the development of the maglev train. **2**
NB - NOT MEISSNER EFFECT

MUST SHOW DEPTH OF KNOWLEDGE

DESCRIBES THAT
- Superconductors have led to much stronger electromagnets
- Superconducting electromagnets support and propel maglev trains, (diagram optional but useful) } 2

missing one area (of the 2) noted above } 1

Student Number.....

From Quanta to Quarks. (25 Marks) **Marks**

(a) Discuss Rutherford's proposal of the nuclear atom with orbiting electrons 4

Must describe, then give FOR / AGAINST argument

① Describes nuclear atom (diagram will do if labelled)
② Give experimental evidence for at least 1 feature } 4 - 3
③ Gives at least 1 argument against the model e.g. no emr detected from accelerating electrons

Describes nuclear atom but missing evidence for OR against } 3-2

Describes Nuclear atom } 1

(b) In refining the model of the atom, Bohr began with three postulates. State 2 of Bohr's postulates. 2

OR "stationary States"

ANY 2 OF - (ONLY FIRST 2 are marked)

1) orbiting electrons exist on quantised energy levels. Electrons on these levels are stable and emit no energy

2) Energy is absorbed or emitted when electrons change E level according to $hf = E_1 - E_2$

3) Angular momentum of electrons is quantised

(c) Identify experimental evidence that supported one of Bohr's postulates and explain how it provided this support. 2

Correct identification of relevant evidence (1 mark)

Justifies how the stated evidence supports the particular evidence (1 mark)

* De Broglie only provides indirect support for 1ST POSTULATE - 1 mark
* Davidson and Germer accepted ONLY IF linked to 3RD POSTULATE and explained with algebraic prove.

(d) Define the term transmutation. 1

The transformation of 1 element into another by the bombardment of nuclei with particles.

Student Number.....

Marks

(e) As a result of the studying the electrons emitted during beta decay, Pauli suggested the existence of a then unknown particle. Discuss Pauli's suggestion, and relate this to the energy of the emitted electrons. 4

("NEUTRINO" was not used by Pauli)

4 marks
- Outlines what the suggestion of Pauli's was
- Gives reasons for the suggestion relating to β particle KE's + Cons. of p.
- Gives reasons against the proposal - ie no experimental detection

3 marks
As above but omits or communicates one of the points poorly

2 MM
Demonstrates some understanding of Pauli's suggestion

1
Some attempt

(f) Calculate the mass of a particle that has a De Broglie wavelength of 2.5×10^{-12} m when moving with speed of $200 ms^{-1}$. 1

$\lambda = \frac{h}{mv}$, $m = \frac{h}{\lambda v}$

$= \frac{6.63 \times 10^{-34}}{2.5 \times 10^{-12} \times 200}$

$= 1.33 \times 10^{-24}$ kg

(g) Calculate the energy of the lowest frequency photon emitted in the Balmer series? 2

Correct working essential

lowest f when $n_f = 2$, $n_i = 1$

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

$= 1.097 \times 10^{7} \left(\frac{1}{4} - \frac{1}{9}\right)$

$\frac{1}{\lambda} = 1.097 (0.25 - 0.11)$ $\times 10^{7}$

$\lambda = 9.116 \times 10^{-8}$

$f = \frac{c}{\lambda} = \frac{3 \times 10^{8}}{9.116 \times 10^{-8}} = 3.291 \times 10^{15}$ Hz

$E = hf = 3.06 \times 10^{-19}$ J

(h) Write the transmutation equation for the beta decay of Bi^{210}_{83}. 2

$Bi^{210}_{83} \longrightarrow \beta^{0}_{-1} + Po^{210}_{84} + \bar{\nu}$

(or ν)

* -1 mark for EACH missing or incorrect part

For full marks - MUST MAKE EXPLICIT statement about the "SIGNIFICANCE OF THE CONSERVATION LAWS".

Student Number.....

Marks

(i) Explain the significance of the conservation laws, in Chadwick's discovery of the neutron. 4

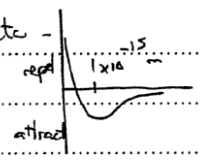
* 4-3

1. Describes the Bothe + Becker expt resulting in protons being ejected from paraffin.
2. Explains that the Law of Cons. of momentum could not be satisfied unless the highly penetrative projectile was much more massive that initially suggested
3. Explains that conservation of mass and charge suggested particle had to be similar in mass to a proton and have NO CHARGE
4. EXPLICIT STATEMENT OF "SIGNIFICANT OF CONSERVATION LAWS".

2-1 Identifies conservation of momentum as being relevant

(j) Justify the existence of the strong nuclear force. 3

- Describes nature of nuclear force, range etc - - that is very short range



- Outlines gravitational and electrostatic forces and relative sizes of each (Electrostatic repulsion is much greater)
- explains need for S.N.F. to overcome electrostatic repulsion in stable nuclei.

3

END OF EXAMINATION

Describes the nature of SNF and refer to strong electrostatic forces 2

Some idea 1