2020
Higher School Certificate
Trial Examination

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A data sheet, formulae sheets and Periodic Table are provided
- For questions in Section II, show all relevant working in questions involving calculations
- Write your student number and/or name at the top of every page

Total marks – 100

Section I (Pages 2–12)
20 marks
- Attempt Questions 1–20
- Allow about 35 minutes for this part

Section II (Pages 13–32)
80 marks
- Attempt Questions 21–36
- Allow about 2 hours and 25 minutes for this section

This paper MUST NOT be removed from the examination room

STUDENT NUMBER/NAME:....................................

STUDENT NUMBER/NAME..............................

Section I
20 marks

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

Select the alternative A, B, C or D that best answers the question and indicate your choice with a cross (X) in the appropriate space on the grid below.

	A	B	C	D
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	A	B	C	D
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18				
19				
20				

1 Which variable(s) determine the maximum height of a projectile?

A. Launch elevation angle of 45° only

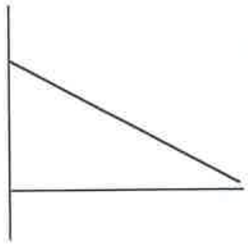
B. Launch speed only

C. Launch speed and launch elevation angle

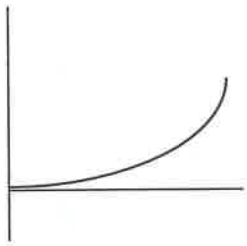
D. Launch speed and range

2 Which graph shows the relationship between the mass and surface gravitational field of planets with the same radius?

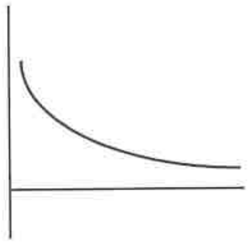
(A)



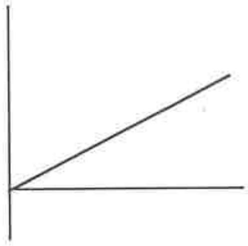
(B)



(C)



(D)



3 Which statement best accounts for the difference between projectile and uniform circular motion?

A. In projectile motion, linear motion is in a constant direction relative to the frame of reference, while in circular motion it is always changing.

B. In projectile motion, the force is in a constant direction relative to the frame of reference, while in circular motion it is always perpendicular to the velocity of the object undergoing circular motion.

C. In projectile motion, the acceleration is in the same direction as the motion, while in circular motion it is always perpendicular to the motion.

D. In projectile motion, the horizontal velocity is constant, while in circular motion the vertical motion is constant.

4 The diagram shows a worker who is having trouble lifting a heavy box using a lever.

How could he use his strength more effectively?

A. By pushing perpendicularly to the lever at the end of the bar

B. By pushing vertically at the end of the bar

C. By pushing perpendicular to the lever closer to the box

D. By pushing vertically closer to the box

5 The escape velocity of Earth is 11 200 m s^{-1} and yet a space craft, moving at much lower speed, can travel away from the Earth and towards distant planets.

Which statement about this is correct?

A. If a space craft turns off its rockets, it will slow down and be pulled back to Earth.

B. To escape the Earth's gravitational field, a space craft will have to accelerate to 11 200 m s^{-1} at some stage during the trip.

C. A space craft in orbit around the Earth could use rockets to accelerate and escape Earth's gravity at a lower speed.

D. The escape velocity depends on the mass of the spacecraft.

6 Which statement about an induction motor is correct?

A. It has no moving parts.

B. It utilises a rotating magnetic field.

C. It is the only type of motor using AC current.

D. It does not have a current-carrying conductor.

7 What happens to the electric field strength between two parallel plates if the voltage between them is doubled and the distance between them is halved?

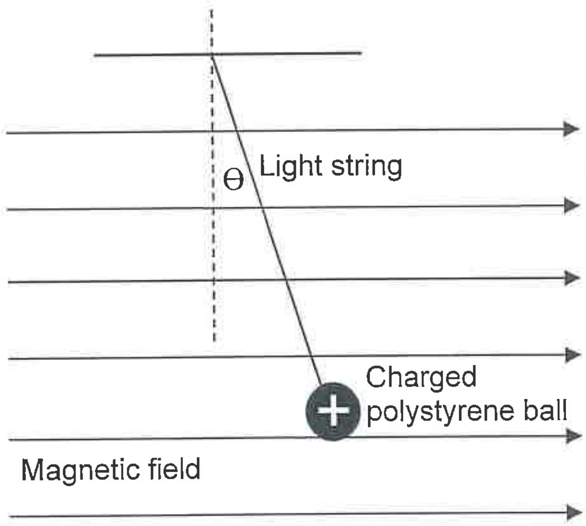
A. Electric field strength stays the same.

B. Electric field strength halves.

C. Electric field strength doubles.

D. Electric field strength becomes four time greater.

8 A student drew a diagram to show what would happen if a charged, very light, polystyrene ball was hung from a fixed point in a strong magnetic field.



Which statement about this situation is correct?

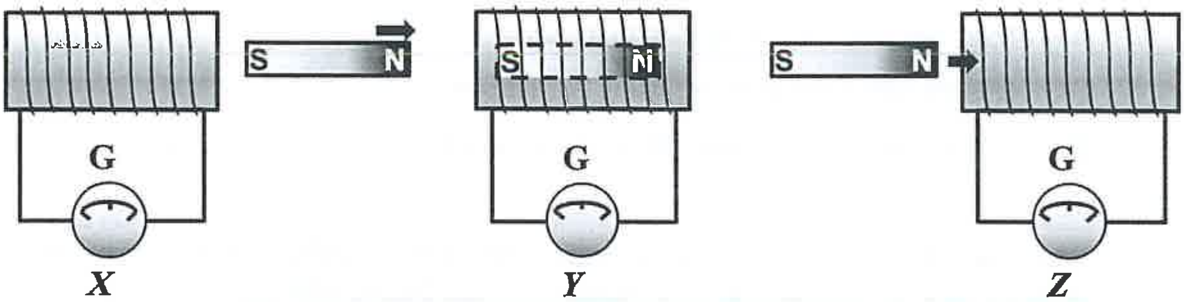
A. The diagram is totally incorrect because a stationary charge in a magnetic field does not experience a force.

B. The diagram will only be correct for a ball which is charged positively.

C. If the strength of the magnetic field is increased, then the angle Θ will also increase.

D. If the charge on the ball was negative, then it would hang in the opposite direction.

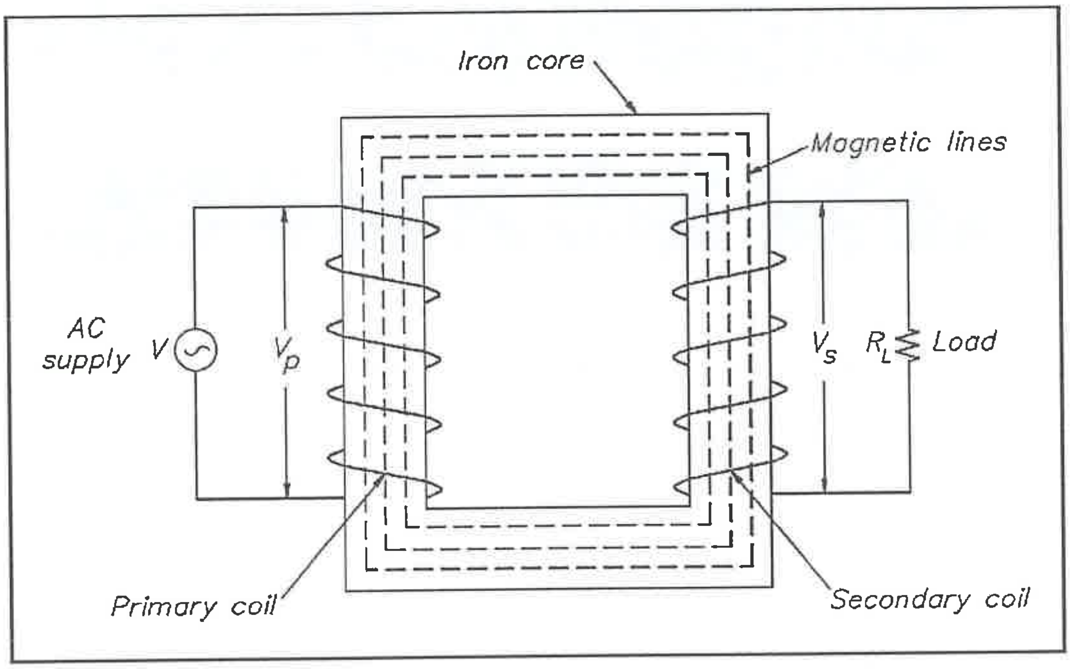
9 A magnet moves from left to right at constant speed towards, through and out of the middle coil of wire, as shown in the diagram.



Which choice correctly shows the relationship between the readings on galvanometer *X* as the magnet moves away from coil *X*, on galvanometer *Y* when the magnet is completely inside the coil and on galvanometer *Z* as the magnet moves towards its coil?

	Galvanometer X (Magnet moves away from coil X)	*Galvanometer Y (Magnet inside coil Y)*	*Galvanometer Z (Magnet moves towards coil Z)*
A.	↗	↗	↗
B.	↖	↑	↖
C.	↖	↑	↗
D.	↑	↗	↑

10 A student designed and built a step-up transformer as part of his practical work and included the diagram below of his design in the written report.



Which statement is a correct evaluation of his experimental design?

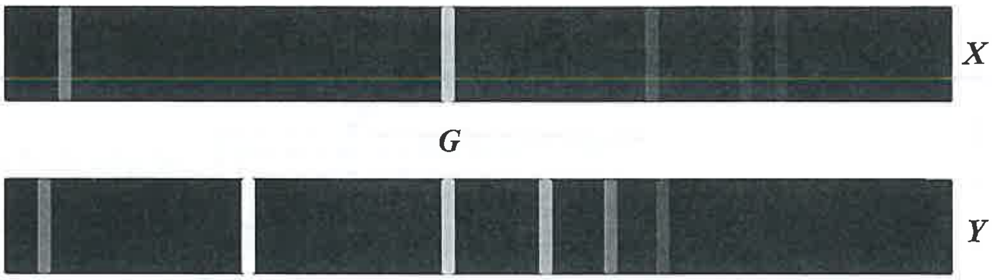
A. The design is correct because the output voltage will be larger than the input voltage.

B. The design is incorrect because the windings of the coils are drawn in opposite directions.

C. The design is incorrect because it represents a step-down transformer.

D. The design is incorrect because it has equal numbers of turns in both coils.

11 The diagram shows the atomic spectra of two different elements *X* and *Y*.



Given that atomic spectra are "fingerprints" used to identify elements, which choice best accounts for the fact that these two elements have a spectral line at point *G*?

A. The diagram must be incorrect as every element will have completely different spectral lines.

B. Coincidentally, there is an electron transition, with a very similar energy value in both elements.

C. The orbital levels in elements often have the same energy values as the same orbital levels in other elements.

D. The energy levels of the orbits in elements are directly proportional to the number of the electron orbit.

12 How did Newton's particle theory of light explain refraction?

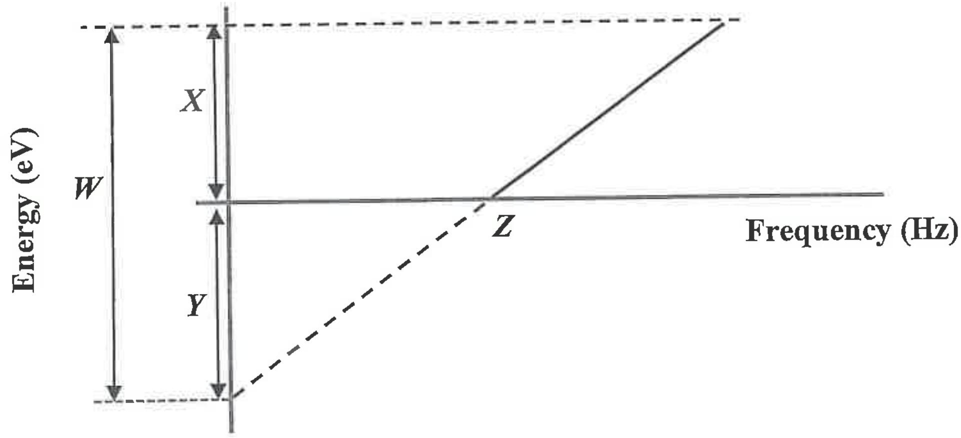
A. Stronger forces within the refracting medium changed the direction of travel of the light particles as they entered the medium.

B. Because the refracting medium was so dense compared to air, the light particles were forced to slow down.

C. The light particles scattered in the medium because the medium particles were closer together than air particles.

D. Newton's particle theory of light could not explain refraction.

13 The graph shows information about the emission of photoelectrons from a metal.



Which choice correctly identifies the sections labelled W, *X*, *Y* and *Z*?

	W	*X*	*Y*	*Z*
A.	Energy of incident photon	Work function of emitter	Kinetic energy of emitted photoelectron	Threshold frequency
B.	Kinetic energy of emitted photoelectron	Energy of incident photon	Threshold frequency	Work function of emitter
C.	Threshold energy	Kinetic energy of emitted photoelectron	Energy of incident photon	Work function of emitter
D.	Energy of incident photon	Kinetic energy of emitted photoelectron	Work function of emitter	Threshold frequency

14 According to Max Planck's black body experiments, which characteristic of an object determined the wavelength of the peak radiation emitted by a hot object?

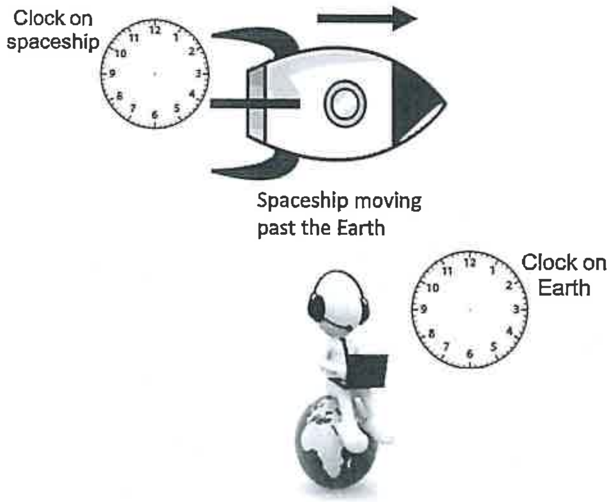
A. The type of material the object is made of

B. The temperature of the object

C. The type of material and its temperature

D. The temperature of the object and its shape

15 The diagram below shows an observer on Earth observing time on his clock and on the clock of a spaceship which is moving past the Earth him at near light speed.



Which statement about this situation is correct?

A. The clock on the ship will run slower.

B. The clock on the ship will run faster.

C. The clock on Earth will run faster.

D. The clock on Earth will run slower.

16 How long would it take for the radioactivity of a 200 g sample of a radioactive substance with a half-life of 16.2 years, to decay to 15% of its original value?

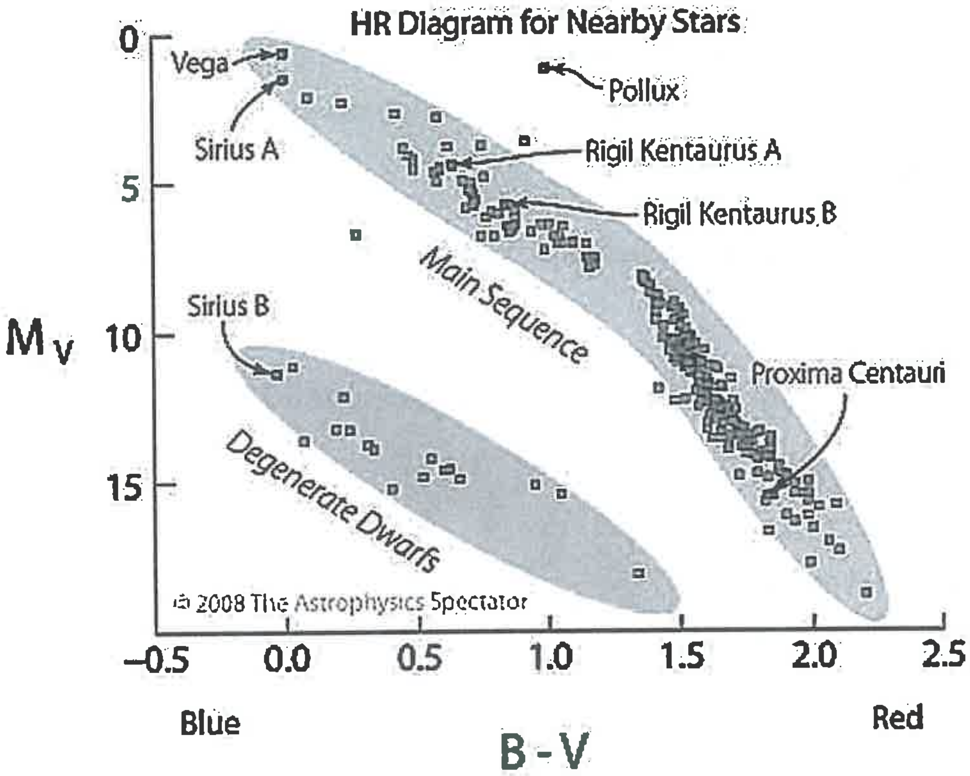
A. 28.1 years

B. 44.34 years

C. 60.54 years

D. 76.74 years

17 The diagram below is the Hertzsprung-Russell diagram for the nearby stars.



The stars Vega and Proxima Centauri differ greatly in magnitude and colour and are consequently at opposite ends of the main Sequence.

How do astronomers explain this difference?

A. The stars are fusing different elements for energy.

B. The stars are located in different areas of the galaxy.

C. Vega moved up the main sequence at a faster rate than Proxima Centauri.

D. The original mass of Vega when formed was greater than the original mass of Proxima Centauri.

18 What was Schrodinger's main contribution to the current model of the atom?

A. Schrodinger performed diffraction experiments verifying the wave properties of electrons.

B. Schrodinger's work was the basis of Bohr's model of the atom.

C. Schrodinger's wave equations were very important in the development of modern quantum mechanics.

D. Schrodinger was the first to apply quantum ideas to the understanding of the atom.

19 What is the relationship between binding energy and mass defect in a spontaneous nuclear reaction?

A. The mass defect is the equivalent of the binding energy of the products.

B. The mass defect is the equivalent of the binding energy of the reactant.

C. The mass defect is the equivalent of the binding energy loss of the products compared to the reactants.

D. The mass defect is the equivalent of the binding energy gain of the products compared to the reactants.

20 What are the elementary particles in the Standard Model of matter?

A. Fermions and bosons

B. Quarks and mesons

C. Lepton and electrons

D. Quarks, leptons and electrons

STUDENT NUMBER/NAME..............................

Section II

80 marks
Attempt Questions 21–36
Allow about 2 hours and 25 minutes for this part

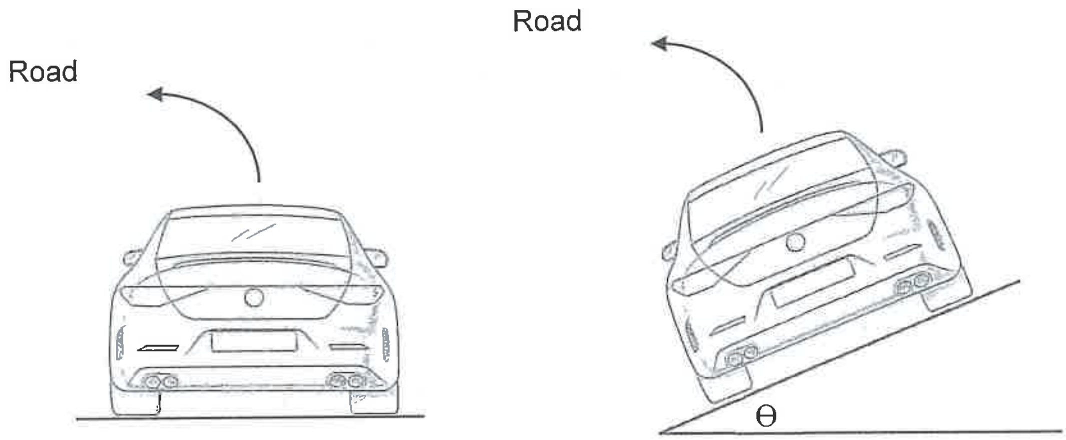
Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Show all relevant working in questions involving calculations.

Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Question 21 (4 marks) **Marks**

The diagram shows identical cars on rough road surfaces, one on a curved horizontal road and one on a curved road banked at $\Theta°$. Both roads curve towards the left, with the curves part of the same radius circle. **4**



With the help of additions to the diagram above, explain why the car can safely take the banked curve at a higher speed than the identical car driving on the horizontal curved road.

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Question 22 (9 marks) **Marks**

A stroboscopic photograph was taken of student competing a long jump event. The distance between the student in the first and last images is 2.2 m. The camera used to take the pictures took one frame every 0.1 s.

(a) Calculate, using projectile motion equations, the maximum height of the student above the ground. Identify any assumptions made in your calculation **5**

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Question 22 continues on the next page

Question 22 (continued) **Marks**

(b) At what velocity did the student launch upwards? **4**

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End of Question 22

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Question 23 (3 marks) **Marks**

The total energy of a satellite is equal to the sum of its gravitational potential energy and its orbital kinetic energy. However, the work done to put that satellite into orbit is less than this. **3**

Explain how this does not contravene the law of conservation of energy.

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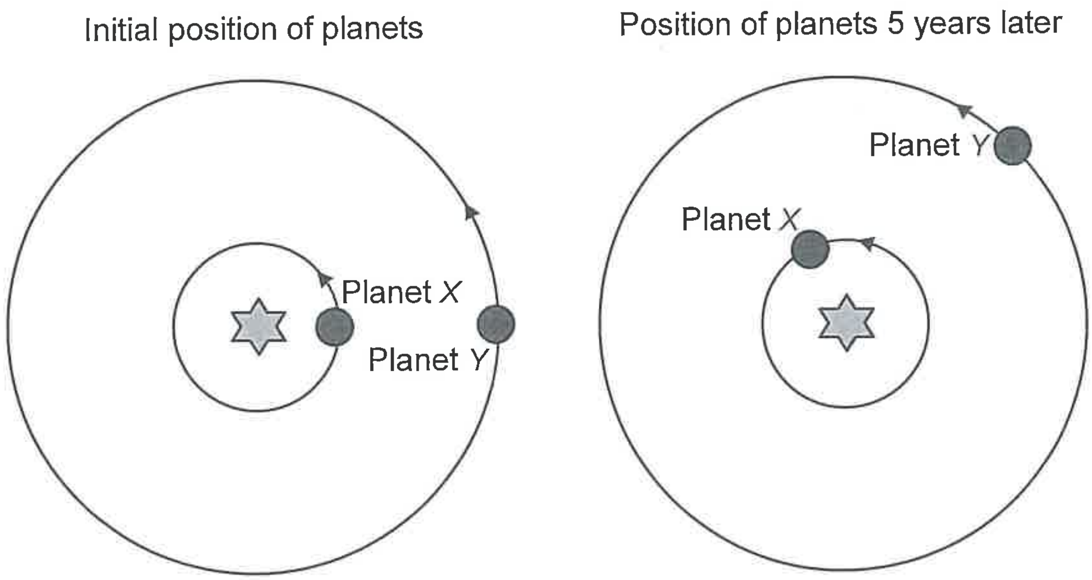
Question 24 (3 marks) **Marks**

Two planets X and Y travel anticlockwise in circular orbits about a star, as seen in the diagram. The radii of the orbits X and Y are in the ratio 2:5. **3**

The planets are shown below at a time interval of 5 years. Initially they were aligned, making a straight line with the star. Five years later, planet X has rotated through 120°, as shown.



Determine how long it takes planet Y to orbit the star.

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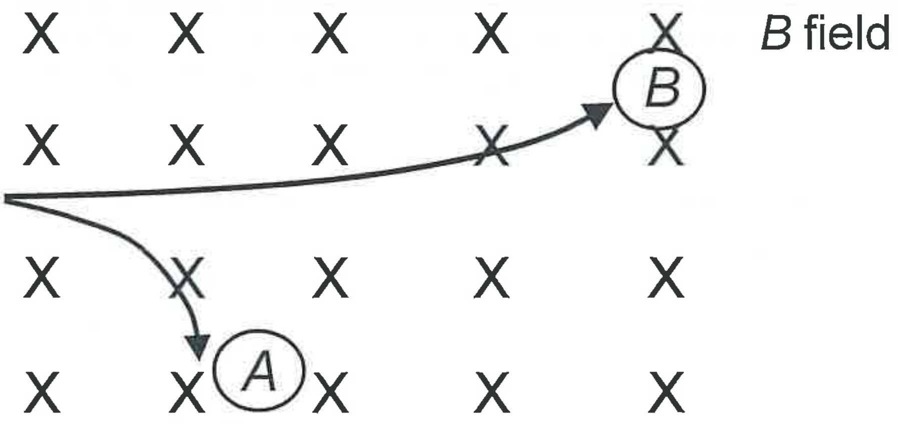
Question 25 (4 marks) **Marks**

Charged particles *A* and *B* move into a magnetic field and move along different circular paths.



(a) What *must be different* about particles *A* and *B*? Justify your answer. 1

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(b) What *might be different* about particles *A* and *B*? Justify your answer. 3

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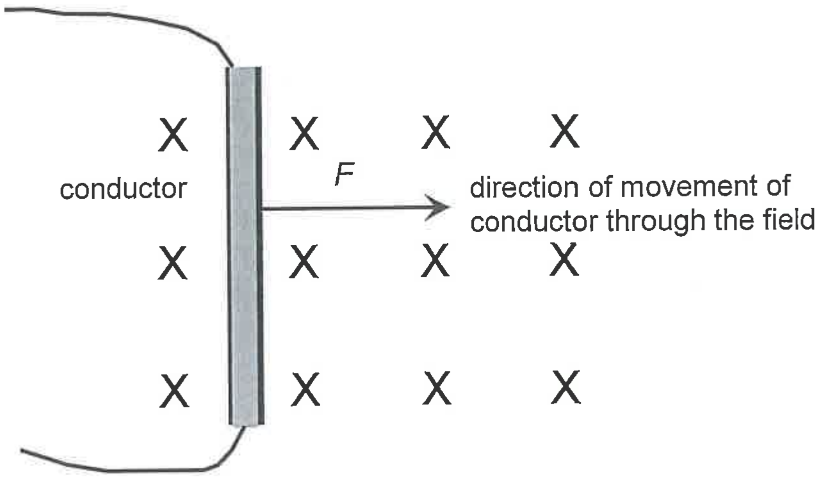
Question 26 (4 marks) **Marks**

A conductor which is connected to a galvanometer is moved by a force *F* through a magnetic field, as shown below. **4**



In terms of the principles of physics involved, predict the direction of the induced current in the conductor and explain why it *must* be in this direction.

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Question 27 (4 marks) **Marks**

The old definition of the ampere stated:

> *The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed one metre apart in vacuum, would produce between these conductors a force equal to* 2×10^{-7} *newtons per metre of length.*

Explain how this definition of the ampere relates to Newton's Third Law and calculate the size of the force between two parallel current carrying wires, each 0.65 metres long, carrying 0.375 amperes each, and separated by a distance of 13.5 mm **4**

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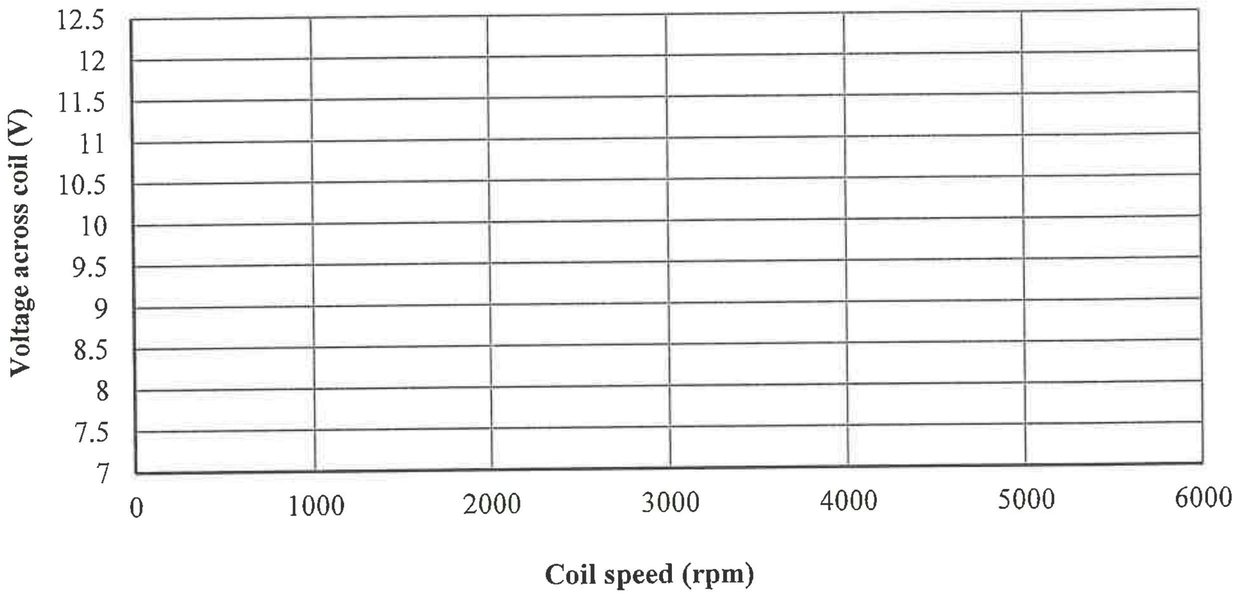
Question 28 (9 marks) **Marks**

The table shows the results of an experiment on the relationship between the rotational speed of a motor coil and the net voltage across the coil. The motor was connected to a 12 V power supply. Assume that there is no load attached and frictional effects are zero.

Speed of coil (rpm)	*Voltage across coil (V)*
0	12.0
1000	11.3
2000	10.1
3000	9.8
4000	9.3
5000	8.7
6000	7.6

(a) Graph this data on the axes below. **2**



Question 28 continues on the next page

Question 28 (continued) **Marks**

(b) Explain, in terms of the principles of physics involved, why the net voltage across the coil is decreasing and predict its minimum value when the motor reaches its maximum operating speed. **4**

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(c) On the basis of his graph the student concluded that the net voltage across motor coils is directly proportional to the speed of the coil. **3**

Evaluate the student's conclusion.

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End of Question 28

Question 29 (8 marks) **Marks**

Outline the contribution of James Maxwell to our understanding of the nature of light and outline the experimental evidence, found soon after his death, that supported Maxwell's theory. **8**

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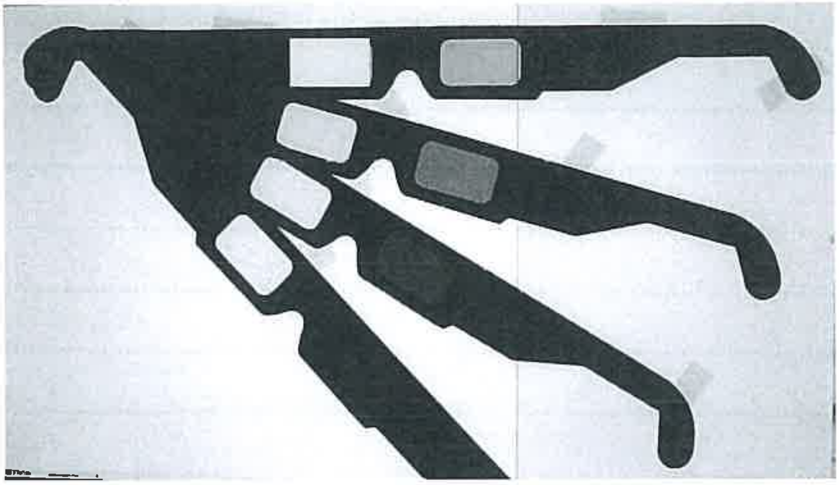
Question 30 (4 marks) **Marks**

The photograph below shows the two lenses of a pair of glasses in front of the same light source. The arm of the glasses is pivoted on the left-hand side so that the angle of the arm relative to the light source can be changed. The photograph shows the two lenses at four different positions. **4**



In terms of the principles of physics involved, account for the lack of change in the light passing through the left-hand lens compared to the changing amount of light passing through the right-hand lens as the angle of inclination of the lenses is increased.

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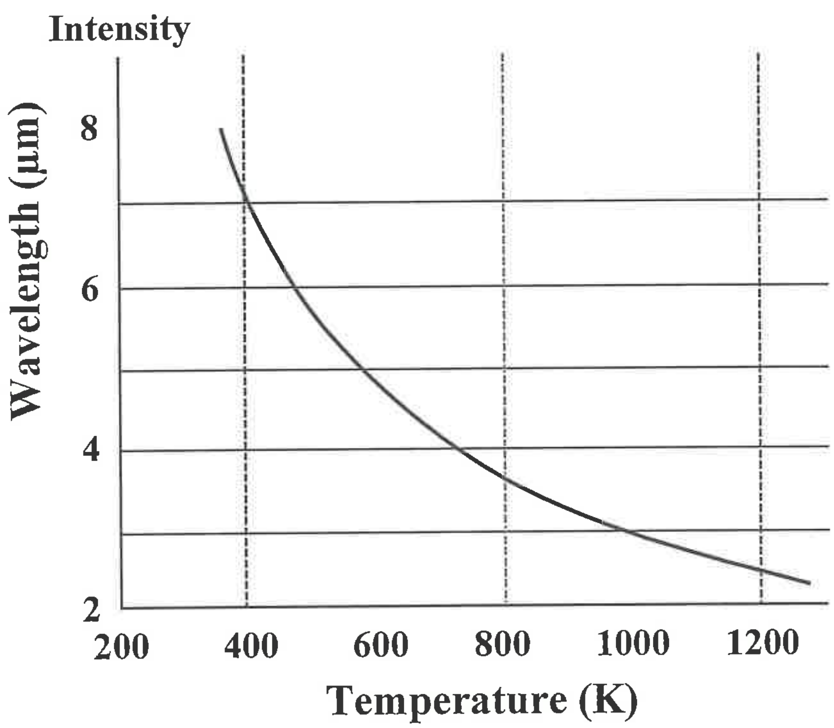
Question 31 (4 marks) **Marks**

The graph below shows the wavelength of the peak intensity radiation emitted by a standard black body at different surface temperatures. **4**



Temperature dependence of wavelength of maximum radiation intensity.

Show that this graph is consistent with Wien's law.

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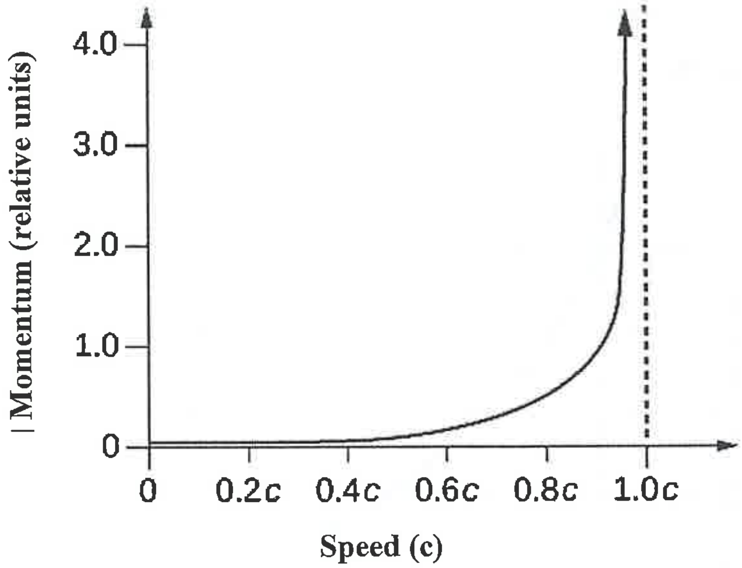
Question 32 (4 marks) **Marks**

The diagram shows how the momentum of an object changes as it approaches light speed.



(a) Explain why this graph is not a straight line as classical theory would predict. **2**

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(b) Calculate relativistic momentum of a proton moving at 0.8 c. **2**

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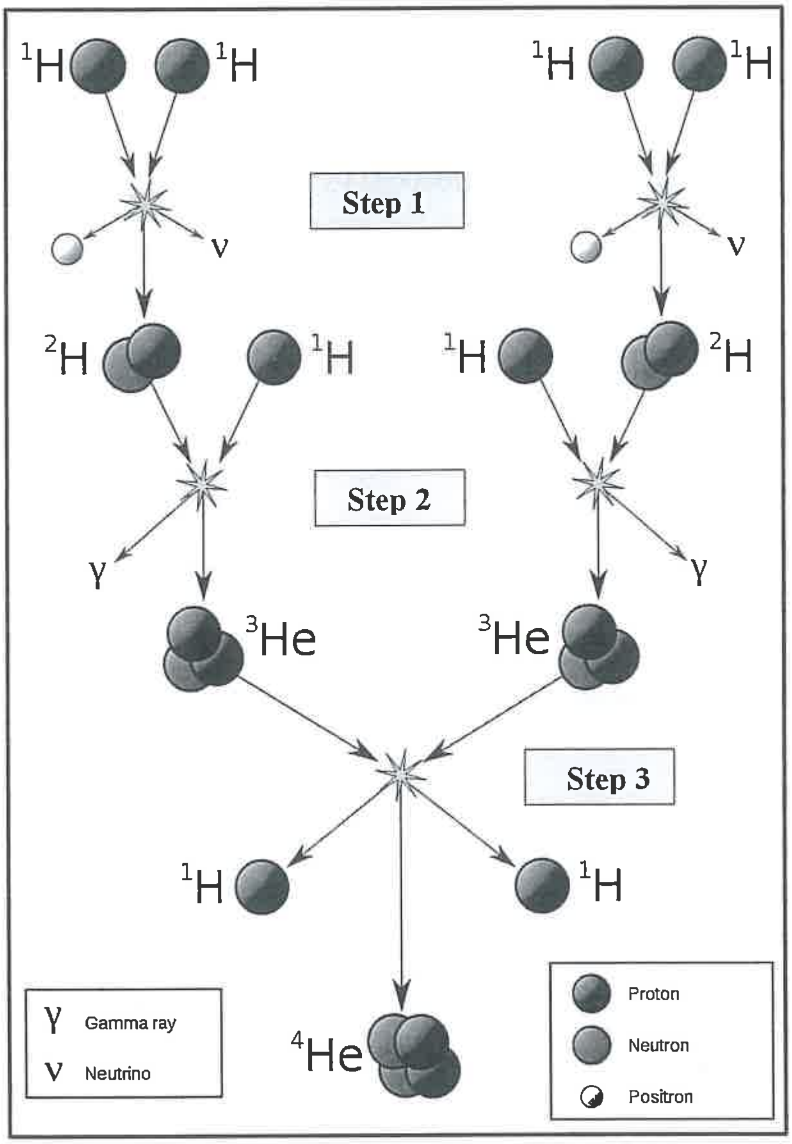
Question 33 (4 marks) **Marks**

The diagram shows the three main steps in the PP chain which produces about 90% of the energy from the Sun. The table on the right lists the masses of the particles involved in these reactions in atomic mass units, *u*.



Particle	*Mass (u)*
$^{0}_{+1}e$	0.0005488
$^{1}_{1}H$	1.007825
$^{2}_{1}H$	2.014102
$^{3}_{2}He$	3.016029
$^{4}_{2}He$	4.002603
ν_e	negligible
γ	negligible

Question 33 continues on the next page

Question 33 (continued) **Marks**

(a) Use the information in the diagram to write a balanced nuclear equation for the reaction in step 1 of this cycle. **2**

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(b) Use the information in the table to calculate the energy produced by the step 1 reaction in MeV. **2**

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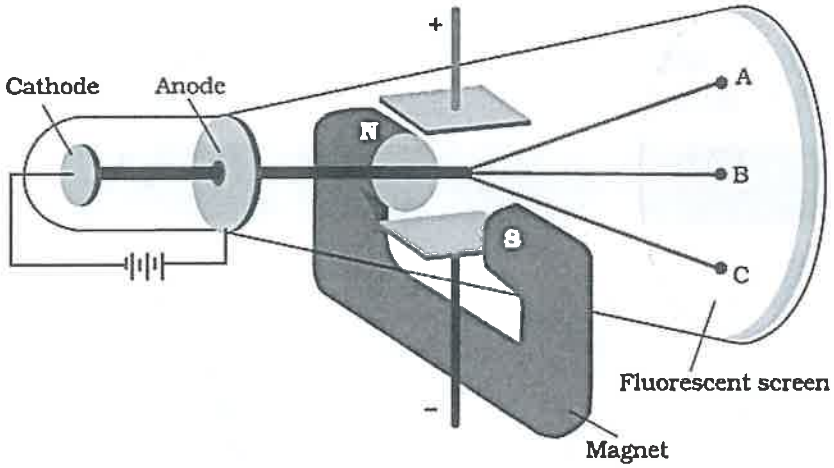
End of Question 33

Question 34 (8 marks) **Marks**

The diagram shows apparatus similar to that used by J J Thomson in early cathode ray tube experiments. **8**



Explain how Thomson used this apparatus to determine the nature of cathode rays and outline how his interpretation of the results contributed to our understanding of the structure of matter.

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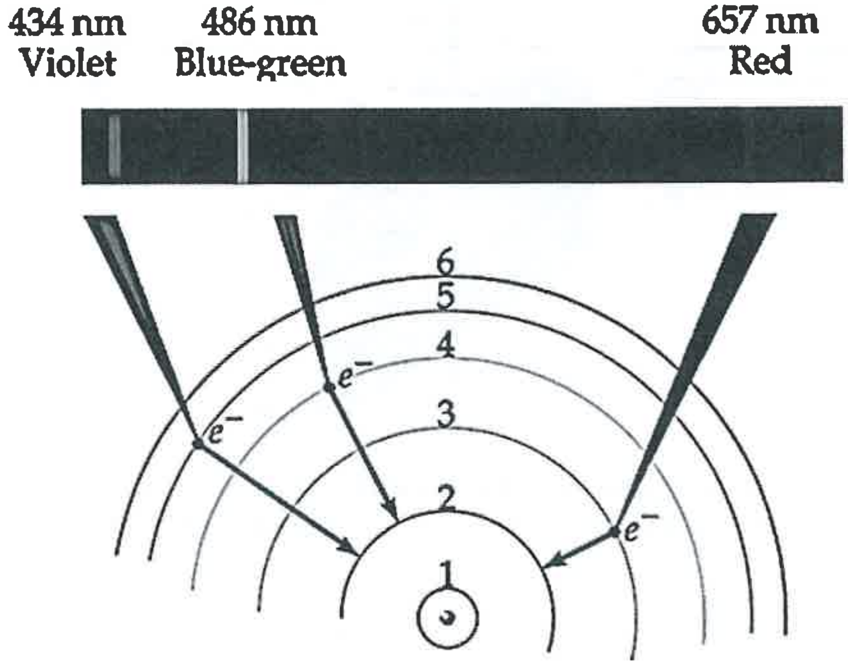
Question 35 (3 marks) **Marks**

Explain, in terms of principles or models of physics involved, what the diagram aims to communicate. 3



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Question 36 (5 marks) **Marks**

Leptons are a group of particles in the Standard Model of Matter. **5**

Outline the nature and properties of leptons and where they fit into the model of matter.

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End of paper

Extra writing space

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	$3.00 \times 10^{8} \text{ m s}^{-1}$
Electric permittivity constant, ε_0	$8.854 \times 10^{-12} \text{ A}^2 \text{ s}^4 \text{ kg}^{-1} \text{ m}^{-3}$
Magnetic permeability constant, μ_0	$4\pi \times 10^{-7} \text{ N A}^{-2}$
Universal gravitational constant, G	$6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Mass of Earth, M_E	6.0×10^{24} kg
Radius of Earth, r_E	6.371×10^{6} m
Planck constant, h	6.626×10^{-34} J s
Rydberg constant, R (hydrogen)	$1.097 \times 10^{7} \text{ m}^{-1}$
Atomic mass unit, u	1.661×10^{-27} kg $931.5 \text{ MeV}/c^2$
1 eV	1.602×10^{-19} J
Density of water, ρ	$1.00 \times 10^{3} \text{ kg m}^{-3}$
Specific heat capacity of water	$4.18 \times 10^{3} \text{ J kg}^{-1} \text{ K}^{-1}$
Wien's displacement constant, b	2.898×10^{-3} m K

FORMULAE SHEET

Motion, forces and gravity

$s = ut + \frac{1}{2}at^2$

$v = u + at$

$v^2 = u^2 + 2as$

$\vec{F}_{\text{net}} = m\vec{a}$

$\Delta U = mg\Delta h$

$W = F_{||}s = Fs\cos\theta$

$P = \frac{\Delta E}{\Delta t}$

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

$P = F_{||}v = Fv\cos\theta$

$\sum \frac{1}{2}mv^2_{\text{before}} = \sum \frac{1}{2}mv^2_{\text{after}}$

$\sum m\vec{v}_{\text{before}} = \sum m\vec{v}_{\text{after}}$

$\Delta\vec{p} = \vec{F}_{\text{net}}\Delta t$

$a_{\text{c}} = \frac{v^2}{r}$

$\omega = \frac{\Delta\theta}{t}$

$F_{\text{c}} = \frac{mv^2}{r}$

$\tau = r_{\perp}F = rF\sin\theta$

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

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

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

$U = -\frac{GMm}{r}$

Waves and thermodynamics

$v = f\lambda$

$f_{\text{beat}} = |f_2 - f_1|$

$f = \frac{1}{T}$

$f' = f\frac{(v_{\text{wave}} + v_{\text{observer}})}{(v_{\text{wave}} - v_{\text{source}})}$

$d\sin\theta = m\lambda$

$n_1\sin\theta_1 = n_2\sin\theta_2$

$n_{\text{x}} = \frac{c}{v_{\text{x}}}$

$\sin\theta_{\text{c}} = \frac{n_2}{n_1}$

$I = I_{\text{max}}\cos^2\theta$

$I_1r_1^2 = I_2r_2^2$

$Q = mc\Delta T$

$\frac{Q}{t} = \frac{kA\Delta T}{d}$

Electricity and magnetism

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

$$V = \frac{\Delta U}{q}$$

$$W = qV$$

$$W = qEd$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$B = \frac{\mu_0 N I}{L}$$

$$\Phi = B_{\parallel} A = BA\cos\theta$$

$$\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$$

$$\frac{V_\text{p}}{V_\text{s}} = \frac{N_\text{p}}{N_\text{s}}$$

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

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

$$I = \frac{q}{t}$$

$$V = IR$$

$$P = VI$$

$$F = qv_{\perp}B = qvB\sin\theta$$

$$F = lI_{\perp}B = lIB\sin\theta$$

$$\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r}$$

$$\tau = nIA_{\perp}B = nIAB\sin\theta$$

$$V_\text{p} I_\text{p} = V_\text{s} I_\text{s}$$

Quantum, special relativity and nuclear

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

$$K_\text{max} = hf - \phi$$

$$\lambda_\text{max} = \frac{b}{T}$$

$$E = mc^2$$

$$E = hf$$

$$\frac{1}{\lambda} = R\left(\frac{1}{n_\text{f}^2} - \frac{1}{n_\text{i}^2}\right)$$

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

$$l = l_0\sqrt{\left(1 - \frac{v^2}{c^2}\right)}$$

$$p_\text{v} = \frac{m_0 v}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$$

$$N_\text{t} = N_0 e^{-\lambda t}$$

$$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$$

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	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson

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

Standard atomic weights are abridged to four significant figures.
Elements with no reported values in the table have no stable nuclides.
Information on elements with atomic numbers 113 and above is sourced from the International Union of Pure and Applied Chemistry Periodic Table of the Elements (November 2016 version).
The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of all other data. Some data may have been modified.

NSW INDEPENDENT TRIAL EXAMS – 2020
PHYSICS – TRIAL HSC EXAMINATION
MARKING GUIDELINES

Section I

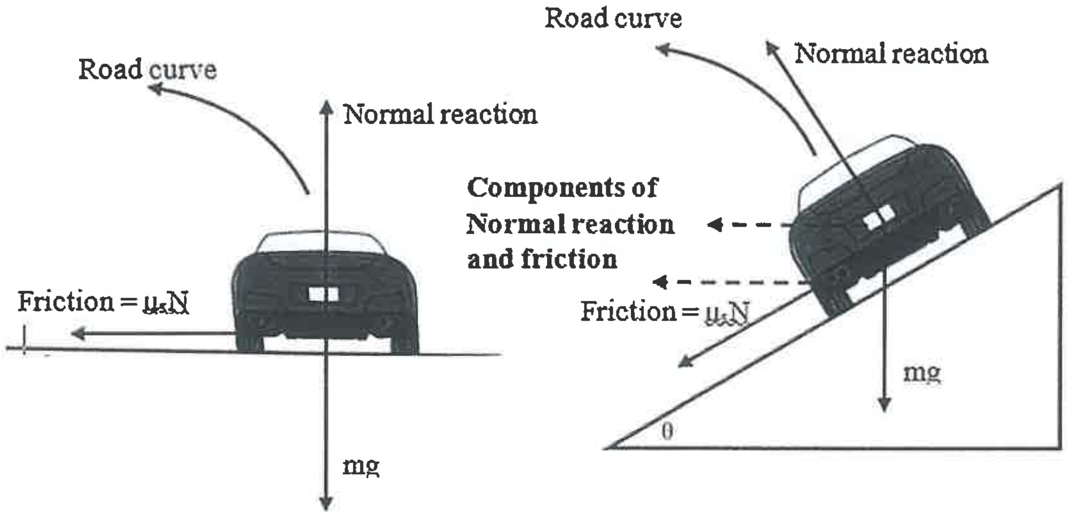
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
C	D	B	A	C	B	D	A	C	D	B	A	D	B	A	B	D	C	D	A

Section II

Q21

Criteria	Marks
• Identifies ALL forces acting, draws components of forces on diagram and compares the magnitudes of their contribution to centripetal force	4
• Identifies all forces acting and draws components of forces on diagram contributing to centripetal force	3
• Identifies the contribution of the normal reaction component to centripetal force	2
• Provides some relevant information	1

Sample answer:



On the horizontal road, the friction alone provides the centripetal force to hold car in curve. On the banked road, only a component of the frictional force is acting horizontally but the horizontal component of the normal reaction force contributes. This is significantly larger than the reduction in the frictional force towards the centre of the motion. Therefore, the net centripetal force is larger and since mass and radius of curvature are the same, the car can go faster around the banked curve.

Q22(a)

Criteria	Marks
• Calculates the maximum height and makes clear TWO assumptions	5
• Calculates the maximum height and makes clear ONE assumption OR • Provides maximum height calculation with ONE error and TWO assumptions	4
• Calculates the maximum height OR • Provides maximum height calculation with ONE error and ONE assumption	3
• Provides maximum height calculation with ONE error	2
• Provides some relevant information	1

Sample answer: The number of spaces in the photograph = 7, therefore the time of flight = 0.7 s

Time to rise to top of path = half time of flight = 0.35 s Vertical velocity at top = 0

$v_{top} = u + at \quad 0 = u - 9.8 \times 0.35$

Therefore $u_{vertical} = 3.43\ \text{m s}^{-1}$ upwards

From $v_{top}^2 = u_v^2 + 2a\Delta y$, $0 = 3.43^2 - 19.6\Delta y$

Maximum height = 0.60 m

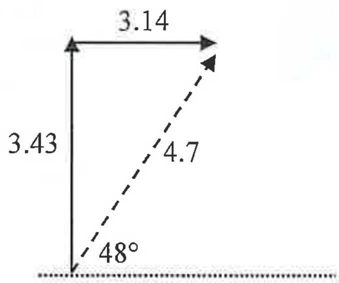
It must be assumed that the jumper is in the air for precisely 7 intervals but the first and last intervals may have been less. The jumper is not a point object so the answer would apply to the centre of mass of the jumper. Therefore, his feet would have been closer to the ground than 0.6 m. Also, the rotation of parts of the body may have applied forces apart from gravity affecting the height of the centre of mass.

Q22(b)

Criteria	Marks
• Calculates launch speed and direction	4
• Calculates launch speed and direction using vectors with ONE error	3
• Calculates launch speed using vectors with ONE error	2
• Provides some relevant information	1

Sample answer: Initial horizontal speed is = 2.2 m/0.7 = 3.14 m s^{-1}

Launch speed = vector sum of horizontal and vertical velocities



Launch speed = 4.7 m s^{-1} at 48° to the horizontal

Q23

Criteria	Marks
• Explains clearly how energy is conserved	3
• Identifies the difference in gravitational potential energy in relation to definition	2
• Identifies the difference in gravitational potential energy	1

Sample answer: The work done to provide the orbital kinetic energy is given by the formula $1/2mv^2$. Because gravitational potential energy is calculated based on distance from the centre of the Earth, the work done to raise the satellite to its orbital position is the difference in the gravitational potential energy between the orbit position and the surface of the Earth. The satellite also had kinetic energy at launch due to the Earth's rotation.

The total energy of the satellite in orbit is the gravitational potential energy at the Earth's surface plus the work done to provide its kinetic energy plus the work done to increase the potential energy to that of the orbit which is less than the orbital potential energy. The law of conservation of energy is not contravened.

Q24

Criteria	Marks
• Calculates period of planet Y	3
• Calculates period of planet X and correctly substitutes into Kepler's law of periods	2
• Calculates period of planet X OR • Correctly substitutes into Kepler's law of periods	1

Sample answer: Planet X travels 120/360 = 0.33 rotation in 5 years
Therefore, X travels one rotation in 5/0.33 = 15 years
Kepler's law of periods states that $(T_Y^2)/(R_Y)^3 = (T_X^2)/(R_X)^3$
Hence $(T_Y^2)/(T_X^2) = (R_Y)^3/(R_X)^3$
$(T_Y^2)/(T_X^2) = 5^3/2^3$ $T_Y^2 = 15^2 \times 5^3/2^3$ $T_Y = 59$ years

Q25(a)

Criteria	Marks
• Identifies sign of charge	1

Sample answer: The signs must be different (A is negative and B is positive) because they curve in opposite directions within the field.

Q25(b)

Criteria	Marks
• Identifies THREE detailed possibilities and reason	3
• Identifies TWO detailed possibilities and reason OR • Three detailed possibilities	2
• Identifies TWO possibilities	1

Sample answer: In a magnetic field, the force on a charge moving at right angles to the field equals Bqv. Hence $Bqv = mv^2/r$ and $r = mv/Bq$. The radii of curvature of B is larger than A, therefore the mass of A could be smaller, the velocity of B could be larger, the charge of A be larger than B or a combination of these variables could apply.

Q26

Criteria	Marks
• Provides a correct prediction and a well-reasoned explanation identifying TWO physics principles	3-4
• Provides a correct prediction based on conservation of energy	2
• Provides a correct prediction	1

Sample answer: The induced current in the conductor will be towards the top of the page. It must be in this direction in order to obey Lenz's law, based on the law of conservation of energy which states that energy cannot be created or destroyed, only changed from one form to another. If the current was down the page, then according to the motor effect, the magnetic field it induced would interact with the applied magnetic field (the field into the page) to produce a force on the conductor to the right as given by the right-hand palm rule. This would increase the movement to the right and increase its kinetic energy without the need to continue to apply the external force, F.

Q27

Criteria	Marks
• Applies Newton's Third law to the ampere definition and calculates the force between the two wires	4
• Applies Newton's Third law to the ampere definition and shows some correct working when calculating the force between the two wires	3
• Applies Newton's Third law to the ampere definition OR • Calculates the force between the two wires	2
• Provides some correct information	1

Sample answer: In the definition the conductors exert equal and opposite forces on each other according to Newton's Third Law. The force on conductor 1 by conductor 2 (action) is equal in size but opposite in direction to the force on conductor 2 by conductor 1 (reaction). The forces may pull the conductors together or push the conductors apart.

The size of the force is given by:

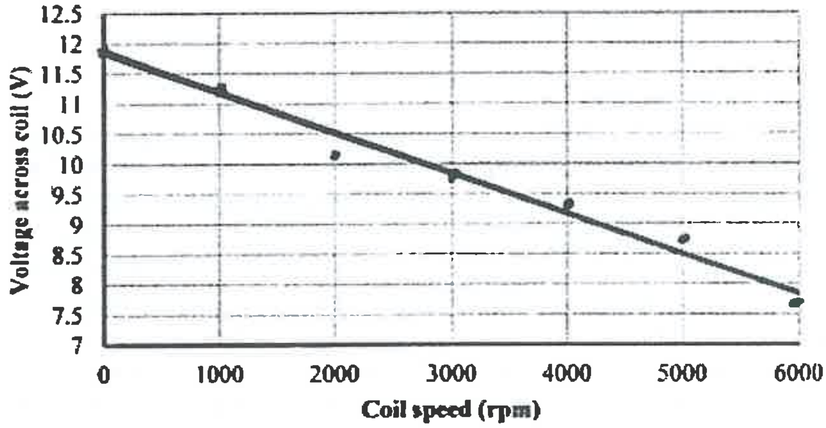
$$\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r}$$

$F = 2 \times 10^{-7} \times (0.375)^2 / (13.5 \times 10^{-3})$
$= 2.08 \times 10^{-6}$ N

Q28(a)

Criteria	Marks
• Correctly plots points and draws a ruled line of best fit	2
• Correctly plots some points OR • Draws a ruled line of best fit	1

Sample answer:



Q28(b)

Criteria	Marks
• Explains the change in voltage in terms of physics principles and justifies the predicted minimum value	4
• Identifies the cause of the change in voltage and correctly predicts the minimum value	3
• Explains the change in voltage in terms of physics principles OR • Justifies the predicted minimum value	2
• Identifies induction as the cause of the change in voltage OR • Correctly predicts the minimum value	1

Sample answer: The voltage is decreasing because the movement of the sides of the coil through the magnetic field will induce a back emf in the coil (Faraday's law of induction). The direction of this emf must be such that it opposes the motion of the coil (Lenz's Law) so as not to contravene the law of conservation of energy.

When the motor reaches its operating speed, the voltage across it will be zero and the back emf will equal the supply voltage.

Q28(c)

Criteria	Marks
• Judges conclusion incorrect based on TWO requirements for inversely proportional graph and application to other motors	3
• Judges conclusion incorrect based on TWO requirements for inversely proportional graph OR • Judges conclusion incorrect based on ONE requirement for inversely proportional graph and application to other motors	2
• Judges conclusion incorrect based on ONE requirement for inversely proportional graph OR • Judges conclusion incorrect based on application to other motors	1

Sample answer: The student's statement is incorrect – the decrease in the net voltage is a linear function of the speed of the rotor but not directly proportional, requiring a straight line through the origin with a positive gradient. Having made only one set of measurements and used only one type of motor, any conclusion could only apply to this motor and would not be valid for all motors.

Q29

Criteria	Marks
• Shows a comprehensive understanding of the implications of Maxwell's theory • Relates the results of Hertz's experiments to Maxwell's theory	7–8
• Provides details of Maxwell's theory • Describes Hertz's experiment	5–6
• Provides details of Maxwell's theory OR • Describes Hertz's experiment	3–4
• Provides some relevant information	1–2

Sample answer: In 1864 Maxwell put forward his electromagnetic theory of light propagation, stating that electricity, magnetism, and light could all be explained using the same theory. He realised the significance of experiments done by Faraday converting electrical energy to magnetic energy. He proposed that light was propagated by alternating electric and magnetic fields, which he believed would vibrate perpendicular to one another in the form of an electromagnetic transverse wave. He described the mutual induction of time and space changing perpendicular electric and magnetic fields. Maxwell's equation postulated that the speed of all electromagnetic waves was $1/\sqrt{(\mu_0 \varepsilon_0)}$ and found the value to be very close to the experimental speed of light, providing evidence for his theory of the nature of light. He went on to predict that there would be a continuous frequency range of electromagnetic radiation which extended beyond the visible spectrum at both ends.

Soon after Maxwell died, Hertz performed a series of experiments in which he produced electromagnetic waves of various frequencies. A transmitter produced an oscillating spark which induced sparks across the gap of a nearby induction coil. The speed of the waves between the transmitter and the receiver was the same as light and the waves exhibited the properties of light, providing evidence for Maxwell's work.

NB Maxwell is quoted as saying: "The undulatory theory of light also assumes the existence of a medium. We now have to show that the properties of the electromagnetic medium are those of the luminiferous medium." Hence his theory does not directly imply that no medium is needed, as suggested in a current HSC text.

Q30

Criteria	Marks
• Identifies light source and lens as polarised and the light through the right lens depends on the angle between the planes of polarisation OR • Applies Malus's law	4
• Identifies light source and lens as polarised and the light through the right lens depends on the angle between the planes of polarisation	3
• Identifies light source and lens as polarised	2
• The light is polarised OR • The right lens is polarised	1

Sample answer: Because the light intensity through the right-hand lens changes, the incident light from the back must be polarised as well as the right-hand lens material. Because the angle of inclination of this lens changes, the angle between the polarisation planes changes and according to Malus's Law, the intensity of light through the lens changes. This varies as $\cos^2\Theta$ where Θ is the angle between the two planes of polarisation. In the last position, the angle is 90°.

The intensity of the light passing through the left-hand lens does not change because that lens is not polarised.

Q31

Criteria	Marks
• States Wien's law, calculates $\lambda_{max} \times T$ using THREE readings from graph and compares average to Wien's law constant	4
• States Wien's law, calculates $\lambda_{max} \times T$ using TWO readings from graph and compares average to Wien's law constant	3
• States Wien's law, calculates $\lambda_{max} \times T$ using ONE reading from graph and compares to Wien's law constant	2
• Calculates $\lambda_{max} \times T$ using ONE reading from graph	1

Sample answer:

Wien's law states that $\lambda_{max}=\frac{b}{T}$. Therefore $\lambda_{max} \times T$ is constant, equal to b.

Using three wavelength readings and their corresponding temperature intercepts:
Wavelength 400×10^{-6} m $\times$ 7.1 K = 2.84×10^{-3} m K
Wavelength $720 \times 10^{-6} \times$ 4.0 K = 2.88×10^{-3} m K
Wavelength 1200×10^{-6} m $\times$ 2.5 K = 2.80×10^{-3} m K

Average value of product = 2.8 which is close to Wein's law constant b, 2.898×10^{-3}.
The graph therefore supports Wein's law.

Q32(a)

Criteria	Marks
• Explains the difference between classical theory and calculations based on Einstein's special theory of relativity	2
• Identifies increase in mass	1

Sample answer: Classical theory would consider the mass of the object to be constant regardless of its speed. However, from Einstein's work we know that at speeds approaching that of light, there is a significant increase in the mass of an object – it has relativistic mass instead of just its rest mass – hence the graph is curved because of this increase in mass as well as speed.

Q32(b)

Criteria	Marks
• Calculates relativistic momentum correctly	2
• Calculates relativistic momentum based on incorrect relativistic mass calculation	1

Sample answer:

At 0.8c, the gamma factor = $\frac{1}{\sqrt{1-v^2/c^2}} = \frac{1}{0.6} = 1.67$

Therefore, the relativistic mass of the proton = $1.673 \times 10^{-27} \times 1.67 = 2.79 \times 10^{-27}$ kg
So, relativistic momentum of the proton = $2.79 \times 10^{-27} \times 0.8 \times 3 \times 10^{8} = 6.7 \times 10^{-19}$ kg m s^{-1}

Q33(a)

Criteria	Marks
• Provides correct equation	2
• Provides equation with ONE error	1

Sample answer: $2\,{}^{1}_{1}\text{H} + 2\,{}^{1}_{1}\text{H} \qquad 2\,{}^{2}_{1}\text{H} + 2\,{}^{0}_{+1}\text{e} + 2\text{v}_{e}$

Q33(b)

Criteria	Marks
• Determines correctly the energy produced in MeV	2
• Calculates mass of reactants minus products and converts incorrectly to MeV	1

Sample answer: Mass defect = (4 × 1.007825) – (2 × 2.014102) – (2 × 0.0005488) = 0.0019984 u
Energy released in MeV = 0.001998 × 931.5 = 1.86 MeV

Q34

Criteria	Marks
• Describes the deflection of cathode rays in electric field and its importance in the debate about the nature of cathode rays • Provides a comprehensive description of use of magnetic field as well as electric to determine charge/mass ratio • Outlines basis for identifying the cathode rays as a charged subatomic particle	7–8
• Describes the deflection of cathode rays by electric fields • Outlines how the charge/mass ratio was found • Identifies cathode rays as negatively charged particles	5–6
• Describes the deflection of cathode rays by electric fields • Outlines how the charge/mass ratio was found	3–4
• Provides some relevant information	1–2

Sample answer: In his experiment Thomson used an extended cathode ray tube with a slot in the anode to produce a focussed beam of cathode rays. He first deflected the cathode rays with an electric field to position A. This result provided strong evidence for cathode rays being negatively charged particles (waves cannot be charged) and settled the debate that had been ongoing for years as to whether they were waves or particles. This debate had raged because although the cathode rays were deflected by magnetic fields, the electric fields used had not been strong enough to produce a visible deflection, so it was thought the cathode rays might be uncharged, and therefore possibly waves.

In further experiments, the beam of electrons was passed through a magnetic field perpendicular to the electrons' velocity, produced by current carrying coils on each side of tube. The deflection of the beam in magnetic field was measured at the end of the tube and used to calculate the radius of the curved (circular) path of electrons in magnetic field, B. The electric field E perpendicular to the magnetic field was then adjusted so that the forces deflecting the beam due to E and B fields cancelled. From his measurements and the size of the electric and magnetic field applied, Thomson calculated the charge to mass ratio of the cathode ray particles.

It is at this point that Thomson used his results as the basis for a brilliant assumption: that the charge on cathode ray particles was similar in size to that on a hydrogen ion and then calculated their mass. (His value was close to the value accepted today). He further assumed they were the same as the particles predicted by George Stoney in 1894 to be part of an atom and responsible for dynamic (flowing) electricity. He gave them Stoney's name, "*electrons*". Thomson's work provided evidence for the first subatomic particles to be discovered.

Q35

Criteria	Marks
• Shows a clear understanding of the energy, frequency and wavelength associated with electrons moving to lower energy levels	3
• Relates electron movement to emitted energy wavelength	2
• Provides some relevant information	1

Sample answer: The diagram is showing electron transfers from higher energy level orbits to lower energy level orbits within the Bohr model of the atom. These transfers release electromagnetic radiation of specific frequencies given by the equation $E = hf$. The wavelengths of the energy is calculated from $c = f\lambda$ and are the wavelengths of the spectral lines for the element involved, as shown in diagram.

Q36

Criteria	Marks
• Provides at least THREE details about leptons and clearly explains where they fit into the Standard model	5
• Provides at least THREE details about leptons and attempts to explain where they fit into the Standard model	4
• Provides TWO details about leptons and attempts to explain where they fit into the Standard model	3
• Provides TWO details about leptons OR • Provides ONE detail about leptons and attempts to explain where they fit into the Standard model	2
• Provides some relevant information	1

Sample answer: In the Standard Model, there are two types of elementary particles, fermions and bosons. The fermions are the particles that make up visible matter and there are two groups of these fundamental particles, leptons and quarks. Leptons have a ½ integer spin and respond only to electromagnetic, weak, and gravitational forces and do not take part in strong interactions. There are 6 types (called flavours) of leptons – electrons, muons, tau, electron neutrinos, muon neutrinos, tau neutrinos. Only the electron and the electron neutrino are found in normal matter.

NSW INDEPENDENT TRIAL EXAMS – 2020
PHYSICS – TRIAL HSC EXAMINATION – MAPPING GRID

Question	Marks	Content module		Syllabus Outcomes (PH)	Targeted performance bands
Section I					
1	1	5	Projectile Motion	12-6, 12-12	2-3
2	1	5	Motion in a Gravitational Field	12-5, 12-12	3-4
3	1	5	Projectile Motion Circular motion	12-6, 12-12	2-3
4	1	5	Circular Motion	12-6, 12-12	2-3
5	1	5	Projectile Motion	12-6, 12-12	3-4
6	1	6	Applications of the Motor Effect	12-6, 12-13	2-3
7	1	6	Charged Particles, Conductors and Electric and Magnetic Fields	12-6, 12-13	3-4
8	1	6	Charged Particles, Conductors and Electric and Magnetic Fields	12-6, 12-13	3-4
9	1	6	Electromagnetic Induction	12-6, 12-13	4-5
10	1	6	Electromagnetic Induction	12-6, 12-13	2-3
11	1	7	Electromagnetic Spectrum	12-6, 12-14	3-4
12	1	7	Light: Wave Model	12-6, 12-14	3-4
13	1	7	Light: Quantum Model	12-6, 12-14	4-5
14	1	7	Light: Quantum Model	12-6, 12-14	3-4
15	1	7	Light and Special Relativity	12-6, 12-14	3-4
16	1	8	Properties of the Nucleus	12-6, 12-15	4-5
17	1	8	Origins of the Elements	12-6, 12-15	3-4
18	1	8	Quantum Mechanical Nature of the Atom	12-6, 12-15	4-5
19	1	8	Properties of the Nucleus	12-6, 12-15	4-5
20	1	8	Deep inside the Atom	12-6, 12-15	2-3
Section II					
21	4	5	Circular Motion	12-6, 12-7, 12-6, 12-12	3-5
22(a)	5	5	Projectile Motion	12-4, 12-5, 12-12	3-4
22(b)	4	5	Projectile Motion	12-6, 12-12	4-5
23	3	5	Motion in a Gravitational Field	12-6, 12-7, 12-12	4-6
24	3	5	Motion in a Gravitational Field	12-6, 12-12	3-5
25(a)	1	6	Charged Particles, Conductors and Electric and Magnetic Fields	12-7, 12-13	3-4
25(b)	3	6	Charged Particles, Conductors and Electric and Magnetic Fields	12-7, 12-13	4-5
26	4	6	Electromagnetic Induction	12-7, 12-13	3-4
27	4	6	The Motor Effect	12-13	3-4
28(a)	2	6	Applications of the Motor Effect	12-4	2-3
28(b)	4	6	Applications of the Motor Effect	12-7, 12-13	4-5
28(c)	3	6	Applications of the Motor Effect	12-5, 12-13	2-3
29	8	7	Electromagnetic Spectrum	12-7, 12-14	3-6
30	4	7	Light: Wave Model	12-6, 12-14	4-5
31	4	7	Light: Quantum Model	12-5, 12-6, 12-14	4-5
32(a)	2	7	Light and Special Relativity	12-7, 12-14	3-4
32(b)	2	7	Light and Special Relativity	12-6, 12-14	3-4
33(a)	2	8	Properties of the Nucleus	12-7, 12-15	2-3
33(b)	2	8	Properties of the Nucleus	12-6,12-15	3-4
34	8	8	Structure of the Atom	12-7, 12-15	3-6
35	3	8	Quantum Mechanical Nature of the Atom	12-7, 12-15	3-4
36	5	8	Deep inside the Atom	12-7, 12-15	3-5