Student Number: ……

Teacher's Name: ……

2022

Task 4: Trial Examination

Weighting: 30%

HSC Physics Booklet 1

General Instructions

- Reading time - 5 minutes
- Working time - 3 hours
- Write using black pen
- NESA approved calculators may be used
- A data sheet, formulae sheets and Periodic Table are provided at the back of this paper
- For questions in Section II, show all relevant working in questions involving calculations
- This paper MUST NOT be removed from the examination room.

Subject Teachers:
Ms Disney
Mr Fiander
Mr Sloan
Mr Solomonides
Mr Truong

Total marks - 100

BOOKLET 1

Section I - 20 marks (16 pages)

- Attempt Questions 1-20
- Allow about 35 minutes for this section

BOOKLET 2

Section II - PART 1 - 39 marks (16 pages)

- Attempt Questions 21-28
- Allow about 70 minutes for this part

BOOKLET 3

Section II - PART 2 - 41 marks (15 pages)

- Attempt Questions 29-35
- Allow about 75 minutes for this part

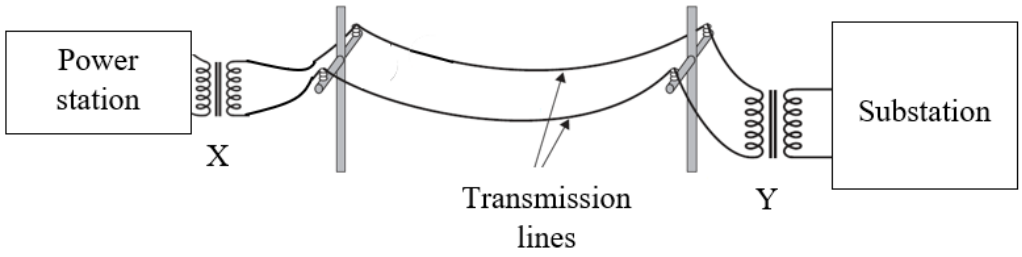
If extra booklets are required, each question must be completed in a new booklet. Indicate question number clearly.

Section I
20 marks

Attempt Questions 1-20
Allow about 35 minutes for this section

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

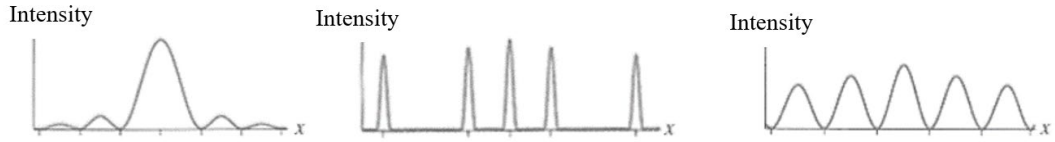
1. The diagram below shows part of the electricity distribution system from a power station. Points X and Y are transformers.



Identify whether X and Y are step up or step down transformers.

	Transformer X	Transformer Y
A.	Step up	Step up
B.	Step down	Step down
C.	Step up	Step down
D.	Step down	Step up

2. The following graphs show the intensity pattern for light passing through a single slit, double slit and diffraction grating.



Identify which graph belongs to which set of slits?

	Graph 1	Graph 2	Graph 3
A.	Double slit	Single slit	Diffraction grating
B.	Single slit	Diffraction grating	Double slit
C.	Diffraction grating	Single slit	Double slit
D.	Single slit	Double slit	Diffraction grating

3. A ball is projected horizontally, 46 m above the ground, with an initial velocity of 25 ms^{-1}.

Calculate the horizontal displacement of the object at the time it reaches the ground.

A. 54 m

B. 77 m

C. 190 m

D. 235 m

4. A planet orbits a star in circular motion. It takes 182 Earth days for the planet to complete one orbit of its star.

Calculate its angular velocity.

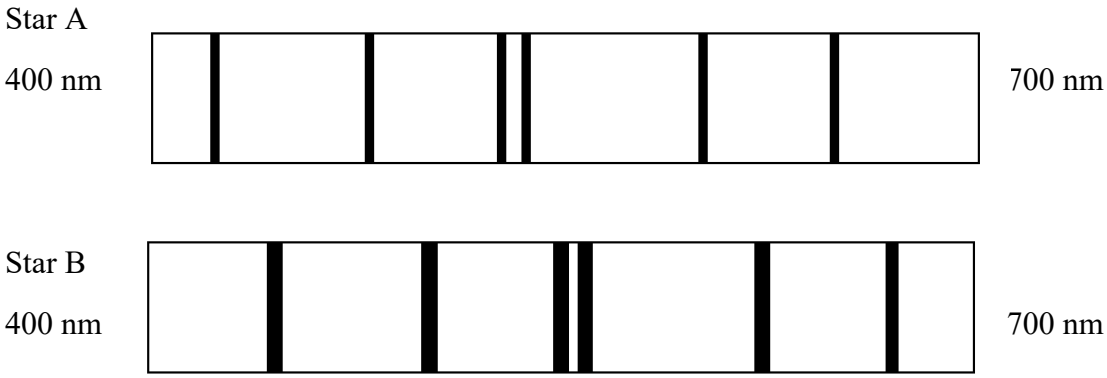
A. 2.289×10^{-5} rad s^{-1}

B. 2.397×10^{-5} rad s^{-1}

C. 1.998×10^{-7} rad s^{-1}

D. 3.996×10^{-7} rad s^{-1}

5. The following elemental spectra are from two stars in a distant galaxy.



Which of the following comparisons about Star A and B is correct?

A. Star B is more dense and has a faster translational velocity than Star A.

B. Star A is more dense with a different chemical composition than Star B.

C. Star B has a faster rotational velocity but slower translational velocity than Star A.

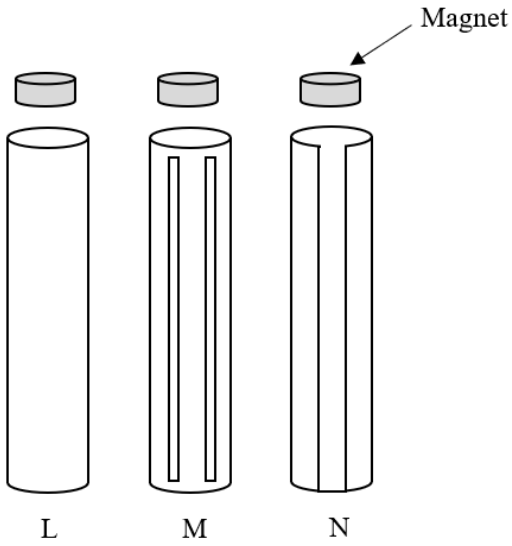
D. Star A has a faster rotational velocity but slower translational velocity than Star B.

6. Three identical strong magnets were dropped at the same time so they passed through three copper tubes as shown below.

Tube L does not have any slits.

Tube M was slotted (contained slits in the metal).

Tube N was not a complete tube.



What is the correct order that the magnets would appear from the bottom of the tubes?

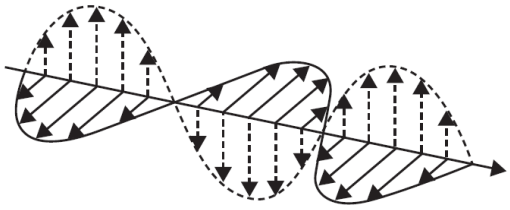
A. N, M, L

B. L, M, N

C. M, N, L

D. N, L, M

7. Maxwell developed laws to explain the production and properties of electromagnetic waves. The image below shows a traditional model of some of Maxwell's predictions about electromagnetic waves.



Which of Maxwell's predictions is demonstrated in the model above?

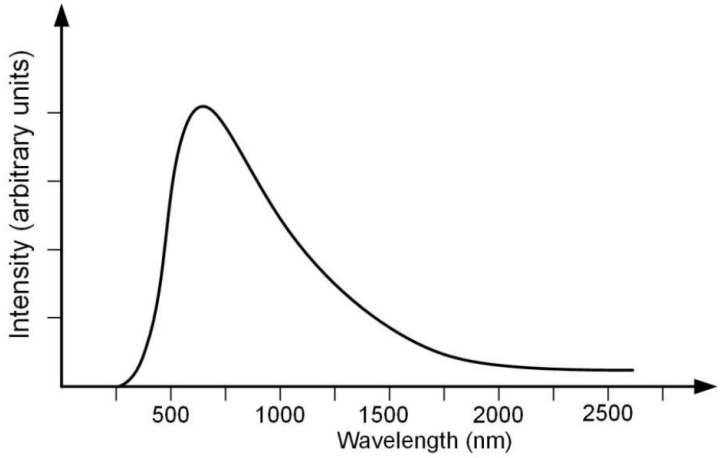
A. Electromagnetic waves have a variety of wavelengths.

B. Electromagnetic waves consist of oscillating electric and magnetic fields.

C. Electric fields are perpendicular to magnetic fields and both are parallel to the direction of travel.

D. An oscillating charged particle creates a changing electric field, which creates a changing magnetic field.

8. The graph below shows the intensity of light emitted at different wavelengths from an unknown star.



Determine the surface temperature of the star.

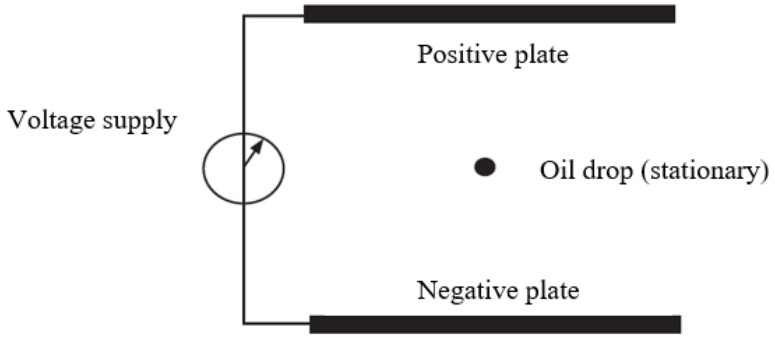
A. 4459 K

B. 5796 K

C. 11592 K

D. 22429 K

9. Millikan used an apparatus similar to the one pictured below to determine the mass of an electron.



Which of the following is a correct formula for the mass of an electron in terms of the voltage between the plates?

A. $V = \frac{mgd}{q}$

B. $m = \frac{qE}{g}$

C. $m = \frac{qV}{gd}$

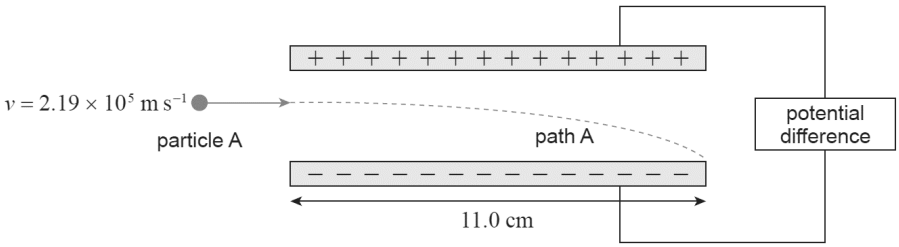
D. $m = \frac{eVg}{d}$

10. Different models of the atom had limitations that were generally overcome by the next proposed models. The table below shows scientists and limitations of their proposed models.

Which limitation does not match the named scientist?

	Scientist	**Limitation**
A.	Bohr	Could not explain all spectral lines of any element other than hydrogen.
B.	Bohr	Could not explain relative intensity of different spectral lines from the same element.
C.	Rutherford	Did not explain what made up the "empty space" in the atom.
D.	Rutherford	Orbiting electrons did not emit electromagnetic radiation so did not follow the known laws of physics.

11. Particle A is fired perpendicularly into a uniform electric field as shown below.



A second particle with double the charge and four times the mass of particle A is fired perpendicularly into the same field, and at the same speed as particle A.

How does the potential difference between the plates need to change so that the second particle follows the same path as particle A?

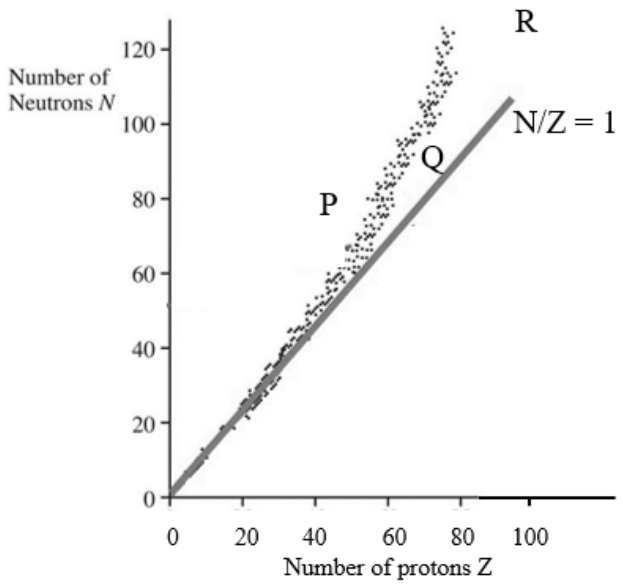
A. Doubled

B. Halved

C. No change

D. Tripled

12. The N/Z (neutron/proton) graph below shows isotopes of some elements.



Which of the following is a correct statement about isotopes P, Q and R?

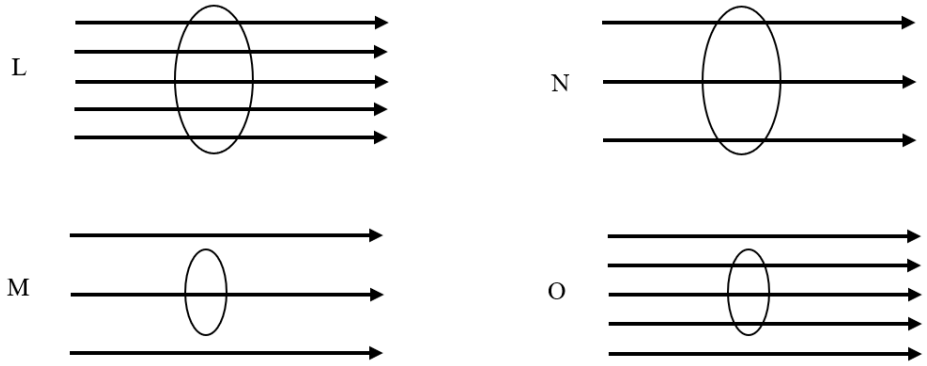
A. P, Q and R are all alpha emitters.

B. P and Q are both beta negative emitters.

C. Q is a beta negative emitter, R is an alpha emitter.

D. P is a beta negative emitter, Q is a beta positive emitter.

13. The four images below show a magnetic field passing through a loop of wire which is free to rotate about the vertical axis within the magnetic field. The loops of wire in L and N are the same size. The loops of wire in M and O are the same size.



The change in flux that occurs when each loop of wire rotates at the same speed is:

A. equal in L and N.

B. greatest in M and least in O.

C. greater in M than in L.

D. greatest in L and least in M.

14. Two lasers of different wavelength were shone through a double slit. One of the lasers had an unknown wavelength.

The third bright band of the laser with wavelength 650 nm lined up perfectly with the fifth dark band of the laser with unknown wavelength.

Determine the wavelength of the unknown laser.

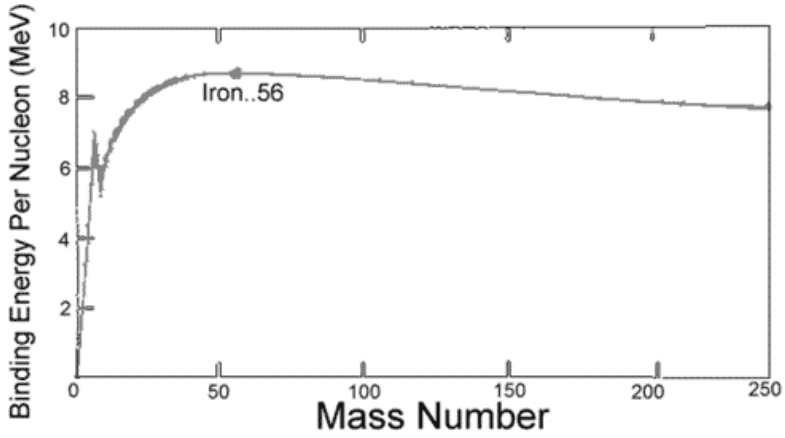
A. 390 nm

B. 433 nm

C. 488 nm

D. 975 nm

15. Iron-56 is an important isotope in star fusion due to its binding energy, which can be seen in the following graph.



Why is iron-56 the last element produced in nucleosynthesis in post-main sequence stars?

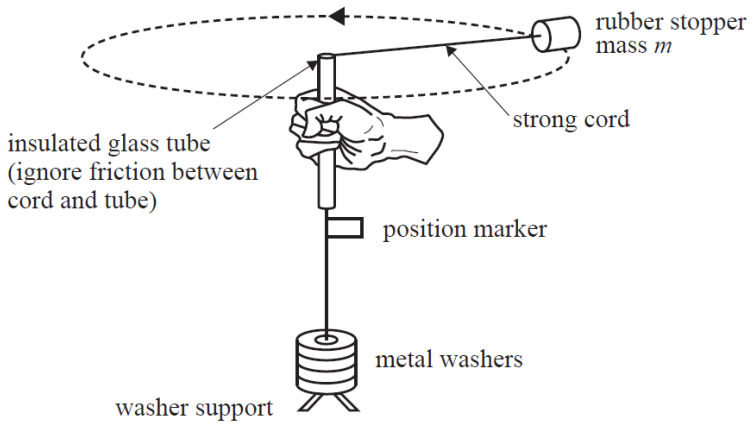
A. It is the isotope with the highest binding energy.

B. Other elements are produced during supernova explosions.

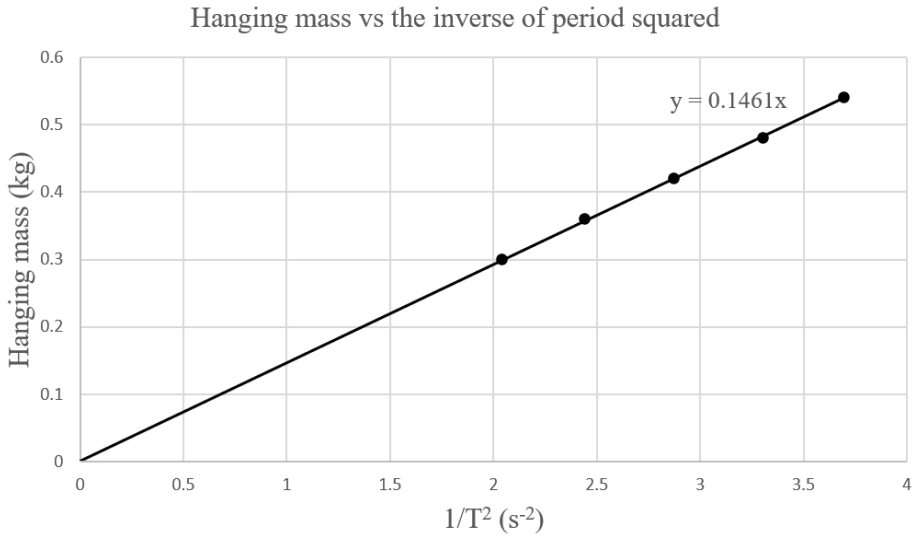
C. It is the largest element that forms in a fusion reaction that releases energy.

D. Elements with higher atomic number are more efficiently produced through fusion processes.

16. A student conducted an experiment as shown below to measure the mass of a rubber stopper being swung in uniform circular motion with a radius of 0.50 m.



The student changed the number of metal washers hanging from the cord, and then measured the period of the rubber stopper as it moved in circular motion. The student produced the graph below to present the data collected.



Determine the mass of the rubber stopper.

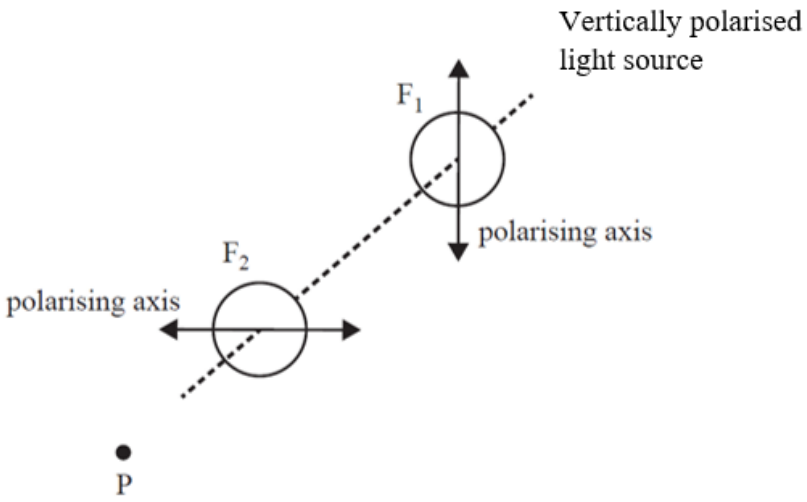
A. 0.000755 kg

B. 0.0725 kg

C. 0.228 kg

D. 0.456 kg

17. A student set out to investigate Malus' Law using the setup below.



The F_2 polarising film was rotated through an angle of θ°. The resulting intensity of light at point P was 36% of the intensity of the original polarised light source.

What is the value of θ?

A. 22°

B. 37°

C. 53°

D. 68°

18. Planet X is three times the radius of Planet Y and two times the mass.

What is the ratio of the gravitational field strength of Planet X to Planet Y?

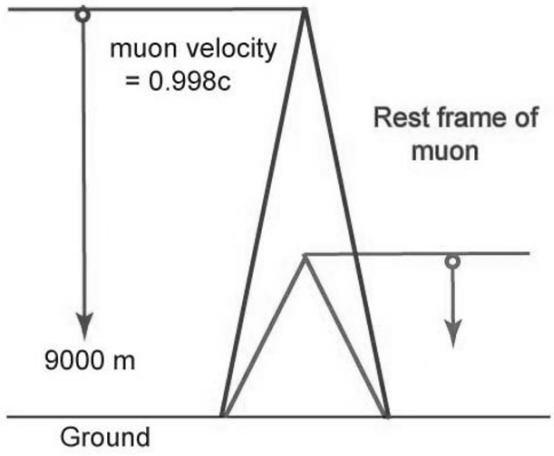
A. 0.22 : 1

B. 0.66 : 1

C. 1.5 : 1

D. 4.5 : 1

19. Muons are created in the upper atmosphere by radioactive processes, approximately 9 km above the surface of the Earth. Muons have a half life of approximately 2.20×10^{-6} s in their own frame so do not have time to travel the distance to Earth's surface before they decay.



Muons are often used as evidence of time dilation in special relativity.

Using the information above, what is the reason that muons can be used as evidence of time dilation?

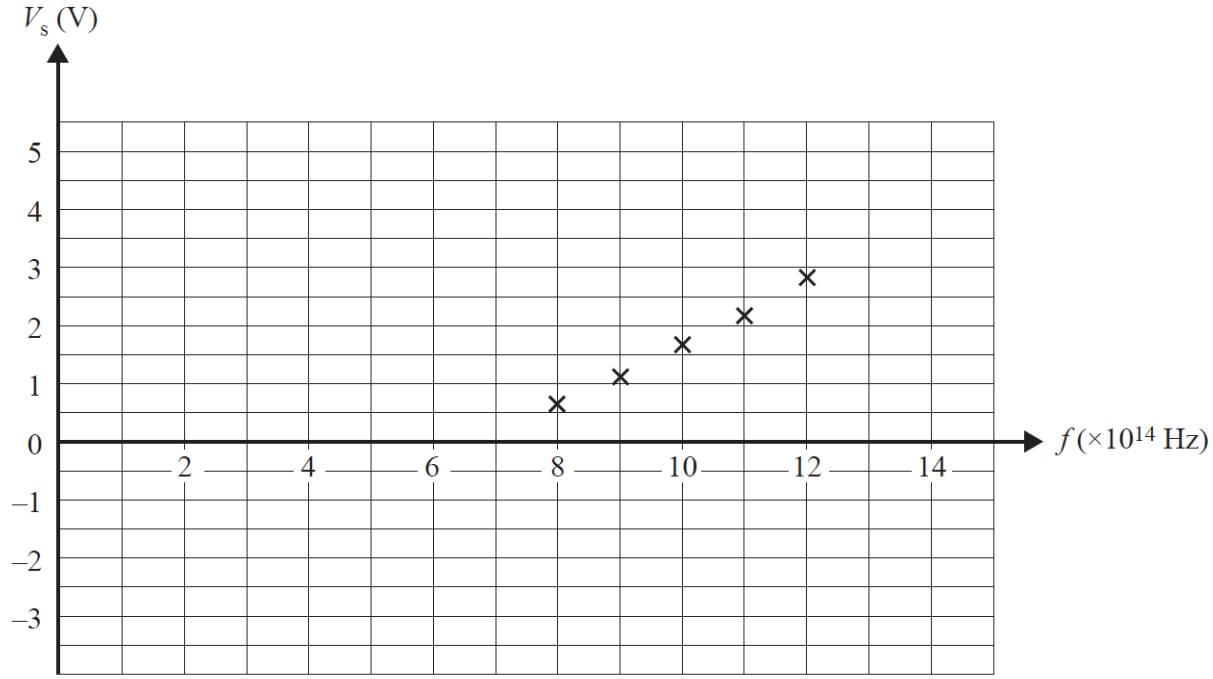
A. In its rest frame the muon has a half life of 2.2μs. As it travels at relativistic speeds (0.998c), this gives enough time for the muons to reach Earth's surface.

B. In its rest frame the muon has a half life of 2.2 μs. In our frame the muon has a half life of 49 μs and so can travel further before decaying and reach the Earth's surface.

C. In its rest frame the muon has a half life of 0.10 μs. In our frame the muon has a half life of 2.2 μs and so can travel further before decaying and reach the Earth's surface.

D. In its rest frame the muon has a half life of 2.2 μs. In our frame the muon has a half life of 35 μs and so can travel further before decaying and reach the Earth's surface.

20. A student was investigating the photoelectric effect by measuring stopping voltage for different frequencies of light. He plotted his results on the graph shown below.



From these results, which option shows the values of the slope of the graph, work function and cut off frequency?

	Order of magnitude of slope	**Work function (J)**	**Cut off frequency (Hz)**
A.	10^{-34}	3.8	6.8×10^{14}
B.	10^{-34}	6.09×10^{-19}	6.8×10^{14}
C.	10^{-15}	6.09×10^{-19}	6.8×10^{14}
D.	10^{-15}	3.8	7.2×10^{14}

END OF BOOKLET 1

Student Number: ……

Teacher's Name: ……

2022

Task 4: Trial Examination

HSC Physics Booklet 2

BOOKLET 2

Section II - PART 1 - 39 marks (16 pages)

- Attempt Questions 21-28
- Allow about 70 minutes for this part

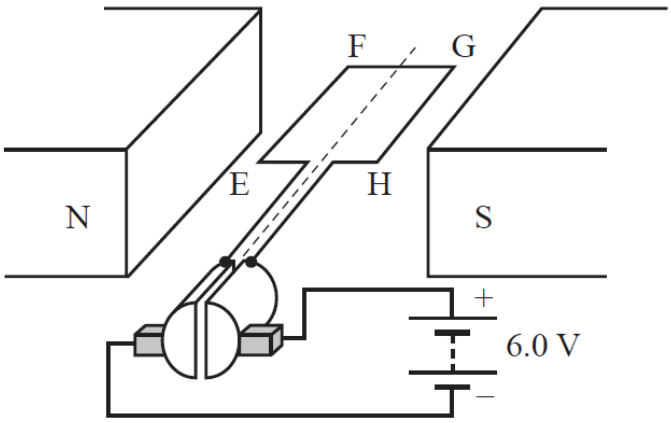
- If using writing booklets, include all Booklet 2 questions in the SAME writing booklet. Label the writing booklet "BOOKLET 2"

Number of extra writing booklets used_____

Question 21 (5 marks)

In the simple DC motor shown below, a single loop of wire forms a rectangular coil.

Side EF is 6.0 cm and side FG is 4.0 cm in length. The coil is placed into a magnetic field of 2.4×10^{-2} T and a current of 1.2 A flows through the coil.



(a) Calculate the magnitude of the torque generated by the motor when in the position shown. **2**

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(b) On the axes below, sketch a graph to indicate how the torque changes as the coil rotates through one full revolution from the position shown in the diagram. **3**

Question 22 (5 marks)

The fission of uranium-235 produces energy in nuclear reactors according to the following equation:

$$ {}^{1}_{0}\mathrm{n} + {}^{235}_{92}\mathrm{U} \rightarrow {}^{92}_{36}\mathrm{Kr} + {}^{141}_{56}\mathrm{Ba} + 3\,{}^{1}_{0}\mathrm{n} $$

The masses of the particles involved (in u) are given below.

Neutron	1.009
Uranium-235	235.044
Krypton-92	91.926
Barium-141	140.914

(a) Calculate the energy released in MeV from the fission of one atom of uranium-235. **2**

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(b) The fission of uranium-235 is considered to be a better source of energy than the combustion of fossil fuels like coal.

- 1.0 kg of uranium-235 contains 2.56×10^{24} atoms.
- 1.0 kg of coal produces 31.2×10^{6} J of energy when combusted.

Calculate the ratio of the energy produced by 1.0 kg of uranium-235 to the energy produced by 1.0 kg of coal. **3**

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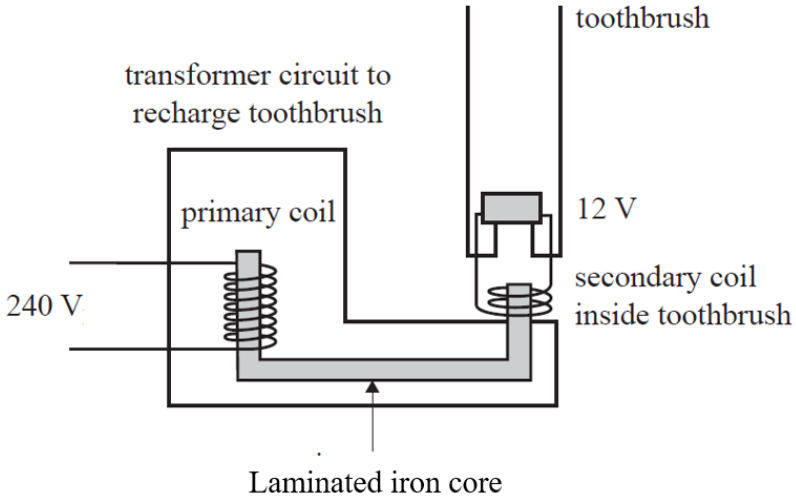
Question 23 (5 marks)

A student designs a charger for an electric toothbrush that involves a transformer. The charger plugs into a 240 V household power point, while the toothbrush requires 12 V to charge. The basic design for the charger is shown below. The number of coils shown in the diagram is NOT accurate.



(a) Justify the use of a laminated iron core in transformers. **2**

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(b) By using a relevant equation, explain how the design of this transformer produces the required output voltage for the toothbrush to charge. **3**

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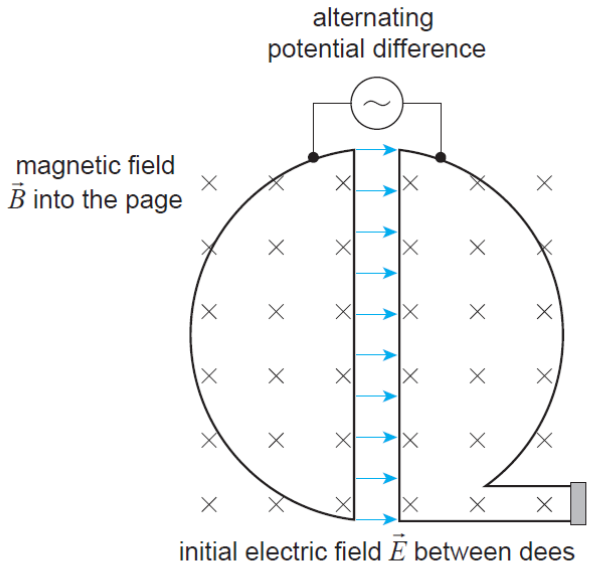
Question 24 (7 marks)

The diagram below shows a cyclotron used to accelerate particles to high speeds.



[This diagram is not drawn to scale.]

(a) Describe the roles of both the electric and magnetic fields in a cyclotron that causes a charged particle to reach extremely high speeds. **3**

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(b) The study of the Standard Model of Matter was difficult for many years. The invention of particle accelerators allowed scientists to provide evidence of the Standard Model for the first time in a laboratory. **4**

Explain how particle accelerators are able to provide evidence for the Standard Model of matter. Include a specific example in your answer.

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Question 25 (3 marks)

The table below shows data about four of the moons of Saturn. A fifth moon, Rhea, has an orbital period of 3.90×10^5 s.

Moon	Orbital period (s)	Orbital radius (m)
Mimas	8.14×10^4	1.86×10^8
Enceladus	1.18×10^5	2.38×10^8
Tethys	1.63×10^5	2.95×10^8
Dione	2.36×10^5	3.77×10^8

Explain qualitatively how you could use the data in the table to calculate the orbital radius of Rhea. **3**

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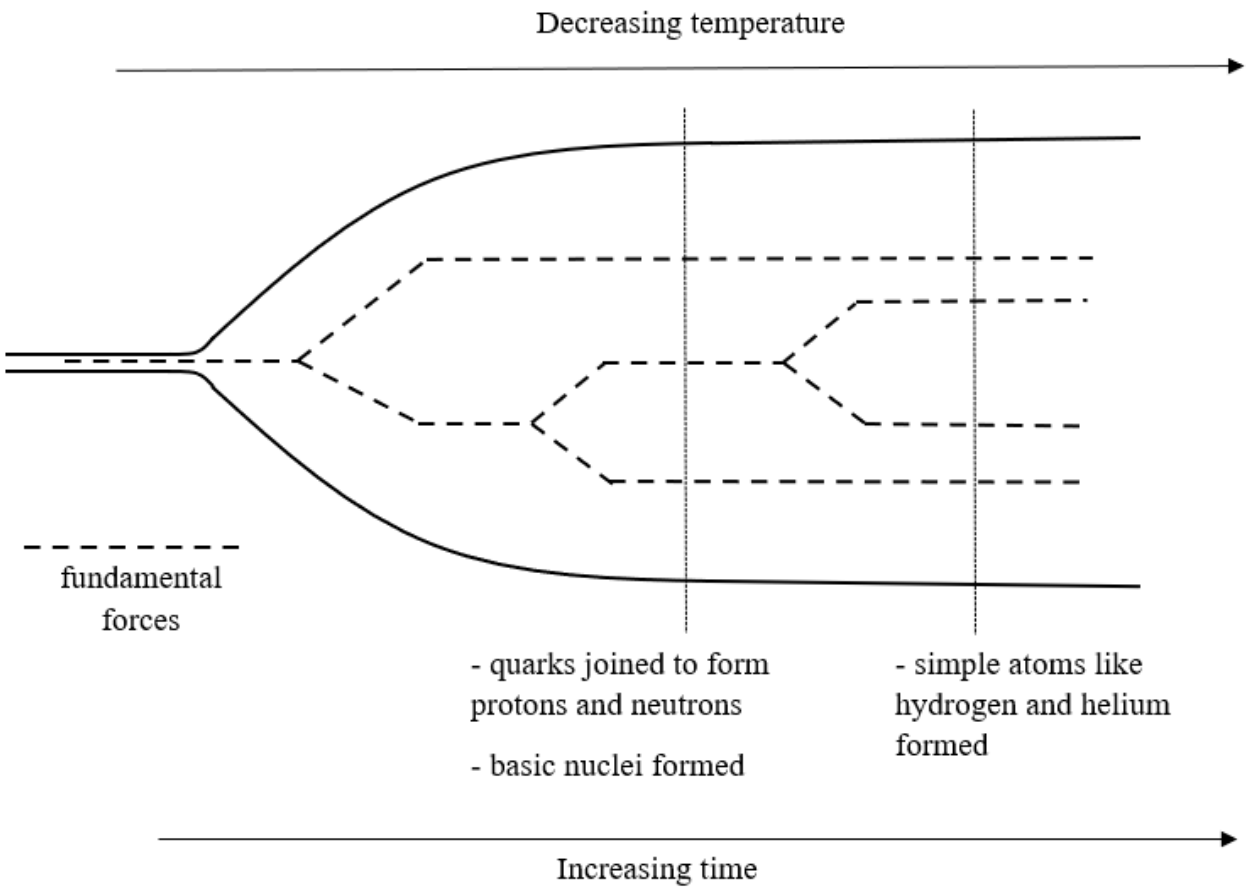
Question 26 (6 marks)

The diagram below shows some key events in the formation of the early universe.



Analyse the sequence of events that occurred after the Big Bang that led to the formation of simple atoms like the helium atom. **6**

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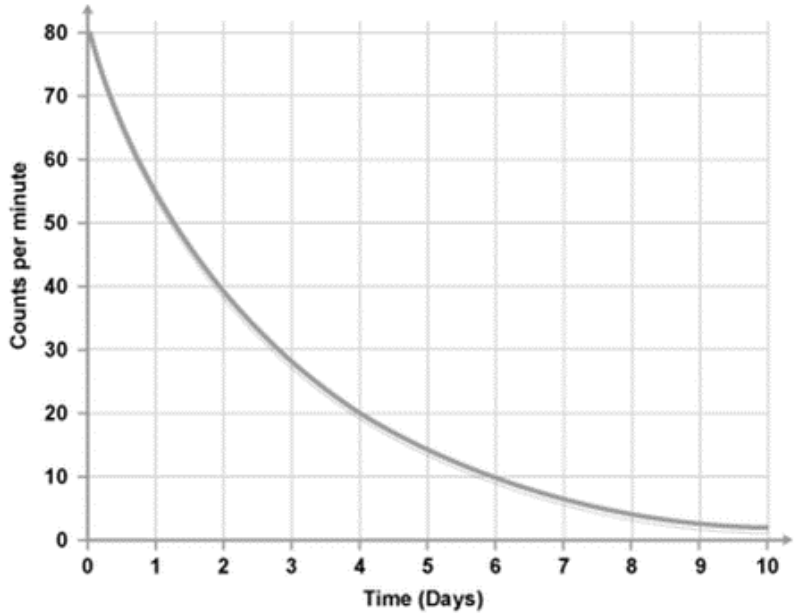
Question 27 (3 marks)

The graph below shows the decay of a sample of an unknown radioactive isotope.



The table below shows isotopes that could match the one displayed on the graph.

Decay constant	Radioisotope
172800 s^{-1}	Cobalt-59
0.3465 s^{-1}	Actinium-210
6.68 x 10^{-6} s^{-1}	Bismuth-187
4.01 x 10^{-6} s^{-1}	Lead-198
2.86 x 10^{-6} s^{-1}	Radon-209

By calculating the decay constant from the information in the graph, determine which radioactive isotope from the table is shown on the graph. **3**

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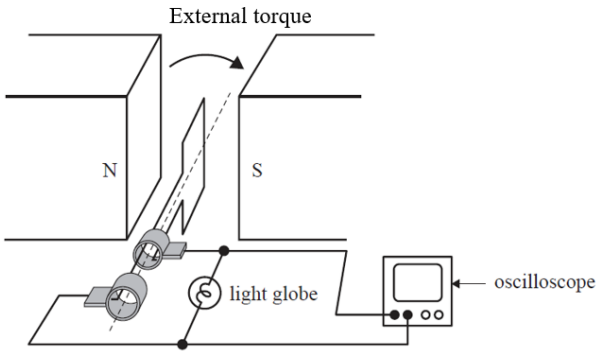
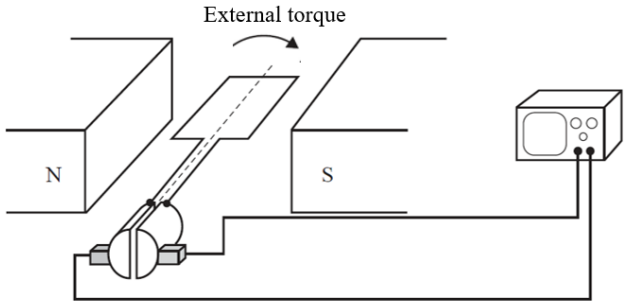
Question 28 (5 marks)

The diagrams below show a simple AC generator and DC generator.

AC Generator



DC Generator



Complete the table below, describing ONE similarity and ONE difference for each of the structure, mechanism of electricity generation, and output of each type of generator. **5**

	Similarity	**Difference**
Structure		
Process of electricity generation		
Output		

Student Number: ……

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2022

Task 4: Trial Examination

HSC Physics
Booklet 3

BOOKLET 3

Section II - PART 2 - 41 marks (15 pages)

- Attempt Questions 29-35
- Allow about 75 minutes for this part

- If using writing booklets, include all Booklet 3 questions in a DIFFERENT writing booklet to the Booklet 2 questions.
- Label the writing booklet "BOOKLET 3".

Number of extra writing booklets used_____

Question 29 (5 marks)

The model of the atom has changed significantly since Thomson first proposed the plum pudding model of the atom. Experiments played a key role in advancing the atomic model.

Significant experiments included the Rutherford's gold foil experiment, Chadwick's experiment and the Davisson-Germer experiment.

Draw a fully labelled diagram of ONE of these experiments and explain how the experiment advanced the atomic model at the time. **5**

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Question 30 (7 marks)

The diagram below shows the setup for an investigation into the acceleration of a trolley down a ramp at an angle of 20.0° to the horizontal. An equation can be derived to determine the theoretical acceleration of an object down a ramp at a specific angle.

L: a trolley fixed in place. A solenoid is attached to the trolley and connected to a power pack. 12 V DC electricity is flowing through the solenoid.

M: a free-moving trolley.

N: a strong magnet fixed in place.

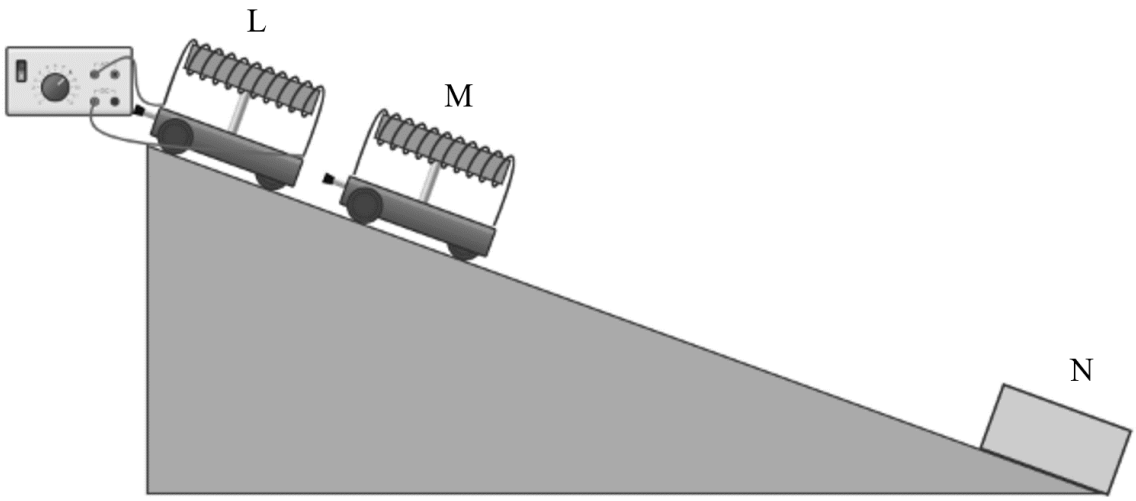
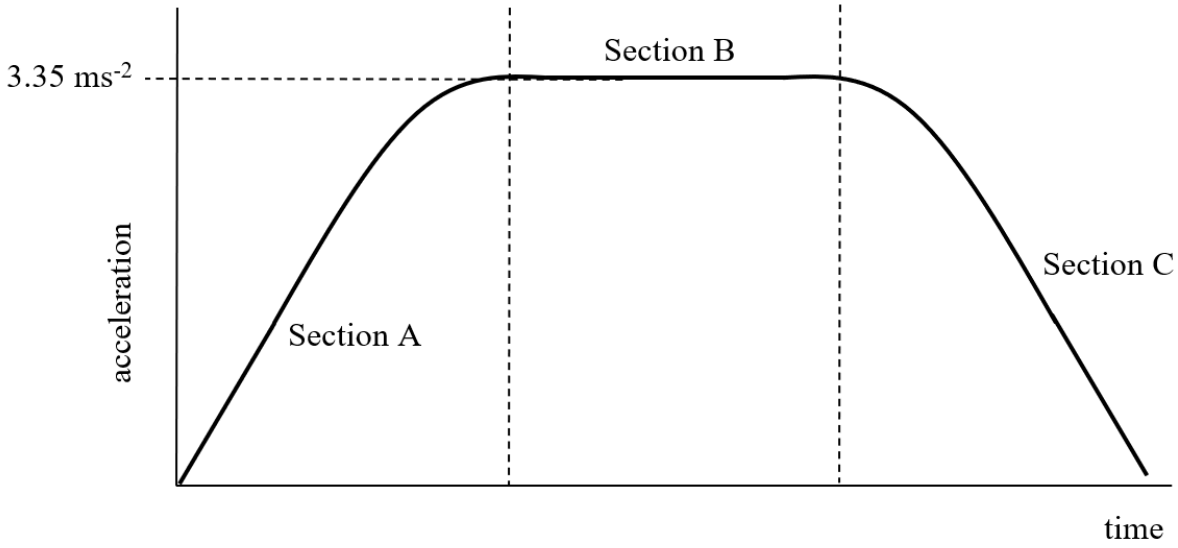


Diagram is NOT drawn to scale.

Trolley M was released and moved down the ramp. The acceleration of trolley M was measured with a data logger and the following graph was produced.



Account for the acceleration of trolley M in Sections A, B and C of the graph, and for the maximum recorded acceleration value. **7**

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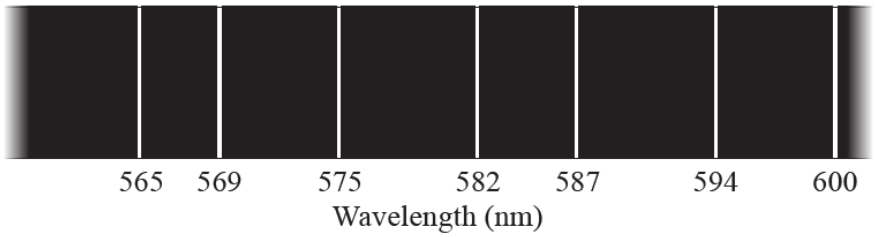
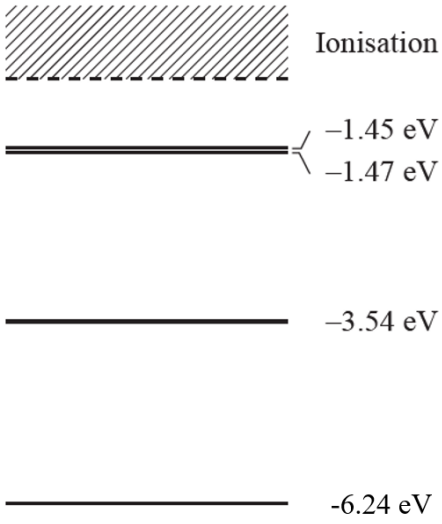
Question 31 (3 marks)

The diagram below shows a section of the emission spectrum for a mixture of gases.



The energy level diagram for an element is shown below. The only visible line produced by this element is the n = 2 to n = 1 transition.



Is this element in the mixture of gases? Justify your answer. **3**

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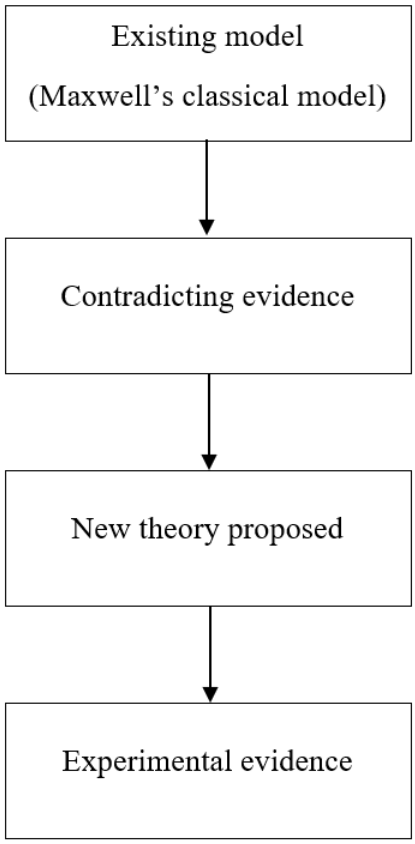
Question 32 (9 marks)

The flowchart below shows how a scientific model is advanced.



Analyse how the particle model of light was developed following evidence that contradicted Maxwell's classical model. You must include annotations on the flowchart as part of your response. **9**

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Space for answer continues over the page.

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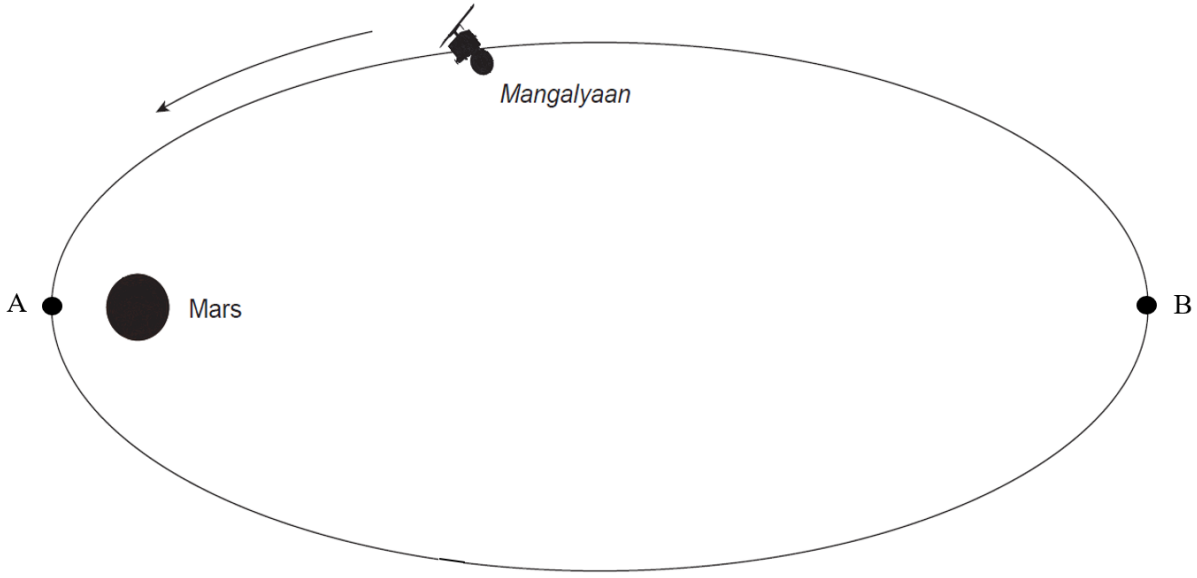
Question 33 (5 marks)

Kepler's first law suggests that an object's orbit about a larger object is an ellipse. In the diagram below, a satellite can be seen orbiting Mars in an elliptical orbit. The total mass of the satellite is 677 kg, and the mass of Mars is 6.39×10^{23} kg.

At the closest point of its orbit (point A), the satellite is 3 805 km from the centre of Mars. At the furthest point of its orbit (point B), it is 47 972 km from the centre of Mars.



[This diagram is not drawn to scale.]

(a) Show that the gravitational potential energy of the satellite at point A is approximately -7.6×10^9 J. **2**

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(b) Justify why the speed of the satellite is fastest at point A. **3**

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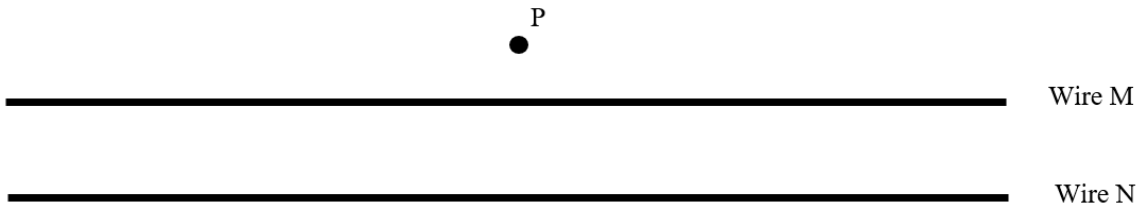
Question 34 (6 marks)

The diagram below shows two parallel wires (M and N) that are connected to different circuits, so have different current passing through them.

Point P is a point in space close to wire M.



(a) The circuit containing wire M was switched on. The wire N circuit was not switched on. **1**

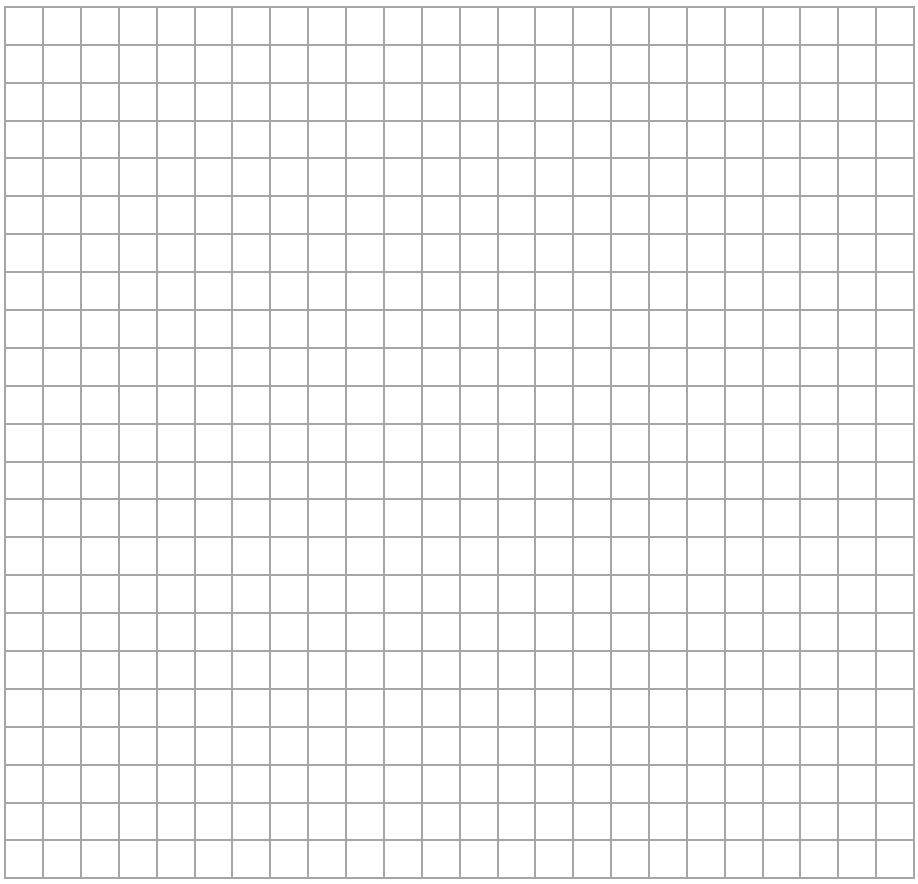
The magnetic field at point P is directed out of the page, what is the direction of current in the wire?

……

(b) Both wire M and N circuits were switched on and the force between the two wires was recorded. The distance between the two wires was increased and the force measured again. This was repeated a number of times until the following data was collected.

Distance between the wires - r (m)	**1/r (m^{-1})**	**Force between the wires (N)**
0.010	100	3.9×10^{-3}
0.015	67	2.7×10^{-3}
0.020	50	2.0×10^{-3}
0.040	25	0.9×10^{-3}
0.100	10	0.4×10^{-3}

On the grid on the following page, plot a graph of force against 1/r and draw a line of best fit. **4**



(c) Write an equation in terms of the quantities in the parallel wires formula that represents the slope of the graph above. **1**

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Question 35 (6 marks)

The graph below shows the results collected during a photoelectric experiment in which frequency and intensity of light were kept constant.

(a) Explain how features of this graph show the photoelectric effect theory proposed by Einstein. **3**

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(b) Sketch on the graph above a curve that shows how the photocurrent would change if the frequency of light was increased, and the intensity was doubled. **3**

12 Phys Trial Exam – Marking Guidelines

Multiple choice answers

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

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

Question 21 Band 2-5

Zoom link:

https://knox.zoom.us/rec/play/aW2oM_jd-kzkCENQr2HLZ73B8d4_0gD5VsWsJuaehH-lCPRo65VCN5bp4RqMcqVzmFFYjV_U6vRTHayI.aqLpX6wI9ew1zODj

(a) Marking Criteria:	Marks
Appropriate equation used to determine correct torque value using data provided.	2
Some working towards calculating torque.	1

Markers comments

This question was VERY well answered by the cohort. With the vast majority of students achieving 2 of the 2 marks on offer. This question was the first short answer question, should have been an easy question to achieve and build some confidence!

What worked well:

- Majority of students were able to identify the correct equation from the formula sheet and apply it to this stimulus.
- Whilst it was not marked, majority of students answered the question to the correct significant figures and units.
- The level of working out seen across the cohort was good, with majority of students showing full working, including formula, data and conversions and substitutions (ICESRA and SUDS).

Even Better if:

- It was disappointing to see some very silly mistakes.
    - Some students had no idea and chose the wrong formulas.
    - Some students did not convert the lengths of the wires to meters
    - Some students did not show units (this was penalised).
    - Be careful on how you write your units – nm is nanometers – Nm is Newton meters!

Student Samples

(a) Calculate the magnitude of the torque generated by the motor when in the position shown. 2

$\tau = nBIA\sin\theta$ $A = 0.06m \times 0.04m$ $\sin\theta = 1$

$I = 1.2A$

$B = 2.4 \times 10^{-2} T$

$\therefore \tau = (2.4 \times 10^{-2})(1.2)(0.06 \times 0.04)$

$= 6.9 \times 10^{-5} Nm$

(a) Calculate the magnitude of the torque generated by the motor when in the position shown. 2

at position $n = 1$ $I = 1.2$ $A = 0.06 \times 0.04$ $B = 2.4 \times 10^{-2}$

$T = nIAB\sin\theta$ at this point $\theta = 90$

$T = 1.2 \times (0.06 \times 0.04) \times 2.4 \times 10^{-2} \times \sin 90$

$T = 6.9 \times 10^{-5} Nm$

(b) Marking Criteria:	Marks
Graph shows sinusoidal relationship starting at a maximum, reaching zero twice, always on one side of the horizontal axis	3
Graph mostly correct with ONE omission or error such as ● Not reaching zero ● Starting at zero ● Being more or less than one cycle ● Going above and below the axis	2
Graph has some correct feature	1

Markers comments

This question was VERY well answered by the cohort. With a good spread of students, about 2/3 of students achieved 3 of the 3 marks on offer.

What worked well:

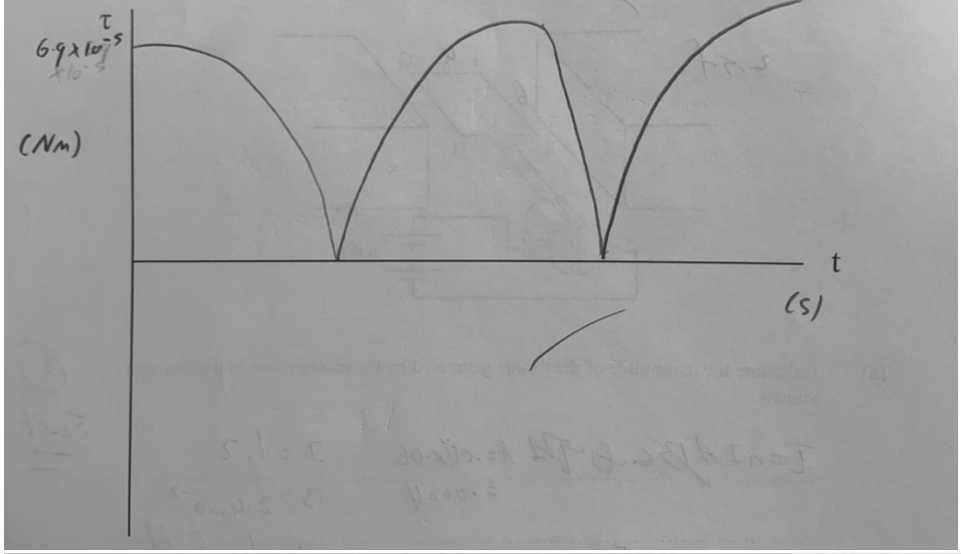
- Students were able to draw the correct graph
- Some students drew more than one revolution, though they annotated their graph at the one revolution mark, therefore this was not penalised.
- Most students were able to identify and draw all features of the graph.

Even Better if:

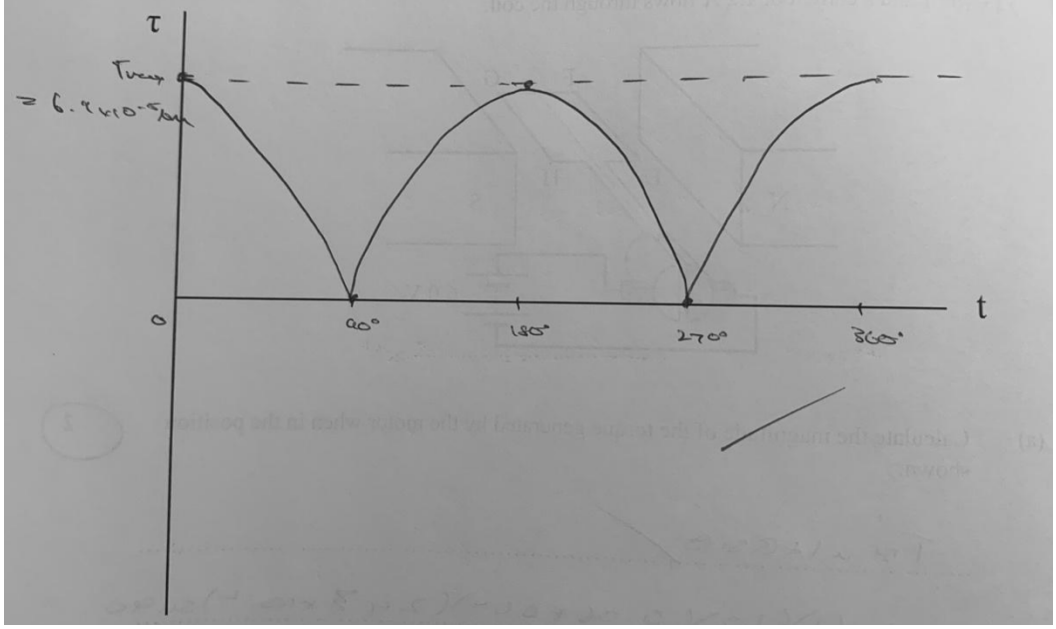
- Be careful with your sinusoidal shape – some graphs were drawn very poorly in terms of shape
- If you drew a sine curve – maximum 1
- If your graph was not above the axis – maximum 2

Student Samples

(b) On the axes below, sketch a graph to indicate how the torque changes as the coil rotates through one full revolution from the position shown in the diagram. 3



(b) On the axes below, sketch a graph to indicate how the torque changes as the coil rotates through one full revolution from the position shown in the diagram. 3



Qu 22 – Band 2-5

Zoom Link

https://knox.zoom.us/rec/play/iE8tiZliTpasJTF9FkMqyWkVeQ8G-1ehq91zpkUBdJGMcpX-zNab2PD1cXxu1TJQFN4YY3mF04A-gFGO.WFqf-hiPnJaoGs0g?autoplay=true

(a) Marking Criteria:	Marks
Correct answer given with working shown	2
One correct step shown in working	1

Markers comments

Generally well answered with ⅔ of students achieving full marks.

There were a number of ways in which student could complete the questions

What worked well

- Students were aware of units and significant figures in their calculations
- Most students took care with layout of working

Even Better if

- Need to work smarter, not harder. Easier ways to complete calculations (See example below).
- Better understand units and convert between them.

Student Sample

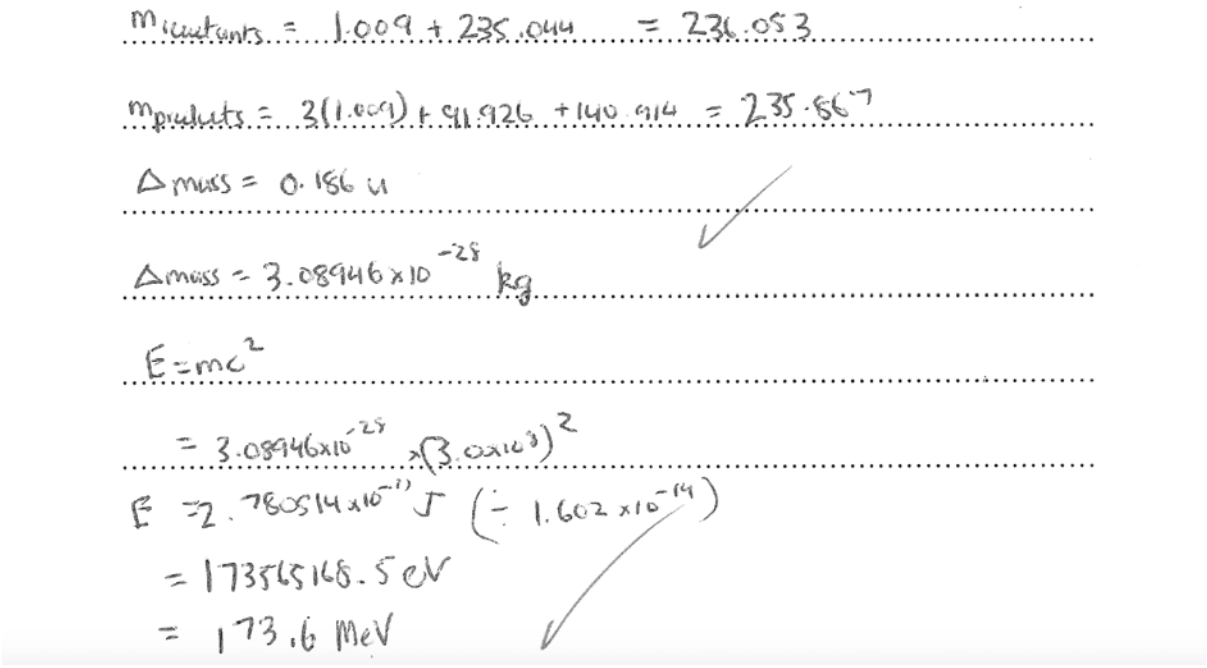
(a) Calculate the energy released in MeV from the fission of one atom of uranium-235. **2**

$(1.009 + 235.044) - (91.926 + 140.914 + (3 \times 1.009))$

$236.053 - 235.867 = 0.186$ u

$0.186 \times 931.5 = 173.3$ MeV (4 S.F.)

(a) Calculate the energy released in MeV from the fission of one atom of uranium-235. **2**



(b) Marking Criteria:	Marks
Correct answer given with logical working shown	3
Substantially correct answer with a minor error or omission	2
A correct calculation given / correct working with mistake	1

Markers Comments

Generally not well done by the students. Only 1/2 of students received full marks.

What worked well

- Students that got the wrong answer in part a were not penalised as errors were carried forward
- Most students presented their work in a logical sequence

Even better if

- Student listed equations
- Showed calculations - lots of number jumping without rationale
- Review this concept. some confusion on energy mass changes.
- E = mc2 must use kg

(b) The fission of uranium-235 is considered to be a better source of energy than the combustion of fossil fuels like coal.

- 1.0 kg of uranium-235 contains 2.56×10^{24} atoms.
- 1.0 kg of coal produces 31.2×10^{6} J of energy when combusted.

Calculate the ratio of the energy produced by 1.0 kg of uranium-235 to the energy produced by 1.0 kg of coal. **3**

- From (a), fission of one U-235 atom releases 173.3 MeV.
- In 1.0 kg / 2.56×10^{24} atoms
  => Energy released = $173.259 \times 2.56 \times 10^{24}$
  = $4.43543... \times 10^{26}$ MeV
  = 7.11×10^{13} J (3 s.f.)

($\times 10^6$, $\div 1.602 \times 10^{-19}$ (MeV -> J))

- Ratio of energy released by U-235 : energy released by coal
  => 7.11×10^{13} J : 31.2×10^{6} J
  $2.28 \times 10^{6} : 1$ ✓
  i.e. 2.28×10^{6} more energy produced by U-235.

Question 23a Band 2-4

Zoom link:

https://knox.zoom.us/rec/play/AiCiDP5vw-5rpAuaYn7KxZZCoA_s-YIgQLOnKiBHkEo6YDFnu49xiIzZF9VXQ9EMkegGSubbx7xvDGPA.xYJyismLS8dJRluS

Marking Criteria:	Marks
Structure of laminated core linked to efficiency in performance of transformer	2
Some correct point is made about the core	1

Markers comments

This question was well answered by the cohort. With majority of students achieving 2 of the 2 marks on offer.

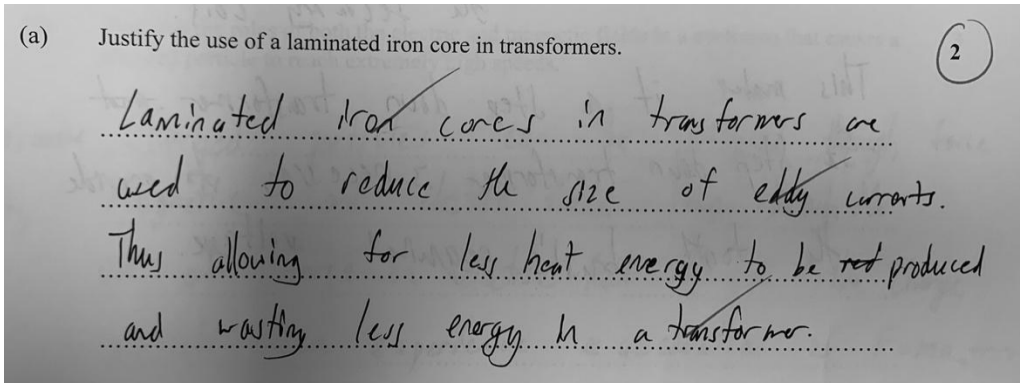
What worked well:

- Students have a good understanding of transformers and the use of laminated cores

Even Better if:

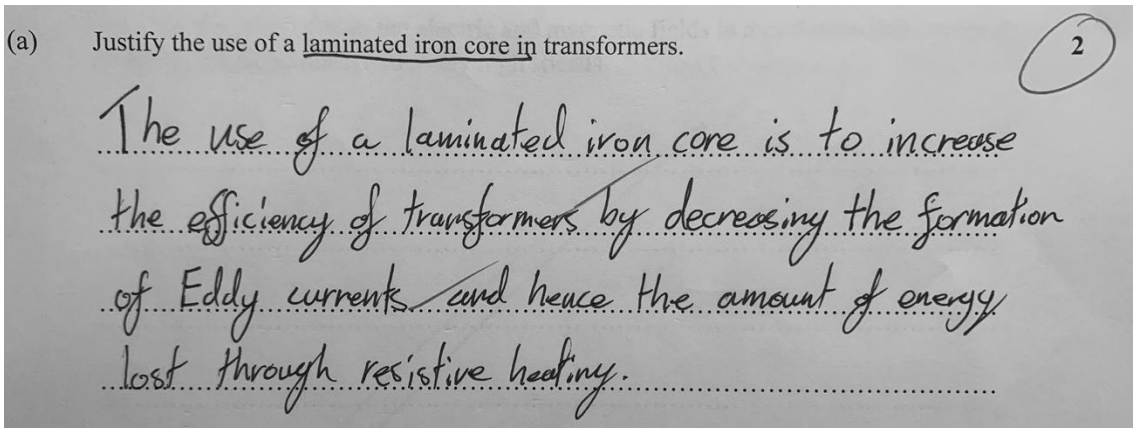
- There is some confusion between students on the function of lamination – lamination has nothing to do with improving flux linkage (this was ignored and not penalised – can be in the HSC depending on the marking criteria). The soft iron core allows for flux linkage – this means ANY soft iron core allows flux linkage. The lamination is responsible for making the eddy currents smaller (literacy lesson here, smaller means smaller, not less, not reduced, but smaller size), therefore reducing the resistive heating in the core.
- Some students say lamination reduces the production of eddy currents – again, eddy currents are still produced, but their size is smaller. (not penalised)
- Some students spoke about the amount of eddy currents – again, not relevant as it is a function of their size. (not penalised)
- The above that were not penalised was due to the banding of this question – as a band 2-4 question, most students in this cohort should be achieve 2 of the 2 marks on offer – ie it was not marked very strictly – but again, a question like this could be in the HSC.
- Some students went on a tangent to explain to me how transformers work, this is irrelevant to the question – don't waste time, answer the question and move on!

Student Samples



(a) Justify the use of a laminated iron core in transformers. 2

Laminated iron cores in transformers are used to reduce the size of eddy currents. Thus allowing for less heat energy to be ~~not~~ produced and wasting less energy in a transformer.



(a) Justify the use of a laminated iron core in transformers. 2

The use of a laminated iron core is to increase the efficiency of transformers by decreasing the formation of Eddy currents and hence the amount of energy lost through resistive heating.

Question 23b Band 2-4

Marking Criteria:	Marks
Uses appropriate equation linking voltage p/s to number coils p/s to show more coils needed in primary than secondary	3
Linked voltage p/s to number coils p/s to show more coils needed in primary than secondary with some errors or omissions	2
Some correct point is made about coils/voltage relevant to question	1

Markers comments

This question was well answered by the cohort. With a good spread of students, about 1/2 of students achieved 3 of the 3 marks on offer.

What worked well:

- Most students were able to identify the correct transformer equation
- Students were able to use the stimulus in their question, obtaining data from the stimulus.
- Question was very well attempted by the cohort with VERY rare non attempts! – this is excellent! Attempt all questions!

Even Better if:

- Disappointing to see some students only did the mathematical work for this question and did not EXPLAIN how the mathematics apply to the DESIGN of the transformer. This does not answer the question.
- Some students found the correct ratio for the voltage – but did not relate this to the number of coils or the design of the transformer
- Some students went on the wrong tangent, writing about the core etc – this was ignored as the question was about the output voltage and not the efficiency.

Student Samples

(b) By using a relevant equation, explain how the design of this transformer produces the required output voltage for the toothbrush to charge. 3

- The input and output voltage as well as the number of coils in the primary and secondary coil is linked by the equation: $\frac{V_p}{V_s} = \frac{N_p}{N_s}$ ✓
- And, since $V_p = 240V$ $V_s = 12V$, $\frac{N_p}{N_s} = \frac{240}{12} = 20$ ✓
- Thus, by ensuring the primary coil has 20 times the number of coils than the secondary coil in the transformer, voltage can 'step-down' from 240V to the required 12V for the toothbrush. ✓

Excellent.

(b) By using a relevant equation, explain how the design of this transformer produces the required output voltage for the toothbrush to charge. 3

$V_p = 240V$ $V_s = 12V$

$\frac{V_p}{V_s} = \frac{N_p}{N_s}$

$\therefore \frac{N_p}{N_s} = 20$ ✓

The required output voltage can be achieved if the number of coils in the primary coil is 20 times that of the secondary coil. ✓

Excellent.

Question 24 Band 2-6

Zoom

https://knox.zoom.us/rec/play/vq5re-41z13BWjnHQ2av_tVIULKifkxXUHDvD7nXKAkcUH9lU8KZ8rBy3w2msX6_ExrtRFjB35BJnYv0.9XrDiDK5OJkchA3W?autoplay=true

(a) Marking Criteria:	Marks
Response effectively describes most of the following; ● The increase in speed of the particle in the electric field region between the dees during each cross of the space ● The factor of alternating current in E Field ● Direction of forces ● Change of direction (UCM) of the particle inside the dees in the magnetic field ● Enlarged radius of path as speed increased in mag field	3
Response mostly describes the increase in speed of the particle in the electric field region between the dees during each cross of the space and the change of direction (UCM) of the particle inside the dees in the magnetic field	2
Response makes some correct statement about the electric or magnetic field.	1

Markers comments

Generally answered well with ⅔ of students achieving full marks

What worked well

- Most students included equations in their responses.
- Used structure; Headings and subheadings.

Even better if

- Annotate your diagram. Often answers were unclear as to the path of the electron.
- Logical sequence of ideas
- Clear forces and effects with each field (See examples)
- Need to use subject specific terminology “spin around” “back and forth”

(a) Describe the roles of both the electric and magnetic fields in a cyclotron that causes a charged particle to reach extremely high speeds. **3**

- the E-field is responsible for accelerating the charged particle by $a = \frac{qV}{md}$
- the B-field ensures that the particle undergoes uniform circular motion in the dees so that it can get accelerated back into the other dee as the E-field AC switches direction due to AC supply. Process repeats to increase particle speed

(b) Marking Criteria:	Marks
Response effectively describes most of the key features: ● high kinetic energy of particles, attained in particle accelerators ● enables collisions ● reactions that can be used to observe fundamental particles ● Examples of interactions between them.	3
Response describes most of the key features of the way in which high kinetic energy of particles, attained in particle accelerators, enables collisions which cause reactions that can be used to observe fundamental particles and the interactions between them.	2
Response provides some correct information about particle accelerators	1

Markers comments

Mostly well completed. ⅔ of students receiving full marks.

What worked well

- Students addressed all areas of the question - it was multifaceted
- Good knowledge of content / examples

Even better if

- Needed to clearly link collisions as the method to break apart particles
- Need to use subject specific terminology

Explain how particle accelerators are able to provide evidence for the Standard Model of matter. Include a specific example in your answer.

- Particles of known mass are collided at high velocity, the resultant products' mass are evaluated & compared to the total mass of the input particle. the new / 'missing' mass is suspected to be a fundamental particle released in the collision. Example is the evidence towards the existence of the Higgs Boson particle from the Large Hadron Collider.

Question 25 Band 2-5

Zoom link:

https://knox.zoom.us/rec/play/PGPw5rFNnAl1lBwy9Z5Wl53PadbyDqiiRvRMuRk-ZUAh1oMOCJ56Wbh8AbxuyqfdBHKJm5nSb65w5bQx.0HlCmeZledqSrAFm

Marking Criteria:	Marks
Thorough explanation provided referring to Kepler's third law and relevant equations	3
Correct explanation given without reference to Kepler's law but using relevant equation	2
A correct piece of information given	1

Markers comments

This question was well answered by the cohort. With a good spread of students, about 2/3 of students achieved 3 of the 3 marks on offer.

What worked well:

- Students were able to relate the data to Kepler's third law and identify the relevant equations.
- Some students were able to relate the data to constructing a graph of R^3/T^2 and using the LOBF from that graph to find the unknown (EXCELLENT!)

Even Better if:

- Some students did not read the question – it asks you to explain qualitatively – qualitative means using words!
- Some students only completed calculations – this does not answer the question and you achieved a maximum of 1 mark.
- Some students alluded to Kepler's third law – don't allude – be explicit – as a marker, I wanted to see the full equation, then identifying that it was the same planet and hence the $GM/4\pi^2$ was constant for all moons.
- Some students only gave half the answer – yes I understand that the constant can be calculated from the data, but then how do you USE this to get the orbital radius?

Student Samples

Explain qualitatively how you could use the data in the table to calculate the orbital radius of Rhea. (3)

- Kepler's 3rd Law states that for any ~~two~~ objects orbiting the same central mass (like a moon around Saturn), it will satisfy $\frac{r^3}{T^2} = \frac{GM}{4\pi^2} = \text{constant}$ ✓
- To find r of Rhea, we can substitute any of the datapoints in the above table into $\frac{r^3}{T^2} = \text{constant}$ to find the value of this constant (could average values of constant for increased reliability)
- Then, by $\frac{r_{Rhea}^3}{T_{Rhea}^2} = \text{constant}$, where $T_{Rhea} = 3.90 \times 10^5$ s, we can now find r_{Rhea} as required ✓

Excellent.

Explain qualitatively how you could use the data in the table to calculate the orbital radius of Rhea. (3)

- It is known that all 5 moons orbit the same object ✓ hence by Kepler's 3rd Law ($\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$), it can been seen since G, M, π are constant; the ratio of radius cubed to period squared is equal for all objects orbiting the same mass ✓
  - ↳ hence by equating the ratio of r^3 to T^2 between Rhea and one of the other moons, ~~the~~ orbital radius can thus be calculated as Rhea's period is known & radius and period of other 4 moons ~~are~~ also known

excellent.

Qu 26 Band 2-6

Q26)
Zoom: https://knox.zoom.us/rec/share/AljzJ8BUCq0gZn1YiMNbQ-7YADcPWJRILuStLJcn51tHU61SbcEdE_4yiN5NyI0A.kRrrVCpydYkKiWoG

Marking Criteria:	**Marks**
Extensive analysis of the sequence of events shown including - correct role of forces, fundamental particles and temperature in the formation of particles, nuclei and atoms.	6
Thorough analysis of the sequence of events shown including - correct role of forces, fundamental particles and temperature in the formation of particles, nuclei and atoms.	5
Sound description of the sequence of events shown including - correct role of forces, fundamental particles and temperature in the formation of particles, nuclei and atoms.	4
Sound description of the sequence of events shown including - role of forces and fundamental particles and/or temperature in the formation of particles, nuclei and atoms.	3
Some correct statements shown on at least ONE of the forces and particles in the formation of nuclei or atoms	2
One relevant and correct statement made	1

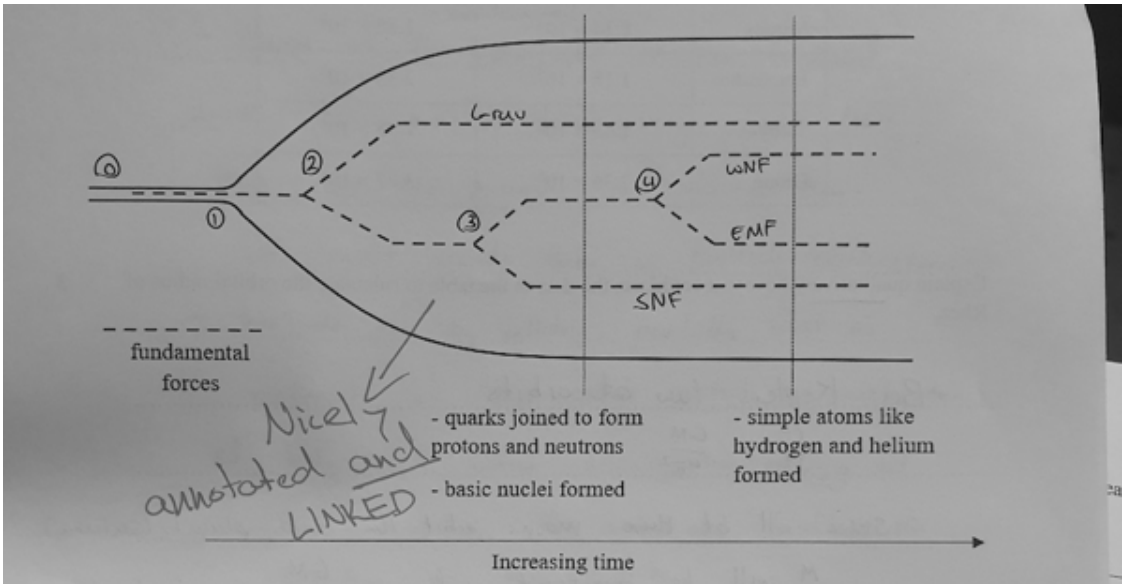
General comments and **W**hat **W**orked **W**ell:

- This question was marked holistically based on the marking criteria above.
- Reasonably attempted question with a cohort average of 3.5.
- The good responses **annotated the stimul**us given in the question. The even better responses linked and related their annotations to their written response. This enabled their ideas to be communicated with more clarity 'punch.'
- The better responses structured and communicated their ideas and understanding using '**dot-points**' and **clear headings**.

Even **B**etter **I**f:

- Carefully **R**ead **T**he **Q**uestion (RTQ). The key verb in this question asked for **analysis**. Many boys simply described at best – thus not accessing higher band marks.
- Responses lacked depth and detail which indicates an area for students to review.
- Responses are required to address specific aspects of the question and stimulus provided with depth and correct detail – not merely rewording the given stimulus.

Sample



Nicely annotated and LINKED

Analyse the sequence of events that occurred after the Big Bang that led to the formation of simple atoms like the helium atom. 6

- Initially, the universe was contained within a singularity (0) ✓

- This singularity began to expand (1), releasing matter and antimatter stored within. This matter / antimatter included quarks and leptons, and their antimatter equivalents. As releasing radiant energy, matter and antimatter annihilated, the universe was ✓

6

Space for answer continues over page

Well answered Q.

Great level of Depth + Detail to ATQ.

nicely worded.

initially extremely hot; however as the rate of annihilation decreased as antimatter was reduced, temperature began to dissipate as the universe continued to expand.

- The first fundamental force to decouple was gravity (G), however as all fundamental particles are low in mass this had little effect on atom formation and ↑KE!
- Following this, the strong nuclear force decoupled; the force responsible for binding quarks together, and as a result protons (2 up quarks + 1 down quark) and neutrons (2 down quarks + 1 up quark) began to form. Small nuclei (such as hydrogen (1p, 1n) and helium (2p, 2n)) began to form.
- The last two forces to decouple were the weak nuclear force and electromagnetic force (EM). This electromagnetic force allowed protons and electrons to attract, and led to electrons being attracted to nuclei → the first atoms formed. E.g. 2e⁻ attracted to a helium nucleus (2p+2n), leading to the formation of a helium-4 atom.

well structured.

well linked.

Question 27 Band 2-5

Zoom

https://knox.zoom.us/rec/play/kYzUNIg2vPXp-SMXfrRq6GDxGQCOIG_QLOu475jgl1oZk0TNsO4aCLprrdWFDZE4PVJwPbcLV0Apv8_h.Amoep1cgZBaj6VCC?autoplay=true

Marking Criteria:	Marks
Graph used to find half life and correct Calculation done to determine decay constant. Conclusion made about isotope identity	3
Substantially correct calculation with minor error OR Correct calculation but no identification of isotope	2
Some correct step in the calculation	1

Markers Comments

Generally done well. About ½ the students received full marks

What worked well

- Most calculations shown in detail required.
- Students selected an isotope rather than just leaving a number - RTQ.

Even better if

- Need to state equation.
- Students need to review half life concept.
- Suck the life out of the stimulus - miscalculation of half life (in seconds).

Student Sample

By calculating the decay constant from the information in the graph, determine which radioactive isotope from the table is shown on the graph. 3

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

$= 172800$ seconds ✓

$\therefore \lambda = \frac{\ln 2}{172800}$

$= 4.011268... \times 10^{-6}\ s^{-1}$ ✓

$\therefore$ By inspection radio-isotope must be

$= 4 \times 10^{-6}\ s^{-1}$ (lf) Lead-198 ✓

Question 28 Band 2-6

Q28) Zoom:
https://knox.zoom.us/rec/share/Yq_yxMehX95R0rdcMf12H9sM9qnhDOgDTpG_xRY0ds0e5S1gfRXlV1Ftukn0GeQ5.WRHazV_WD1A2k3XU

Marking Criteria:	**Marks**
Correct similarities and differences extensively described and relevant.	5
Correct similarities and differences thoroughly described and relevant, with one major error or minor omission.	4
Correct similarities and differences soundly described and identified, with some errors and omissions.	3
At least two correct similarities or differences soundly described.	2
One relevant and correct statement made	1

General comments and **W**hat **W**orked **W**ell:

- This question was marked holistically based on the marking criteria above.
- A well attempted question with a cohort average of 3.5.
- Most responses structured and communicated their ideas and understanding using 'dot-points.'
-

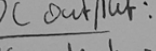
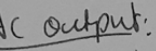
Even **B**etter **I**f:

- Carefully **R**ead **T**he **Q**uestion (RTQ). The key verb in this question asked for a **description** of the similarities and differences. Rather than describing, many boys simply identified the similarities and differences – thus not accessing higher band marks. In addition, some boys made the error thinking that this question was about motors.
- **Annotate** and use the **stimulus**. Link to your response where applicable.
- **Use diagrams** to enhance and assist the ideas you are trying to convey. Eg the difference in output of an AC and DC Generator.
- Know the content and careful with **syntax** and **specific details** (e.g DC uses a split ring commutator – not a 'slit' ring)
- Avoid writing over-generalised statements such as "DC generators have DC and AC generators have AC."

Sample

Complete the table below, describing ONE similarity and ONE difference for each of the structure, mechanism of electricity generation, and output of each type of generator. 5

5

	Similarity	Difference
Structure	both generators involve stationary magnetic fields to operate and produce ~~another~~ a $\Delta\Phi$ resulting in current. ✓	the AC generator has a 'slip' ring, whilst the DC generator uses a 'split' ring. ✓
Process of electricity generation	Both ~~have~~ use the pricipal of electromagnetic induction to form currents via Faraday's law & stating a $\Delta\Phi \rightarrow$ current in the coil. ✓	The DC generator has split rings which ~~for~~means that the current will always be positive, whilst the AC generator ~~produces~~ current that oscillates between positive and negative. ✓
Output	Both generators convert kinetic energy to an output of electrical energy in the form of current through the circuit. ✓	DC output:  DC output is always positive in current direction ✓ AC output:  ✓ Ac output current oscillates based on which part of rotation it is in, and produces positive and negative current periodically.

Question 29 Band 2-6

Marking Criteria:	Marks
Detailed, correct and fully labelled diagram of experimental setup AND Extensive explanation of the experimental setup and results and the conclusion drawn and significance of the experiment in advancing the model AND Specific reference to how it advanced the atomic model from a well enunciated preceding model	5
Correct and labelled diagram of experimental setup AND Thorough explanation of the setup/results/conclusion drawn/significance of the experiment AND Some reference to how it advanced the atomic model from a preceding model	4
A substantially correct experimental diagram AND Sound description some of the setup and results/conclusion drawn of the experiment	3
Some points made about the setup and/or results of the experiment and/or new model and/or an effective diagram	2
One relevant point made about the experiment	1

Note: Most students (> 90 %) chose Rutherford's experiment

WWW:

- thorough and fully labelled & annotated diagram (s) saves many words in response
- clear structure enabled succinct response that addressed all key points well

EBI:

- facts were better known and understood eg 1. many students talked about protons in the gold foil experiment which were discovered 4 years after it was finished 2. many students indicated that Rutherford expected alpha particles to be absorbed by the gold foil when in fact they were expected to pass through the low density 'plum-pudding' atom unaffected 3. many students think that Rutherford used some sort of particle gun which was invented 30 years after his death (he used an alpha emitting radioactive source) 4. Rutherford fired electrons/protons/'particles' etc

  Poor facts convince the marker you don't know your stuff - you need to convince them in the HSC that you are all over it!

- a logical sequence presented all aspects of the question clearly
- all students included all relevant details (even in abbreviated or point form) needed to address all aspects of question *(read with a pen)*

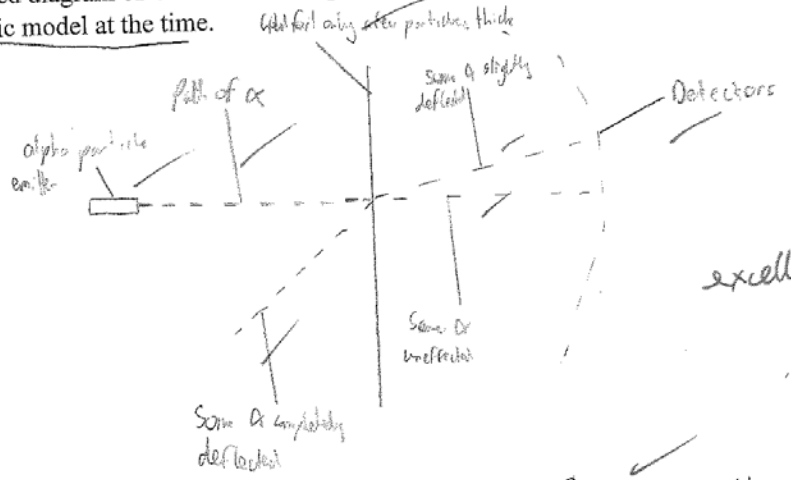
Significant experiments included the Rutherford's gold foil [illegible]
experiment and the Davisson-Germer experiment.

5

Draw a fully labelled diagram of ONE of these experiments and explain how the experiment advanced the atomic model at the time.

5

Rutherford:



excellent

Prior to Rutherford's theory was Thomson's Plum Pudding model. Which was negative 'bits' in a positive area. Rutherford's gold foil experiment involved firing α particles at a thin foil strip. The scientist predicted all would pass through unaffected however he found that some particles were deflected as seen, and in some extreme cases (1 in 8000) completely deflected also as shown. This lead him to conclude the atom was mostly empty space with the mass in the centre creating for how some particles were repelled by the +ve nucleus or completely deflected when they approached head on. He said the electrons were on the outside in orbits but did not elaborate or explain any limitations. This was the first model to suggest a 'nucleus' or the atom being mostly empty space. It looked like:

Question 30 Band 2-6

Marking Criteria:	Marks
Extensive response accounts for each section with full, correct, detailed qualitative and quantitative physics	7
Thorough response accounts for each section with predominantly correct, detailed physics	5-6
Sound response accounts for most sections with some appropriate physics OR Section A or C extensive response with others weak/very weak	3-4
Limited response accounts for one section with appropriate physics or superficially accounts for two sections or very weak across 3 sections	2
Some correct physics statement made about the situation.	1

WWW:

- Most students approached question with clear and useful structure
- Many students showed excellent knowledge of Physics and good logic and used scientific language effectively to communicate high levels of detail in exceptional responses
- Very, very few non-attempts or half-hearted attempts

EBI:

- students knew that eddy currents DON'T flow in solenoids but only in blocks or sheets of conductive material
- students perceived that moving away from the electromagnet at the top (L) AND towards the magnet at bottom (N) were BOTH change of flux situations
- students represented ALL steps of the Faraday and Lenz process: change of flux -> Faraday's emf -> current -> magnetic field in M -> in direction to exert force to oppose change in flux
- students were clear that decreasing positive acceleration is not the same as slowing down NOR decelerating (at no stage does the trolley slow down or decelerate or stop for that matter)

Account for the acceleration of trolley M in Sections A, B and C of the graph, and for the maximum recorded acceleration value. 7

7

hot!

Section A

· The acceleration of M is initially 0 due to the trolley being released from rest

· The trolley will experience Force and hence acceleration due to gravity at a rate of $g\sin\theta = 9.8\sin 20.0^\circ = 3.35\ ms^{-2}$ 3sf

HOWEVER

As the trolley moves away from L, it experiences a change in magnetic flux and by Faraday's Law, an emf is induced in M and thus a current

The current in M will flow such that ~~a~~ a magnetic field is induced opposing the original magnetic field (Lenz's Law)

$\Delta\phi$ (to the left)

∴ L and M will experience an attractive force between their two closest ends.

∴ $F_{net} = F_g - F_{magnetic}$

$F_{magnetic}$ decreases however as M moves further away until $F_{net} = F_g$

↳ a increases at decreasing rate.

Section B

· The acceleration of M is now solely due to gravity acting on the trolley down the ramp i.e. $g\sin\theta = 9.8\sin 20.0^\circ = 3.35 ms^{-2}$

· This is also the maximum recorded acceleration value

Space for answer continues over the page.

Section C

As M moves towards N

Once again, there is a $\Delta\Phi$

↳ Faraday's Law an emf is induced hence a current

↳ Direction of current will flow in order to create an induced magnetic field to oppose the initial $\Delta\Phi$ from magnetic field (Lenz's Law)

∴ M and N will have the same polarity on the ends closest to one another

∴ M experiences $F_{repulsion}$

∴ $F_{net} = F_g - F_{repulsion}$

$F_{repulsion}$ increases as M becomes closer to N ∴ decrease in a at a increasing rate.

$a = 0$ when M reaches N

Question 31 Band 2-5

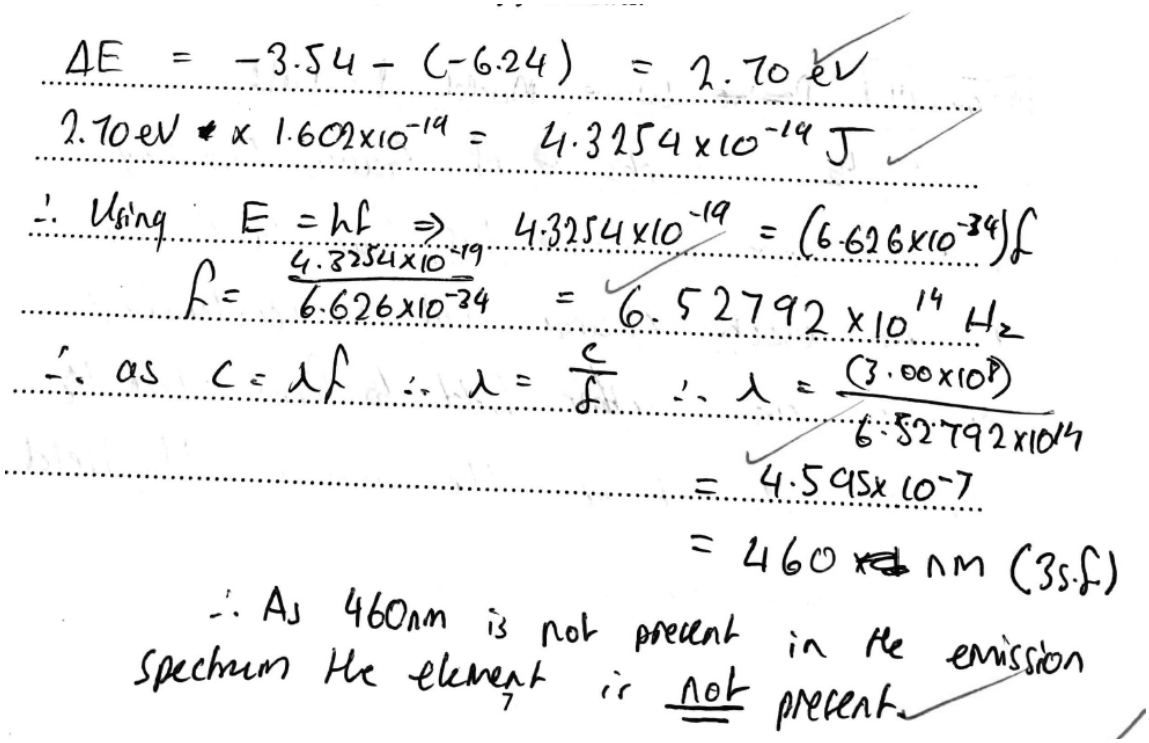
Marking Criteria:	Marks
Correct calculation done and conclusion made	3
Calculation mostly correct with minor error	2
One correct step in calculation made	1

Generally well done by a majority of students. A few points to note – this was marked at a Band 2-5 level so a few things were let go…. They may not be in the HSC, so please ensure you note whether this is an improvement you need.

- Not showing correct calculation of the energy gap (it is not 6.24-3.54 = 2.7). Correct formula is E = Ei – Ef. This is an exception to the normal rule of "final – initial". If you do "final – initial" then you get a negative energy – which is not possible…
- Not showing the conversion from eV to Joules – show your calculations – not penalised here, but would have made at least two-thirds of the full marks go down to 2/3 if a Band 2-6 question.
- Not ATQ – MUST make a statement about why it's not in the mixture. A number of students calculated a number then just said "so it's not in the mixture". A wavelength alone is NOT a reason.

MAJOR ISSUE;

- Use of the Rydberg equation – which is only for the hydrogen atom. This was clearly NOT a hydrogen atom.
- Likewise, stating that Balmer drops to n =2 so using the n=3 to n=2 drop – despite the question clearly stating n = 2 to n = 1 was a visible transition.



Qu 32 Band 2-6

Marking Criteria:	Marks
Extensive analysis of the evidence, model and experiments around the change from wave to particle model	8-9
Thorough explanation/analysis of all/most of the process used to change from wave to particle model	6-7
Sound description of some parts of the process used to change from wave to particle model	4-5
Some parts of the model described	2-3
Some parts of the model identified	1

Marks ranged from 0 (non attempts) to 9 – most students were around the 4-5 mark range where they knew part/all of the information – but not having the detail, not focusing on advancement of the model, or missing steps.

Good bits:

- Good structure from the majority
- Good annotations from nearly everyone – please see below for a sample of annotations that are exceptionally well done. This person could have scored 3-4 marks out of 9 on the annotations alone.
- Good general understanding of the progression of a model – well done
- Good general understanding of the concepts involved
- Good use of diagrams of UV catastrophe and photoelectric effect (can you please make them larger and clearer – even put them in their own space on the page – so they can be read without a magnifying glass??)

Not so good:

MAJOR ISSUE:

- Confusing WHO and WHEN was involved with this period of time and model development.
    - Maxwell's model is EM waves – thus the model should have been described (what is an EM wave?). Note that stating the four laws is NOT a description of Maxwell's model. Focus on the electric and magnetic fields
    - Contradicting evidence is the UV catastrophe. Maxwell's model suggests infinite INTENSITY (not temperature) when wavelength decreases (as frequency increases, oscillation speed increases, thus accelerating faster and releasing more intense EM radiation). Observations of blackbody radiation from stars and other blackbody experiments showed that there is a peak intensity then intensity drops at lower wavelengths – contradicting the prediction made by Maxwell.
    - New theory from PLANCK (before Einstein and before photoelectric effect) – proposed quanta of energy that mathematically could explain the observed curve (side note: very well done for the students who did explain the curve – very high level understanding shown – well done!!).
    - Experimental evidence – photoelectric effect – MUST show how wave does not work, and particle does – most students just stated the observations whch is not enough to show why it is experimental evidence of particle theory.
- Not a lot of students acknowledged that Maxwell's model was still valid for lots of situations just not this one (lots of comments about disproving the wave model…). LIGHT AS A WAVE WAS NOT DISPROVED, IT JUST DOESN'T WORK IN THIS SITUATION.

- Using Newton and Huygens (theories were very early – way before the work of Maxwell, Planck and Einstein). Get timelines in order!!

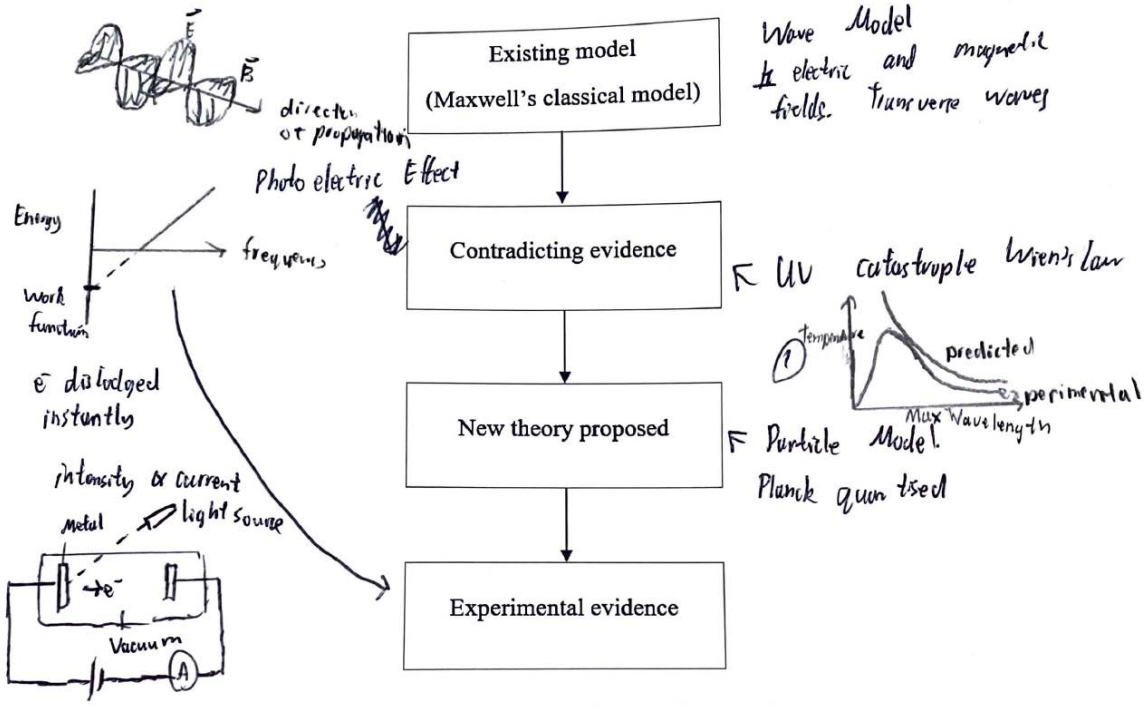
Other issues:

- Lacking the fine detail of the descriptions
- LINKS missing – lots of correct statements, but not showing links to previous model
- Missing explanations of WHY the particle model was supported/wave model was not supported – just statements/descriptions (see below for items that could be explained better)

Concepts to explain better/in more detail:

- Explain **<u>why</u>** classical model predicts lower wavelength = higher intensity
- Describe Maxwell's model – what did it actually mean (what is an EMR wave? What was the evidence that waves were electromagnetic?)
- Where did the "observed" come from on the UV catastrophe graph – what was being observed?
- **<u>Why</u>** do the observed features of the photoelectric effect show a particle not a wave?

A set of excellent annotations (that nearly scored 4/9 before I even read the answer)



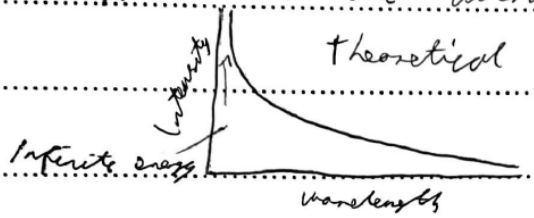
Student Sample

• Maxwell's classical model predicted that light was an electromagnetic wave. ✓

• This predicted that ~~oscillating~~ accelerating charged particles would create electric fields that created magnetic fields which would self-perpetuate as waves. good

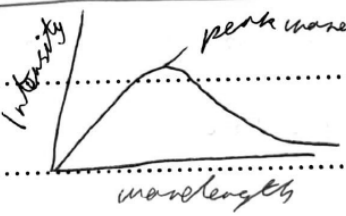
• Using this theory, and the ~~fact~~ idea that hot objects produce light due to oscillating charged particles, it was theorised that objects release light waves where intensity increases with frequency.

• This was known as the ultraviolet catastrophe. ✓✓ excellent



• This broke the Law of Conservation of energy as it suggested infinite intensity was produced and ∴ infinite energy. ✓ → from what??

• And the experimental results also differed from this:



and had a peak wavelength.

• This suggested that Maxwell's theory was incomplete as it could not explain this evidence ✓✓

• A new theory was then proposed in order to satisfy this evidence:

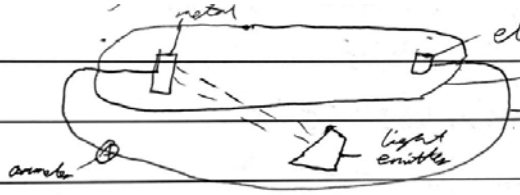
• This was the quantum theory of light proposed by Einstein. ✓

• Before this Planck had hypothesised that if light was quantised ~~as multiples of a constant~~ then the theoretical results would match the experimental ✓

• Einstein proposed ~~this~~ his theory where light was quantised packets of energy called photons with experimental evidence to support it. ✓ ($E=hf$) $E=hf$

• The photoelectric effect acted as his evidence.

• When light was ~~shined~~ shone onto a piece of metal in a vacuum, it emitted electrons: ✓



Electrons are emitted when they gain enough energy

The following observations supported the new theory:

- Electrons were emitted instantaneously
  - This suggests that light emits all of its energy to the electron at once – supports that light is quantised ✓ what does wave theory say?
- There is a minimum frequency for electrons to be emitted from the metal.
  - This suggests that light doesn't slowly give energy to an electron or all frequencies would emit them good. PTO →

  - It also suggests that the energy of light is directly proportional to its frequency supporting $E=hf$
- The only factor that affected the photocurrent was intensity.
  - This suggested that each payload (and frequency) of light hit one electron as high energy waves could theoretically release multiple electrons at once increasing photocurrent.

  ∴ Supported the idea of the photon. good.

Since Maxwell's model had flaws, a new theory was proposed and experimental evidence to support it meant it replaced the previous model, thus developing the particle model of light.

Question 33 Band 2-6

Q33a)Zoom:
https://knox.zoom.us/rec/share/r68yGUmjaqP6KRcs5wDoGv-oU5dXPLELYyLr0TYm4DTkztYfn2me2tSRLsJTDT2H.sVoqqFGGytLGXQDb

Marking Criteria:	**Marks**
Full working using appropriate equation yields a value that rounds to 7.6 x 10^9 J.	2
Some relevant piece of working completed.	1

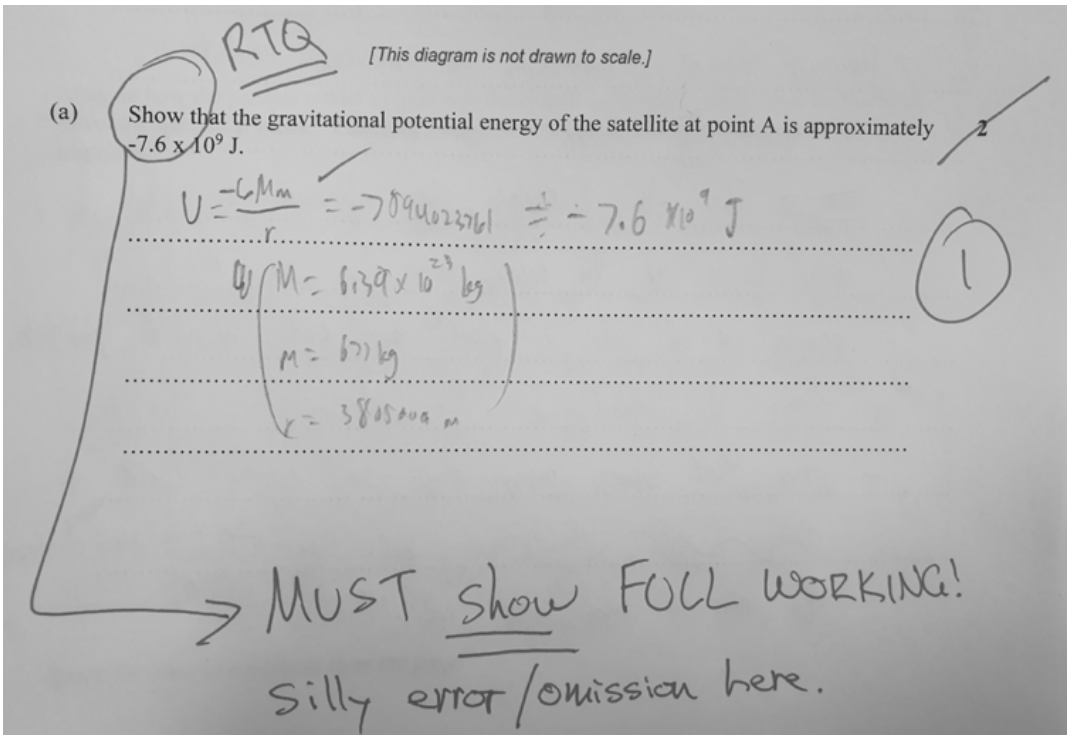
General comments and **W**hat **W**orked **W**ell (**WWW**):

- A very well attempted question with a cohort average of 1.75.
- Nearly all responses showed **good structure** and substitution in their working.

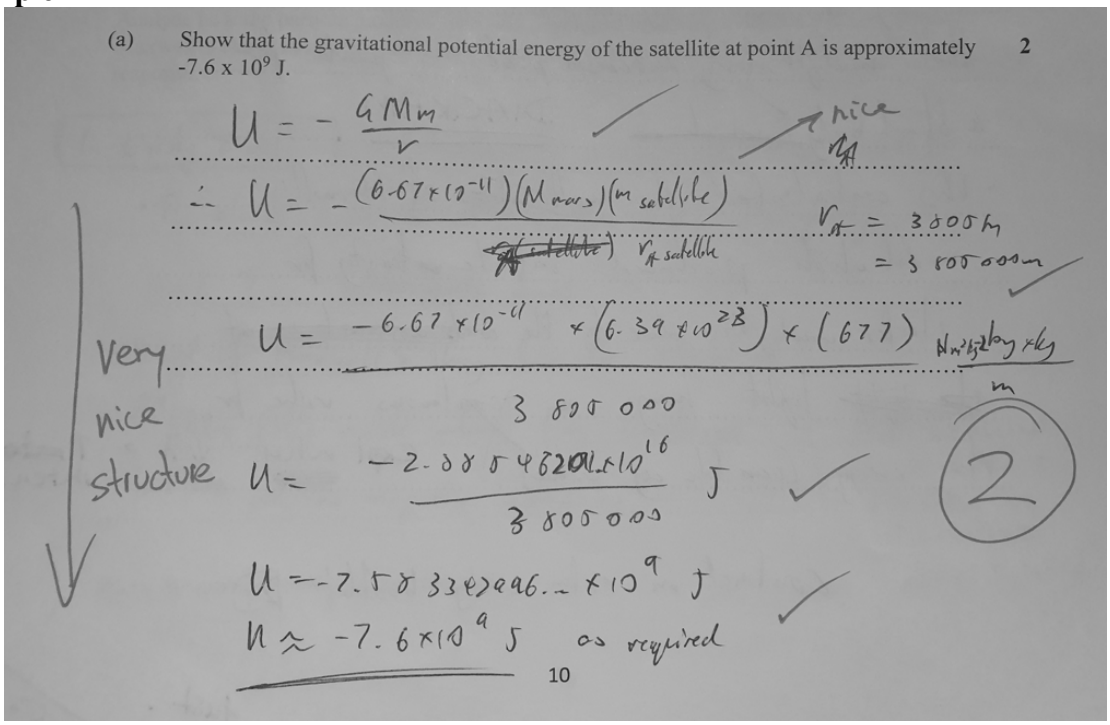
Even **B**etter **I**f (**EBI**):

- Carefully **R**ead **T**he **Q**uestion (RTQ) and avoid silly errors - convert radius from km to m.
- **Show full working**. Avoid "short cuts."

Sample A



Sample B



(a) Show that the gravitational potential energy of the satellite at point A is approximately -7.6 x 10^9 J. 2

$U = -\frac{GMm}{r}$ ✓ nice

$\therefore U = -\frac{(6.67\times10^{-11})(M_{mars})(m_{satellite})}{r_{A\ satellite}}$

$r_A = 3\,000\,\text{km} = 3\,800\,000\,\text{m}$ ✓

$U = -6.67\times10^{-11} \times (6.39\times10^{23}) \times (677)$ Numbers only

$\frac{3\,800\,000}{m}$

$U = \frac{-2.8854820\ldots\times10^{16}}{3\,800\,000}$ J ✓

$U = -7.5833\ldots\times10^{9}$ J ✓

$U \approx -7.6\times10^{9}$ J as required

Very nice structure

2

10

Q33b)

Marking Criteria:	Marks
Response uses Conservation of Energy or Kepler's Law to thoroughly justify why the speed of the satellite is fastest at point A.	3
Response uses Conservation of Energy or Kepler's Law to soundly justify why the speed of the satellite is fastest at point A.	2
Some correct and relevant point shown.	1

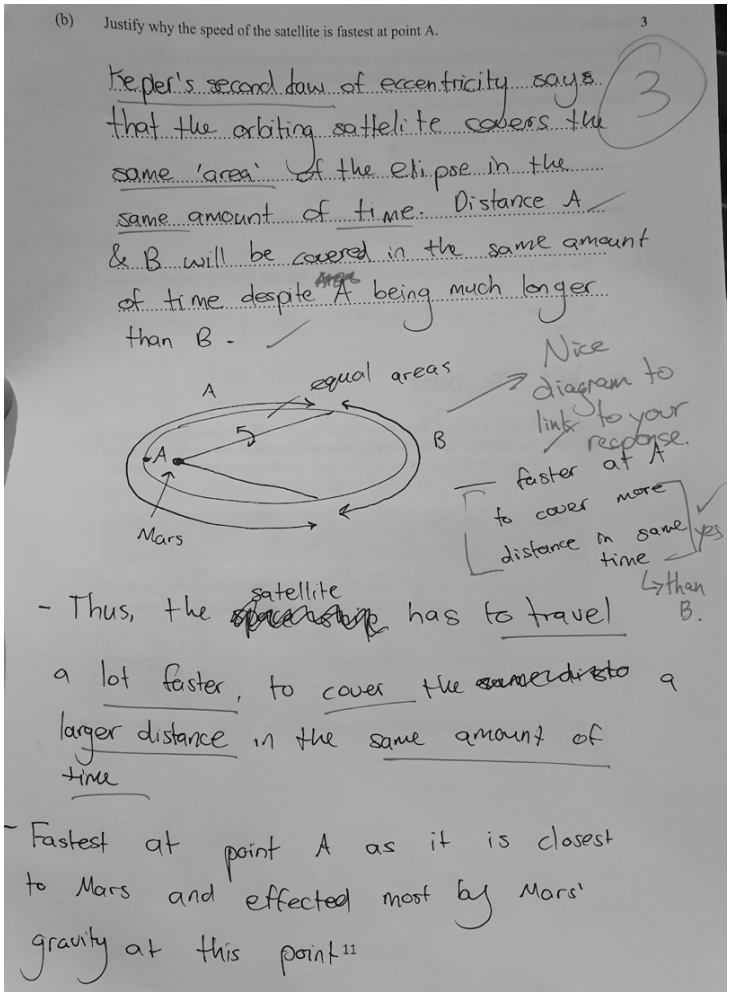
General comments and **W**hat **W**orked **W**ell (**WWW**):

- A reasonable attempted question with a cohort average of 1.8
- Nearly all responses showed good structure with the better responses **annotating the stimulus** and then linking to their written response.
- Strong responses often **drew a labelled diagram** to further increase the clarity of their written response.

Even **B**etter **I**f (**EBI**):

- Carefully **R**ead **T**he **Q**uestion (RTQ) and stimulus. The question clearly states and shows an object in an elliptical path – NOT circular path. Therefore UCM and related equation is not relevant here. Responses that incorporated UCM showed "good" physics – but it is NOT relevant to the question.
- Strong responses communicated their ideas with depth/detail. Linking correct ideas or relating written ideas shows "good physics" rather than having isolated statements.

Sample



Question 34 Band 2-5

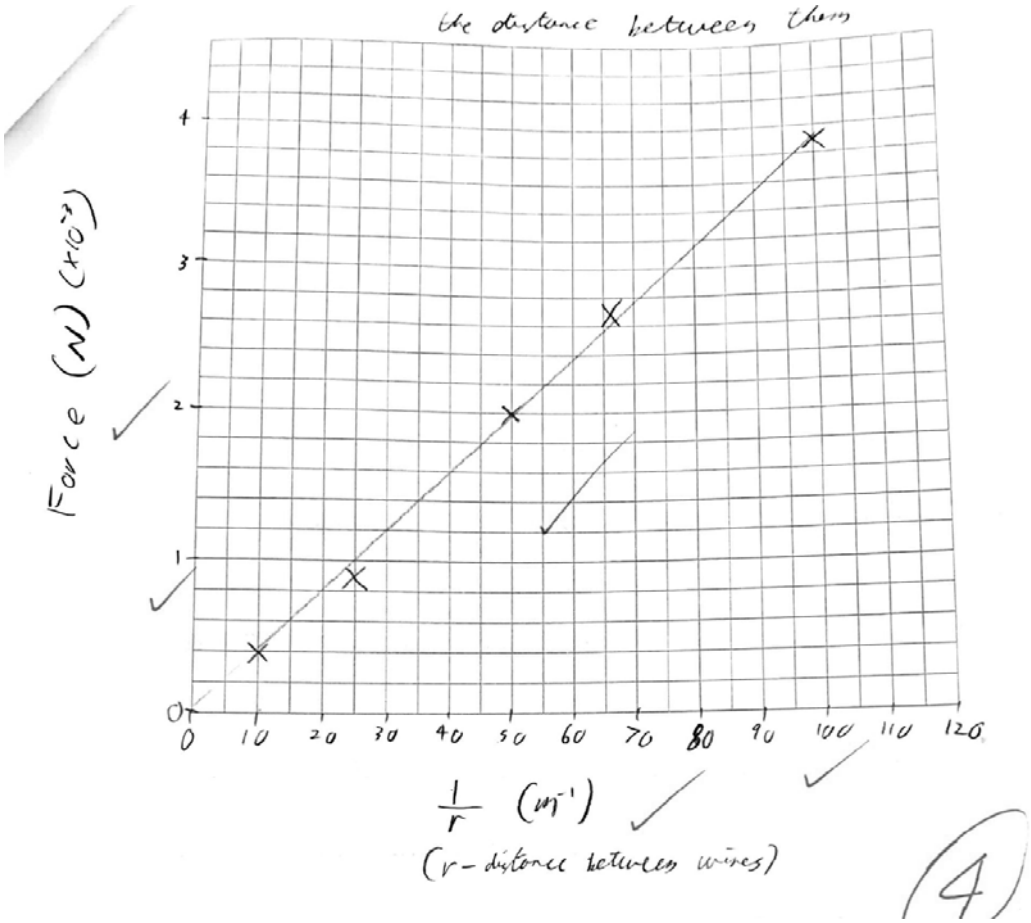
(a) Marking Criteria:	Marks
Correct direction	1

Vast majority of the cohort got this right – please note question does not ask for an explanation – don't give one unless specifically asked. A few students need to review use of right hand grip rule for a single wire.

(b) Marking Criteria:	Marks
Graph is correct with: ● Correct scales, axes labels and units, correct plotted points and appropriate LOBF	4
Substantially correct graph with minor error/omission	3
Some correct graph features	2
One correct graph feature	1

Excellent work on the graphing, scales were good, LOBF very well done – just a few students made a careless mistake when plotting one of the points.

Majority of the cohort awarded 4 marks, a few 3s. A few non attempts – this is easy marks, do questions like this first. Get them out the way, should be a few extra easy marks.

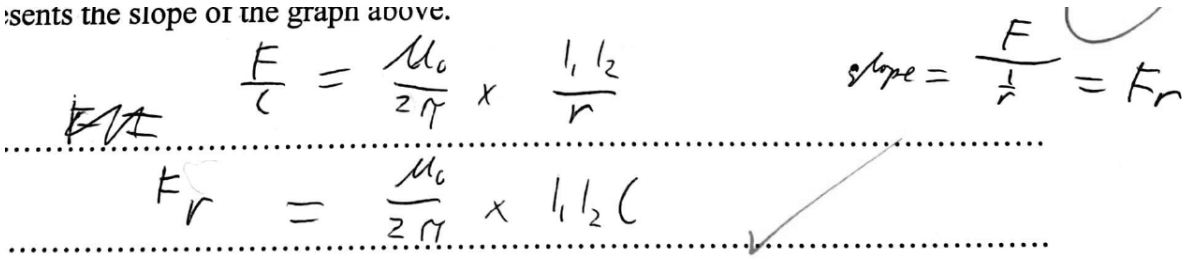


(c) Marking Criteria:	Marks
Correct equation given	1

A majority of the cohort achieved the mark for this question.

Common reasons for not getting the mark:

- Using the wrong formula – force around a current carrying conductor, solenoid equation and coulombs law were all used instead of the parallel wires equation
- Not ATQ and not making the SLOPE the subject of the equation.
- Having trouble making Fr the subject of the equation – some simple errors in rearranging formula.



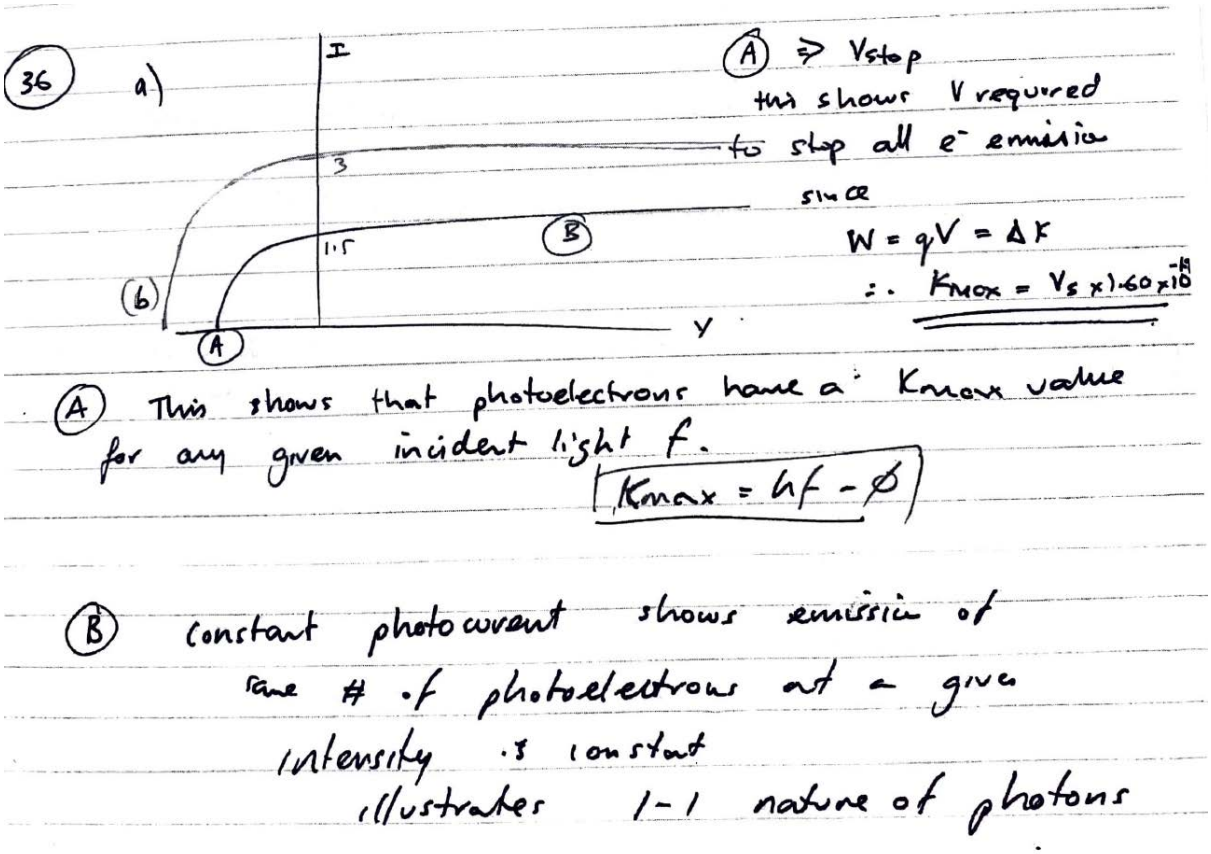
Question 35 Band 2-6

(a) Marking Criteria:	Marks
Explains two features of graph and links clearly to features of photoelectric effect theory	3
Identifies and links two features OR Explains one feature clearly with links to PE effect	2
Identifies a feature of the graph with some link to the PE Effect	1

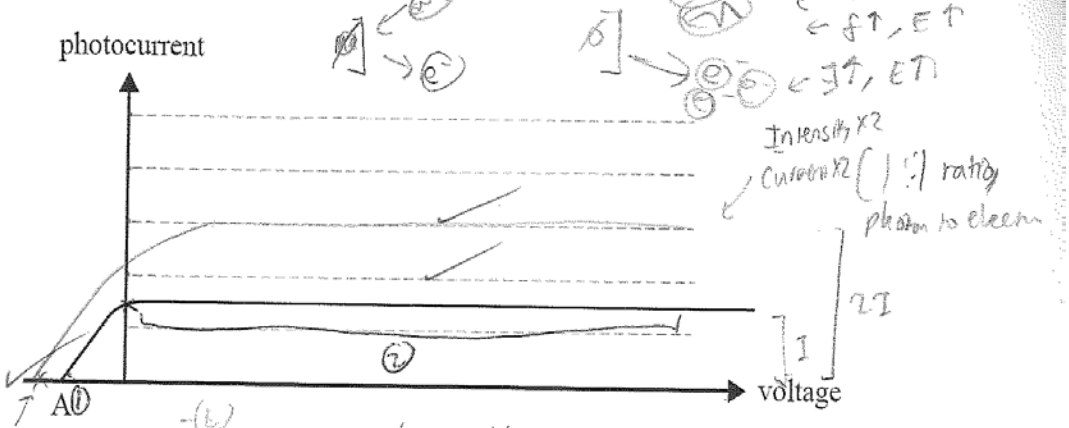
- Very few 3s scored - few students understood the significance of the point marked A.
- Many students struggled to make clear statements about the features of the graph of relevance - (i) constant current and (ii) voltage value at which current ceases.
- Links to theory were often omitted/unclear/incorrect.
- Many students correctly described the constant current and linked it to constant light intensity with correct referencing of PE theory as explained by the big E.

(b) Marking Criteria:	Marks
Curve drawn correctly showing: ● Vs shifted to the left ● photocurrent doubled (grid used) ● photocurrent uniform over range of voltages	3
Two of the above correct	2
One of the above correct	1

- Generally done well. Many students scored 2 or more.
- Common error was drawing the curve to the same -ve voltage value which would indicate electrons had same Kmax which could not occur if frequency was doubled.



The graph below shows the results collected during a photoelectric experiment in which frequency and intensity of light were kept constant.



f↑, E↑ ↗ A ① -(b) able to overcome more qV (W) E=W, E=qV E↑, V↑.

(a) Explain how features of this graph show the photoelectric effect theory proposed by Einstein. **3**

3

Kmax = hf − ϕ.

① E=hf, photons need to transfer enough energy to overcome (work function) (W) + (Stopping Voltage x charge) to electrons.

does Einstein You need certain amount of energy to e electron, as ery is instantly increased.

As f constant, E constant, V ↓ (−ve → +ve),

Net E(Kmax) > 0, this some electrons could emit, $\frac{q}{t}$ = current.

② Current = $\frac{q}{t}$. Even though V↑ (W=qV, W↑, KE↑),

good work! ☺

current no change, as the number of photons hitting metal constant, thus number of electrons emitted constant, thus the current doesn't change. Einstein's theory, as ↑ KE ≠ ↑ Current.

(b) Sketch on the graph above a curve that shows how the photocurrent would change if the frequency of light was increased, and the intensity was doubled. **3**

3

Intensity x2 → 1 photon = 1 electron
Current x2 → 2 photons = 2 electrons (1:1 ratio)