Student Number: .....

Teacher's Name: .....

2020

Task 4: Trial Examination

Weighting: 30%

HSC Physics Booklet 1

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 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 Nunan, Mr Sloan, Mr Solomonides, Mr Truong, Mr Barkl, Mr Fiander

Total marks - 100

BOOKLET 1

Section I - 20 marks

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

BOOKLET 2

Section II - PART 1 - 30 marks

- Attempt Questions 21-28
- Allow about 55 minutes for this part

BOOKLET 3

Section II - PART 2 - 50 marks

- Attempt Questions 29-37
- Allow about 90 minutes for this part

EXTRA BOOKLETS USED: **(please circle)** YES / NO

IF EXTRA BOOKLETS USED - HOW MANY BOOKLETS USED? (please circle)

1 2 3 4 5 or write number here.....

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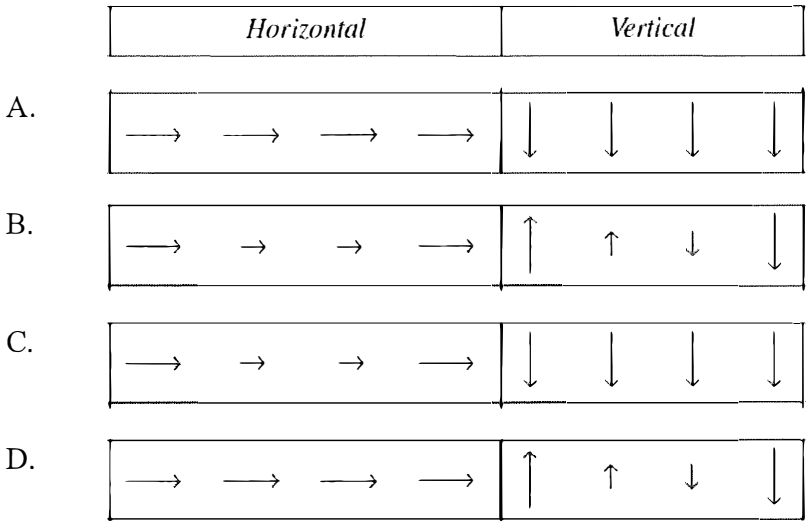
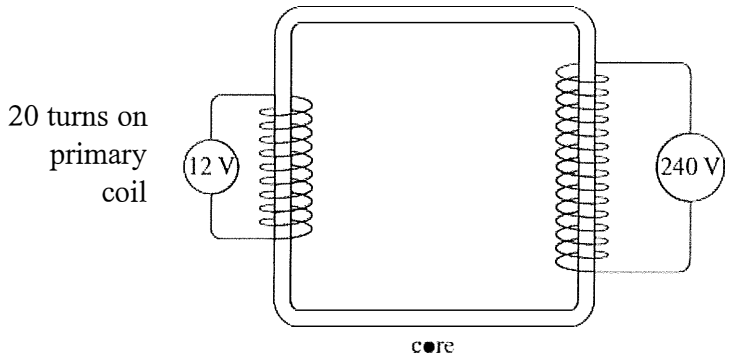
Use the multiple-choice answer sheet for Questions 1-20

1. A projectile is launched from ground level, at an angle.

   Which of the following options shows how the horizontal and vertical components of its velocity change over time?



2. The diagram below shows a simple transformer.



Assuming it is an ideal transformer what is the number of turns on the secondary coil?

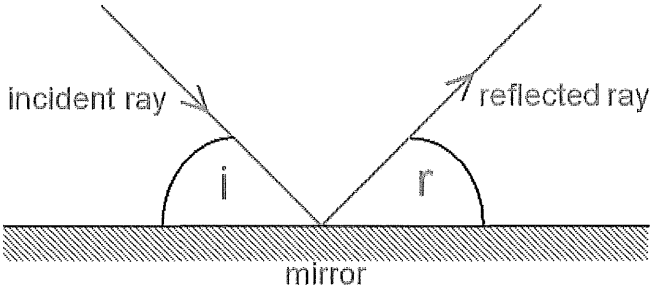
A. 1

B. 20

C. 200

D. 400

3. A ray of light strikes a flat mirror and reflects as shown:



Which of the following statements is most correct regarding Newton and Huygens' proposed models of light?

A. Newton's model could not explain this phenomenon satisfactorily.

B. Both models provided a reasonable mechanism for this phenomenon.

C. Huygen's model predicted that light would spread out in all directions.

D. Neither model provided a reasonable mechanism for the phenomenon.

4. Which of the following statements about the orbits of the planets is NOT one of Kepler's three Laws?

   A. The Earth moves faster when it is closer to the Sun.

   B. Mars' orbit has an elliptical shape with the Sun at one focus.

   C. The total orbital energy of Neptune has the same magnitude as its kinetic energy.

   D. The ratio of the period squared to the radius cubed of Venus and Mercury is the same.

5. Which of the following actions would increase the voltage output of a simple DC generator?

   A. Increasing the rotation speed of the rotor.

   B. Reducing the number of windings in the coil.

   C. Using slip rings instead of a split ring commutator.

   D. Wrapping the windings around a laminated, aluminium core.

6. A 200 g mass is swung in a horizontal circle with a radius of 1.5 m. It completes 10 revolutions in 3 seconds.

   Calculate the magnitude of the centripetal force.

   A. 66 N

   B. 131 N

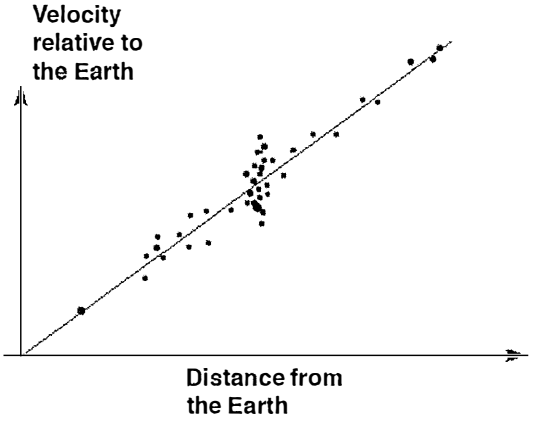
   C. 1180 N

   D. 13 100 N

7. Which of the following correctly describes the experimental evidence for the Big Bang having occurred and our currently expanding universe?

	Evidence for Big Bang	Expanding Universe
A.	Red shifts in light from galaxies that is smaller the further away they are.	The presence of Cosmic Microwave Background Radiation.
B.	The temperature of the universe being very close to absolute zero.	Red shifts in light from galaxies that is smaller the further away they are.
C.	The presence of Cosmic Microwave Background Radiation.	Red shifts in light from galaxies that is larger the further away they are.
D.	The presence of Cosmic Microwave Background Radiation.	Blue shifts in light from galaxies that is larger the further away they are.

8. The velocity of a variety of galaxies was measured and plotted on a graph as shown below.



From this graph, which of the following is true about the slope of the graph?

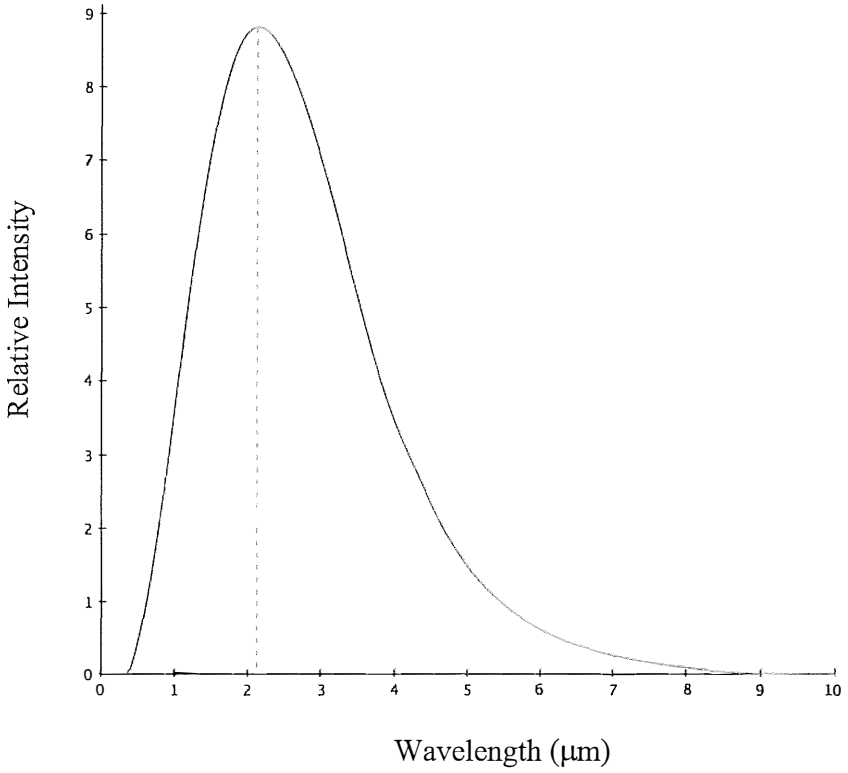
A. It is Hubble's constant.

B. It is the age of the universe.

C. It is the inverse of Hubble's constant.

D. It cannot be used to find the age of the universe.

9. A star produces the intensity graph shown below.



What is the temperature of the star, in Kelvin?

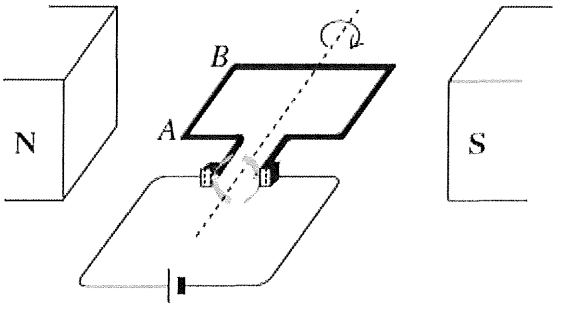
A. 1380 K

B. 1449 K

C. 13800 K

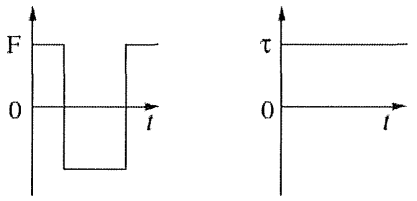
D. 14490 K

10. The diagram below shows a simple DC motor with current flowing through the coil.

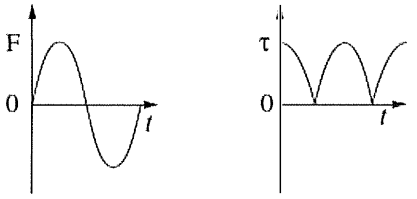


Which pair of graphs below show the force on wire AB and the torque on the rotor as the coil turns through one rotation?

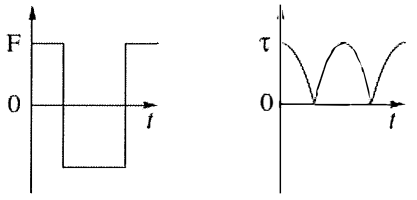
A.



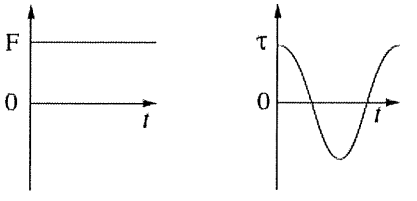
B.



C.



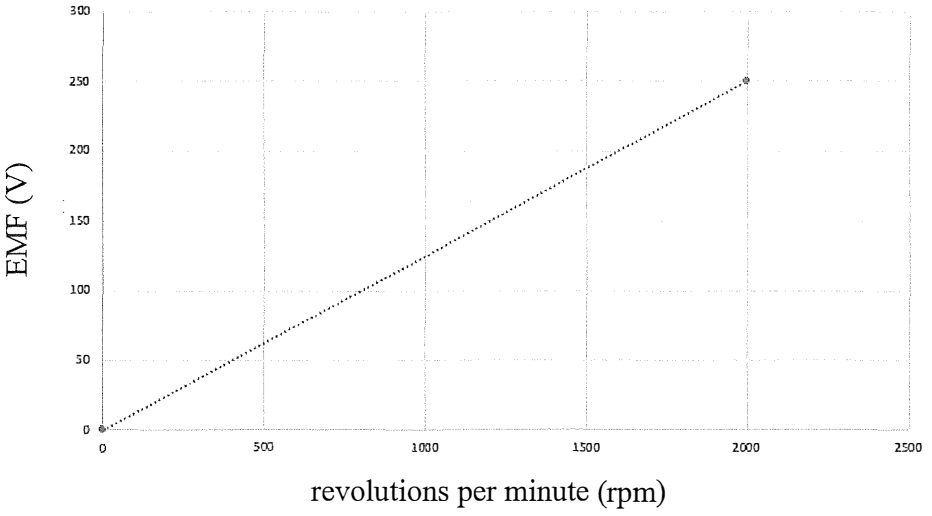
D.



11. Which of the following is experimental evidence for the named feature of special relativity?

	Feature of special relativity	Evidence for the feature
A.	Time dilation	Mass of electrons in particle accelerators.
B.	Time dilation	Muons falling to Earth.
C.	Length contraction	Thought experiment with light and mirrors on a train.
D.	Length contraction	Atomic clocks on planes travelling at high speed.

12. A student determined the supply voltage to be 250 V and measured the back EMF in an ideal motor at different rotational speeds. The back emf values were then plotted on the graph below:



Which of the following statements is correct?

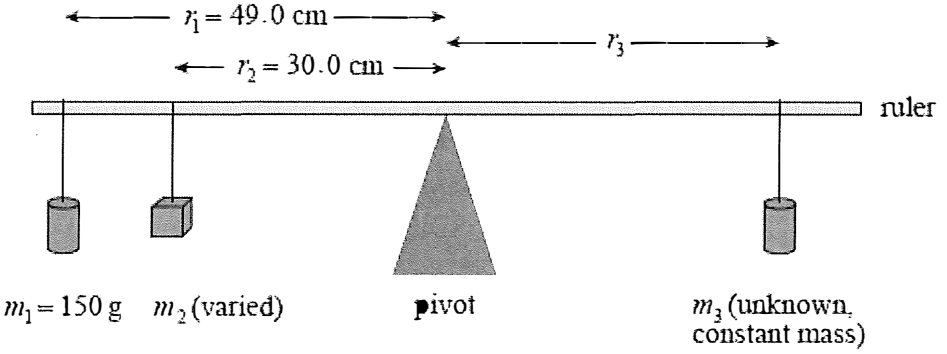
A. The motor produces the most torque at 2000 rpm.

B. The motor will rotate at greater than 2000 rpm when operating normally.

C. The motor only produces torque when rotating at more than 2000 rpm.

D. The motor produces zero torque at 2000 rpm.

13. A Knox student used the following experimental setup to investigate torque. At one point in the experiment they set m_2 to 100 g. The mass m_3 was then moved so that the ruler was horizontally balanced. At this point, r_3 was measured to be 39.0 cm.



What is the value of m_3?

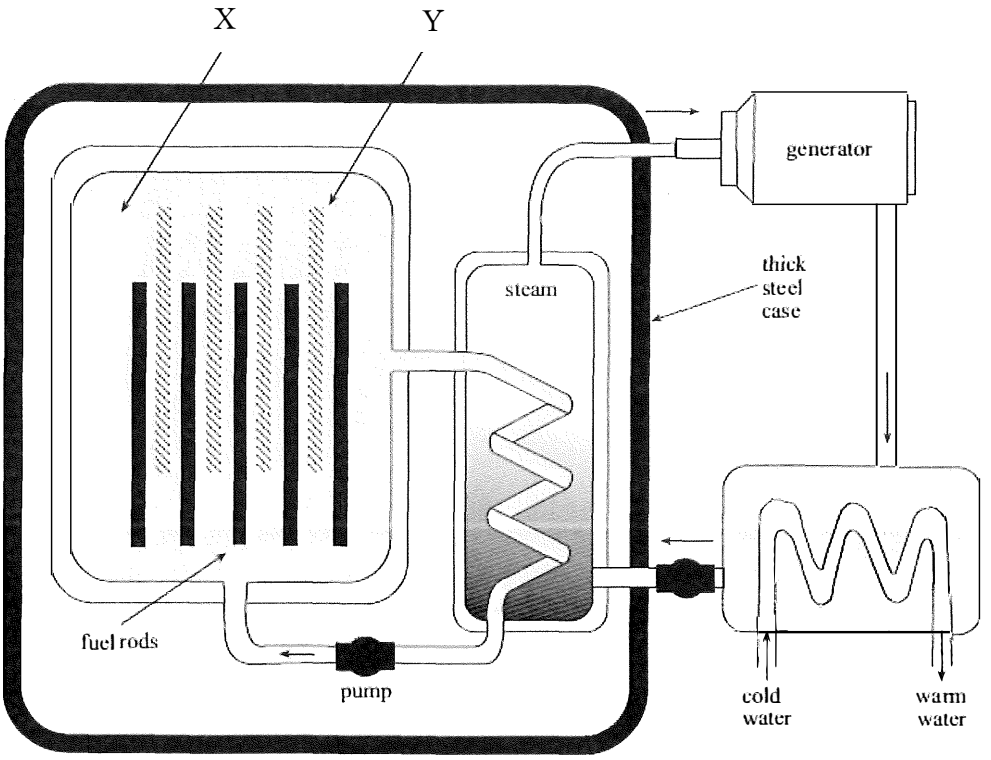
A. 188 g

B. 241 g

C. 265 g

D. 506 g

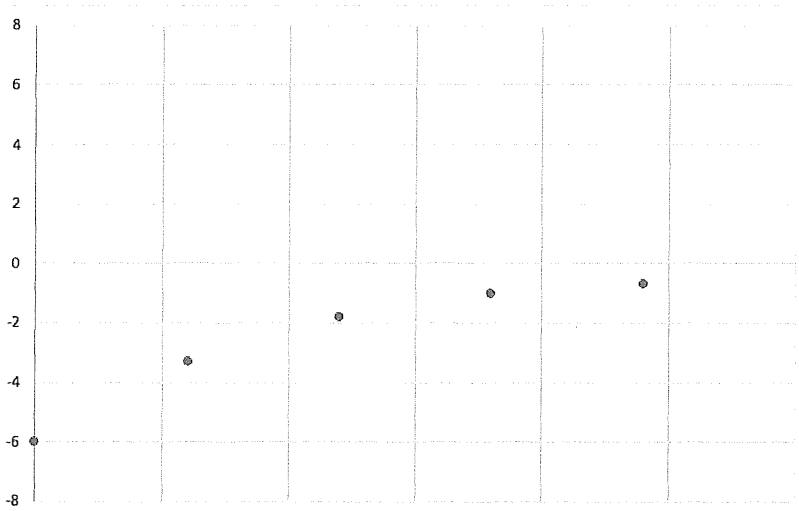
14. A simplified diagram of a water-moderated fission power station is shown.



Identify the name and function of the components X and Y.

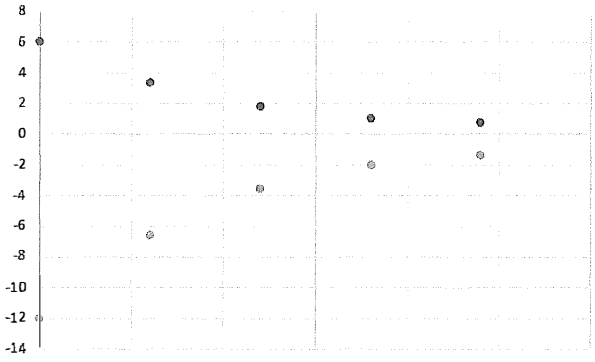
	Component X		Component Y	
	Name	**Function**	**Name**	**Function**
A.	Moderator	Absorbs neutrons so they don't react	Fuel Rods	Contain mostly U-235 for use as a fuel
B.	Moderator	Absorbs neutrons so they don't react	Control Rods	Slows neutrons so they are the correct speed to react
C.	Fuel	Extra fuel when rods are used up	Control Rods	Slows neutrons so they are the correct speed to react
D.	Moderator	Slows neutrons so they are the correct speed to react	Control Rods	Absorbs neutrons so they don't react

15. The total energy of a satellite in orbit at different heights is shown below:

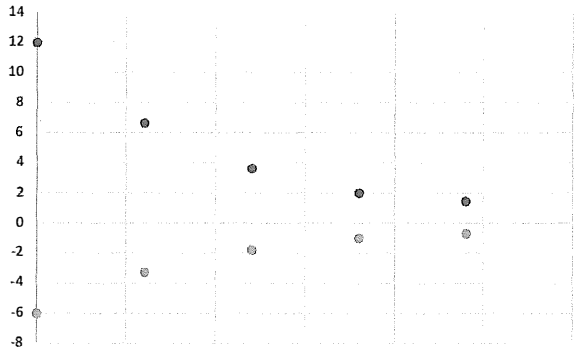


Which of the following graphs shows the correct kinetic and potential energies for this satellite?

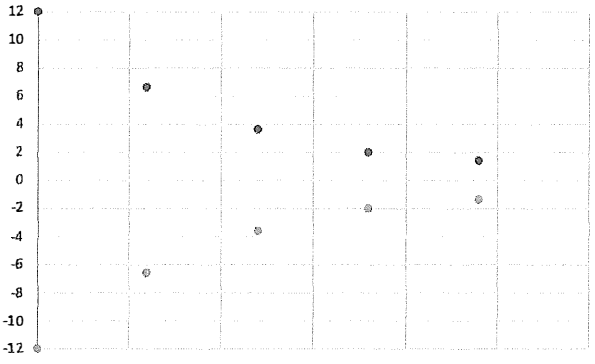
A.



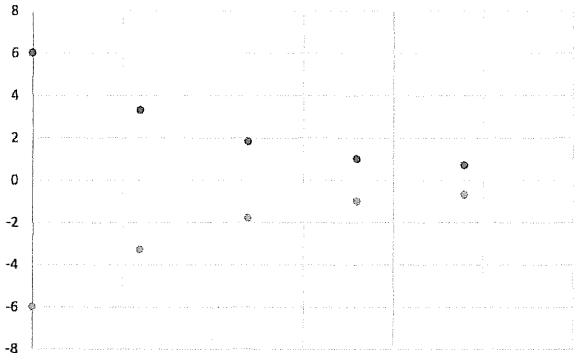
C.



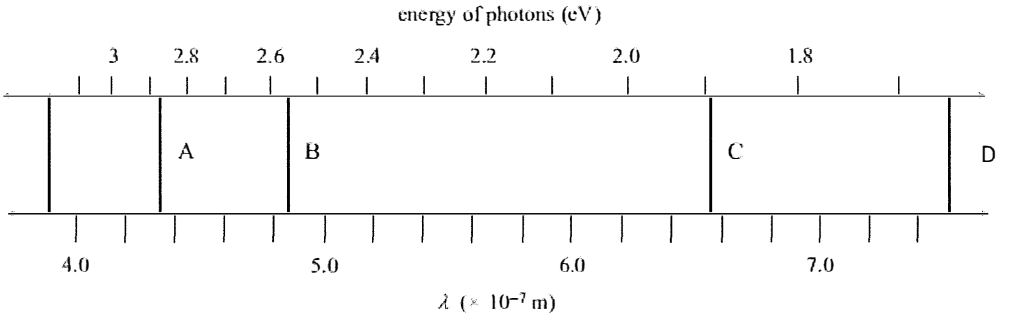
B.



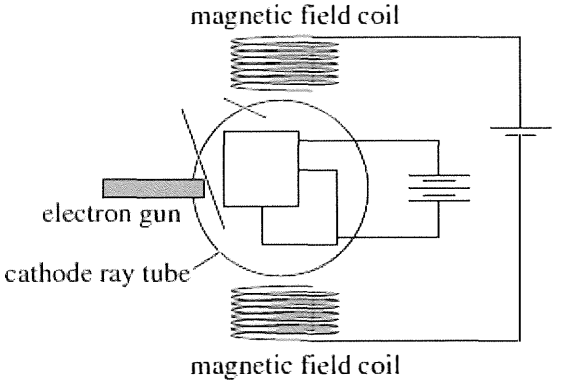
D.



16. Identify which spectral line is the result of the n = 3 to n = 2 electron transition in hydrogen.



17. The following apparatus was used to measure the charge-to-mass ratio of electrons.



The beam of electrons from the electron gun was straight when the electric field strength was set to 2.57×10^4 Vm^{-1}.

If the speed of the electrons entering the field was 1.44×10^7 ms^{-1}, what is the strength of the magnetic field?

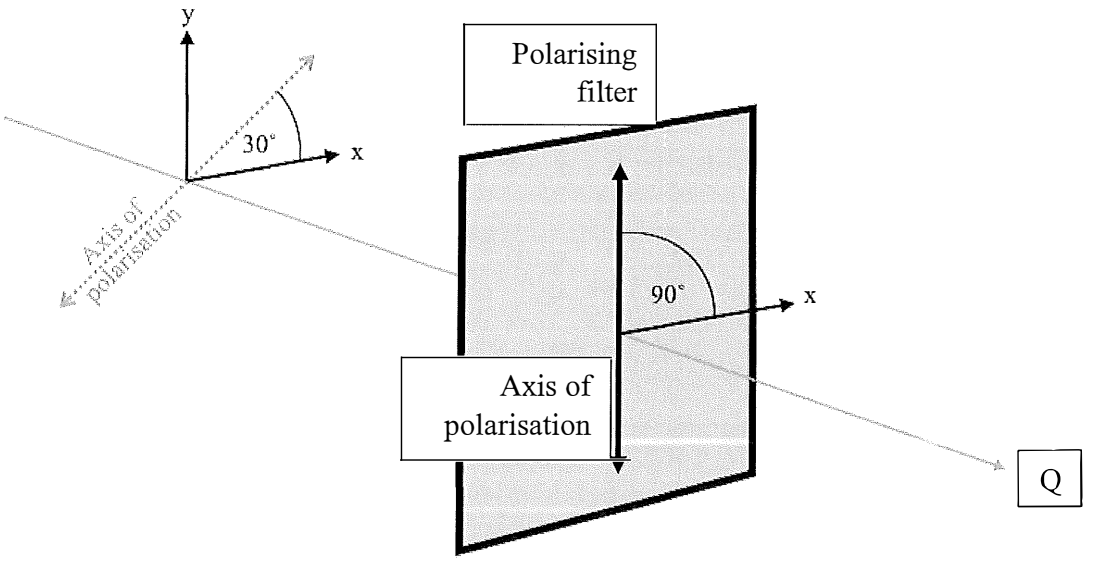
A. 4.1×10^{-12} T

B. 0.0018 T

C. 560 T

D. 3.7×10^{11} T

18. A light from a polarised source is entering a polarising filter as shown below. The initial light source is set at an angle as shown and the axis of polarisation of the incoming light can be rotated by rotating the light source.



What adjustment from the list below would produce the greatest increase in light intensity at point Q?

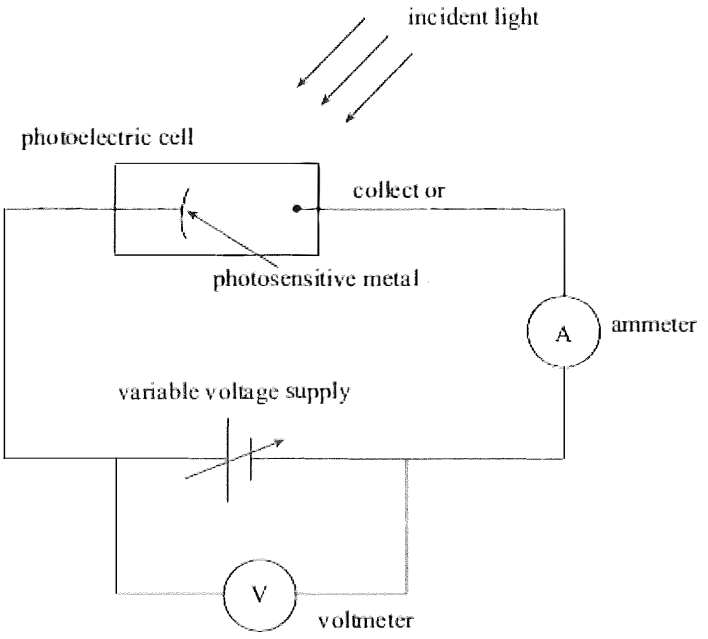
A. Rotating the light source clockwise 10 degrees.

B. Rotating the light source clockwise 150 degrees.

C. Rotating the light source anti-clockwise 70 degrees.

D. Rotating the light source anti-clockwise 110 degrees.

19. In a photoelectric experiment using the apparatus shown below, the stopping voltage for light of a given frequency was measured.



When the wavelength of light hitting the photosensitive metal was 4.50×10^{-7} m, the stopping voltage was 1.14 V. What is the work function of the metal?

A. 1.9×10^{-19} J

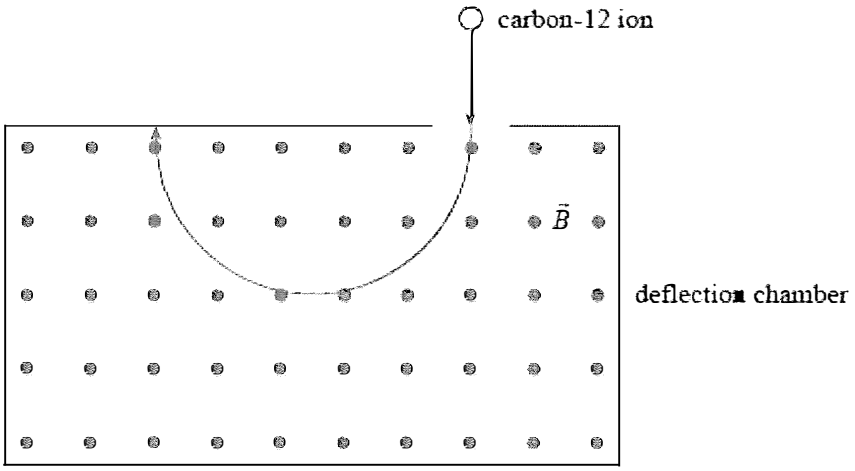
B. 2.6×10^{-19} J

C. 3.0×10^{-19} J

D. 6.2×10^{-19} J

20. In analytical machines, magnetic fields are used to analyse the mass and charge on ions. In the experiment shown below, a carbon-12 ion was formed by either the loss or gain of one electron and fired perpendicularly into a magnetic field of strength 0.25 T as shown.

The carbon-12 ion has a mass of exactly 12.00 amu and its velocity when it entered the field was 3.135×10^6 ms^{-1}.



What is the radius of the path and the sign (+/-) of the carbon-12 ion?

	Radius	**Sign**
A.	0.130 m	Positive
B.	0.230 m	Negative
C.	0.260 m	Positive
D.	1.560 m	Positive

END OF BOOKLET 1

Student Number: .....

Teacher's Name: .....

2020

Task 4: Trial Examination

HSC Physics
Booklet 2

BOOKLET 2

Section II - PART 1 - 30 marks

- Attempt Questions 21-28
- Allow about 55 minutes for this part

Instructions:
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 booklets are available upon request. If you use a booklet, clearly indicate which question you are answering and indicate in this paper that a booklet has been used.

Use a new booklet for each question.

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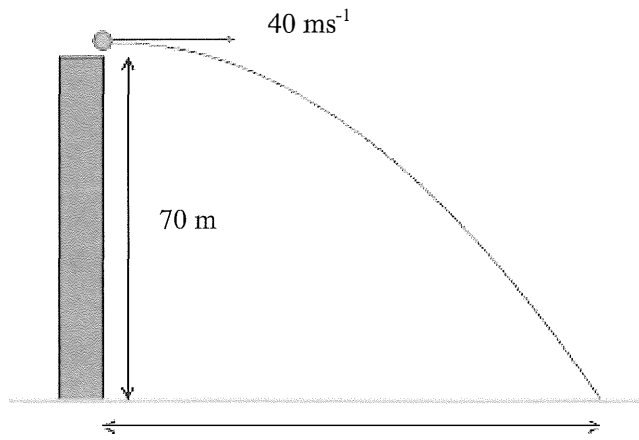
Question 21 (5 marks)

An object is launched horizontally from the edge of a cliff, at 40 ms^{-1} and lands in the ocean, 70 m below, as shown in the diagram below.



(a) Calculate the distance from the base of the cliff to where the object lands in the ocean. **2**

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(b) Calculate the velocity of the object as it hits the water. **3**

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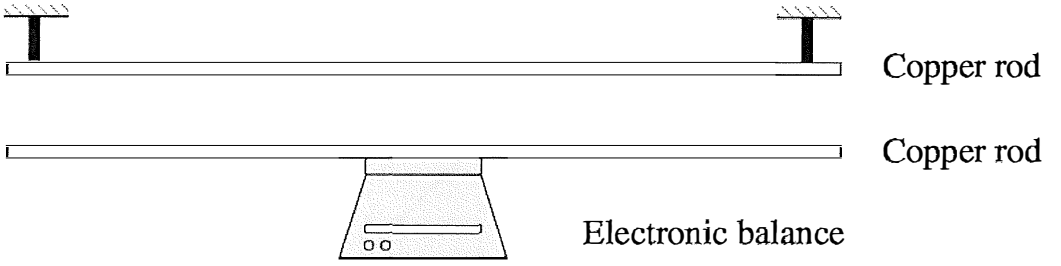
Question 22 (4 marks)

The diagram below shows two parallel copper rods each of length of 0.218 m, 5.38 cm apart and with a mass of 25.000 g. The top rod is fixed in position while the bottom rod is resting on an electronic balance. A current of equal magnitude is then applied to both copper rods.



(a) When the equal magnitude current is passed through both rods the electronic balance reading changes to 25.003g. Calculate the force between the two rods. **1**

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(b) Determine the magnitude of current flowing in each copper rod. **3**

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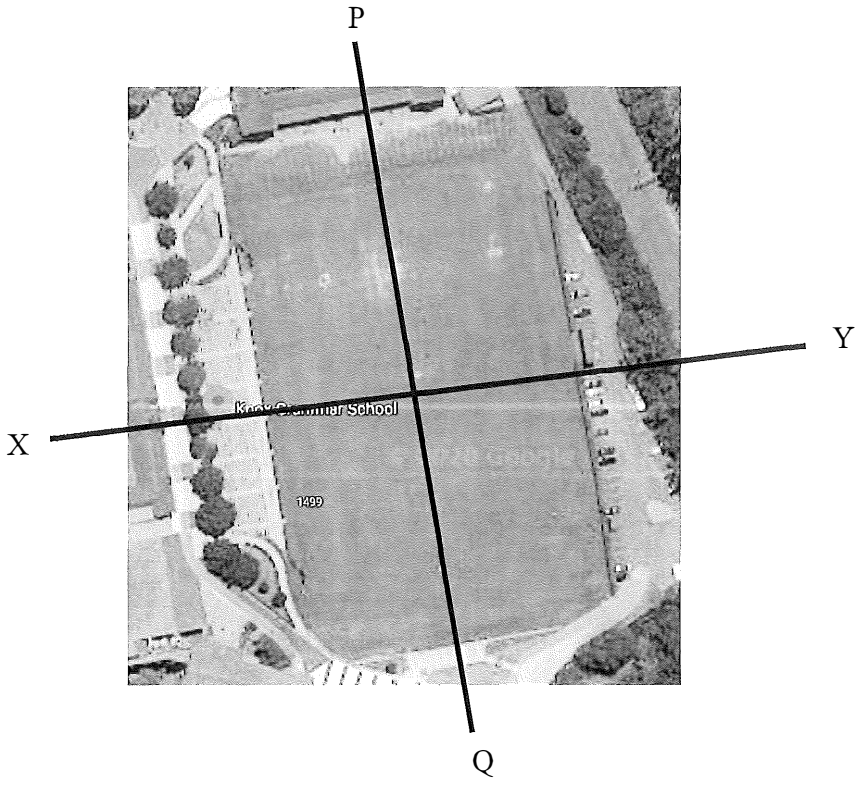
Question 23 (4 marks)

A spacecraft was travelling over Knox Grammar School at a speed of 0.835c. It travels over Knox 1 (the main school rugby ground) along the line joining point P to point Q as shown on the diagram below:



(a) The length of Knox 1 in the P-Q direction as measured by an observer on the ground was found to be 145 m. What is the length of Knox 1 (in the P-Q direction) as measured by an observer on the spacecraft? **2**

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(b) The spacecraft returns and flies at the same speed in a perpendicular direction, from X to Y. Justify any changes in the length of Knox 1 (in the P-Q direction) as measured by the observer on the spacecraft. **2**

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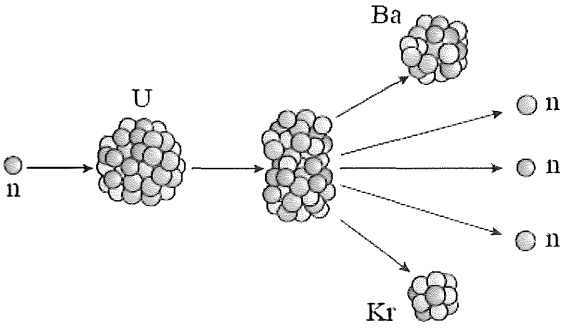
Question 24 (3 marks)

The fission of uranium that occurs after absorbing a neutron in a collision is shown in the diagram and equation below:



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

The mass of some of the particles involved in this fission are shown below:

- uranium-235 $m = 3.9017 \times 10^{-25}$ kg
- barium-141 $m = 2.28922 \times 10^{-25}$ kg
- krypton-92 $m = 1.57534 \times 10^{-25}$ kg

Calculate the energy released, in MeV, during this fission. **3**

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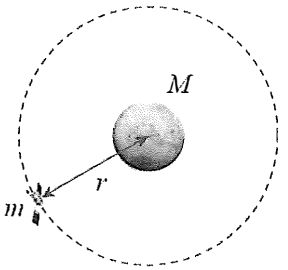
Question 25 (4 marks)

The image below shows a satellite orbiting the Earth at a radius of r metres.



[*This diagram is not drawn to scale.*]

The orbital velocity for this satellite (mass m) can be found using information about the centripetal force acting on the satellite. In this case, the centripetal force is provided by the gravitational force of the Earth (mass M).

(a) Derive an equation for the orbital velocity of the satellite in terms of the gravitational constant, G, the mass of the Earth, M, and the orbital radius, r. **2**

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(b) Given the Earth has a mass of 6.0×10^{24} kg and a radius of 6370 km, determine the required speed of a satellite to be in a stable orbit at an altitude of 1000 km. **2**

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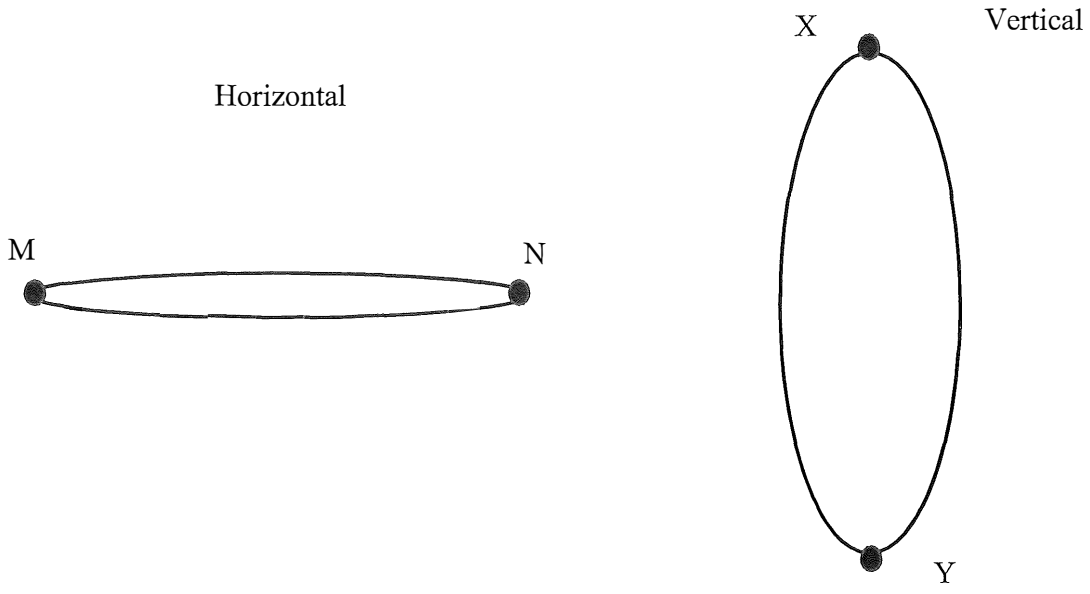
Question 26 (4 marks)

A student has an object tied to the end of a rope. They first swing the object in a flat, horizontal circle as shown on the left below. They then swing the same object, with the same speed and radius, in a vertical circle as shown on the right below.



Using labelled force vectors on the diagrams above, compare the forces acting on the object when moving in horizontal and vertical uniform circular motion. You should consider points M, N, X and Y in your answer. **4**

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Question 27 (4 marks)

Analyse the significance of Maxwell's contribution to our understanding of light. **4**

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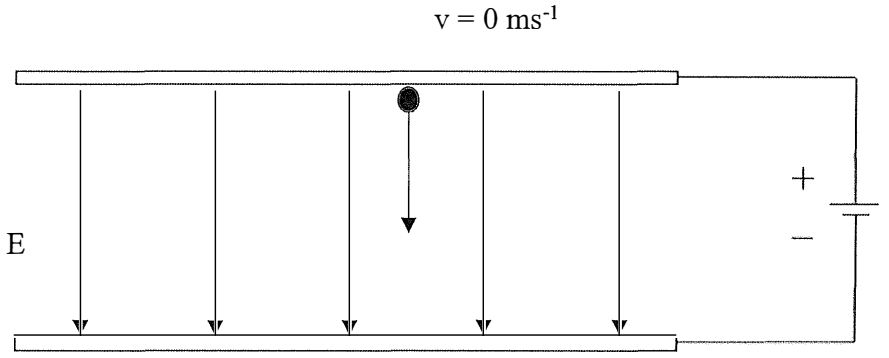
Question 28 (2 marks)

The diagram below shows a uniform electric field provided by two parallel plates. A proton is placed at the top plate and then released, accelerating downwards until it reaches its maximum speed as it strikes the bottom plate.



Derive an expression for the maximum velocity of a particle, accelerated from rest in a uniform field, in terms of m, q, E and d. *Ignore any effects of gravity.*

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END OF BOOKLET 2

Student Number: ……

Teacher's Name: ……

2020

Task 4: Trial Examination

HSC Physics
Booklet 3

BOOKLET 3

Section II - PART 2 - 50 marks

- Attempt Questions 29-37
- Allow about 90 minutes for this part

Instructions:
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 booklets are available upon request. If you use a booklet, clearly indicate which question you are answering and indicate in this paper that a booklet has been used.

Use a new booklet for each question.

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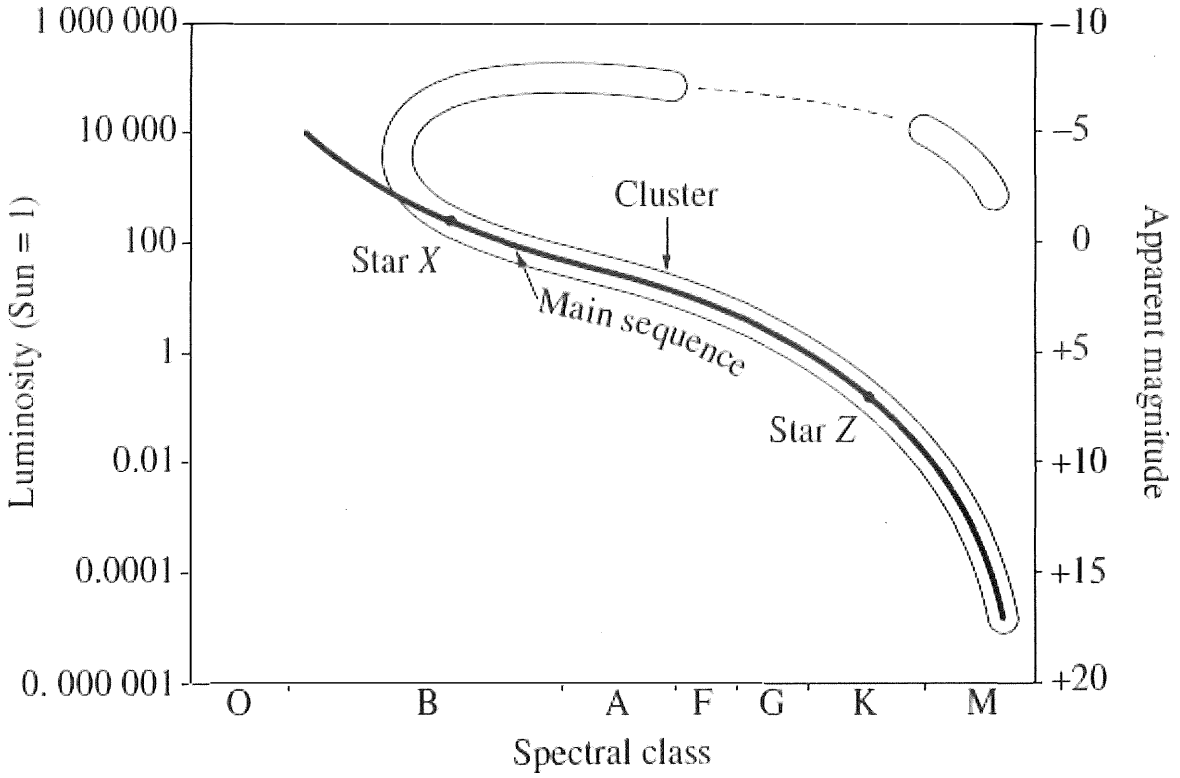
Question 29 (6 marks)

The Hertzsprung-Russell diagram for a star cluster is shown below:



(a) Predict the next stage in the most likely evolutionary pathway for Star X. **1**

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(b) Contrast the nuclear fusion processes occurring in Star X and Star Z. Use relevant nuclear equations to support your answer. **5**

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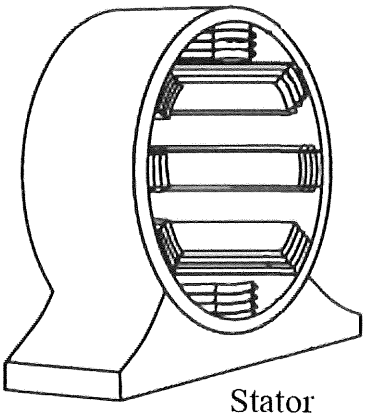
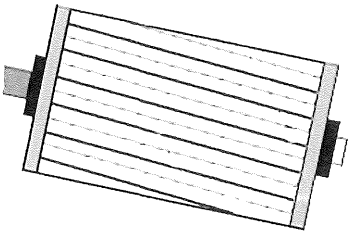
Question 30 (5 marks)

By annotating the diagram below to help with your answer, explain how an AC induction motor generates torque. **5**



Stator



Squirrel cage rotor

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Question 31 (5 marks)

Classical wave theory predicted the behaviour of electrons and light during the photoelectric effect experiment. Based on the classical wave theory of light, the following two predictions were made about the photoelectric effect.

1. That light of any frequency will cause electrons to be emitted from a metal.
2. The more intense the light, the more kinetic energy the emitted electrons will have.

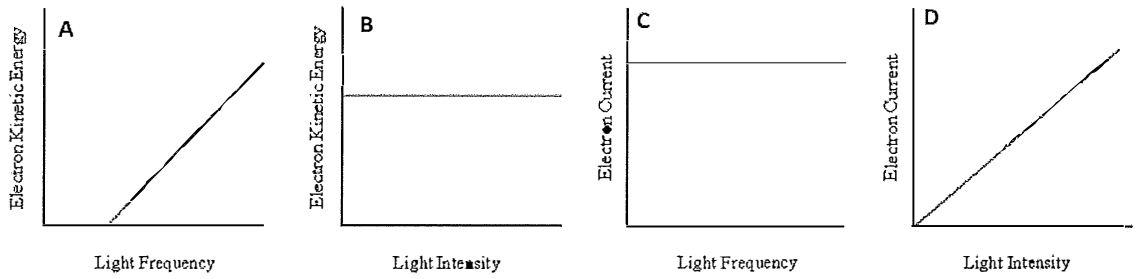
After conducting photoelectric effect experiments, a variety of measurements were taken, and are summarised in the graphs below.

A - maximum kinetic energy of electrons at different frequencies of light.

B - maximum kinetic energy of electrons for a constant frequency but changing intensity of light. The frequency of this light was above the cut-off frequency.

C - current generated in the circuit with constant light intensity at a range of light frequencies.

D - current generated in the circuit with constant light frequency at a range of light intensities.



Analyse the evidence from each graph to explain why the classical wave theory predictions (1. and 2.) were incorrect. **5**

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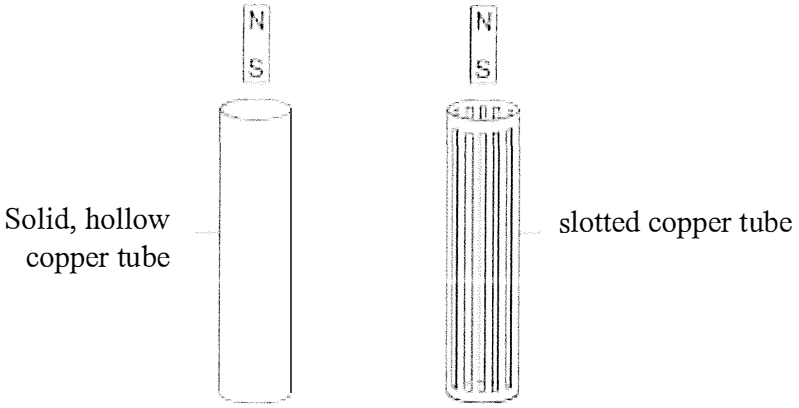
Question 32 (4 marks)

A student drops a bar magnet of mass 25.3 g through a solid, but hollow, copper tube of length 1.35 m and records the time taken to pass through the length of the tube as 0.843 s.

Slots are then made in the tube, similar to that pictured on the right below. The time taken for the same magnet to pass through the same length slotted tube was recorded. The student then calculated acceleration of the magnet in the slotted tube to be 9.8 ms^{-2}, the same as gravitational acceleration.



Justify the formation of an upwards force acting on the magnet when passing through the solid, hollow, copper tube (left of diagram) and determine the magnitude of this upwards force. **4**

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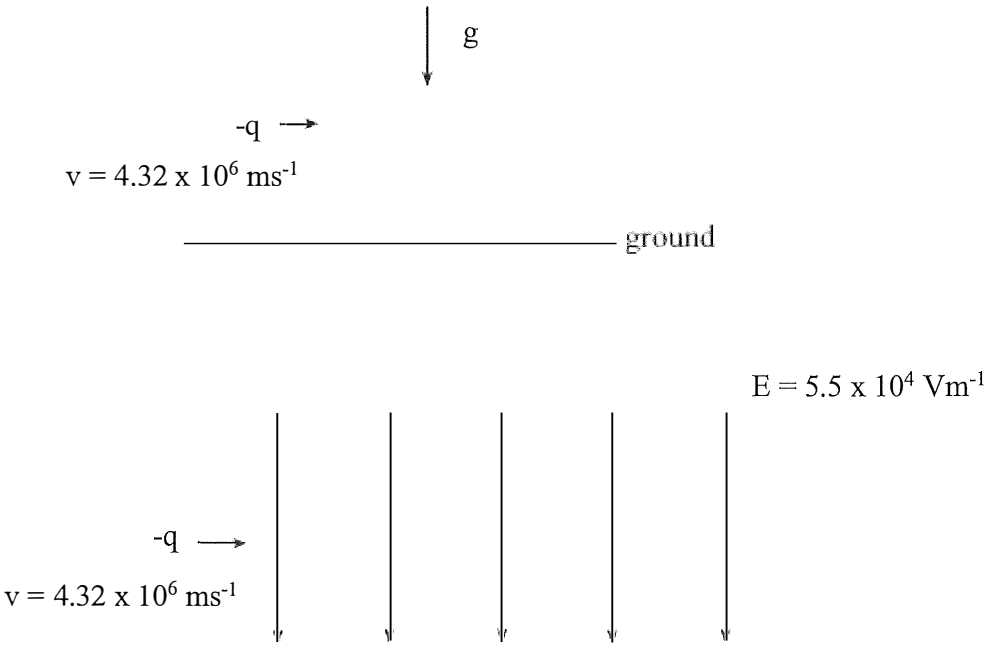
Question 33 (7 marks)

Electrons in uniform gravitational fields and uniform electric fields are subject to forces, and thus have a specific and predictable motion when moving within the fields. **7**

The diagram below shows electrons being fired horizontally into a vertically oriented electric field, and a uniform gravitational field at the surface of the Earth.



Compare qualitatively and quantitatively the motion of the electrons in the two fields.

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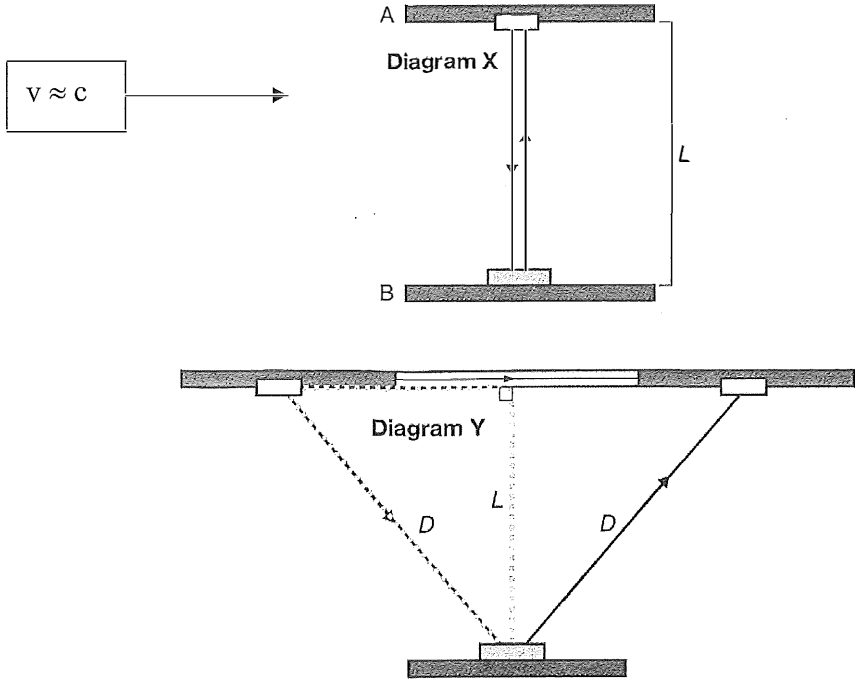
Question 34 (4 marks)

In Einstein's thought experiment, a beam of light travels from the ceiling of a train carriage, moving at relativistic speed towards the right, reflects off a mirror on the floor and back to the light source. Diagram X shows what a passenger on the train observes. Diagram Y shows what a person outside the train carriage observes. **4**



By referencing features of the diagrams above, explain how these observations show time dilation. You **DO NOT** have to derive the time dilation formula shown on the data sheet.

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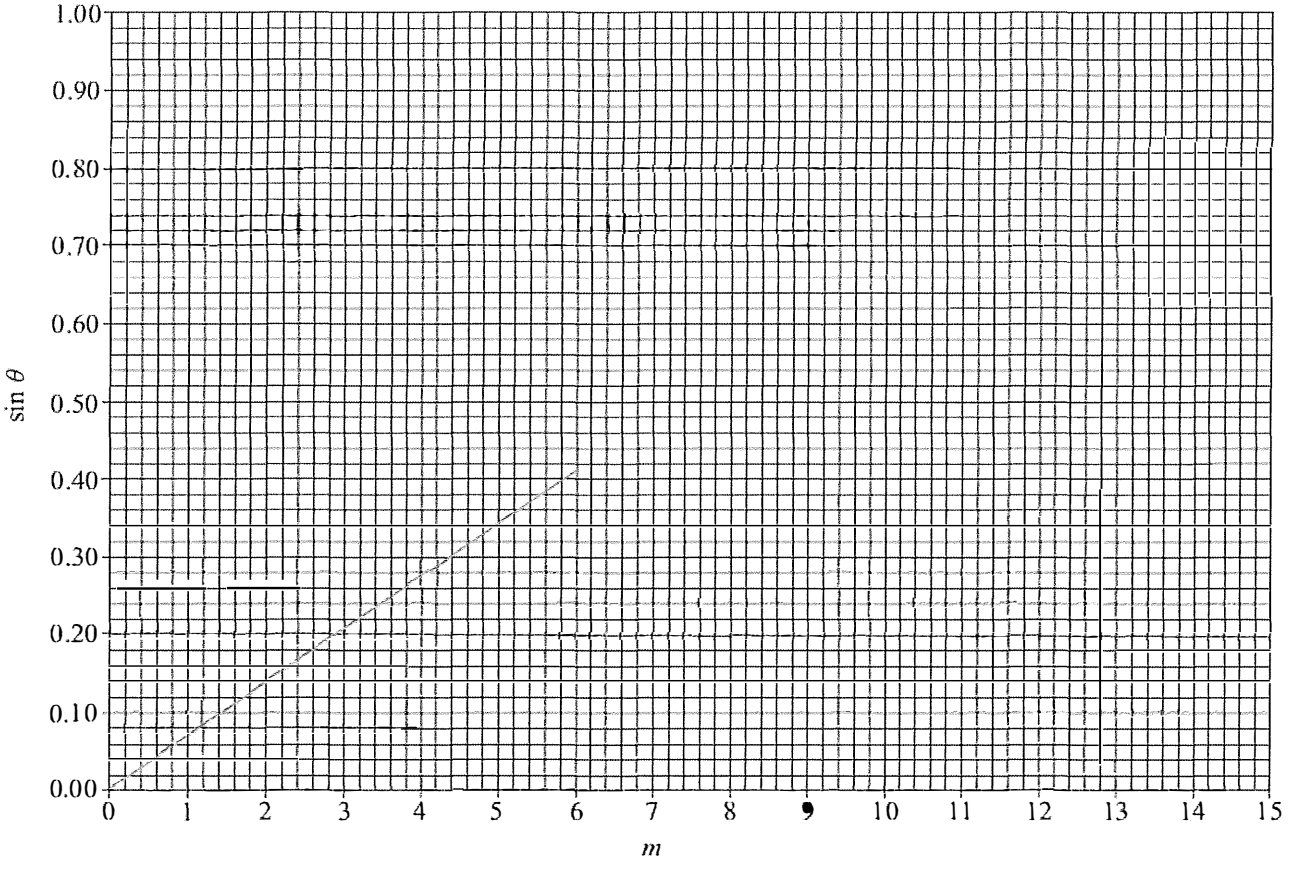
Question 35 (6 marks)

A student performs an experiment using a diffraction grating with 100 slits per mm. A laser of unknown wavelength is shone through the grating.

A graph of the sine of the angular position of each maxima in the diffraction pattern, sin θ, against the order of the maxima (first order, second order etc) is shown below.



(a) Use the gradient of the line of best fit to calculate the wavelength of the laser light used in this experiment. **4**

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(b) Use the graph to determine the maximum order that can be produced by this diffraction grating. **2**

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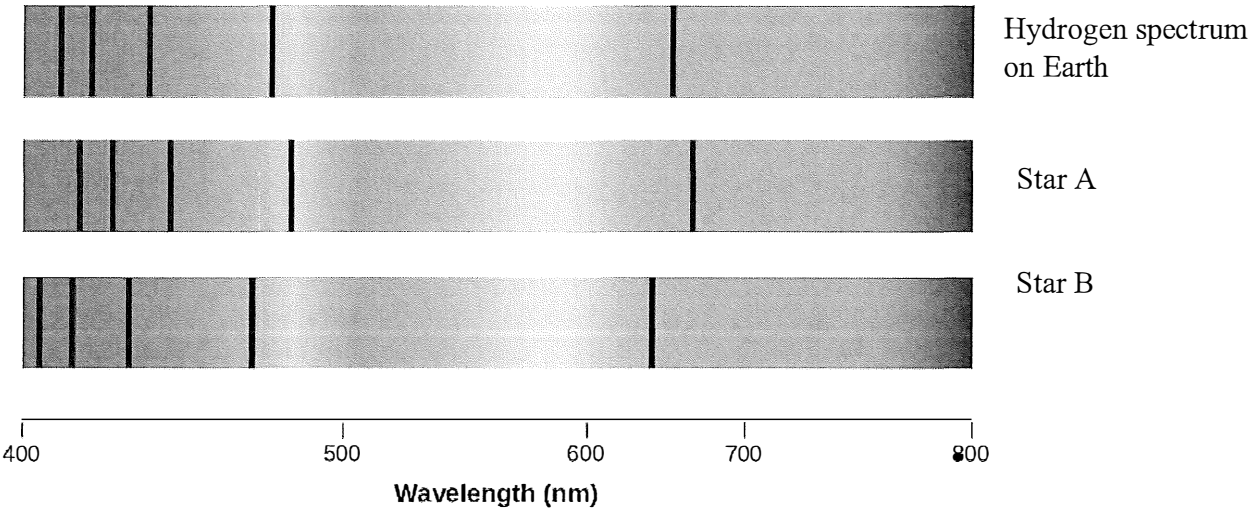
Question 36 (4 marks)

An astronomer analysed the light from two stars, A and B. The emission spectra from each star was compared to the emission spectrum of hydrogen produced in a laboratory on Earth. The observation was also made that the spectral lines for Star B were wider than the spectral lines for Star A.

The spectra of hydrogen produced on Earth, and the two stars are shown below.



Analyse the differences between the motion of Star A and Star B. **4**

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Question 37 (9 marks)

Analyse the development of the atomic model through history with a focus on the work of Rutherford, Bohr and de Broglie. **9**

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END OF EXAMINATION

Year 12 Physics Trial Marking Guideline.

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

SHORT/EXTENDED ANSWERS:

Question	Content	Type	Marks	Marked by
21	Projectile motion	calcs	5	ET

a) Band 2-4

Criteria	Marks
• Correct calculation shown with full working, including units.	2
• Some correct steps shown in calculation with key errors, no units OR working not shown.	1

b) Band 2-6

Criteria	Marks
• Correct calculation shown with full working, including units and angle	3
• Mostly correct calculation shown, with minor errors, units included in answer.	2
• Some correct steps shown in calculation with key errors, no units OR working not shown.	1

(a) Calculate the distance (s_x) from the base of the cliff to where the object lands in the ocean. 2

$u = 40\,ms^{-1}$

$\theta = 0°$

$s_y = 70\,m$

$g = -9.8\,ms^{-2}$

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

$t^2 = \frac{2s_y}{a_y}$; $u_y = 0$

$t = \sqrt{\frac{2(70)}{9.8}}$

$= 3.77964473...$

$t = 3.8\,s$ (2 s.f.)

$s_x = u_x t$

$= u\cos\theta$

$= 40(3.8)\cos 0$

$= 151.185789...$ (exact value)

$s_x = 1.5 \times 10^2\,m$ (2 s.f.)

(b) Calculate the velocity (v) of the object as it hits the water. 3

$u = 40\,ms^{-1}$

$\theta = 0°$

$a_y = -9.8\,ms^{-1}$

$t = 3.8\,s$

$u_y = 0\,ms^{-1}$

$v_x = u_x$

$= u\cos\theta$

$= 40\cos 0$

$u_x = 40\,ms^{-1}$

$v_y = u_y + a_y t$

$= -9.8(3.8)$

$= -37.040518...$ (exact value)

$v_y = -37\,ms^{-1}$ (2 s.f.)

$v = \sqrt{v_x^2 + v_y^2}$

$= \sqrt{40^2 + 37^2}$

$= 54.516053268...$ (exact value)

$v = 55\,ms^{-1}$ (2 s.f.)

$\tan\theta = \frac{v_y}{v_x}$

$\tan\theta = \frac{37}{40}$

$\theta = 42.800086534...$ (exact value)

$\theta = 43°$ (2 s.f.)

$v = 55\,ms^{-1}$, 43° to the horizontal (2 s.f.) 5

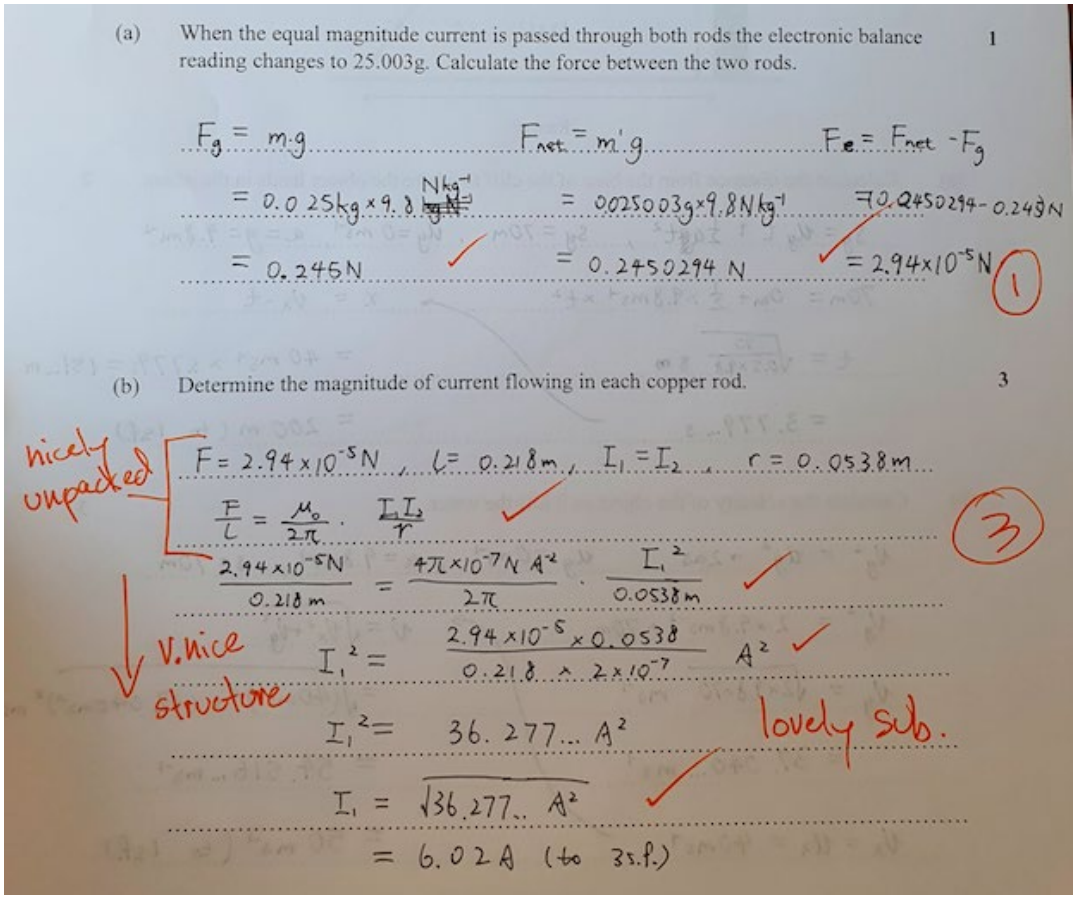
22	Parallel rods	calc	4	ASolom

a)

Criteria	Marks
• Correct calculation shown with full working, including Δmass in correct SI units – i.e kilograms.	1

b)

Criteria	Marks
• Correct equation identified and shown. Full working shown with values correctly substituted and equation correctly rearranged to yield a correct calculated value.	3
• Mostly correct calculation shown with minor errors or omissions.	2
• Some correct steps shown in calculation with key errors or omissions.	1



23	Length contraction	calc/written	4	PF

23a) Band 2-6

Criteria	**Marks**
Student correctly calculates length showing all working	2
Student calculates length with minor errors or omissions	1

Answers

$l = l_0 \sqrt{\left(1 - \frac{v^2}{c^2}\right)}$ $\quad l_0 = 145\ m$

$v = 0.835c$

$$l = 145\ m \sqrt{\left(1 - \frac{(0.835c)^2}{c^2}\right)}$$

$$l = 79.79\ m$$

$$l = 79.8\ m\ 3sf$$

23b) Band 2-4

Criteria	**Marks**
Student provides a justification to why the length of P-Q will not change	2
Student states that length P-Q will not change without any justification	1

Answers

- The length of Knox 1 (P-Q) will not change

Because

- Only lengths in the direction of motion will be contracted
- Lengths at right angles to the motion will be unaffected
- Both reference frames (ground and spaceship) view the length of Knox 1 (P-Q) to be the same

24	energy-mass conversion	calc	3	ASolom

Criteria	Marks
Correctly calculates energy released during the given fission reaction, in MeV. Response/calculation shows required and necessary steps with full working.	3
Calculates energy released during the given fission reaction, in MeV, with minor errors or omissions. OR Correctly calculates energy released during the given fission reaction showing required and necessary steps with full working.	2
Attempts calculating energy released with major errors or omissions.	1

Answers

$$m_{reactants} = 1.675\ x\ 10^{-27} + 3.9017\ x\ 10^{-25}$$
$$m_{reactants} = 3.91845\ x\ 10^{-25}$$

$$m_{products} = 2.28922\ x\ 10^{-25} + 1.57534\ x\ 10^{-25} + 3(1.675\ x\ 10^{-27})$$
$$m_{products} = 3.91481\ x\ 10^{-25}$$

$\Delta mass = -3.64\ x\ 10^{-28}$ kg

$$E = mc^2$$
$$E = 3.64\ x\ 10^{-28}\ x\ 3.00\ x\ 10^{8}$$
$$E = 3.276\ x\ 10^{-11}\ J$$

$$1\ eV = 1.602\ x\ 10^{-19}\ J$$

E = 2.04494 x10^8 eV
E = 204 MeV

25	satellite orbits	derivation/calc	4	ET

a) Band 2-6

Criteria	**Marks**
Student correctly derives an equation for orbital velocity showing full working, using terms provided	2
Student derives an equation for orbital velocity with minor errors or omissions	1

Sample Answer

$$F_g = F_c$$

$$\therefore \frac{GM\cancel{m}}{r^2} = \frac{\cancel{m}v^2}{r}$$

$$\therefore \frac{GM}{r^2} = \frac{v^2}{r}$$

$$\therefore v^2 = \frac{GM\cancel{r}}{\cancel{r^2}}$$

$$\therefore v = \sqrt{\frac{GM}{r}}$$

b) Band 2-6

Criteria	**Marks**
Student correctly calculates speed of satellite showing full working	2
Student calculates speed of satellite with minor errors or omissions	1

(b) Given the Earth has a mass of 6.0×10^{24} kg and a radius of 6370 km, determine the required speed of a satellite to be in a stable orbit at an altitude of 1000 km. **2**

$M = 6.0 \times 10^{24}$ kg

$G = 6.67 \times 10^{-11}$ Nm^{2}kg^{-2}

$r = 6370 + 1000$

$= 7370$ km

$r = 7.370 \times 10^6$ m

$V = \sqrt{\frac{GM}{r}}$

$= \sqrt{\frac{(6.67 \times 10^{-11})(6.0 \times 10^{24})}{7.370 \times 10^6}}$

$= 7368.43823...$

$V = 7.4 \times 10^3$ ms^{-1} (2 s.f)

26	ucm force comparison	written	4	ET

Band 2-6

● Extensive annotation of diagram with correct magnitude and direction labelled force vectors. ● Extensive comparison of the FORCES, including at least one similarity and one difference ● All labelled points discussed in answer	4
● Mostly correct annotation of diagram with correct magnitude and direction labelled force vectors - minor errors or omissions ● Thorough comparison of the forces, including at least one similarity and one difference	3
● Some drawing and labelling of forces on diagram ● Some attempt to provide one similarity and one difference OR a thorough and correct description of forces (no comparison) OR ● Mostly correct annotation of diagram with correct magnitude and direction labelled force vectors - minor errors or omissions ● No comparison of forces provided OR ● Thorough comparison of the forces, including at least one similarity and one difference ● No labelling of forces on diagram	2
● Some attempt to draw forces on the diagram ● OR ● One similarity OR one difference between forces provided	1

27	maxwell contribution	written	4	PF

Criteria	**Mark**
Extensive analysis of Maxwell's work with high levels of detail provided.	4
Thorough analysis of Maxwell's work - with minor omissions or errors	3
Sound attempt to describe Maxwell's work	2
Relevant statement made about Maxwell's work	1

28	derivation E field	derivation	2	ASolom

Criteria	Marks
● Expression correctly derived in terms of m, q, E and d. Response shows full working with no errors or omissions.	2
● A major component or part of the derivation is shown.	1

29	HR diagram/nuclear processes	written	6	AD

(a) Band 2-4

Marking Criteria	**Marks**
● Correctly predicts the next stage of Star X in its evolutionary pathway	1

Suggested answer: Red giant or supergiant

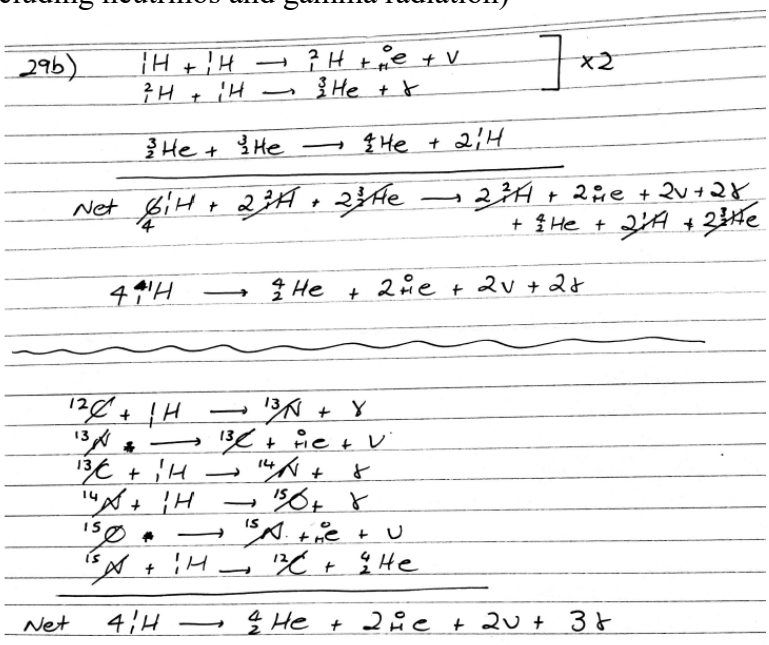
(b) Band 2-6

Marking Criteria	**Marks**
● Extensive and explicit description of at least three significant differences between the stars ● Demonstrates extensive understanding of both CNO and p-p cycles ● At least the two net equations included (and correct with ALL products)	5
● Thorough description of at least three significant differences ● Demonstrates substantially correct understanding of CNO and p-p cycles but missing detail ● Both net equations substantially correct but with minor errors	4
● Sound description of at least two differences ● Demonstrates an understanding of the CNO and p-p cycles but with key omissions or details lacking ● At least one net equation substantially correct but with errors	3
● Limited description of at least one difference ● OR ● List of relevant facts about both stars with minimal/no description or contrast provided	2
● One piece of relevant information	1

Differences could include (X to Z):

- main process (CNO, p-p) - could be linked to conditions (temperature/pressure) required for each type of fusion
- products (3 gamma, 2 gamma - rest same)
- catalyst (yes C-12, no)
- intermediate products (isotopes of C/N/O, H-2/He-3)
- number protons used in process (4 x H-1, 6 x H-1)
- structure of process (cycle, linear chain)

Possible equations: (note, only two main net equations compulsory - must show all products including neutrinos and gamma radiation)



30	AC motor	written	5	AD

Band 2-6

Criteria	**Mark**
A cause and effect response effectively incorporates aspects of the diagram to follow a chain of logic that links the AC supply current through all key steps to the delivered torque	5
A cause and effect response links the AC supply current through some key steps to the delivered torque with a significant error or omission or without reference to diagram	4
Response outlines a substantially correct process with some significant errors or omissions	3
Response outlines some relevant processes for functioning of AC induction motor with various key omissions	2
A limited outline features an aspect of AC induction motor process	1

Suggested response:

CAUSE:
Phased AC current is provided to opposite pairs of stator coils, causing the fields to turn off and on in sequence, creating a rotating magnetic field in the stator (seen in diagram)
Thus, change in flux experienced by squirrel cage rotor (SCR) bars (seen in diagram)
Therefore, emf is induced in SCR (Faraday's)
Thus, current flows in circuit along bars and connecting end plates (seen in diagram)
The direction of this current establishes a magnetic field that interacts with the stator coil field to reduce the cause of the original change in flux (Lenz)
EFFECT: This interaction results in a magnetic force, which causes a torque on the SCR
OR
EFFECT: This current in the SCR experiences a motor effect force, which causes a torque on the SCR

31	PE effect graph analysis	written	5	AD

Band 2-6

Criteria	**Marks**
Student provides an extensive and logical analysis of the evidence from the four graphs with correct and detailed photoelectric effect theory, to explain why both classical wave theory predictions were incorrect. Student makes clear and obvious links between evidence and the classical wave model predictions.	5
Student provides a thorough analysis of the evidence of the two key graphs (A and B), with substantially correct photoelectric effect theory (lacking some detail), to explain why both classical wave theory predictions were incorrect.	4
Student provides an analysis of the evidence at least two graphs, with some/minimal correct photoelectric effect theory (brief or lacking detail), to explain why classical wave theory predictions were incorrect.	3
Student provides a basic analysis of the evidence from at least one graph, with an attempt at providing photoelectric effect theory and relates this to why at least one of the classical wave theory predictions was incorrect. OR Provides correct statements about at least two graphs but with no photoelectric effect theory to justify statements	2
Student provides any relevant information	1

Suggested answer structure

Graph A -

- GRAPH DESCRIPTION (NOT INFERENCE): shows that kinetic energy of electrons is proportional to the frequency of the light
- RELEVANT THEORY: the electrons that have kinetic energy have been emitted from the metal, with the kinetic energy equal to the incoming photon energy (hf) minus the energy needed to remove the electron from the metal (work function) according to the equation K_{max} = hf - (work function)
- LINK THEORY TO THE GRAPH: the graph shows an x-axis intercept so for some frequencies of light, the K_{max} of the electrons is zero - this is because these electrons have not had enough energy to overcome the work function so have not been emitted from the metal - this intercept/value is the threshold frequency (E = hf - so related to the energy of the photon).
- CONCLUSION/PREDICTION: It can thus be concluded that there are some frequencies of light that do not have enough energy to overcome the work function so don't emit electrons. This disproves Prediction 1 - as not all frequencies of light result in electron emission.

32	lenz's law copper tubes	calculation	4	MB

Band 2-6

● Full, correct calculation of magnitude of magnetic field, with correct units and all working shown ● Thorough justification for upwards force in terms of Lenz's law and eddy currents	4
● Substantially correct calculation AND justification with minor errors or omissions in one or both	3
● A substantially correct calculation and justification ● OR ● Correct calculation OR Thorough justification provided	2
● One relevant piece of information provided	1

- The steps are:
    - flux cutting
    - emf generated [Faraday]
    - eddy currents with associated field produced
    - direction of current produces a field which interacts with and opposes the change in flux [Lenz]
    - retarding force

33	electron movement in field	written/calc	7	ASloan

Band 2-6 = accessible to everyone!

Criteria	**Mark**
Response effectively compares clear, significant factors related to MOTION of electrons in each situation including at least two similarities and differences, and including both qualitative and quantitative information, with calculations or processes to correctly determine relevant values (a_g, a_E, v_x, v_Y) for both situations.	7
Response compares clear, significant factors related to MOTION with similarities and differences, including both qualitative and quantitative information, with calculations or processes to determine a less relevant value (F, K) for both situations.	5-6
Response compares factors related to MOTION and features similarities and/or differences, including some qualitative and/or quantitative information OR Response provides factors related to MOTION, including some qualitative and/or quantitative information	3-4
Response notes a valid similarity and/or difference OR Response provides a factor related to MOTION, including some qualitative or quantitative information	1-2

Accepted points of comparison.

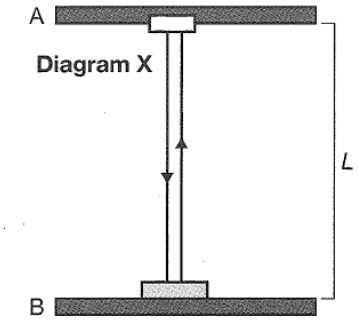
	qualitative	quantitative
Similarity	● v_x = constant ● v_y : changes due to constant acceleration ● motion is parabolic arc/projectile	● $v_x = 4.32 \times 10^6$ ms^{-1}
difference	● Arc curves down in g field ● Arc curves up in E field ● Arc is flatter in g field ● Arc is sharper in E field ● Motion towards arrows in g field ● Motion opposite to arrows in E field ● Acceleration is greater in E field than g field	● $a_E = 9.67 \times 10^{15}$ ms^{-2} • $a_g = 9.8$ ms^{-2} with relevant calculations included ● velocity at any point in time is greater with relevant calculations included

34	**Explain** how THESE observations show time dilation.

Band 2-6

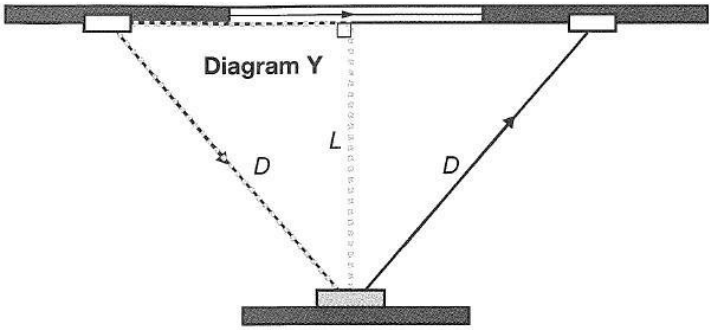
Uses annotation on, or features of, the stimulus, as well as words, to EXPLAIN how the thought experiment shows the concept that the time for an event, recorded by observers in different FoRs, is specifically different, and show that, by linking speed, distance and time and, since c is constant for all observers, and light travels further observed by the moving observer, then a specific conclusion such as $\Delta t_v > \Delta t_0$	4
Gives a good explanation by using most of the above OR Uses all of the above components without clear explanatory logic.	3
Satisfactory explanation by making some links.	2
Limited response, identifying some relevant features.	1

No relative motion between observer and train



$2L = c\,\Delta t_0$
$\Delta t_0 = 2L / c$

Train is in relative motion to observer



$D > L$
$2D > 2L$
$c\,\Delta t_v .> c\,\Delta t_0$
$\Delta t_v .> \Delta t_0$

Sample answer:
With reference to the diagrams it can be seen that as v increases, D > L. Since speed = distance/time and the speed of light is a constant, if the light travels further then the time recorded for the event by the outside observer MUST be greater than the time recorded for the event by the inside observer ie $\Delta t_v .> \Delta t_0$

35	grating graphing	calc	6	MB

(a) Band 2-6

4	Calculates gdt, relates to λ/d and so finds λ = 690 nm
3	As above but with minor error [eg: units, calculation error]
2	Finds incorrect gdt but deduces a λ correctly OR calculates correct gdt and attempts to find λ OR calculates gdt [with minor error], and uses correct method to find λ [with minor error]
1	Attempts to calculate gdt and find λ

Sample answer: Grating is 100 slits / mm -> separation is 0.0100mm or 10um

$$dSin\theta = m\lambda \quad so \quad \frac{\lambda}{d} = \frac{Sin\theta}{m} = gradient$$

$gdt = \frac{0.4-0}{5.8-0} = 6.897x10^{-2}$ [no unit!]

Since $gdt = \frac{\lambda}{d}$

$then \quad \lambda = [d][gdt] = [10\mu m][6.897x10^{-2} = 0.6897\mu m = 690nm = 0.69\ \mu m\ [2\ SF]$

(b) Band 2-6

2	Produces LOBF to read *m* when Sinθ = 1 and gives *m* as an integer value
1	Any correct information - including identification of the 90 degree value OR correct answer with no explicit reference to the graph

Sample answer:

$\theta_{max} = 90^0 \quad so \quad Sin\theta_{max} = 1$

Produce the LOBF on the graph to show that

When $Sin\theta = 1$ then $m = 14.6$ Thus, the maximum order is 14

36	star spectra analysis	written	4	MB

Band 2-6

4	Two differences identified and thoroughly analysed
3	Two differences identified, one thoroughly and one satisfactorily [briefly] analysed
2	Two differences identified, both satisfactorily analysed OR one difference, thoroughly analysed OR no differences identified but two thoroughly expressed conclusions stated
1	Two differences identified OR one difference, satisfactorily analysed OR no differences identified but two satisfactorily expressed conclusions stated

Sample answer:

Observed differences	**Analysis**
λ is increased λ is decreased	A is red-shifted and so A is moving away from Earth B is blue-shifted and so B is moving towards Earth
A has narrow spectral lines B has broad spectral lines	One edge of B is approaching as the opposite edge recedes, adding both blue and red shift to the output of the star, Hence, rotation of B > A

37	Atomic structure	written	9	GN

Marking Criteria	Marks
● Extensive analysis of the atomic model and its development through history with a focus on the three specified physicists Rutherford, Bohr and de Broglie; ● Addresses **ALL** significant key features of the experiments, results and findings/conclusions for each Physicist. Included other Physicists to provide historical context to focus models. ● Extensively addresses the benefits and limitations of each model in relation to developing the atomic model; ● Provides detailed labelled schematic diagrams and relevant Physics formulas.	9
● Thorough analysis of the atomic model and its development through history with a focus on the three specified physicists Rutherford, Bohr and de Broglie; ● Addresses **MOST** of the key features of the experiments, results and findings/conclusions for each Physicist. Included other Physicist/s to provide historical context to focus models. ● Thoroughly addresses the benefits and limitations of each model in relation to developing the atomic model; ● Provides some relevant diagrams and relevant Physics formulas.	7-8
● Sound analysis of the atomic model and its development through history with a focus on the three specified physicists; ● Addresses at least three key features of the experiments, results and findings/conclusions for each Physicist; ● Addresses some of the benefits and limitations of each model in relation to developing the atomic model. ● Limited use of labelled, schematic diagrams.	5-6
● Basic analysis of the atomic model and its development through history with a focus on the three specified physicists; ● Addresses at least two key features of the experiments, results and findings/conclusions for each Physicist; ● Addresses key benefits and limitations of a model in relation to developing the atomic model; ● Limited use of schematic diagrams/atomic models ● **OR** Addresses analysis of two of the models thoroughly. ● **OR** Correctly outlines each model without analysis.	3-4
● Limited discussion of the atomic models **OR** provides some relevant and outlines some detail in relation to one/two of the experiments/models.	2-1

Analyse: Identify components and the relationships among them; Draw out and relate implications.