Student Number: ....

ABBOTSLEIGH

YEAR 12 PHYSICS

ASSESSMENT TASK 4

2023

General Instructions

- Read the questions carefully.
- Answer all questions.
- Carry out this task under test conditions.
- Reading time – 5 minutes
- Working time – 3.00 hours
- Write using black or blue pen only.
- Draw diagrams using pencil and ruler.
- NESA approved calculators may be used.
- Write your student number at the top of this page.
- A data sheet and Periodic Table are provided at the back of this paper.

Section 1
- Multiple Choice questions: 20 marks
- Allow about 35 minutes for this part.

Section 2
- Free responses: 80 marks
- Allow about 2 hours and 25 minutes for this part.

Total marks: 100 marks

	Skills	**Knowledge**	**Total**
Section 1 Multiple Choice (20 marks)	/ 9	/ 11	/ 20
Section 2 Free Response (80 marks)	/ 24	/ 56	/ 80
Total	/ 33	/ 67	/ 100

Section 1
(20 marks)

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

Use the multiple-choice answer sheet at the back of this paper for Questions 1–20.

1 What is the temperature of a black body whose intensity peaks at $5.4 \times 10^{14}\ Hz$.

(A) 1.6×10^{12} K

(B) 1.6×10^{12} °C

(C) 5.2×10^{3} K

(D) 5.2×10^{3} °C

Questions 2 and 3 refer to the following information.

A 400 nm laser is shone through a diffraction grating which has 10 lines/mm. A screen is placed 3.0 m away on which several bright bands are seen.

2 The pattern on the screen is best explained by:

(A) The interference of light as each slit acts as a source.

(B) Each band corresponding to a slit in the diffraction grating through which light is passing.

(C) The interference of the laser with background light.

(D) The particle nature of light.

3 Calculate the distance from the central bright band to an adjacent bright band.

(A) $1.2 \times 10^{-7}\ m$

(B) $1.2 \times 10^{-2}\ m$

(C) $8.3 \times 10^{-2}\ m$

(D) $83\ m$

4 What is the momentum of an electron which has been accelerated to 0.98c in a particle accelerator as measured by a detector?

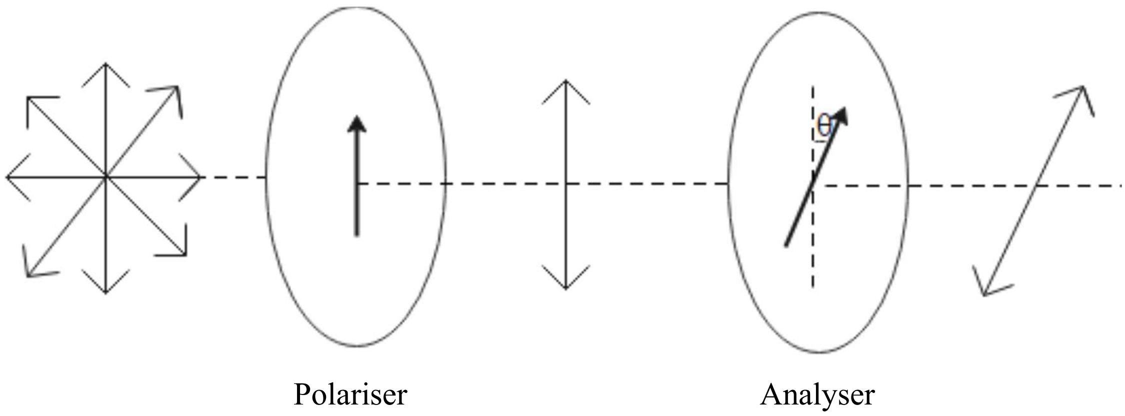
(A) 5.3×10^{-23} kg m s^{-1}

(B) 2.7×10^{-22} kg m s^{-1}

(C) 1.3×10^{-21} kg m s^{-1}

(D) 2.8×10^{-20} kg m s^{-1}

5 The diagram below represents an experimental apparatus. The intensity of light entering the polarizer is 513 lux.



What is the intensity of light as it leaves the analyser if the angle between the polariser and analyser is 17.0°.

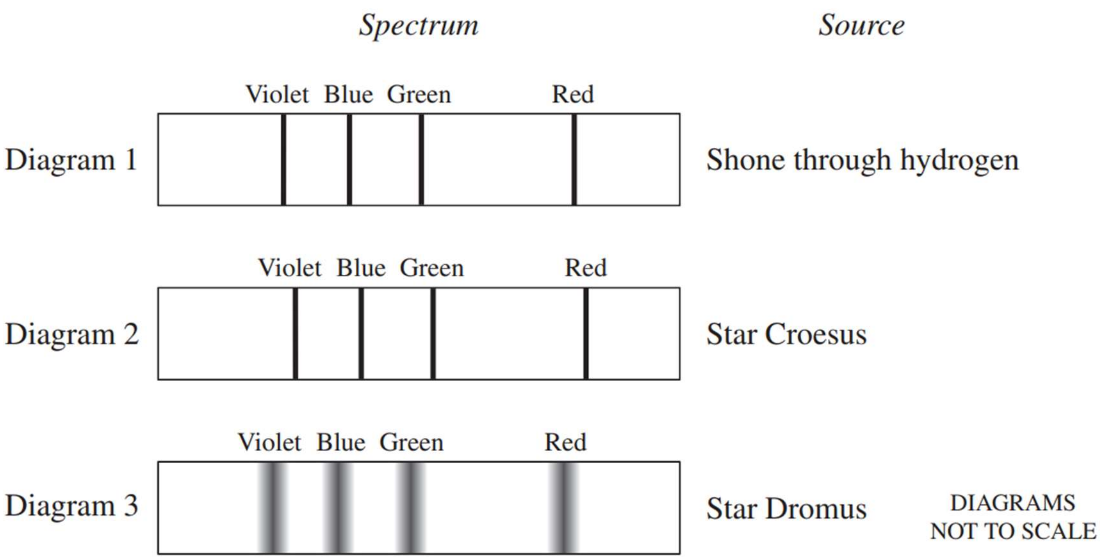
(A) 235 lux

(B) 245 lux

(C) 257 lux

(D) 469 lux

6 Diagram 1 shows the absorption spectrum of light produced by an incandescent filament, after it has been shone through a quantity of hydrogen gas. Diagrams 2 and 3 show the spectra obtained from two stars: Croesus and Dromus. The dark lines in the diagrams are absorption bands.



Which of the following conclusions CANNOT be drawn from the diagrams?

(A) Dromus is rotating faster than Croesus.

(B) Both stars contain hydrogen.

(C) Dromus is moving towards us.

(D) Croesus has a higher surface temperature than Dromus.

7 Which row of the table correctly matches the scientists to the type of experiment they performed when attempting to measure the speed of light?

	Romer	*Bradley*	*Fizeau*	*Foucault*
(A)	Rotating Component	Rotating Component	Astronomical Methods	Astronomical Methods
(B)	Astronomical Methods	Astronomical Methods	Rotating Component	Rotating Component
(C)	Rotating Component	Astronomical Methods	Astronomical Methods	Rotating Component
(D)	Astronomical Methods	Rotating Component	Rotating Component	Astronomical Methods

8 Some early experiments into the nature of cathode ray tubes included the Maltese cross experiment, the paddle wheel experiment, deflecting a beam with a magnet, and deflecting a beam with an electric field. Which of the following conclusions could NOT be drawn from these early experiments?

(A) Cathode rays consist of negatively charged particles.

(B) Cathode rays travel in straight lines.

(C) Cathode rays can do work.

(D) The mass of the particles in cathode rays.

9 An oil drop is suspended between horizontal charged plates separated by 3.2 mm and 4.7 kV with the positive plate on the bottom as shown below.

The oil drop was estimated to have a volume of $2.1 \times 10^{-16}\ m^3$. Given that the density of oil is $8.0 \times 10^2\ kg\ m^{-3}$, how many excess or missing electrons are on the drop of oil?

(A) 5 excess electrons

(B) 5 missing electrons

(C) 7 excess electrons

(D) 7 missing electrons

10 Two projectiles are launched horizontally from the same height. However projectile B has twice the initial velocity of A. Which of the following statements is true? (u= initial velocity, t= time of flight, R= range)

(A) $u_{Ax} = \frac{1}{2}u_{Bx};\ u_{Ay} = u_{By};\ t_A = t_B;\ R_A = \frac{1}{2}R_B$

(B) $u_{Ax} = \frac{1}{2}u_{Bx};\ u_{Ay} = u_{By};\ t_A = 2t_B;\ R_A = R_B$

(C) $u_{Ax} = \frac{1}{2}u_{Bx};\ u_{Ay} = u_{By};\ t_A = t_B;\ R_A = R_B$

(D) $u_{Ax} = \frac{1}{2}u_{Bx};\ u_{Ay} = u_{By};\ t_A = 2t_B;\ R_A = 2R_B$

11 A satellite revolves around a planet X1B2 with a period of 2.45×10^7s at an orbital radius of 3.80×10^{10} m. What is the mass of X1B2?

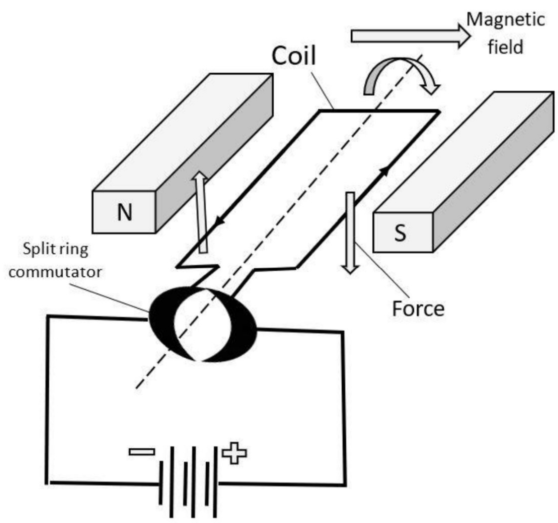
(A) 3.74×10^7kg

(B) 1.42×10^{18}kg

(C) 5.41×10^{28}kg

(D) 1.32×10^{36}kg

12 The diagram below is of a DC motor. The arrows show the direction of force acting on the sides of the coil.



What happens to the magnitude of the forces as the coil rotates?

(A) The forces remain the same at all orientations of the coil to the vertical.

(B) The forces vary as a sine component of the angle to the vertical.

(C) The forces vary as a cos component of the angle to the vertical.

(D) The forces initially increase and then stay constant.

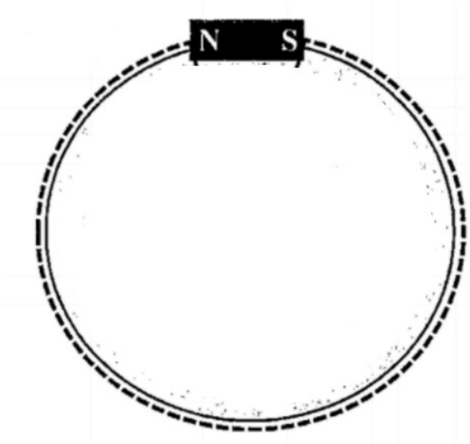
13 Two satellites of equal mass, E and F are orbiting the Earth at altitudes of 2R and 5R respectively, R being the radius of the Earth. Which of the following statements is true?

	Gravitational potential energy	***Escape velocity from the surface of the Earth***	***Orbital velocity***
(A)	$U_F = U_E$	$5V_F = 2U_E$	$U_F = \sqrt{2}U_E$
(B)	$U_F = 2.5U_E$	Equal	$U_F = U_E$
(C)	$2U_F = 5U_E$	$2U_F = 5U_E$	$\sqrt{2}U_F = \sqrt{5}U_E$
(D)	$5U_F = 2U_E$	Equal	$\sqrt{5}U_F = \sqrt{2}U_E$

14 The primary coil of a transformer has 450 turns and the secondary has 1800 turns. Which choice listed in the table below is most appropriate for this transformer?

	Input	*Output*
(A)	5.00 A, 23.0 V	2.00 A, 92.0 V
(B)	5.00 A, 23.0 V	1.25 A, 92.0 V
(C)	10.0 A, 46.0 V	5.00 A, 184 V
(D)	10.0 A, 46.0 V	2.50 A, 69.0 V

15 The diagram below shows the top view of a magnet rotating above a copper disc in an anticlockwise direction.



Which statement below correctly represents the motion of the copper disc?

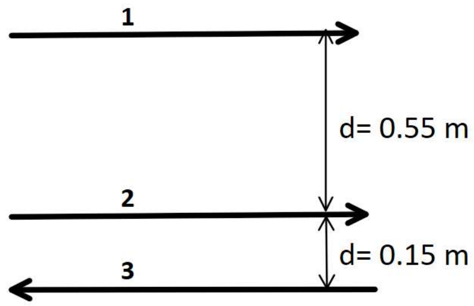
(A) The disc follows the magnet's rotation but at a higher speed than the magnet.

(B) The disc follows the magnet's rotation but at a lower speed than the magnet.

(C) The disc spins in the opposite direction to the magnet's rotation but at a higher speed than the magnet.

(D) The disc spins in the opposite direction to the magnet's rotation but at a lower speed than the magnet.

16 The following diagram shows three current carrying conductors of length 0.500 m carrying 2.5 A in the directions shown.



What is the force acting on conductor 2?

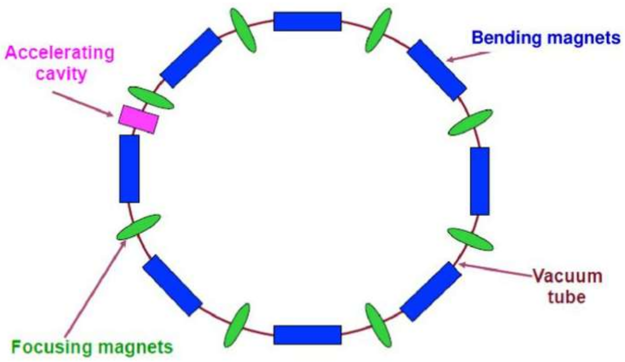
(A) 3.0×10^{-6} N up

(B) 3.0×10^{-6} N down

(C) 5.3×10^{-6} N up

(D) 5.3×10^{-6} N down

17 A proton is moving through the following circular path of radius 102 m with a velocity of 2.25×10^5 ms^{-1}.



Assuming the magnetic field is constant at all points in the path and is perpendicular to the motion, what is the magnitude of the magnetic field needed to maintain the circular motion of the proton?

(A) 3.69×10^{-22} T

(B) 2.30×10^{-5} T

(C) 2.35×10^{-1} T

(D) 1.38×10^{24} T

18 A 10.0 cm conductor rod levitates in an external magnetic field of 4.20 T, that is acting at right angles to the rod. A current of 2.50 A flows through this rod. What is the mass of this rod?

(A) 0.011 kg

(B) 0.11 kg

(C) 1.1 kg

(D) 11 kg

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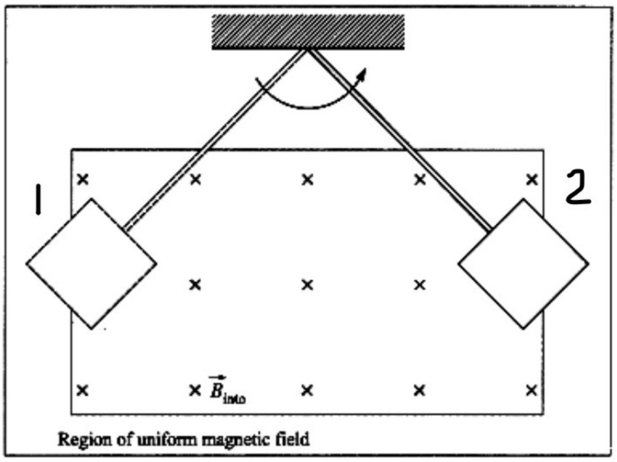


The above diagram shows a metallic plate swinging through an external magnetic field. Which of the following statements about the motion is correct?

(A) At position 1, the plate experiences a resistive force due to eddy currents flowing anticlockwise and at position 2, the plate experiences a resistive force due to clockwise eddy currents.

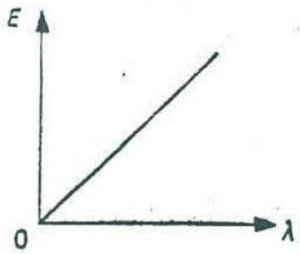
(B) At position 1, the plate experiences an attractive force due to eddy currents flowing anticlockwise and at position 2, the plate experiences a resistive force due to clockwise eddy currents.

(C) At position 1, the plate experiences a resistive force due to eddy currents flowing clockwise and at position 2, the plate also experiences a resistive force due to anticlockwise eddy currents.

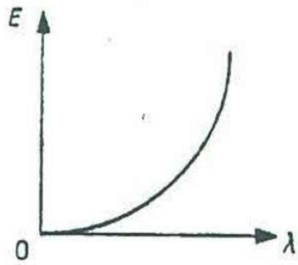
(D) At position 1, the plate experiences a resistive force due to eddy currents flowing anticlockwise and at position 2, the plate experiences a resistive force due to anticlockwise eddy currents.

20 Which of the following graphs shows the relationship between a photon's energy and its wavelength?

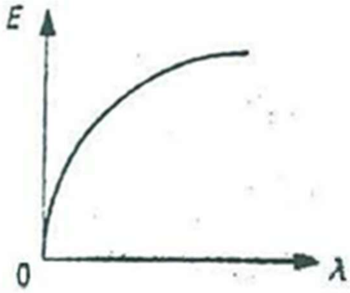
(A)



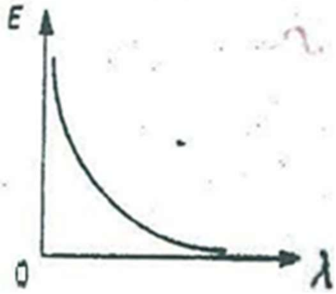
(B)



(C)



(D)



End of Section 1

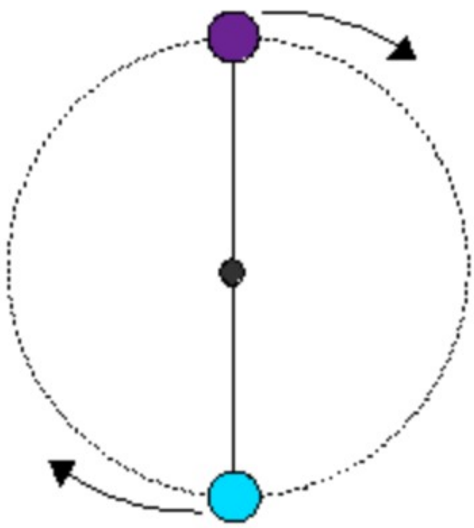
Section 2
(80 marks)

Attempt Questions 21–34
Allow about 2 hours and 25 minutes for this part.

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
Show all relevant working in questions involving calculations.

Question 21 (3 marks) **3**

A ball of mass 0.130 kg is swung around on a string of length 95.5 cm at 5.00 revolutions per second in a vertical circle.



Determine the difference in tension on the ball at the top and the bottom points of the vertical circle.

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Question 22 (4 marks)

Compare the structure and function of an AC generator with that of a DC motor. **4**

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Question 23 (7 marks) **7**

The discovery of the interaction between magnetic and electric fields brought about many laws and applications. Analyse at least 3 laws or principles and at least 2 applications that arose from this discovery.

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Question 23 (continued)

End of Question 23

Question 24 (6 marks)

Lauren throws a basketball with a horizontal component of velocity of 8.00 ms^{-1}. The ball reached the original height from which it is thrown in 3.00 s and took a further 0.11 s to reach the ground.

(a) Calculate the horizontal range. **1**

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(b) Calculate the vertical component of initial velocity. **2**

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(c) Calculate the initial angle of projection. **1**

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(d) Calculate the height at which Lauren threw the ball. **2**

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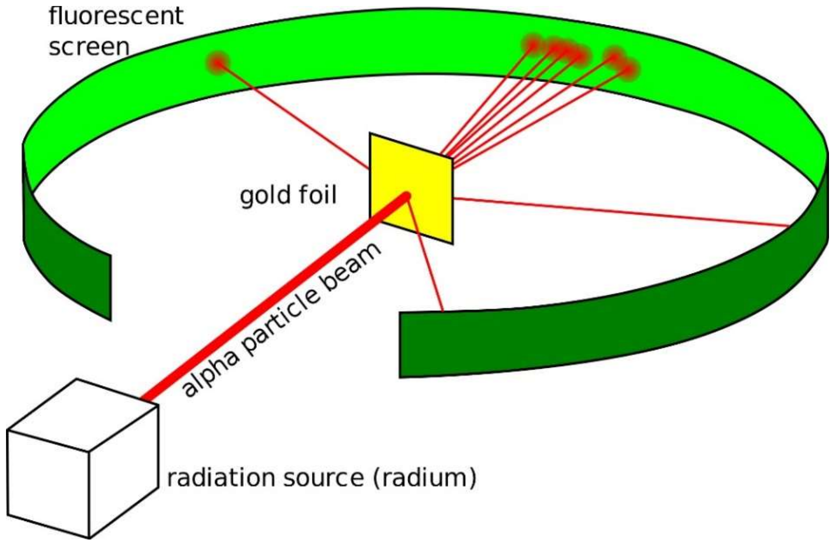
Question 25 (6 marks)

The apparatus for an experiment is shown below.



(a) Explain how the results of this experiment led Rutherford to develop his atomic model. **3**

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(b) Explain how experimental evidence led Chadwick to his discovery of the neutron. **3**

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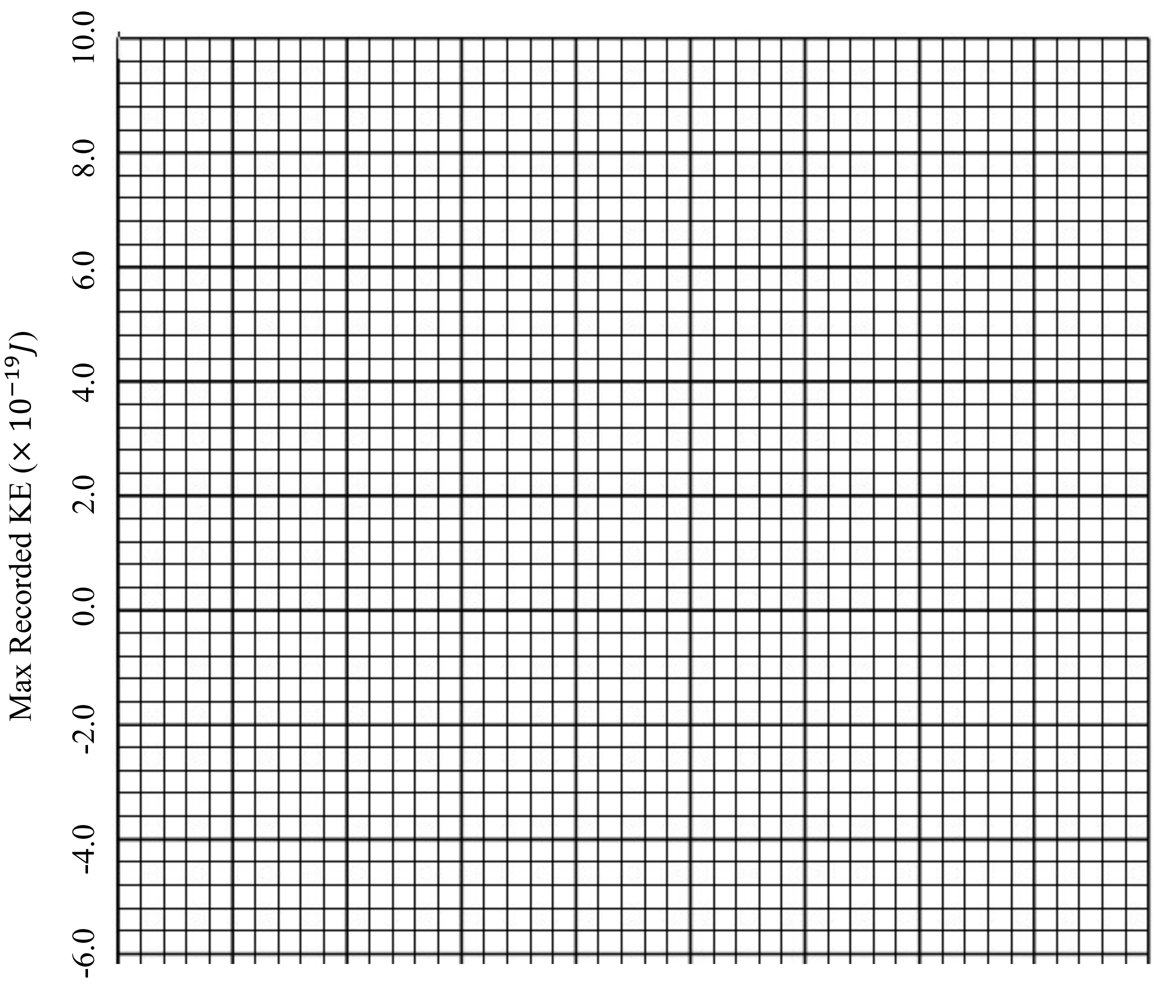
Question 26 (9 marks)

Researchers conducted an experiment to determine the maximum kinetic energy of electrons emitted from a plate of potassium when irradiated with light of various frequencies.

(a) Plot the following data points on the axis provided and add an appropriately extrapolated trendline. **3**

Frequency (Hz)	Max recorded KE (J)
0.00×10^{14}	0.00
2.00×10^{14}	0.00
4.00×10^{14}	0.00
6.00×10^{14}	$0.31 \times^{-19}$
8.00×10^{14}	$1.63 \times^{-19}$
10.00×10^{14}	$2.96 \times^{-19}$
12.00×10^{14}	$4.28 \times^{-19}$
14.00×10^{14}	$5.61 \times^{-19}$
16.00×10^{14}	$6.93 \times^{-19}$



Question 26 continues on next page

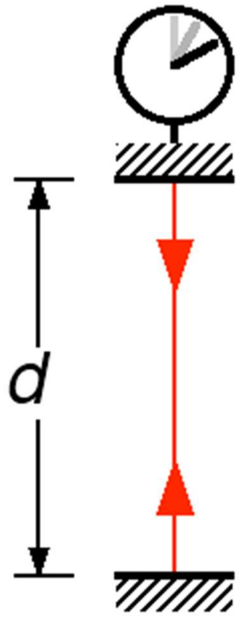
Question 26 (continued)

(b) Write an equation for your line of best fit and analyse its features. **6**

End of question 26

Question 27 (7 marks)

A light clock is a theoretical device which times how long it takes a photon to bounce between two horizontal mirrors.



(a) Explain how the above light clock thought experiment led Einstein to the conclusion that time dilates as you travel close to the speed of light. **3**

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Question 27 continues on next page

Question 27 (continued)

(b) A train is moving at $2.87 \times 10^8\ ms^{-1}$. How much time passes for a passenger on the train if 2.93 ns pass for a person on a stationary platform? **2**

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(c) Explain how either the study of muons OR the Hafele–Keating experiment provides evidence for time dilation. **2**

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Question 28 (2 marks) **2**

Determine the orbital radius around the earth at which the acceleration due to gravity is 2.45 ms^{-2}.

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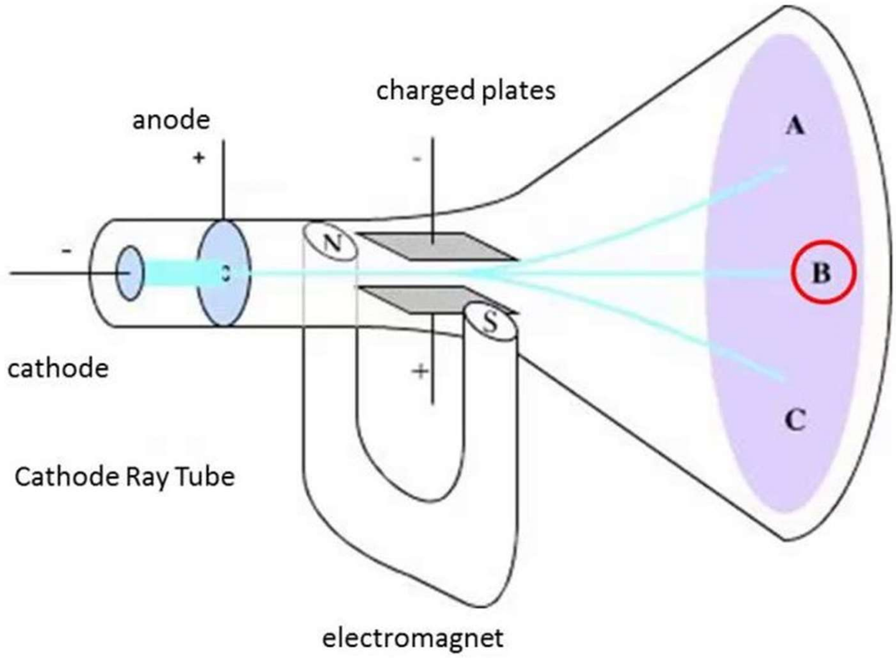
Question 29 (6 marks)

Thomson used an apparatus similar to the one below to investigate the properties of cathode rays.



(a) The charged plates were separated by a distance of 2.00cm and a potential difference of 13.0V was applied to them. The magnetic field generated by the electromagnet was measured to be 0.120 mT. When the electric field was turned off, the radius of curvature was measured to be 25.6 cm. Calculate the charge to mass ratio of the particles within the cathode rays as Thomson did. **4**

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Question 29 continues on next page

Question 29 (continued)

(b) Compare Thomson's and Millikan's experiments. **2**

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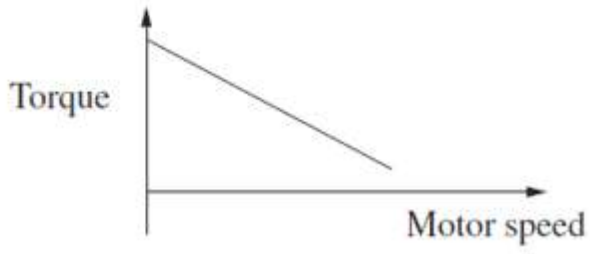
Question 30 (3 marks) **3**

The following graph shows the torque generated in a DC motor as a function of the motor speed. Explain the trend.



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Question 31 (9 marks) **9**

Throughout the course you have learnt about four attempts to explain the nature of light:

- Newton's corpuscular model of light
- Huygens wave model of light
- Maxwell's theory of electromagnetism
- Plank and Einstein's particle model of light.

Briefly describe each of these models and analyse the evidence which led scientists to progress their understanding through these various models.

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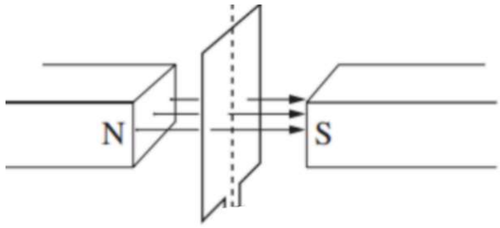
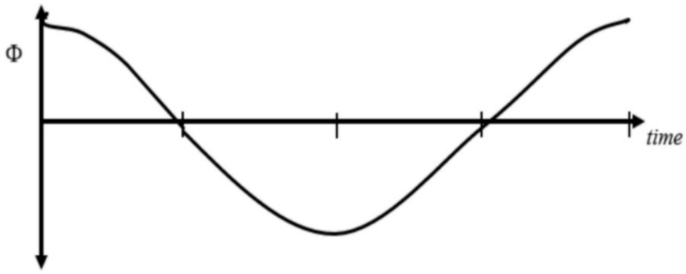
Question 31 (continued)

Question 32 (8 marks)

The diagram below shows a coil rotating from the position shown in a magnetic field. The graph then represents the change in flux through the coil. The coil's circuit is not complete.





(a) On the graph above, sketch a curve to represent the variation in induced emf over time in the same coil. Label the curve as "emf 1". **1**

(b) Also on the same graph, using a different colour pen/pencil, sketch a curve to represent the variation in induced emf over time in the same coil if it is rotated at two times the speed. Label this curve as "emf 2" **2**

(c) If the plane of the coil which has 500 turns and an enclosed area of 2.25×10^{-3} m^2, makes an angle of 30° to an external magnetic field of 3.2 T, calculate the magnetic flux through each turn of the coil. **1**

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(d) If the coil takes 0.52 s to rotate from a position of maximum to minimum flux, calculate the magnitude of the induced emf. **1**

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Question 32 continues on next page

Question 32 (continued)

(e) If this coil is now connected to a light bulb which completes the circuit, explain any changes in the speed of rotation assuming the applied external torque remains constant. **3**

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Question 33 (3 marks) **3**

$^{19}_{8}O$ is a β^- emitter with a half-life of 26.47 s. A sample of $^{19}_{8}O$ was placed in a detection box with a sample of an unknown radioactive isotope X. Both samples had the same initial number of atoms and isotope X has a half-life of 52.94 s.

After placing the samples in the box, only half the number of β^- particles predicted were detected. A large number of photons were detected. What is the most likely explanation for these observations?

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Question 34 (7 marks)
A road has a banked corner of radius 66.0 m. The maximum frictional force that the road can provide is 1/6th of the normal contact force. A stationary car of mass 1000.0 kg when parked on this road will only just remain at rest rather than slide down the slope.

(a) Calculate the angle of banking of the road. **3**

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(b) Calculate the maximum speed at which the car could go around the bend. **4**

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End of Task

Student Number: ....

Multiple-choice Answer Sheet (Questions 1-20)

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

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

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ~~●~~ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word ***correct*** and drawing an arrow as follows.

correct

A ~~●~~ B ~~●~~ C ○ D ○

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

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ASSESSMENT TASK 4-23 - Marking Guidelines

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

Solutions to calculations

1. $\lambda T = b \Rightarrow \frac{c}{f}T = b \Rightarrow \frac{3.00\times10^8}{5.4\times10^{14}} \times T = 2.898\times10^{-3} \Rightarrow T = 5216.4 \approx 5.2\times10^3 K$

3. $dsin\theta = n\lambda \Rightarrow \frac{dx}{L} = n\lambda \Rightarrow \frac{10^{-4}x}{3.0} = 400\times10^{-9} \Rightarrow x = 1.2\times10^{-2}$m

4. $p_v = \frac{p_0}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{mv}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{9.109\times10^{-31}\times0.98\times3.00\times10^8}{\sqrt{1-\frac{0.98^2}{c^2}}} \Rightarrow p_v = 1.3457\times10^{-21} \approx 1.3\times10^{-21}$kgms^{-1}

5. $I = I_0cos^2\theta \Rightarrow I = \frac{513}{2}cos^2 17 = 234.574 \approx 235\ lux$

9. $mg = qE \Rightarrow mg = \frac{qV}{d} \Rightarrow m = V\times density = 2.1\times10^{-16}\times8.0\times10^2 \Rightarrow q = \frac{mgd}{V} = \frac{2.1\times10^{-16}\times8.0\times10^2\times9.8\times0.0032}{4700}$=1.12095$\times10^{-18}$C

Number of missing electrons(e move to positive plate)=$\frac{1.12095\times10^{-18}}{1.602\times10^{-19}} = 6.99 \approx 7$

11. $\frac{R^3}{T^2} = \frac{GM}{4\pi^2} \Rightarrow \frac{(3.8\times10^{10})^2}{(2.45\times10^7)^3} = \frac{6.67\times10^{-11}\times M}{4\pi^2} \Rightarrow M = 5.40520\ldots\times10^{28} \approx 5.41\times10^{28}$kg

14. $P_{input} = P_{output} \Rightarrow V_pI_p = V_sI_s \Rightarrow 5.00\times23.0 = 1.25\times92.0$

16. F on conductor 2= F from 1 up + F from 3 up=$\frac{\mu_0 I^2 l}{2\pi}\left(\frac{1}{r_1}+\frac{1}{r_2}\right) = \frac{4\pi\times10^{-7}\times2.5^2\times0.500}{2\pi}\left(\frac{1}{0.55}+\frac{1}{0.15}\right)$=5.3 $\times10^{-6}$N up

17. $qvB = \frac{mv^2}{r} \Rightarrow 1.602\times10^{-19}\times B = \frac{1.673\times10^{-27}\times2.25\times10^5}{102} \Rightarrow B = 2.30\times10^{-5}$T

18. $BIl = mg \Rightarrow 4.20\times2.50\times0.10 = m\times9.8 \Rightarrow m = \frac{4.20\times2.50\times0.10}{9.8} = 0.10714\ldots \approx 0.11$kg

Question 21 (3 marks)

correctly determines the difference in tension at the top and bottom of the vertical circle	3
determines the tension correctly at either the bottom or top and calculates the difference in tension	2
determines the tension at any one point	1

Sample answer:

$$At\ the\ bottom: T - mg = F_c \Rightarrow T = mg + F_c\,; At\ the\ top, T + mg = F_c \Rightarrow T = F_c - mg$$

Difference= $mg + F_c - (F_c - mg)$= $2mg$ = 2 × 0.130 × 9.8=2.548 N≈ 2.55 N

Question 22 (4 marks)

correctly compares AC generator with a DC motor- includes one similarity and difference about structure AND function	4
makes one error in the comparison	3
has two similarities/differences for either structure OR function	2
makes one correct comparison	1

Sample answer:

SIMILARITIES	STRUCTURE: Both contain coils of conductor wires wrapped around an iron armature, an external magnetic field	FUNCTION The coils rotate in an external magnetic field. Emf induced in both
DIFFERENCES	AC GENERATOR	DC MOTOR
STRUCTURE	Connected to the external circuit through slip rings	Connected to the external circuit through split ring commutator

FUNCTION	Converts mechanical energy to electrical energy	Converts electrical energy to kinetic
	Generates AC	Input is DC and back emf induced
	Magnets can rotate around the coil while the coil is stationary	The coil rotates in the magnetic field
	Faraday's and Lenz's laws	Motor effect

Question 23 (7 marks)

comprehensively discusses any three laws/principles- motor effect, Ampere's law, Faraday's and Lenz's law AND use of these in any two applications- motors, generators, transformers, electromagnetic braking, back emf in DC motors	6-7
detailed discussion of most points mentioned above	4-5
some detail included	2-3
attempts at defining the principles/laws OR the applications	1

Sample answer:

The interaction between magnetic and electric fields have led to the formulation of many principles. Among them are the following:

Motor effect: when a current carrying conductor is placed in an external magnetic field, the interaction of its own magnetic field with the external causes a force to act on the conductor which causes it to move. This led to important applications such as the motors, ammeters, galvanometers, voltmeters etc. In a motor the electrical energy carried by the current is changed to rotational kinetic energy which turns fan blades etc.

Ampere's law: Two current carrying conductors when placed in each others' magnetic fields experience a force of either repulsion or attraction. Useful to keep the transmission lines carrying currents in the same direction a minimum distance apart so that they will not touch each other as they experience a force of attraction.

Electromagnetic induction (Faraday's law): Any conductor that experiences a changing flux with time (due to a changing external magnetic field or a changing area) has an emf induced in it. This is the principle of generators where an AC voltage is induced in the coil and led into the external circuit as Ac or changed to DC with split ring commutator connection to the external circuit. Also the principle of transformers where an AC voltage in the primary induces and AC voltage that is higher or lower in the secondary of the transformer depending on the number of turns of the coils.

Electromagnetic induction and Lenz's law: Once the circuit is completed induced current flows as a result of the induced emf in a direction to create a magnetic field that opposed the original change that caused it. Electromagnetic braking used it in the form of eddy current in a solid conductor that flow to oppose the original motion/change that caused it and lead to stop the motion of the device.

Accepted Maxwell's contributions and link to applications

Question 24a (1 mark)

correctly calculates the range	1

Sample answer:

$Range = u_x t = 8.00 \times 3.00 + 8.00 \times 0.11 = 24.88 \approx 24.9\ \text{m}$

Question 24b (2 marks)

correctly determines the vertical component of the initial velocity to	2
makes one error in the calculation	1

Sample answer:

$$t_{\frac{1}{2}} = 1.50s; a = -g$$

$v_y = u_y + at => 0 = u_y - 9.8 \times 1.50 => u_y = 14.7$ ms-1

Question 24c (1 mark)

correctly calculates the angle of projection	1

Sample answer:

$$tan\theta = \frac{u_y}{u_x} => \theta = tan^{-1}\frac{u_y}{u_x} = tan^{-1}\frac{14.7}{8.00} => \theta = 61.4441 \ldots = 61.4^{\circ}$$

Question 24d (2 marks)

correctly determines the height from which the ball was thrown	2
makes one error in the calculation	1

Sample answer:

$\Delta y = u_y t + \frac{1}{2}gt^2 => 14.7 \times 0.11 + \frac{1}{2} \times 9.8 \times 0.11^2 = 1.676 \ldots \approx 1.68\text{m}$

Question 25a (3 marks)

Clearly explains how the GM experiment led Rutherford to his model	3
Describes how GM experiment led Rutherford to his model	2
Some relevant information given	1

Sample answer:

In the experiment most alpha particles passed straight through the gold foil while a small number were reflected or deflected.

This suggested that they were encountering a small, solid positively charged mass which was deflecting the positively charged alpha particles

Hence, Rutherford proposed his planetary model of the atoms with a positive nucleus at the centre.

This was marked generously, the best answers explained that the positive charge caused the deflection due to electrostatic repulsion.

Question 25b (3 marks)

Clearly explains how experimental evidence led Chadwick to his discovery	3
Describes an experiment which led Chadwick to his discovery	2
Some relevant information given	1

Sample answer:

Alpha particles are fired at a sheet of beryllium. There was then an unknown radiation emitted. If this radiation was directed towards a sheet of paraffin wax, high energy protons were emitted from it. And this could be only possible if the unknown radiation had very large energy which could not be associated with gamma.

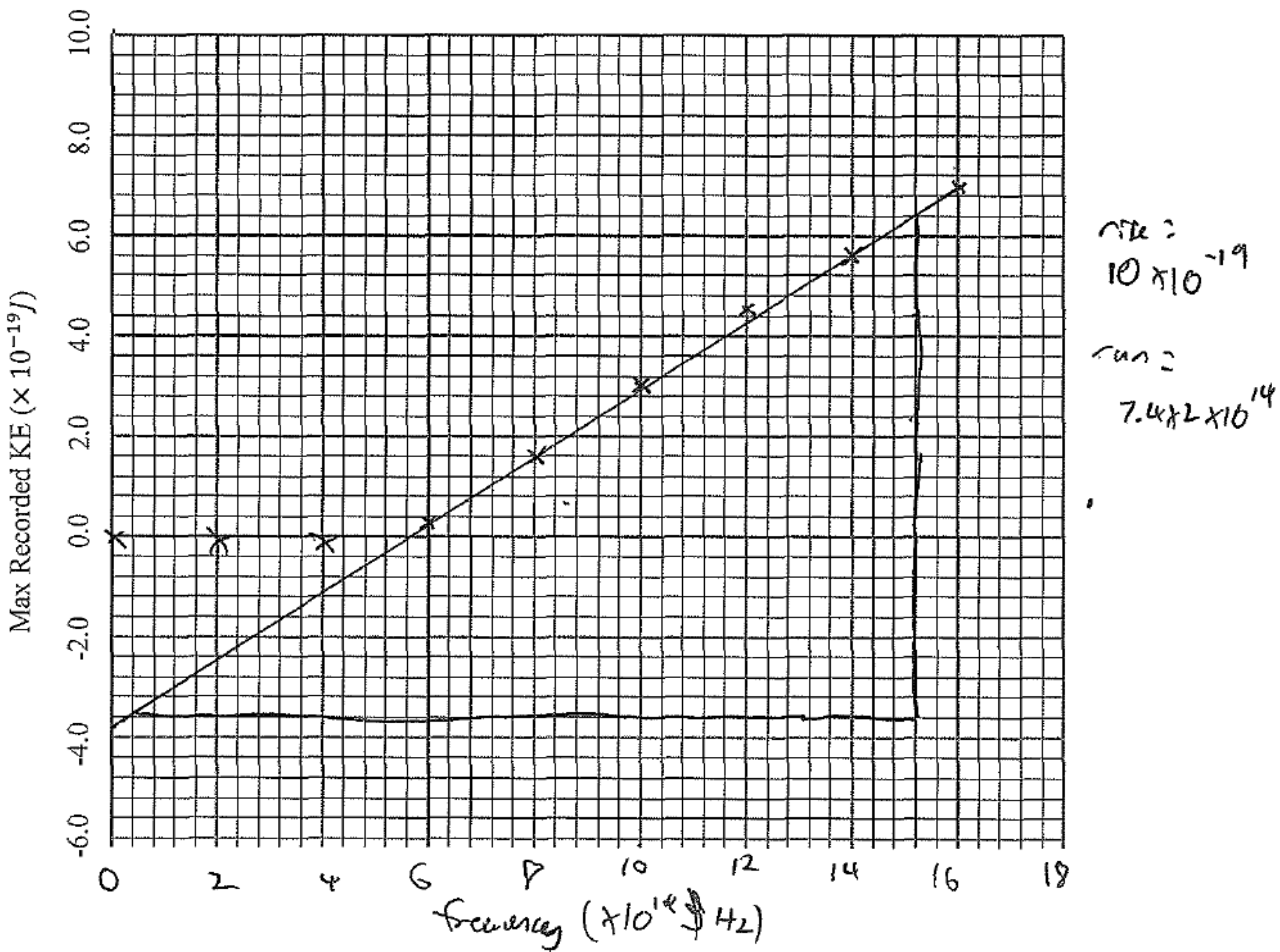
Chadwick used conservation laws to identify the unknown radiation as neutrons, with both mass and speed contributing to the high energy of this radiation.

Experiment described but no link to reason why the radiation had to have mass to explain the high energy value

Question 26a (3 marks)

A graph with correctly plotted points, correct axis spacing and label, and appropriate line of best fit.	3
2 of the above points	2
An attempt at a graph with some correct features.	1

Sample answer:



Question 26 continues on Next Page

Common mistakes: Including first three points in the line of best fit, not extending the line of best fit to get y - intercept, poor line of best fit

Question 26b (6 marks)

A correct equation given with all of its features clearly explained (including h, E=hf, and ϕ)	6
A correct equation given with an attempt to explain its features.	4-5
Correct equation given OR errors in equation but an attempt made to explain the features	2-3
Some relevant information given.	1

Sample answer:

$$m = \frac{6.4 \times 10^{-19} - (-3.6 \times 10^{-19})}{(15.2 \times 10^{14} - 0.4 \times 10^{14})} = \frac{10 \times 10^{-19}}{14.8 \times 10^{14}} = 6.67 \times 10^{-34} \text{J/Hz}$$

$$b = -\phi = -3.8 \times 10^{-19}$$

$$k_{max} = 6.67 \times 10^{-34} f - 3.8 \times 10^{-19}$$

The gradient of the above graph is equal to planks constant which is a universal constant related to the quantization of energy in discrete packets, E=hf.

The y-intercept is equal to the work function of potassium. This is the minimum energy needed to remove an electron from the surface of the photoelectric material.

The max energy of an electron can thus be given by the equation where $6.67 \times 10^{-34} f$ is the energy of a given photon and 3.8 is the amount of that energy which is needed to remove it from the surface.

Common mistakes: using data points that do not lie on the LOBF, wrong gradient calculation, wrong y- intercept, not interpreting gradient as h, not defining work function, not representing equation in terms of f and work function

Question 27a (3 marks)

Clearly explains how the light clock thought experiment led Einstein to his conclusion about time dilation	3
Attempts to explains how the light clock thought experiment led Einstein to his conclusion about time dilation	2
Some relevant information given	1

Sample answer:

When the moving light clock is viewed from a stationary frame of reference, the photons appear to travel further than when viewed from within the moving frame. Since c must be a constant in both frames of reference, t must dilate since $v = \frac{d}{t}$.

1 mark if used holding up mirror thought experiment instead

Question 27b (2 marks)

Correctly calculates the time	2
Makes 1 error	1

Sample answer:

$$t_0 = t \times \sqrt{1 - \frac{(2.87 \times 10^8)^2}{(3.00 \times 10^8)^2}}$$

$$t_0 = 8.53 \times 10^{-10} s$$

Many students mixed up t *and* t_0

Question 27c (2 marks)

Explains how either experiment provides evidence for time-dilation	2
Describes one of the experiments	1

Sample answer:

The detection of muons at the earths surface provides evidence for time dilation since as time dilates, more time will pass for an observer. So their half life appears longer for us, allowing them to reach the earths surface even though only a fraction a second has passed for them.

Note that 2.2μs is the average life of muons (not half life which =1.56μs) – there was a typo on class notes, not penalised

Atomic clocks placed on a plane flown around the world and then compared to a reference clock can provide evidence for time dilation. If they are flown eastward the clock will be behind time as the clock is travelling faster, if flown west they will be ahead of time since the clock is travelling slower. Since only 2 marks was marked generously and awarded marks if said the clock on jet was behind time.

Question 28 (2 marks)

correctly determines the orbital radius	2
makes an error	1

Sample answer:

$g = \frac{GM}{(R+h)^2}$ => $2.45 = \frac{6.67\times10^{-11}\times6.0\times10^{24}}{(R)^2}$ => $R = 1.2780725 \ldots \times 10^7 \approx 1.3 \times 10^7$m

Common mistakes made: forgetting the formula for g or not being able to derive it, and mistaking the “r” in the formula as altitude.

Question 29a (4 marks)

Correctly calculates the charge to mass ratio using the values given	4
Makes 1 error	3
Makes 2 errors	2
Correctly equates F_B and F_E OR F_B and F_c	1

Sample answer:

$$F_E = F_B$$
$$qE = qvB$$
$$v = \frac{E}{B}$$
$$F_B = F_c$$
$$qvB = \frac{mv^2}{r}$$
$$\frac{q}{m} = \frac{E}{B^2 r}$$
$$\frac{q}{m} = 1.76 \times 10^{11}$$

Question 29b (2 marks)

Provides one similarity AND one difference	2
Provides one similarity OR one difference	1

Sample answer:

Both studied the properties of the electron

Both used electric fields

Thomson determined q/m while Millikan determined q

Thomson equated F_B and F_E while Millikan equated F_E and F_g

Question 30 (3 marks)

comprehensively explains the trend in the relationship between torque and motor speed, relating the change to a formula or principle	3
lacks some detail in the explanation	2
attempts to explain the trend	1

Sample answer:

As the motor speed increases in a DC motor, the back emf induced (Faraday's law) increases. Since this opposes the supplied emf (Lenz's law), the net emf in the coil decreases, and therefore the current flowing in the coil decreases. The torque which depends on the amount of current flowing in the coil therefore decreases. ($\tau = nBIAsin\theta$

Common mistakes: not recognising the creation of back emf in a DC motor and its relation to speed of rotation, and not relating current to torque.

Question 31 (9 marks)

Describes each model of light and extensively explains what led scientists to progress their understanding	8-9
Describes each model of light and thoroughly explains what led scientists to progress their understanding	6-7
Describes each model of light and attempts to explain the evidence but some errors.	4-5
Several errors in descriptions or explanations provided	2-3
Some relevant information given	1

Sample answer:

Newtons corpuscular model

- Light exists as particles called corpuscles
- These particles speed up in water or glass
- Could explain reflection and refraction
- Youngs double slit experiment demonstrated how two sources of light can create an interference pattern similar to that produced by waves.
- Failed to explain polarisation or interference so eventually society accepted Huygens model

Huygens wave model

- Light exists as a longitudinal wave
- Each point on a wavefront acts as a new source of light
- While this could be used to explain interference (young's double slit experiment), it could not explain polarization as only transverse waves can be polarized

Maxwells theory of electromagnetism

- Maxwell unified the theories of electricity and magnetism
- His equations predicated the existence of electromagnetic radiation which was a type of transverse wave
- The predicted speed of these waves were incredibly close to the speed of light, as such light was accepted to be an electromagnetic wave
- This was then able to explain polarization and Malus's law
- According to EM, blackbodies should emit an infinite amount of UV radiation and photoelectric materials should emit photons at all frequencies.
    - Since neither of these are experimentally correct, there was a need for further refinement.

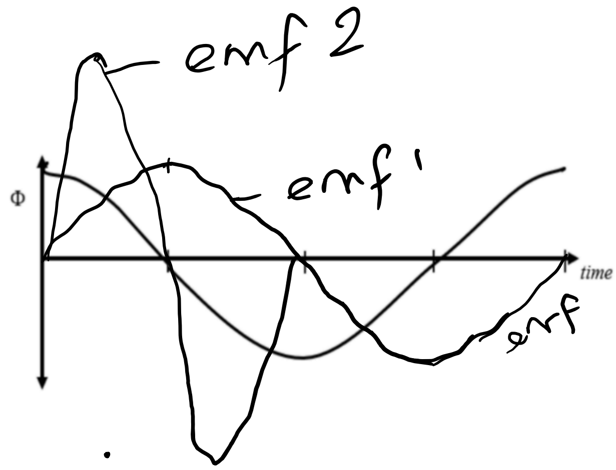
Plank and Einsteins particle model of light

- Both the BB radiation curve and PEE can be explained by assuming that light exists in quantized packets called photons.
    - Electrons are only emitted if the photon has enough energy to separate it from the material.
- While this explains these two phenomena, it cannot explain some of the wave nature of light such as interference
- This creates a need for a wave-particle duality theory

Question 32a (1 mark)

correctly draws the graph of induced emf over time	1

Sample answer:



Common mistake: not recognising that the emf is 90^0 out of phase with the magnetic flux.

Question 32b (2 marks)

correctly indicates twice the amplitude and four times the frequency of the original	2
correctly indicates twice the amplitude OR four times the frequency of the original	1

Sample answer:

Shown in 32a.

Common mistake: that frequency AND amplitude become double.

Question 32c (1 mark)

correctly determines the magnitude of magnetic flux through the coil	1

Sample answer:

$\emptyset = BA\ cos\theta \Rightarrow 3.2\ \times 2.25 \times 10^{-3} cos60 = 3.6 \times 10^{-3}\text{Wb}$

Common mistake: cos 60 NOT cos 30

Question 32d (1 mark)

Correctly determines the magnitude of the induced emf	1

Sample answer:

$$max. flux = 3.2 \times 2.25 \times 10^{-3}$$

$$emf = -n\frac{d\emptyset}{dt} = -500 \times \frac{3.2 \times 2.25 \times 10^{-3}}{0.52} = 6.9230 \ldots \approx 6.9\ V$$

Common mistake: Not reading the question- maximum to minimum flux

Question 32e (3 marks)

comprehensively explains the changes in speed of rotation when circuit is complete	3
lacks some detail	2
includes some relevant detail	1

Sample answer:

When the coil is rotated in an external magnetic field, an emf is induced, however no current flows because of an incomplete circuit. When the circuit is completed, a current flows. This current according to Lenz's law creates a magnetic field that opposes the change that caused it. This creates a force that opposes the rotation of the coil and it slows down as the torque that turns the coil is constant.

Common mistake: Not relating the current through Lenz's law to an opposing force created by an opposing magnetic field causing the speed to reduce, under a constant torque.

Question 33 (3 marks)

Clearly explains that isotope X must be a positron emitter and justifies the observations	3
Explains that isotope X must be a positron emitter and justifies one of the observations	2
Identifies that isotope X must be a positron emitter OR Suggests gamma emitter	1

Sample answer:

X is a positron emitter, but since it has a longer half life, it emits less particles than the oxygen isotope.

The positrons will collide and annihilate with the electrons releasing photons (this is why there is a large amount of photons detected)

Since there are more electrons emitted, there will still be some left to detect.

Question 34a (3 marks)

correctly determines the angle of banking of the road	3
makes one error	2
Includes some relevant detail	1

Sample answer:

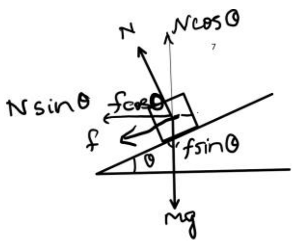
$$\boldsymbol{Nsin\theta = fcos\theta\ (when\ car\ is\ parked) => f = \frac{1}{6}N => Nsin\theta = \frac{1}{6}Ncos\theta => tan\theta = \frac{1}{6} => \theta = 9.46233 \approx 9.46^{\circ}}$$

Common mistake: Not using the correct angle relationship between forces.

Question 34b (4 marks)

correctly calculates the maximum speed around the bend	4
makes one error in the calculation	3
resolves the forces correctly OR expresses correct mathematical relationships	2
includes some relevant detail	1

Sample answer:



$$Vertical: Ncos\theta - (fsin\theta + mg) = 0 => Ncos\theta - \left(\frac{1}{6}Nsin\theta + mg\right) = 0 => N\cos 9.446233 - (\frac{1}{6}Nsin9.46233 + 1000.0 \times 9.8) = 0 => N = 10219.04153N$$

$Horizontal: \frac{mv^2}{r} = Nsin\theta + fcos\theta => Nsin\theta + \frac{1}{6}Ncos\theta = \frac{mv^2}{r} => 10219.04153sin9.46233 + \frac{1}{6} \times 10219.04153cos9.46233) = \frac{1000v^2}{66.0} = v = 14.89 \ldots \approx 14.9$ ms^{-1}

Common mistake: wrong resolution of forces