Baulkham Hills High School

2023 Trial Higher School Certificate Examination

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- A data sheet, formulae sheet and Periodic Table are provided
- If additional space is needed, ensure to say 'continued' and use pages 2627, clearly identifying the question number.

Total Marks: 100

Section I – 20 marks (pages 2-8)

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

Section II – 80 marks (pages 9-24)

- Attempt Questions 21-34
- Allow about 2 hours and 25 minutes for this section

Section I

20 marks
Attempt Questions 1–20
Allow about 35 minutes for this section

Use the Section II answer sheet for Questions 1-20.

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1. Which of the following best describes the relationship between the work done on an object when it moves between two altitudes and its gravitational potential energy?

   A) The work done on the object equals its gravitational potential energy.

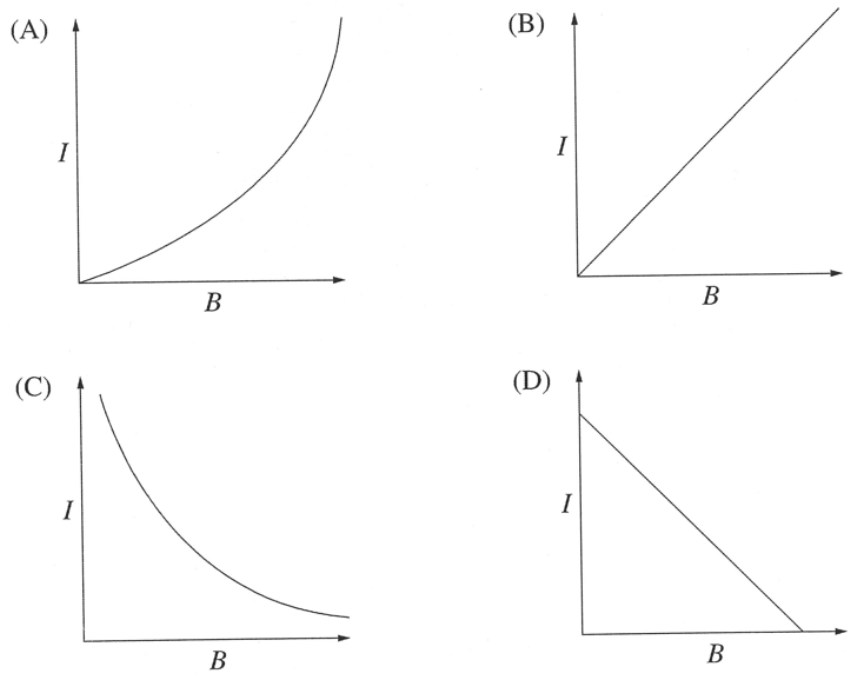
   B) The work done on the object equals the change in its gravitational potential energy.

   C) The work done on the object equals the increase in its gravitational potential energy.

   D) The work done on the object equals the decrease in its gravitational potential energy.

2. Jonathan and Felix place a current-carrying wire so that it is perpendicular to a magnetic field.

   Which graph correctly shows the relationship between the magnetic field strength *(B)* and current *(I)* if the force on the current-carrying wire is to remain constant?



3. Jet, an astronaut floating in the International Space Station while it is orbiting Earth, feels weightless.

   This is because

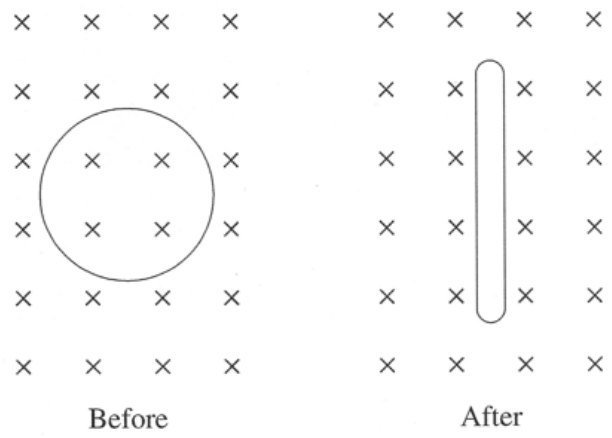
   A) His mass is now zero.

   B) The gravitational force on him is zero.

   C) The gravitational force is balanced by the centrifugal force.

   D) Gravity is the only force acting on him.

4. Wethmi places a circular loop of wire in a magnetic field so that it doesn't move. She then pushes the sides together to change the shape, as shown in the diagram below.

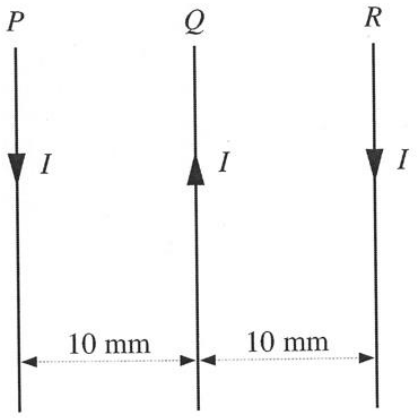


As Wethmi compresses the loop, a current flows.

Which of the following shows the direction of the current and explains why it is induced?

	Current direction	*Why the current is induced?*
A)	Clockwise	Change in magnetic flux
B)	Anticlockwise	Change in magnetic flux
C)	Clockwise	Change in magnetic flux density
D)	Anticlockwise	Change in magnetic flux density

5. Rohan and Darshpreet fix in place three straight, conductors, *P*, *Q* and *R*, carrying currents of the same magnitude, *I*. The magnitude of the force between conductors *P* and *Q* is *F* newtons.



What is the net force on conductor R when it is in the position shown above?

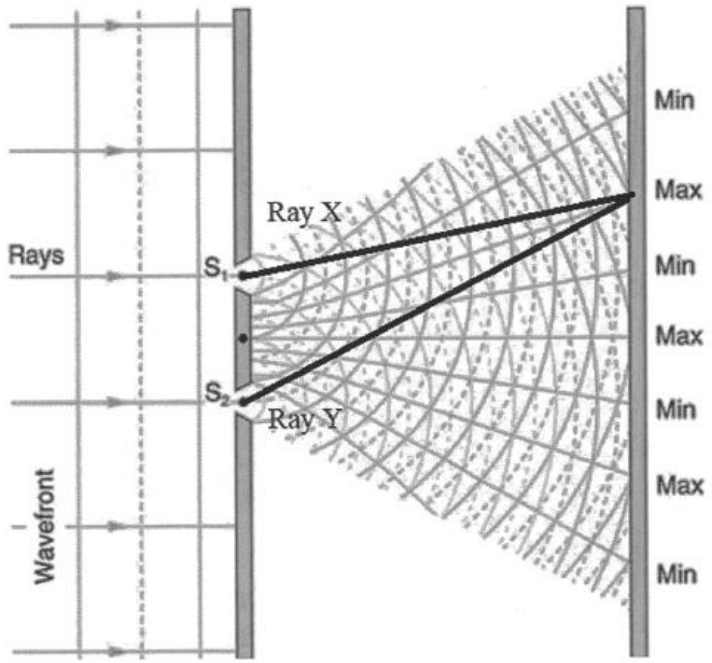
A) F/2 N to the left

B) F/2 N to the right

C) 3F/2 N to the left

D) 3F/2 N to the right

6. A light source of wavelength λ shines on two slits, S_1 and S_2, separated by distance d. Two light rays from slits S_1 and S_2 (Ray X and Ray Y) are shown in the diagram below.



What is the path difference between rays X and Y?

A) 0.5 λ

B) 1.0 λ

C) 1.5 λ

D) 2.0 λ

7. The escape velocity of Earth is 11 200 ms^{-1} and yet a spacecraft, moving at a much lower speed, can travel away from the Earth and toward distant planets.

Which of the following statements about this is correct?

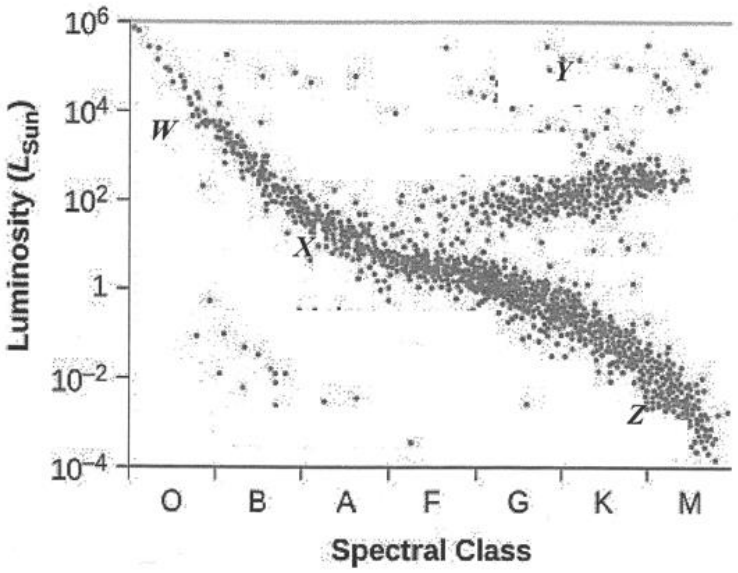
A) If the spacecraft turns off its rockets, it will slow down and be pulled back to Earth.

B) To escape the Earth's gravitational field, a spacecraft in orbit will have to accelerate to a minimum of 11 200 ms^{-1}.

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

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

Use the diagram below, which shows four stars, marked *W*, *X*, *Y* and *Z*, to answer questions 8 and 9.



8. Which of the following gives the correct features of the relevant star?

   A) Star *W* is the hottest and largest.

   B) Star X is a relatively small, yellow star, similar to our Sun.

   C) Star Y is the largest and hottest of the four.

   D) Star Z is the smallest and has the shortest lifespan.

9. Identify the predominant nuclear reactions involved in the three stars W, X and Y.

	W	*Y*	*X*
A)	Proton-Proton	CNO cycle	Proton-Proton
B)	Proton-Proton	Proton-Proton	CNO cycle
C)	CNO cycle	Proton-Proton	Triple alpha
D)	CNO cycle	Triple alpha	Proton-Proton

10. A proton is travelling at half the speed of light at an angle of 7.5^0 to the direction of the magnetic field in a particle accelerator. The accelerator's magnetic field strength is 2.0×10^{-2} T.

    The force on the proton is closest to

    A) 2.356×10^{-13} N

    B) 6.273×10^{-14} N

    C) 6.172×10^{-14} N

    D) 1.19×10^{-15} N

11. *Gliese 581c* is an Earth like planet discovered in 2007 orbiting a star 20 light years from the Sun. Astronomers suspect its mass is 6 times that of the Earth.

Assuming that the radius of Gliese 581c is twice that of the Earth, what would be the acceleration due to gravity be at its surface?

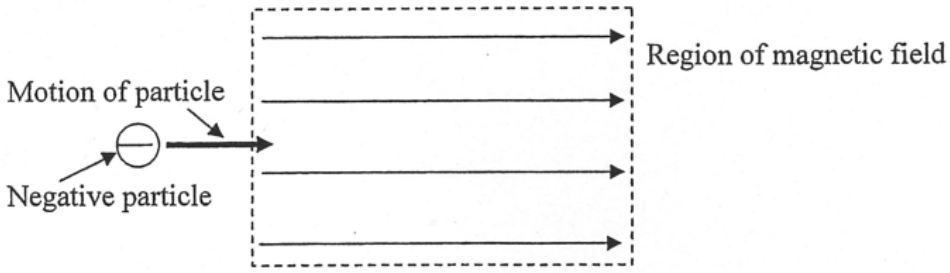
A) 3.3 ms^{-2}

B) 6.5 ms^{-2}

C) 14.7 ms^{-2}

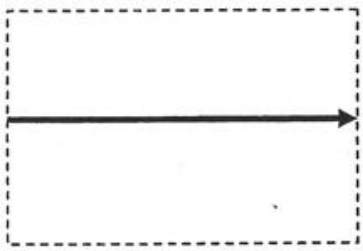
D) 29.4 ms^{-2}

12. A negatively charged particle enters a uniform magnetic field, as shown below.



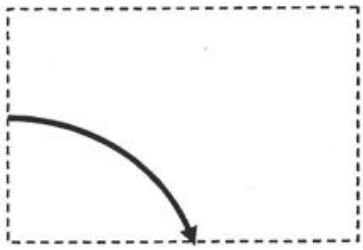
Which of the following best demonstrates what happens to this particle once it is in the magnetic field?

(A)



(B)

(C)



(D)

Particle curves up out of the page.

13. One of the consequences of special relativity is that

A) Forces that are not real can be felt by some observers.

B) People travelling at high speeds will be crushed by length contraction.

C) Time can move backward.

D) Two events may appear to be simultaneous to one observer but not another.

14. Europa, a moon of Jupiter, has an orbital diameter of 1.34×10^9 m and a period of 3.55 Earth days.

What is the mass of Jupiter?

A) 1.48×10^{23} kg

B) 1.83×10^{27} kg

C) 1.89×10^{27} kg

D) 1.51×10^{28} kg

15. Daniel sent a microwave signal from Earth to Lucy, who was in a spacecraft which was travelling directly towards the Earth at a speed of 0.4 c.

What was the speed of Daniel's signal as received by Lucy?

A) 0.4 c

B) 0.1 c

C) 1.0 c

D) 1.4 c

16. Which wave behaviour provided evidence for the transverse nature of light?

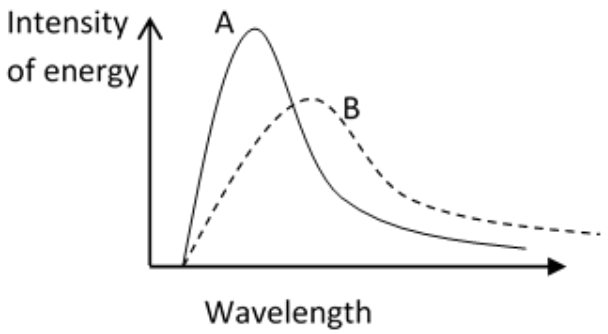
A) Polarisation

B) Diffraction

C) Interference

D) Refraction

17. The graph below shows the electromagnetic radiation emitted from two stars, A and B.



Why is there a drop in the intensity at very short wavelengths for the typical black body radiation traces shown in the graph below?

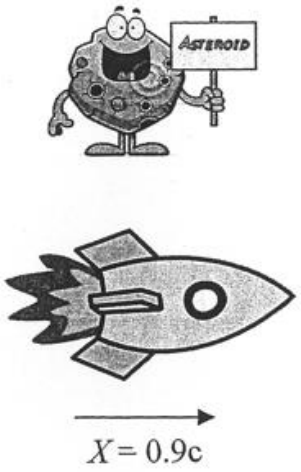
A) The energy of each photon is reduced at very short wavelengths.

B) There are fewer photons with high energy at very short wavelengths.

C) Only photons of very short wavelengths are reabsorbed by the black body.

D) Photons of very short wavelengths interact, causing destructive interference.

18. Angela is travelling in her spacecraft, X past an observer on an asteroid of 0.9 c, as shown below.



Which of the following statements about how the observers sees Angela's spacecraft is correct?

A) It will be more massive, but not as long.

B) It will be more massive, not as long or as wide.

C) It will be more massive and not as wide.

D) it will be less massive and not as long.

19. An ideal transformer is used to convert an input of 800 V to an output current of 24 A. There are 5700 turns in the primary coils and 460 turns in the secondary.

What is the current on the primary?

A) 1.94 A

B) 3.81 A

C) 13.8 A

D) 64.6 A

20. Thompson carried out an experiment with a modified form of cathode ray tube, where a new, unknown type charged particles are injected into a region perpendicular to a magnetic field. He measured the charge to mass ratio *q/m*.

What does the new charge to mass ratio become if the particle velocity is doubled and the magnetic field strength is tripled?

(A) 0.66 *q/m*

(B) 1.33 *q/m*

(C) 1.66 *q/m*

(D) 1.75 *q/m*

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Physics 2023

Section II Answer Booklet

Student Number

Teacher Name

80 marks
Attempt Questions 21-34
Allow about 2 hours and 35 minutes for this section

Instructions

- Write your teacher's name and student number at the top of this page.
- Answer the questions is the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Select the response which best answers the question and indicate your choice by placing an 'X' over A, B, C or D on the grid below

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**

Question 21 (6 marks)

A rocket is in orbit, distance *R* from the centre of the Earth. At this position, it has a gravitational potential energy (U) equal to -4E J. The rocket is then boosted to an orbit where its gravitational potential energy is -E J.

a) Complete the table below to show the missing values. **2**

	Gravitational Potential Energy (J)	*Orbital kinetic energy (J)*	*Total Energy (J)*
Initial position			
Final position			

b) Explain how the gravitational potential energy of the rocket seems to decrease from -4E to -E, even though it is boosted to a higher orbit. **2**

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c) Justify the change in kinetic energy of the rocket by deriving the relationship between the kinetic energy of an orbiting object and the radius of its orbit. **2**

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Question 22 (2 marks)

An astronomer recorded hydrogen spectral data from a star. She noticed the spectral lines she recorded for this star were shifted to a lower wavelength by 30.0×10^{-10} m and were broader than expected.

State what caused each of these two observations. **2**

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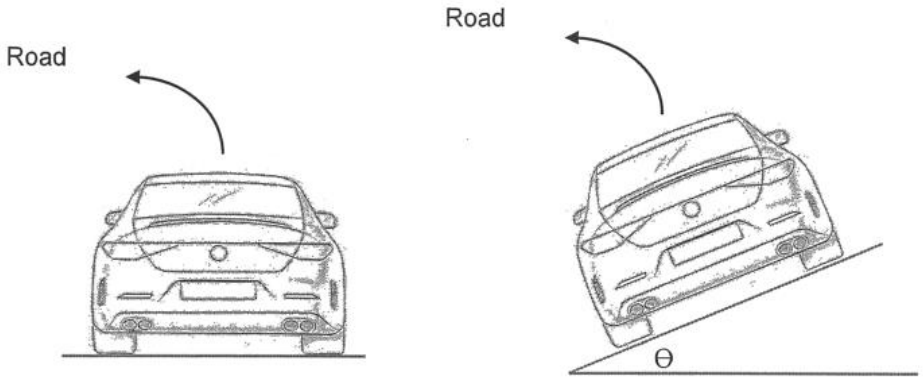
Question 23 (6 marks)

A year 12 Physics student who owned a motorcycle decided to give up riding it as he was worried for his safety, especially at very high speeds. Therefore, he sold his motorbike and purchased a 1,500 kg car. When driving his car, he remembered what he learned in class about travelling around curves and the forces involved.

The diagram below shows the student's new car travelling around curves of the same 12 m radius, but with the right hand curve banked, as shown below.



a) Determine the frictional force required by the 4 tyres in total to prevent the car skidding on the horizontal road if the student drives it at a speed of 30 km/h. **3**

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b) Determine the angle of the banked track needed for the car to safely travel around the banked road if the car travels at 40 km/h assuming that there is no friction between the tyres and the road. **3**

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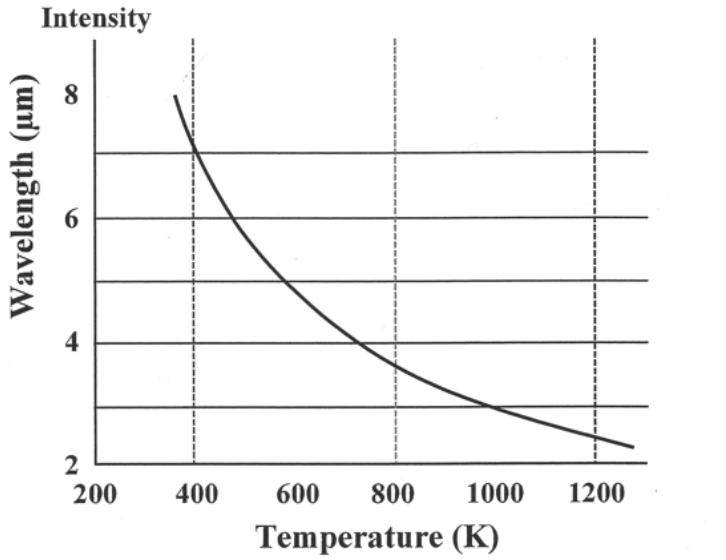
Question 24 (4 marks)

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



Temperature dependence of wavelength of maximum radiation intensity.

Show that the graph is consistent with Wien's Law. **4**

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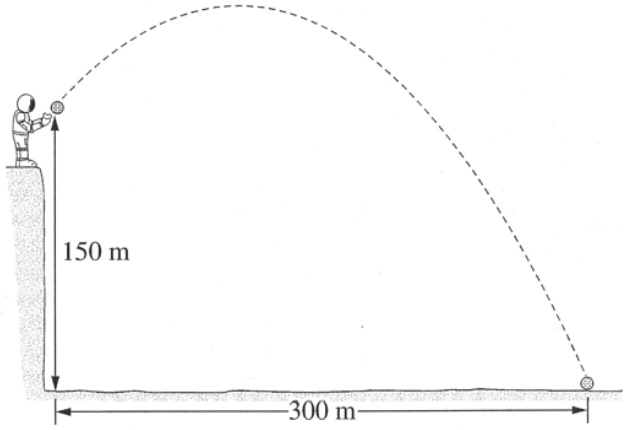
Question 25 (7 marks)

Vanessa, Parleen and Isabella were accepted by NASA and sent to the Moon as astronauts. While on the Moon, Isabella and Parleen tell Vanessa to get rid of her chewing gum. After opening the visor on her helmet, Vanessa spits the gum out from the top of a cliff, hitting the ground below 18.63 s later.

The acceleration due to gravity on the Moon is 1.6 ms^{-2}.



a) Determine the horizontal component of the chewing gum's velocity. **2**

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b) Determine the vertical component of the gum's initial velocity. **3**

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c) The mass of the Moon is miraculously doubled and its radius increased so that is three times larger. On the diagram above, carefully sketch the new trajectory of the gum if Vanessa spat it out with the same initial velocity. Clearly justify your reasoning below. **2**

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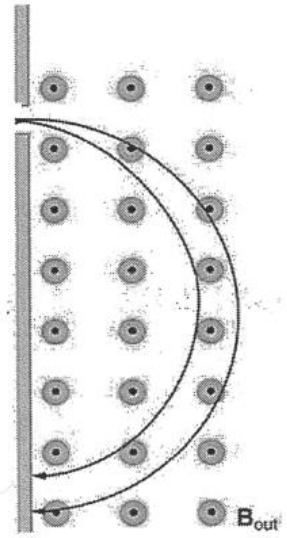
Question 26 (4 marks)

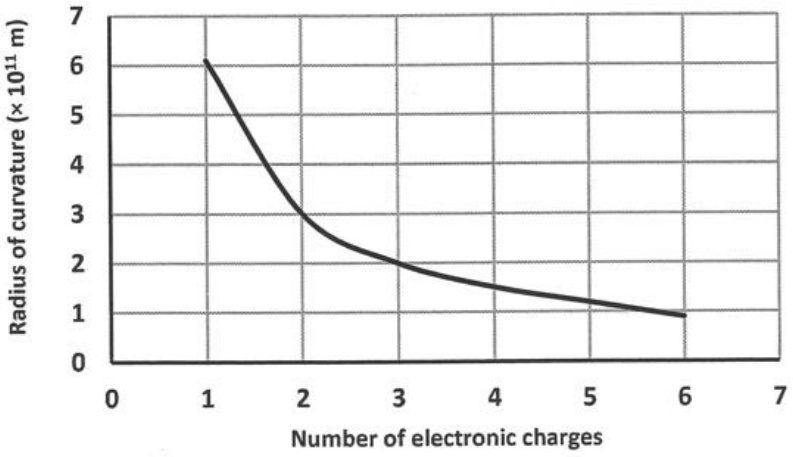
Justin, Arya and Prapann used a mass spectrometer to determine the relationship between the charge on a particle and its path in a magnetic field. The diagram below shows the path of two of the six particles observed.



Their results are shown in the table below.

Charge on particle (Number of electronic charges)	*Radius of curvature of path ($\times 10^{-11}$ m)*
1	6.1
2	2.9
3	2.1
4	1.5
5	1.2
6	0.9

They plotted their results, which are shown on the graph below. They concluded that the radius of the path followed by a charged particle in a magnetic field is inversely proportional to the magnitude of the charge.



Question 26 continues over page…

Question 26 continued…

Evaluate their conclusion. Fully justify your evaluation. **4**

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Question 27 (2 marks)

A distant star has several planets orbiting it. Information on the planets are shown below.

Planet	*Radius (m)*	*Period (s)*
Chinson	6.1×10^8	4.2×10^4
Harry	?	$8.4 \times \times 10^4$
Danny	1.56×10^9	$1.68 \times \times 10^5$

Calculate the orbital radius of Harry **2**

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Question 28 (6 marks)

Fully explain how an emf is produced across the brushes in a DC generator. In your answer, include a labelled diagram and a suitable graph. **6**

Question 29 (10 marks)

In 1905, Einstein published his Theory of Special Relativity. However, there were no real physical observations at that time to support his theory.

a) Outline TWO later observations that was consistent with specific implications of Einstein's theory. **4**

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b) With reference to Einstein's theory of special relatively, comment on the significance of the Michelson-Morley experiment to our understanding of the nature of light. **2**

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c) Evaluate the significance of $E=mc^2$ to our understanding of physics. **4**

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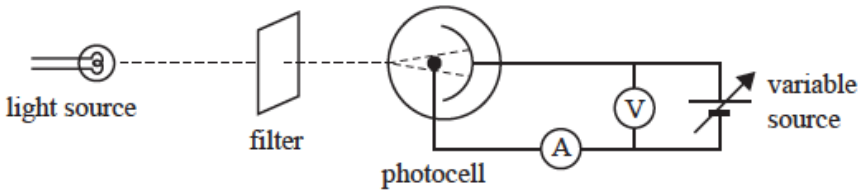
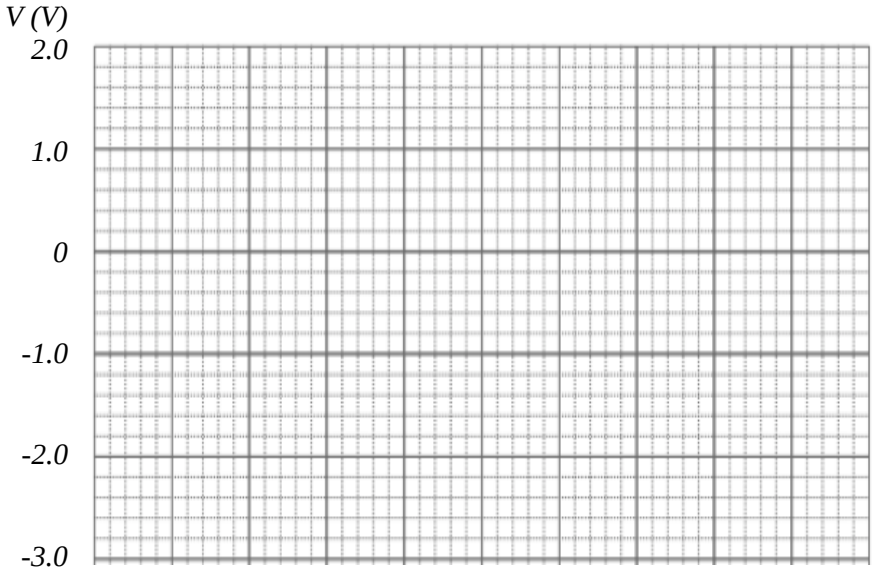
Question 30 (10 marks)

Xin Xin and Chanul carried out a photoelectric effect experiment. Photons from a light source travel through a filter onto a photocell. The filters are changed to shine a particular wavelength onto the photocell. The variable voltage is increased until the current just goes to zero, and then recorded. They repeat this process for different frequencies.



Frequency (Hz)	Voltage (V)
6.0×10^{14}	0.16
7.0×10^{14}	0.52
7.5×10^{14}	0.72
8.0×10^{14}	0.88
9.0×10^{14}	1.35

(a) Plot a graph of the results here. Use the range from zero to $9x10^{14}$ Hz. **3**



(b) Explain how the stopping voltage is related to the electrons' kinetic energy. **2**

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Question 30 continued…

c) Use the graph to determine the work function in eV, as well as Plank's constant. **2**

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(d) For each frequency, Chanul and Xin Xin doubled the intensity of the incident light. Describe how the new graph compares with the original graph. Do these two graphs support the wave model or particle model of light? Justify your answer. **3**

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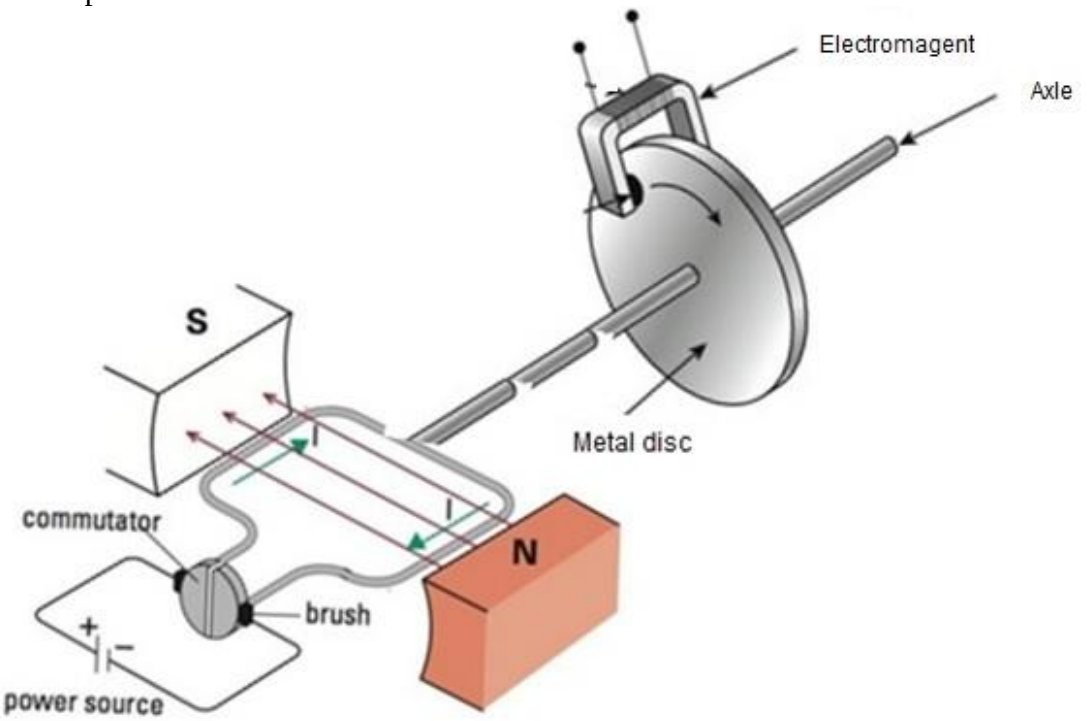
Question 31 (9 marks)

Mr Blunden chose two of his best students, Alivia and Qiandai, to perform an experiment with a simple electric motor coupled to a metal disc.



Qiandai and Alivia obtained the following results as the current through the electromagnet was changed.

Time (s)	*Current in the motor's coil (A)*
0	0.20
5	0.20
10	0.30
15	0.40
20	0.50
25	0.55
30	0.55

Assuming that the motor's power source was kept constant throughout the experiment, fully explain Alivia and Qiandai results, with the aid of a relevant graph and annotations on the diagram above. **9**

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Question 31 continued….

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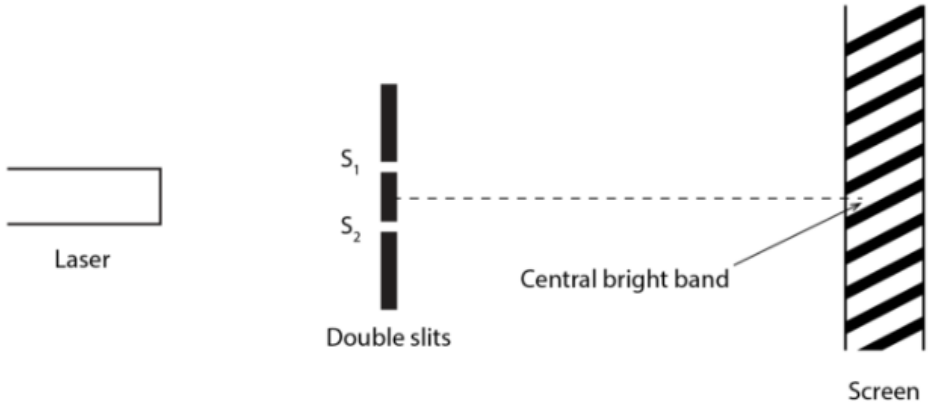
Question 32 (5 marks)

Dylan performed an experiment to demonstrate Young's double slit experiment, as shown below.



Monochromatic light is passed through the slits S_1 and S_2.

a) Dylan makes an adjustment that resulted in the new distance between the central maximum and the adjacent fringes increasing. Outline TWO possible changes that Dylan could have made. **2**

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b) At the time that Young's double slit experiment was originally conducted, there were two competing theories of the nature of light. Explain how Young's experiment supported one of those models, but not the competing model. **3**

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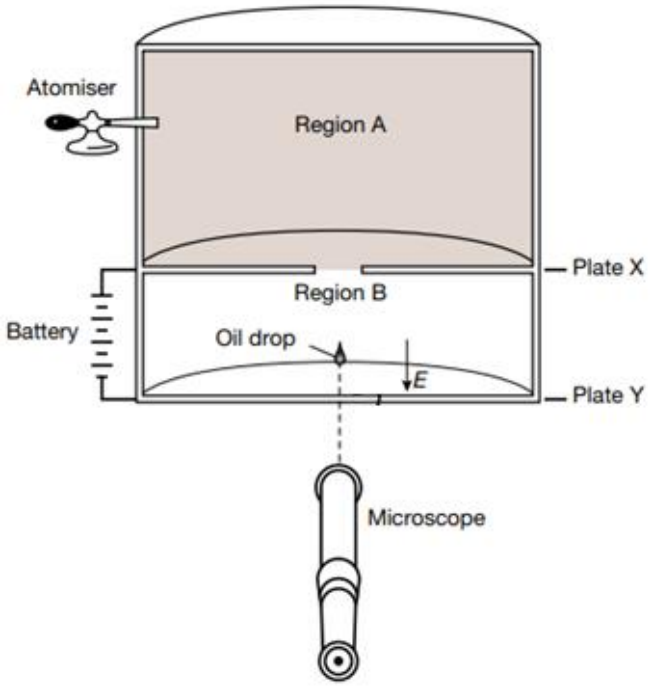
Question 33 (5 marks)

The diagram below shows equipment like that used by Milliken in his experiments with oil drops in 1909.



Explain how Milliken used this equipment and how his interpretation of his results contributed to our understanding of matter. In your answer, refer to J J Thomson's experiment. **5**

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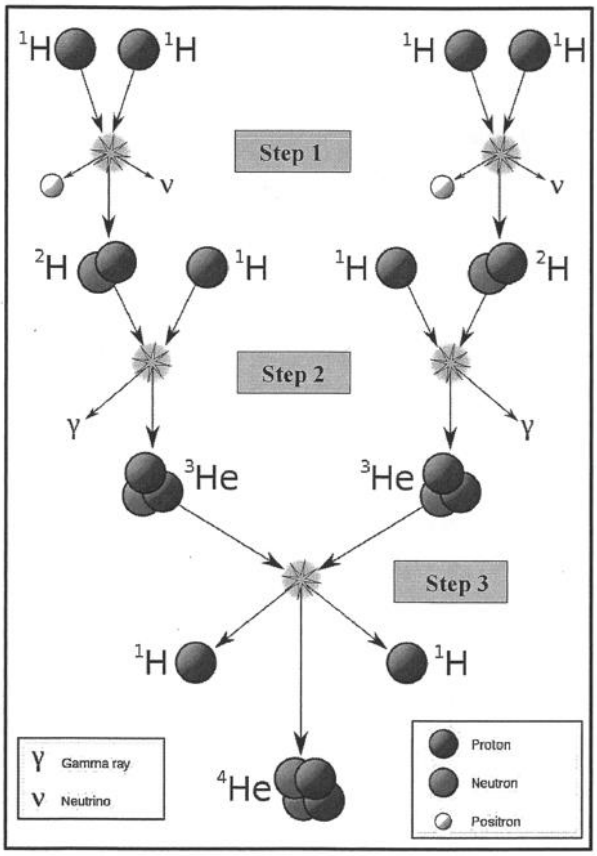
Question 34 (4 marks)

The information below relates to the Proton-proton chain, which provides over 90% of the Sun's energy.



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

a) Use the information in the table to calculate the energy produced by fusing hydrogen to form one helium nucleus in MeV. **2**

……...

……...

……...

……...

……...

b) White dwarfs are not a part of the main sequence. State TWO other essential characteristics of a white dwarf which distinguish it from other groups in the H-R diagram. **2**

……...

……...

……...

……...

……...

……...

END OF PAPER

Additional Paper

Additional Paper

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Physics 2023

Section II Answer Booklet

Student Number

Teacher Name

80 marks
Attempt Questions 21-34
Allow about 2 hours and 35 minutes for this section

Instructions

- Write your teacher's name and student number at the top of this page.
- Answer the questions is the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Select the response which best answers the question and indicate your choice by placing an 'X' over A, B, C or D on the grid below

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

Section I

20 marks
Attempt Questions 1–20
Allow about 35 minutes for this section

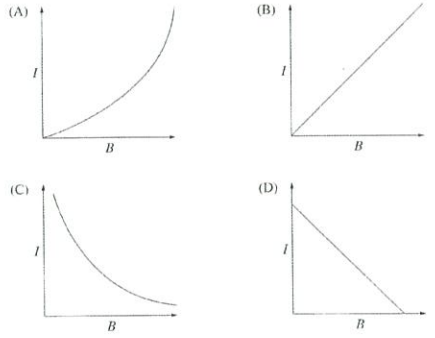
Use the Section II answer sheet for Questions 1-20.

1. Which of the following best describes the relationship between the work done on an object when it moves between two altitudes and its gravitational potential energy?

   A) The work done on the object equals its gravitational potential energy.
   B) The work done on the object equals the change in its gravitational potential energy.
   C) The work done on the object equals the increase in its gravitational potential energy.
   D) The work done on the object equals the decrease in its gravitational potential energy.

2. Jonathan and Felix place a current-carrying wire so that it is perpendicular to a magnetic field.

   Which graph correctly shows the relationship between the magnetic field strength *(B)* and current *(I)* if the force on the current-carrying wire is to remain constant?

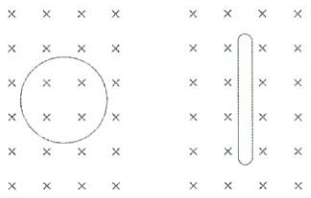


3. Jet, an astronaut floating in the International Space Station while it is orbiting Earth, feels weightless.

   This is because

   A) His mass is now zero.
   B) The gravitational force on him is zero.
   C) The gravitational force is balanced by the centrifugal force.
   D) Gravity is the only force acting on him.

4. Wethmi places a circular loop of wire in a magnetic field so that it doesn't move. She then pushes the sides together to change the shape, as shown in the diagram below.

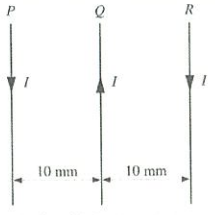


   As Wethmi compresses the loop, a current flows.

   Which of the following shows the direction of the current and explains why it is induced?

	Current direction	*Why the current is induced?*
A)	Clockwise	Change in magnetic flux
B)	Anticlockwise	Change in magnetic flux
C)	Clockwise	Change in magnetic flux density
D)	Anticlockwise	Change in magnetic flux density

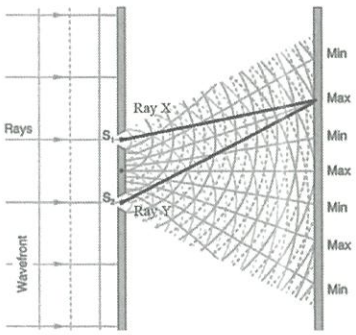
5. Rohan and Darshpreet fix in place three straight, conductors, *P*, *Q* and *R*, carrying currents of the same magnitude, *I*. The magnitude of the force between conductors *P* and *Q* is *F* newtons.



   What is the net force on conductor R when it is in the position shown above?

   A) F/2 N to the left
   B) F/2 N to the right
   C) 3F/2 N to the left
   D) 3F/2 N to the right

6. A light source of wavelength λ shines on two slits, S_1 and S_2, separated by distance d. Two light rays from slits S_1 and S_2 (Ray X and Ray Y) are shown in the diagram below.



   What is the path difference between rays X and Y?

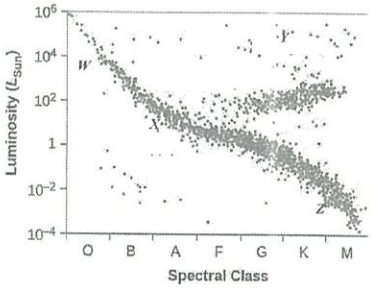
   A) 0.5 λ
   B) 1.0 λ
   C) 1.5 λ
   D) 2.0 λ

7. The escape velocity of Earth is 11 200 ms^{-1} and yet a spacecraft, moving at a much lower speed, can travel away from the Earth and toward distant planets.

   Which of the following statements about this is correct?

   A) If the spacecraft turns off its rockets, it will slow down and be pulled back to Earth.
   B) To escape the Earth's gravitational field, a spacecraft in orbit will have to accelerate to a minimum of 11 200 ms^{-1}.
   C) A spacecraft in orbit around the Earth could use rockets to accelerate and escape the Earth's gravity at a lower speed.
   D) The escape velocity depends on the mass of the spacecraft.

Use the diagram below, which shows four stars, marked *W*, *X*, *Y* and *Z*, to answer questions 8 and 9.



8. Which of the following gives the correct features of the relevant star?

   A) Star *W* is the hottest and largest.
   B) Star X is a relatively small, yellow star, similar to our Sun.
   C) Star Y is the largest and hottest of the four.
   D) Star Z is the smallest and has the shortest lifespan.

9. Identify the predominant nuclear reactions involved in the three stars W, X and Y.

	W	*Y*	*X*
A)	Proton-Proton	CNO cycle	Proton-Proton
B)	Proton-Proton	Proton-Proton	CNO cycle
C)	CNO cycle	Proton-Proton	Triple alpha
D)	CNO cycle	Triple alpha	Proton-Proton

10. A proton is travelling at half the speed of light at an angle of 7.5^0 to the direction of the magnetic field in a particle accelerator. The accelerator's magnetic field strength is 2.0×10^{-2} T.

    The force on the proton is closest to

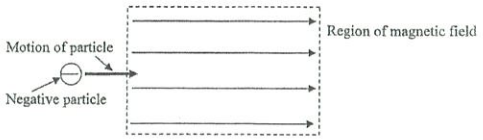
    A) 2.356×10^{-13} N
    B) 6.273×10^{-14} N
    C) 6.172×10^{-14} N
    D) 1.19×10^{-15} N

11. *Gliese 581c* is an Earth like planet discovered in 2007 orbiting a star 20 light years from the Sun. Astronomers suspect its mass is 6 times that of the Earth.

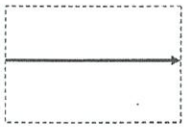
Assuming that the radius of Gliese 581c is twice that of the Earth, what would be the acceleration due to gravity be at its surface?

A) 3.3 ms^{-2}
B) 6.5 ms^{-2}
C) 14.7 ms^{-2}
D) 29.4 ms^{-2}

12. A negatively charged particle enters a uniform magnetic field, as shown below.



Which of the following best demonstrates what happens to this particle once it is in the magnetic field?

(A)


(B)


(C)


(D) Particle curves up out of the page.

13. One of the consequences of special relativity is that

A) Forces that are not real can be felt by some observers.
B) People travelling at high speeds will be crushed by length contraction.
C) Time can move backward.
D) Two events may appear to be simultaneous to one observer but not another.

14. Europa, a moon of Jupiter, has an orbital diameter of 1.34×10^9 m and a period of 3.55 Earth days.

What is the mass of Jupiter?

A) 1.48×10^{23} kg
B) 1.83×10^{27} kg
C) 1.89×10^{27} kg
D) 1.51×10^{28} kg

15. Daniel sent a microwave signal from Earth to Lucy, who was in a spacecraft which was travelling directly towards the Earth at a speed of 0.4 c.

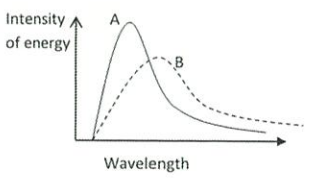
What was the speed of Daniel's signal as received by Lucy?

A) 0.4 c
B) 0.1 c
C) 1.0 c
D) 1.4 c

16. Which wave behaviour provided evidence for the transverse nature of light?

A) Polarisation
B) Diffraction
C) Interference
D) Refraction

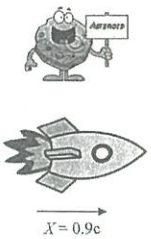
17. The graph below shows the electromagnetic radiation emitted from two stars, A and B.



Why is there a drop in the intensity at very short wavelengths for the typical black body radiation traces shown in the graph below?

A) The energy of each photon is reduced at very short wavelengths.
B) There are fewer photons with high energy at very short wavelengths.
C) Only photons of very short wavelengths are reabsorbed by the black body.
D) Photons of very short wavelengths interact, causing destructive interference.

18. Angela is travelling in her spacecraft, X past an observer on an asteroid of 0.9 c, as shown below.



Which of the following statements about how the observers sees Angela's spacecraft is correct?

A) It will be more massive, but not as long.
B) It will be more massive, not as long or as wide.
C) It will be more massive and not as wide.
D) it will be less massive and not as long.

19. An ideal transformer is used to convert an input of 800 V to an output current of 24 A. There are 5700 turns in the primary coils and 460 turns in the secondary.

What is the current on the primary?

A) 1.94 A
B) 3.81 A
C) 13.8 A
D) 64.6 A

20. Thompson carried out an experiment with a modified form of cathode ray tube, where a new, unknown type charged particles are injected into a region perpendicular to a magnetic field. He measured the charge to mass ratio q/m.

What does the new charge to mass ratio become if the particle velocity is doubled and the magnetic field strength is tripled?

(A) 0.66 q/m
(B) 1.33 q/m
(C) 1.66 q/m
(D) 1.75 q/m

Question 21 (6 marks)

RM

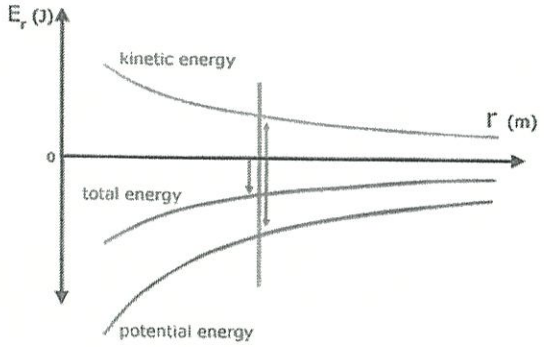
A rocket is in orbit, distance *R* from the centre of the Earth. At this position, it has a gravitational potential energy (U) equal to -4E J. The rocket is then boosted to an orbit where its gravitational potential energy is -E J.

a) Complete the table below to show the missing values. **2**

	Gravitational Potential Energy (J)	*Orbital kinetic energy (J)*	*Total Energy (J)*
Initial position	-4E	2E	-2E
Final position	-E	E/2	-E/2

One mark for each correctly completed row.

To answer the question, you must consider the relationship between the GPE and KE in the system as the rocket is changing in orbit.



b) Explain how the gravitational potential energy of the rocket seems to decrease from -4E to -E, even though it is boosted to a higher orbit. **2**

Mark	**Criteria**
1	-4E to -E is an increase as the energy becomes less negative.
2	Explanation discussing the decrease in field strength as the rocket moves further away from the Earth or that it will increase to a infinite distance at which GPE must equal ZERO.
Student Sample	gravitational potential energy becomes zero potential at an infinite distance from the object being orbitted. Boosting from a lower orbit to a higher one, work is being done to move the rocket towards the point of zero potential energy. Therefore, gravitational potential decreases. 2

RM

c) Justify the change in kinetic energy of the rocket by deriving the relationship between the kinetic energy of an orbiting object and the radius of its orbit. **2**

Mark	Criteria
1	Derivation of KE in a gravitational field
2	Final answer to show the proportionality or a statement stating that as the radius increased the KE will decrease.
Student Sample	$K.E. = \frac{1}{2}mv^2$ note: $F_{centripetal} = F_{gravitational}$ $\frac{mv^2}{r} = \frac{GMm}{r^2}$ $v_{orbital} = \sqrt{\frac{GM}{r}}$ $\therefore K.E. = \frac{1}{2} \times m \times \left(\sqrt{\frac{GM}{r}}\right)^2 = \frac{1}{2} \times m \times \frac{GM}{r} = \frac{GMm}{2r}$ ✓ 2 ↳ $GPE = -2 \cdot KE \Rightarrow$ as per table $GPE = 2 \times$ Total energy uestion 22 (2 marks)

Question 22 (2 marks)

An astronomer recorded hydrogen spectral data from a star. She noticed the spectral lines she recorded for this star were shifted to a lower wavelength by 30.0×10^{-10} m and were broader than expected.

State what caused each of these two observations. **2**

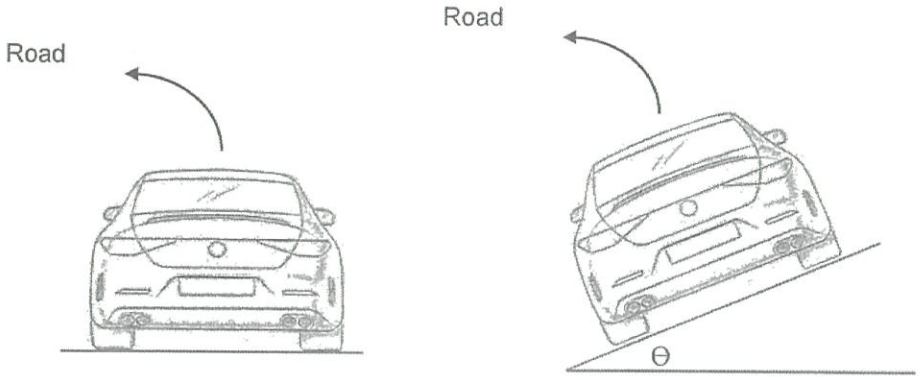
Mark	Criteria
	One mark for any of the following points for a maximum of 2 • Blue shifted and therefore moving towards the observer • High density • High rotational velocity • High pressure
Notes	Read the verb – state means you do not need to explain or justify your answer (think about the time you may have wasted on this)

RM

Question 23 (6 marks)

A year 12 Physics student who owned a motorcycle decided to give up riding it as he was worried for his safety, especially at very high speeds. Therefore, he sold his motorbike and purchased a 1,500 kg car. When driving his car, he remembered what he learned in class about travelling around curves and the forces involved.

The diagram below shows the student's new car travelling around curves of the same 12 m radius, but with the right hand curve banked, as shown below.



a) Determine the frictional force required by the 4 tyres in total to prevent the car skidding on the horizontal road if the student drives it at a speed of 30 km/h. **3**

Mark	Criteria
1	$F_c = F_{friction}$
1	Full working
1	Answer with units and direction
Notes	Force is a vector quantity. Before you start working you must show the marker how you got to that calculation
Student Sample	$F_{friction} = F_{centripetal}$ ✓ $= \frac{mv^2}{r}$ $= 1500 \times \frac{(30 \div 3.6)^2}{12}$ $= 8680.56\,N$ ✓ 3 $8700\,N$ $=$ ~~8700N~~ (to 1 d.p.) towards the centre of its motion.

RM

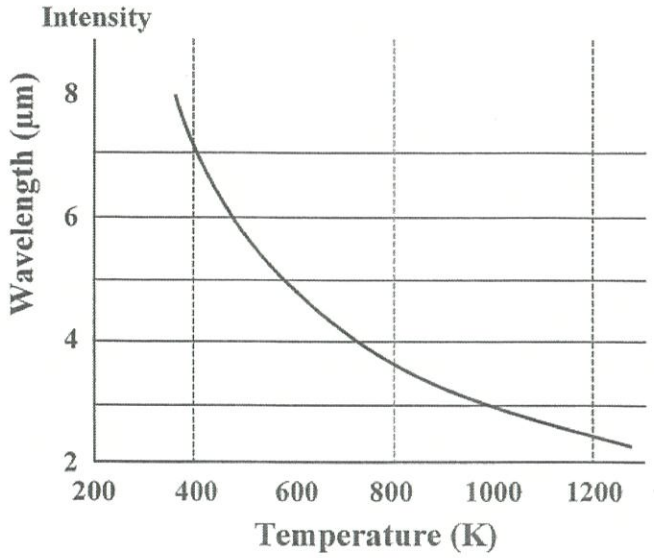
b) Determine the angle of the banked track needed for the car to safely travel around the banked road if the car travels at 40 km/h assuming that there is no friction between the tyres and the road. **3**

Mark	**Criteria**
1	Equation
1	Full working
1	Correct answer
Notes	At times you may be marked for deriving the equation, however, in this case
Student Sample	$\sum F_y = 0$ $\sum F_x = F_{centripetal}$ $F_{normal}\cos\theta = F_{weight}$ $= F_{normal}\sin\theta$ $\hookrightarrow F_N\cos\theta = mg$ ...(2) $\hookrightarrow \frac{mv^2}{r} = F_N\sin\theta$ ...(1) (1) ÷ (2) $\tan\theta = \frac{v^2}{rg}$ 3 $\theta = \tan^{-1}\left(\frac{v^2}{rg}\right)$ $= \tan^{-1}\left(\frac{(40 \div 3.6)^2}{12 \times 9.8}\right)$ $= 46.40$ $= 46^\circ$ (2 sig. fig.)

Question 24 (4 marks)

RM

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



Temperature dependence of wavelength of maximum radiation intensity.

Show that the graph is consistent with Wien's Law. **4**

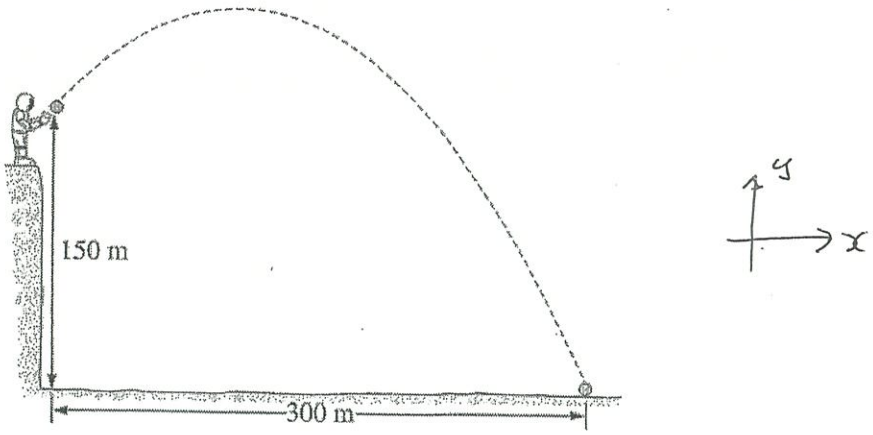
Mark	Criteria
1	State Wien's Law
1	Refers to the graph directly (Quotes values or uses one value)
1	Uses Wiens law and (two or more) values from the graph to test the constant
1	Statement which matches the working (Yes it is consistent or no it is not)
Notes	If you're provided with a law and values, you should fully justify if it is consistent. You cannot vaguely describe the trend and align this to Wein's law.
Student Sample	Wien's law states that $\lambda_{max} = \frac{b}{T}$ at 400 K: $T = 400\,K$ (from graph) $\lambda = 7 \times 10^{-6}\,m$ (from graph) Sub $T = 400$ $\lambda_{max} = \frac{2.898 \times 10^{-3}}{400}$ $= 7.245 \times 10^{-6}$ $= 7 \times 10^{-6}\,m$ (1sf) ∴ consistent for 400 K since $\lambda = 7 \times 10^{-6}\,m$ (from graph) Wiens law states that the max wavelength emitted by a blackbody is inversely proportional to it's temperature. at $T = 800K$ (from graph) $\lambda_{max} = \frac{2.898 \times 10^{-3}}{800K}$ $\lambda_{max} = 3.6225 \times 10^{-6}$ $= 3.6 \times 10^{-6}\,m$ (2sf) ∴ from graph at $T = 800K$, $\lambda_{max} = 3.6 \times 10^{-6}\,m$ ∴ The graph is consistent at 800K for (2sf) Wien's law. ∴ The graph is consistent with Wien's Law.

JC

Question 25 (7 marks)

Vanessa, Parleen and Isabella were accepted by NASA and sent to the Moon as astronauts. While on the Moon, Isabella and Parleen tell Vanessa to get rid of her chewing gum. After opening the visor on her helmet, Vanessa spits the gum out from the top of a cliff, hitting the ground below 18.63 s later.

The acceleration due to gravity on the Moon is 1.6 ms^{-2}.



a) Determine the horizontal component of the chewing gum's velocity. 2

$s_x = u_x t$; $u_x = s_x/t = 300/18.63 = 16.10 = 16.1$ m/s (2 or 3 sf)

(1) - formula, sub.

(1) - answer correct with 2 or 3 s.f.

b) Determine the vertical component of the gum's initial velocity. 3

$s = ut + \frac{1}{2}at^2$; $u = (s_y - \frac{1}{2}a_y t^2)/t = \frac{-150 - \frac{1}{2}(-1.6)18.63^2}{18.63} = 6.8$ m/s

(1) - correct formula

(1) - correct sub with correct signs (ok in wrong f)

(1) - correct answer (with sign)

c) The mass of the Moon is miraculously doubled and its radius increased so that is three times larger. On the diagram above, carefully sketch the new trajectory of the gum if Vanessa spat it out with the same initial velocity. Clearly justify your reasoning below. 2

(1) - find $g' < g$ JUSTIFIED, $g' = \frac{2}{3^2}g = \frac{2}{9}g$

(1) - correct sketch based of $g' <, > g$

($g' < g$ higher, further ; $g' > g$ lower, shorter)

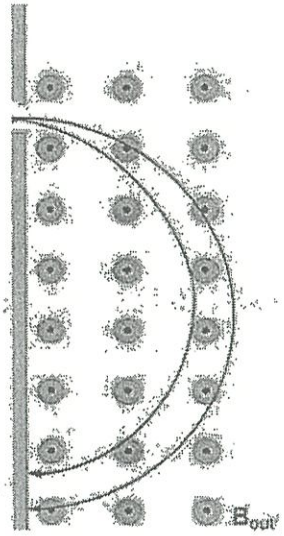
13

13

Question 26 (4 marks)

JC

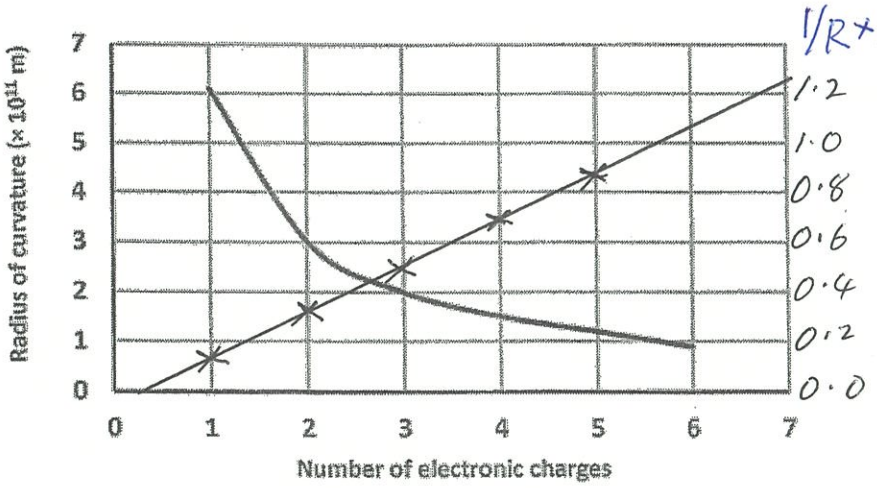
Justin, Arya and Prapann used a mass spectrometer to determine the relationship between the charge on a particle and its path in a magnetic field. The diagram below shows the path of two of the six particles observed.



Their results are shown in the table below.

RQ = const	Q Charge on particle (Number of electronic charges)	R Radius of curvature of path ($\times 10^{-11}$ m)	1/R
6.1	1	6.1	0.164
5.8	2	2.9	0.345
6.3	3	2.1	0.476
6.0	4	1.5	0.667
6.0	5	1.2	0.833
5.4	6	0.9	1.111

They plotted their results, which are shown on the graph below. They concluded that the radius of the path followed by a charged particle in a magnetic field is inversely proportional to the magnitude of the charge.



14

Question 26 continues over page...

Don't use 'math' words, eg 'parabolic' (it is a parabola, a special case of parabolic.) [Also don't say exponential unless its $y = e^{ax}$] JC

Question 26 continued...

Evaluate their conclusion. Fully justify your evaluation. 4

'E' ① - sensible judgement (correct/valid/not valid ....)

"gifte" ① - justification (even theoretical which is OFF TOPIC)

(i) { ① - justification based on EXPERIMENTAL DATA

(ii) { ① - presented in an organised, clear way

This question is clearly based on their interpretation of Data.

See first page of this question where cites: (NOTE if in HSC, must say this)

- graph $1/x$, is a straight line ∴ better way to show $Q \propto \frac{1}{R}$

OR - multiply QR and show product is the same for each set of data value. [As, if $Q = k/R$, then $k = QR$]

Question 27 (2 marks)

A distant star has several planets orbiting it. Information on the planets are shown below.

Planet	*Radius (m)*	*Period (s)*
Chinson	6.1×10^8	4.2×10^4
Harry	?	$8.4 \times \times 10^4$
Danny	1.56×10^9	$1.68 \times \times 10^5$

Calculate the orbital radius of Harry 2

① - correct formula $\frac{T_H^2}{R_H^3} = k = \frac{T_D^2}{R_D^3}$

$\therefore R_H = (T_H/T_D)^{2/3} R_D = \left(\frac{8.4 \times 10^4}{1.68 \times 10^5}\right)^{2/3} \times 1.59 \times 10^9$

$= 9.83 \times 10^8$ m or 9.68×10^8 (chinson).

① - correct result

JC

Question 28 (6 marks)

Fully explain how an emf is produced across the brushes in a DC generator. In your answer, include a labelled diagram and a suitable graph. **6**

NOTE - your total mark rounds down eg 4½ → 4

Diagram: Must be 'correct' and uses metalanguage.	
(2) MARKS ↑ OR ↓	- clear, neat, with labels includes magnets, armature/coil/rota, split ring commutator, brushes, open terminal/Load/voltmeter.
(1) mark	- reasonable attempt missing some of the above.

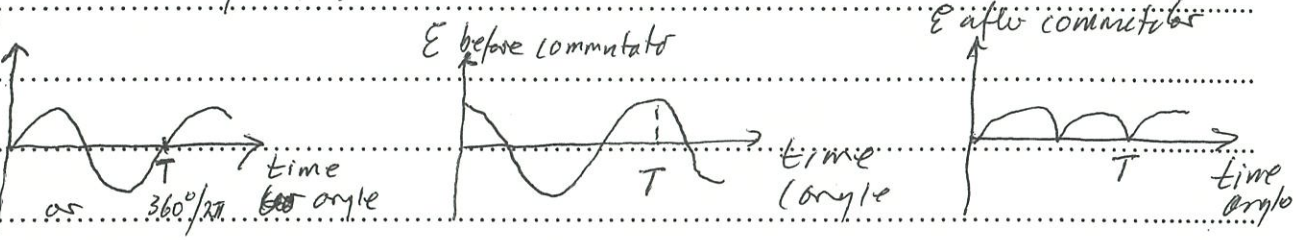
a (1) mark - Faraday's Law explained (rate of change of Φ)

b (1) mark - proper description of flux ($\Phi = n B A \cos\theta(t)$) with A.

c (1) mark - explains commutator, redirects terminal voltage every 180°

d (1) mark - ~~Do~~ one correct relevant graph with sufficient table including period.

eg.



Note - lose mark if terminal is shorted (eg Ammeter) or has power supply

- correct language (Emf, not voltage)

general notes: • If you write 2 pages for expected half page answer indicates you cannot distil the question - not a band 6 attribute.
• ANSWER THE QUESTION.
• BEST TO REFER TO THE SYLLABUS. JC

Question 29 (10 marks)

In 1905, Einstein published his Theory of Special Relativity. However, there were no real physical observations at that time to support his theory.

• Think AND PLAN YOUR ANSWER.

a) Outline TWO later observations that was consistent with specific implications of Einstein's theory. 4

(1) - identifies/names observation one

(1) - Outlines Obs. one and relates to specific theory

(1) - } as above for 2nd option.
(1) - }

eg. muons arriving at Earths surface in greater numbers than expected by classical theory. is explained by time dilation of muons half life as observed from Earth. ($t_v = \gamma t_0$)

Note. Michaelson Morley was not a later observation.

others: are length contraction, mass dilation, limiting speed to c .. etc.

b) With reference to Einstein's theory of special relatively, comment on the significance of the Michelson-Morley experiment to our understanding of the nature of light. 2

Was a null result which implied (by Einstein interpretation)

(1) - a mechanical medium such as the suggested aether was not required for propagation of electromagnetic waves

(1) - the speed of light is a universal constant, independent of the speed of source or observer.

[DO NOT NEED TO DESCRIBE the M+M experiment.]

c) Evaluate the significance of $E=mc^2$ to our understanding of physics. 4

(1) - A clearly stated Judgement ↖

(2) - A named process and an outline of that process

OR

(1) - Another named process

eg. • Energy source for Sun, Fusion, binding energy released equal to mass defect $BE = \Delta m c^2$.

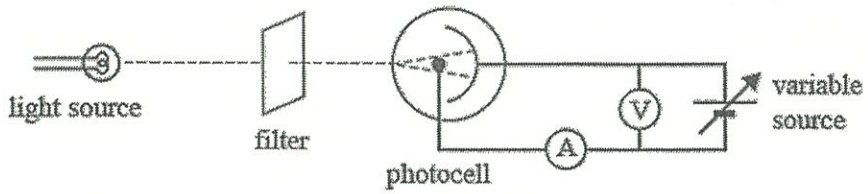
• matter/antimater anhilation/creation mass ⇔ γ radiation

(1) states $E=mc^2$ shows mass is a form of energy., or equivalent to energy, that is energy can be converted to energy and vice versa.

JC

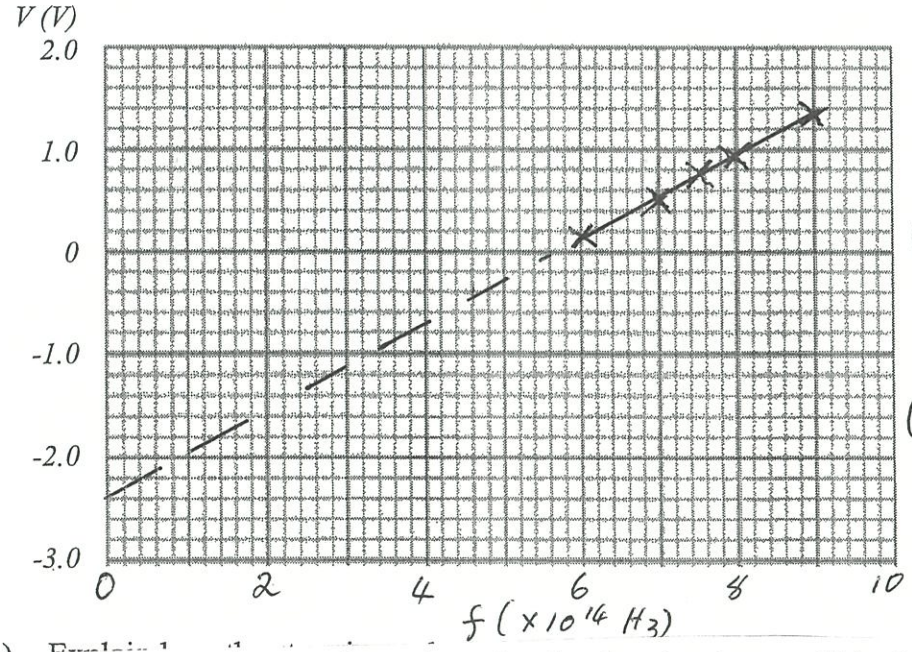
Question 30 (10 marks)

Xin Xin and Chanul carried out a photoelectric effect experiment. ~~Electrons~~ Photons from a light source travel through a filter onto a photocell. The filters are changed to shine a particular wavelength onto the photocell. The variable voltage is increased until the current just goes to zero, and then recorded. They repeat this process for different frequencies.



Frequency (Hz)	Voltage (V)
6.0×10^{14}	0.16
7.0×10^{14}	0.52
7.5×10^{14}	0.72
8.0×10^{14}	0.88
9.0×10^{14}	1.35

(a) Plot a graph of the results here. Use the range from zero to 9×10^{14} Hz. 3



Read the Question

① - 0-9 (or 10), scale full graph width; sensible scale

① - correctly plotted Line of Best Fit over plotted points

① - Extrapolates intercepts between (-2.0) and (-2.5) V.

(b) Explain how the stopping voltage is related to the electrons' kinetic energy. 2

① - maximum possible energy is supplied by voltage

$KE_{MAX} = eV$ [J] or $KE_{MAX} = V$ [eV] ← must state eV in this form

② - Assumes electron has not lost energy to collisions within the metal or with residual gas atoms in the evacuated tube.

Question 30 continues over page...

RB

c) Use the graph to determine the work function in eV, as well as Plank's constant. **2**

work function (in eV) (1)

planck's constant - calculation + answer (1)

(d) For each frequency, Chanul and Xin Xin doubled the intensity of the incident light. Describe how the new graph compares with the original graph. Do these two graphs support the wave model or particle model of light? Justify your answer. **3**

(1) graph is identical

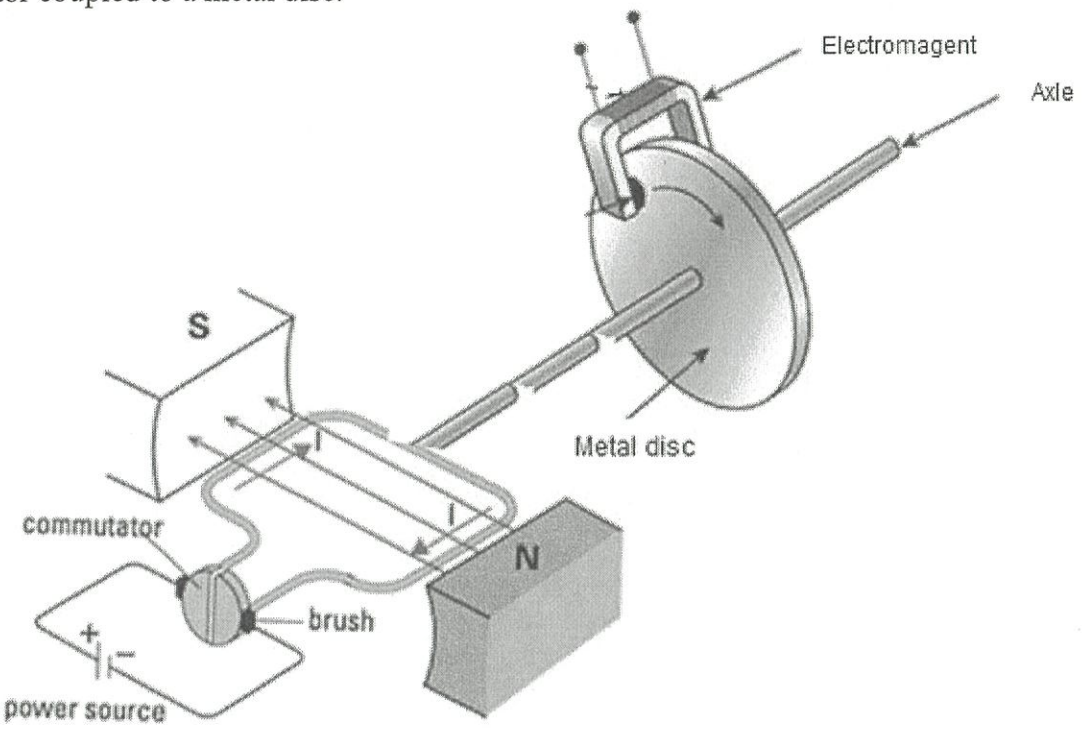
(1) supports particle model

(1) why supports particle model.
- ∆ answer accepted, as long as it was valid.

Question 31 (9 marks)

RB

Mr Blunden chose two of his best students, Alivia and Qiandai, to perform an experiment with a simple electric motor coupled to a metal disc.



Qiandai and Alivia obtained the following results as the current through the electromagnet was changed.

Time (s)	*Current in the motor's coil (A)*
0	0.20
5	0.20
10	0.30
15	0.40
20	0.50
25	0.55
30	0.55

Assuming that the motor's power source was kept constant throughout the experiment, fully explain Alivia and Qiandai results, with the aid of a relevant graph and annotations on the diagram above. **9**

① relevant graph

① graph referred to in text

① annotations on diagram - MUST be information added -

① basic explanation of electromagnetic braking not just answers

① full " " " including both FL & LL stated.

① motor speed ↓ → back emf ↓

① back emf ↓ → net emf ↑ (concept)

① net emf ↑ → current in coil ↑

① link of results table to text / explanation

additional writing space over page...

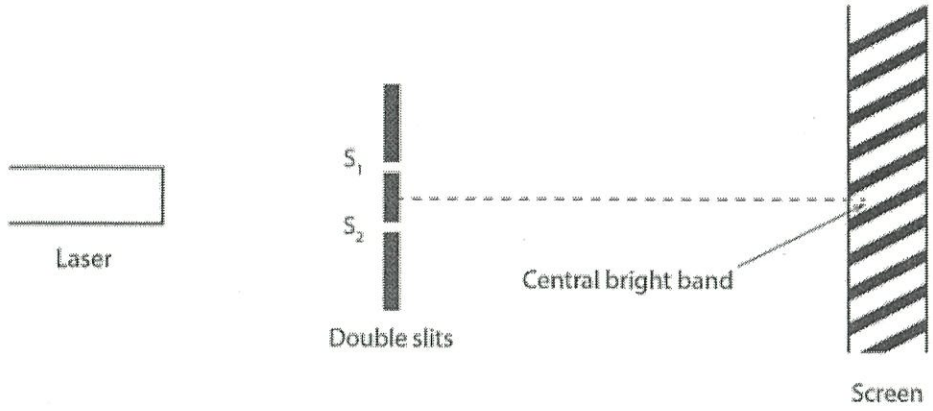
NB. if totally missed what was going on, but back emf in motors explained → 1 mk.

20

Question 32 (5 marks)

RB

Dylan performed an experiment to demonstrate Young's double slit experiment, as shown below.



Monochromatic light is passed through the slits S_1 and S_2.

a) Dylan makes an adjustment that resulted in the new distance between the central maximum and the adjacent fringes increasing. Outline TWO possible changes that Dylan could have made. **2**

Any two of the following - 1 mk for each correct
- move screen further away
- ↓ slit separation
- λ ↑
- f ↓

b) At the time that Young's double slit experiment was originally conducted, there were two competing theories of the nature of light. Explain how Young's experiment supported one of those models, but not the competing model. **3**

(1) Corpuscular / particle = Newton + waves = Huygens.

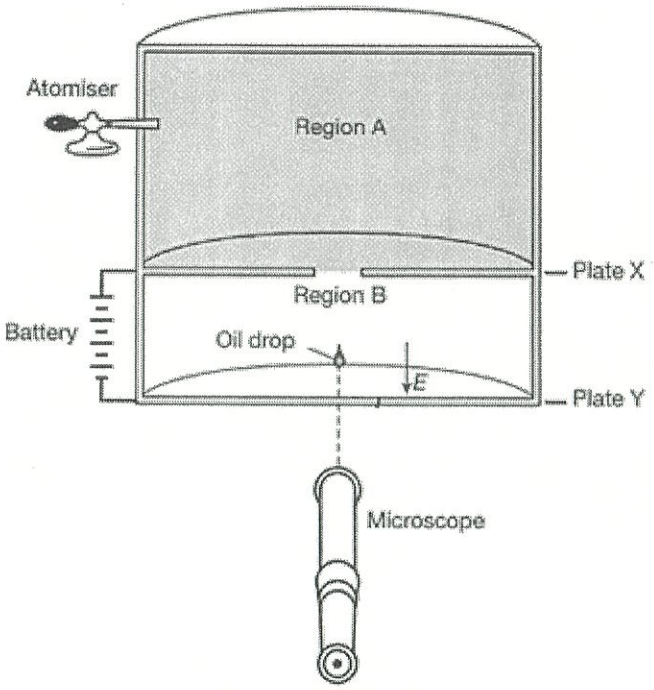
(1) why supported Huygen's model - as interference patte

(1) why not supported Newton's model - different predictions (2) lines.

RB

Question 33 (5 marks)

The diagram below shows equipment like that used by Milliken in his experiments with oil drops in 1909.



Explain how Milliken used this equipment and how his interpretation of his results contributed to our understanding of matter. In your answer, refer to J J Thomson's experiment. **5**

① charged oil drops - friction / X rays

① balanced $qE + mg \rightarrow e^-$ charge calculated

(both concepts for the mark)

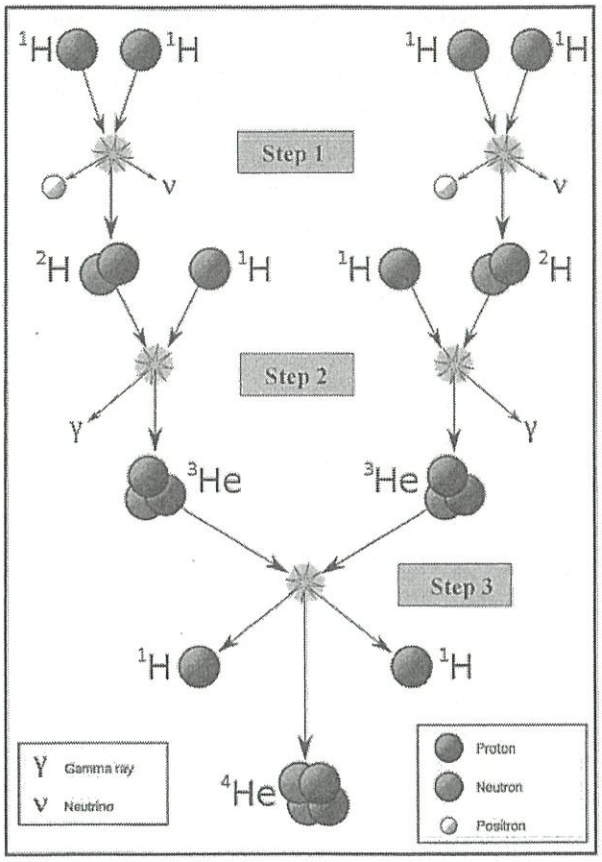
① calculated mass using Thomson's q:m ratio ①

① quantised charge - multiples of $\sim 1.602 \times 10^{-19} C$

K.S, R, B.

Question 34 (4 marks)

The information below relates to the Proton-proton chain, which provides over 90% of the Sun's energy.



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

a) Use the information in the table to calculate the energy produced by fusing hydrogen to form one helium nucleus in MeV. **2**

$E = mc^2$ ①

$= (4.92 \times 10^{-29})(3 \times 10^{8})^2$

$= 4.338 \times 10^{-12}$ J

$= 27.08$ MeV ①

If no calculation is made, but net equation shown. ①

b) White dwarfs are not a part of the main sequence. State TWO other essential characteristics of a white dwarf which distinguish it from other groups in the H-R diagram. **2**

1. No fusion - essential ①

2. Low luminosity, high surface temp, high density, small size, other correct relevant characteristic ①