JAMES RUSE AGRICULTURAL HIGH SCHOOL

2015

PHYSICS

PRELIMINARY EXAMINATION

PART A and B

THEORY

General Instructions

- Reading time - 5 minutes
- Working time - 110 minutes
- Board-approved calculators may be used
- Write using blue or black pen
- Draw diagrams using pencil
- A Data Sheet, Formulae Sheet and a Periodic Table are provided
- Write your Student Number in the space provided on the top of pages 8 and 19

Total: 85 marks

PART A	**Theory – 15 Multiple Choice Questions**	15 marks	Allow about 20 minutes
PART B	**Theory – Extended Response Questions**	45 marks	Allow about 55 minutes
PART C	**Data Processing**	25 marks	Allow about 35 minutes

PART A 15 Multiple Choice Questions 15 marks.

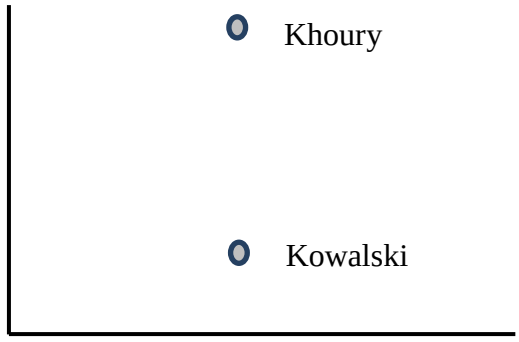
1. Which star characteristics are closely related to the dominant wavelength of the light emitted by a star?

   (A) Size and surface temperature
   (B) Colour and size
   (C) Brightness and dominant frequency
   (D) Surface temperature and colour

2. The telescope was:

   (A) invented by astronomers to view planets better.
   (B) used by Galileo to support the geocentric model of the universe.
   (C) instrumental in supporting the heliocentric model of the universe.
   (D) used to try and disprove the heliocentric model of the universe.

3. The position of the star "Khoury" is directly above the star "Kowalski" on a H-R diagram, as shown.



H-R diagram

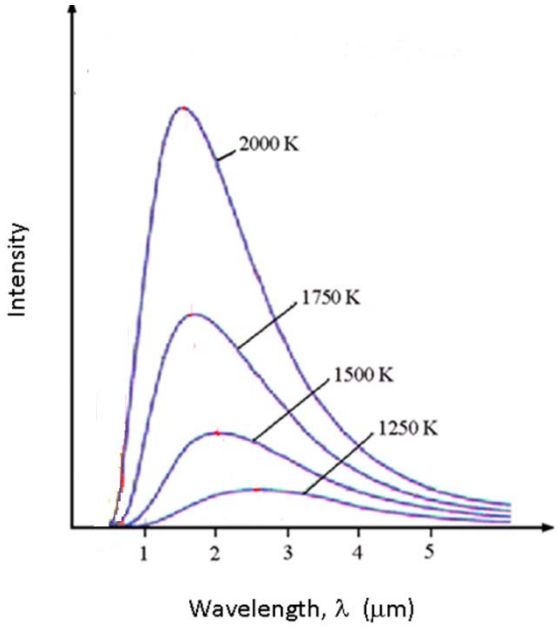
   Which statement is correct?

   (A) Khoury must be hotter than Kowalski.
   (B) Khoury must be closer to Earth than Kowalski.
   (C) Khoury must be older than Kowalski.
   (D) Khoury must be larger than Kowalski.

4. In a particular star both hydrogen and helium are reactants in energy producing reactions. To which group of stars does this star belong?

   (A) black holes
   (B) main sequence stars
   (C) red giants
   (D) white dwarfs

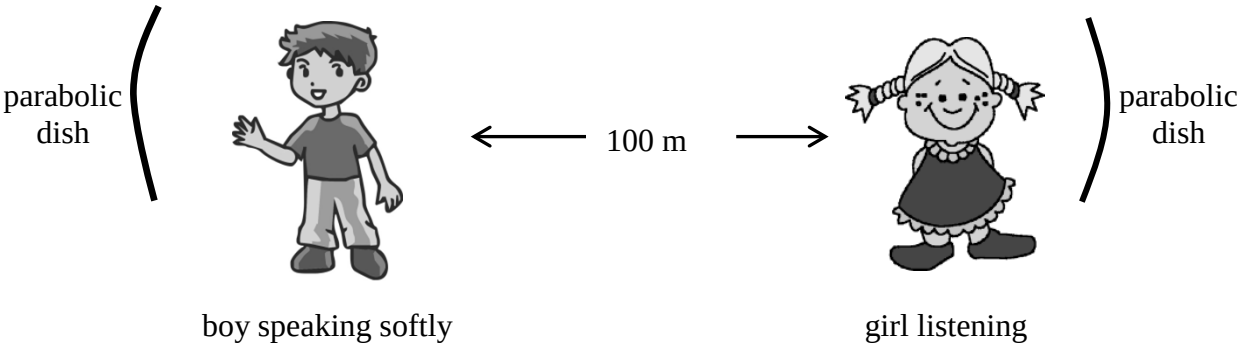
5. The relationship between the temperature of a hot body and the radiation that is emitted is shown in the graph below.



What is the correct inference that can be drawn from the graph?

(A) At any given temperature the hot body radiates energy at a single frequency.
(B) As the temperature increases the hot body glows more brightly.
(C) As the temperature increases the wavelength at which the irradiance peaks increases.
(D) As the temperature decreases the frequency at which the irradiance peaks increases.

6. A boy talks softly into a large smooth parabolic dish, as shown in the diagram below. His voice is heard easily by the girl standing 100 m away listening while standing near another parabolic dish.



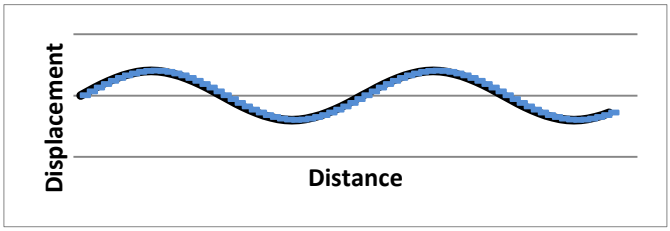
The property of waves which allows this to happen is:

(A) modulation
(B) dispersion
(C) refraction
(D) reflection

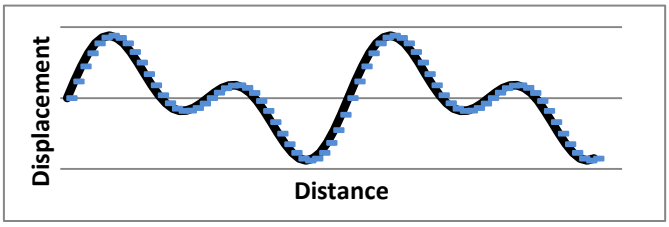
7. A 440 Hz sound wave was produced in a concert hall at the same time as a 880 Hz sound wave with the same amplitude.

The resultant wave shape would most closely resemble:

(A)

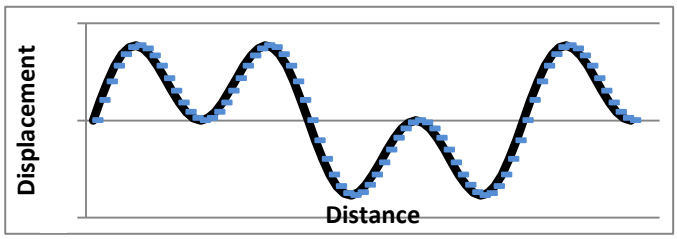


(B)

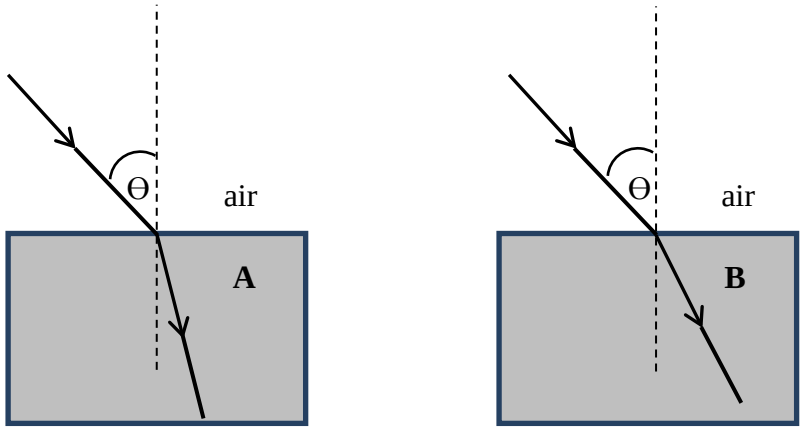


(C)

(D)



8. A laser light source was directed into two different transparent media, A and B, with the same incident angle, Θ, as shown.



Which statement about the laser light's wavelength is correct?

(A) $\lambda_{air} < \lambda_A < \lambda_B$

(B) $\lambda_A < \lambda_B < \lambda_{air}$

(C) $\lambda_{air} < \lambda_B < \lambda_A$

(D) λ is the same in all three mediums

9. Which of the following statements about electromagnetic waves is INCORRECT?

(A) Gamma rays have shorter wavelengths than ultraviolet rays.
(B) Radiowaves are part of the electromagnetic spectrum.
(C) Microwaves can be used for telecommunications.
(D) X-rays travel faster in a vacuum than infra-red rays.

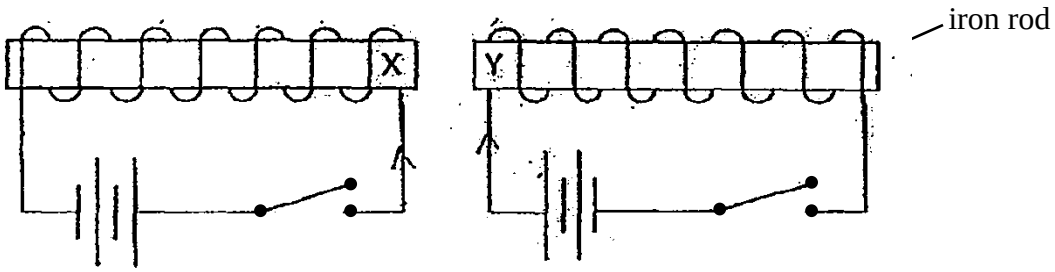
10. Which of the following wires (all made from the same material) would have the most resistance?

(A) A short and thick wire.
(B) A short and thin wire.
(C) A long and thick wire.
(D) A long and thin wire.

11. The most dangerous aspect of receiving a shock from a 240 V AC power source is:

(A) getting burned from the spark.
(B) making the muscles spasm.
(C) sending the heart into fibrillation.
(D) being thrown across the room.

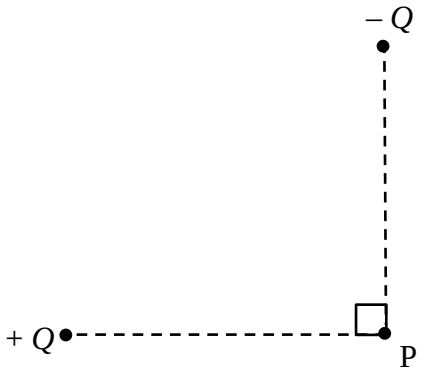
12. In the set-up shown below, both switches are closed and currents in both solenoids flow as shown.



Choose the correct alternative.

	X	Y	Force
(A)	S pole	S pole	repulsive
(B)	N pole	N pole	repulsive
(C)	S pole	N pole	attractive
(D)	N pole	S pole	attractive

13. Two point charges of equal magnitude, $+Q$ and $-Q$, are each placed equidistant from point P, as shown below.



What is the direction of the resultant electric field at **P**?

(A) 

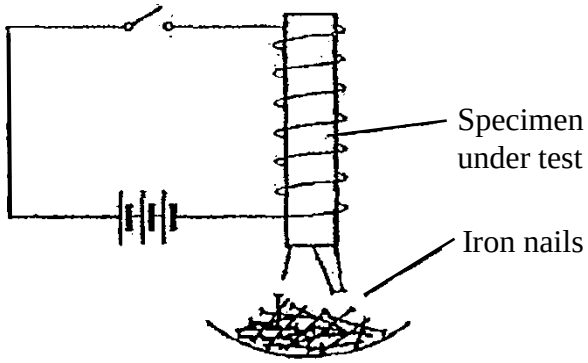
(B) 

(C) 

(D) 

14. Four different magnetic substances were tested using the apparatus shown in the diagram. The table below shows the number of iron nails each substance picks up when the switch is closed and when the switch is re-opened.

Which substance would make the best permanent magnet?



	Number of nails picked up when switch is closed	Number of nails held when switch is re-opened
(A)	35	4
(B)	20	10
(C)	20	20
(D)	40	3

15. A student repeated an investigation three times and achieved similar results (< 5% variation). She came to the following conclusions about her results:

i. The results were accurate.
ii. The results were reliable.
iii. The results were valid.
iv. The effect of random errors on the results was negligible.
v. The effect of systematic errors on the results was negligible.

Which of these conclusions are correct?

(A) i and ii only are correct.
(B) ii and iv only are correct.
(C) i, ii and iii only are correct.
(D) All of them are correct.

ANSWER BOOKLET

PART A Multiple Choice Answer Sheet 15 marks

Student No. …….....

Choose the most appropriate answer and fill in the response oval completely.

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 ○

PART B 12 questions 45 marks

Attempt questions 21 – 32.
Allow about 55 minutes for this part.
Show all relevant working in questions involving calculations.

Question 21 (2 marks)

Identify THREE wavebands filtered out by the Earth's atmosphere**.** **2**

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Question 22 (3 marks)

An astronomer on Earth observes two equally bright stars in the night sky. Star A is 3.6 light years from the earth and has a luminosity of 4×10^{26} W. Star B has a luminosity of 2.5×10^{25} W.

How far away, relative to star A, is star B from Earth? **3**

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Question 23 (7 marks)

In your course, you performed an investigation to determine the refractive index of a rectangular perspex/glass prism.

(a) Draw a fully labelled diagram of your experimental set-up. **3**

(b) Draw a table (do not complete it) of your experimental results. **1**

(c) Outline the method (in point form) you used to determine the refractive index of perspex/glass. **3**

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Question 24 (5 marks)

The refractive index of diamond, $n_{diamond} = 2.4$ $n_{glass} = 1.5$ $n_{water} = 1.3$ and $n_{air} = 1$.

(a) Calculate the speed of light in diamond. **1**

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(b) Determine the angle of refraction for a beam of light entering glass from air with an incident angle of 45°. **2**

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(c) Determine the critical angle for a beam of light entering water from glass. **2**

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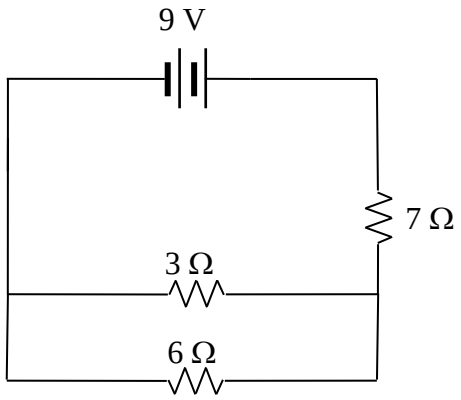
Question 25 (2 marks)

Place an ammeter and a voltmeter in the circuit below in order to correctly measure the current through the 7 Ω resistor and the voltage across the 3 Ω resistor. **2**



Question 26 (4 marks)

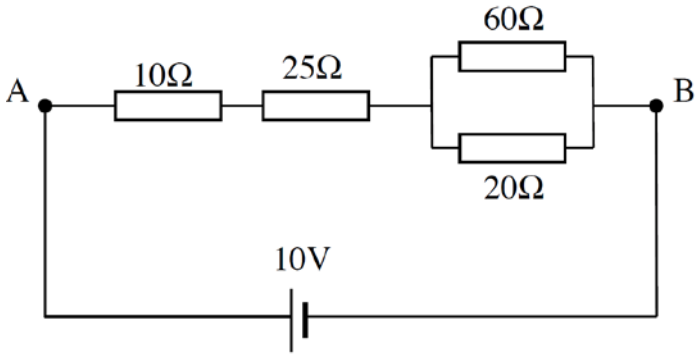
Draw magnetic field lines for the arrangements shown below.

(a) Between two magnetic south poles: **2**

(b) Surrounding a current carrying conductor as shown below: **2**

Question 27 (6 marks)

Consider the circuit below:



Calculate:

(a) the resistance between the terminals A and B. **2**

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(b) the potential difference across the 25 Ω resistor. **2**

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(c) the power dissipated in the 60 Ω resistor. **2**

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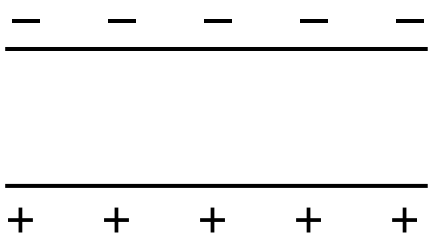
Question 28 (4 marks)

Draw the appropriate electric field lines for each of the following situations:

(a) Two oppositely charged parallel plates **1**



(b) Two oppositely charged point charges (dipole) **1**

(c) Determine the magnitude of the acceleration of a proton placed in an electric field of magnitude $5 \times 10^{-3}\ N\ C^{-1}$. **2**

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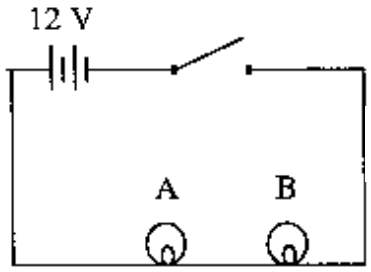
Question 29 (4 marks)

A student set up two electrical circuits as shown in the diagrams below.

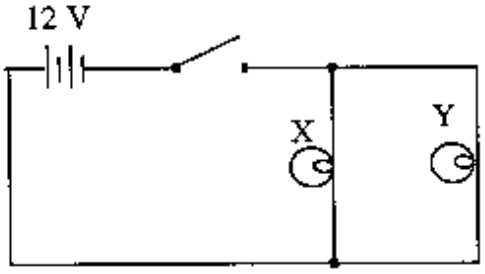
All four globes, A, B, X and Y are identical.

The switches were closed and all the globes glowed. (i.e. all the globes work!)

The brightness of a globe is a measure of the power dissipated in it.



1st circuit



2nd circuit

Compare, quantitatively, the brightness of all 4 globes, in both circuits, after the switches are closed. Explain your reasoning. **4**

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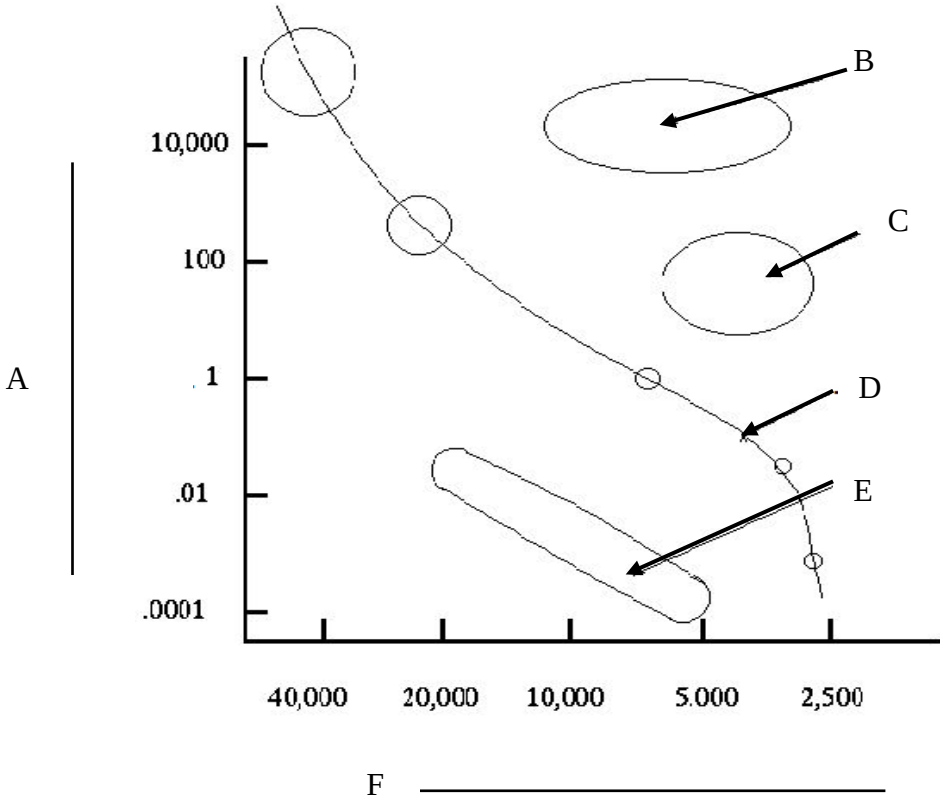
Question 30 (4 marks)

(a) Identify the parts A – F of the Hertzsprung – Russell (H-R) diagram shown below. **3**



A: …….

B: …….

C: …….

D: …….

E: …….

F: …….

(b) Clearly indicate the position of our sun with the letter S on the H-R diagram above. **1**

Question 31 (5 marks)

Our current theory of the origin of the universe is known as the Big Bang theory. **5**
It is based, among other things, on the idea of an expanding universe.

Describe this theory AND the significant experimental evidence upon which it is based.
Include the contributions of Friedmann and Hubble in your answer.

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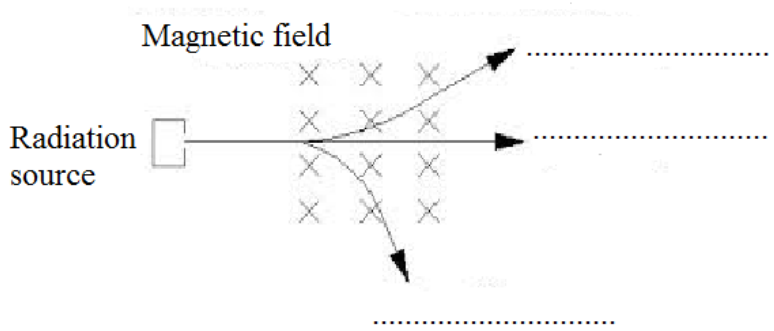
Question 32 (4 marks)

(a) Identify the radioactive emissions on the diagram below from an unstable radiation source. **3**



(b) Two of the above radioactive emissions are charged particles. **1**
Compare their relative ionising abilities.

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End of Theory paper

Student No. …….....

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PHYSICS

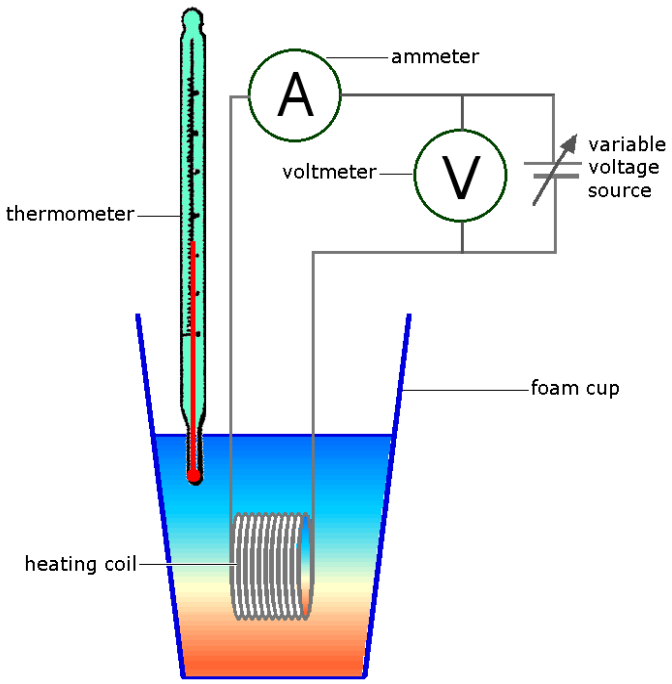
PART C

DATA PROCESSING

PART C Data Processing Section 25 marks Allow about 35 minutes

Question 33 (5 marks)

A student used the apparatus shown to investigate the heating of 300 g of water using a heating coil.



Measurements of voltage, current and water temperature were taken every two minutes for 10 minutes and recorded in a results table, as shown below.

Results:

Time (minutes)	*Voltage (V)*	*Current (A)*	*Water Temperature (^oC)*
0	9.5	2.5	18.0
2	9.3	2.3	20.2
4	9.4	2.4	21.8
6	9.6	2.7	22.7
8	9.4	2.6	24.3
10	9.2	2.2	25.9

Question 33 (continued)

(a) Calculate the electrical energy used in 10 minutes. **2**

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(b) Are these results consistent with the law of conservation of energy? **3**

Justify your answer using appropriate calculations.

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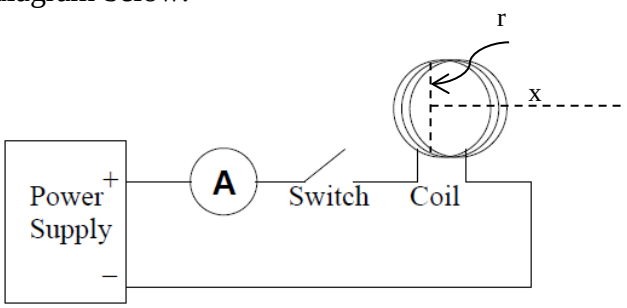
Question 34 (10 marks)

A student set up an experiment to determine the magnitude and direction of the magnetic field generated by a current passing through a specific geometry of a circular wire.
The field strength was measured along the axis of the coil of radius r at distances x from the plane of the coil as shown in the diagram below.



According to the Biot-Savart Law and Ampere's Law, the magnetic field a distance x away, B_x, is given by

$$B_x = \frac{\mu_0 NI}{2} \cdot \frac{r^2}{(r^2 + x^2)^{3/2}}$$

Where r = radius of the circular coil
I = current passing through the circular coil
x = distance from the center of the coil along its axis
$\mu_0 = 4\pi \times 10^{-7}\ N\ A^{-2}$ = magnetic permeability of vacuum
N = number of loops in the coil

The measured values of the magnetic field strength B_x and current I are shown in the table below.

$\boldsymbol{I(A)}$	$\boldsymbol{B_x(\times 10^{-4}\ T)}$
1.15	21
1.98	35
3.17	58
3.75	71
4.95	92
6.03	120
6.96	130
8.30	155
8.90	166
10.00	190

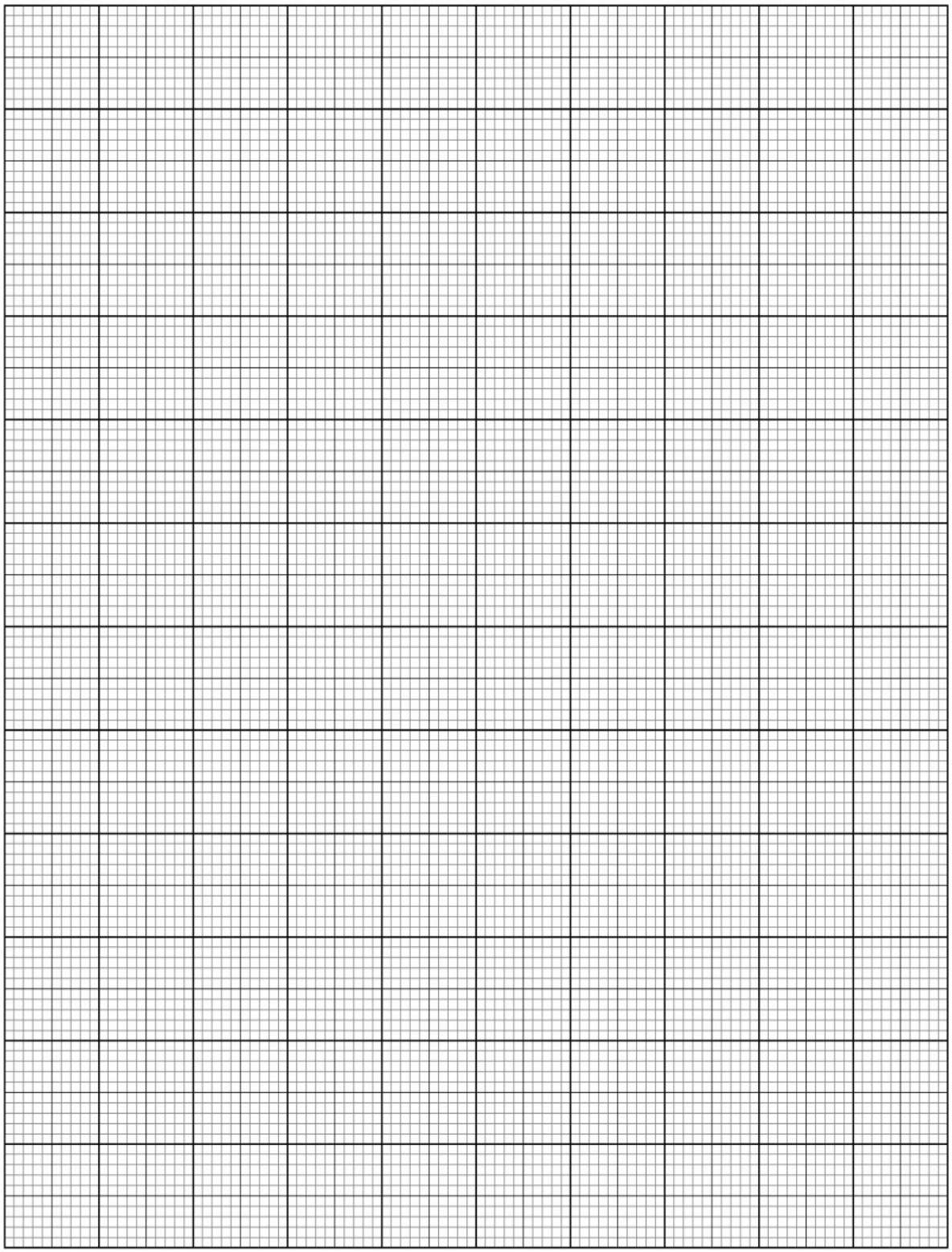
(a) Identify the dependent and independent variable in this experiment. **1**

Dependent : …….

Independent: …….

Question 34 (continued)

(b) Plot a graph of B_x against I. Include a line of best fit. **4**



Question 34 (continued)

(c) Determine the gradient of the line of best fit. Show all working. **3**

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(d) Using the gradient of the graph and the equation $B_x = \frac{\mu_0 NI}{2} . \frac{r^2}{(r^2+x^2)^{3/2}}$, determine the number of turns in the coil when $x = 0$ and $r = 3\ cm$. **2**

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Question 35 (10 marks)

Kepler's Third Law of Planetary Motion relates the time period of an orbit (T) with the radius of the orbit (R). This can be expressed mathematically as:

$$T^2 = \left(\frac{4\pi^2}{GM}\right) R^3$$

where $G = 6.67 \times 10^{-11}\ N\ m^2\ kg^{-2}$
$M =$ mass of the central body being orbited in kg.

Some orbital data for five of Saturn's moons are shown in the table below.

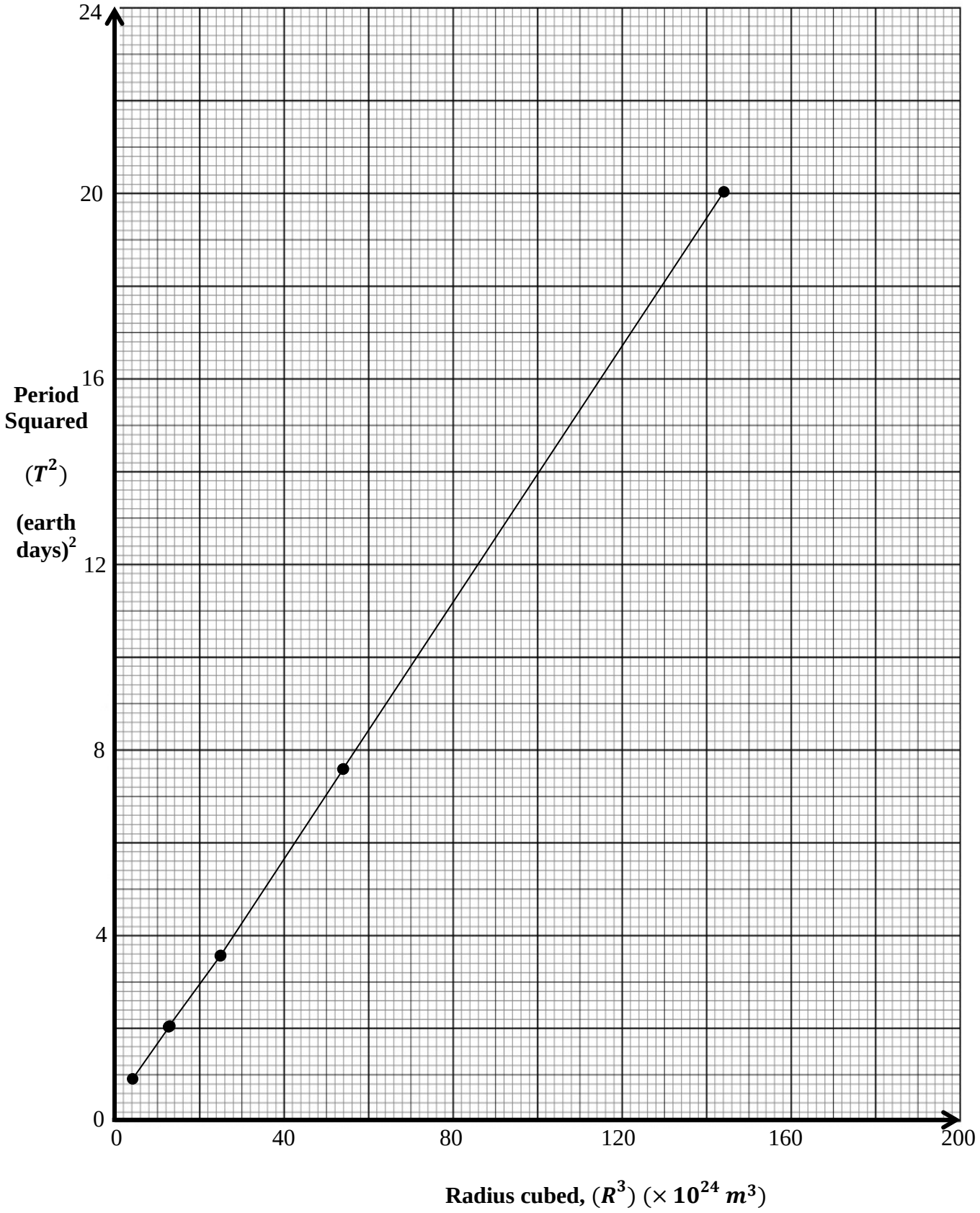
However, using all the calculated data, a graph of T^2 (in earth days squared) versus R^3 (in metres cubed) was drawn as shown on the next page.

(a) Using the graph, complete the table below. **5**

Note: 1 Earth day $= 86\ 400\ s$

Saturn's Moon	***Orbital Period, T (Earth Days)***	***Orbital Radius, R ($\times 10^8\ m$)***	***Period squared, T^2 ($\times 10^9 s^2$)***	***Radius cubed, R^3 ($\times 10^{24} m^3$)***
Mimas	0.94	1.28		
Enceladus	1.41	2.38		
Calypso	1.89	2.92		
Dione		3.77		
Rhea	4.53			

Graph of Period Squared versus Radius Cubed



Question 35 (continued)

(b) Using the graph, calculate a value for M, the mass of Saturn. **2**

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(c) If the mass of Saturn were doubled but the orbital radii of the moons remained the same, would the lunar time periods increase, decrease or remain the same? **1**

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(d) Justify your answer mathematically. If the time period has changed, indicate by what factor it has changed. **2**

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END OF EXAMINATION

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PART A 15 Multiple Choice Questions 15 marks.

1. Which star characteristics are closely related to the dominant wavelength of the light emitted by a star?

   (A) Size and surface temperature
   (B) Colour and size
   (C) Brightness and dominant frequency
   (D) Surface temperature and colour

2. The telescope was:

   (A) invented by astronomers to view planets better.
   (B) used by Galileo to support the geocentric model of the universe.
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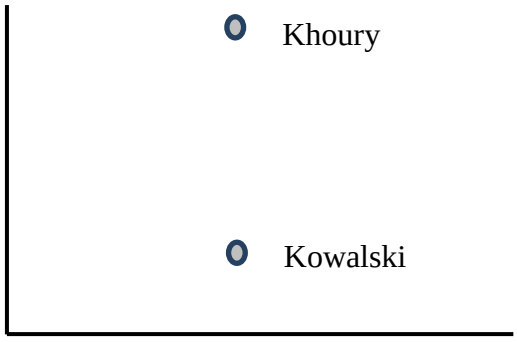

H-R diagram

   Which statement is correct?

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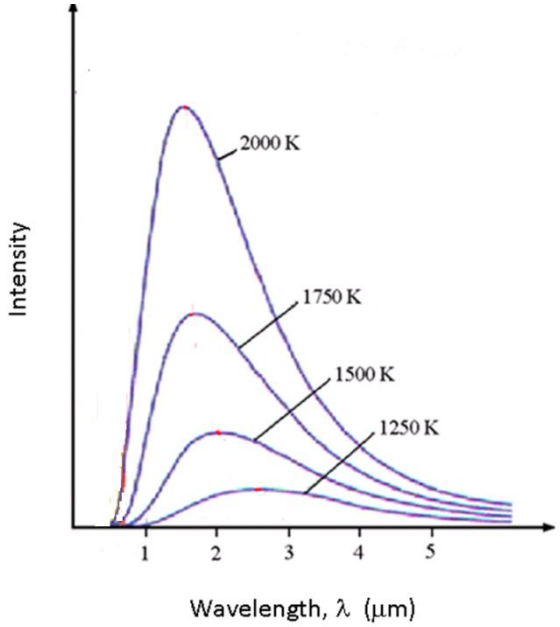
   (D) white dwarfs

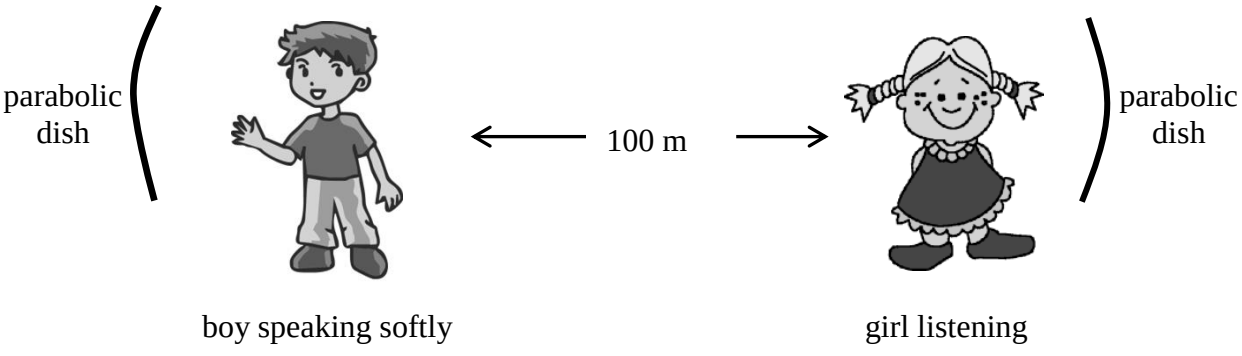
5. The relationship between the temperature of a hot body and the radiation that is emitted is shown in the graph below.



What is the correct inference that can be drawn from the graph?

(A) At any given temperature the hot body radiates energy at a single frequency.
(B) As the temperature increases the hot body glows more brightly.
(C) As the temperature increases the wavelength at which the irradiance peaks increases.
(D) As the temperature decreases the frequency at which the irradiance peaks increases.

6. A boy talks softly into a large smooth parabolic dish, as shown in the diagram below. His voice is heard easily by the girl standing 100 m away listening while standing near another parabolic dish.



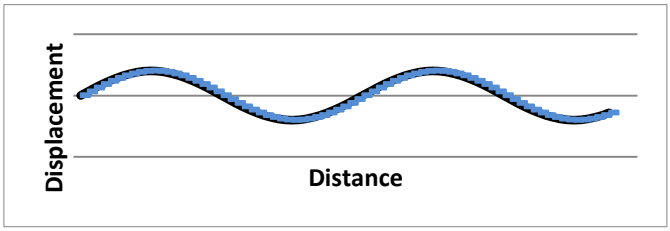
The property of waves which allows this to happen is:

(A) modulation
(B) dispersion
(C) refraction
(D) reflection

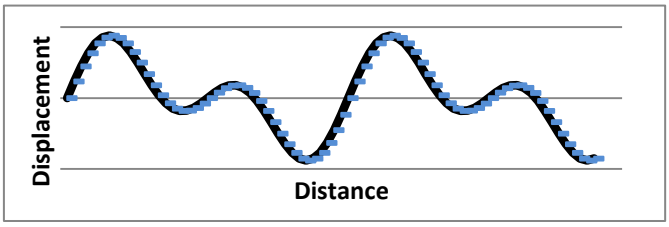
7. A 440 Hz sound wave was produced in a concert hall at the same time as a 880 Hz sound wave with the same amplitude.

The resultant wave shape would most closely resemble:

(A)

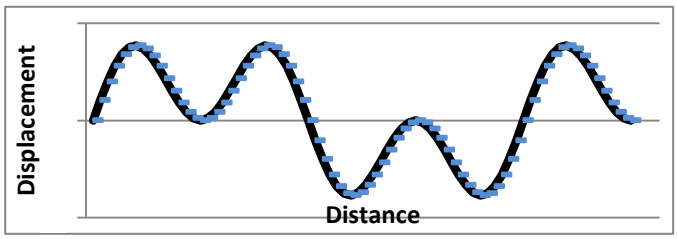


(B)

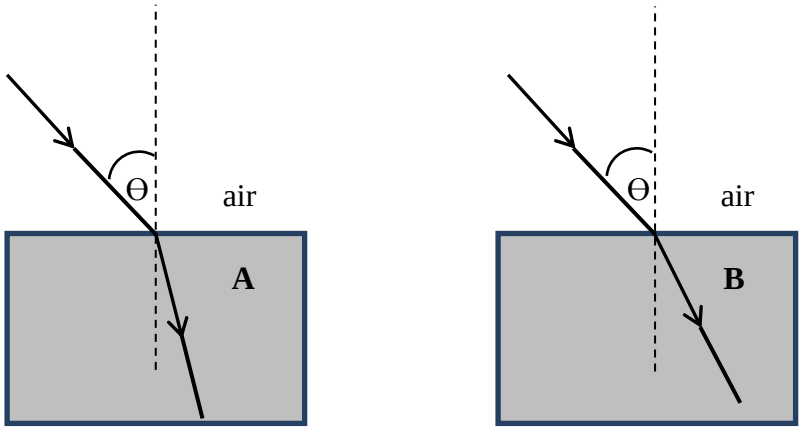


(C)

(D)



8. A laser light source was directed into two different transparent media, A and B, with the same incident angle, Θ, as shown.



Which statement about the laser light's wavelength is correct?

(A) $\lambda_{air} < \lambda_A < \lambda_B$

(B) $\lambda_A < \lambda_B < \lambda_{air}$

(C) $\lambda_{air} < \lambda_B < \lambda_A$

(D) λ is the same in all three mediums

9. Which of the following statements about electromagnetic waves is INCORRECT?

(A) Gamma rays have shorter wavelengths than ultraviolet rays.
(B) Radiowaves are part of the electromagnetic spectrum.
(C) Microwaves can be used for telecommunications.
(D) X-rays travel faster in a vacuum than infra-red rays.

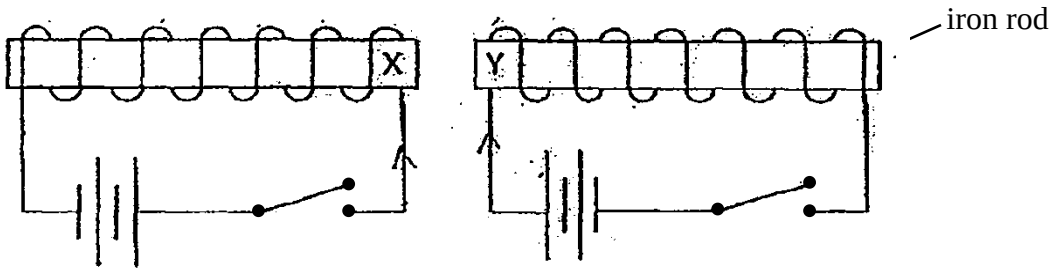
10. Which of the following wires (all made from the same material) would have the most resistance?

(A) A short and thick wire.
(B) A short and thin wire.
(C) A long and thick wire.
(D) A long and thin wire.

11. The most dangerous aspect of receiving a shock from a 240 V AC power source is:

(A) getting burned from the spark.
(B) making the muscles spasm.
(C) sending the heart into fibrillation.
(D) being thrown across the room.

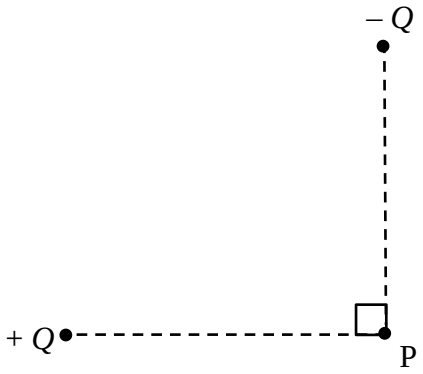
12. In the set-up shown below, both switches are closed and currents in both solenoids flow as shown.



Choose the correct alternative.

	X	Y	Force
(A)	S pole	S pole	repulsive
(B)	N pole	N pole	repulsive
(C)	S pole	N pole	attractive
(D)	N pole	S pole	attractive

13. Two point charges of equal magnitude, $+Q$ and $-Q$, are each placed equidistant from point P, as shown below.



What is the direction of the resultant electric field at **P**?

(A) 

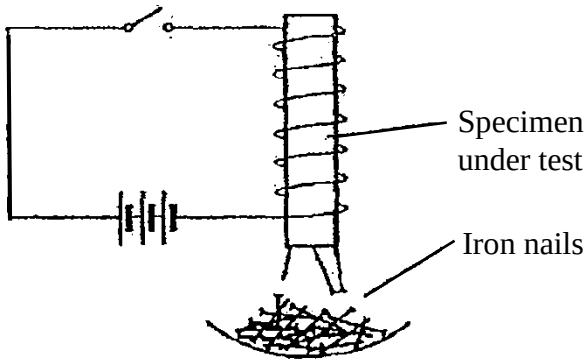
(B) 

(C) 

(D) 

14. Four different magnetic substances were tested using the apparatus shown in the diagram. The table below shows the number of iron nails each substance picks up when the switch is closed and when the switch is re-opened.

Which substance would make the best permanent magnet?



	Number of nails picked up when switch is closed	Number of nails held when switch is re-opened
(A)	35	4
(B)	20	10
(C)	20	20
(D)	40	3

15. A student repeated an investigation three times and achieved similar results (< 5% variation). She came to the following conclusions about her results:

i. The results were accurate.
ii. The results were reliable.
iii. The results were valid.
iv. The effect of random errors on the results was negligible.
v. The effect of systematic errors on the results was negligible.

Which of these conclusions are correct?

(A) i and ii only are correct.
(B) ii and iv only are correct.
(C) i, ii and iii only are correct.
(D) All of them are correct.

ANSWER BOOKLET

PART A Multiple Choice Answer Sheet 15 marks

Student No. …….....

Choose the most appropriate answer and fill in the response oval completely.

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 ○

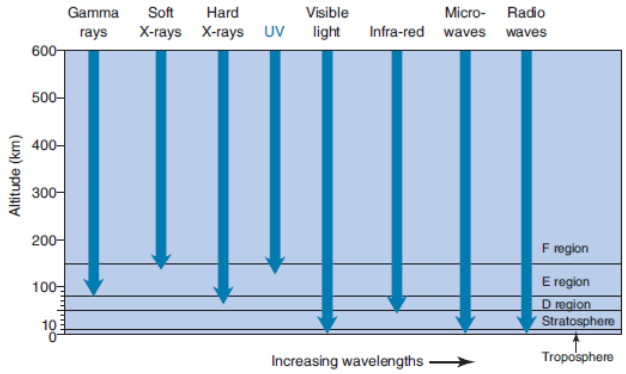
PART B 12 questions 45 marks

Attempt questions 21 – 32.
Allow about 55 minutes for this part.
Show all relevant working in questions involving calculations.

Question 21 (2 marks)

Identify THREE wavebands filtered out by the Earth's atmosphere. **2**

Gamma rays, X-rays, UV light, IR, radio waves (long wavelength)



Marking Criteria	Marks
Any three	2
Any two	1

Question 22 (3 marks)

An astronomer on Earth observes two equally bright stars in the night sky. Star A is 3.6 light years from the earth and has a luminosity of 4×10^{26} W. Star B has a luminosity of 2.5×10^{25} W.

How far away, relative to star A, is star B from Earth? **3**

$$B_{star\ A} = B_{star\ B}$$

$$\frac{L_{star\ A}}{4\pi r^2} = \frac{L_{star\ B}}{4\pi r^2}$$

$$\frac{4\times10^{26}}{4\pi(3.6)^2} = \frac{2.5\times10^{25}}{4\pi(r_B^2)}$$

$$r_{star\ B} = 0.9\ ly$$

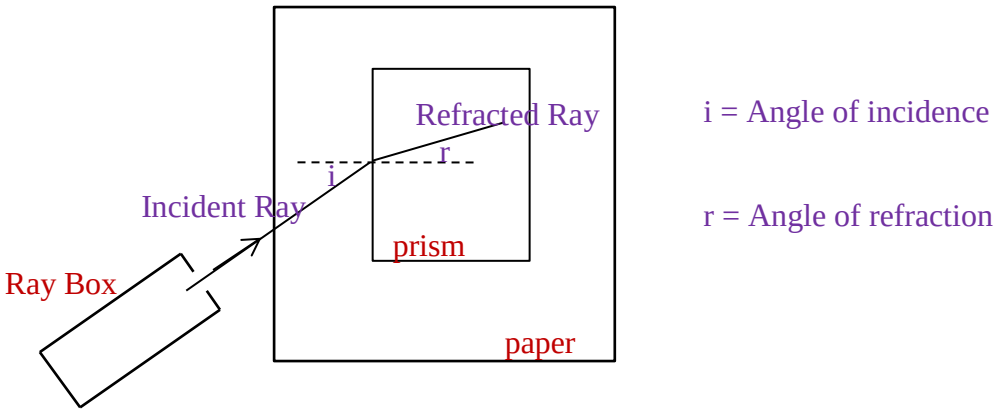
∴ star B is ¼ the distance that star A is from Earth

Marking Criteria	Marks
• Correctly substitutes into an appropriate formula • Correctly obtains the distance star B is from Earth compared to star A OR • Correctly expresses the ratio of the distance of star B to star A	3
• Any two of the above	2
• Shows some process to obtain the distance star B is from earth	1

Question 23 (7 marks)

In your course, you performed an investigation to determine the refractive index of a rectangular perspex/glass prism.

(a) Draw a fully labelled diagram of your experimental set-up. 3



Marking Criteria	Marks
• Correct equipment, including ray box, paper, protractor, ruler, prism • labelled fully • angle of incidence, angle of refraction, and direction of incident and refracted rays	3
• Any two of the above	2
• Anyone of the above	1

(b) Draw a table (do not complete it) of your experimental results. **1**

Angle of incidence (i)	Angle of refraction (r)	sin i	sin r

(c) Outline the method (in point form) you used to determine the refractive index of perspex/glass. **3**

- **Set up and connect equipment as shown above**
- **Choose an angle of incidence of say 10^0, and measure the corresponding angle of refraction. Record in table.**
- **Repeat for angles of incidence of 20^0 to 70^0**
- **Complete table for $\sin i$ and $\sin r$, and calculate their ratio.**
- **Graph $\sin i$ versus $\sin r$**
- **Find gradient of graph. This will yield the refractive index, n, given that $n_{air} \approx 1$**

Marking Criteria	Marks
• Appropriate angles of incidence chosen, • Correctly indicates steps to be taken (graphing or calculation) • and how n is to be determined (slope or average)	3
• Any two of the above	2
• Anyone one of the above	1

Question 24 (5 marks)

The refractive index of diamond, $n_{diamond} = 2.4$ $n_{glass} = 1.5$ $n_{water} = 1.3$ and $n_{air} = 1$.

(a) Calculate the speed of light in diamond. **1**

$$n = \frac{c}{v}$$
$$\therefore v = \frac{c}{n}$$
$$= \frac{3\times10^8}{2.4}$$
$$= 1.25 \times 10^8\ m\ s^{-1}$$

(b) Determine the angle of refraction for a beam of light entering glass from air with an incident angle of 45°. **2**

$$n_{air} \sin i = n_{glass} \sin r$$

$$\therefore \sin r = 1 \times \frac{\sin 45^0}{1.5}$$
$$\therefore r \approx 28^0$$

Marking Criteria	Marks
• Correctly substitutes into Snell's law, and obtains correct angle of refraction	2
• Any one of the above, with appropriate angle	1

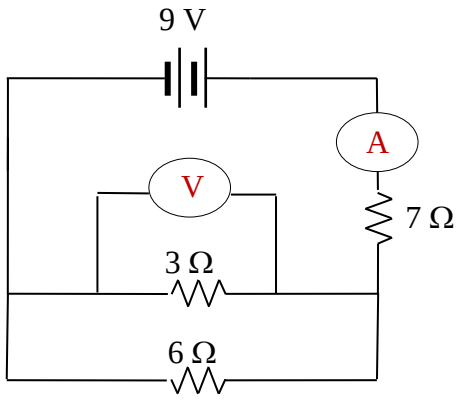
(c) Determine the critical angle for a beam of light entering water from glass. **2**

$$\therefore \sin i_c = \frac{1.3}{1.5} \times \sin 90^0$$
$$\therefore i_c \approx 60^0$$

Marking Criteria	Marks
• Correctly uses 90^0 as the angle of refraction • Correctly computes the critical angle, by substituting into Snell's law	2
• Correctly uses 90^0 as the angle of refraction	1

Question 25 (2 marks)

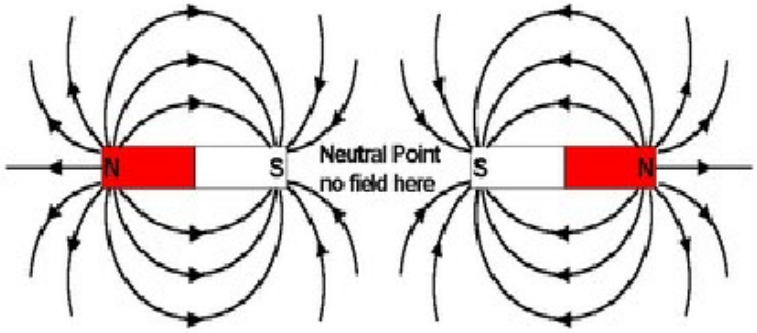
Place an ammeter and a voltmeter in the circuit below in order to correctly measure the current through the 7 Ω resistor and the voltage across the 3 Ω resistor. **2**



Marking Criteria	Marks
• Correctly ammeter position • Correctly voltmeter position	2
• Any one of the above	1

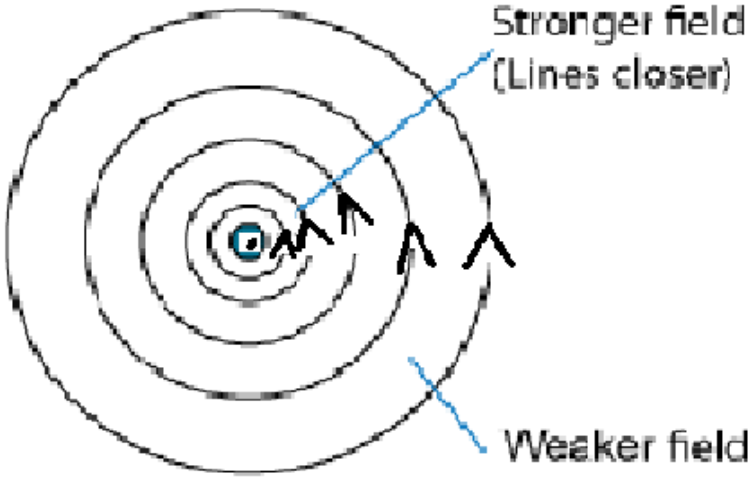
Question 26 (4 marks) Draw magnetic field lines for the arrangements shown below.

(a) Between two magnetic south poles: **2**



Criteria	Marks
• Correct representation of field lines • Correct direction of field lines • Correct null region	2
• Any two of the above	1

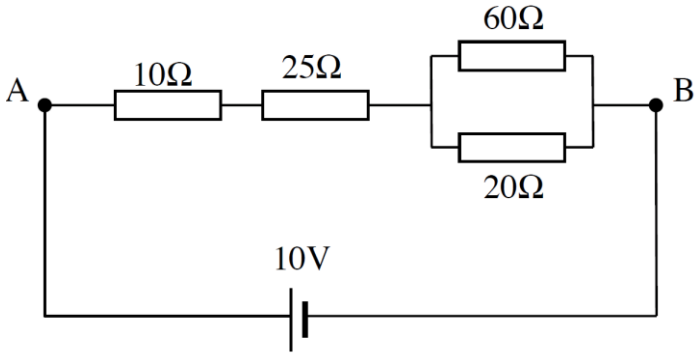
(b) Surrounding a current carrying conductor as shown below: **2**



Marking Criteria	Marks
• Correct representation of field lines (decreasing magnitude with distance) • Correct direction of field lines	2
• Any one of the above	1

Question 27 (6 marks)

Consider the circuit below:



Calculate:

(a) the resistance between the terminals A and B.

$$\frac{1}{R_{//}} = \frac{1}{60} + \frac{1}{20}$$
$$\therefore R_{//} = 15\ \Omega$$
$$\text{Hence } R_{total} = 10 + 15 + 25 = 50\ \Omega$$

Marking Criteria	Marks
• Correct process with final correct answer and units	2
• Any one of the above	1

(b) the potential difference across the 25 Ω resistor. **2**

$$I_{main} = \frac{V}{I} = \frac{10}{50}$$
$$= 0.2\ A$$
$$\therefore V_{25} = 25 \times 0.2 = 5\ V$$

Alternative Solution
Ratio of Resistances:
$R_{10} : R_{25} : R_{//} = 10 : 25 : 15 = 2 : 5 : 3$
Hence: $V_{10} : V_{25} : V_{//} = 2 : 5 : 3$
Hence $V_{25} = \frac{5}{10} \times 10 = 5\ V$

Marking Criteria	Marks
• Correct process with final correct answer and units	2
• Any one of the above	1

(c) the power dissipated in the 60 Ω resistor. **2**

Voltage drop across 10 Ω : $V_{10} = 0.2 \times 10 = 2\ V$

Voltage drop across 25 Ω : $V_{25} = 5\ V$

Hence Voltage drop across 60 Ω : $V_{60} = 10 - 5 - 2 = 3\ V$

Current through 60 Ω : $I_{60} = \frac{3}{60} = 0.05\ A$

Hence power dissipated in 60 Ω : $P_{60} = VI = 3 \times 0.05\ A = 0.15\ W$

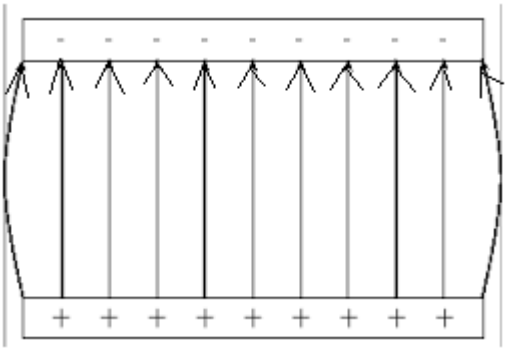
Alternative Solution
Power dissipated:
$P_{60} = \frac{V^2}{R} = \frac{3^2}{60} = 0.15\ W$

Marking Criteria	Marks
• Correct process with final correct answer and units	2
• Any one of the above	1

Question 28 (4 marks)

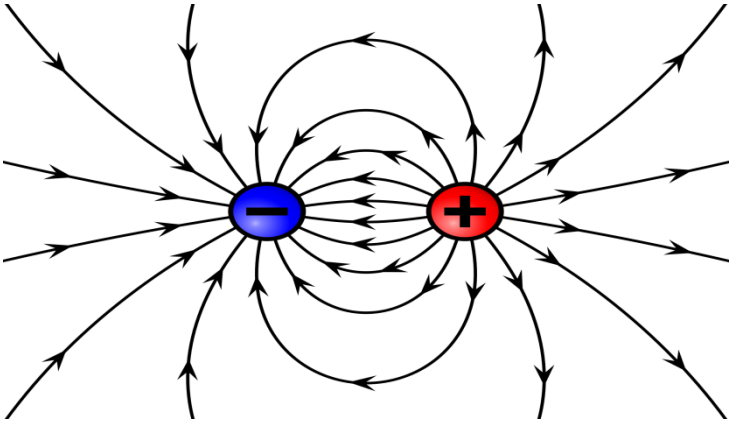
Draw the appropriate electric field lines for each of the following situations:

(a) Two oppositely charged parallel plates **1**



Marking Criteria	Marks
• Correct field lines with direction, magnitude and end effects	1

(b) Two oppositely charged point charges (dipole) **1**



Marking Criteria	Marks
• Correct field lines with direction and magnitude	1

(c) Determine the magnitude of the acceleration of a proton placed in an electric field of magnitude $5 \times 10^{-3}\ N\ C^{-1}$. **2**

Force on proton: $F = Eq$

$= 5 \times 10^{-3} \times 1.6 \times 10^{-19}$

$= 8 \times 10^{-22}\ N$

Hence from Newton II, acceleration of proton:

$$a = \frac{F}{m}$$

$$= \frac{8 \times 10^{-22}}{1.67 \times 10^{-27}}$$

$$= 4.8 \times 10^{5}\ m\ s^{-2}$$

Marking Criteria	Marks
• Correct process with final correct answer and units	2
• Substitution into correct formula resulting in incorrect answer	1

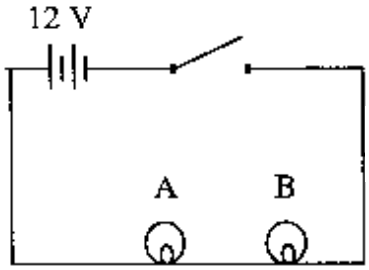
Question 29 (4 marks)

A student set up two electrical circuits as shown in the diagrams below.

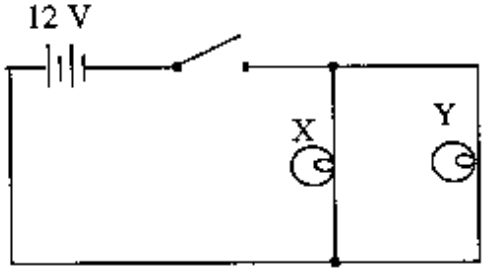
All four globes, A, B, X and Y are identical.

The switches were closed and all the globes glowed. (i.e. all the globes work!)

The brightness of a globe is a measure of the power dissipated in it.



1st circuit



2nd circuit

Compare, quantitatively, the brightness of all 4 globes, in both circuits, after the switches are closed. Explain your reasoning. **4**

Globe A = Globe B because $P=V^2/R$ and both V (6v) and R are identical

Globe X = Globe Y because $P=V^2/R$ and both V (12v) and R are identical

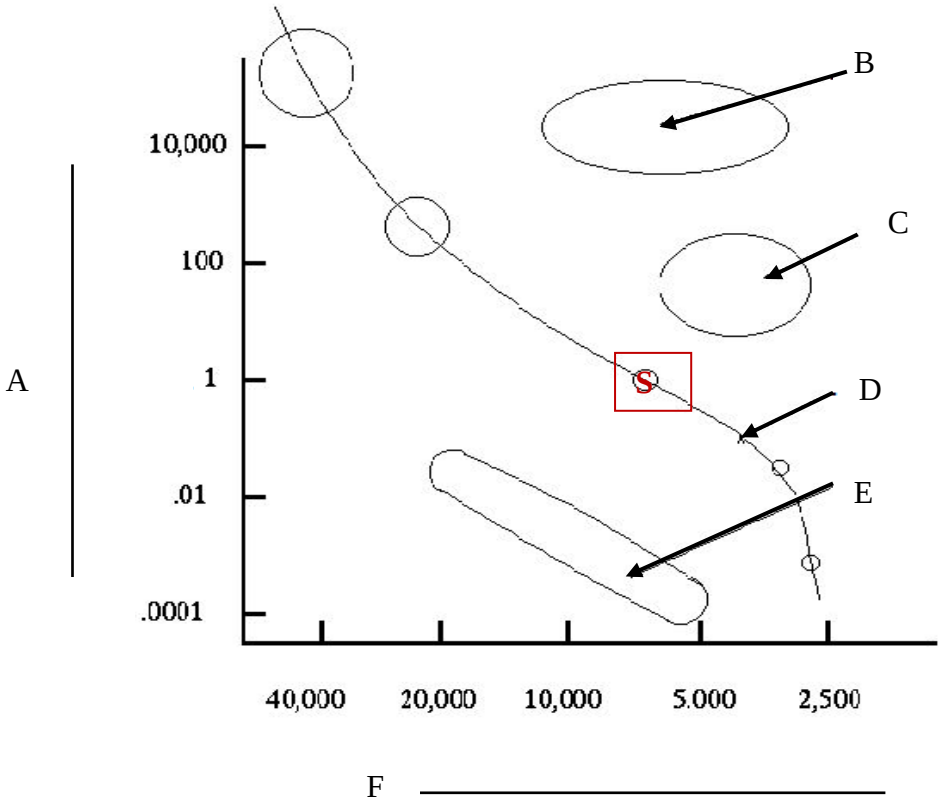
Globe X/Y is brighter than Globe A/B because X/Y have twice the voltage across them as A/B

Globe X/Y is 4× brighter than Globe A/B because $P \alpha V^2$

Marking Criteria	*Marks*
• 4 of the above (answer and reason)	4
• 3 of the above (answer and reason)	3
• 2 of the above (answer and reason)	2
• 1 of the above (answer and reason)	1

Question 30 (4 marks)

(a) Identify the parts A – F of the Hertzsprung – Russell (H-R) diagram shown below. **3**



A: Luminosity (relative to our Sun)

B: Supergiants

C: Red giants

D: Main sequence stars

E: White dwarfs

F: Surface temperature

Marking Criteria	*Marks*
• All 6 correct	3
• 4-5 correct	2
• 2-3	1

(b) Clearly indicate the position of our sun with the letter S on the H-R diagram above. **1**

Question 31 (5 marks)

Our current theory of the origin of the universe is known as the Big Bang theory. **5**
It is based, among other things, on the idea of an expanding universe.

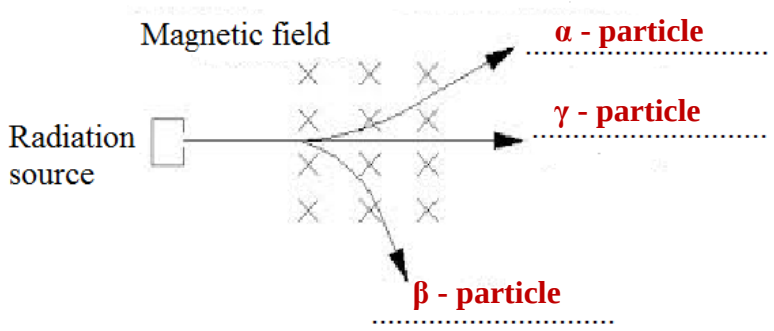
Describe this theory AND the significant experimental evidence upon which it is based.
Include the contributions of Friedmann and Hubble in your answer.

- The Big Bang theory asserts that energy gave rise to matter in an explosion called the "big bang".
- The theory is based upon on an expanding universe, correctly predicted by Friedmann (based on Einstein's work on General Relativity), a Russian mathematician/theoretical physicist in 1922.
- Edwin Hubble, in 1927, provided the first evidence supporting this theory when he discovered galaxies other than our own which were receding away from us (red-shift). Furthermore, He showed that the recession velocity of these galaxies was proportional to the distance from us, the further galaxies having a higher recession speed and hence a larger red-shift.
(Hubble's Law $v = H_0 D$)
- Friedmann's expanding universe also predicted the existence of an "afterglow" of the big bang in the form of remnant EM radiation in the microwave range. This Cosmic Background Radiation was discovered by American physicists Penzias and Wilson in 1963.

Marking Criteria	***Marks***
Correctly describes the big bang theory and the supporting evidence including: • conversion of energy into matter – 1 mark • Friedmann's contribution – 1 mark • Hubble's contribution: red shift and $v = H_0 D$ – 2 marks • Cosmic Background Radiation – 1 mark	**5**
Correctly describes 4 of the above	**4**
Correctly describes 3 of the above	**3**
Correctly describes 2 of the above	**2**
Correctly describes 1 of the above	**1**

Question 32 (4 marks)

(a) Identify the radioactive emissions on the diagram below from an unstable radiation source. **3**



Marking Criteria	*Marks*
• Correctly identifies all 3 emissions	3
• Correctly identifies 2 emissions OR α–particles and β–particles reversed	2
• Correctly identifies 1 emission	1

(b) Two of the above radioactive emissions are charged particles. **1**
Compare their relative ionising abilities.

An α – particle is much more ionising than a β – particle
(mostly due to its much larger mass)

End of Theory paper

Student No. …….....

JAMES RUSE AGRICULTURAL HIGH SCHOOL

2015

PHYSICS

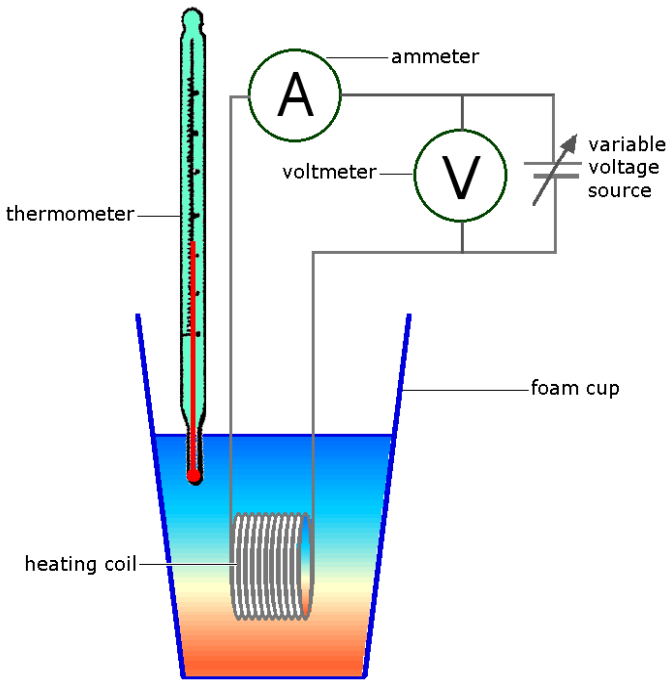
PART C

DATA PROCESSING

PART C Data Processing Section 25 marks Allow about 35 minutes

Question 33 (5 marks)

A student used the apparatus shown to investigate the heating of 300 g of water using a heating coil.



Measurements of voltage, current and water temperature were taken every two minutes for 10 minutes and recorded in a results table, as shown below.

Results:

Time (minutes)	*Voltage (V)*	*Current (A)*	*Water Temperature (^oC)*
0	9.5	2.5	18.0
2	9.3	2.3	20.2
4	9.4	2.4	21.8
6	9.6	2.7	22.7
8	9.4	2.6	24.3
10	9.2	2.2	25.9

Question 33 (continued)

(a) Calculate the electrical energy used in 10 minutes. **2**

$$E = V_{ave} I_{ave} t$$
$$= (9.4 \times 2.45) \times (10 \times 60)$$
$$= 13\,818\ J$$

Marking Criteria	***Marks***
• Correct use of average quantities AND conversion of mins to secs.	2
• One of the above	1

(b) Are these results consistent with the law of conservation of energy? **3**

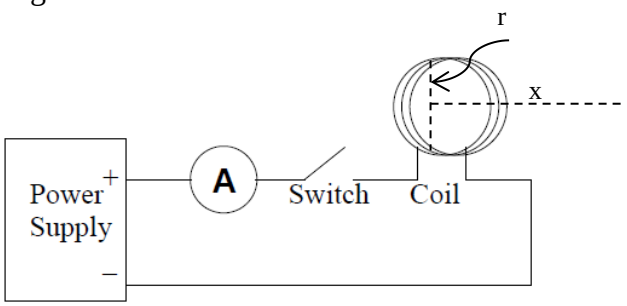
Justify your answer using appropriate calculations.

$$Q = mc\Delta T$$
$$= 0.3 \times 4180 \times 7.9$$
$$= 9907\ J$$

Marking Criteria	Marks
• Correct formula • Correct substitution into formula • Correct conclusion about conservation of energy	3
• Any 2 of the above	2
• Any 1 of the above	1

Question 34 (10 marks)

A student set up an experiment to determine the magnitude and direction of the magnetic field generated by a current passing through a specific geometry of a circular wire.
The field strength was measured along the axis of the coil of radius r at distances x from the plane of the coil as shown in the diagram below.



According to the Biot-Savart Law and Ampere's Law, the magnetic field a distance x away, B_x, is given by

$$B_x = \frac{\mu_0 NI}{2} \cdot \frac{r^2}{(r^2 + x^2)^{3/2}}$$

Where $r =$ radius of the circular coil
$I =$ current passing through the circular coil
$x =$ distance from the center of the coil along its axis
$\mu_0 = 4\pi \times 10^{-7}\ N\ A^{-2} =$ magnetic permeability of vacuum
$N =$ number of loops in the coil

The measured values of the magnetic field strength B_x and current I are shown in the table below.

$\boldsymbol{I(A)}$	$\boldsymbol{B_x(\times 10^{-4}\ T)}$
1.15	21
1.98	35
3.17	58
3.75	71
4.95	92
6.03	120
6.96	130
8.30	155
8.90	166
10.00	190

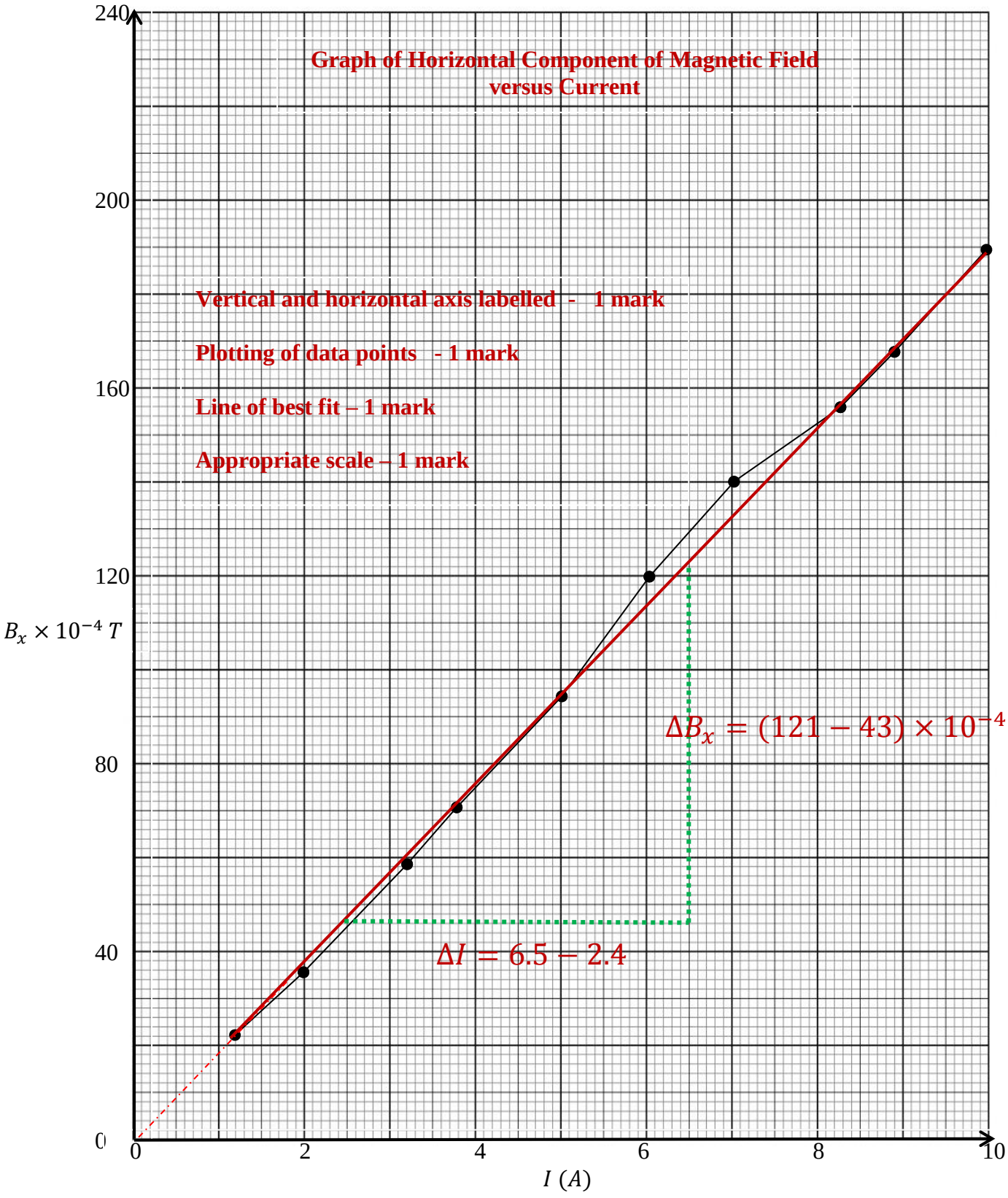
(a) Identify the dependent and independent variable in this experiment. **1**

Dependent : Magnetic field, B_x
Independent: Current, I

Marking Criteria	*Marks*
• Two correct variables	1

Question 34 (continued)

(b) Plot a graph of B_x against I. Include a line of best fit. **4**



Question 34 (continued)

(c) Determine the gradient of the line of best fit. Show all working. **3**

$$gradient = \frac{\Delta B_x}{\Delta I}$$
$$= \frac{(121-43)\times10^{-4}}{6.5-2.4}$$
$$= 1.9 \times 10^{-3}\ T\ A^{-1}$$

Marking Criteria	*Marks*
• Correct slope, with appropriate working and units	3
• Any two of the above	2
• Any one of the above	1

(d) Using the gradient of the graph and the equation $B_x = \frac{\mu_0 NI}{2}.\frac{r^2}{(r^2+x^2)^{3/2}}$, determine the number of turns in the coil when $x = 0$ and $r = 3\ cm$. **2**

$$B_x = \frac{\mu_0 NI}{2r}$$

$$N = \left(\frac{B_x}{I}\right)\frac{2r}{\mu_0}$$

$$= 1.9 \times 10^{-3}\ \frac{2\times0.03}{4\pi\times10^{-7}}$$

$$\sim 91\ turns$$

Marking Criteria	*Marks*
• Correct substitution of slope into formula, with correct number of turns ($\pm$ 5% variation)	2
• Correct substitution of slope into formula	1

Question 35 (10 marks)

Kepler's Third Law of Planetary Motion relates the time period of an orbit (T) with the radius of the orbit (R). This can be expressed mathematically as:

$$T^2 = \left(\frac{4\pi^2}{GM}\right) R^3$$

where $G = 6.67 \times 10^{-11}\ N\ m^2\ kg^{-2}$
$M =$ mass of the central body being orbited in kg.

Some orbital data for five of Saturn's moons are shown in the table below.

However, using all the calculated data, a graph of T^2 (in earth days squared) versus R^3 (in metres cubed) was drawn as shown on the next page.

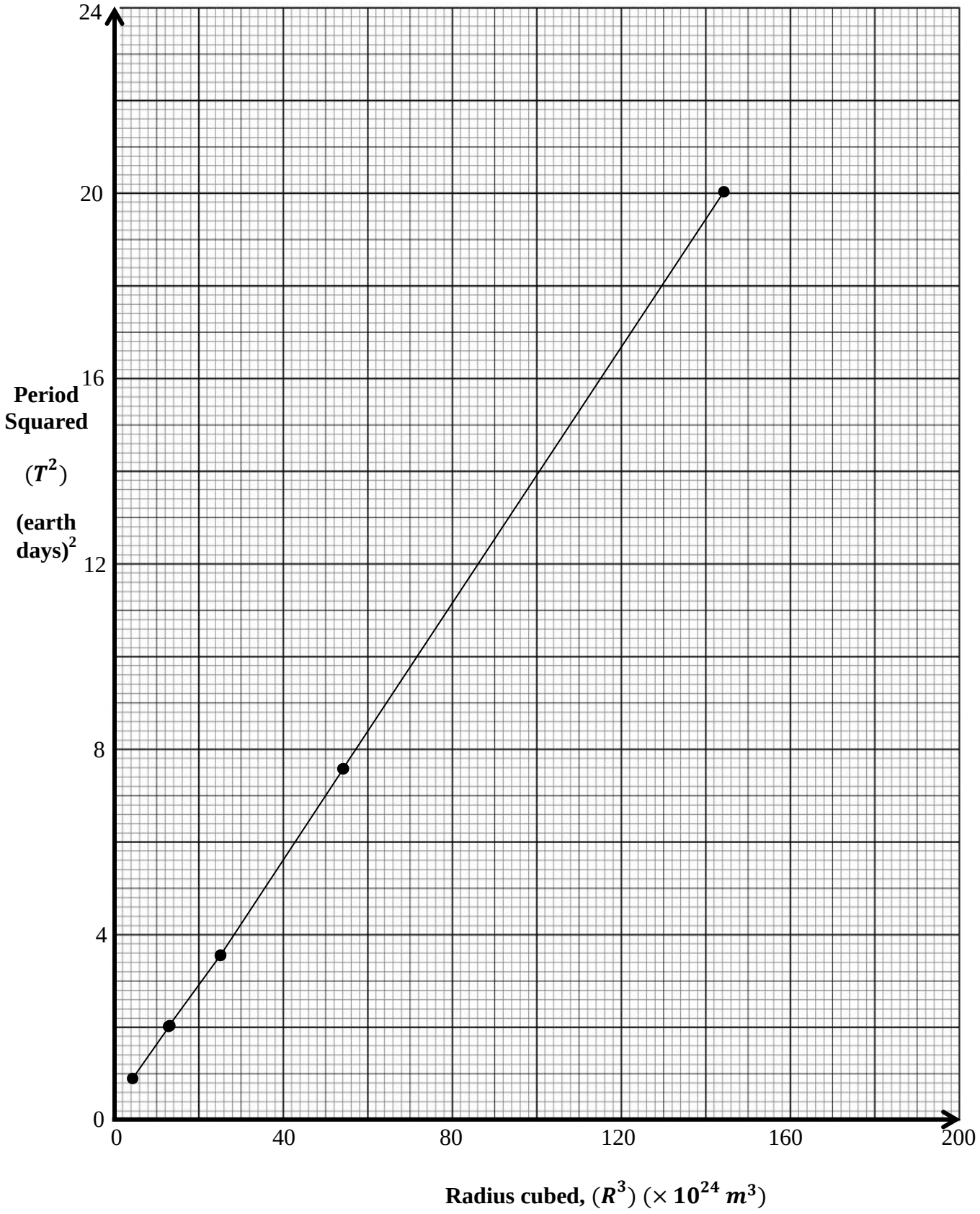
(a) Using the graph, complete the table below. **5**

Note: 1 Earth day $= 86\ 400\ s$

Saturn's Moon	***Orbital Period, T (Earth Days)***	***Orbital Radius, R ($\times 10^8$ m)***	***Period squared, T^2 ($\times 10^9 s^2$)***	***Radius cubed, R^3 ($\times 10^{24} m^3$)***
Mimas	0.94	1.28	**6.6**	**4.5**
Enceladus	1.41	2.38	**14.8**	**1.33**
Calypso	1.89	2.92	**26.7**	**24.9**
Dione	**2.74**	3.77	**56.0**	**53.6**
Rhea	4.53	**5.25**	**153.2**	**144.7**

Marking Criteria	***Marks***
• Correct T for Dione, correct R for Rhea, correct for T^2 column (twice), correct R^3 column	5
• Any 4 of the above	4
• Any 3 of the above	3
• Any 2 of the above	2
• Any 1 of the above	1

Graph of Period Squared versus Radius Cubed



Question 35 (continued)

(b) Using the graph, calculate a value for M, the mass of Saturn. **2**

$$gradient = \frac{\Delta T^2}{\Delta R^3}$$

$$= \frac{(14-3)\times(86400)^2}{(100-20)\times10^{24}}$$

$$= 1.026 \times 10^{-15}\ s^2\ m^{-3}$$

Hence $$M = \frac{4\pi^2}{G} \times \frac{1}{gradient}$$

$$= \frac{4\pi^2}{6.67\times10^{-11}} \times \frac{1}{1.026\times10^{-15}}$$

$$= 5.766 \times 10^{26}\ kg$$

Marking Criteria	*Marks*
• Correct gradient, correct mass	2
• Correct gradient or correct process	1

(c) If the mass of Saturn were doubled but the orbital radii of the moons remained the same, would the lunar time periods increase, decrease or remain the same? **1**

decrease

(d) Justify your answer mathematically. If the time period has changed, indicate by what factor it has changed. **2**

$$\frac{T^2}{R^3} = \left(\frac{4\pi^2}{G2M}\right)$$

Hence $\frac{T^2}{R^3} = \frac{1}{2} \times constant$

Therefore the period decreases by a factor $\frac{1}{\sqrt{2}}$

Marking Criteria	*Marks*
• Correct factor and correct working	2
• Any of the above/ or process	1

END OF EXAMINATION