Surname	Centre Number	Candidate Number
First name(s)		2

GCE A LEVEL

S25-A420U20-1

A420U20-1

MONDAY, 9 JUNE 2025 – MORNING

PHYSICS – A level component 2

Electricity and the Universe

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**12**	
2.	**14**	
3.	**12**	
4.	**13**	
5.	**13**	
6.	**10**	
7.	**18**	
8.	**8**	
Total	**100**	

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ADDITIONAL MATERIALS

In addition to this examination paper, you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question **4**(a).

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Answer **all** questions.

1. (a) (i) 'Copper is an electrical conductor.' Explain what this statement means. [1]

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(ii) Derive the equation $I = nAve$ for the current in a wire when the drift velocity of the free electrons is v. Include a clearly labelled diagram. [4]

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(iii) Two copper wires of diameter 0.20 mm and 0.30 mm are joined in series and a pd is applied. The drift velocity, v, of the free electrons in the wire of diameter 0.20 mm is $6.0 \times 10^{-4}\,\text{m s}^{-1}$.
Calculate the drift velocity in the wire of diameter 0.30 mm. [2]

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(b) A torch battery converts 12 960 J of chemical energy into electrical energy whilst supplying a current of 0.15 A for 4 hours. In this time, only 11 664 J of this energy is supplied to the bulb.

(i) Calculate the emf of the battery **and** the pd across the bulb, including the units of both quantities. [3]

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(ii) Hence or otherwise calculate the battery's internal resistance. [2]

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2. David investigates how the current, I, in a filament lamp varies with the potential difference, V, across it.

(a) Sketch a circuit diagram of the apparatus David could use to obtain a range of readings of I and V. [1]

(b) The relationship between I and V can be expressed as:

$$I = kV^n$$

where k and n are unknown constants.
By taking logs of both sides of the equation, complete the following expression showing how it can be written in the form $y = mx + c$. [1]

$\ln I =$ ..... + ...

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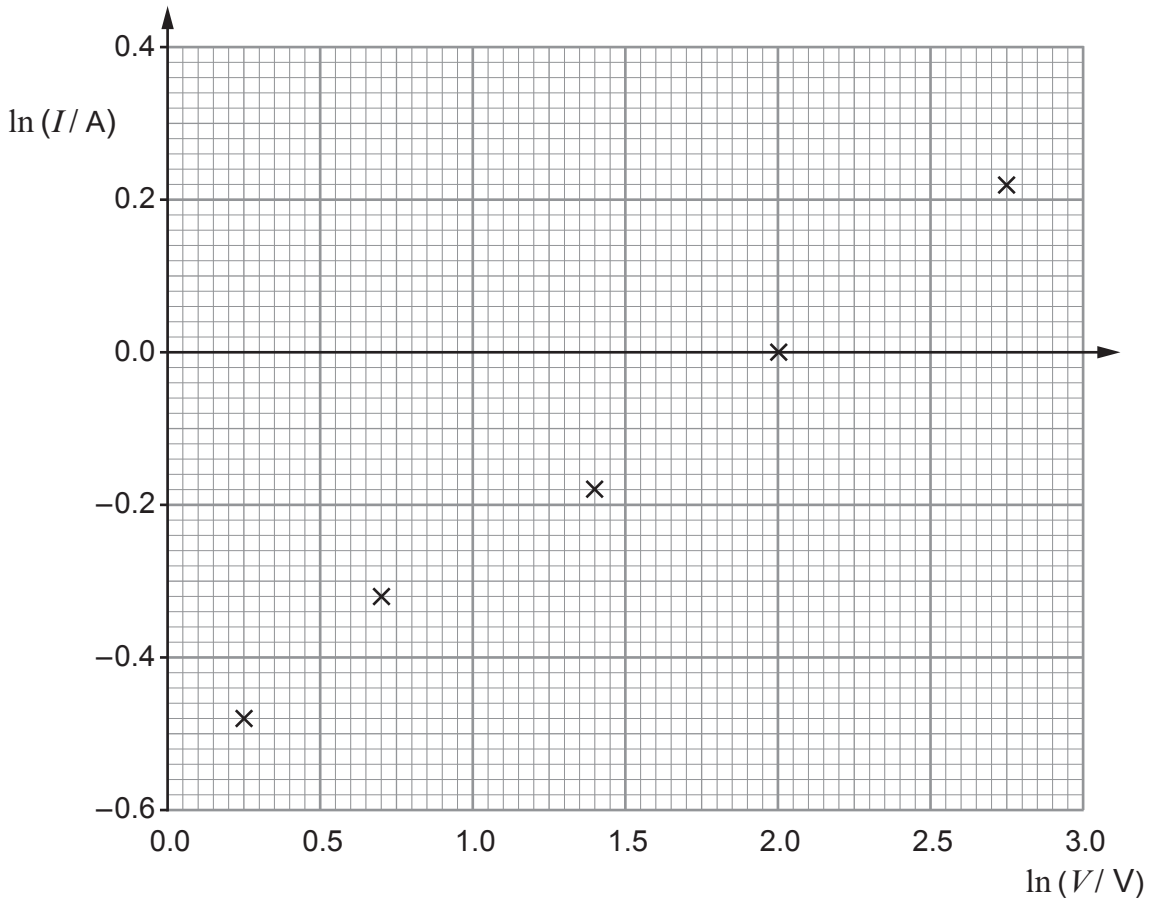
(c) David records one set of readings from his investigation and uses them to draw a graph of $\ln I$ against $\ln V$ as shown.



(i) Determine values for k and n **and** hence write down an equation showing the relationship between I and V for this filament lamp. Analysis of uncertainties is **not** required. [6]

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(ii) David's teacher comments:

"Your readings do not justify a high degree of confidence in the values for n and k."

State why the teacher is correct **and** what David should do to increase confidence in his results. [2]

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(d) The experiment is repeated with 3 identical lamps connected in parallel. These lamps are identical to the one lamp used previously by David. Write down the values for n and k for this arrangement. Explain your answers. [4]

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3. (a) Show that the unit of resistance, Ω, can be expressed in the following **two** ways. [3]

VA^{-1} JsC^{-2}

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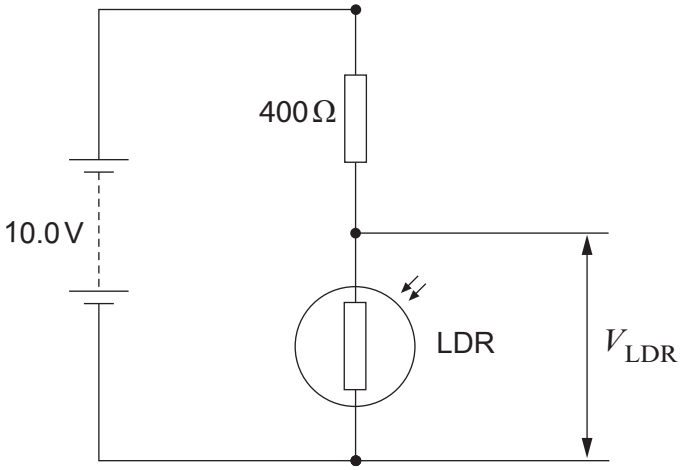
(b) Eleanor is investigating electrical components in circuits. She constructs the circuit below.



The light-dependent resistor (LDR) has a resistance of 1600 Ω in the dark and 320 Ω in daylight.

(i) Calculate V_{LDR} in the dark. [2]

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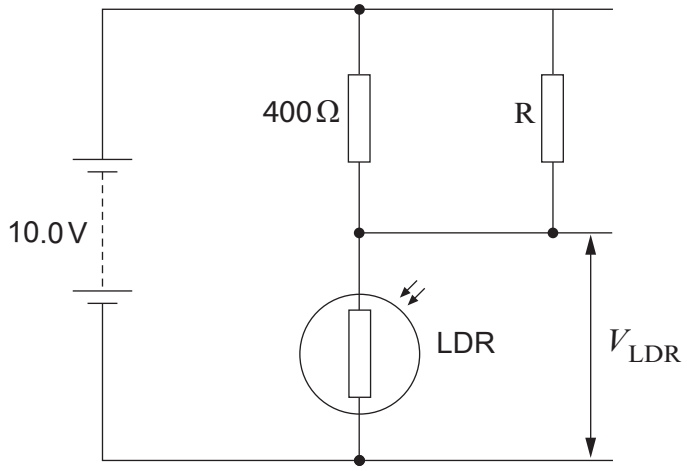
(ii) Eleanor now wishes to modify her circuit by adding another resistor, R, as shown below, so that **in daylight**, the pd across the LDR **is the same as** the voltage (V_{LDR}) calculated in (b)(i). Show that the resistance of R should be 100 Ω. [4]



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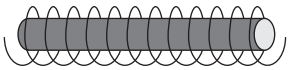
(c) Eleanor decides to construct the resistor, R, by winding a length, l, of nichrome wire around an insulator.



The nichrome wire available to Eleanor has the following properties.

Resistance material	Resistivity / Ω m	Diameter / mm	Available length / m
nichrome	1.1×10^{-6}	0.16	2.0

Assuming that the diameter cannot be changed, determine the modification Eleanor should make to the wire to enable a resistor with the same resistance as R to be constructed. [3]

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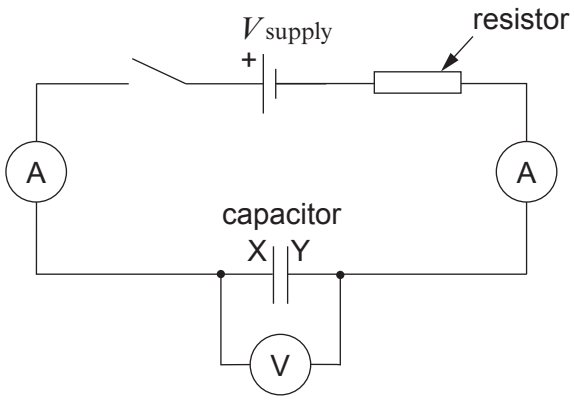
4. (a) A student sets up the following circuit in which the capacitor is initially uncharged.



When the switch is closed, the charge on each plate of the capacitor increases until it reaches a maximum value. Give a **detailed** description of why this occurs.
Include reference to the meters shown and the plates X and Y of the capacitor in your answer. Mathematical or algebraic responses are not required. [6 QER]

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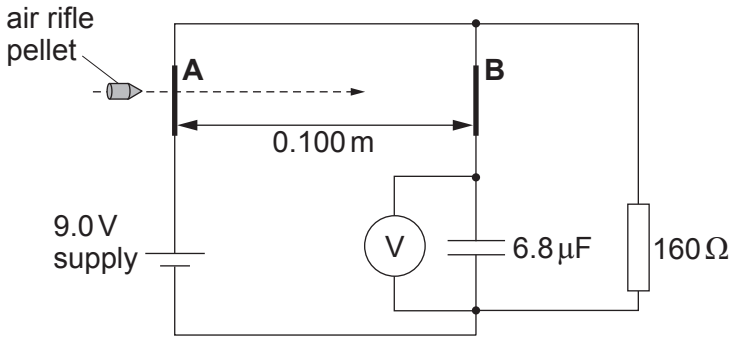
(b) Two students, Robert and Paula, use two different methods to determine the speed of an air rifle pellet.

(i) Robert uses the following arrangement.



Initially, the voltmeter reading is 9.0 V. The pellet first breaks the circuit at **A**, which disconnects the supply to the capacitor. The capacitor immediately starts to discharge through the resistor and continues to discharge until the pellet breaks the circuit at **B**. The final voltmeter reading is 6.0 V.

I. Calculate the time taken for the pellet to travel from **A** to **B**. [3]

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II. Hence determine the speed of the pellet. [1]

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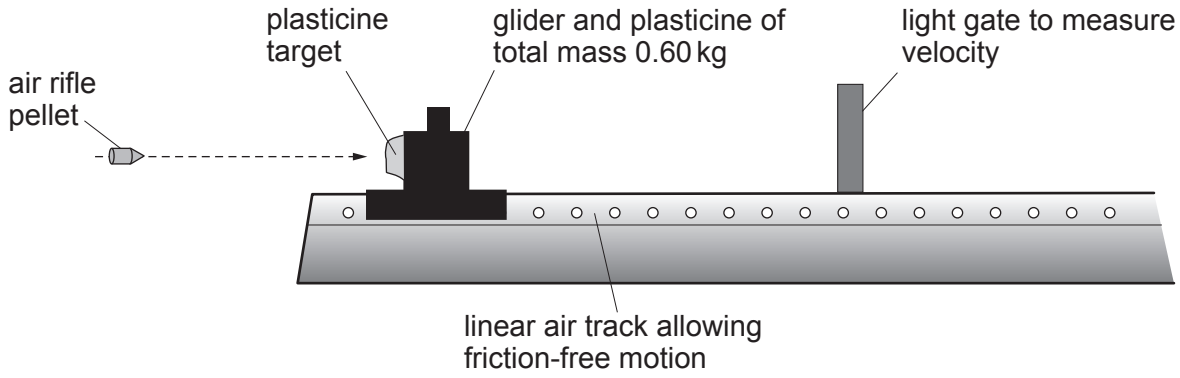
(ii) Paula uses the following arrangement.



Initially the glider and plasticine are at rest. The pellet strikes the plasticine and is embedded in it. The combination then passes through the light gate where the velocity is recorded.

The following measurements are taken:

Mass of glider and plasticine = 0.60 kg
Mass of pellet = 0.54 g
Velocity recorded at light gate = 0.20 m s^{-1}

Determine whether these measurements are consistent with the speed calculated in part (b)(i)II. [3]

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5. (a) Describe a method to investigate the force-extension properties of rubber in the form of an elastic band as **it is loaded only**. You should describe how the extension is accurately measured. [3]

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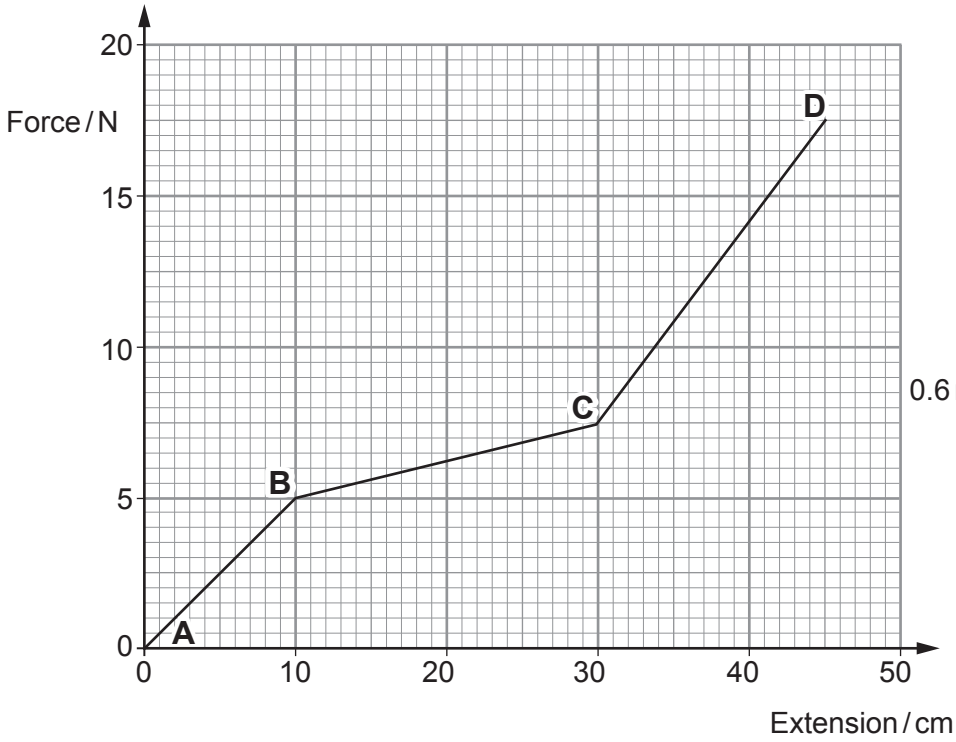
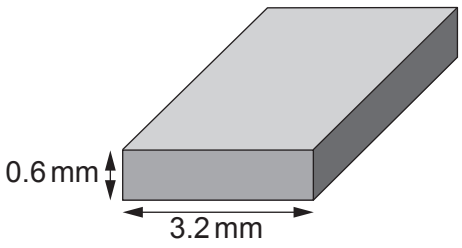
(b) Below is a simplified graph of force against extension for a 12.00 cm length of rubber, in which the curved lines have been approximated to straight lines. Next to the graph is a diagram showing the cross-section of the length of rubber, which is not drawn to scale.





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(i) Show that the line for the region **AB** is consistent with this sample of rubber having a Young modulus of approximately 3 MPa in this region. [2]

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(ii) Briefly explain the changes in the molecular arrangement in the regions **BC** and **CD**. [2]

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(iii) A student suggests that 1.5 times more work is done in stretching the rubber from **C** to **D** than from **B** to **C**. Determine whether the student is correct. [3]

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(c) Explain how a car tyre manufacturer might use the term **'hysteresis'** to advise drivers that driving with under-inflated tyres (tyres below the recommended pressure) is a bad idea. [3]

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6. (a) In a Physics exam, a student gave the following response to the question: **Define electric potential, V, at a point in an electric field.**

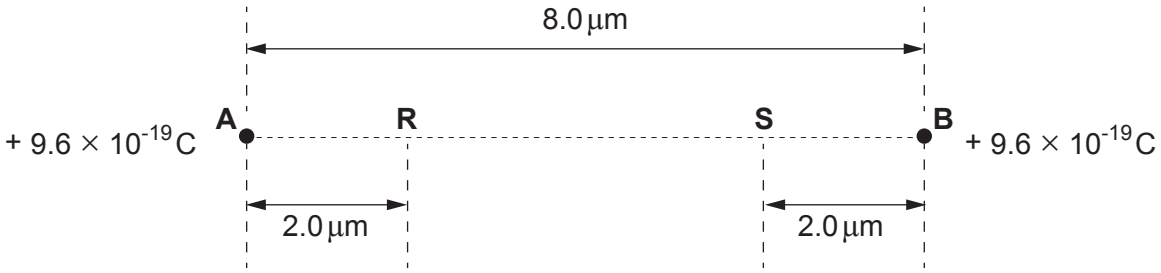
"It is the work done in bringing a positive charge to that point in the field."

Give **two** reasons why the student gained no marks for this response. [1]

Reason 1: .....

Reason 2: .....

(b) Two point charges, each of charge $+9.6 \times 10^{-19}$ C, are placed at points **A** and **B** in a vacuum. They are separated by 8.0 μm as shown.



Points **R** and **S** are situated on the line **AB** as shown.

(i) Determine the magnitude and direction of the electric field strength at **R**. [3]

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(ii) A teacher states:

"When a small test charge is moved between **R** and **S**, the net work done is zero."

Explain, **without calculation**, why the teacher is correct. [2]

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Examiner only

(iii) Calculate the work done in moving a proton from the mid-point of **AB** to point **S**. [4]

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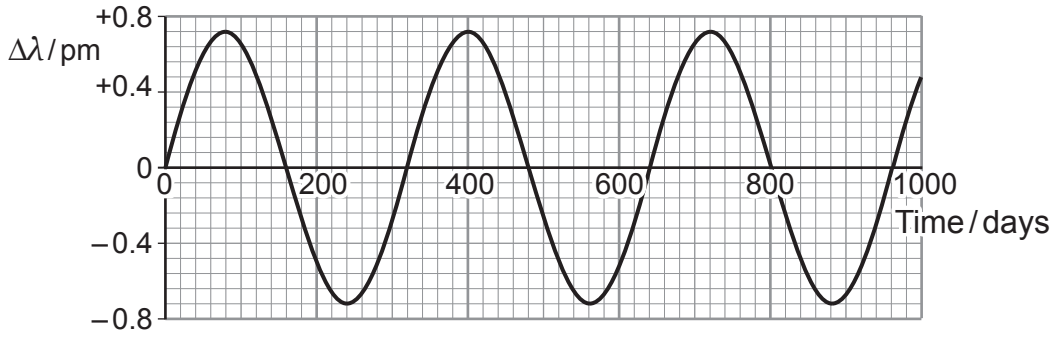
7. Astronomers recently discovered a large planet orbiting a star using data obtained from the light spectrum of the star. The graph shows the changing Doppler shift of the wavelength of light used to analyse the star.



(a) The following diagram shows the orbits of the planet and the star in relation to Earth. Points **A** and **B** are two positions of the star in its circular orbit.

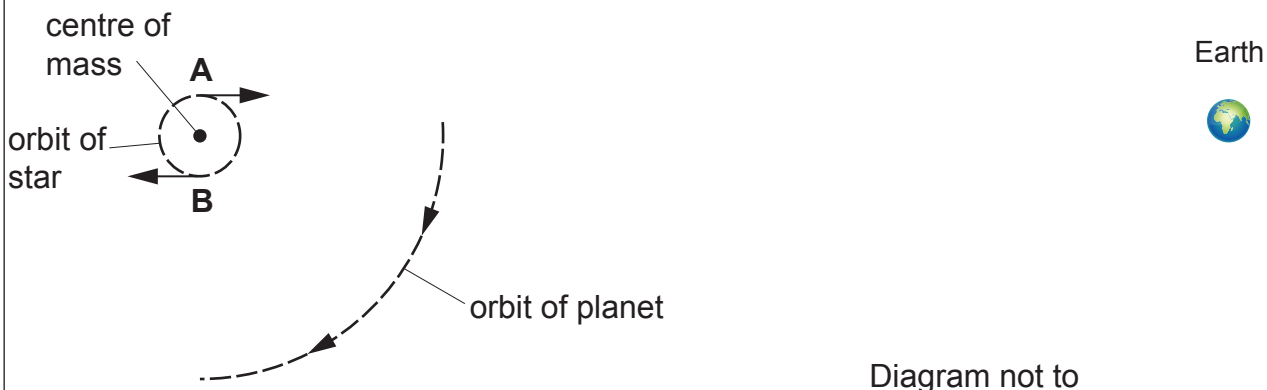


Diagram not to scale

Use the diagram and points **A** and **B** to explain how the variation in wavelength of the spectral line from the star occurs. Calculations are not required. [3]

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(b) Use information from the graph to answer the following.

(i) Show that the orbital speed of the star about the centre of mass is approximately 360 m s^{-1}. The wavelength of light used to obtain the data is 598 nm. [3]

(ii) Show that the radius of orbit of the star is approximately 1.6×10^9 m. [3]

(iii) The mass of the star is 1.6×10^{29} kg. Assuming this is far greater than the mass of the planet, calculate the mass of the planet. [5]

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(c) Astronomers describe the planet as:

"A gas giant similar to Saturn, with the same density as Saturn but 8 times the mass."

Determine the ratio:

$$\frac{(g \text{ at surface of planet})}{(g \text{ at surface of Saturn})}$$

[4]

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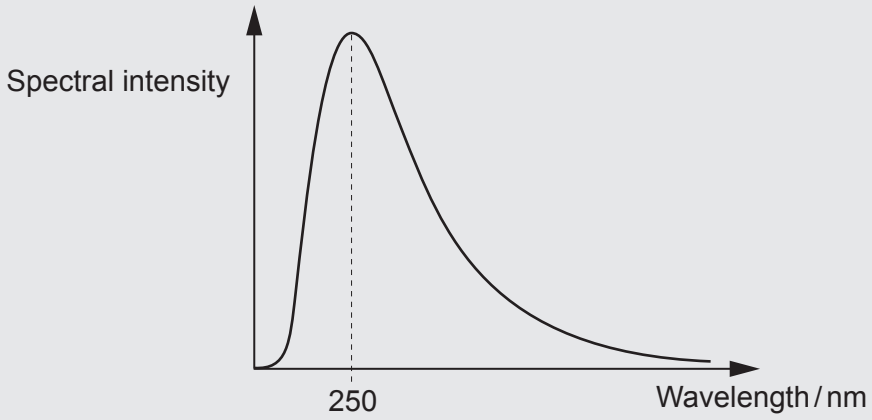
8. (a) A textbook gives the following data about a star.

- Intensity of radiation from the star at Earth = 1.37×10^{-15} W m^{-2}
- Distance of the star from Earth = 1.82×10^{21} m
- Surface area of the star = 5.54×10^{19} m^2
- A simplified **black body** spectrum for the star is shown below:



(i) Explain what is meant by the term 'black body'. [1]

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(ii) Determine whether the information given in the first three bullet points is consistent with the wavelength at peak intensity shown by the graph. [4]

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(b) (i) State what is meant by the term 'multiwavelength astronomy'. [1]

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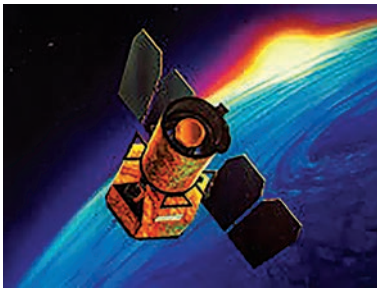
(ii) Information about three different telescopes used to study objects in space is given below.

Herschel Telescope	Galaxy Evolution Explorer (GALEX)	Chandra
		
Herschel is a 3.5 m diameter telescope operating at mid-infrared, far-infrared, and sub-mm wavelengths.	The Galaxy Evolution Explorer (GALEX) is an orbiting space telescope observing galaxies in ultraviolet light across 10 billion years of cosmic history.	NASA's Chandra X-ray Observatory is designed to observe high resolution X-ray images from high-energy regions of the universe.

Suggest which of the telescopes would be the most appropriate to use to study the star in part (a). Explain your answer. [2]

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END OF PAPER

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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