

- 9 (a) State what is meant by the mass defect of a nucleus.
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- [2]
- (b) The nuclear fusion reaction for the formation of helium-4 from deuterium is represented by

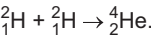


Table 9.1 shows the masses of the nuclides involved in this reaction.

Table 9.1

nuclide	nuclide mass/u
${}^2_1\text{H}$	2.013 553
${}^4_2\text{He}$	4.001 505

Calculate the energy released in the formation of 1.00 mol of helium-4.

energy = J [4]

- (c) The star Sirius has a radius of $1.19 \times 10^9\text{ m}$ and loses mass due to nuclear fusion at a rate of $1.09 \times 10^{11}\text{ kg s}^{-1}$. Assume that the power of the radiation emitted by the star is equal to the power released by this process.
- (i) Determine a value for the luminosity of Sirius. Give a unit with your answer.

luminosity = unit [2]

- (ii) Use your answer in (c)(i) to determine the surface temperature of Sirius.

surface temperature = K [2]

- (d) Explain how cosmologists use standard candles to estimate the distance of a galaxy from the Earth.
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- [3]

[Total: 13]

2 A student investigates the relationship between the luminosity of a star and its mass.

The student obtains data of relative luminosity λ and relative mass μ for six stars, where

$$\lambda = \frac{\text{luminosity of star}}{\text{luminosity of Sun}}$$

and

$$\mu = \frac{\text{mass of star}}{\text{mass of Sun}}.$$

It is suggested that λ and μ are related by the equation

$$\lambda = k\mu^n$$

where k and n are constants.

(a) A graph is plotted of $\lg \lambda$ on the y -axis against $\lg \mu$ on the x -axis.

Determine expressions for the gradient and y -intercept.

gradient =

y -intercept =

[1]

(b) Values of μ and λ are given in Table 2.1.

Table 2.1

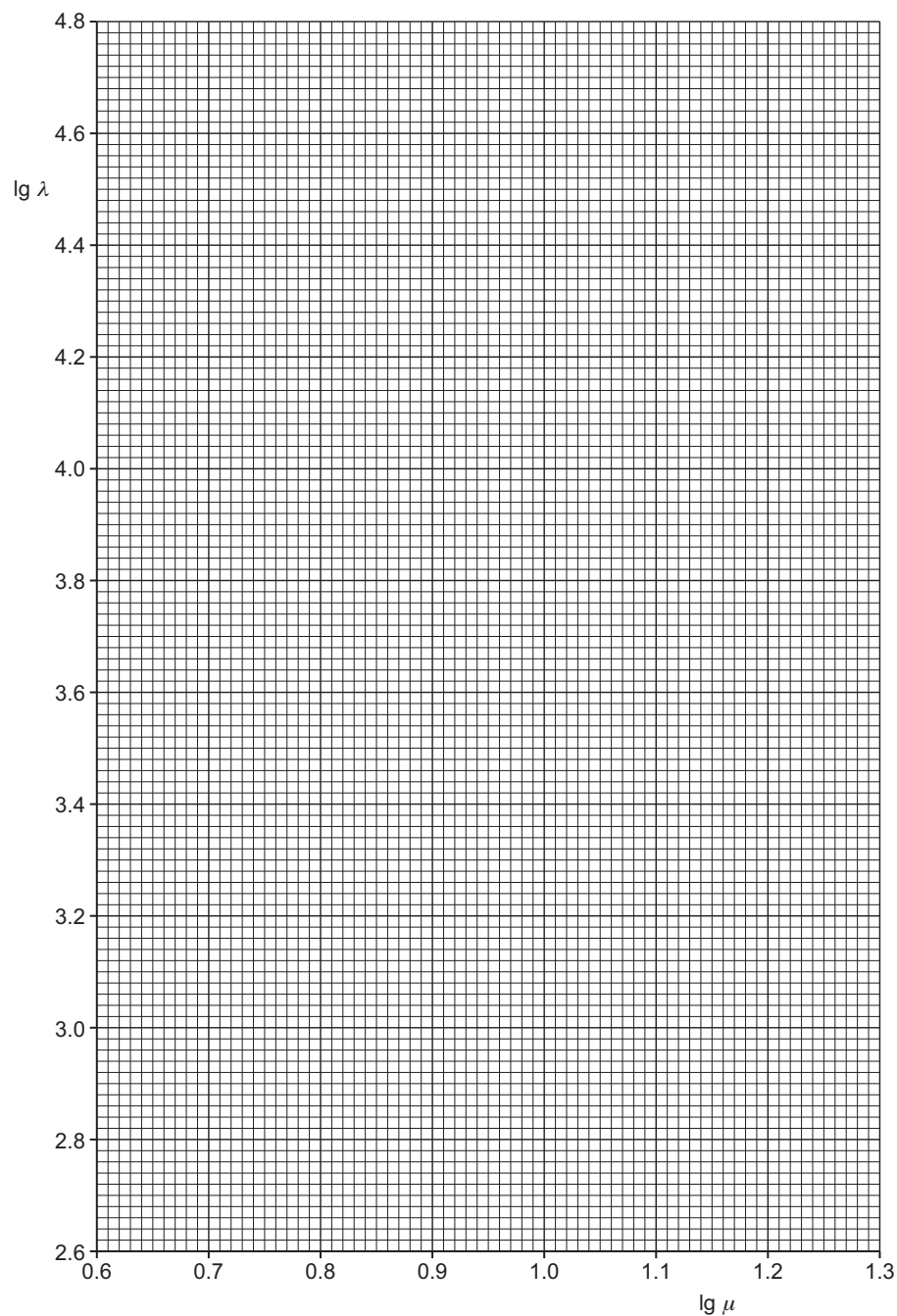
μ	λ	$\lg \mu$	$\lg \lambda$
4.6 ± 0.4	500		
5.4 ± 0.4	800		
8.4 ± 0.4	3200		
11 ± 1	7000		
16 ± 1	25 000		
18 ± 1	38 000		

Calculate and record values of $\lg \mu$ and $\lg \lambda$ in Table 2.1.
Include the absolute uncertainties in $\lg \mu$.

[2]

- (c) (i) Plot a graph of $\lg \lambda$ against $\lg \mu$.
Include error bars for $\lg \mu$. [2]
- (ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Label both lines. [2]
- (iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

gradient = [2]



- (iv) Determine the y -intercept of the line of best fit. Include the absolute uncertainty in your answer.

y -intercept = [2]

- (d) Using your answers to (a), (c)(iii) and (c)(iv), determine the values of k and n . Include the absolute uncertainties in your values. You need not be concerned with units.

k =

n = [3]

- (e) The mass of the Sun is 2.0×10^{30} kg. The star Alpha Centauri B has a value of λ of 0.46.

Determine the mass M of Alpha Centauri B.

M = kg [1]

[Total: 15]