3 When a force F is applied to a spring with stiffness k, the elastic potential energy stored is E.

What is the elastic potential energy stored when a force $2F$ is applied to a spring with stiffness $2k$?

☒ **A** $\frac{E}{2}$

☒ **B** E

☒ **C** $2E$

☒ **D** $8E$

(Total for Question 3 = 1 mark)

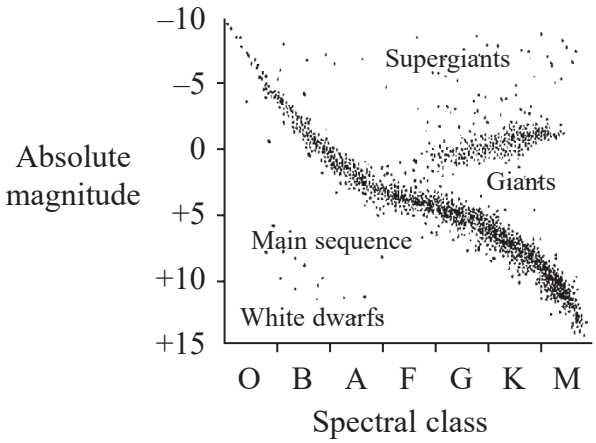
4 There are several different methods that can be used to determine the distance from our solar system to astronomical objects. These include the measurement of red shift, trigonometrical parallax and the use of standard candles.

Which row of the table shows a suitable method for each of the objects named?

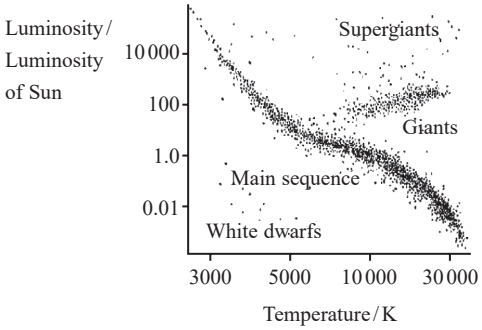
	Nearby star	Nearby galaxy	Very distant galaxy
☒ **A**	parallax	red shift	standard candle
☒ **B**	red shift	standard candle	parallax
☒ **C**	parallax	standard candle	red shift
☒ **D**	red shift	parallax	standard candle

(Total for Question 4 = 1 mark)

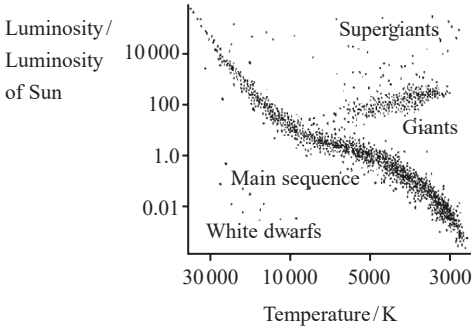
9 A student finds a Hertzsprung-Russell diagram in an old astronomy book and notices that the axes aren't the same as in her current textbook.



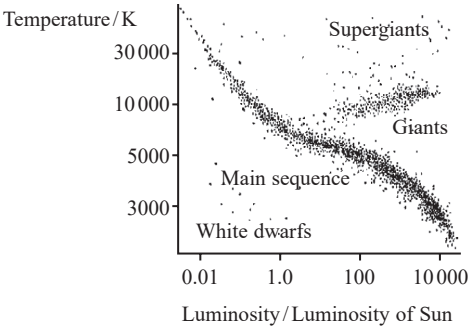
Which of the following graphs shows a correct alternative way to label the axes?



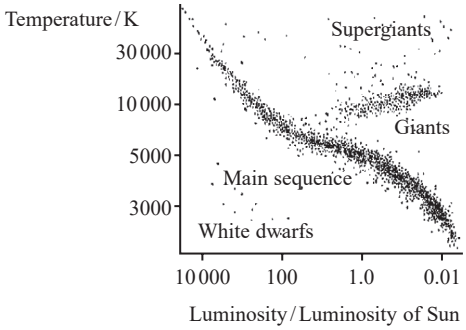
A



B



C

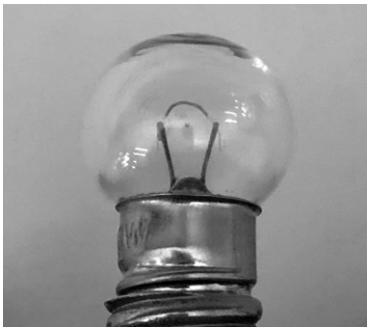


D

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 9 = 1 mark)

14 The photograph shows a filament bulb.



The filament is an emitter with 35% of the power output of a black body radiator of the same temperature.

(a) When a potential difference (p.d) of 2.0 V is applied across the bulb, there is a current of 0.37 A in the filament.

Calculate the temperature of the filament.

surface area of filament = $3.9 \times 10^{-6}\,m^2$

(3)

Temperature = ...

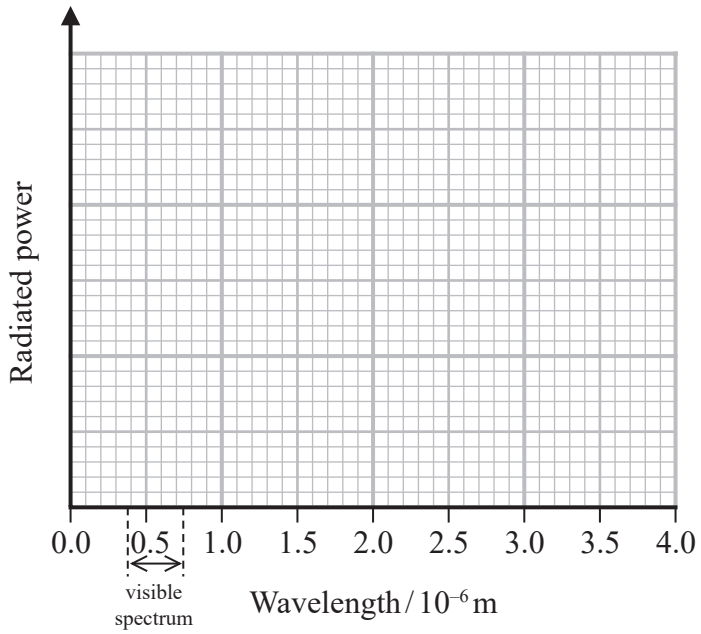
(b) In an experiment to investigate the efficiency of a filament light bulb a p.d. was applied. The p.d. and current were measured and the light bulb was observed. The p.d. was then increased and new measurements taken.

When a small p.d. is applied to the bulb, no light is visible. If the p.d. is gradually increased, the filament starts to glow and eventually appears white.

(i) Add to the graph to show the distribution of radiation from a black body at a temperature of 2026 K.

Your answer should include a calculation.

(5)



(ii) Use your graph to explain why filament light bulbs are considered inefficient.

(2)

(Total for Question 14 = 10 marks)

***13** The energy radiated by stars is released by nuclear fusion.

Explain the conditions required to bring about and maintain nuclear fusion in stars.

(Total for Question 13 = 6 marks)

15 One of the largest stars in our galaxy is VY Canis Majoris. This star's radius is 1420 times the radius of the Sun. The luminosity of this star is 270 000 times the luminosity of the Sun.

A student states that the surface temperature of VY Canis Majoris must be much greater than the surface temperature of the Sun.

(a) Determine whether the student's statement is correct.

surface temperature of Sun = 5780 K
luminosity of Sun = 3.85×10^{26} W
radius of Sun = 6.96×10^{8} m

(3)

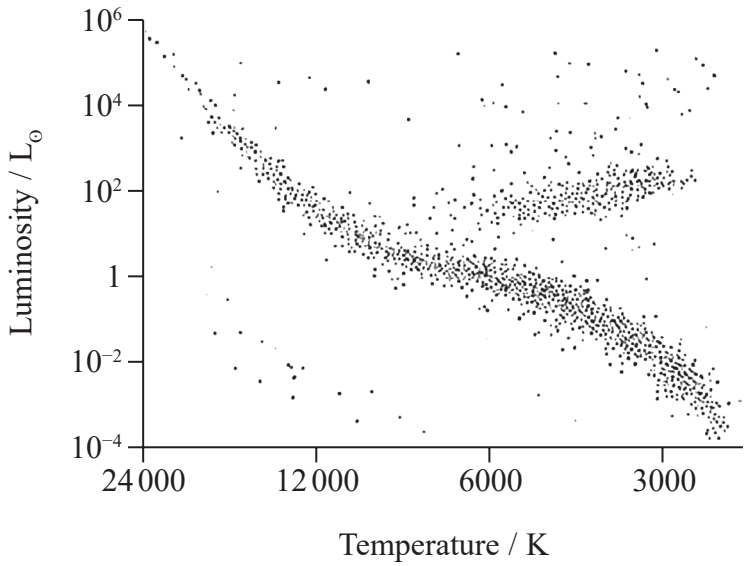
(b) Calculate the wavelength with maximum intensity in the black body radiation spectrum of VY Canis Majoris.

(2)

Wavelength = ...

(c) Add the position of VY Canis Majoris to the Hertzsprung Russell diagram to determine which type of star it is.

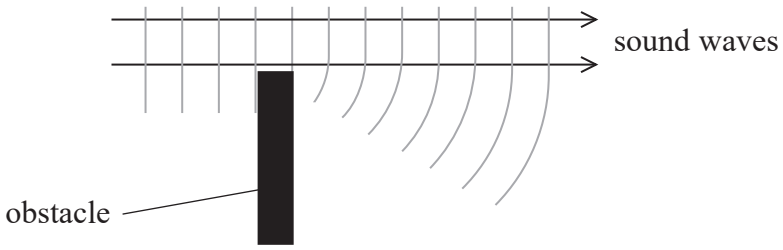
(2)



Type of star .....

(Total for Question 15 = 7 marks)

3 Sound waves can diffract around obstacles as shown in the diagram.



The diffraction effect is

- ☒ **A** greater for large amplitude sound waves.
- ☒ **B** greater for low frequency sound waves.
- ☒ **C** independent of the frequency of the sound waves.
- ☒ **D** independent of the speed of the sound waves.

(Total for Question 3 = 1 mark)

4 Which of the following is a valid unit for luminosity?

- ☒ **A** $\mathrm{W\,m^{-2}}$
- ☒ **B** $\mathrm{N\,m\,s^{-2}}$
- ☒ **C** $\mathrm{J\,s^{-1}}$
- ☒ **D** $\mathrm{J\,m^{-2}}$

(Total for Question 4 = 1 mark)

5 Betelgeuse is a red giant star.

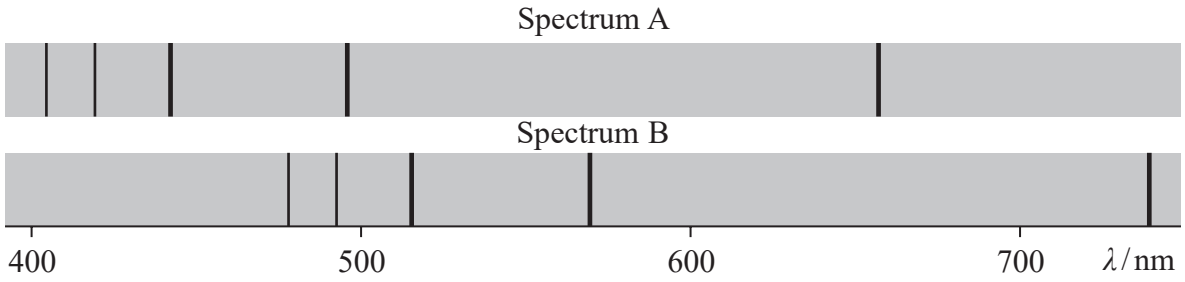
The surface temperature of Betelgeuse is T_B and the surface area of Betelgeuse is A_B.
The surface temperature of the Sun is T_S and the surface area of the Sun is A_S.

Which row in the table shows a correct comparison of the surface temperature and surface area of Betelgeuse with those of the Sun?

	$T_B > T_S$	$A_B > A_S$
☒ **A**	false	false
☒ **B**	false	true
☒ **C**	true	false
☒ **D**	true	true

(Total for Question 5 = 1 mark)

14 The diagram shows the spectra produced by two stars. Spectrum A is produced from the light from the Sun and spectrum B is produced from the light from a distant star.



The dark lines are produced when light from the core of the star is absorbed by hydrogen atoms in the outer regions of the star. Light is then re-radiated, but in all directions, giving rise to the dark lines in the spectrum.

(a) Explain why the long wavelength lines are shifted by a greater amount than the short wavelength lines.

(2)

(b) One of the lines in the hydrogen spectrum occurs at a wavelength of 656 nm in the laboratory.

Explain what conclusion can be made from the shift in wavelength of this line in spectrum B. Your answer should include a calculation.

(4)

(Total for Question 14 = 6 marks)