## Practice questions

1 a (i) Describe the formation of a star such as our Sun and its most probable evolution. *(6 marks)*

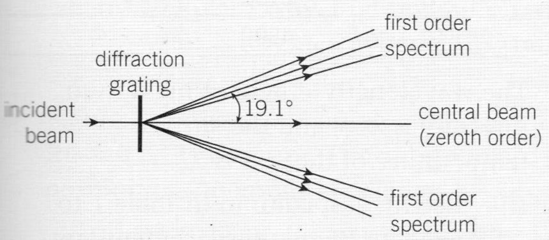
(ii) Describe the probable evolution of a star that is much more massive than our Sun. *(2 marks)*

b The present mass of the Sun is $2.0 \times 10^{30}$ kg. The Sun emits radiation at an average rate of $3.8 \times 10^{26}\,\mathrm{J\,s^{-1}}$. Calculate the time in years for the mass of the Sun to decrease by one millionth of its present mass.
$1\,\mathrm{y} = 3.2 \times 10^{7}\,\mathrm{s}$ *(3 marks)*

*Jan 2011 G485*

2 This question is about the light from low energy compact fluorescent lamps which are replacing filament lamps in the home.

a The light from a compact fluorescent lamp is analysed by passing it through a diffraction grating. Figure 1 shows the angular positions of the three major lines in the first order spectrum and the bright central beam.




▲ Figure 1

(i) On a copy of Figure 1 label one set of the lines in the first order spectrum **R**, **G** and **V** to indicate which is red, green and violet. *(1 mark)*

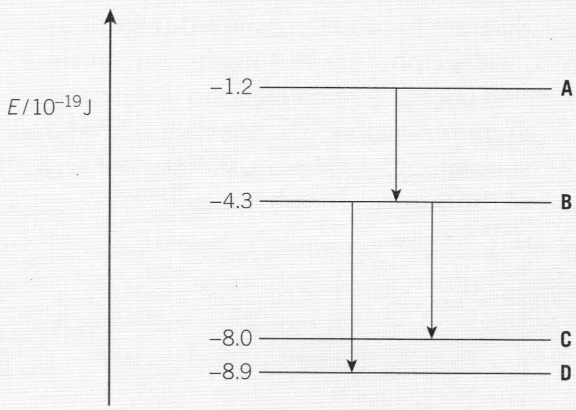
(ii) Explain why the bright central beam appears white. *(1 mark)*

(iii) The line separation *d* on the grating is $1.67 \times 10^{-6}$ m.

Calculate the wavelength $\lambda$ of the light producing the first order line at an angle of 19.1° to the central bright beam. *(3 marks)*

b The wavelength of the violet light is 436 nm. Calculate the energy of a photon of this wavelength. *(3 marks)*

c The energy level diagram of Figure 2 is for the atoms emitting light in the lamp. The three electron transitions between the four levels **A**, **B**, **C**, and **D** shown produce the photons of red, green, and violet light. The energy *E* of an electron bound to an atom is negative. The ionisation level, not shown on the diagram, defines the zero of the vertical energy scale.




▲ Figure 2

Label the arrows on a copy of Figure 2 **R**, **G**, and **V** to indicate which results in the red, green, and violet photons.

*(2 marks)*

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3 a When a glowing gas discharge tube is viewed through a diffraction grating an emission line spectrum is observed.

(i) Explain what is meant by a *line spectrum*. *(2 marks)*

(ii) Describe how an absorption line spectrum differs from an emission line spectrum. *(1 mark)* b A fluorescent tube used for commercial lighting contains excited mercury atoms. Two bright lines in the visible spectrum of mercury are at wavelength 436 nm and 546 nm.

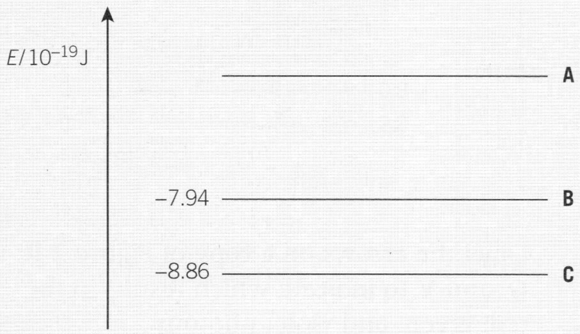
$1\,\text{nm} = 10^{-9}\,\text{m}$

Calculate

(i) the energy of a photon of violet light of wavelength 436 nm *(3 marks)*

(ii) the energy of a photon of green light of wavelength 546 nm. *(1 mark)*

c Electron transitions between the three levels **A**, **B** and **C** in the energy level diagram for a mercury atom (Figure 3) produce photons at 436 nm and 546 nm. The energy *E* of an electron bound to an atom is negative. The ionisation level, not shown on the diagram, defines the zero of the vertical energy scale.




▲ Figure 3

(i) Draw two arrows on a copy of Figure 3 to represent the transitions which give rise to these photons. Label each arrow with its emitted photon wavelength. *(3 marks)*

(ii) Use your values for the energy of the photons from (b) to calculate the value of the energy level **A**. *(2 marks)*

d The light from a distant fluorescent tube is viewed through a diffraction grating aligned so that the tube and the lines on the grating are parallel. The light from the tube is incident as a parallel beam at right angles to the diffraction grating.

The line separation on the grating is $3.3 \times 10^{-6}$ m.

Calculate the angle to the straight through direction of the first order green (546 nm) image of the tube seen through the grating. *(3 marks)*

*Jun 2010 G482*

4 a State *Wien's displacement law.* *(1 mark)*

b An astronomer is analysing light from stars in a particular cluster. Table 1 summarises some of the key data for five stars in this cluster.

▼ Table 1

| $\lambda_{max}$ / nm | $T$ / K | |
|---|---|---|
| 405 | 7200 | |
| 424 | 6800 | |
| 480 | 6000 | |
| 570 | 5100 | |
| 644 | 4500 | |

The wavelength of light at maximum intensity is $\lambda_{max}$ and the surface temperature of the star is $T$.

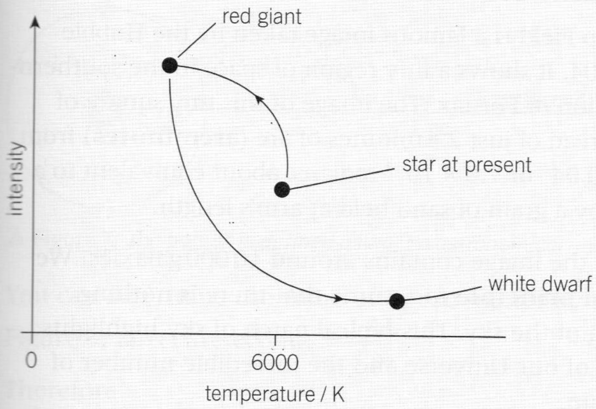
(i) Use the last column in Table 1 to validate Wien's displacement law. *(3 marks)*

(ii) Hence determine the surface temperature of a white dwarf for which $\lambda_{max}$ is 138 nm. *(3 marks)*

c The luminosity of the white dwarf in (b)(ii) is $1.0 \times 10^{25}$ W. Determine its radius. *(3 marks)*

**5** **a** Describe briefly the sequence of events which occur in the formation of a star, such as our Sun, from interstellar dust and gas clouds. *(4 marks)*

**b** Figure 4 shows the evolution of a star similar to our Sun on a graph of intensity of emitted radiation against temperature.

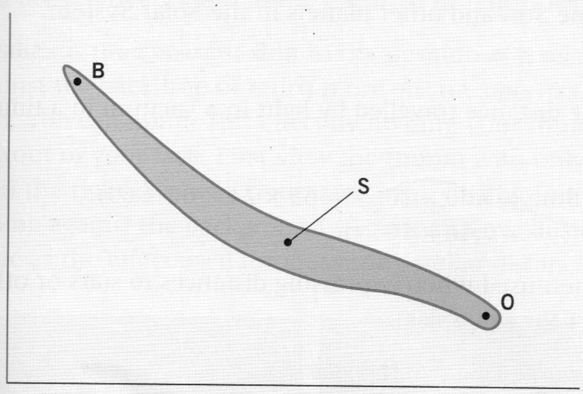



▲ Figure 4

(i) The final evolutionary stage of the star is a white dwarf. Describe some of the characteristics of a white dwarf. *(2 marks)*

(ii) Explain why, in its evolution, the star is brightest when at its coolest. *(2 marks)*

**6** Figure 5 shows an incomplete Hertzsprung-Russell (HR) diagram. The approximate position of the Sun is labelled as **S**.




▲ Figure 5

**a** On a copy of Figure 5

(i) name the region of stars which is shaded *(1 mark)*

(ii) carefully label the axes *(2 marks)*

(iii) mark the regions occupied by red giants and white dwarfs. *(2 marks)*

**b** Describe the evolution of a star that is much more massive than our Sun. *(5 marks)*

**c** **B** and **O** show positions of two stars. Explain which star is likely to live longer. *(3 marks)*

**7** **a** (i) Define the luminosity of a star. *(1 mark)*

(ii) An astronomer has made measurements on a distant star in our galaxy. The star has a surface temperature of (6000 ± 200 K and a radius of $(8.3 \pm 0.2) \times 10^7$ m. Calculate the luminosity of the star and the absolute uncertainty in this value. *(4 marks)*

**b** Show how the luminosity $L$ of a star is related to its intensity at a distance $r$ from the star. *(2 marks)*

**c** Wien's law related the peak wavelength $\lambda$ of electromagnetic waves emitted from a star and its surface temperature $T$ in kelvin. Figure 6 shows a graph of $\lg(\lambda / \text{m})$ against $\lg(T/K)$.


▲ Figure 7

(i) Explain why the graph has a gradient of −1. *(2 marks)*

(ii) Use Figure 6 to calculate the surface temperature of a star with λ = 480 nm. *(3 marks)*