



A-Level Physics

Classification of Ions

Question Paper

Time available: 70 minutes

Marks available: 48 marks

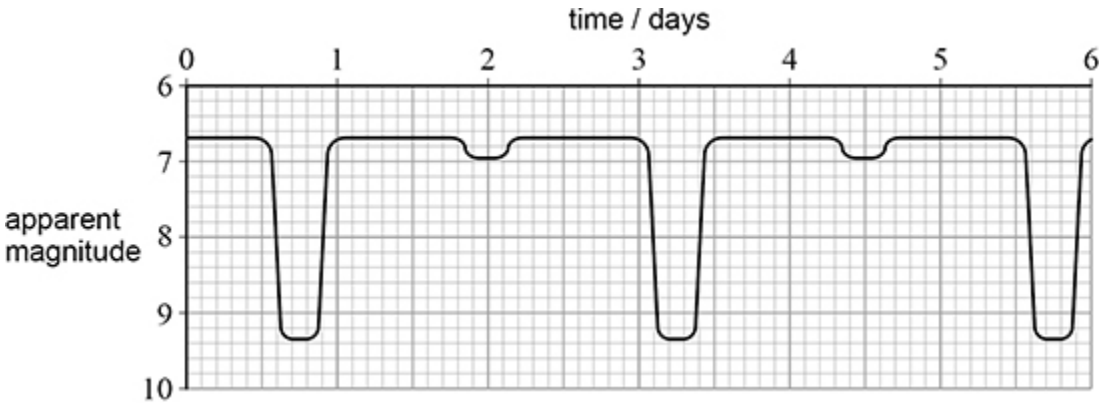
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1.

U Cephei is an eclipsing binary system consisting of two stars that orbit their common centre of mass.

The primary star is class B; the secondary star is class G.

The figure below shows the variation of apparent magnitude of U Cephei with time as observed from Earth.



(a) Explain the shape of the graph in the figure above.

(2)

A particular spectral line has a wavelength of 486.136 nm when measured from a source in the laboratory.

This line is also present in the absorption spectrum of the primary star of U Cephei. When observed from Earth, the wavelength of the primary star's absorption line varies as shown in the table below.

	Wavelength / nm
maximum value	486.498
minimum value	485.672

(d) State why the average of the values in above table is different from the laboratory value.

(1)

(c) Show that the orbital speed of the primary star is about 250 km s^{-1} .

(3)

(d) Calculate the orbital radius of the primary star.

orbital radius = _____ m

(2)

(e) Which absorption lines would be most prominent in the spectrum of the primary star?

Tick (✓) **one** box.

hydrogen

hydrogen and helium

ionised metals

neutral metals

(1)

- (f) A different eclipsing binary star system is thought to consist of a white dwarf star and a neutron star.

Discuss how astronomers could confirm this.

(2)
(Total 11 marks)

2.

3C 273 was the first quasar to be discovered.

IC 1101 is one of the largest galaxies known.

The table below shows some information about these objects.

	Absolute magnitude	Apparent magnitude	Distance / Mpc
quasar 3C 273	X	12.8	760
galaxy IC 1101	-22.8	14.7	320

- (a) State the property of the quasar that led to its discovery.

(1)

- (b) Show that the absolute magnitude X of quasar 3C 273 is about -27

- (c) Assume that the quasar and the galaxy are both viewed from the same distance.

Explain which would be the brighter object.

Go on to calculate the ratio $\frac{\text{brightness of brighter object}}{\text{brightness of dimmer object}}$.

ratio = _____

(3)

- (d) The black hole at the centre of IC 1101 has a mass of $7.1 \times 10^{11} M_{\odot}$ where M_{\odot} is the mass of the Sun.

Calculate the average density within the event horizon of the black hole.

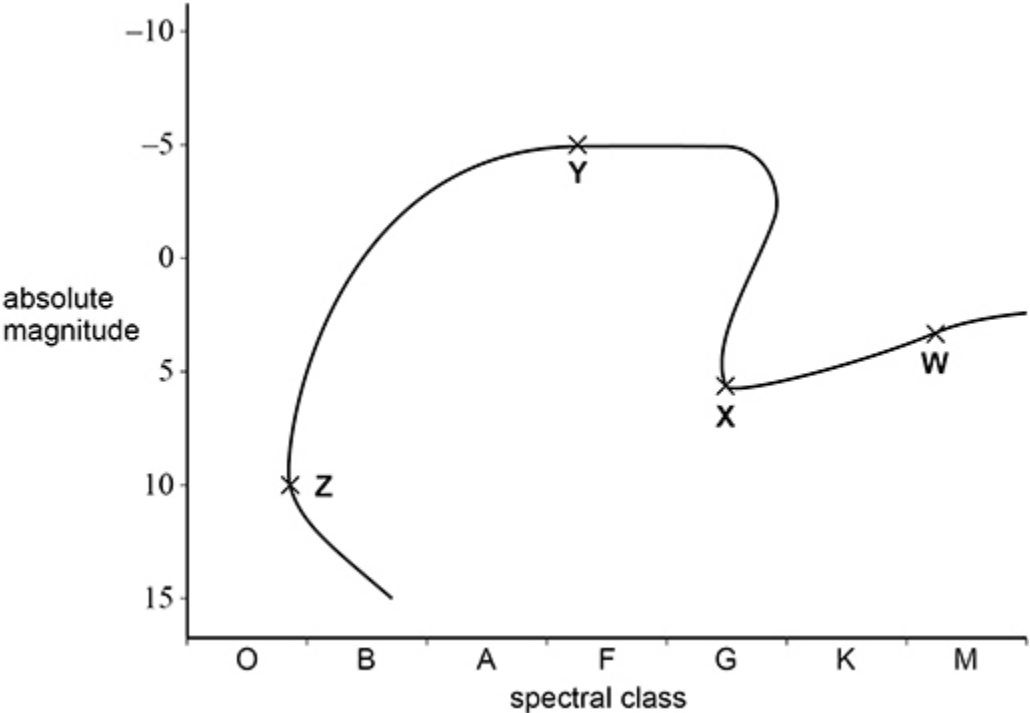
average density = _____ kg m^{-3}

(3)

(Total 9 marks)

3.

The figure below shows the evolution of a star similar to the Sun on a Hertzsprung-Russell (HR) diagram.



(a) State the evolutionary stage of the star at each of the points W, X, Y and Z.

- W _____
- X _____
- Y _____
- Z _____

(3)

Theta Carinae is a star with a radius five times that of the Sun. It has a surface temperature of 31 000 K.

(b) Annotate the figure above with a T to show the position of Theta Carinae.

(1)

An astronomer suggests that an Earth-sized planet orbits Theta Carinae.

(c) Explain **one** difficulty with using the transit method to detect this planet.

(2)

(d) The astronomer suggests that the Earth-sized planet receives a similar amount of power from Theta Carinae as the Earth does from the Sun.

The average power output of the Sun is 3.8×10^{26} W.

Determine the orbital radius of the Earth-sized planet orbiting Theta Carinae.

orbital radius = _____ m

(5)

(Total 11 marks)

4.

The table summarises some information about four stars in the constellation Cassiopeia.

Name	Colour	Apparent magnitude	Distance / ly
Caph	white	2.3	55
Ruchbah	blue/white	2.7	99
Schedar	orange	2.2	228
Tsih	blue	2.2	610

- (a) Which star has the highest surface temperature?
Tick (✓) **one** box.

Caph

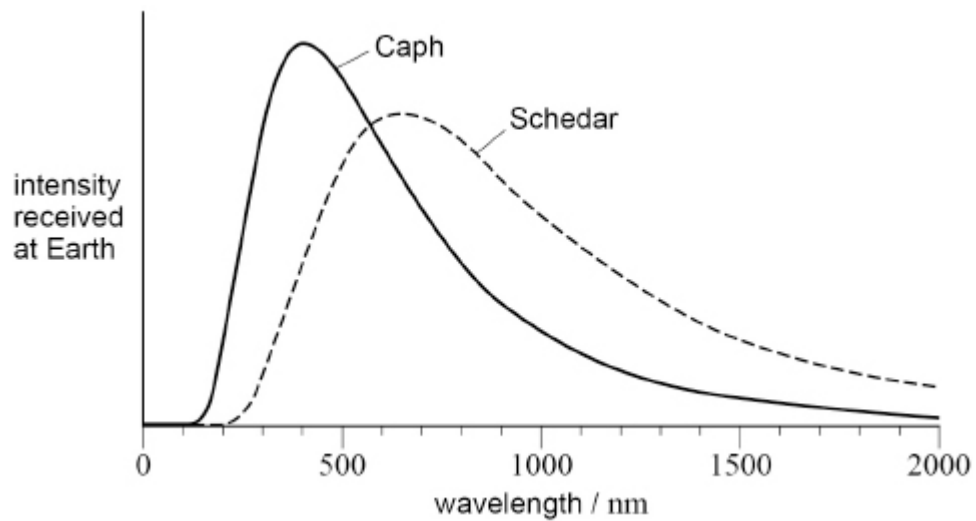
Ruchbah

Schedar

Tsih

(1)

- (b) The graph below shows the intensity received at Earth from two of the stars, plotted against wavelength.
The effect of absorption by the Earth's atmosphere is not shown.



Discuss what information can be found from the graph about the temperature and colour of these stars.

Support your answer with suitable calculations.

(4)

(c) State which star in the table above is dimmest on the absolute magnitude scale.

(1)

(d) Calculate the absolute magnitude of Schedar.

absolute magnitude = _____

(3)

- (e) Tsih has a mass over 15 times the mass of the Sun.
Tsih may eventually collapse to form a black hole.

Calculate the radius of the event horizon for a black hole with a mass 15 times that of the Sun.

radius = _____ m

(2)

(Total 11 marks)

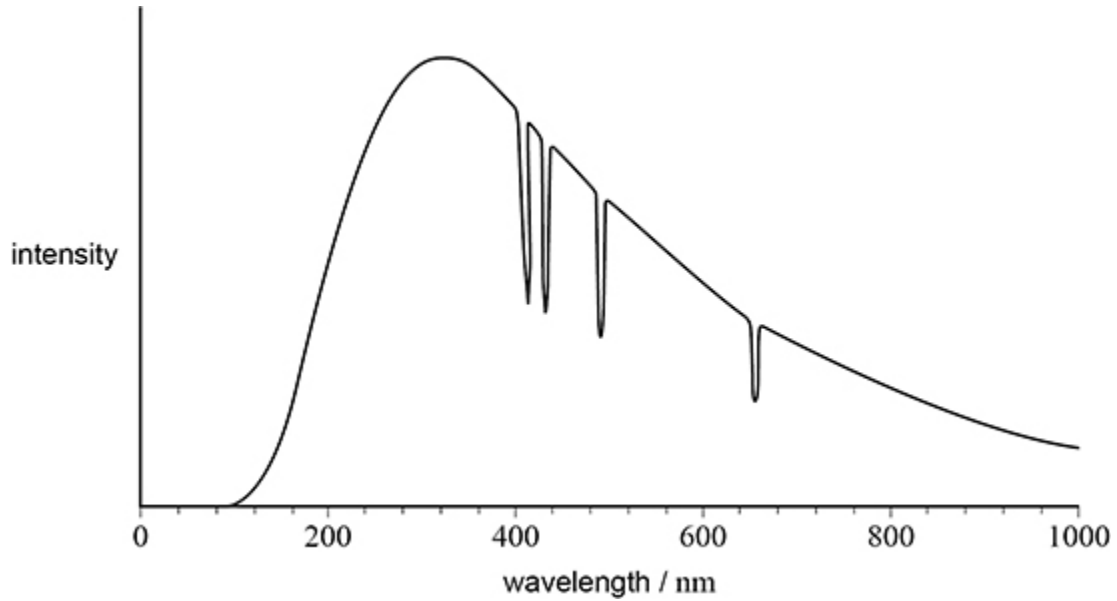
5.

Miaplacidus and Avior are two stars in the constellation Carina.

Miaplacidus is a class A star.

Avior is a class K star.

The figure below shows how the intensity of radiation arriving at the Earth varies with wavelength for **one** of these stars. Only the important features of the variation are shown.



Deduce, with reference to the figure, the identity of the star.

In your answer you should:

- explain the overall shape of the graph
- describe the processes in the star that lead to the decreases in intensity
- state the identity of the star.

(Total 6 marks)