A2 Level Physics

Chapter 12 – Space

12.1.2 Stars and Hertzsprung-Russell diagram

Worked Examples

Stars

Exam Style Question 1

When a star ceases to be Main Sequence, it may evolve in several different ways. Explain the circumstances which will lead to the formation of a neutron star.

Stars

Exam Style Question 1

Explain the circumstances which will lead to the formation of a neutron star.

When a star of mass greater than the Sun reaches the end of its red giant phase, it continues to increase its surface area and eventually becomes a red super giant.

When the core collapses, its mass is greater than 1.4 solar masses. Further nuclear fusion reactions occur in its collapsing core, raising the temperature to billions of Kelvin. This is because the gravitational pressures are enormous and overcome the Fermi pressure. During this stage the immense pressure causes protons to absorb electrons and become neutrons.

The final collapse produces intense heating, where the outer shell surrounding the neutron core rapidly collapses and rebound against the solid neutron core. This generates a shock wave, which explodes the surface layers of the star as a supernova.

Under certain conditions the nucleus of a supernova explosion remains intact, forming a neutron star of incredibly high density.

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Stars

Exam Style Question 2

Explain what is meant by a white dwarf when describing the evolution of a star.

Stars

Exam Style Question 2

Explain what is meant by a white dwarf when describing the evolution of a star.

A core/star left behind after a red giant has shed its outer layers.

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Stars

Exam Style Question 3

a) A star radiates energy produced from fusion reactions within its core. Explain what is meant by fusion and explain the conditions necessary for fusion to occur in the core of a star.

b) Describe and explain the evolution of a star much more massive than our Sun.

Stars

Exam Style Question 3

(a) Explain what is meant by fusion and explain the conditions necessary for fusion to occur in the core of a star.

Fusion is the joining of lighter nuclei to make heavier nuclei.

Fusion can occur when you have a:
1) High temperature ($\sim 10^7\ K$)
2) High pressure required in the core.

The high temperature and pressure is needed because the protons (or nuclei) repel each other because of their positive charge so with a high temperature and high pressure they come close enough for strong nuclear forces to come into play and they can combine.

(b) Describe and explain the evolution of a star much more massive than our Sun.

When hydrogen/helium runs out the outer layers of the star expands and a super red giant is formed.

The core of the star collapses rapidly and a supernova is formed. Depending on the initial mass of the star the remnant is either a neutron star or a black hole.

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Stars

Exam Style Question 4

(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.

(b) Fig. 8.1 shows the evolution of a star similar to our Sun on a graph of intensity of emitted radiation against temperature.

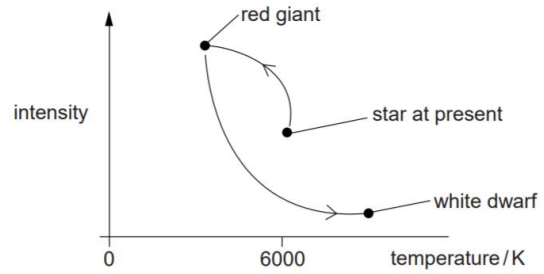

Fig. 8.1

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

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

Stars

Exam Style Question 4

(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.

- Interstellar dust and gas cloud is drawn together by gravitational force/gravity.
- There is a loss in PE and increase in KE, and an increase in temperature.
- Fusion of protons/hydrogen nuclei occur.
- Energy is released in fusion reactions.
- A stable star is formed when gravitational pressure is equal to radiation (or internal) pressure.

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

- Extremely dense and low luminosity
- No fusion reactions occur
- It is a remnant of a low-mass star

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

It is a Red giant therefore it is cooler but has a large surface area and therefore radiates large amounts of energy.

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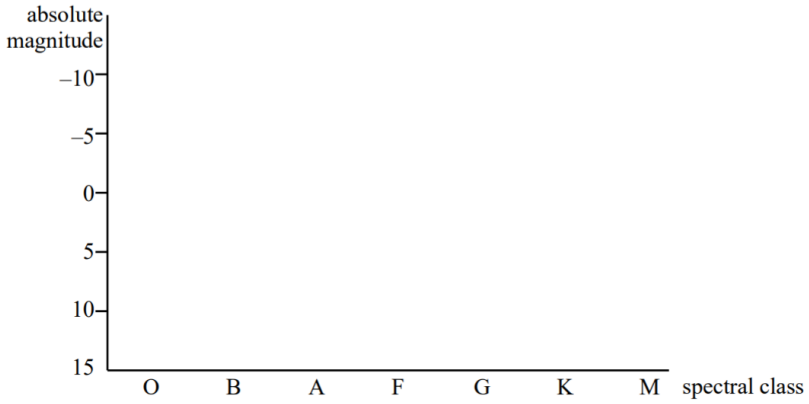
Stars

Exam Style Question 5

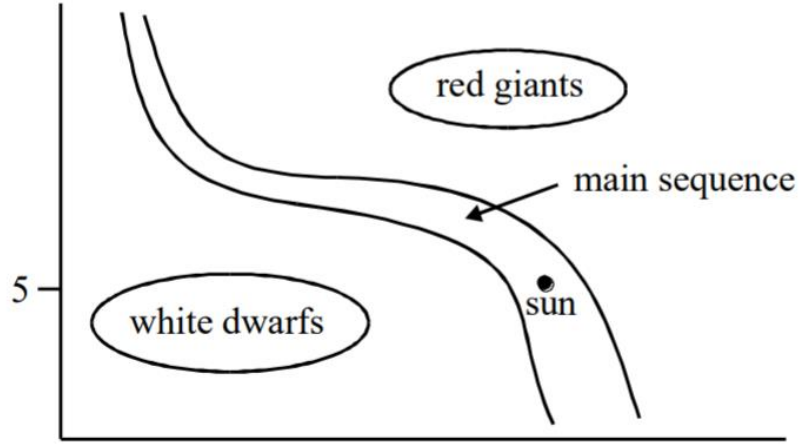
(a) Use the axes to draw a labelled Hertzspung-Russell diagram which shows the regions of the Main Sequence stars, White Dwarfs and Red Giants. Label the approximate position of the Sun.



Stars

Exam Style Question 5

(a) Use the axes to draw a labelled Hertzspung-Russell diagram which shows the regions of the Main Sequence stars, White Dwarfs and Red Giants. Label the approximate position of the Sun.



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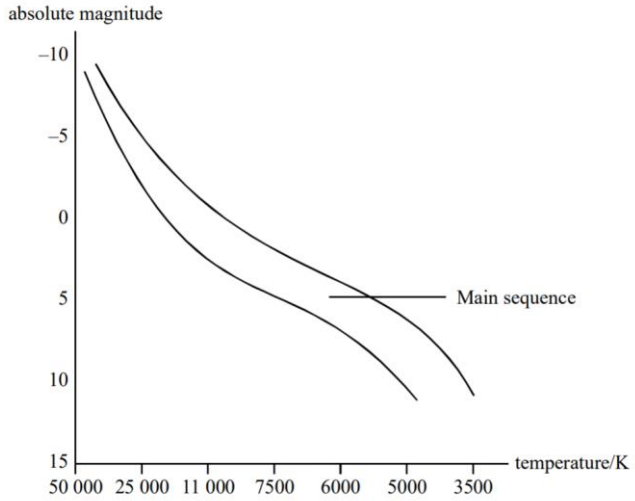
Stars

Exam Style Question 6

A Hertzsprung-Russell diagram for Main Sequence stars is shown below.



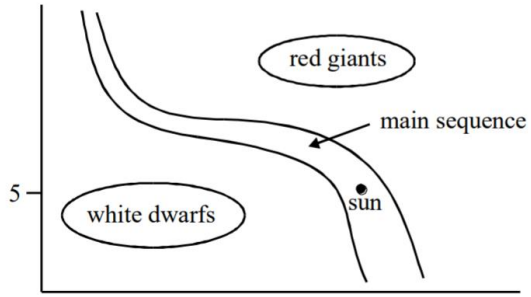
(a) (i) Label on the diagram the regions occupied by White Dwarfs and Red Giants.

(ii) Use the diagram to explain why Red Giant stars must be very much larger than White Dwarfs.

Stars

Exam Style Question 6

(a)(i) Label on the diagram the regions occupied by White Dwarfs and Red Giants.



(ii) Use the diagram to explain why Red Giant stars must be very much larger than White Dwarfs.

Red Giants are colder than White Dwarfs however Red Giants have a lower absolute magnitude compared to white dwarfs therefore Red Giants are brighter. This must mean Red Giants must have a larger surface area for it to be colder but brighter.

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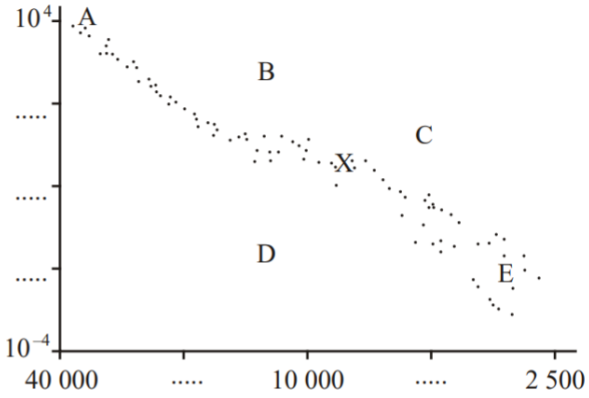
Stars

Exam Style Question 7

On the Hertzsprung-Russell diagram shown below X indicates the position of the Sun.



(i) Add labels and units to each axis.

(ii) Complete the scale on the y-axis by adding three further values where indicated.

(iii) Complete the scale on the x-axis by adding two further values where indicated.

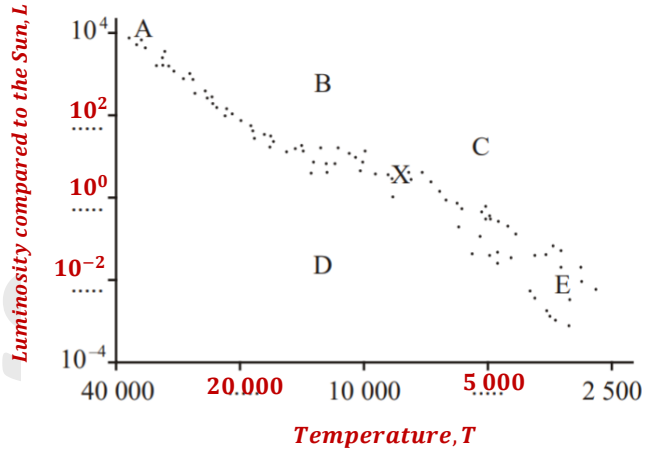
(iv) Letters A, B, C, D and E represent different stars. Identify all stars which could be:

a red giant	
a low mass star on the main sequence	

Stars

Exam Style Question 7

(i) Add labels and units to each axis.
(ii) Complete the scale on the y-axis by adding three further values where indicated.
(iii) Complete the scale on the x-axis by adding two further values where indicated.



(iv) Letters A, B, C, D and E represent different stars. Identify all stars which could be:

a red giant	B and C
a low mass star on the main sequence	E

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Please see ’12.1.1 Stars and Hertzsprung-Russell diagram notes’ pack for revision notes.

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