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OCR

A Level

A Level Physics

Astrophysics 1

Name:

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Total Marks: /30

1. Amongst all that you see in the night sky, there exist a variety of stars. Yet, it is thought that all stars originate from clouds of dust and gas. Understanding how stars are formed and how they evolve is an important aspect of our understanding of the universe.

Total for Question 1: 12

(a) A protostar is an extremely hot, dense sphere of dust and gas. Why don't all protostars evolve to form stars? [2]

(b) The majority of most stars' lives are spent in the main sequence phase. During this time they are stable and maintain an approximately constant size. Therefore, since gravitational forces act to compress the star, other forces must resist this compression. What are they and what is responsible for them? [2]

(c) Electron degeneracy pressure prevents the gravitational collapse of white dwarfs if their masses are less than the Chandrasekhar limit.

i. What is the origin of the electron degeneracy pressure? [2]

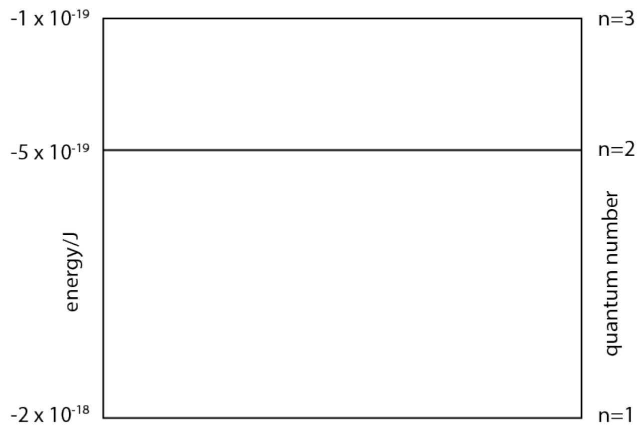
ii. Briefly describe the possible fates of stars whose masses exceed the limit. [2]

(d) A Hertzsprung-Russell diagram is a graph showing the relationship between stellar luminosity and temperature.

i. Explain why, when a red giant becomes a white dwarf, it moves towards the lower left of the diagram. [2]

ii. Black holes are not usually plotted on Hertzsprung-Russell diagrams. Explain why this is the case. [2]

2. The sketch below shows the first three electron energy levels in an isolated gas atom. These have been annotated with their energies and their quantum numbers. Total for Question 2: 8



(a) An electron is excited to the n=3 energy level. What was the frequency of the photon it absorbed? [2]

(b) The excited electron later de-excites. Rather than falling down to the ground state, it comes to an intermediate halt in the n=1 level. Explain, quantitatively where appropriate, what happens. State the frequency of any new particles created. [3]

(c) Compare and contrast *emission, absorption* and *continuous* line spectra. [3]

3. The Sirius system is the brightest star system visible in the night sky. Sirius B is a white dwarf with a luminosity of only 0.056 $L_{\odot}$ and a peak spectral wavelength of $\lambda_{max} = 1.2 \times 10^{-7}$ m. In contrast, the red supergiant Betelgeuse has a peak wavelength of $\lambda_{max} = 8.5 \times 10^{-7}$ m and a surface temperature of 3400 K. The luminosity of our sun ($L_{\odot}$) is 3.85×10^{26} W. Total for Question 3: 10

   (a) Define the term *black body*. [1]

   (b) The wavelength of a light source, such as a star, can be calculated experimentally using a diffraction grating. Outline how you would do this, taking care to include details of the experimental setup, any measurements that must be taken and any calculations required. [3]

(c) Arnav is asked to calculate the wavelength of starlight from Zeta. He measures the angle between the beam and the eighth-order maximum as $0.14°$and uses a grating with a slit spacing of 1 mm. What is the wavelength of the light used? [2]

(d) Using a combination of Wien's displacement law and Stefan's law, calculate the radius of Sirius B. [4]