White Dwarf Stars

1. A stable white dwarf star has mass $M = 10^{30}$ kg and radius $R = 8 \times 10^8$ m. What is the degeneracy pressure of the electron gas in the star?
2. At what particle-density does a completely degenerate electron gas in a star have enough kinetic-energy per particle to permit the reaction

$$p^+ + e^- + 0.8\ \text{MeV} \longrightarrow n$$

where p^+, e^- and n are proton, electron and neutron respectively. What is the minimum density of the neutron star?

3. Assuming the electron gas in a WDS to be strongly degenerate and non-relativistic, show that the Mass-Radius relationship is

$$M^{1/3} R = \text{constant}$$

Find the radius of Sun for it to become a stable WDS.

Bose-Einstein Condensation

1. An ideal gas of Rb^{87} particles at 100°K is compressed isothermally. Find out the number-density of the gas at which the Bose-Einstein condensation starts in it.
2. An ideal Bose gas with spinless particles of mass 6.65×10^{-27} kg has a particle-density $n = 10^{26}\ m^{-3}$. Find the percentage of particles in the ground energy-level at $T = 0.043$ °K. What is the entropy of the gas at this temperature?

Saha's Ionization formula

1. Find out the percentage of ionization in H_2 gas at the centre of a star, given that the density of the star is 10^5 kg m^{-3} and its temperature is 1.5×10^7 K.

2. Show that the density (in m^{-3}) of atomic hydrogen in a star at a temperature T, such that 50% of the hydrogen atoms in the star are ionized, is given by the relation

$$\ln n = 49.93 + \frac{3}{2}\ln T - \frac{1.58 \times 10^5}{T}$$

(for H_2, $2g_i/g_a = 1$, $I = 13.6$ eV).