Name of the Student:_____
Max. Marks : 20 Marks **Time : 20 Minutes**

Q1.

The Sun's energy is produced by the fusion of protons. Near the Sun's surface the protons have a mean kinetic energy of 0.75 eV which is too low for fusion to take place. The core, however, has a temperature of about 1.5×10^6 K and a pressure of about 1.0×10^{16} Pa. This core consists of a plasma of (mainly) protons. Within the core the density, pressure and temperature of the proton plasma are sufficiently high for nuclear fusion to occur.
The energy is thought to be produced mainly by a cycle called the hydrogen cycle. The overall effect in one cycle is that 4 protons fuse to form a helium nucleus. The total mass of hydrogen that fuses each second is 7.0×10^{11} kg of which about 5.0×10^9 kg per second is converted into energy that is radiated.

When answering the following questions assume, where necessary, that the plasma behaves like an ideal gas.

(a) (i) Use the mean value of the kinetic energy of protons near the Sun's surface to calculate the temperature near its surface.

temperature near the Sun's surface _____ K

(3)

(ii) Calculate the closest distance of approach for two protons near the Sun's surface.

closest distance of approach _____ m

(3)

(iii) Explain why fusion cannot occur near the surface.

_____

_____

_____

_____

_____

(3)

(b) (i) Calculate the number of protons in each cubic metre of the Sun's core.

number of protons _____

(3)

(ii) Calculate the density of the Sun's core.

density of the Sun's core _____ kg m^{-3}

(2)

(c) (i) Show that the data given in the passage in question (a) suggest that every second, about 4×10^{38} protons fuse to form helium nuclei.

(2)

(ii) The total binding energy of a helium nucleus is 4.5×10^{-12} J.
Determine with an appropriate calculation whether the mass that is converted into radiant energy, stated in the passage, is consistent with this value.

(4)
(Total 20 marks)