Homework 3

**Pang-Yuxuan-1901110223**

****Question 1:****

**(a)**

Calculateby definition:



Define, then: , change the integration:



As we know, then:



By definition:



**(b)**

Total thermal energy can be calculated as:



For single-atom gas:



By the relation:, finally calculated:



Using the conversion relationship: :

****Question 1:****

The ionization fraction is defined by:



Assume that , are shown in table below:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Element | zero | Ⅰ | Ⅱ | Ⅲ | Ⅳ | Ⅴ | Ⅵ |
| H | 2 | 1 |  |  |  |  |  |
| C | 9 | 6 | 1 | 2 | 1 | 2 | 1 |

The ionization potential of the three elements are come from book “Physical quantity and celestial physical quantity” by Allen, as shown in table below:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Element | Ⅰ | Ⅱ | Ⅲ | Ⅳ | Ⅴ | Ⅵ |
| H | 13.598 |  |  |  |  |  |
| C | 11.260 | 24.383 | 47.887 | 64.492 | 392.08 | 489.98 |

I choose a typical 

**(a)**

As for hydrogen, Saha equation writes as:



where

****Question 2:****

**(a)**

First, calculate functions of all kinds of situation:

**For ideal gas:**

Ideal gas is non-relativistic and given by Maxwell-Boltzmann distribution:



So, the pressure of non-relativistic ideal gas is:



Ascan be calculate by:



The pressure can be calculated by:



Quantum-mechanical description of the gas**:**

The number of quantum states in a spatial volume and with momenta  is given by (whereis the number of intrinsic quantum states of the particle):



Electrons are fermions with two spin states:



**For electrons or nucleons**, the fraction of states with energythat will be occupied at temperatureis given by fermion’s distribution:



Assume that electrons are complete degeneracy, then the maximum momentum:



For non-relativistic situation:



Putinto function:

For relativistic situation:



Putinto function:

**For radiation**

The fraction of states with energythat is occupied is:



Since photons are relativistic:



For ionized hydrogen:,

(i)

For non-relativistic situation:



Thus: 

For relativistic situation:



Thus: 

(ii)

Pressure is equal between radiation and ideal gas:



Thus: 

(iii) 

(iv)

The ratio of Coulomb energy to kinetic energy is usually called the Coulomb parameter:



For ionized hydrogen, and, and the criterion ofis 170:

Thus:

****Question 3:****

**(a)**

From question 2, we know that completely degenerate in extreme relativistic limit:



So, the parameter in polytropic relationisand.

Polytropic index

The relation betweenis:

, 

where (from book table 4-1)

Thus: 

Change it to sun mass, and finally we get:



**(b)**

Only He, the parameter of He is:

Relative quality: , electrons: , proportion: 

Thus:



**(c)**

For only C and O with proportion 3 to 1:

Relative quality: , electrons: 

proportion: 

Thus:



****Question 4:****

**(a)**

Sun’ luminosity: 

The energy come from one pp chain is nearly 

So, the number of reactions per second take place in the sun is:



**(b)**

Every pp chain produces one He atom, which mass is: 

So, the mass of He produced in the sun every second is:



**(c)**

?

**(d)**

The total number neutrino produced by the Sun per second is:



Assumed that the neutrino emission is spherically symmetrical, then the number reach the earth is:



****Question 5:****