

Special '6 Saha's equation in
case of double ionization?

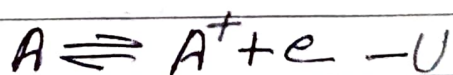
If both single and double ionization occur, Saha's equation is modified. If α_1 and α_2 represent the degree of ionization for single and double ionization respectively then it can be shown that

$$\frac{\alpha_2(\alpha_1 + 2\alpha_2)}{\alpha_1(1 + \alpha_1 + 2\alpha_2)} P = \frac{\left(\frac{2\pi m}{h^2}\right)^{3/2}}{g_e g_a^+} (kT)^{5/2} e^{-U/kT}$$

g_a

Applications:-

(1) Calculation of percentage of ionization of elements: For calculating the percentage of ionization of an element by the above formula, under varying conditions of temperature and pressure, we need a knowledge of the heat of ionization. For an atom,



Where U is the energy released due to ionization. For an atom and is given by

$$U = V_i \times 1.62 \times 10^{-12} \text{ ergs}$$

where V_i is the ionisation potential of atom.

$$\therefore 1 \text{ calorie} = 4.18 \times 10^7 \text{ ergs}$$

$$\therefore U = V_i \times 1.62 \times 10^{-12} / 4.18 \times 10^7 \text{ calories}$$

$$\therefore U \text{ for one gram atom} =$$

$$\frac{V_i \times 1.62 \times 10^{-12}}{4.18 \times 10^7 \times 1.62 \times 10^{-24}}$$

$$= V_i \times 23050 \text{ calories.}$$

for Na $V_i = 5.12$ volts.

$$\therefore U = 117 \text{ K calories}$$

Hence from the ionization formula, it is possible to calculate the percentage ionization α for different values of temperature and pressure.

For Ca, $g_e = 2$ $g_i^+ = 2$ and $g_e^- = 1$

Therefore, the ionization formula for Ca is

$$\log \frac{\alpha^2}{1-\alpha^2} p = \frac{5}{2} \log T + \log k + \log 4 - \frac{U}{4.57T}$$

where $I = \left\{ (2\pi m)^{3/2} k^{5/2} \right\} / h^3$

Thus the percentage of ionisation of an atom depends to a large extent upon the factor U and temperature and hence upon the ionisation potential.

(2) Explanation of stellar spectra:

Fowler and Milne observed that there is a remarkable difference between the variation of principal lines of neutral elements and that of the subordinate lines in the stellar spectra. The principal lines are most intense at the lowest temperature and gradually die out with the increase of temperature but the subordinate lines appear at a stage depending upon the excitation potential of the element. They are very faint at the lowest temperature, gradually attain a maximum intensity and again fall off to zero intensity. This sequence is explained on the assumption that at the lowest temperature all the atoms are in the ground state and there is none

in the higher states, with the rise of temperature the highest states begin to come out where the temperature further rises the atoms begin to get ionized and the proportion of atoms in the excited state begins to drop and lines due to ionized atoms i.e. subordinate lines begin to appear.

Frankoffer lines due to the Sun have been photographed and as many as 20027 lines covering the wavelength region 2725 \AA and from 7833 \AA to 10195 \AA have been identified. Since the earth is a minute fraction of the ~~Sun~~ Sun, all the 92 elements found in the earth have been identified in the solar spectra by application of ionisation theory.