orbits). As the temperature increases toward $\theta_{el,H}$, some atoms begin to lose their electron. The gas is *ionized* and becomes a *plasma*.[21]

The energy level series of a multielectron atom is as yet too difficult for analytic determination. However, for most atoms the values of $g_{el,\ell}$ and $\varepsilon_{el,\ell}$ for at least the first several levels have been measured spectroscopically (see the JANAF Tables). Like the hydrogen atom, at low temperatures the electrons of these atoms are unexcited; they occupy the lowest accessible states.[22] As the temperature level is increased some of the electrons are excited to higher levels. At still higher temperatures, some of the atoms would lose a single electron; they are then *singly ionized*. Upon further increases in temperature the atoms would successively lose a second and more electrons, and become doubly, triply, etc., ionized. For the hydrogen atom the ionization temperature is the coefficient of the entire electronic level series, $\theta_{el,H} = \theta_{I,H}$. For multielectron atoms no single constant is sufficient to describe the entire series. However, we can indicate the relative magnitude of this mode using a characteristic temperature defined from the energy for the first ionization state, $\theta_I = \Delta\varepsilon_{1,1}/k$. The values for a few atoms are listed in Table IIIC-B1. Notice that the ionization temperatures of the multielectron atoms listed are of the same order as that determined for the hydrogen atom, $\theta_I \sim 10^5$K. The table does not list ionization temperatures for molecules, as most molecules tend to dissociate before they are appreciably ionized.

II. DISSOCIATION

A molecule is formed when a covalent or ionic force acts among the positively charged nuclei and negatively charged electrons of the participating atoms. That is, molecular bonds are formed by electronic interactions. A schematic representation of the first few energy levels of a representative diatomic molecule is shown in Fig. IIIC-B1. The figure also shows a few of the vibrational levels above each electronic minimum and a few much

[21]The plasma state is relatively uncommon on earth. (It is present within a fluorescent tube, an electric arc, and a fusion reactor.) Nevertheless, the plasma state is the preponderant condition of matter in the universe, as most of the matter is concentrated in the stars.

[22]Free electrons are Fermions, thus at low temperature they fill up the states starting with the lowest level.

Ans. A3. The only parameter that depends on j in the series n_j/g_j is the magnitude of the energy of the successive levels, ε_j. Their order is defined to be sequentially increasing. Thus the first exponential in the series is the largest.

$$\left.\frac{n_j}{g_j}\right|_{max} = \frac{n_1}{g_1} = \frac{N\, e^{-\varepsilon_1/kT}}{Z}$$