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HYDROGEN'S ENERGY LEVELS

$$E_n = -Z^2 \frac{1}{n^2} R_y$$

$$R_y = 13.61 \text{ eV}$$

$$I_H = -E_1 = 13.61 \text{ eV}$$

CONSIDER  $\text{Li}$

$$I_{\text{Li}} = 520.2 \text{ kJ mol}^{-1}$$

$$I_{\text{Li}} = 520.2 \times 10^3 \cancel{\text{J}} \left( \frac{\text{eV}}{1.602 \times 10^{-19} \cancel{\text{J}}} \right) \frac{1}{6.022 \times 10^{23}}$$

$$= \frac{520.2 \times 10^3}{(1.602)(6.022)} 10^{-4} \text{ eV} = 5.392 \text{ eV}$$

$$5.392 \text{ eV} = Z_{\text{eff}}^2 R_y \Rightarrow Z_{\text{eff}} = \sqrt{\frac{5.392}{13.6}}$$

$$Z_{\text{eff}} = 0.63$$

$$\text{Na} \quad \Sigma_{\text{Na}} = 495.8 \text{ kJ mol}^{-1}$$

$$= 5.139 \text{ eV}$$

$$-E_0 = Z_{\text{eff}}^2 R_y = 5.139 \text{ eV}$$

$$\boxed{Z_{\text{eff}} = \sqrt{\frac{5.139 \text{ eV}}{R_y}} = 0.61}$$

15.94 The first ionization energy of K is  $419 \text{ kJ mol}^{-1}$

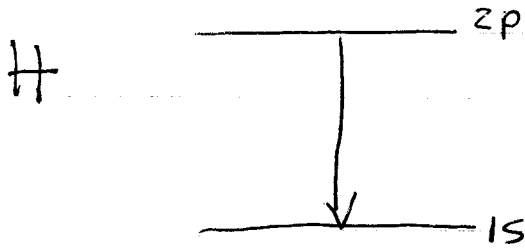
$$\begin{aligned}\Delta E_1 &= \frac{hc}{\lambda_1} = \frac{(6.626 \times 10^{-34} \text{ J s})(2.9979 \times 10^8 \text{ m s}^{-1})(6.022 \times 10^{23} \text{ mol}^{-1})}{650 \times 10^{-9} \text{ m}} \\ &= 1.84 \times 10^5 \text{ J mol}^{-1} = 184 \text{ kJ mol}^{-1}\end{aligned}$$

$$419 \text{ kJ mol}^{-1} = 184 \text{ kJ mol}^{-1} + \Delta E_2 \quad \Delta E_2 = 235 \text{ kJ mol}^{-1}$$

$$\lambda_2 = \frac{hc}{\Delta E_2} = \frac{(6.626 \times 10^{-34} \text{ J s})(3.00 \times 10^8 \text{ m s}^{-1})(6.022 \times 10^{23} \text{ mol}^{-1})}{2.35 \times 10^5 \text{ J mol}^{-1}} = 509 \times 10^{-9} \text{ m}$$

This is the maximum wavelength that the second photon may have.

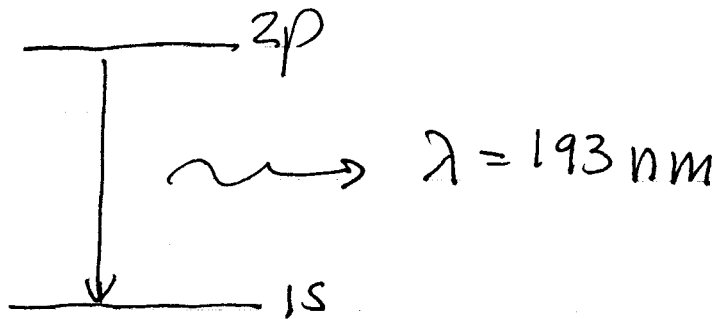
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$$16.2 \times 10^{-19} \text{ J}$$

$$10.1 \text{ eV}$$

FOR IRON



$$E = h\nu = \frac{hc}{\lambda} = \frac{6.626 \times 10^{-34} \text{ Js } 2.9979 \times 10^8 \text{ m s}^{-1}}{193 \times 10^{-9} \text{ m}}$$

$$E = \frac{(6.626)(2.9979)}{1.93} \times 10^{-19} \text{ J} = 10.3 \times 10^{-19} \text{ J}$$

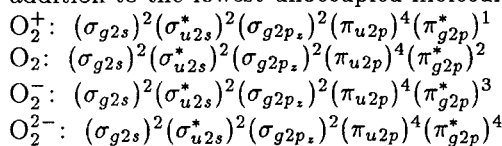
THE BIGGER NUCLEAR CHARGE "COMPRESSES"

THE ENERGY LEVELS, SO THAT THE 2P

IS CLOSER TO THE 1S IN THE CASE OF IRON

16.2 (a) The correlation diagram for  $O_2^-$  is identical to that given for  $O_2$  in text Figure 16.11b except that an additional electron is added to either the  $\pi_{2p_x}^*$  or  $\pi_{2p_y}^*$  level.

(b) The ground-state electron configuration of  $O_2$  is listed in Table 16.2. The configurations of the ions in the problem can be derived by removal of electrons from the highest occupied or addition to the lowest unoccupied molecular orbitals:

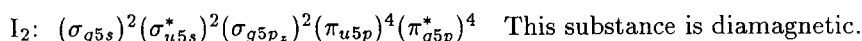


(c) The bond orders of the species are 5/2 (for  $O_2^+$ ), 2 (for  $O_2$ ), 3/2 (for  $O_2^-$ ) and 1 (for  $O_2^{2-}$ ).

(d) All of the species except  $O_2^{2-}$  should be paramagnetic. A species with an odd number of electrons is automatically paramagnetic; the reason for the paramagnetism of ordinary  $O_2$  is discussed in the text.

(e) In the series given in (c), each additional electron occupies a  $\pi^*$  antibonding orbital. The bond dissociation energy decreases along the series.

16.4 It is not necessary to show any configuration for core electrons, which play little part in bonding. Then:



16.6 (a)  $X_2: (\sigma_{g2s})^2(\sigma_{u2s}^*)^2(\sigma_{g2p})^2(\pi_{u2p})^4(\pi_{g2p}^*)^2: O_2$ . Bond order: 2.

(b)  $Q_2^-: (\sigma_{g2s})^2(\sigma_{u2s}^*)^2(\pi_{u2p})^3: B_2^-$ . Bond order:  $\frac{3}{2}$ .

(c)  $Z_2^{2+}: (\sigma_{g2s})^2(\sigma_{u2s}^*)^2(\sigma_{g2p})^2(\pi_{u2p})^4(\pi_{g2p}^*)^2: F_2^{2+}$ . Bond order: 2.

16.8 (a) paramagnetic (b) paramagnetic (c) paramagnetic

16.10 The nitrogen atomic orbitals should be lower in energy than the corresponding beryllium orbitals. The molecule of BeN has 7 valence electrons and a bond order of 3/2. The substance should be paramagnetic.

16.12 The nitrosyl molecular ion forms from nitrogen oxide by the loss of an electron from the highest occupied molecular orbital. The configuration of NO is  $(\sigma_{2s})^2(\sigma_{2s}^*)^2(\pi_{2p})^4(\sigma_{2p_z})^2(\pi_{2p}^*)^1$  so the electron comes from a  $\pi_{2p}^*$  orbital. Because this is an antibonding orbital, the bonding in  $NO^+$  should be stronger and the bond should be shorter than in NO. Moreover,  $NO^+$  should be diamagnetic.

16.14 The  $HeH^+$  ion has the electron configuration  $(\sigma_{1s})^2$ . Its bond order is 1, and it is diamagnetic. The lower energy state should be reached by the reaction  $HeH^+ \rightarrow He + H^+$ . This set of products is more stable than  $He^+ + H$  because in it the two electrons are both close to the +2 charge of the helium nucleus instead of the +1 charge of the hydrogen nucleus and very roughly the same distance from each other.