Inorganic Chemistry 1 QUANTUM THEORY BOHR THEORY

Derivation of Bohr Orbit Energy E_n in terms of a_o

$$Q_0 = \frac{h^2 \epsilon_0}{\pi e^2 m}$$

$$E_{n} = -\frac{e^{4}m}{8\epsilon_{o}^{2}h^{2}n^{2}} = -\frac{e^{2}}{8\pi\epsilon_{o}n^{2}}\left(\frac{\pi\epsilon_{o}^{2}m}{h^{2}\epsilon_{o}}\right)$$

$$E_{n} = -\frac{e^{2}}{8\pi\epsilon_{o}n^{2}a_{o}}$$

$$\frac{1}{q_{o}}$$

$$n = 1 \quad \therefore \quad E_{1} = -\frac{\left(1602 \times 10^{-19}\right)^{2}}{8\pi (8.84 \times 10^{-12})(1)^{2} (0.529 \times 10^{-10} \text{m})}$$

$$E_{1} = -2.18 \times 10^{-18} J$$

$$n = 2$$

$$E_{2} = -\frac{2.18 \times 10^{-18}}{2^{2}} = -\frac{2.18 \times 10^{-18}}{4} = -5.45 \times 10^{-19} J$$

$$h=3$$
 $E_3 = \frac{-2.18 \times 10^{-18}}{9} = -2.42 \times 10^{-19} J$

$$n=4$$
 $E_4 = -\frac{2.18 \times 10^{-18}}{16} = -1.36 \times 10^{-19} J$

$$n=6$$
 $E_6 = \frac{-2./8 \times 10^{-18}}{36} = -6.06 \times 10^{-20} J$

£00 = 0

$$E_6 = -6.06 \times 10^{-20} \text{ J (sth excited state)}$$
4th excited state: n=5

$$E_{4} = -1.36 \times 10^{-19} J = -13.6 \times 10^{-20} J$$

$$(3rd \ excited \ state : \ n=4)$$

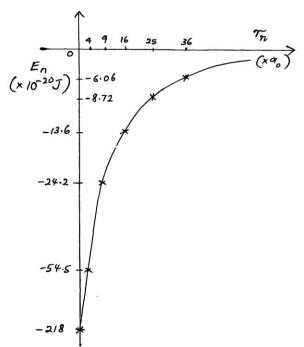
$$E_{10} = -13.6 \times 10^{-20} J$$

$$E_{3} = -2.42 \times 10^{-19} J = -24.2 \times 10^{-20} J$$
(2nd excited state: n=3)
E
increases

$$E_2 = -5.48 \times 10^{-19} J = -54.5 \times 10^{-20} J$$
(1st excited state: n = 2)

$$E_1 = -2.18 \times 10^{-18} J = -218 \times 10^{-20} J$$

(Ground State)



Derivation of Energy Difference, $\triangle E$ in terms of a_0

$$E_{n} = -\frac{e^{2}}{8\pi\epsilon_{o} q_{o} n^{2}}$$

$$\Delta E = E_{y} - E_{x} \qquad E_{y} > E_{x}$$

$$\Delta E = \frac{e^{2}}{8\pi\epsilon_{o} q_{o}} \left[\frac{1}{n_{x}^{2}} - \frac{1}{n_{y}^{2}} \right]$$

Problem-solving Example 13

Calculate the energy difference, ΔE between the first energy level (ground state) and the seventh energy level in hydrogen atom using the data given. $\left[Q_0 = 0.529 \, \mathring{A} \right] ; e = 1.602 \times 10^{-19} \, \mathrm{C} ; \in_0 = 8.84 \times 10^{-12} \, \mathrm{N}^{-1} \, \mathrm{m}^{-2} \, \mathrm{C}^2 \right]$

Solution:

$$\Delta E = \frac{e^2}{8\pi \epsilon_0 a_0} \left(\frac{1}{n_{\chi^2}} - \frac{1}{n_{y^2}} \right)$$

$$Q_0 = 0.529 \, \text{n}$$

$$= 0.529 \times 10^{-10} \, \text{m}$$

$$\Delta E = \frac{\left(1.602 \times 10^{-19}\right)^2}{8\pi \left(9.94 \times 10^{-12}\right) \left(0.529 \times 10^{-10} \text{m}\right)} \left(\frac{1}{1^2} - \frac{1}{7^2} \right)$$

$$n_{\chi} = 1 \, \text{for } \Delta E = \frac{2.57 \times 10^{-38}}{1.18 \times 10^{-20}} \left(1 - \frac{1}{49} \right)$$

$$= 2.178 \times 10^{-18} \left(0.979\right)$$

$$\Delta E = 2.134 \times 10^{-18} \, \text{J photon}^{-1} \left(\text{Ans}\right).$$

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