PSEUDO-HYDROGEN ATOM / ONE-ELECTRON SYSTEM CATION (HYDROGEN-LIKE ATOM)

Problem-solving Example 18

For lithium atom (Z = 3) , which ionization energy can be determined using Bohr formula or Bohr Theory ? Calculate the energy in kJ mol^{-1}.

Solution

Solution :

For Li atom, there are three ionization energy :

$Li(g) \longrightarrow Li^{+}(g) + e^{-}$ (1st ionization energy)
3 electrons → 2 electrons

$Li^{+}(g) \longrightarrow Li^{2+}(g) + e^{-}$ (2nd ionization energy)
2 electrons → 1 electron

$Li^{2+}(g) \longrightarrow Li^{3+}(g) + e^{-}$ (3rd ionization energy)
1 electron

Li^{2+} ion is hydrogen-like atom (pseudo-hydrogen atom) has a single electron. So the third ionization energy for Li atom can be calculated using Bohr formula.

$$\Delta E_{IE} = (2.178 \times 10^{-18}\ J)\, Z^2 \left[\frac{1}{1^2} - \frac{1}{\infty^2}\right]$$

$$= (2.178 \times 10^{-18}\ J)(3^2)$$

$$\Delta E_{IE} = 1.96 \times 10^{-17}\ J\,atom^{-1}$$

$$= (1.96 \times 10^{-17})(6.022 \times 10^{23}) = 1.18 \times 10^{7}\ J\,mol^{-1}$$

$$= 1.18 \times 10^{4}\ kJ\,mol^{-1}$$

Note:

For any hydrogen-like atom which has a single electron, the following can be determined using Bohr formula:

a) Fourth ionization energy for Be atom ($Z = 4$) for the proc

$Be^{3+}(g) \longrightarrow Be^{4+}(g) + e^{-}$
(1 electron)

b) Fifth ionization energy for B atom ($Z = 5$) for the process:

$B^{4+}(g) \longrightarrow B^{5+}(g) + e^{-}$

c) Sixth ionization energy for C atom ($Z = 6$) for the process:

$C^{5+}(g) \longrightarrow C^{6+}(g) + e^{-}$

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