Key

CH301H – Principles of Chemistry I: Honors
Fall 2017, Unique 50135

Quiz 1, 12 September 2017

The outermost electron in a gold atom ($Z = 79$) sits 166 pm away from the nucleus. (1 pm = 1×10^{-12} m)

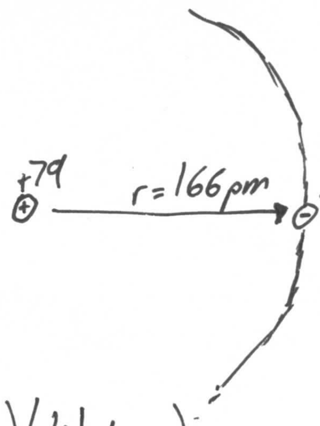
a) Using only this information, determine the Columbic potential energy of the outermost electron interacting with nucleus.

b) The first ionization energy of a gold atom is 890 kJ mol^{-1}. Determine the effective nuclear charge of the gold nucleus.

c) If your answers to parts a and b are different, explain why.

The following constants may be useful:
$\varepsilon_0 = 8.85 \times 10^{-12}\ C^{2}\ J^{-1}\ m^{-1}$
$N_A = 6.022 \times 10^{23}\ mol^{-1}$
$e = 1.602 \times 10^{-19}$ C

a) $V(r) = \frac{q_1 q_2}{4\pi\varepsilon_0 r} = \frac{(+79)(-1)e^2}{4\pi\varepsilon_0 r}$



$$= \frac{-79(1.602\cdot10^{-19}C)^2}{4\pi(8.85\cdot10^{-12}C^2/J\cdot m)(166\cdot10^{-12}m)}$$

$$V(r) \doteq -1.10\cdot10^{-16}\ J/atom \left(6.022\cdot10^{23}\ atoms/mol\right)\left(kJ/1000\ J\right)$$

or

$$-6.61\cdot10^{4}\ kJ/mol$$

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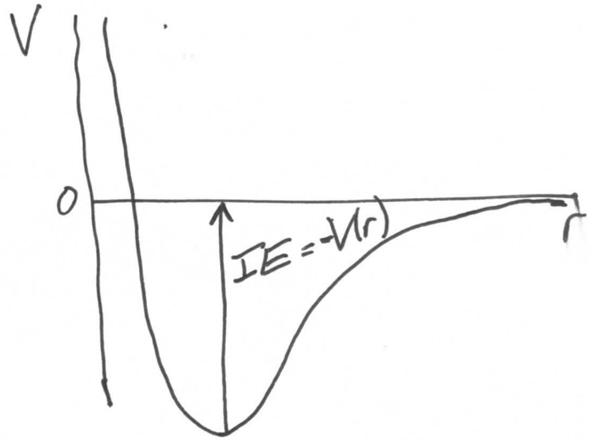
b) $V(r) = \frac{q_1 q_2}{4\pi\varepsilon_0 r}$; $V(r) = -IE$



$$-IE = \frac{(Z_{eff})(-1)e^2}{4\pi\varepsilon_0 r}$$

$$Z_{eff} = \frac{4\pi\varepsilon_0 r\cdot IE}{e^2}$$

$$= \frac{4\pi(8.85\cdot10^{-12}C^2/Jm)(166\cdot10^{-12}m)(890\cdot10^{3}J/mol)\left(\frac{1\ mol}{6.022\cdot10^{23}\ atom}\right)}{(1.602\cdot10^{-19}C)^2}$$

$$Z_{eff} = 1.06$$

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c) This effective nuclear charge is drastically different than the actual nuclear charge used in part a). This difference arises due to the presense of 78 other electrons. The electrons shield the full positive charge ~~from~~ of the ~~~~ nucleus by adding repulsive potential energy to the valence electron. This is why the energy in part a) is so much lower than the actual Ionization Energy given in part b).