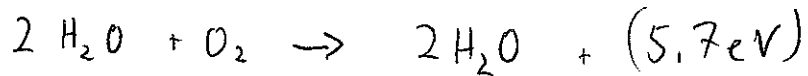


10.5



bond strengths

$$\text{H}_2 \quad 4.5 \text{ eV}$$

$$\text{O}_2 \quad 5.2 \text{ eV}$$

$$\text{H-OH} \quad 5.2 \text{ eV}$$

$$\text{O-H} \quad -?$$

Breaking both bonds in H_2O is breaking H-OH, then O-H

$$\begin{array}{ccccccc} \text{H-OH} & & \text{O-H} & & \text{H}_2 & & \text{O}_2 \\ 2(5.2 \text{eV}) & + & 2(\text{O-H}) & - & 2(4.5 \text{eV}) & - & (5.2 \text{eV}) = 5.7 \end{array}$$

$$\text{O-H} = 4.5 \text{eV}$$

$$\text{O-H} + \text{H-OH} = 10 \text{eV}$$

10.7

longer bond length implies smaller binding energy because binding energy is dominated by the $\frac{Ke^2}{r}$ term.

Smaller r means lower energy and stronger, higher energy binding energy

10.10

ionization energy of Lithium - 5.4 eV

electron affinity of iodine is 3.4 eV
fluorine

bond length of LiF is 0.16 nm

one estimate from

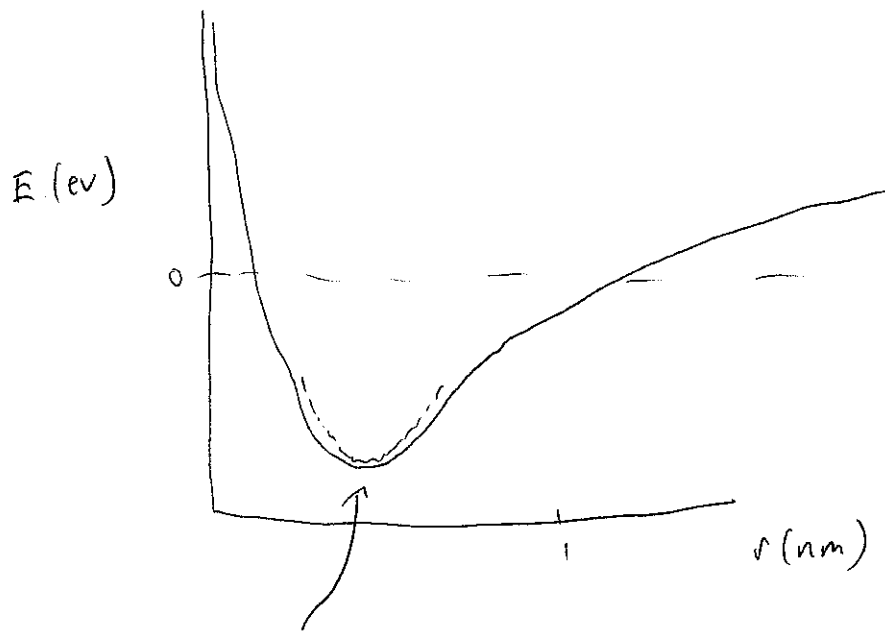
$$E(r) = 5.4 \text{ eV} - 3.4 \text{ eV} - \frac{Ke^2}{r} + \frac{C e^{-ar}}{r}$$

$$E(r) \sim 5.4 \text{ eV} - 3.4 \text{ eV} - \frac{1.44 \text{ eV} \cdot \text{nm}}{0.16 \text{ nm}}$$

$$\sim 7 \text{ eV}$$

↑
this term ~~is~~ is
changing rapidly
with r

10, 12



The shape of potential that determines the vibrational energy scale has a spatial scale of \sim the bond length.

Given this constraint, when we calculate rotational, vibrational energies, vibrational is always greater.

10.17 CO molecule

$$f = 6.42 \times 10^{13} \text{ Hz}$$

harmonic oscillator $E = (n - \frac{1}{2}) h\nu$

$$h\nu = 2\pi f h$$

$$\frac{n_2}{n_1} = \frac{e^{-E_2/KT}}{e^{-E_1/KT}} = e^{-(E_2 - E_1)/KT}$$

$$E_2 - E_1 = (2 - \frac{1}{2}) h\nu - (1 - \frac{1}{2}) h\nu = h\nu = 2\pi f h$$

$$\frac{n_2}{n_1} = \exp \left[\frac{2\pi f h}{KT} \right]$$

$$KT = 0.02585 \quad \text{at } T = 300 \text{ K (room temp)}$$

$$\frac{n_2}{n_1} \approx 3 \times 10^{-5}$$

10.25

(O) molecule absorbs a photon $\lambda = .652 \text{ nm}$

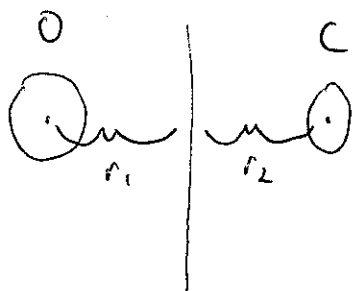
$$E = \frac{hc}{\lambda} = \frac{1240 \text{ eV} \cdot \text{nm}}{.652 \times 10^3 \text{ nm}} = .0019 \text{ eV}$$

This small energy must be a rotational transition
 $E_r = \frac{l(l+1)\hbar^2}{2I}$

C-O bond length is 0.11 nm

(1) Carbon $Z=6, A=12$

(2) Oxygen $Z=8, A=16$



$$r_1 + r_2 = 0.11 \text{ nm}$$

$$r_1 = \frac{M_2}{M_1 + M_2} \cdot 0.11 \text{ nm} \quad r_2 = \frac{M_1}{M_1 + M_2} \cdot 0.11 \text{ nm}$$

$$I = \frac{M_1 M_2}{M_1 + M_2} (0.11 \text{ nm})^2 = \left(\frac{48}{7}\right) \left(\frac{930 \text{ MeV}}{c^2}\right) (.11 \text{ nm})^2$$

$$\frac{(l+1)(l+2)\hbar^2}{2I} - \frac{l(l+1)\hbar^2}{2I} = .0019 \text{ eV}$$

$$(l+1)(l+2) - l(l+1) = \frac{(.0019 \text{ eV}) 2I}{\hbar^2} = \frac{(.0019 \text{ eV}) 2 \left(\frac{48}{7}\right) (.11 \text{ nm})^2 (930 \text{ MeV})}{\hbar^2 c^2}$$

$$l \approx 3$$

transition is $l=3 \rightarrow l=4$