3.091 OCW Scholar

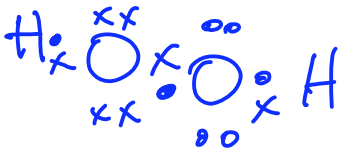
Self-Asessment
Bonding and Molecules

Supplemental Exam Problems for Study
Solutions Key

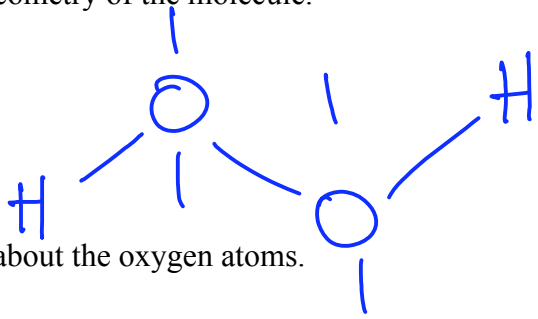
Problem #1

Answer the following questions about hydrogen peroxide (H_2O_2).

(a) Draw the Lewis structure of H_2O_2.



(b) Draw a 3-dimensional representation of the molecular geometry of the molecule.



(c) Name the geometry of the electron distribution about the oxygen atoms.

tetrahedral

(d) Determine the per cent ionic character of the O–H bond.

$\chi_O = 3.44$ $\chi_H = 2.20$ $\therefore \Delta\chi = 1.24 \Rightarrow$ % ionic character is

$[1 - \exp\{-\frac{1}{4}(\Delta\chi)^2\}] \times 100 = 32\%$

(e) Is the molecule polar or nonpolar? Explain.

nonpolar – symmetric dispersal of polar bonds

(f) Is it chiral or achiral? Explain.

achiral – symmetric dispersal of atoms around center of symmetry

(g) Calculate the maximum wavelength of a beam of neutrons capable of breaking the O–H bond in H_2O_2.

DATA: Average Bond Energies (kJ/mol)

O–O	142
H–H	432

$$E_{OH} = \sqrt{E_{O\text{-}O} \cdot E_{H\text{-}H}} + 96.3(\chi_O - \chi_H)^2 = (142 \cdot 432)^{1/2} + 96.3(1.24)^2$$

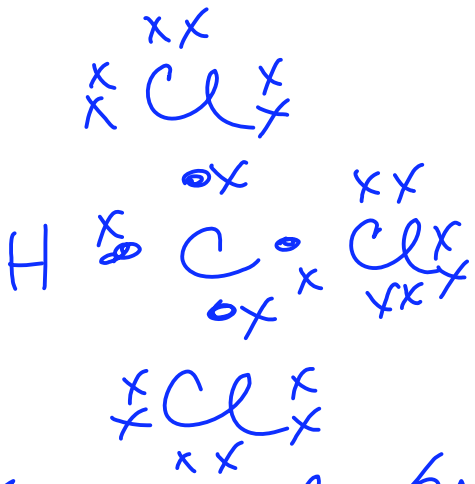
$$= 248 + 148 = 396 \text{ kJ/mol} / N_A = 6.57 \times 10^{-19} \text{ J/bond}$$

$$E_{neutron} = \frac{p^2}{2m} = \frac{h^2}{2m\lambda^2} = E_{bond} \Rightarrow \lambda = \frac{h}{(2mE)^{1/2}}$$

$$\therefore \lambda_{neutron} = \left(\frac{6.6 \times 10^{-34}}{2 \times 1.67 \times 10^{-27} \times 6.57 \times 10^{-19}}\right)^{1/2} = 1.41 \times 10^{-11} \text{ m}$$

Problem #2

(a) Draw the Lewis structure of trichloromethane ($CHCl_3$).



(b) Is $CHCl_3$ polar or nonpolar? Explain.

polar – asymmetric molecule with polar bonds between different atom pairs

(c) Calculate the maximum wavelength of electromagnetic radiation capable of breaking the C–Cl bond in $CHCl_3$.

DATA: bond energy (kJ/mol)

C–C = 346

Cl–Cl = 240

H–H = 432

$E_{C-Cl\ bond} \leq E_{e\text{-}m\ radiation}$

$E_{C-Cl} = \sqrt{E_{CC} \cdot E_{ClCl}} + 96.3(\chi_C - \chi_{Cl})^2$

$= (346 \cdot 240)^{1/2} + 96.3(2.55 - 3.16)^2$

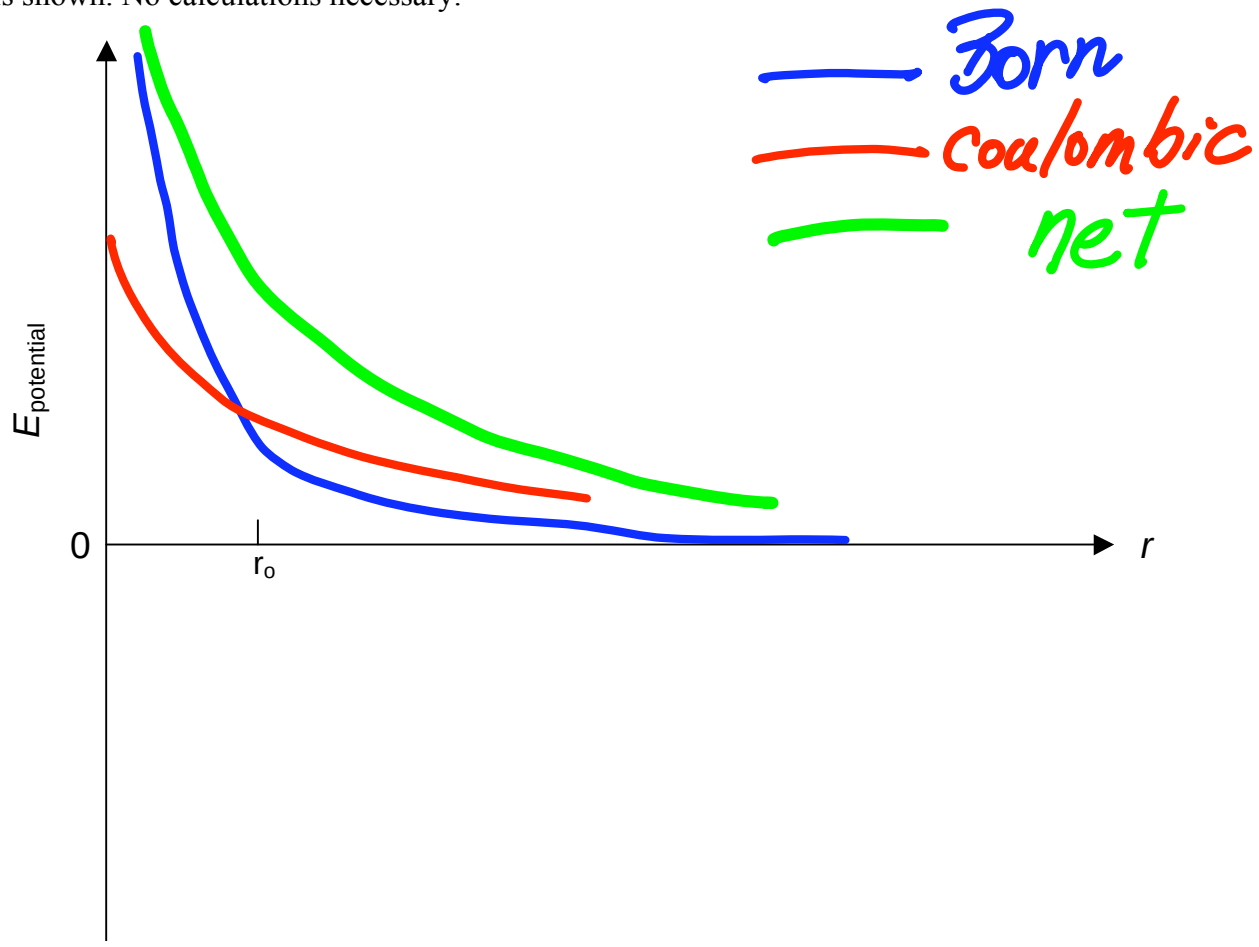
$= 288 + 36 = 324\ kJ/mol = E_{photon} = \frac{hc}{\lambda}$

$\therefore \lambda = \frac{hc}{E_{C-Cl}} = \frac{(6.6 \times 10^{-34})(3 \times 10^8)}{\frac{324 \times 10^3}{6.02 \times 10^{23}}}$

$= 3.68 \times 10^{-7}\ m$

Problem #3

Sketch the relationship between potential energy ($E_{potential}$) and internuclear distance (r) for the interaction between a bromide ion (Br^-) and an iodide ion (I^-). For reference, the distance $r_o = r_{Br^-} + r_{I^-}$ is shown. No calculations necessary.



3.091SC Introduction to Solid State Chemistry

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