5.3 Bond Enthalpies

- Bond breaking = endothermic process

bond enthalpy: energy needed to break 1 mol of bonds in gaseous molec. under std conditions

average bond enthalpy: energy needed to break 1 mol of a bond in a gaseous molec. averaged over similar compounds

ex: $Cl_2 \rightarrow 2Cl$ $\Delta H^\circ = +242\ kJ\,mol^{-1}$ (1 atom)

Hess's Law:

$H_2O \rightarrow H + OH$ $\Delta H^\circ = +502\ kJ\,mol^{-1}$ (2 atoms)

$OH \rightarrow H + O$ $\Delta H^\circ = +427\ kJ\,mol^{-1}$

$H_2O \rightarrow H + H + O$ $\Delta H^\circ = +929\ kJ\,mol^{-1}$

avg: $\frac{+929}{2} = \underline{464.5}\ kJ\,mol^{-1}$ for O-H

↓ # varies slightly due O-H in diff molecs

done in g state to reduce ← effect of IMFs

* multiple bonds: higher bond enthalpies & shorter bond lengths than single bonds

Bond formation = exothermic process
same amt of energy needed to break bonds as is given off in making bonds

Which process is endothermic? why?

$2Cl \rightarrow Cl_2$

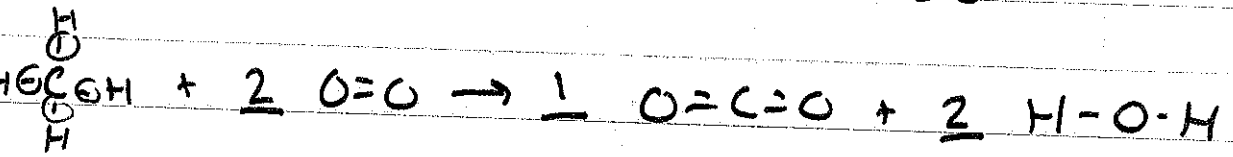
$Na \rightarrow Na^+ + e^-$

$Na^+ + Cl^- \rightarrow NaCl$

$Na(g) \rightarrow Na(s)$

Calculating energy changes from bonds in rxn

$\_CH_4 + \underline{2}\ O_2 \longrightarrow \_\_ CO_2 + \underline{2}\ H_2O$



$\underline{1}$ + $\underline{2}$ O=O → $\underline{1}$ O=C=O + $\underline{2}$ H-O-H

breaking (+) forming (-)

$4(C-H) + 2(O=O) + 2(C=O) + 4(O-H)$

$4(+413) + 2(+498) + 2(-804) + 4(+463)$

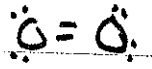
$(+2652) + (-3,460)$

$-808\ kJmol^{-1}$ (exo rxn)

↓

bonds formed stronger than bonds broken

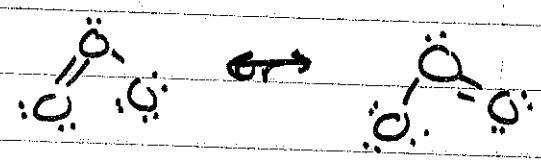
Ozone depletion

O_2 

2 bonds b/w O

↓

stronger ∴ broken by higher energy UV light (shorter λ)

O_3 

1.5 bonds b/w O

$E_{photon} = h\nu$ — h - Planck's constant, ν - frequency

$c = \lambda \times \nu$

$\nu = c/\lambda$

$$E_{photon} = \frac{h \times c}{\lambda}$$

bond energy of ozone = 363 $kJ\,mol^{-1}$

$L \times E_{photon} = 363\,kJ = 363000\,J\,mol^{-1}$

$$E_{photon} = \frac{363000\,J}{6.02 \times 10^{23}}$$ ← get rid of mols

$$\lambda = \frac{hc}{E} = \frac{6.63 \times 10^{-34}\,Js \times 3.00 \times 10^{8}\,ms^{-1}}{6.02 \times 10^{-19}}$$

$= 3.30 \times 10^{-7}\,m$

$= 330\,nm$ ← UV length needed to break O_3

Formation & depletion of ozone
- explains increase in temp @ 12 km above earth's surface

O_2 broken by $\lambda < 242$ nm

Chapman cycle

1) $O_{2(g)} \xrightarrow{UV < 242\,nm} O\cdot_{(g)} + O\cdot_{(g)}$ (atomic oxygen)

free radicals - very reactive

2) $O\cdot_{(g)} + O_{2(g)} \rightarrow O_{3(g)}$ exothermic (forms bond) → release heat to stratosphere

3) $O_{3(g)} \xrightarrow{UV < 330\,nm} O\cdot_{(g)} + O_{2(g)}$ (endo)

4) $O_3 + O\cdot \rightarrow 2O_2$ exo (more bonds)

steady state: O_3 formation = O_3 depletion

↑ what if this disappears)