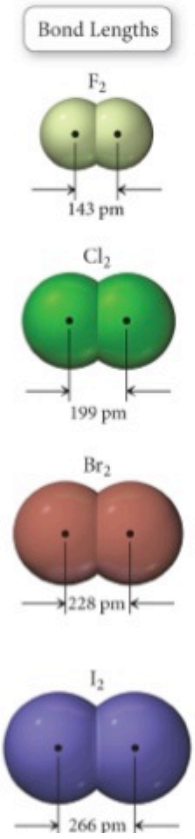
9.10 Bond Lengths and Strengths



- A **bond length** is the distance between the two nuclei in a chemical bond.
- Bond lengths increase as the atoms become larger, *e.g.* $F_2 < Cl_2 < Br_2 < I_2$
- Shorter bonds are usually **stronger** and longer bonds **weaker**.

Bond	Bond Length (pm)	Bond Strength (kJ/mol)
N—F	139	272
N—Cl	191	200
N—Br	214	243
N—I	222	159

- The **bond energy (BE)** is the energy required to break a chemical bond:

(always positive)

$A\cdot + B\cdot \longrightarrow A-B$ always exothermic

Bond order: BE: single < double < triple

bond length: triple < double < single

Bond	Bond Length (pm)	Bond Strength (kJ/mol)
C≡C	120 pm	837 kJ/mol
C=C	134 pm	611 kJ/mol
C—C	154 pm	347 kJ mol

ΔH for a reaction can be considered to be the difference between the bond energies of the reactants and those of the products.

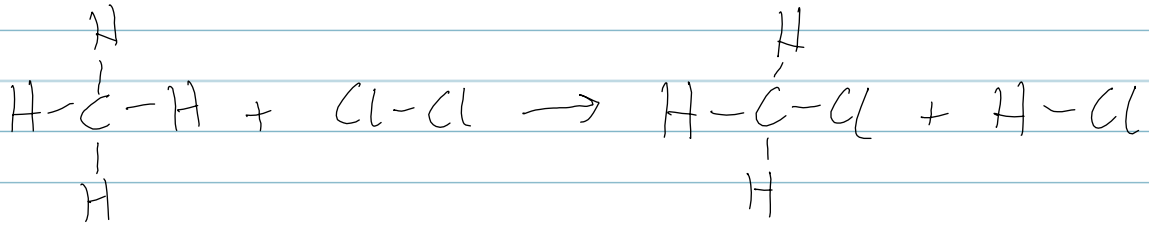
- If the products have stronger bonds than the reactants, the reaction will be **exothermic**.
- If the products have weaker bonds than the reactants, the reaction will be **endothermic**.
- **Fuels** are substances with relatively weak bonds that can be converted to products with stronger bonds, releasing energy.

Bond energies can be used to calculate ΔH_{rxn} for reactions in the gas phase:

$\Delta H_{rxn} = \Sigma$ BE(bonds broken in reactants) $- \Sigma$ BE(bonds formed in products)

Example: Use bond energies to calculate ΔH_{rxn} for:

$CH_4\,(g) + Cl_2\,(g) \rightarrow CH_3Cl\,(g) + HCl\,(g)$



$\Delta H_{rxn} = BE_{C-H} + BE_{Cl-Cl} - (BE_{C-Cl} + BE_{H-Cl})$

Table 9-3 $\Delta H_{rxn} = 414\text{ kJ} + 243\text{ kJ} - (339\text{ kJ} + 431\text{ kJ})$

$= -113\text{ kJ}$ (Figure 9.12)

Including all bonds

$4 \times 414\text{ kJ} + 243\text{ kJ} - (3 \times 414\text{ kJ} + 339\text{ kJ} + 431\text{ kJ}) = -113\text{ kJ}$

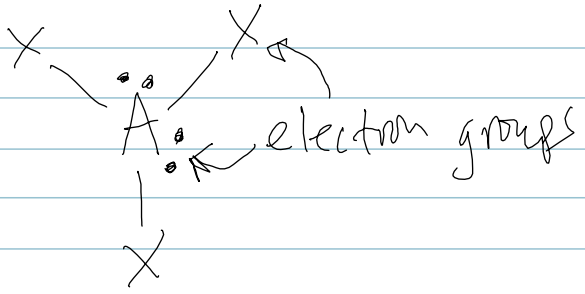
10.2 The Shapes of Molecules – VSEPR

The 3D Shape of a molecule can be predicted using **Valence Shell Electron Pair Repulsion (VSEPR)** theory.

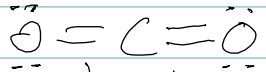
Basic idea: Because of repulsion between electrons, molecules will adopt a shape that allows the electrons in bonds and lone pairs to be located as far as possible from each other.

The shape of a molecule depends on the number of **electron groups** around the central atom.

- Electron groups are other atoms bonded to the central atom, or lone pairs on the central atom.

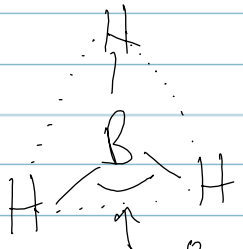


2 electron groups! linear

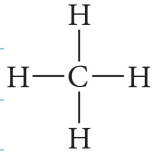


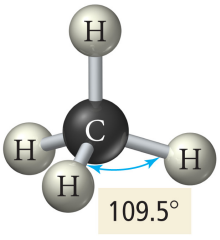
bond angle = 180°

3 electron groups (flat) → trigonal planar



4 electron groups





Tetrahedral geometry