**Bond Enthalpy**

**Bond energy** is defined as the amount of energy required to break a bond. These values are positive, indicating that bond breaking is endothermic. Bond energies are reported in kilojoules per mole (kJ/mol). The energy for breaking a hydrogen-hydrogen bond is +436 kJ/mol so when a hydrogen-hydrogen bond is formed the process releases 436 kJ/mol (therefore -436 kJ/mol).

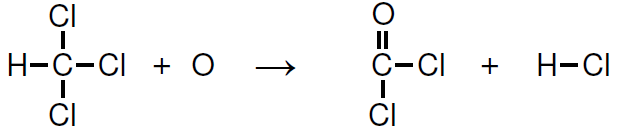
In a chemical reaction several bonds are broken and formed. For example in the reaction below a hydrogen-hydrogen bond is broken and a fluorine-fluorine bond is broken. Two hydrogen-fluorine bonds are formed. The overall energy change for this process is calculated below.

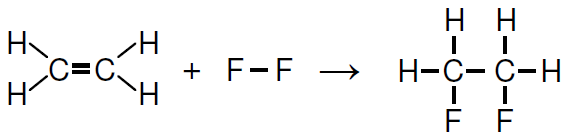
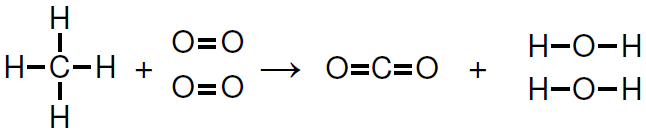
|  |
| --- |
| **Example**  H–H  Bond Energy: 436 kJ/mol  F–F  Bond Energy: 155 kJ/mol  H–F  Bond Energy: 567 kJ/mol  H2(g) + F2(g) 🡪 2HF  ∆Hrxn = [energy used for breaking bonds] – [energy formed in making bonds]  [(436 kJ/mol) + (155 kJ/mol)] – [2(567 kJ/mol)]  = - 543 kJ/mol |

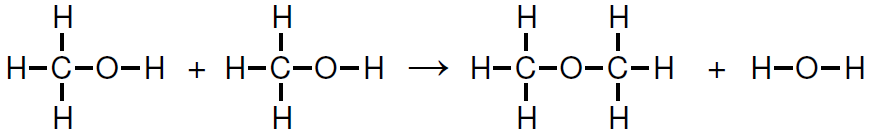
**Average Bond Energies (kJ/mol)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| H–H  H–Cl  H–F  N–H  N–O  O–H  O–O  F–F | 436 kJ/mol  431 kJ/mol  567 kJ/mol  391 kJ/mol  201 kJ/mol  463 kJ/mol  146 kJ/mol  155 kJ/mol | C–H  C–C  C–N  C–O  C–F  C–Cl  C–S  Cl–Cl | 413 kJ/mol  348 kJ/mol  293 kJ/mol  358 kJ/mol  485 kJ/mol  328 kJ/mol  259 kJ/mol  242 kJ/mol | C=C  C≡C  C=O  O=O  C≡O  C=N  N=N  N≡N  C≡N | 614 kJ/mol  839 kJ/mol  799 kJ/mol  495 kJ/mol  1072 kJ/mol  615 kJ/mol  418 kJ/mol  941 kJ/mol  891 kJ/mol |

Estimate the enthalpy change (∆Hrxn) for the following reactions using the bond energies above.

1.  4. 

2. 5. 

3.

Draw Lewis structures for reactants and products. Estimate the enthalpy change (∆Hrxn) for the reactions using bond energies.

6. 2H2O2 (g) 🡪 2H2O (g) + O2 (g) 9. 2C2H6 (g) + 7O2 (g) 🡪 4CO2 (g) + 6H2O (g)

7. N2 (g) + 3H2 (g) 🡪 2NH3 (g) 10. CH4 (g) + 3Cl2 (g) 🡪 CHCl3 (g) + 3HCl (g)

8. H2 (g) + C2H4 (g) 🡪 C2H6 (g) 11. HCN (g) + 2H2 (g) 🡪 CH3NH2 (g)

**Answers:**

-2831 kJ/mol -808 kJ/mol -549 kJ/mol -489 kJ/mol -312 kJ/mol -203 kJ/mol -184 kJ/mol

-138 kJ/mol -124 kJ/mol -97 kJ/mol 0 kJ/mol