

1.5: Bond Length and Bond Strength

The Relationship between Bond Order and Bond Energy

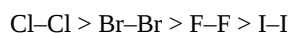
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Table 8.6 Average Bond Energies (kJ/mol) for Commonly Encountered Bonds at 273 K

| Single Bonds | | | | | | | | | | Multiple Bonds | |
|--------------|------|-------|-----|------|------|------|------|-------|-----|----------------|------|
| H-H | 432 | C-C | 346 | N-N | ≈167 | O-O | ≈142 | F-F | 155 | C=C | 602 |
| H-C | 411 | C-Si | 318 | N-O | 201 | O-F | 190 | F-Cl | 249 | C≡C | 835 |
| H-Si | 318 | C-N | 305 | N-F | 283 | O-Cl | 218 | F-Br | 249 | C=N | 615 |
| H-N | 386 | C-O | 358 | N-Cl | 313 | O-Br | 201 | F-I | 278 | C≡N | 887 |
| H-P | ≈322 | C-S | 272 | N-Br | 243 | O-I | 201 | Cl-Cl | 240 | C=O | 749 |
| H-O | 459 | C-F | 485 | P-P | 201 | S-S | 226 | Cl-Br | 216 | C≡O | 1072 |
| H-S | 363 | C-Cl | 327 | | | S-F | 284 | Cl-I | 208 | N=N | 418 |
| H-F | 565 | C-Br | 285 | | | S-Cl | 255 | Br-Br | 190 | N≡N | 942 |
| H-Cl | 428 | C-I | 213 | | | S-Br | 218 | Br-I | 175 | N=O | 607 |
| H-Br | 362 | Si-Si | 222 | | | | | I-I | 149 | O=O | 494 |
| H-I | 295 | Si-O | 452 | | | | | | | S=O | 532 |

Source: Data from J. E. Huheey, E. A. Keiter, and R. L. Keiter, *Inorganic Chemistry*, 4th ed. (1993).

- Bonds between hydrogen and atoms in the same column of the periodic table decrease in strength as we go down the column. Thus an H-F bond is stronger than an H-I bond, H-C is stronger than H-Si, H-N is stronger than H-P, H-O is stronger than H-S, and so forth. The reason for this is that the region of space in which electrons are shared between two atoms becomes proportionally smaller as one of the atoms becomes larger (part (a) in Figure 8.11).
- Bonds between like atoms usually become *weaker* as we go down a column (important exceptions are noted later). For example, the C-C single bond is stronger than the Si-Si single bond, which is stronger than the Ge-Ge bond, and so forth. As two bonded atoms become larger, the region between them occupied by bonding electrons becomes *proportionally* smaller, as illustrated in part (b) in Figure 8.11. Noteworthy exceptions are single bonds between the period 2 atoms of groups 15, 16, and 17 (i.e., N, O, F), which are unusually weak compared with single bonds between their larger congeners. It is likely that the N-N, O-O, and F-F single bonds are weaker than might be expected due to strong repulsive interactions between lone pairs of electrons on *adjacent* atoms. The trend in bond energies for the halogens is therefore



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Note

Bonds between hydrogen and atoms in a given column in the periodic table are weaker down the column; bonds between like atoms usually become weaker down a column.

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Note

Bond strengths increase as bond order **increases**, while bond distances **decrease**.

Table: Average bond energies:

| Bond | (kJ/mol) |
|------|----------|
| C-F | 485 |
| C-Cl | 328 |
| C-Br | 276 |
| C-I | 240 |
| C-C | 348 |
| C-N | 293 |
| C-O | 358 |
| C-F | 485 |
| C-C | 348 |
| C=C | 614 |
| C≡C | 839 |

Contributors

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