

Topic 4E - Contributions to Enthalpy

Table 8-3 Average Bond Enthalpies

Molar Enthalpy of Atomization (kJ mol ⁻¹) [†]		Bond Enthalpy (kJ mol ⁻¹) [‡]								
		H—	C—	C=	C≡	N—	N=	N≡	O—	O=
H	218.0	436	413			391			463	
C	716.7	413	348	615	812	292	615	891	351	728
N	472.7	391	292	615	891	161	418	945		
O	249.2	463	351	728	1076				139	498
S	278.8	339	259	477						
F	79.0	563	441			270			185	
Cl	121.7	432	328			200			203	
Br	111.9	366	276							
I	106.8	299	240							

[†]From Appendix D.[‡]From L. Pauling, *The Nature of the Chemical Bond*, 3rd ed. (Cornell University Press, Ithaca, New York, 1960).

TABLE 13.6

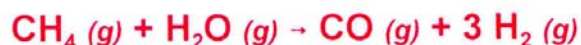
Average Bond Energies (kJ/mol)

Single Bonds				Multiple Bonds			
H—H	432	N—H	391	I—I	149	C=C	614
H—F	565	N—N	160	I—Cl	208	C≡C	839
H—Cl	427	N—F	272	I—Br	175	O=O	495
H—Br	363	N—Cl	200			C=O*	745
H—I	295	N—Br	243	S—H	347	C≡O	1072
		N—O	201	S—F	327	N=O	607
C—H	413	O—H	467	S—Cl	253	N=N	418
C—C	347	O—O	146	S—Br	218	N≡N	941
C—N	305	O—F	190	S—S	266	C=N	615
C—O	358	O—Cl	203			C≡N	891
C—F	485	O—I	234	Si—Si	340		
C—Cl	339			Si—H	393		
C—Br	276	F—F	154	Si—C	360		
C—I	240	F—Cl	253	Si—O	452		
C—S	259	F—Br	237				
		Cl—Cl	239				
		Cl—Br	218				
		Br—Br	193				

*C=O (CO₂) = 799

Bond Enthalpies

Steam reforming of methane:



ΔH° of reaction based on enthalpies of formation:

$$\Delta H^\circ = \Delta H_f^\circ (\text{CO}) + 3 \Delta H_f^\circ (\text{H}_2) - \Delta H_f^\circ (\text{CH}_4) - \Delta H_f^\circ (\text{H}_2\text{O})$$

$$= -111 + 3 (0) - (-75) - (-242) = + 206 \text{ kJ}$$

ΔH° of reaction based on bond enthalpies:

$$\Delta H^\circ = -[\Delta H (\text{C}\equiv\text{O}) + 3 \Delta H (\text{H}-\text{H})] + [4 \Delta H (\text{C}-\text{H}) + 2 \Delta H (\text{O}-\text{H})]$$

$$= -[1,076 + 3 (436)] + [4 (413) + 2 (463)] = + 194 \text{ kJ}$$

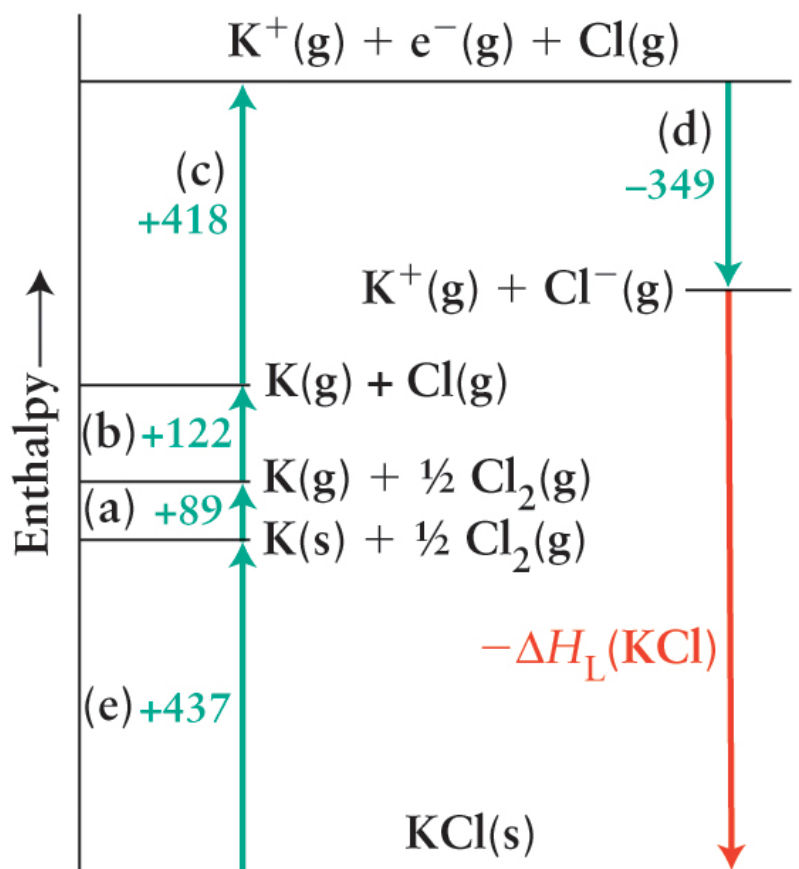


FIGURE 8.33 The Born–Haber cycle used to determine the lattice enthalpy of potassium chloride (see Example 8.12). The enthalpy changes are in kilojoules per mole.