4.2 IONIZATION ENERGY

TABLE 4.2 Ionization Energy of the Elements

The minimum amount of energy required to remove the least strongly bound electron from a gaseous atom (or ion) is called the ionization energy and is expressed in MJ · mol^{-1}. Remember that 96.485 kJ = 1.000 eV = 23.0605 kcal. In Table 4.2 the successive stages of ionization are indicated by the heading of each column: I denotes first spectra arising from a neutral atom; viz.,

$$M(\text{gas}) \rightarrow M^{+}(\text{gas}) + e^{-}$$

II, second spectra from singly ionized atoms, and so on for successive stages of ionization.

At. no.	Element	Spectrum (in MJ · mol^{-1})					
		I	II	III	IV	V	VI
1	H	1.312					
2	He	2.372	5.251				
3	Li	0.520	7.298	11.815			
4	Be	0.899	1.757	14.849	21.007		
5	B	0.801	2.427	3.660	25.027	32.828	
6	C	1.086	2.353	4.620	6.223	37.832	47.191
7	N	1.402	2.856	4.578	7.475	9.445	53.268
8	O	1.314	3.388	5.300	7.469	10.989	13.326
9	F	1.681	3.374	6.147	8.408	11.022	15.164
10	Ne	2.081	3.952	6.122	9.370	12.177	15.238
11	Na	0.496	4.562	6.912	9.543	13.353	16.610
12	Mg	0.738	1.451	7.733	10.540	13.629	17.994
13	Al	0.578	1.817	2.745	11.577	14.831	18.377
14	Si	0.786	1.577	3.231	4.355	16.091	19.784
15	P	1.012	1.903	2.912	4.956	6.274	21.268
16	S	1.000	2.251	3.361	4.564	7.004	8.495
17	Cl	1.251	2.297	3.822	5.158	6.54	9.362
18	Ar	1.521	2.666	3.931	5.771	7.238	8.787
19	K	0.419	3.051	4.411	5.877	7.976	9.649
20	Ca	0.590	1.145	4.912	6.474	8.144	10.496
21	Sc	0.631	1.235	2.389	7.089	8.844	10.719
22	Ti	0.658	1.310	2.652	4.175	9.573	11.516
23	V	0.650	1.414	2.828	4.507	6.299	12.362
24	Cr	0.653	1.592	2.987	4.743	6.70	8.738
25	Mn	0.717	1.509	3.248	4.94	6.99	9.22
26	Fe	0.759	1.561	2.957	5.63	7.24	9.56
27	Co	0.758	1.646	3.232	4.95	7.67	9.84
28	Ni	0.737	1.753	3.393	5.30	7.34	10.4
29	Cu	0.745	1.958	3.555	5.536	7.70	9.9
30	Zn	0.906	1.733	3.833	5.73	7.95	10.4
31	Ga	0.579	1.979	2.963	6.2		
32	Ge	0.762	1.537	3.302	4.410	9.022	
33	As	0.947	1.798	2.735	4.837	6.043	12.31
34	Sc	0.941	2.045	2.974	4.143	6.99	7.883
35	Br	1.140	2.10	3.47	4.56	5.76	8.55
36	Kr	1.351	2.350	3.565	5.07	6.24	7.57
37	Rb	0.403	2.632	3.9	5.08	6.85	8.14
38	Sr	0.549	1.064	4.138	5.5	6.91	8.76
39	Y	0.616	1.181	1.980	5.96	7.43	8.97
40	Zr	0.660	1.267	2.218	3.313	7.75	

TABLE 4.2 Ionization Energy of the Elements (*Continued*)

At. no.	Element	Spectrum (in MJ · mol^{-1}) I	II	III	IV	V	VI
41	Nb	0.664	1.382	2.416	3.695	4.877	9.847
42	Mo	0.685	1.558	2.621	4.477	5.91	6.641
43	Tc	0.702	1.472	2.850			
44	Ru	0.711	1.617	2.747			
45	Rh	0.720	1.744	2.997			
46	Pd	0.805	1.875	3.177			
47	Ag	0.731	2.073	3.361			
48	Cd	0.868	1.631	3.616			
49	In	0.558	1.821	2.704	5.2		
50	Sn	0.709	1.412	2.943	3.930	6.974	
51	Sb	0.834	1.595	2.44	4.26	5.4	10.4
52	Te	0.869	1.795	2.698	3.610	5.668	6.82
53	I	1.008	1.846	3.2			
54	Xe	1.170	2.046	3.099			
55	Cs	0.376	2.234				
56	Ba	0.503	0.965				
57	La	0.538	1.067	1.850	4.820	5.94	
58	Ce	0.528	1.047	1.949	3.547	6.325	7.487
59	Pr	0.523	1.018	2.086	3.761	5.551	
60	Nd	0.530	1.035	2.13	3.90		
61	Pm	0.535	1.052	2.15	3.97		
62	Sm	0.543	1.068	2.26	3.99		
63	Eu	0.547	1.085	2.40	4.12		
64	Gd	0.592	1.167	1.99	4.26		
65	Tb	0.564	1.112	2.114	3.839		
66	Dy	0.572	1.126	2.20	3.99		
67	Ho	0.581	1.139	2.204	4.10		
68	Er	0.589	1.151	2.194	4.13		
69	Tm	0.596	1.163	2.285	4.13		
70	Yb	0.603	1.174	2.417	4.203		
71	Lu	0.524	1.34	2.022	4.366		
72	Hf	0.68	1.44	2.25	3.216		
73	Ta	0.761					
74	W	0.770					
75	Re	0.760					
76	Os	0.84					
77	Ir	0.88					
78	Pt	0.87	1.791				
79	Au	0.890	1.98				
80	Hg	1.007	1.810	3.30			
81	Tl	0.589	1.971	2.878			
82	Pb	0.716	1.450	3.081	4.083	6.64	
83	Bi	0.703	1.610	2.466	4.371	5.40	8.52
84	Po	0.812					
85	At						
86	Rn	1.037					
87	Fr						
88	Ra	0.509	0.979				
89	Ac	0.67	1.17				
90	Th	0.587	1.11	1.93	2.78		
91	Pa	0.568					

TABLE 4.2 Ionization Energy of the Elements (*Continued*)

At. no.	Element	Spectrum (in MJ · mol^{-1}) I	II	III	IV	V	VI
92	U	0.598					
93	Np	0.605					
94	Pu	0.585					
95	Am	0.578					
96	Cm	0.581					
97	Bk	0.601					
98	Cf	0.608					
99	Es	0.619					
100	Fm	0.627					
101	Md	0.635					
102	No	0.642					

Source: C. E. Moore, *National Standard Reference Data Series 34*, U.S. Government Printing Office, Washington, D.C., 1970; W. C. Martin, Zalubas, R., and Hagan, L., *J. Phys. Chem. Reference Data*, **3**:771 (1974) and National Standard Reference Data Series, National Bureau of Standards (U.S.), No. 60 (1978) for the Rare Earth Elements; and Cohen, E. R. and Taylor, B. N., *J. Phys. Chem. Reference Data*, **17**:1795 (1988).