

Chapter 7

Periodic Properties of the Elements

- Explain the meaning of effective nuclear charge, Z_{eff} , and how Z_{eff} depends on nuclear charge and electron configuration.
- Predict the trends in atomic radii, ionic radii, ionization energy, and electron affinity by using the periodic table.
- Explain how the radius of an atom changes upon losing electrons to form a cation or gaining electrons to form an anion.
- Write the electron configurations of ions.
- Explain how the ionization energy changes as we remove successive electrons, and the jump in ionization energy that occurs when the ionization corresponds to removing a core electron.
- Explain how irregularities in the periodic trends for electron affinity can be related to electron configuration.
- Explain the differences in chemical and physical properties of metals and nonmetals, including the basicity of metal oxides and the acidity of nonmetal oxides.
- Correlate atomic properties, such as ionization energy, with electron configuration, and explain how these relate to the chemical reactivity and physical properties of the alkali and alkaline earth metals (groups 1A and 2A).
- Write balanced equations for the reactions of the group 1A and 2A metals with water, oxygen, hydrogen, and the halogens.
- List and explain the unique characteristics of hydrogen.
- Correlate the atomic properties (such as ionization energy, electron configuration, and electron affinity) of group 6A, 7A, and 8A elements with their chemical reactivity and physical properties.

Development of Periodic Table

H																	He			
Li	Be											B	C	N	O	F	Ne			
Na	Mg											Al	Si	P	S	Cl	Ar			
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr			
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe			
Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn			
Fr	Ra	Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Uut	Fl	Uup	Lv	Uus	Uuo			
		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb					
		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No					
Ancient Times (9 elements)			Middle Ages–1700 (6 elements)			1735–1843 (42 elements)			1843–1886 (18 elements)			1894–1918 (11 elements)			1923–1961 (17 elements)			1965– (15 elements)		

- Dmitri Mendeleev and Lothar Meyer (~1869) independently came to the same conclusion about how elements should be grouped in the **periodic table**.
- Henry Moseley (1913) developed the concept of **atomic numbers** (the number of protons in the nucleus of an atom)

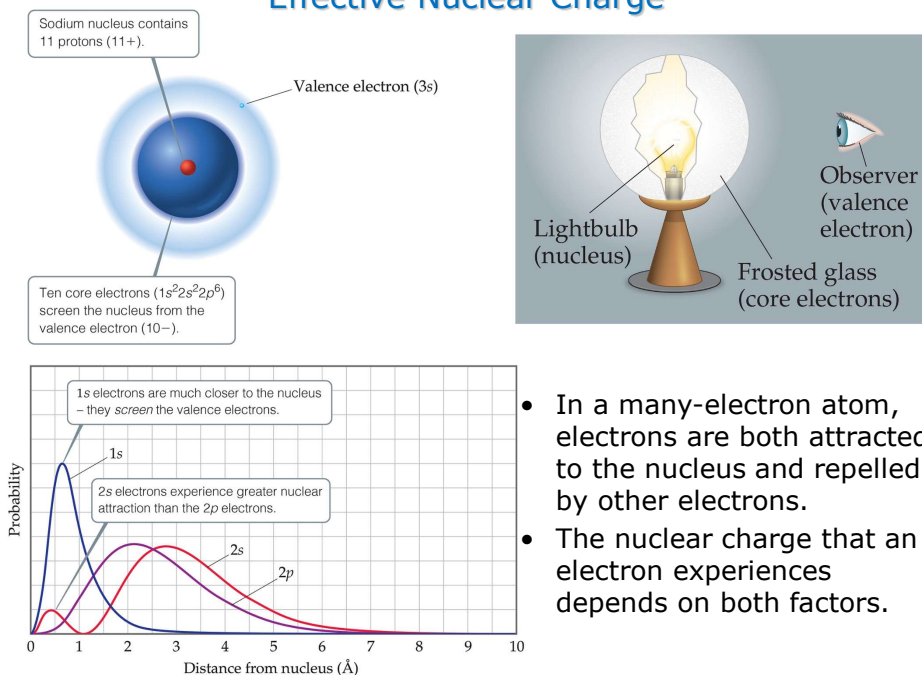
Predictions and the Periodic Table

TABLE 7.1 Comparison of the Properties of Eka-Silicon Predicted by Mendeleev with the Observed Properties of Germanium

Property	Mendeleev's Predictions for Eka-Silicon (made in 1871)	Observed Properties of Germanium (discovered in 1886)
Atomic weight	72	72.59
Density (g/cm ³)	5.5	5.35
Specific heat (J/g-K)	0.305	0.309
Melting point (°C)	High	947
Color	Dark gray	Grayish white
Formula of oxide	XO ₂	GeO ₂
Density of oxide (g/cm ³)	4.7	4.70
Formula of chloride	XCl ₄	GeCl ₄
Boiling point of chloride(°C)	A little under 100	84

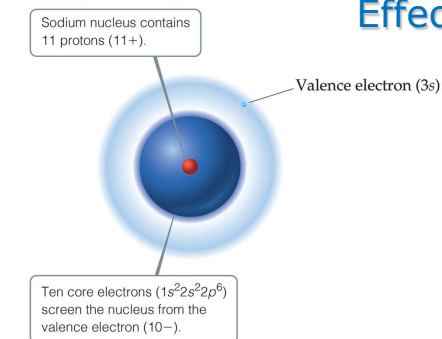
Mendeleev, for instance, predicted the discovery of germanium (which he called eka-silicon) as an element with an atomic weight between that of zinc and arsenic, but with chemical properties similar to those of silicon.

Effective Nuclear Charge



- In a many-electron atom, electrons are both attracted to the nucleus and repelled by other electrons.
- The nuclear charge that an electron experiences depends on both factors.

Effective Nuclear Charge



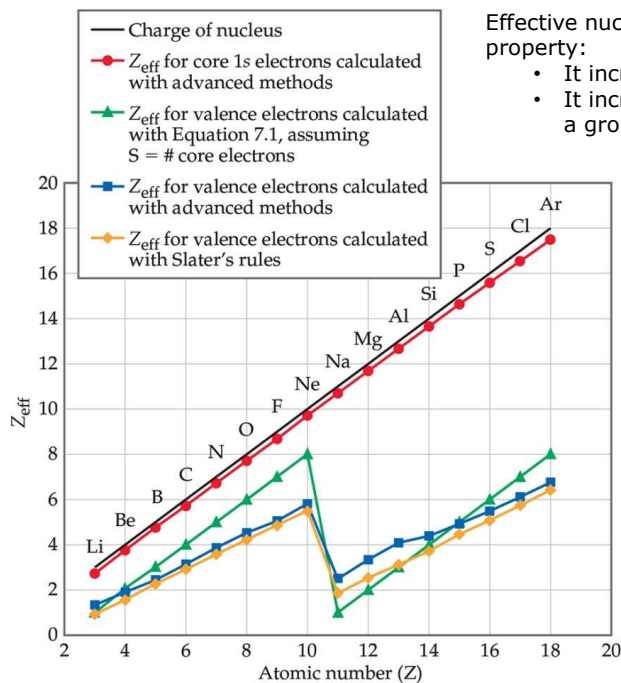
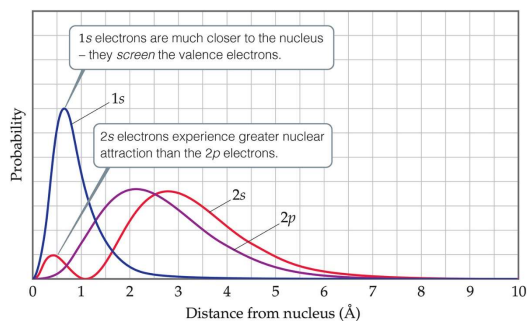
The effective nuclear charge, Z_{eff} is:

$$Z_{\text{eff}} = Z - S$$

where Z is the atomic number and S is a screening constant, usually close to the number of inner (core) electrons.

The valence electrons do not screen as efficiently as core electrons.

Z_{eff} is a representation of the *average* electrical field experienced by a single electron.

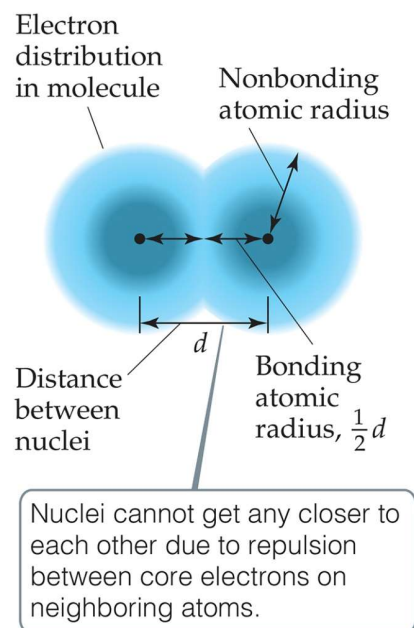


Effective nuclear charge is a periodic property:

- It increases across a period.
- It increases *slightly* down a group.

Sizes of Atoms

- The **nonbonding atomic radius**, or **van der Waals radius**, is half of the shortest distance separating two nuclei during a collision of atoms.
- The **bonding atomic radius** is defined as one-half of the distance between covalently bonded nuclei.

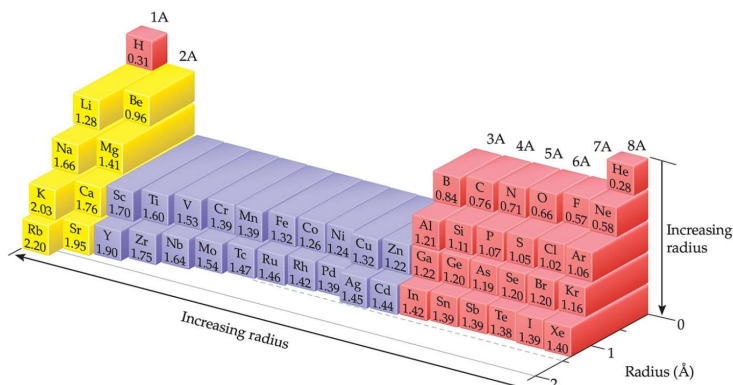










































Periodic Trends in Atomic Radii




Bonding atomic radius tends to...

...decrease from left to right across a row
due to increasing Z_{eff} .

...increase from top to bottom of a column
due to increasing value of n



Group 1A	Group 2A	Group 3A	Group 6A	Group 7A
Li^+ 0.90   Li 1.28	Be^{2+} 0.59   Be 0.96	B^{3+} 0.41   B 0.84	O^{2-} 1.26   O 0.66	F^- 1.19   F 0.57
Na^+ 1.16   Na 1.66	Mg^{2+} 0.86   Mg 1.41	Al^{3+} 0.68   Al 1.21	S^{2-} 1.70   S 1.05	Cl^- 1.67   Cl 1.02
K^+ 1.52   K 2.03	Ca^{2+} 1.14   Ca 1.76	Ga^{3+} 0.76   Ga 1.22	Se^{2-} 1.84   Se 1.20	Br^- 1.82   Br 1.20
Rb^+ 1.66   Rb 2.20	Sr^{2+} 1.32   Sr 1.95	In^{3+} 0.94   In 1.42	Te^{2-} 2.07   Te 1.38	I^- 2.06   I 1.39

 = cation
  = anion
  = neutral atom

Sizes of Ions

Ionic size depends upon:

- Nuclear charge, number of electrons, orbitals in which electrons reside.
- Cations are smaller than their parent atoms.
 - The outermost electron is removed and repulsions are reduced.
- Anions are larger than their parent atoms.
 - Electrons are added and repulsions are increased.

Sizes of Ions

- In an **isoelectronic series**, ions have the same number of electrons.
- Ionic size decreases with an increasing nuclear charge.
- Increasing nuclear charge with decreasing ionic radius as atomic number increases.

Increasing nuclear charge →				
8 protons	9 protons	11 protons	12 protons	13 protons
10 electrons	10 electrons	10 electrons	10 electrons	10 electrons
O^{2-}	F^-	Na^+	Mg^{2+}	Al^{3+}
1.26 Å	1.19 Å	1.16 Å	0.86 Å	0.68 Å
Decreasing ionic radius →				

Ionization Energy

Amount of energy required to remove an electron from the ground state of a gaseous atom or ion.

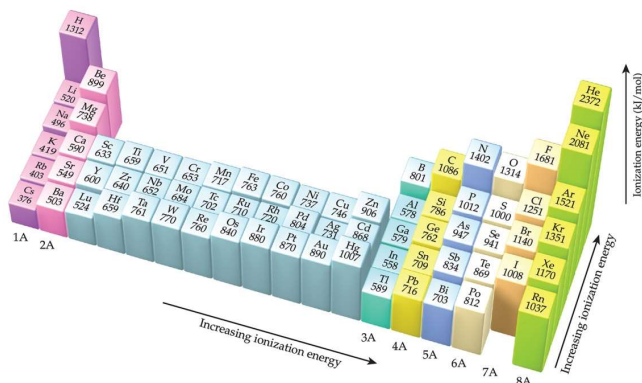
- **First** ionization energy is that energy required to remove **first electron**.
- **Second** ionization energy is that energy required to remove **second electron**, etc.

TABLE 7.2 Successive Values of Ionization Energies, I , for the Elements Sodium through Argon (kJ/mol)

Element	I_1	I_2	I_3	I_4	I_5	I_6	I_7
Na	496	4562					
Mg	738	1451	7733				
Al	578	1817	2745	11,577			
Si	786	1577	3232	4356	16,091		
P	1012	1907	2914	4964	6274	21,267	
S	1000	2252	3357	4556	7004	8496	27,107
Cl	1251	2298	3822	5159	6542	9362	11,018
Ar	1521	2666	3931	5771	7238	8781	11,995

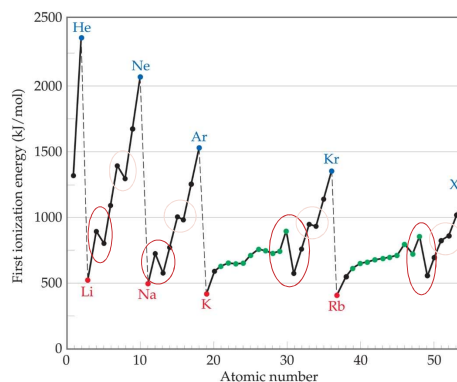
Trends in First Ionization Energies

- I_1 generally decreases down a group. For atoms in the same group, Z_{eff} is essentially the same, but the valence electrons are farther from the nucleus.
- I_1 generally increases across a period.
- The s - and p -block elements show a larger range of values for I_1 .
- The d -block generally increases slightly across the period; the f -block elements show only small changes.



Irregularities in First Ionization Energies

- Discontinuity occurs between Groups IIA and IIIA.
- Electron removed from *p*-orbital rather than *s*-orbital
 - Electron farther from nucleus
 - Small amount of repulsion by *s* electrons.
- The second occurs between Groups VA and VIA.
 - Electron removed comes from doubly occupied orbital.
 - Repulsion from other electron in orbital helps in its removal.



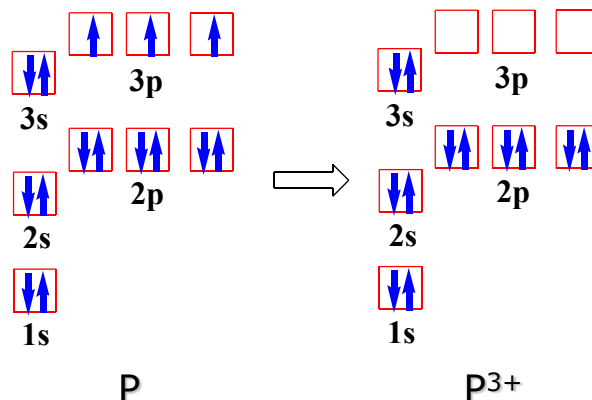
Oxygen



Nitrogen

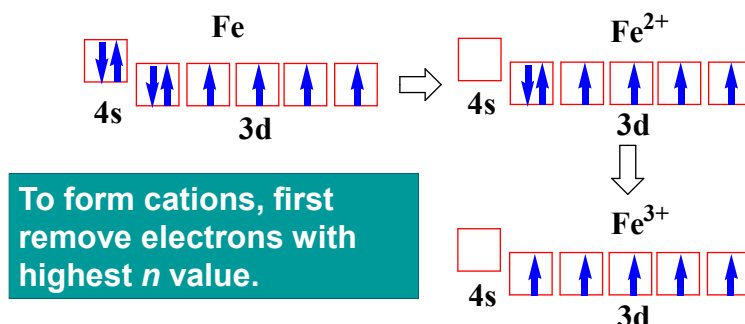
Electronic Configurations of Ions

To form cations from elements remove e^- 's from the subshell with the **highest n** .



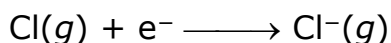
Electronic Configurations of Ions

For transition metals, remove ns electrons and then $(n - 1)d$ electrons.



Electron Affinity

Energy change accompanying addition of electron to gaseous atom:



1A	2A	3A	4A	5A	6A	7A	8A
H -73							He > 0
Li -60	Be > 0	B -27	C -122	N > 0	O -141	F -328	Ne > 0
Na -53	Mg > 0	Al -43	Si -134	P -72	S -200	Cl -349	Ar > 0
K -48	Ca -2	Ga -30	Ge -119	As -78	Se -195	Br -325	Kr > 0
Rb -47	Sr -5	In -30	Sn -107	Sb -103	Te -190	I -295	Xe > 0

In general, electron affinity becomes more exothermic as you go from left to right across a row.

Three notable exceptions include the following:

- 1) Group 2A: s sublevel is full
- 2) Group 5A: p sublevel is half-full
- 3) Group 8A: p sublevel is full

Halogens have the most negative electron affinity.

Metal, Nonmetals, and Metalloids

TABLE 7.3 Characteristic Properties of Metals and Nonmetals

Metals	Nonmetals
Have a shiny luster; various colors, although most are silvery	Do not have a luster; various colors
Solids are malleable and ductile	Solids are usually brittle; some are hard, and some are soft
Good conductors of heat and electricity	Poor conductors of heat and electricity
Most metal oxides are ionic solids that are basic	Most nonmetal oxides are molecular substances that form acidic solutions
Tend to form cations in aqueous solution	Tend to form anions or oxyanions in aqueous solution



	← Increasing metallic character																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
↑ Increasing metallic character	1A																	8A																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
	1																	2																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
	H																	He																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
	3	4															5	6	7	8	9	10																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
	Li	Be															B	C	N	O	F	Ne																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	Ra	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
Fr	Ra	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
87	88	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000
Fr	Ra	Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		

Metals versus Nonmetals

Metals tend to form cations.

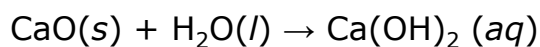
Nonmetals tend to form anions.

1A																	7A	8A			
H ⁺																	H ⁻	N O B L E G A S E S			
2A																	3A		4A	5A	6A
Li ⁺		Transition metals														Al ³⁺			N ³⁻	O ²⁻	F ⁻
Na ⁺	Mg ²⁺																		P ³⁻	S ²⁻	Cl ⁻
K ⁺	Ca ²⁺	Sc ³⁺	Ti ⁴⁺	V ⁵⁺ V ⁴⁺	Cr ³⁺	Mn ²⁺ Mn ⁴⁺	Fe ²⁺ Fe ³⁺	Co ²⁺ Co ³⁺	Ni ²⁺	Cu ⁺ Cu ²⁺	Zn ²⁺				Se ²⁻	Br ⁻					
Rb ⁺	Sr ²⁺	Y ³⁺	Zr ⁴⁺							Pd ²⁺	Ag ⁺	Cd ²⁺			Sn ²⁺ Sn ⁴⁺	Sb ³⁺ Sb ⁵⁺	Te ²⁻	I ⁻			
Cs ⁺	Ba ²⁺	Lu ³⁺	Hf ⁴⁺							Pt ²⁺	Au ⁺ Au ³⁺	Hg ²⁺ Hg ²⁺			Pb ²⁺ Pb ⁴⁺	Bi ³⁺ Bi ⁵⁺					

Metals



- Compounds formed between metals and nonmetals tend to be ionic.
- Metal oxides tend to be **basic**.

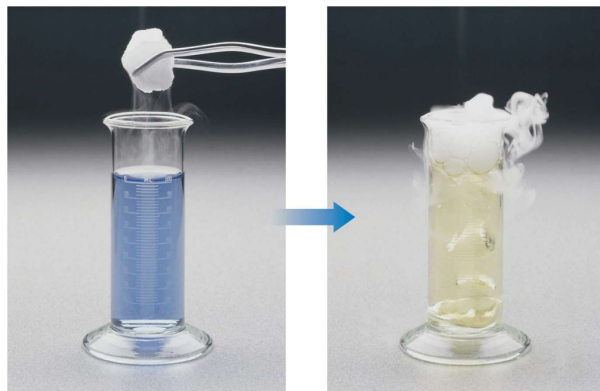


Nonmetals



- Dull, brittle substances that are poor conductors of heat and electricity.
- Large negative electron affinity, tend to gain electrons in reactions with metals to acquire noble gas configuration.
- Substances containing only nonmetals are molecular compounds.

Nonmetals



- Most nonmetal oxides are acidic.
- Nonmetal oxides react with bases to form salts and water.

Metalloids



13	14	15	16
5 B	6 C	7 N	8 O
13 Al	14 Si	15 P	16 S
31 Ga	32 Ge	33 As	34 Se
49 In	50 Sn	51 Sb	52 Te

- B, Si, Ge, As, Sb, Te
- Have some characteristics of metals, some of nonmetals.
- For instance, silicon looks shiny (metallic luster), but is brittle and fairly poor conductor (semiconductor).

Group Trends

- Elements in a group have similar properties.
- Trends also exist within groups.
- Groups compared:
 - Group 1A: the alkali metals
 - Group 2A: the alkaline earth metals
 - Group 6A: the oxygen group
 - Group 7A: the halogens
 - Group 8A: the noble gases
 - Hydrogen: nonmetal

Alkali Metals

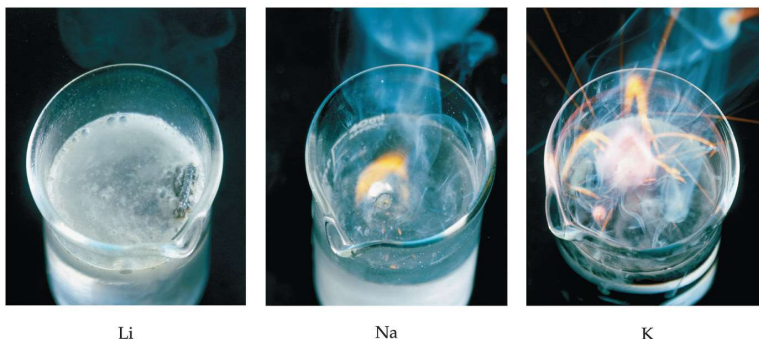
- Soft, metallic solids.
- Name comes from Arabic word for ashes.
- Found only as compounds in nature.
- Have low densities and melting points.
- Also have low ionization energies.



TABLE 7.4 Some Properties of the Alkali Metals

Element	Electron Configuration	Melting Point (°C)	Density (g/cm ³)	Atomic Radius (Å)	<i>I</i> ₁ (kJ/mol)
Lithium	[He]2s ¹	181	0.53	1.28	520
Sodium	[Ne]3s ¹	98	0.97	1.66	496
Potassium	[Ar]4s ¹	63	0.86	2.03	419
Rubidium	[Kr]5s ¹	39	1.53	2.20	403
Cesium	[Xe]6s ¹	28	1.88	2.44	376

Alkali Metals



Li

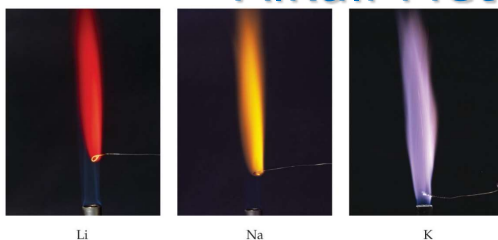
Na

K

Reactions with water are exothermic

React with oxygen, hydrogen, and halogens.

Alkali Metals



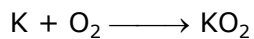
Li

Na

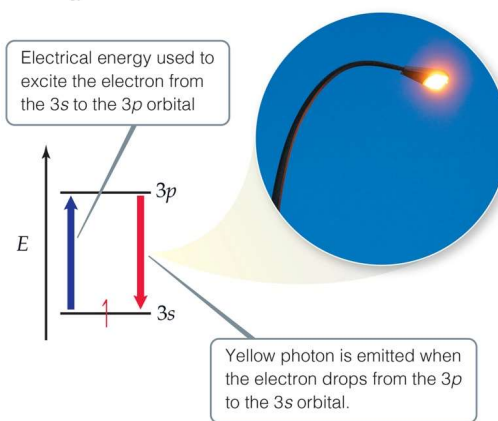
K

Alkali metals (except Li) react with oxygen to form peroxides.

- K, Rb, and Cs also form superoxides:



Produce bright colors when placed in flame.



Alkaline Earth Metals

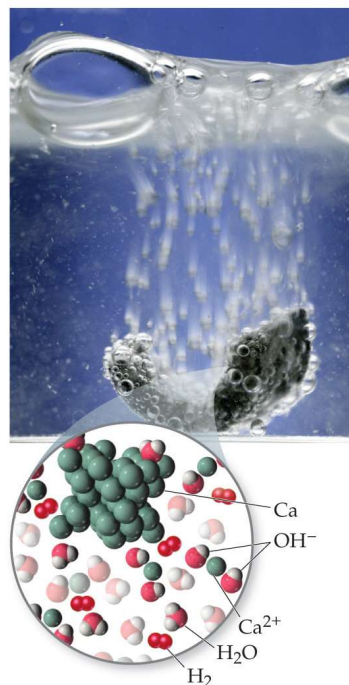
TABLE 7.5 Some Properties of the Alkaline Earth Metals

Element	Electron Configuration	Melting Point (°C)	Density (g/cm ³)	Atomic Radius (Å)	I_1 (kJ/mol)
Beryllium	[He]2s ²	1287	1.85	0.96	899
Magnesium	[Ne]3s ²	650	1.74	1.41	738
Calcium	[Ar]4s ²	842	1.55	1.76	590
Strontium	[Kr]5s ²	777	2.63	1.95	549
Barium	[Xe]6s ²	727	3.51	2.15	503

- Have higher densities and melting points than alkali metals.
- Have low ionization energies, but not as low as alkali metals.

Alkaline Earth Metals

- Be does not react with water, Mg reacts only with steam, but others react readily with water.
- Reactivity tends to increase as go down group.



Hydrogen

- $1s^1$ a metallic electron configuration like the other ns^1 elements
- We do think of acid compounds, like HCl, as having H^+ , however they are really covalent in nature.
- When reacting with metals, hydride anions (H^-) form.
- Forms both ionic (H^- with metals) and molecular compounds (H^+ with nonmetals).

Group 6A - chalcogens

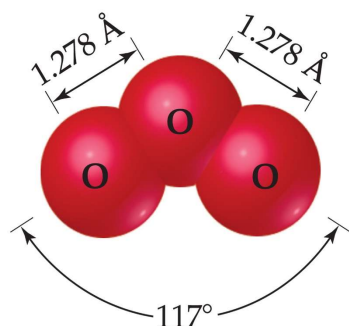
TABLE 7.6 Some Properties of the Group 6A Elements

Element	Electron Configuration	Melting Point ($^{\circ}C$)	Density	Atomic Radius (\AA)	I_1 (kJ/mol)
Oxygen	$[\text{He}]2s^22p^4$	-218	1.43 g/L	0.66	1314
Sulfur	$[\text{Ne}]3s^23p^4$	115	1.96 g/cm ³	1.05	1000
Selenium	$[\text{Ar}]3d^{10}4s^24p^4$	221	4.82 g/cm ³	1.20	941
Tellurium	$[\text{Kr}]4d^{10}5s^25p^4$	450	6.24 g/cm ³	1.38	869
Polonium	$[\text{Xe}]4f^{14}5d^{10}6s^26p^4$	254	9.20 g/cm ³	1.40	812

- Oxygen, sulfur, and selenium are nonmetals.
- Tellurium is a metalloid.
- Radioactive polonium is a metal, forms a cation.

oxygen	8	O
sulfur	16	S
selenium	34	Se
tellurium	52	Te
polonium	84	Po

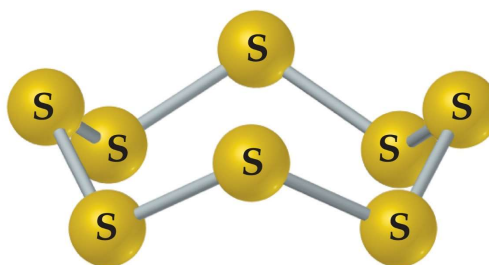
Oxygen and Sulfur



- Two allotropes:
 - O_2 , dioxygen
 - O_3 , ozone
- Three anions:
 - O^{2-} , oxide
 - O_2^{2-} , peroxide
 - O_2^{1-} , superoxide
- Tends to take electrons from other elements (oxidation)



- S is weaker oxidizing agent than oxygen.
- Most stable allotrope is S_8 , a ringed molecule shaped like a crown.



Group VIIA: Halogens

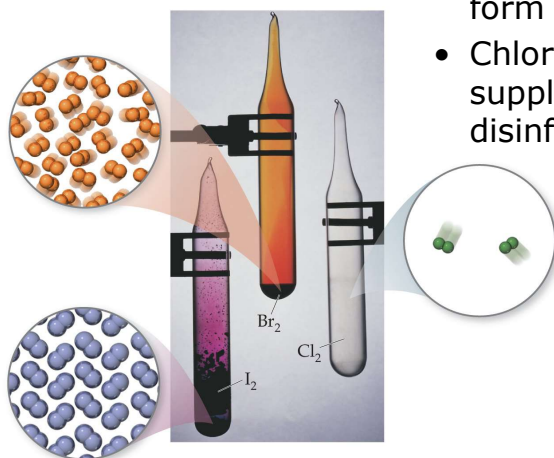
TABLE 7.7 Some Properties of the Halogens

Element	Electron Configuration	Melting Point ($^{\circ}\text{C}$)	Density	Atomic Radius (\AA)	I_1 (kJ/mol)
Fluorine	$[\text{He}]2s^22p^5$	-220	1.69 g/L	0.57	1681
Chlorine	$[\text{Ne}]3s^23p^5$	-102	3.12 g/L	1.02	1251
Bromine	$[\text{Ar}]4s^23d^{10}4p^5$	-7.3	3.12 g/cm ³	1.20	1140
Iodine	$[\text{Kr}]5s^24d^{10}5p^5$	114	4.94 g/cm ³	1.39	1008

- Prototypical nonmetals
- Name comes from the Greek *halos* and *gennao*: "salt formers"

Group VIIA: Halogens

- Large, negative electron affinities
 - Therefore, tend to oxidize other elements easily
- React directly with metals to form metal halides
- Chlorine added to water supplies to serve as disinfectant



Group VIIIA: Noble Gases

TABLE 7.8 Some Properties of the Noble Gases

Element	Electron Configuration	Boiling Point (K)	Density (g/L)	Atomic Radius* (Å)	I_1 (kJ/mol)
Helium	$1s^2$	4.2	0.18	0.28	2372
Neon	$[He]2s^22p^6$	27.1	0.90	0.58	2081
Argon	$[Ne]3s^23p^6$	87.3	1.78	1.06	1521
Krypton	$[Ar]4s^23d^{10}4p^6$	120	3.75	1.16	1351
Xenon	$[Kr]5s^24d^{10}5p^6$	165	5.90	1.40	1170
Radon	$[Xe]6s^24f^{14}5d^{10}6p^6$	211	9.73	1.50	1037

*Only the heaviest of the noble-gas elements form chemical compounds. Thus, the atomic radii for the lighter noble-gas elements are estimated values.

- Monatomic gases
- Large ionization energies
- Positive electron affinities
- Relatively unreactive
 - Only fluorine (F) can remove electrons to form compounds
 - XeF_2 , XeF_4 , XeF_6 , KrF_2 are known



XeF_4