

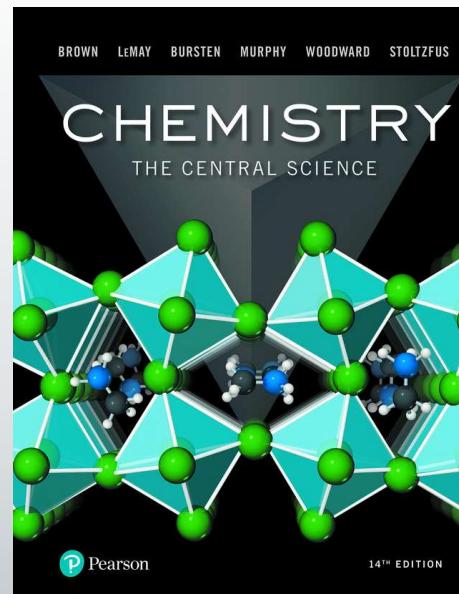
Chapter 7

Periodic Properties of the Elements

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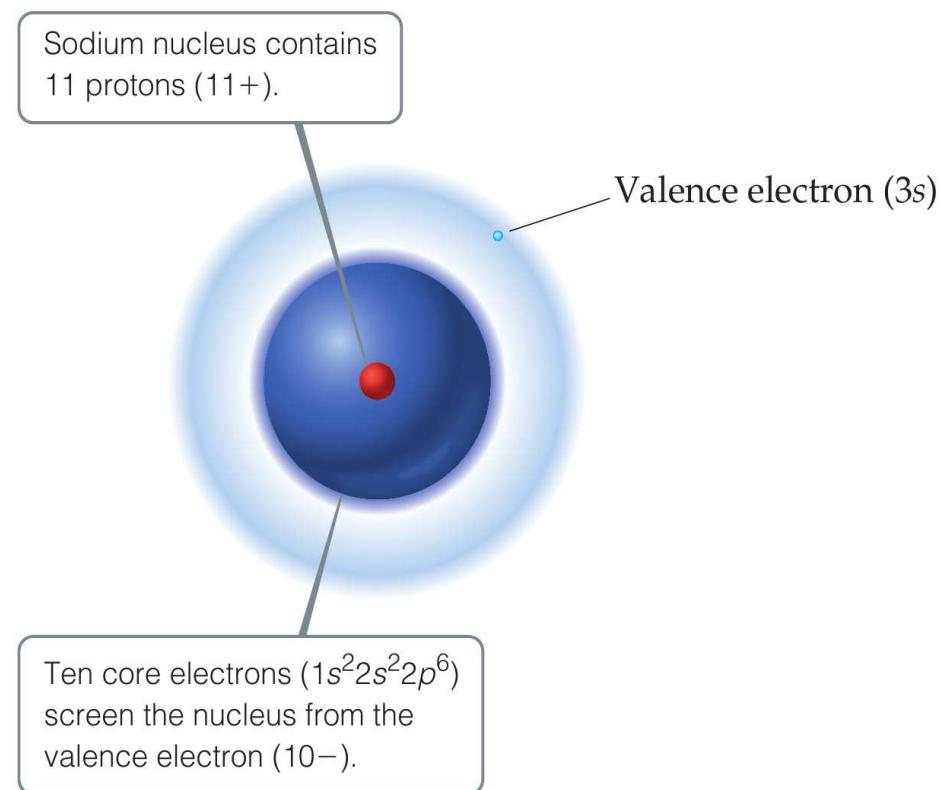
7.2 Effective Nuclear Charge

- ❖ The attractive force between an electron and the nucleus increases as the nuclear charge increases and decreases as the electron moves farther from the nucleus.
- ❖ In a many-electron atom, in addition to the attraction of each electron to the nucleus, each electron experiences the repulsion due to other electrons.
- ❖ Each electron in a many-electron atom is **screened** from the nucleus by the other electrons.
- ❖ The partially screened nuclear charge is called the **effective nuclear charge**, Z_{eff} .

7.2 Effective Nuclear Charge

- ❖ The amount of screening of the actual nuclear charge (Z) is defined by using a **screening constant** (S), appositive number, such that

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



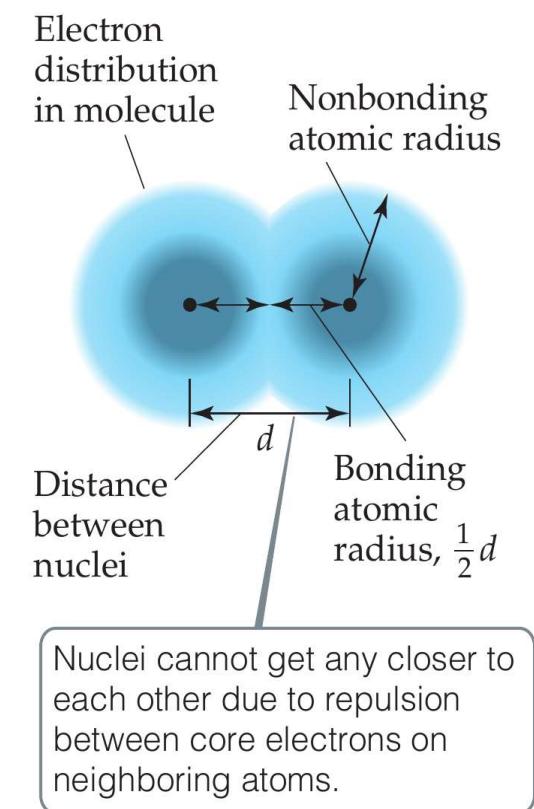
$$Z_{\text{eff}} = 11 - 10 = 1$$

7.2 Effective Nuclear Charge

- ❖ The notion of effective nuclear charge also explains an important effect: For a many-electron atom, the energies of orbitals with the same n value increase with increasing l value (i. e., $ns < np < nd$).
- ❖ The effective nuclear charge **increases** from **left to right** across any period of the periodic table.
- ❖ The effective nuclear charge **increases slightly** as we go down a column because the more diffuse core electron cloud is less able to screen the valence electrons from the nuclear charge.

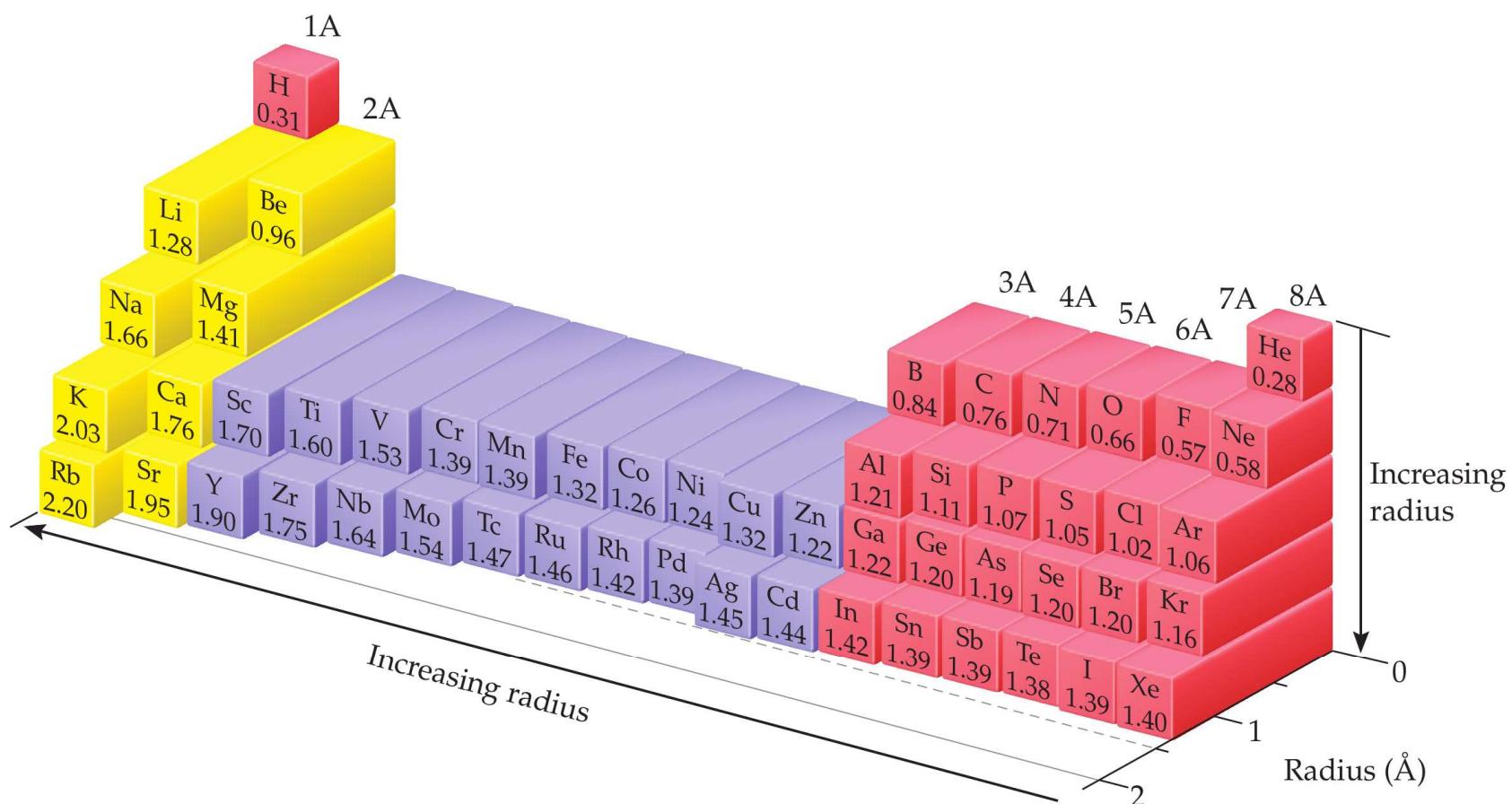
7.3 Sizes of Atoms and Ions

- ❖ According to the quantum-mechanical model, atoms do not have sharply defined boundaries at which the electron distribution becomes zero.
- ❖ The radius of an atom is called the **nonbonding atomic radius** or the **van der Waals radius**.
- ❖ The **bonding atomic radius** (also known as the **covalent radius**) for any atom in a molecule is equal to half of the bond distance d .



▲ **Figure 7.6** Distinction between nonbonding and bonding atomic radii within a molecule.

7.3 Sizes of Atoms and Ions



▲ Figure 7.7 Trends in bonding atomic radii for periods 1 through 5.

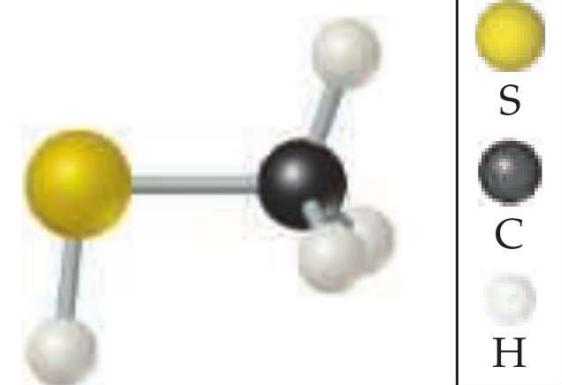
Sample Exercise 7.1

Natural gas used in home heating and cooking is odorless. Because natural gas leaks pose the danger of explosion or suffocation, various smelly substances are added to the gas to allow detection of a leak. One such substance is methyl mercaptan, CH_3SH . Use Figure 7.7 to predict the lengths of the C–S, C–H, and S–H bonds in this molecule.

$$\text{Bond length C} - \text{S} = 0.76 + 1.05 = 1.81 \text{ \AA}$$

$$\text{Bond length C} - \text{H} = 0.76 + 0.31 = 1.07 \text{ \AA}$$

$$\text{Bond length S} - \text{H} = 1.05 + 0.31 = 1.36 \text{ \AA}$$



Methyl mercaptan

7.3 Sizes of Atoms and Ions

Periodic Trends in Atomic Radii

- ❖ Within each group, bonding atomic radius tends to **increase** from top to bottom: This trend results primarily from the increase in the principal quantum number (n) of the outer electrons.
- ❖ Within each period, bonding atomic radius tends to **decrease** from left to right: The major factor influencing this trend is the increase in effective nuclear charge Z_{eff} across a period. The increasing effective nuclear charge steadily draws the valence electrons closer to the nucleus, causing the bonding atomic radius to decrease.

Sample Exercise 7.2

Referring to the periodic table, arrange (as much as possible) the atoms B, C, Al, and Si in order of increasing size.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1.00794	2 Be Beryllium 9.012182	C Solid														He Helium 4.002602	
3 Li Lithium 6.941	4 Be Beryllium 9.012182	Hg Liquid														2 He Helium 4.002602	
11 Na Sodium 22.98976928	12 Mg Magnesium 24.305	H Gas														10 Ne Neon 20.1797	
3 Na Sodium 22.98976928	12 Mg Magnesium 24.305	Rf Unknown														18 Ar Argon 39.948	
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955912	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938045	26 Fe Iron 55.845	27 Co Cobalt 58.93195	28 Ni Nickel 58.6934	29 Cu Copper 63.54	30 Zn Zinc 65.38	13 B Boron 10.811	14 Si Silicon 28.0855	15 P Phosphorus 30.973762	16 S Sulfur 32.065	17 Cl Chlorine 35.453	18 Ar Argon 39.948
4 K Potassium 39.0983	20 Ca Calcium 40.078															273 He Helium 4.002602	
37 Rb Rubidium 83.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.96	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.9055	46 Pd Palladium 106.42	47 Ag Silver 107.8632	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.6	53 I Iodine 126.90447	54 Xe Xenon 131.293
55 Cs Cesium 132.9054519	56 Ba Barium 137.327	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.94783	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.084	79 Au Gold 196.966569	80 Hg Mercury 201.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.9804	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89-103	104 Rf Rutherfordium (267)	105 Db Dubnium (268)	106 Bh Berkelium (271)	107 Hs Hassium (272)	108 Mt Meitnerium (270)	109 Ds Darmstadtium (276)	110 Rg Roentgenium (281)	111 Cn Copernicium (280)	112 Uut Ununtrium (285)	113 Fl Florineum (284)	114 Uup Ununpentium (289)	115 Lv Livermorium (283)	116 Uus Ununhexium (293)	117 Lv Livermorium (294)	118 Uuo Ununoctium (294)

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

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57 La Lanthanum 138.90547	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.242	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92535	66 Dy Dysprosium 162.5	67 Ho Holmium 164.93032	68 Er Erbium 167.259	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.054	71 Lu Lutetium 174.9668
89 Ac Actinium (227)	90 Th Thorium 232.03806	91 Pa Protactinium 231.03588	92 U Uranium 238.03891	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

➤ C < B ~ Si < Al

Sample Exercise 7.2: Practice Exercise 1

By referring to the periodic table, place the following atoms in order of increasing bonding atomic radius: N, O, P, Ge.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1.00794	2 He Helium 4.002602	3 Li Lithium 6.941	4 Be Beryllium 9.012182	5 C Solid	6	7	8	9	10	11	12	13	14	15	16	17	18 He Helium 4.002602
2 Na Sodium 22.98976928	3 Mg Magnesium 24.305	4 Al Aluminum 26.9815386	5 Si Silicon 28.0855	6 C Carbon 12.0107	7 N Nitrogen 14.0067	8 O Oxygen 15.9994	9 F Fluorine 18.9984032	10 Ne Neon 20.1797	11 Cl Chlorine 35.453	12 Ar Argon 39.948	13 B Boron 10.811	14 Si Silicon 28.0855	15 P Phosphorus 30.973762	16 S Sulfur 32.065	17 Cl Chlorine 35.453	18 Ar Argon 39.948	
3 Ca Calcium 40.078	4 Sc Scandium 44.955912	5 Ti Titanium 47.867	6 V Vanadium 50.9415	7 Cr Chromium 51.9961	8 Mn Manganese 54.938045	9 Fe Iron 55.845	10 Co Cobalt 58.93195	11 Ni Nickel 58.6934	12 Cu Copper 63.54	13 Zn Zinc 65.38	14 Ga Gallium 69.723	15 Ge Germanium 72.63	16 As Arsenic 74.9216	17 Se Selenium 78.96	18 Br Bromine 79.904	19 K Potassium 39.0983	20 Ca Calcium 40.078
4 Rb Rubidium 83.4678	5 Sr Strontium 87.62	6 Y Yttrium 88.90585	7 Zr Zirconium 91.224	8 Sc Scandium 44.955912	9 Ti Titanium 47.867	10 V Vanadium 50.9415	11 Cr Chromium 51.9961	12 Mn Manganese 54.938045	13 Fe Iron 55.845	14 Co Cobalt 58.93195	15 Ni Nickel 58.6934	16 Cu Copper 63.54	17 Zn Zinc 65.38	18 Ga Gallium 69.723	19 Ge Germanium 72.63	20 As Arsenic 74.9216	21 Br Bromine 79.904
5 Cs Cesium 132.9054519	6 Ba Barium 137.327	7 Y Yttrium 88.90585	8 Zr Zirconium 91.224	9 Sc Scandium 44.955912	10 Ti Titanium 47.867	11 V Vanadium 50.9415	12 Cr Chromium 51.9961	13 Mn Manganese 54.938045	14 Fe Iron 55.845	15 Co Cobalt 58.93195	16 Ni Nickel 58.6934	17 Cu Copper 63.54	18 Zn Zinc 65.38	19 Ga Gallium 69.723	20 Ge Germanium 72.63	21 As Arsenic 74.9216	22 Br Bromine 79.904
6 Fr Francium (223)	7 Ra Radium (226)	8 Y Yttrium (87)	9 Zr Zirconium (87)	10 Sc Scandium (44)	11 Ti Titanium (47)	12 V Vanadium (50)	13 Cr Chromium (52)	14 Mn Manganese (54)	15 Fe Iron (56)	16 Co Cobalt (58)	17 Ni Nickel (59)	18 Cu Copper (63)	19 Zn Zinc (65)	20 Ga Gallium (69)	21 Ge Germanium (72)	22 As Arsenic (75)	23 Br Bromine (79)
7 Fr Francium (223)	8 Ra Radium (226)	9 Y Yttrium (87)	10 Zr Zirconium (87)	11 Sc Scandium (44)	12 Ti Titanium (47)	13 V Vanadium (50)	14 Cr Chromium (52)	15 Mn Manganese (54)	16 Fe Iron (56)	17 Co Cobalt (58)	18 Ni Nickel (59)	19 Cu Copper (63)	20 Zn Zinc (65)	21 Ga Gallium (69)	22 Ge Germanium (72)	23 As Arsenic (75)	24 Br Bromine (79)
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18 Fr Francium (223)	19 Ra Radium (226)	20 Y Yttrium (87)	21 Zr Zirconium (87)	22 Sc Scandium (44)	23 Ti Titanium (47)	24 V Vanadium (50)	25 Cr Chromium (52)	26 Mn Manganese (54)	27 Fe Iron (56)	28 Co Cobalt (58)	29 Ni Nickel (59)	30 Cu Copper (63)	31 Zn Zinc (65)	32 Ga Gallium (69)	33 Ge Germanium (72)	34 As Arsenic (75)	35 Br Bromine (79)
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20 Fr Francium (223)	21 Ra Radium (226)	22 Y Yttrium (87)	23 Zr Zirconium (87)	24 Sc Scandium (44)	25 Ti Titanium (47)	26 V Vanadium (50)	27 Cr Chromium (52)	28 Mn Manganese (54)	29 Fe Iron (56)	30 Co Cobalt (58)	31 Ni Nickel (59)	32 Cu Copper (63)	33 Zn Zinc (65)	34 Ga Gallium (69)	35 Ge Germanium (72)	36 As Arsenic (75)	37 Br Bromine (79)
21 Fr Francium (223)	22 Ra Radium (226)	23 Y Yttrium (87)	24 Zr Zirconium (87)	25 Sc Scandium (44)	26 Ti Titanium (47)	27 V Vanadium (50)	28 Cr Chromium (52)	29 Mn Manganese (54)	30 Fe Iron (56)	31 Co Cobalt (58)	32 Ni Nickel (59)	33 Cu Copper (63)	34 Zn Zinc (65)	35 Ga Gallium (69)	36 Ge Germanium (72)	37 As Arsenic (75)	38 Br Bromine (79)
22 Fr Francium (223)	23 Ra Radium (226)	24 Y Yttrium (87)	25 Zr Zirconium (87)	26 Sc Scandium (44)	27 Ti Titanium (47)	28 V Vanadium (50)	29 Cr Chromium (52)	30 Mn Manganese (54)	31 Fe Iron (56)	32 Co Cobalt (58)	33 Ni Nickel (59)	34 Cu Copper (63)	35 Zn Zinc (65)	36 Ga Gallium (69)	37 Ge Germanium (72)	38 As Arsenic (75)	39 Br Bromine (79)
23 Fr Francium (223)	24 Ra Radium (226)	25 Y Yttrium (87)	26 Zr Zirconium (87)	27 Sc Scandium (44)	28 Ti Titanium (47)	29 V Vanadium (50)	30 Cr Chromium (52)	31 Mn Manganese (54)	32 Fe Iron (56)	33 Co Cobalt (58)	34 Ni Nickel (59)	35 Cu Copper (63)	36 Zn Zinc (65)	37 Ga Gallium (69)	38 Ge Germanium (72)	39 As Arsenic (75)	40 Br Bromine (79)
24 Fr Francium (223)	25 Ra Radium (226)	26 Y Yttrium (87)	27 Zr Zirconium (87)	28 Sc Scandium (44)	29 Ti Titanium (47)	30 V Vanadium (50)	31 Cr Chromium (52)	32 Mn Manganese (54)	33 Fe Iron (56)	34 Co Cobalt (58)	35 Ni Nickel (59)	36 Cu Copper (63)	37 Zn Zinc (65)	38 Ga Gallium (69)	39 Ge Germanium (72)	40 As Arsenic (75)	41 Br Bromine (79)
25 Fr Francium (223)	26 Ra Radium (226)	27 Y Yttrium (87)	28 Zr Zirconium (87)	29 Sc Scandium (44)	30 Ti Titanium (47)	31 V Vanadium (50)	32 Cr Chromium (52)	33 Mn Manganese (54)	34 Fe Iron (56)	35 Co Cobalt (58)	36 Ni Nickel (59)	37 Cu Copper (63)	38 Zn Zinc (65)	39 Ga Gallium (69)	40 Ge Germanium (72)	41 As Arsenic (75)	42 Br Bromine (79)
26 Fr Francium (223)	27 Ra Radium (226)	28 Y Yttrium (87)	29 Zr Zirconium (87)	30 Sc Scandium (44)	31 Ti Titanium (47)	32 V Vanadium (50)	33 Cr Ch										

7.3 Sizes of Atoms and Ions

Periodic Trends in Ionic Radii

- ❖ When a cation is formed the number of electron–electron repulsions is reduced; therefore, cations are **smaller** than their parent atoms.
- ❖ When electrons are added to an atom to form an anion, the increased electron–electron repulsions cause the electrons to spread out more in space; thus, anions are **larger** than their parent atoms.
- ❖ For ions carrying the same charge, ionic radius increases as we move down a column in the periodic table.

Sample Exercise 7.3

Arrange Mg^{2+} , Ca^{2+} , and Ca in order of decreasing radius.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1.00794	2 Be Beryllium 9.012182	C Solid															2 He Helium 4.002602
3 Li Lithium 6.941	4 Mg Magnesium 24.305	Hg Liquid															10 Ne Neon 20.1797
5 Na Sodium 22.98976928	6 Al Aluminum 26.9815396	H Gas															11 F Fluorine 18.9984032
7 K Potassium 39.0983	8 Si Silicon 28.0855	Rf Unknown															12 Ar Argon 39.948
9 Ca Calcium 40.078	10 Cl Chlorine 35.453																13 Br Bromine 79.904
11 Rb Rubidium 83.4678	12 S Sulfur 32.065																14 Kr Krypton 83.798
13 Sc Scandium 44.955912	15 Ge Germanium 73.63																15 Xe Xenon 131.293
15 Ti Titanium 47.867	16 As Arsenic 74.9216																16 Rn Radon (222)
17 V Vanadium 50.9415	17 Se Selenium 78.96																17 At Astatine (210)
19 Cr Chromium 51.9961	18 Br Bromine 80.9007																18 Uuo Ununoctium (294)
21 Mn Manganese 54.938045	22 Fe Iron 55.845																19 Lu Lutetium 174.9668
23 Co Cobalt 58.93195	24 Ni Nickel 63.54																20 Yb Ytterbium 173.054
25 Fe Iron 55.845	26 Cu Copper 63.58																21 Tm Thulium 168.93421
27 Co Cobalt 58.93195	28 Zn Zinc 65.38																22 Y Yttrium 167.259
29 Cu Copper 63.58	30 Zn Zinc 65.38																23 Fr Francium (223)
31 Ga Gallium 69.723	32 Ge Germanium 73.63																24 Th Thorium (232)
33 As Arsenic 74.9216	34 Se Selenium 78.96																25 Pa Protactinium (231)
35 Br Bromine 79.904	36 Kr Krypton 83.798																26 U Ununoctium (294)
37 Y Yttrium 88.90585	38 Zr Zirconium 91.224																27 Ac Actinium (227)
39 Nb Niobium 95.96	40 Tc Technetium (98)																28 Th Thorium (232)
41 Ru Ruthenium (267)	42 Rh Rhodium (101)																29 Pa Protactinium (231)
43 Tc Technetium (98)	44 Ru Rhodium (101)																30 U Ununoctium (294)
45 Pd Palladium (106)	46 Ag Silver (107)																31 La Lanthanum 138.90547
47 Rh Rhodium (106)	48 Cd Cadmium (112)																32 Ce Cerium 140.116
49 In Indium 114.818	50 Sn Tin 118.71																33 Pr Praseodymium 140.90765
51 Sb Antimony (121)	52 Te Tellurium 127.6																34 Nd Neodymium 144.242
53 I Iodine 126.90447	54 Xe Xenon 131.293																35 Eu Europium 151.964
55 Cs Cesium 132.9054519	56 Os Osmium 190.23																36 Gd Gadolinium 157.25
56 Ba Barium 137.327	57 Ir Iridium 192.217																37 Ho Holmium 164.93032
57-71	58 Ta Tantalum 180.94783																38 Tb Terbium 158.92535
72-103	59 W Tungsten 183.84																39 Dy Dysprosium 162.5
72 Hf Hafnium 178.49	60 Re Rhenium 186.207																40 Tb Terbium 164.93032
73 Ta Tantalum 180.94783	61 Os Osmium 190.23																41 Ho Holmium 164.93032
74 W Tungsten 183.84	62 Ir Iridium 192.217																42 Er Erbium 168.259
75 Re Rhenium 186.207	63 Ds Darmstadtium (281)																43 Tm Thulium 168.93421
76 Os Osmium 190.23	64 Gd Gadolinium 157.25																44 Yb Ytterbium 173.054
77 Ir Iridium 192.217	65 Tb Terbium 158.92535																45 Lu Lutetium 174.9668
78 Pt Platinum 195.084	66 Dy Dysprosium 162.5																46 Y Yttrium 173.054
79 Au Gold 196.966569	67 Tb Terbium 158.92535																47 Lu Lutetium 174.9668
80 Hg Mercury (204)	68 Ho Holmium 164.93032																48 Yt Yttrium 173.054
81 Tl Thallium 204.3833	69 Er Erbium 168.259																49 Lu Lutetium 174.9668
82 Pb Lead 207.2	70 Tm Thulium 168.93421																50 Yt Yttrium 173.054
83 Bi Bismuth 208.9804	71 Yb Ytterbium 173.054																51 Lu Lutetium 174.9668
84 Po Polonium (209)	72 Yt Yttrium 173.054																52 Yt Yttrium 174.9668
85 At Astatine (210)	73 Yt Yttrium 173.054																53 Yt Yttrium 174.9668
86 Rn (220)	74 Yt Yttrium 174.9668																54 Yt Yttrium 174.9668
87 Fr Francium (223)	75 Yt Yttrium 174.9668																55 Yt Yttrium 174.9668
88 Ra Radium (226)	76 Yt Yttrium 174.9668																56 Yt Yttrium 174.9668

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

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➤ $Ca > Ca^{2+} > Mg^{2+}$

Sample Exercise 7.3: Practice Exercise 1

Arrange the following atoms and ions in order of increasing ionic radius: F, S²⁻, Cl, and Se²⁻.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																		
1 H Hydrogen 1.00794	2 Be Beryllium 6.941	3 Li Lithium 7.012182	4 Be Beryllium 9.012182	5 C Solid	6	7	8	9	10	11	12	13	14	15	16	273 He Helium 4.002602																			
11 Na Sodium 22.98976928	12 Mg Magnesium 24.305	13 B Boron 10.811	14 Si Silicon 28.0855	15 C Carbon 12.0107	16 N Nitrogen 14.0067	17 O Oxygen 15.9994	18 F Fluorine 18.9984032	19 Ne Neon 20.1797	20 Ar Argon 39.948	21 Sc Scandium 44.955912	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938045	26 Fe Iron 55.845	27 Co Cobalt 58.93195	28 Ni Nickel 58.6934	29 Cu Copper 63.54	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.63	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798										
39 K Potassium 39.0983	40 Ca Calcium 40.078	41 Sc Scandium 44.955912	42 Ti Titanium 47.867	43 V Vanadium 50.9415	44 Cr Chromium 51.9961	45 Mn Manganese 54.938045	46 Fe Iron 55.845	47 Co Cobalt 58.93195	48 Ni Nickel 58.6934	49 Cu Copper 63.54	50 Zn Zinc 65.38	51 In Indium 114.818	52 Sn Tin 118.71	53 Te Antimony 121.76	54 I Tellurium 127.6	55 Rb Rubidium 83.4678	56 Sr Strontium 87.62	57 Y Yttrium 88.90585	58 Zr Zirconium 91.224	59 Nb Niobium 92.90638	60 Mo Molybdenum 95.96	61 Tc Technetium (98)	62 Ru Ruthenium 101.07	63 Rh Rhodium 102.9055	64 Pd Palladium 106.42	65 Ag Silver 107.8682	66 Cd Cadmium 112.411	67 In Indium 114.818	68 Sn Antimony 118.71	69 Te Tellurium 127.6	70 I Iodine 126.90447				
77 Cs Cesium 132.9054519	78 Ba Barium 137.327	79 Hf Hafnium 178.49	80 Ta Tantalum 180.94783	81 W Tungsten 183.84	82 Re Rhenium 186.207	83 Os Osmium 190.23	84 Ir Iridium 192.217	85 Pt Platinum 195.084	86 Au Gold 196.966569	87 Hg Mercury 201.59	88 Tl Thallium 204.3833	89 Pb Lead 207.2	90 Bi Bismuth 208.9804	91 Po Polonium (209)	92 At Astatine (210)	93 Rn Radium (222)	94 Fr Francium (223)	95 Ra Radium (226)	96 57-71 97 89-103	98 104 99 Rf Rutherfordium (267)	100 105 101 Db Dubnium (268)	102 106 103 Se Seaborgium (271)	104 107 105 Bh Berkelium (272)	106 108 107 Hs Hassium (270)	108 109 109 Mt Meitnerium (276)	110 111 111 Ds Darmstadtium (281)	112 113 113 Rg Roentgenium (280)	114 115 115 Cn Copernicium (285)	116 117 117 Uut Ununtrium (284)	118 118 118 Uup Ununpentium (289)	119 119 119 Fl Flerovium (289)	120 120 120 Uup Ununhexium (293)	121 121 121 Lv Livermorium (293)	122 122 122 Uus Ununoctium (294)	123 123 123 Uuo Ununoctium (294)

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

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57 La Lanthanum 138.90547	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.242	61 Pm Promethium 144.924	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92535	66 Dy Dysprosium 162.5	67 Ho Holmium 164.93032	68 Er Erbium 168.259	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.054	71 Lu Lutetium 174.9668
89 Ac Actinium (227)	90 Th Thorium 232.03806	91 Pa Protactinium 231.03588	92 U Uranium 238.03891	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Ne�en (259)	103 Lr Lawrencium (262)

➤ F < Cl < S²⁻ < Se²⁻

7.3 Sizes of Atoms and Ions

- ❖ An **isoelectronic series** is a group of ions all containing the same number of electrons.
- ❖ In any isoelectronic series, because the number of electrons remains constant, ionic radius decreases with increasing nuclear charge as the electrons are more strongly attracted to the nucleus:

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 →

Sample Exercise 7.4

Arrange the ions K^+ , Cl^- , Ca^{2+} , and S^{2-} in order of decreasing size.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1.00794	2 Be Boron 6.941	3 Li Lithium 7.012182	4 Be Beryllium 9.012182	5 C Solid	6	7	8	9	10	11	12	13	14	15	16	17	273 He Helium 4.002602
11 Na Sodium 22.98976928	12 Mg Magnesium 24.305	13 Al Aluminum 26.9815386	14 Si Silicon 28.0855	15 P Phosphorus 30.973762	16 S Sulfur 32.065	17 Cl Chlorine 35.453	18 Ar Argon 39.948										
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955912	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938045	26 Fe Iron 55.845	27 Co Cobalt 58.93195	28 Ni Nickel 58.6934	29 Cu Copper 63.54	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.63	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798
37 Rb Rubidium 83.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.96	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.9055	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.6	53 I Iodine 126.90447	54 Xe Xenon 131.293
55 Cs Cesium 132.9054519	56 Ba Barium 137.327	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.94783	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.084	79 Au Gold 196.966569	80 Hg Mercury 201.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.9804	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89-103	104 Rf Rutherfordium (267)	105 Db Dubnium (268)	106 Bh Berkelium (271)	107 Hs Hassium (272)	108 Mt Meitnerium (270)	109 Ds Darmstadtium (276)	110 Rg Roentgenium (281)	111 Cn Copernicium (280)	112 Uut Ununtrium (285)	113 Fl Florineum (284)	114 Uup Ununpentium (289)	115 Lv Livermorium (283)	116 Uus Ununseptium (293)	117 Uuo Ununoctium (294)	

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

➤ $S^{2-} > Cl^- > K^+ > Ca^{2+}$

57 La Lanthanum 138.90547	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.242	61 Pm Promethium 144.9242	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92535	66 Dy Dysprosium 162.5	67 Ho Holmium 164.93032	68 Er Erbium 168.259	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.054	71 Lu Lutetium 174.9668
89 Ac Actinium (227)	90 Th Thorium 232.03806	91 Pa Protactinium 231.03588	92 U Uranium 238.03891	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

Sample Exercise 7.4: Practice Exercise 1

Arrange the following ions in order of increasing ionic radius: Br^- , Rb^+ , Se^{2-} , Sr^{2+} , Te^{2-} .

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17		
1 H Hydrogen 1.00794	2 Atomic Sym Name Weight	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17		
C Solid	Hg Liquid	H Gas	Rf Unknown															
3 Li Lithium 6.941	4 Be Beryllium 9.012182	5 Na Sodium 22.99976928	6 Ca Calcium 40.078	7 Sc Scandium 44.959512	8 Ti Titanium 47.867	9 V Vanadium 50.9415	10 Cr Chromium 51.9961	11 Mn Manganese 54.938045	12 Fe Iron 55.845	13 Co Cobalt 58.933195	14 Ni Nickel 58.6934	15 Cu Copper 63.546	16 Zn Zinc 65.38	17 Ga Gallium 69.723	18 Ge Germanium 72.63	19 As Arsenic 74.9216	20 Se Selenium 78.96	21 Kr Krypton 83.798
11 Na Sodium 24.305	12 Al Aluminum 26.951386	13 Li Lithium 26.9994032	14 Si Silicon 28.0855	15 P Phosphorus 30.973762	16 S Sulfur 32.065	17 Cl Chlorine 35.453	18 Ar Argon 39.943	19 F Fluorine 18.9984032	20 Ne Neon 20.1797	21 B Boron 10.811	22 C Carbon 12.0107	23 N Nitrogen 14.0067	24 O Oxygen 15.9994	25 F Fluorine 18.9984032	26 He Helium 4.002602	27 Ne Neon 20.1797		
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.959512	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938045	26 Fe Iron 55.845	27 Co Cobalt 58.933195	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.63	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798	
37 Rb Rubidium 83.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.908585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.96	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.9055	46 Pd Palladium 105.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.813	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.6	53 I Iodine 126.90447	54 Xe Xenon 131.293	
55 Cs Cesium 132.904519	56 Ba Barium 137.327	57-71 Hf Hafnium 178.49	72 Ta Tantalum 180.49788	73 W Tungsten 183.84	74 Re Rhenium 186.207	75 Os Osmium 190.23	76 Ir Iridium 192.217	77 Pt Platinum 195.084	78 Au Gold 196.965669	79 Hg Mercury 200.59	80 Bi Bismuth 204.8833	81 Tl Thallium 207.2	82 Pb Lead 208.9804	83 Po Polonium (209)	84 At Astatine (210)	85 Rn Radon (222)		
87 Fr Francium 223	88 Ra Radium 226	89-103 Rf Rutherfordium (261)	104 Dubnium (262)	105 Sg Seaborgium (263)	106 Bh Bohrium (264)	107 Hs Hassium (265)	108 Mt Meitnerium (266)	109 Ds Darmstadtium (267)	110 Rg Roentgenium (268)	111 Cn Copernicium (269)	112 Uut Ununtrium (270)	113 Fl Florium (271)	114 Uup Ununpentium (272)	115 Lv Livermorium (273)	116 Uus Ununseptium (274)	117 Uuo Ununoctium (275)		

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

➤ $\text{Sr}^{2+} < \text{Rb}^+ < \text{Br}^- < \text{Se}^{2-} < \text{Te}^{2-}$

Periodic Table Design & Interface Copyright © 1997 Michael Dayan Table last updated 06/12/2012																		
57 La Lanthanum 138.9047	58 Ce Cerium 140.116	59 Pr Praseodymium 149.90765	60 Nd Neodymium 144.242	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.9535	66 Dy Dysprosium 162.5	67 Ho Holmium 164.9032	68 Er Erbium 167.259	69 Tm Thulium 169.93421	70 Yb Ytterbium 173.054	71 Lu Lutetium 174.9668				
89 Ac Actinium (227)	90 Th Thorium 232.03806	91 Pa Protactinium 231.03538	92 U Uranium 238.03891	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Emeinsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)				

7.4 Ionization Energy

- ❖ The **ionization energy** of an atom or ion is the minimum energy required to remove an electron from the ground state of the isolated gaseous atom or ion.
- ❖ The **first ionization energy**, I_1 , is the energy needed to remove the first electron from a neutral atom.



- ❖ The **second ionization energy**, I_2 , is the energy needed to remove the second electron.



7.4 Ionization Energy

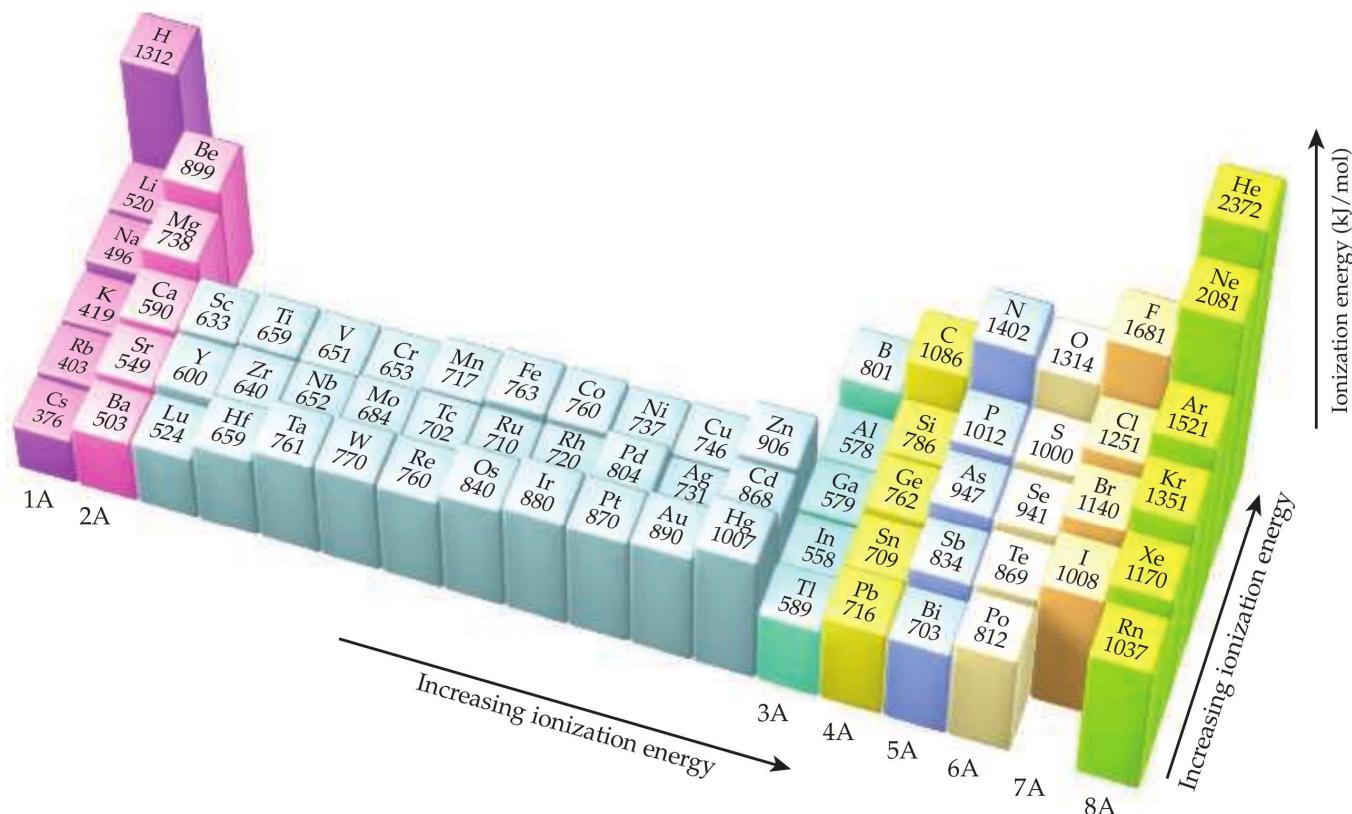
Variations in Successive Ionization Energies

- ❖ The greater the ionization energy, the more difficult it is to remove an electron.
- ❖ Thus, the ionization energies for a given element increase as successive electrons are removed: $I_1 < I_2 < I_3$, and so forth.

7.4 Ionization Energy

Periodic Trends in First Ionization Energies

- ❖ I_1 generally increases as we move left to right across a period.
- ❖ I_1 generally decreases as we move down any column in the periodic table.



▲ Figure 7.10 The first ionization energies of the elements in kJ/mol.

7.4 Ionization Energy

- ❖ The *s*- and *p*-block elements show a larger range of I_1 values than do the transition-metal elements.
- ❖ Generally, the ionization energies of the transition metals increase slowly from left to right in a period.
- ❖ As we move across a period, there is both an increase in effective nuclear charge and a decrease in atomic radius, causing the ionization energy to increase.
- ❖ As we move down a column, the atomic radius increases, while the effective nuclear charge increases only gradually; the increase in radius dominates, so the attraction between the nucleus and the electron decreases, causing the ionization energy to decrease.

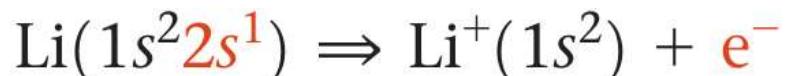
7.4 Ionization Energy

- ❖ The irregularities in a given period are subtle but still readily explained.
- ❖ The decrease in ionization energy from beryllium ($[\text{He}]2s^2$) to boron ($[\text{He}]2s^22p^1$), occurs because the third valence electron of B must occupy the $2p$ subshell, which is empty for Be.
- ❖ The slight decrease in ionization energy when moving from nitrogen ($[\text{He}]2s^22p^3$) to oxygen ($[\text{He}]2s^22p^4$) is the result of the repulsion of paired electrons in the p^4 configuration.

7.4 Ionization Energy

Electron Configurations of Ions

- ❖ When electrons are removed from an atom to form a cation, they are always removed first from the occupied orbitals having the largest principal quantum number, n .



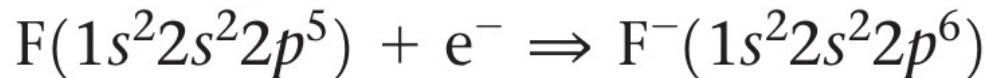
- ❖ Thus, in forming ions, transition metals lose the valence-shells electrons first, then as many d electrons as required to reach the charge of the ion.

7.4 Ionization Energy

- ❖ If there is more than one occupied subshell for a given value of n , the electrons are first removed from the orbital with the highest value of l .



- ❖ Electrons added to an atom to form an anion are added to the empty or partially filled orbital having the lowest value of n .



Sample Exercise 7.6

Referring to the periodic table, arrange the atoms Ne, Na, P, Ar, K in order of increasing first ionization energy.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																
1 H Hydrogen 1.00794	2 He Helium 4.002602	3 Li Lithium 6.941	4 Be Beryllium 9.012182	5 C Solid	6	7	8	9	10	11	12	13	14	15	16	17	18 He Helium 4.002602																
2 Na Sodium 22.98976928	3 Mg Magnesium 24.305	4 Al Aluminum 26.9815396	5 B Boron 10.811	6 C Carbon 12.0107	7 N Nitrogen 14.0067	8 O Oxygen 15.9994	9 F Fluorine 18.9984032	10 Ne Neon 20.1797	11 S Sulfur 32.065	12 Cl Chlorine 35.453	13 Ar Argon 39.948	14	15	16	17	18	19 He Helium 4.002602																
3 Sc Scandium 44.955912	4 Ti Titanium 47.867	5 V Vanadium 50.9415	6 Cr Chromium 51.9961	7 Mn Manganese 54.938045	8 Fe Iron 55.845	9 Co Cobalt 58.93195	10 Ni Nickel 58.6934	11 Cu Copper 63.54	12 Zn Zinc 65.38	13 Ga Gallium 69.723	14 Ge Germanium 72.63	15 As Arsenic 74.9216	16 Se Selenium 78.96	17 Br Bromine 79.904	18 Kr Krypton 83.798	19 Rb Rubidium 83.4678	20 Sr Strontium 87.62	21 Y Yttrium 88.90585	22 Zr Zirconium 91.224	23 Nb Niobium 92.90638	24 Mo Molybdenum 95.96	25 Tc Technetium (98)	26 Ru Ruthenium 101.07	27 Rh Rhodium 102.9055	28 Pd Palladium 106.42	29 Ag Silver 107.8682	30 Cd Cadmium 112.411	31 In Indium 114.818	32 Sn Tin 118.71	33 Sb Antimony 121.76	34 Te Tellurium 127.6	35 I Iodine 126.90447	36 Xe Xenon 131.293
4 Ca Calcium 40.078	5 Sc Scandium 44.955912	6 Ti Titanium 47.867	7 V Vanadium 50.9415	8 Cr Chromium 51.9961	9 Mn Manganese 54.938045	10 Fe Iron 55.845	11 Co Cobalt 58.93195	12 Ni Nickel 58.6934	13 Cu Copper 63.54	14 Zn Zinc 65.38	15 Ga Gallium 69.723	16 Ge Germanium 72.63	17 As Arsenic 74.9216	18 Se Selenium 78.96	19 Br Bromine 79.904	20 Kr Krypton 83.798	21 Sc Scandium 44.955912	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938045	26 Fe Iron 55.845	27 Co Cobalt 58.93195	28 Ni Nickel 58.6934	29 Cu Copper 63.54	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.63	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798	
4 K Potassium 39.0983	5 Rb Rubidium 83.4678	6 Sr Strontium 87.62	7 Y Yttrium 88.90585	8 Zr Zirconium 91.224	9 Sc Scandium 44.955912	10 Ti Titanium 47.867	11 V Vanadium 50.9415	12 Cr Chromium 51.9961	13 Mn Manganese 54.938045	14 Fe Iron 55.845	15 Co Cobalt 58.93195	16 Ni Nickel 58.6934	17 Cu Copper 63.54	18 Zn Zinc 65.38	19 Ga Gallium 69.723	20 Ge Germanium 72.63	21 As Arsenic 74.9216	22 Se Selenium 78.96	23 Br Bromine 79.904	24 Kr Krypton 83.798													
5 Ca Calcium 40.078	6 Sc Scandium 44.955912	7 Ti Titanium 47.867	8 V Vanadium 50.9415	9 Cr Chromium 51.9961	10 Mn Manganese 54.938045	11 Fe Iron 55.845	12 Co Cobalt 58.93195	13 Ni Nickel 58.6934	14 Cu Copper 63.54	15 Zn Zinc 65.38	16 Ga Gallium 69.723	17 Ge Germanium 72.63	18 As Arsenic 74.9216	19 Se Selenium 78.96	20 Br Bromine 79.904	21 Kr Krypton 83.798	22 Ca Calcium 40.078	23 Sc Scandium 44.955912	24 Ti Titanium 47.867	25 V Vanadium 50.9415	26 Cr Chromium 51.9961	27 Mn Manganese 54.938045	28 Fe Iron 55.845	29 Co Cobalt 58.93195	30 Ni Nickel 58.6934	31 Cu Copper 63.54	32 Zn Zinc 65.38	33 Ga Gallium 69.723	34 Ge Germanium 72.63	35 As Arsenic 74.9216	36 Se Selenium 78.96	37 Br Bromine 79.904	38 Kr Krypton 83.798
5 Sc Scandium 44.955912	6 Ti Titanium 47.867	7 V Vanadium 50.9415	8 Cr Chromium 51.9961	9 Mn Manganese 54.938045	10 Fe Iron 55.845	11 Co Cobalt 58.93195	12 Ni Nickel 58.6934	13 Cu Copper 63.54	14 Zn Zinc 65.38	15 Ga Gallium 69.723	16 Ge Germanium 72.63	17 As Arsenic 74.9216	18 Se Selenium 78.96	19 Br Bromine 79.904	20 Kr Krypton 83.798	21 Sc Scandium 44.955912	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938045	26 Fe Iron 55.845	27 Co Cobalt 58.93195	28 Ni Nickel 58.6934	29 Cu Copper 63.54	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.63	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798		
5 Sc Scandium 44.955912	6 Ti Titanium 47.867	7 V Vanadium 50.9415	8 Cr Chromium 51.9961	9 Mn Manganese 54.938045	10 Fe Iron 55.845	11 Co Cobalt 58.93195	12 Ni Nickel 58.6934	13 Cu Copper 63.54	14 Zn Zinc 65.38	15 Ga Gallium 69.723	16 Ge Germanium 72.63	17 As Arsenic 74.9216	18 Se Selenium 78.96	19 Br Bromine 79.904	20 Kr Krypton 83.798	21 Sc Scandium 44.955912	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938045	26 Fe Iron 55.845	27 Co Cobalt 58.93195	28 Ni Nickel 58.6934	29 Cu Copper 63.54	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.63	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798		
5 Sc Scandium 44.955912	6 Ti Titanium 47.867	7 V Vanadium 50.9415	8 Cr Chromium 51.9961	9 Mn Manganese 54.938045	10 Fe Iron 55.845	11 Co Cobalt 58.93195	12 Ni Nickel 58.6934	13 Cu Copper 63.54	14 Zn Zinc 65.38	15 Ga Gallium 69.723	16 Ge Germanium 72.63	17 As Arsenic 74.9216	18 Se Selenium 78.96	19 Br Bromine 79.904	20 Kr Krypton 83.798	21 Sc Scandium 44.955912	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938045	26 Fe Iron 55.845	27 Co Cobalt 58.93195	28 Ni Nickel 58.6934	29 Cu Copper 63.54	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.63	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798		
5 Sc Scandium 44.955912	6 Ti Titanium 47.867	7 V Vanadium 50.9415	8 Cr Chromium 51.9961	9 Mn Manganese 54.938045	10 Fe Iron 55.845	11 Co Cobalt 58.93195	12 Ni Nickel 58.6934	13 Cu Copper 63.54	14 Zn Zinc 65.38	15 Ga Gallium 69.723	16 Ge Germanium 72.63	17 As Arsenic 74.9216	18 Se Selenium 78.96	19 Br Bromine 79.904	20 Kr Krypton 83.798	21 Sc Scandium 44.955912	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938045	26 Fe Iron 55.845	27 Co Cobalt 58.93195	28 Ni Nickel 58.6934	29 Cu Copper 63.54	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.63	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798		
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5 Sc Scandium 44.955912	6 Ti Titanium 47.867	7 V Vanadium 50.9415	8 Cr Chromium 51.9961	9 Mn Manganese 54.938045																													

Sample Exercise 7.7

Write the electron configurations for

a. Ca^{2+}



b. Co^{3+}



c. S^{2-}



7.5 Electron Affinity

- ❖ All ionization energies for atoms are positive: Energy must be **absorbed** to remove an electron.



- ❖ The energy change that occurs when an electron is added to a gaseous atom is called the **electron affinity** because it measures the attraction, or **affinity**, of the atom for the added electron.
- ❖ For most atoms, energy is **released** when an electron is added.



7.5 Electron Affinity

- ❖ The greater the attraction between an atom and an added electron, the more negative the atom's electron affinity.
- ❖ For some elements, such as the noble gases, the electron affinity has a positive value, meaning that the anion is higher in energy than are the separated atom and electron:



- ❖ The fact that the electron affinity is positive means that an electron will not attach itself to an Ar atom; in other words, the Ar^- ion is unstable and does not form.