
Chapter 3

Atomic Structure and the Periodic Table

Periodicity of Element Properties

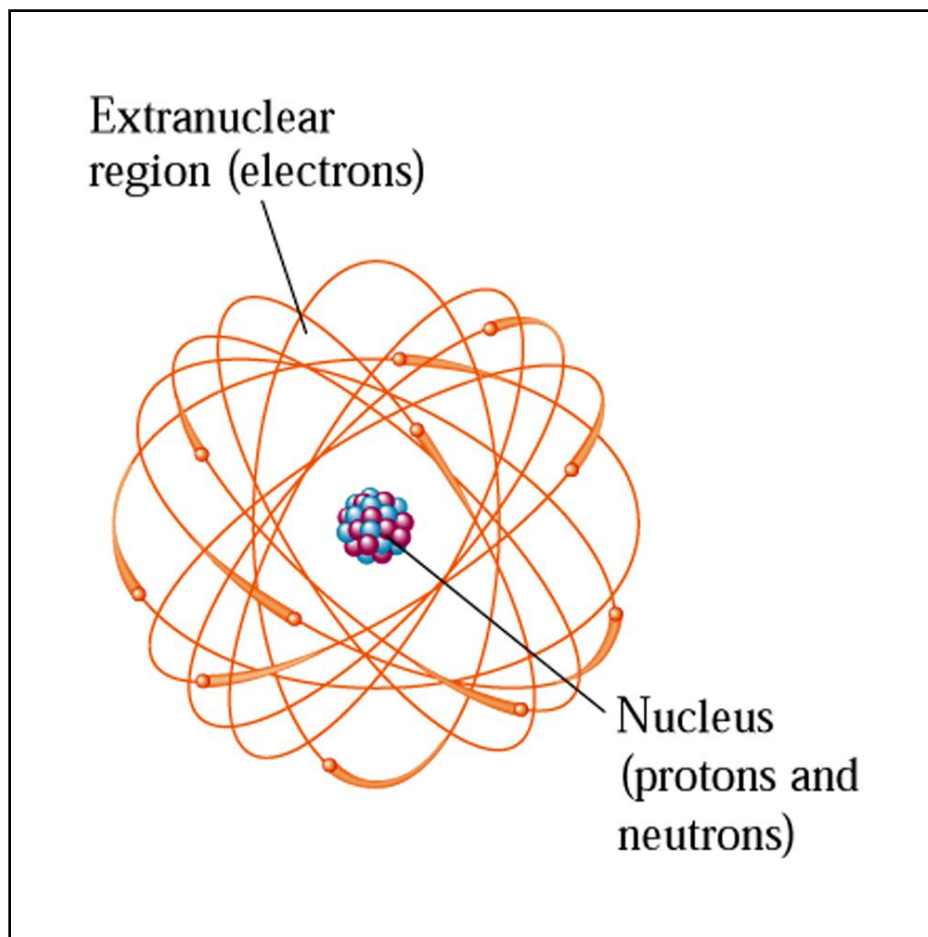


Music consists of a series of tones that build octave after octave. Similarly, elements have properties that recur period after period.



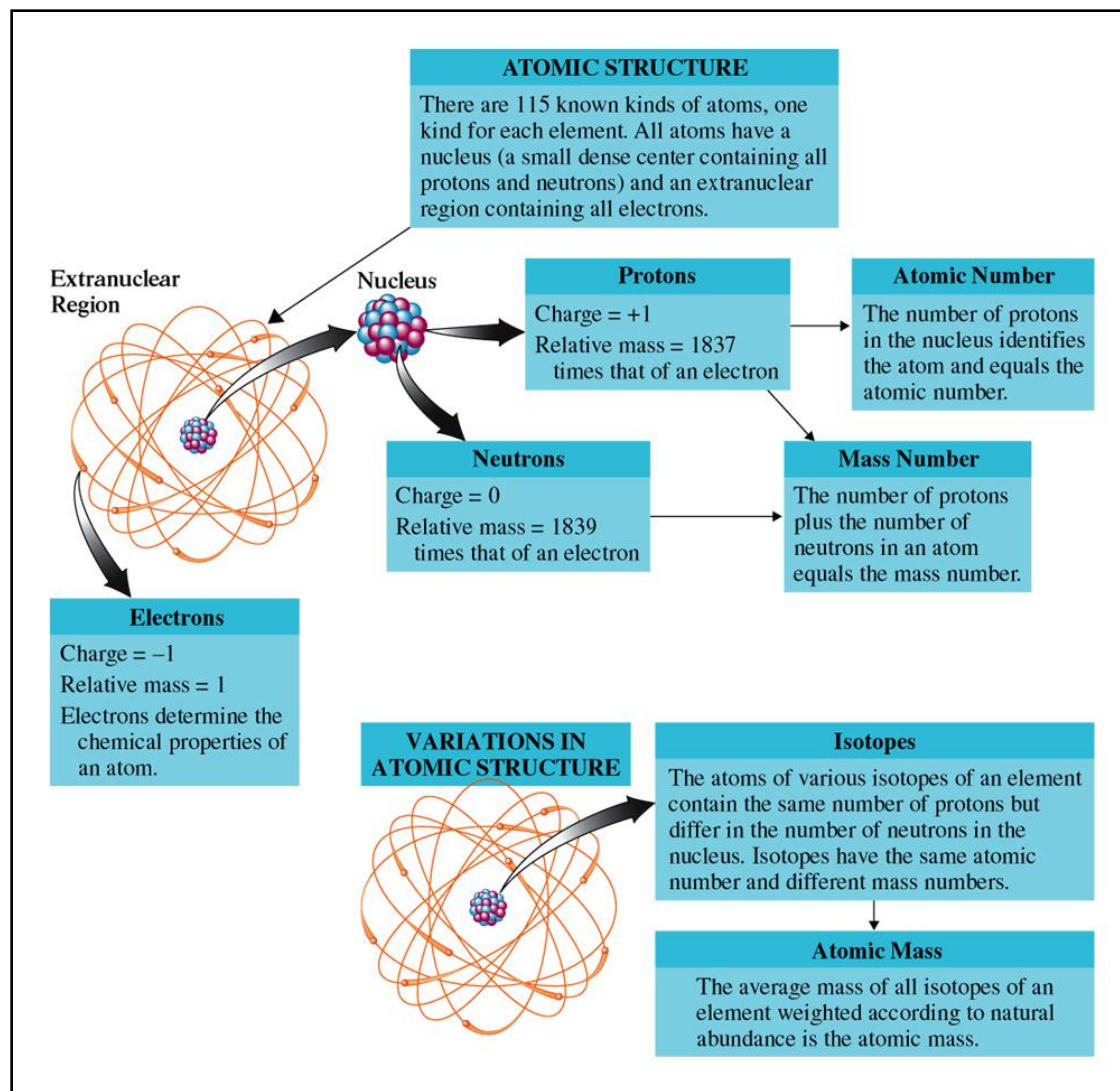
Novastock/PhotoEdit

Nuclear Atom



The protons and neutrons of an atom are found in the central nuclear region, or nucleus, and the electrons are found in an electron cloud outside the nucleus.

Atomic and the Subatomic Particles



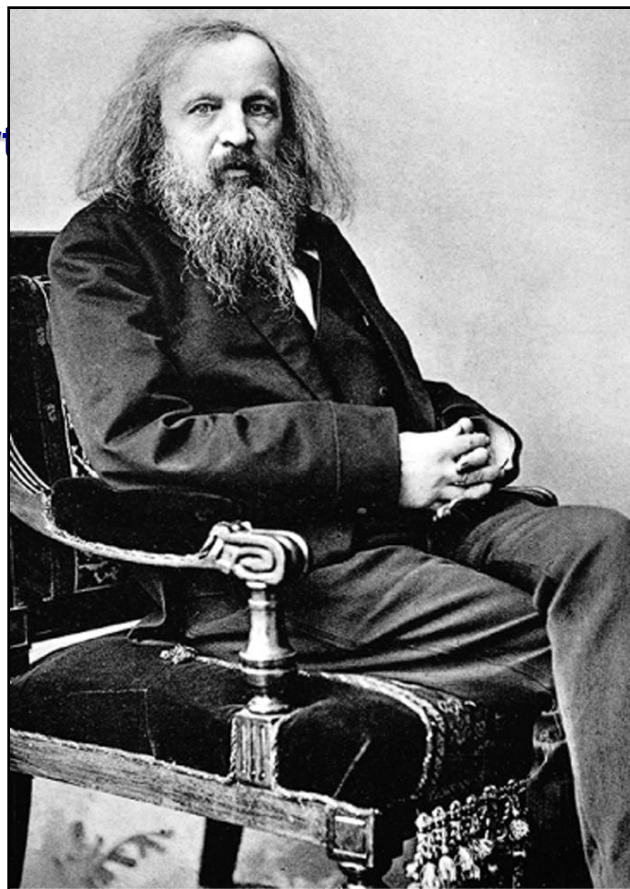
Isotopes and their Abundances

1	Hydrogen	2	Helium	3	Lithium
^1_1H 1.008 amu 99.985% ^2_1H 2.014 amu 0.015% ^3_1H 3.016 amu trace		^3_2He 3.016 amu trace ^4_2He 4.003 amu 100%		^6_3Li 6.015 amu 7.42% ^7_3Li 7.016 amu 92.58%	
4	Beryllium	5	Boron	6	Carbon
^9_4Be 9.012 amu 100%		$^{10}_5\text{B}$ 10.013 amu 19.6% $^{11}_5\text{B}$ 11.009 amu 80.4%		$^{12}_6\text{C}$ 12.000 amu 98.89% $^{13}_6\text{C}$ 13.003 amu 1.11% $^{14}_6\text{C}$ 14.003 amu trace	
7	Nitrogen	8	Oxygen	9	Fluorine
$^{14}_7\text{N}$ 14.003 amu 99.63% $^{15}_7\text{N}$ 15.000 amu 0.37%		$^{16}_8\text{O}$ 15.995 amu 99.759% $^{17}_8\text{O}$ 16.999 amu 0.037% $^{18}_8\text{O}$ 17.999 amu 0.204%		$^{19}_9\text{F}$ 18.998 amu 100%	
10	Neon	11	Sodium	12	Magnesium
$^{20}_{10}\text{Ne}$ 19.992 amu 90.92% $^{21}_{10}\text{Ne}$ 20.994 amu 0.26% $^{22}_{10}\text{Ne}$ 21.991 amu 8.82%		$^{23}_{11}\text{Na}$ 22.990 amu 100%		$^{24}_{12}\text{Mg}$ 23.985 amu 78.70% $^{25}_{12}\text{Mg}$ 24.986 amu 10.13% $^{26}_{12}\text{Mg}$ 25.983 amu 11.17%	

Mendeleev the Founder of Periodic Table



Mendeleev constructed a periodic table as part of his effort to systemize chemistry.



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Pennsylvania Library*

Modern Periodic Table

1 Group IA		2 Group IIA												13 Group IIIA		14 Group IVA		15 Group VA		16 Group VIA		17 Group VIIA		18 Group VIIIA																																			
1	1 H 1.01													5 B 10.81		6 C 12.01		7 N 14.01		8 O 16.00		9 F 19.00		10 Ne 20.18																																			
2	3 Li 6.94	4 Be 9.01												13 Al 26.98		14 Si 28.09		15 P 30.97		16 S 32.07		17 Cl 35.45		18 Ar 39.95																																			
3	11 Na 22.99	12 Mg 24.30		3 Group IIIB		4 Group IVB		5 Group VB		6 Group VIB		7 Group VIIB		8 Group		9 Group VIIIB		10 Group		11 Group IB		12 Group IIB		13 Al 26.98		14 Si 28.09		15 P 30.97		16 S 32.07		17 Cl 35.45		18 Ar 39.95																									
4	19 K 39.10	20 Ca 40.08		21 Sc 44.96		22 Ti 47.87		23 V 50.94		24 Cr 52.00		25 Mn 54.94		26 Fe 55.85		27 Co 58.93		28 Ni 58.69		29 Cu 63.55		30 Zn 65.38		31 Ga 69.72		32 Ge 72.59		33 As 74.92		34 Se 78.96		35 Br 79.90		36 Kr 83.80																									
5	37 Rb 85.47	38 Sr 87.62		39 Y 88.91		40 Zr 91.22		41 Nb 92.91		42 Mo 95.94		43 Tc (98)		44 Ru 101.07		45 Rh 102.91		46 Pd 106.42		47 Ag 107.87		48 Cd 112.41		49 In 114.82		50 Sn 118.71		51 Sb 121.76		52 Te 127.60		53 I 126.90		54 Xe 131.29																									
6	55 Cs 132.91	56 Ba 137.33		57 La 138.91		72 Hf 178.49		73 Ta 180.95		74 W 183.84		75 Re 186.21		76 Os 190.23		77 Ir 192.22		78 Pt 195.08		79 Au 196.97		80 Hg 200.59		81 Tl 204.38		82 Pb 207.2		83 Bi 208.98		84 Po (209)		85 At (210)		86 Rn (222)																									
7	87 Fr (223)	88 Ra (226)		89 Ac (227)		104 Rf (263)		105 Db (262)		106 Sg (266)		107 Bh (267)		108 Hs (269)		109 Mt (276)		110 Ds (271)		111 Rg (272)		112 — (277)		113 — (284)		114 — (289)		115 — (288)																															
																		<table><tr><td>58 Ce 140.12</td><td>59 Pr 140.91</td><td>60 Nd 144.24</td><td>61 Pm (145)</td><td>62 Sm 150.36</td><td>63 Eu 151.96</td><td>64 Gd 157.25</td><td>65 Tb 158.93</td><td>66 Dy 162.50</td><td>67 Ho 164.93</td><td>68 Er 167.26</td><td>69 Tm 168.93</td><td>70 Yb 173.04</td><td>71 Lu 174.97</td></tr><tr><td>90 Th (232)</td><td>91 Pa (231)</td><td>92 U (238)</td><td>93 Np (237)</td><td>94 Pu (242)</td><td>95 Am (243)</td><td>96 Cm (248)</td><td>97 Bk (247)</td><td>98 Cf (251)</td><td>99 Es (252)</td><td>100 Fm (257)</td><td>101 Md (260)</td><td>102 No (259)</td><td>103 Lr (262)</td></tr></table>														58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97	90 Th (232)	91 Pa (231)	92 U (238)	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (248)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (260)	102 No (259)	103 Lr (262)
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The periodic table of the elements is a graphical way to show relationships among the elements.

Very Long form of Periodic table

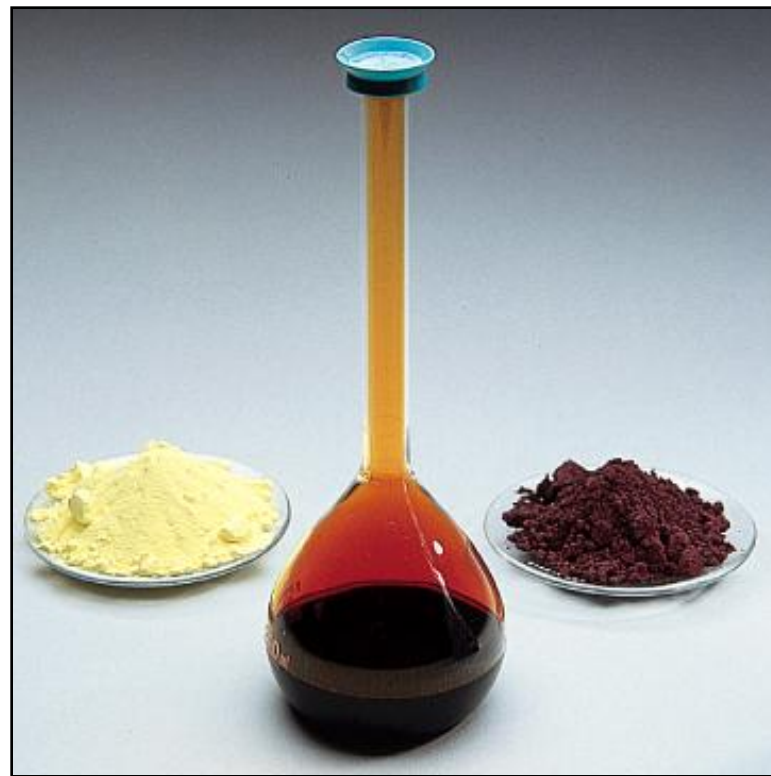
1																2															
3	4													5	6	7	8	9	10												
11	12													13	14	15	16	17	18												
19	20	21											22	23	24	25	26	27	28	29	30	31	32	33	34	35	36				
37	38	39											40	41	42	43	44	45	46	47	48	49	50	51	52	53	54				
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
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			

In this periodic table, elements 58 through 71 and 90 through 103 are shown in their proper positions.

Metals and Non-metals



(a) Some familiar metals are aluminum, lead, tin, and zinc.



(b) Some familiar nonmetals are sulfur, phosphorus, and bromine.

Differences between Metals/Non-metals

Metals

1. High electrical conductivity that decreases with increasing temperature
2. High thermal conductivity
3. Metallic gray or silver luster^a
4. Almost all are solids^b
5. Malleable (can be hammered into sheets)
6. Ductile (can be drawn into wires)

^aExcept copper and gold.

^bExcept mercury; cesium and gallium melt on a hot summer day (85°F) or when held in a person's hand.

Nonmetals

1. Poor electrical conductivity (except carbon in the form of graphite)
2. Good heat insulators (except carbon in the form of diamond)
3. No metallic luster
4. Solids, liquids, or gases
5. Brittle in solid state
6. Nonductile

Boarder Line between Metals

Legend:

- Metal (Grey)
- Nonmetal (Green)

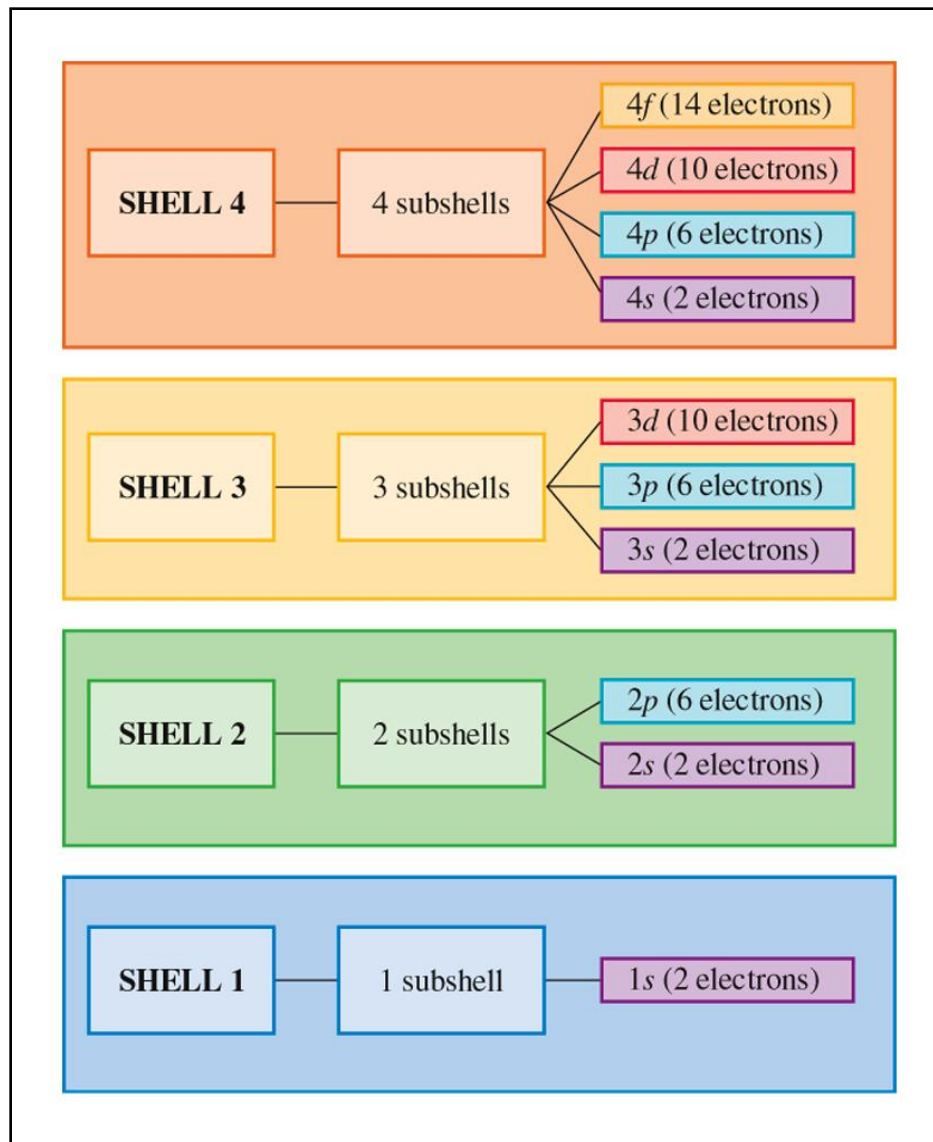
		Group					VIIIA
		IIIA	IVA	VA	VI	VII	
1 H		5 B	6 C	7 N	8 O	9 F	10 Ne
		13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
		30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br
		48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I
		80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At
		112 —	113 —	114 —	115 —		

This portion of the periodic table shows the dividing line between metals and nonmetals.

Electronic Shells and Sub-shells



The number of subshells within a shell is equal to the shell number.



Atomic Orbitals in a Sub-Shell

An s orbital has spherical shape; a p orbital has two lobes; a d orbital has four lobes; and an f orbital has eight lobes.



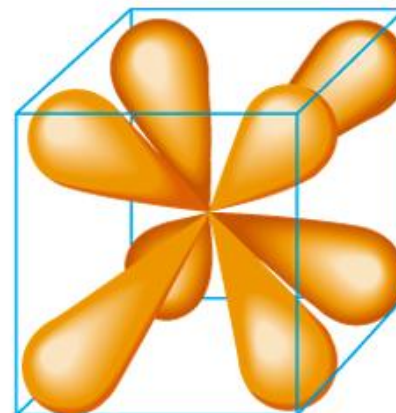
(a) *s* orbital



(b) *p* orbital

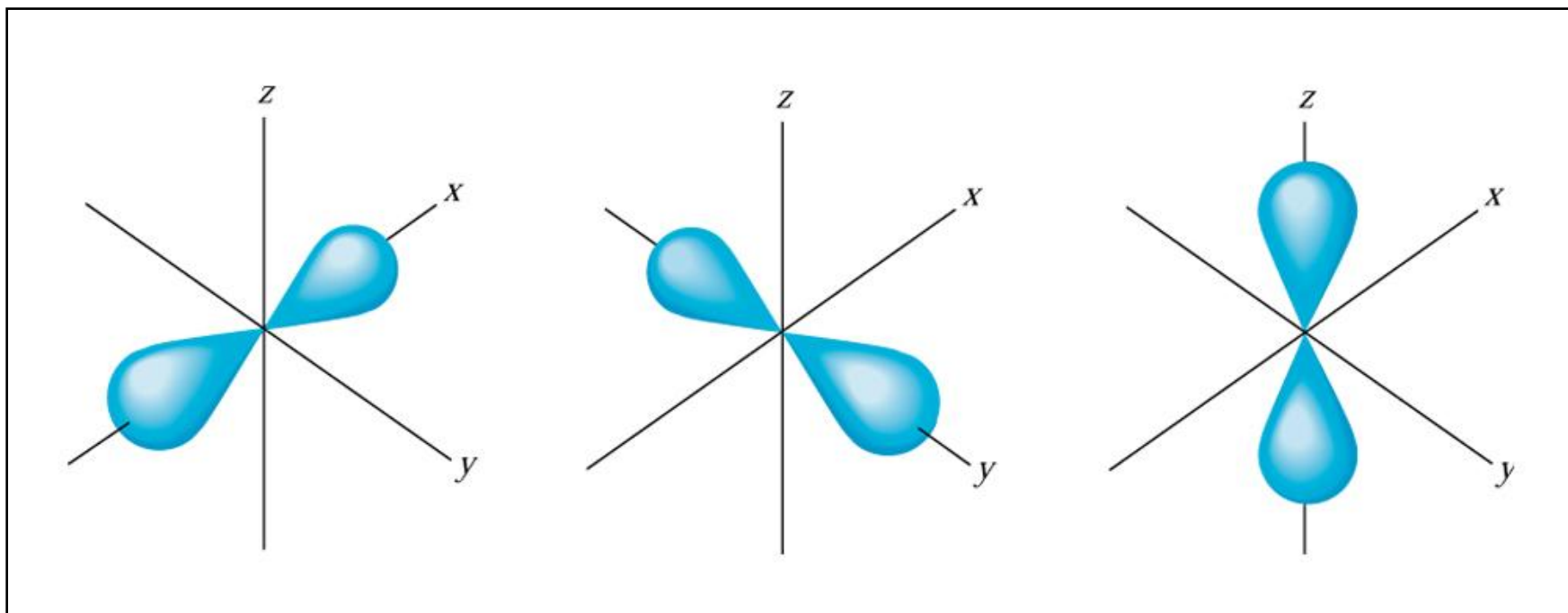


(c) *d* orbital



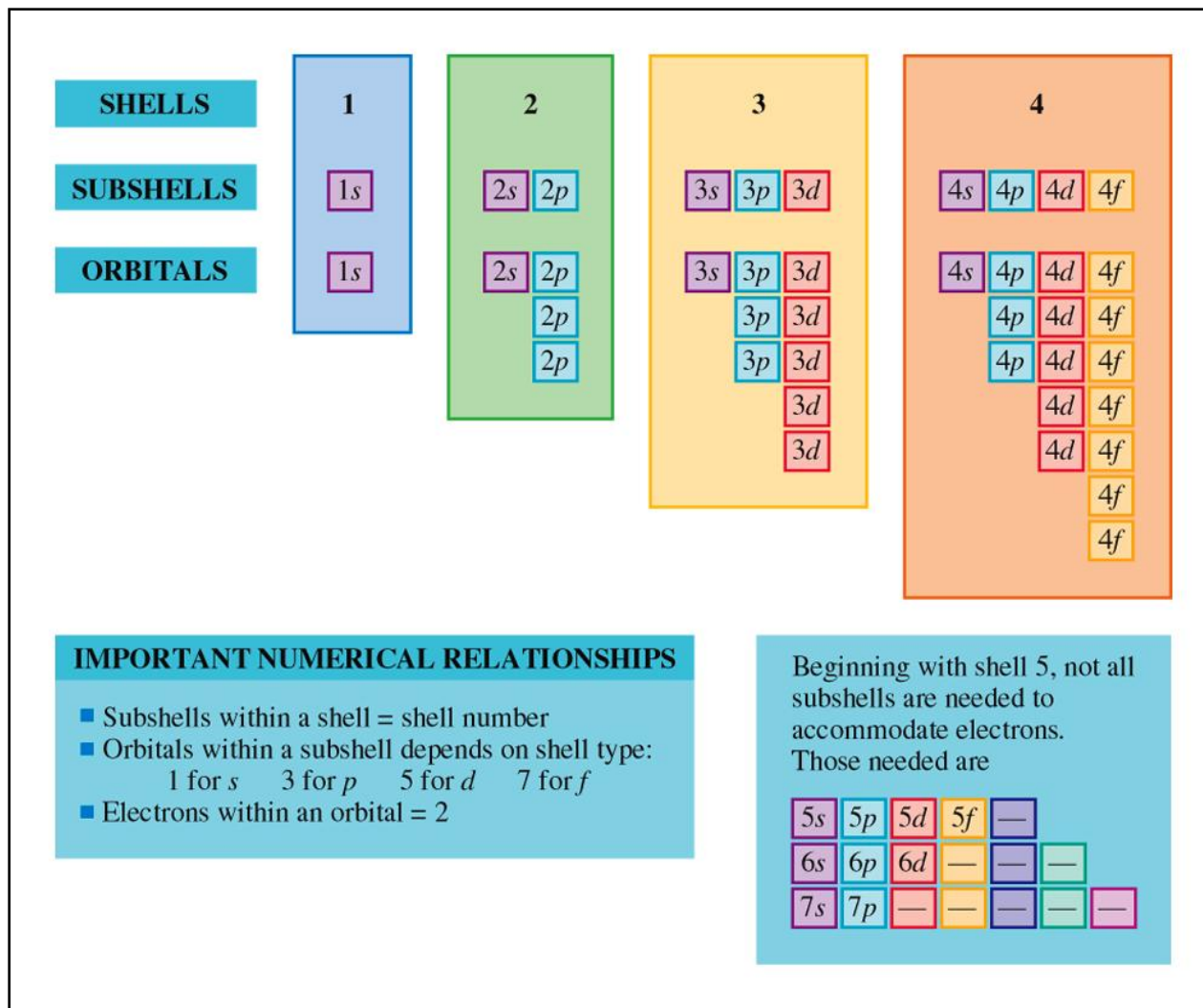
(d) *f* orbital

p- atomic Orbitals and their Orientation in Space

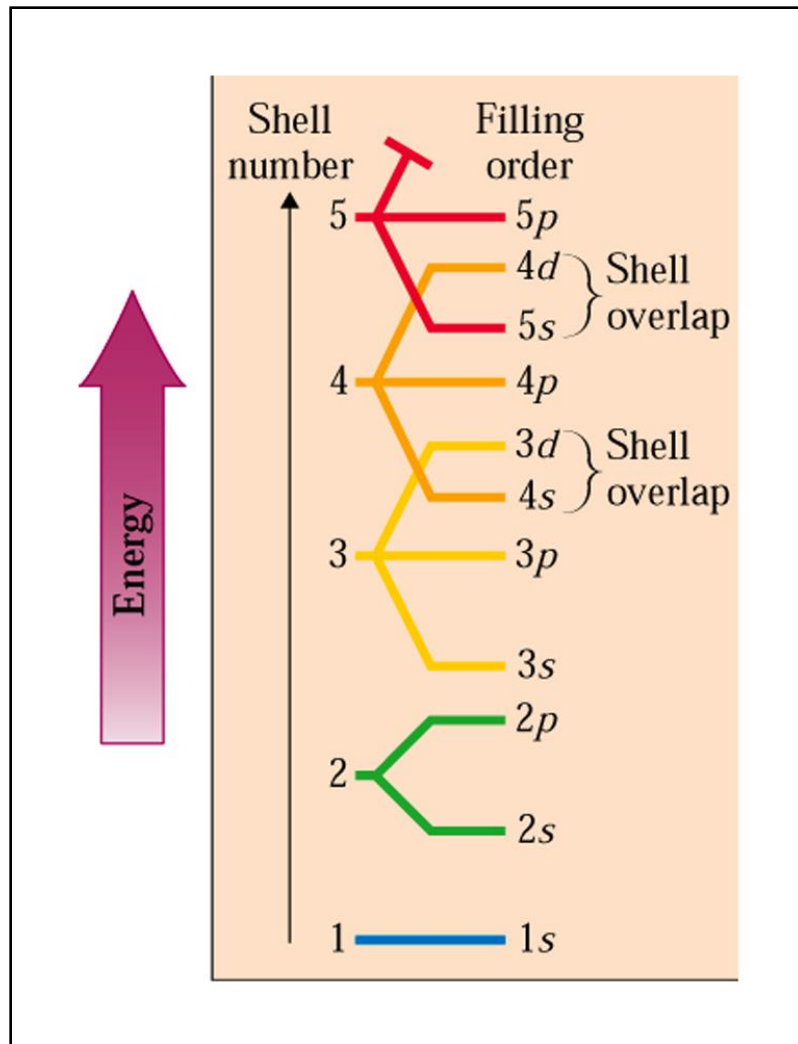


Orbitals within a subshell differ mainly in orientation.

Shell, Sub-shell and Orbital Arrangement



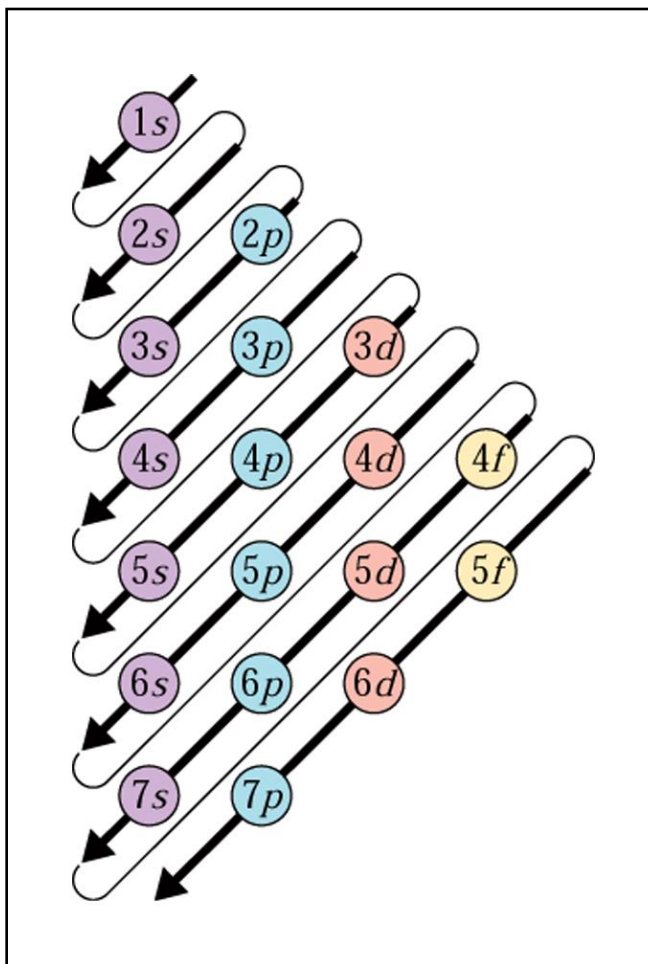
The Order of Filling of Various Atomic Subshells



The order of filling various electron subshells. Subshells of different shells “overlap.”

Filling Order of Atomic Orbitals

The order of filling various electron subshells with electrons follows the same order given by the arrows in this diagram.



Color comes from Electron Jumps

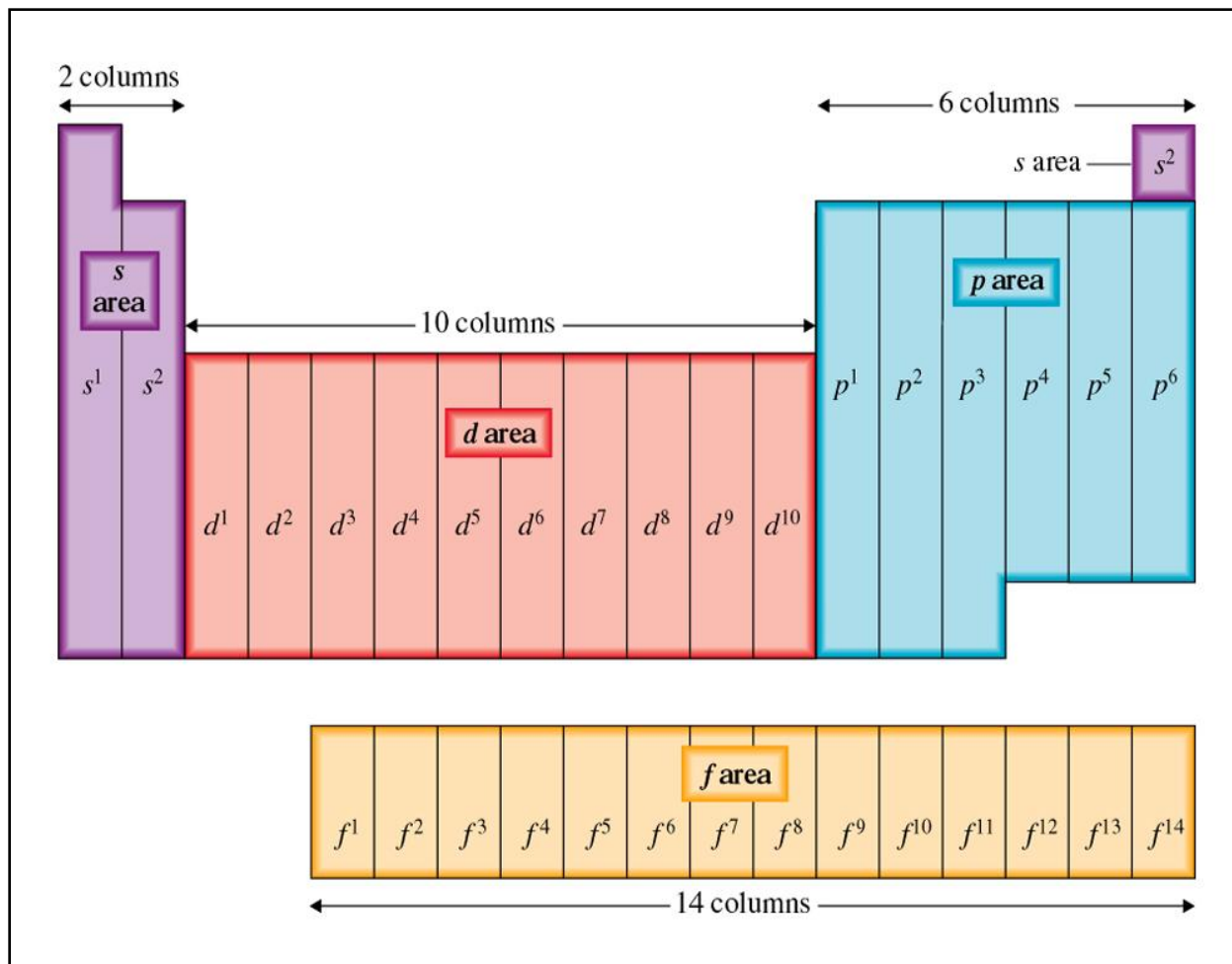


William S. Helsel/Getty Images

The different colors of fireworks result when heat excites the electrons of different kinds of metal atoms.

Orbital Blocks of the Periodic Table

Electron configuration and the positions of the elements in the periodic table.



Element Types and Electronic Configuration

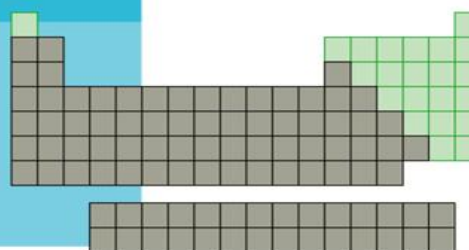
CLASSIFICATION BY PHYSICAL PROPERTIES

Nonmetals

- No metallic luster
- Poor electrical conductivity
- Good heat insulators
- Brittle and nonmalleable

Metals

- Metallic gray or silver luster
- High electrical and thermal conductivity
- Malleable and ductile



CLASSIFICATION BY ELECTRONIC PROPERTIES

Representative elements

- Found in *s* area and first five columns of the *p* area
- Some are metals, some nonmetals

Noble-gas elements

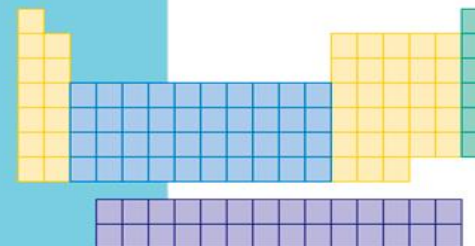
- Found in last column of *p* area plus He (*s* area)
- All are nonmetals

Transition elements

- Found in *d* area
- All are metals

Inner transition elements

- Found in *f* area
- All are metals



PERIODIC TABLE GROUPS WITH SPECIAL NAMES

Alkali metals

- Group IA elements (except for H, a nonmetal)
- Electron configurations end in s^1

Alkaline earth metals

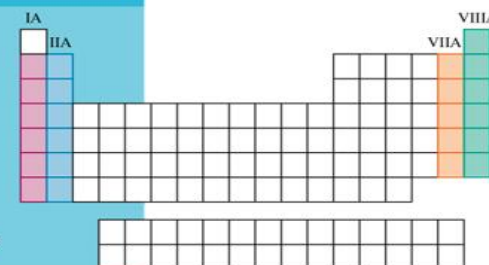
- Group IIA elements
- Electron configurations end in s^2

Halogens

- Group VIIA
- Electron configurations end in p^5

Noble gases

- Group VIIIA elements
- Electron configurations end in p^6 , except for He, which ends in s^2



A classification scheme for the elements based on their electron configuration s .