

Periodic Table & Trends

Regions of the Periodic Table

[illegible]

History of the Periodic Table

- 1871 – **Mendeleev** arranged the elements according to:
 1. Increasing atomic mass
 2. Elements w/ similar properties were put in the same row
- 1913 – **Moseley** arranged the elements according to:
 1. Increasing atomic number
 2. Elements w/ similar properties were put in the same column

Group Names

Alkali +1	Alkaline Earth Metals +2		+3		-3	-2	Halogen -1	Noble Gases 0
H 1								He 2
Li 3	Be 4		B 5	C 6	N 7	O 8	F 9	Ne 10
Na 11	Mg 12		Al 13	Si 14	P 15	S 16	Cl 17	Ar 18

NONMETALS

Rows - periods

The Periodic Law

- Mendeleev understood the ‘Periodic Law’ which states:
- When arranged by **increasing atomic number**, the chemical elements display a **regular and repeating pattern** of chemical and physical properties.

The Periodic Law

- Atoms with similar properties appear in **groups or families** (vertical columns) on the periodic table.
- They are similar because they all have the **same number of valence (outer shell) electrons**, which governs their chemical behavior.

Valence Electrons

- Do you remember how to tell the number of valence electrons for elements in the s- and p-blocks?
- How many valence electrons will the atoms in the d-block (transition metals) and the f-block (inner transition metals) have?
- Most have 2 **valence e-**, some only have 1.

A Different Type of Grouping

- Besides the 4 blocks of the table, there is another way of classifying element:
- Metals
- Nonmetals
- Metalloids or Semi-metals.
- The following slide shows where each group is found.

Main-Group Elements s Subshell fills																		Main-Group Elements p Subshell fills									
1 IA		2 IIA		Transition Metals d Subshell fills								13 IIIA		14 IVA		15 VA		16 VIA		17 VIIA		18 VIIIA					
1	1 H 1s ¹																						2 He 1s ²				
2	3 Li 2s ¹	4 Be 2s ²										5 B 2s ² 2p ¹	6 C 2s ² 2p ²	7 N 2s ² 2p ³	8 O 2s ² 2p ⁴	9 F 2s ² 2p ⁵	10 Ne 2s ² 2p ⁶										
3	11 Na 3s ¹	12 Mg 3s ²	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII B	9	10	11 IB	12 IIB	13 Al 3s ² 3p ¹	14 Si 3s ² 3p ²	15 P 3s ² 3p ³	16 S 3s ² 3p ⁴	17 Cl 3s ² 3p ⁵	18 Ar 3s ² 3p ⁶									
4	19 K 4s ¹	20 Ca 4s ²	21 Sc 3d ¹ 4s ²	22 Ti 3d ² 4s ²	23 V 3d ³ 4s ²	24 Cr 3d ⁵ 4s ¹	25 Mn 3d ⁵ 4s ²	26 Fe 3d ⁶ 4s ²	27 Co 3d ⁷ 4s ²	28 Ni 3d ⁸ 4s ²	29 Cu 3d ¹⁰ 4s ¹	30 Zn 3d ¹⁰ 4s ²	31 Ga 4s ² 4p ¹	32 Ge 4s ² 4p ²	33 As 4s ² 4p ³	34 Se 4s ² 4p ⁴	35 Br 4s ² 4p ⁵	36 Kr 4s ² 4p ⁶									
5	37 Rb 5s ¹	38 Sr 5s ²	39 Y 4d ¹ 5s ²	40 Zr 4d ² 5s ²	41 Nb 4d ⁴ 5s ¹	42 Mo 4d ⁵ 5s ¹	43 Tc 4d ⁵ 5s ²	44 Ru 4d ⁷ 5s ¹	45 Rh 4d ⁸ 5s ¹	46 Pd 4d ¹⁰	47 Ag 4d ¹⁰ 5s ¹	48 Cd 4d ¹⁰ 5s ²	49 In 5s ² 5p ¹	50 Sn 5s ² 5p ²	51 Sb 5s ² 5p ³	52 Te 5s ² 5p ⁴	53 I 5s ² 5p ⁵	54 Xe 5s ² 5p ⁶									
6	55 Cs 6s ¹	56 Ba 6s ²	57 La* 5d ¹ 6s ²	72 Hf 5d ² 6s ²	73 Ta 5d ³ 6s ²	74 W 5d ⁴ 6s ²	75 Re 5d ⁵ 6s ²	76 Os 5d ⁶ 6s ²	77 Ir 5d ⁷ 6s ²	78 Pt 5d ⁹ 6s ¹	79 Au 5d ¹⁰ 6s ¹	80 Hg 5d ¹⁰ 6s ²	81 Tl 6s ² 6p ¹	82 Pb 6s ² 6p ²	83 Bi 6s ² 6p ³	84 Po 6s ² 6p ⁴	85 At 6s ² 6p ⁵	86 Rn 6s ² 6p ⁶									
7	87 Fr 7s ¹	88 Ra 7s ²	89 Ac** 6d ¹ 7s ²	104 Db 6d ² 7s ²	105 Jl 6d ³ 7s ²	106 Rf 6d ⁴ 7s ²	107 Bh 6d ⁵ 7s ²	108 Hn 6d ⁶ 7s ²	109 Mt 6d ⁷ 7s ²	Inner-Transition Metals f Subshell fills																	
			58 Ce 4f ¹ 5d ¹ 6s ²	59 Pr 4f ³ 6s ²	60 Nd 4f ⁴ 6s ²	61 Pm 4f ⁵ 6s ²	62 Sm 4f ⁶ 6s ²	63 Eu 4f ⁷ 6s ²	64 Gd 4f ⁷ 5d ¹ 6s ²	65 Tb 4f ⁹ 6s ²	66 Dy 4f ¹⁰ 6s ²	67 Ho 4f ¹¹ 6s ²	68 Er 4f ¹² 6s ²	69 Tm 4f ¹³ 6s ²	70 Yb 4f												

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
$4f^15d^18s^2$	$4f^16s^2$	$4f^16s^2$	$4f^16s^2$	$4f^16s^2$	$4f^16s^2$	$4f^15d^18s^2$	$4f^16s^2$	$4f^16s^2$	$4f^16s^2$	$4f^16s^2$	$4f^16s^2$	$4f^16s^2$	$4f^16s^2$
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr
$6d^47s^2$	$5f^66d^17s^2$	$5f^66d^17s^2$	$5f^66d^17s^2$	$5f^67s^2$	$5f^77s^2$	$5f^66d^17s^2$	$5f^77s^2$	$5f^77s^2$	$5f^117s^2$	$5f^117s^2$	$5f^117s^2$	$5f^117s^2$	$5f^117s^2$

Metals, Nonmetals, Metalloids

- There is a zig-zag or staircase line that divides the table.
- Metals are on the left of the line, in blue.
- Nonmetals are on the right of the line, in orange.

Main-Group Elements
s Subshell fills

Main-Group Elements
p Subshell fills

1
IA

2
IIA

13
IIIA

14
IVA

15
VA

16
VIA

17
VIIA

18
VIIIA

1
H
1s¹

2
He
1s²

3
Li
2s¹

4
Be
2s²

5
B
2s²2p¹

6
C
2s²2p²

7
N
2s²2p³

8
O
2s²2p⁴

9
F
2s²2p⁵

10
Ne
2s²2p⁶

11
Na
3s¹

12
Mg
3s²

13
Al
3s²3p¹

14
Si
3s²3p²

15
P
3s²3p³

16
S
3s²3p⁴

17
Cl
3s²3p⁵

18
Ar
3s²3p⁶

19
K
4s¹

20
Ca
4s²

21
Sc
3d¹4s²

22
Ti
3d²4s²

23
V
3d³4s²

24
Cr
3d⁵4s¹

25
Mn
3d⁵4s²

26
Fe
3d⁶4s²

27
Co
3d⁷4s²

28
Ni
3d⁸4s²

29
Cu
3d¹⁰4s¹

30
Zn
3d¹⁰4s²

31
Ga
4s²4p¹

32
Ge
4s²4p²

33
As
4s²4p³

34
Se
4s²4p⁴

35
Br
4s²4p⁵

36
Kr
4s²4p⁶

37
Rb
5s¹

38
Sr
5s²

39
Y
4d¹5s²

40
Zr
4d²5s²

41
Nb
4d⁴5s¹

42
Mo
4d⁵5s¹

43
Tc
4d⁵5s²

44
Ru
4d⁷5s¹

45
Rh
4d⁸5s¹

46
Pd
4d¹⁰5s⁰

47
Ag
4d¹⁰5s¹

48
Cd
4d¹⁰5s²

49
In
5s²5p¹

50
Sn
5s²5p²

51
Sb
5s²5p³

52
Te
5s²5p⁴

53
I
5s²5p⁵

54
Xe
5s²5p⁶

55
Cs
6s¹

56
Ba
6s²

57
La
5d¹6s²

58
Ce
4f¹5d¹6s²

59
Pr
4f³6s²

60
Nd
4f⁴6s²

61
Pm
4f⁵6s²

62
Sm
4f⁶6s²

63
Eu
4f⁷6s²

64
Gd
4f⁷5d¹6s²

65
Tb
4f⁹6s²

66
Dy
4f¹⁰6s²

67
Ho
4f¹¹6s²

68
Er
4f¹²6s²

69
Tm
4f¹³6s²

70
Yb
4f¹⁴6s²

71
Lu
4f¹⁴5d¹6s²

72
Hf
5d²6s²

73
Ta
5d³6s²

74
W
5d⁴6s²

75
Re
5d⁵6s²

76
Os
5d⁶6s²

77
Ir
5d⁷6s²

78
Pt
5d⁹6s¹

79
Au
5d¹⁰6s¹

80
Hg
5d¹⁰6s²

81
Tl
6s²6p¹

82
Pb
6s²6p²

83
Bi
6s²6p³

84
Po
6s²6p⁴

85
At
6s²6p⁵

86
Rn
6s²6p⁶

87
Fr
7s¹

88
Ra
7s²

89
Ac
6d¹7s²

90
Th
6d²7s²

91
Pa
5f²6d¹7s²

92
U
5f³6d¹7s²

93
Np
5f⁴6d¹7s²

94
Pu
5f⁶6d¹7s²

95
Am
5f⁷7s²

96
Cm
5f⁷6d¹7s²

97
Bk
5f⁹7s²

98
Cf
5f¹⁰7s²

99
Es
5f¹¹7s²

100
Fm
5f¹²7s²

101
Md
5f¹³7s²

102
No
5f¹⁴7s²

103
Lr
5f¹⁴6d¹7s²

Transition Metals
d Subshell fills

Inner-Transition Metals
f Subshell fills

1
H
1s¹

2
He
1s²

3
Li
2s¹

4
Be
2s²

5
B
2s²2p¹

6
C
2s²2p²

7
N
2s²2p³

8
O
2s²2p⁴

9
F
2s²2p⁵

10
Ne
2s²2p⁶

11
Na
3s¹

12
Mg
3s²

13
Al
3s²3p¹

14
Si
3s²3p²

15
P
3s²3p³

16
S
3s²3p⁴

17
Cl
3s²3p⁵

18
Ar
3s²3p⁶

19
K
4s¹

20
Ca
4s²

21
Sc
3d¹4s²

22
Ti
3d²4s²

23
V
3d³4s²

24
Cr
3d⁵4s¹

25
Mn
3d⁵4s²

26
Fe
3d⁶4s²

27
Co
3d⁷4s²

28
Ni
3d⁸4s²

29
Cu
3d¹⁰4s¹

30
Zn
3d¹⁰4s²

31
Ga
4s²4p¹

32
Ge
4s²4p²

33
As
4s²4p³

34
Se
4s²4p⁴

35
Br
4s²4p⁵

36
Kr
4s²4p⁶

37
Rb
5s¹

38
Sr
5s²

39
Y
4d¹5s²

40
Zr
4d²5s²

41
Nb
4d⁴5s¹

42
Mo
4d⁵5s¹

43
Tc
4d⁵5s²

44
Ru
4d⁷5s¹

45
Rh
4d⁸5s¹

46
Pd
4d¹⁰5s⁰

47
Ag
4d¹⁰5s¹

48
Cd
4d¹⁰5s²

49
In
5s²5p¹

50
Sn
5s²5p²

51
Sb
5s²5p³

52
Te
5s²5p⁴

53
I
5s²5p⁵

54
Xe
5s²5p⁶

55
Cs
6s¹

56
Ba
6s²

57
La
5d¹6s²

58
Ce
4f¹5d¹6s²

59
Pr
4f³6s²

60
Nd
4f⁴6s²

61
Pm
4f⁵6s²

62
Sm
4f⁶6s²

63
Eu
4f⁷6s²

64
Gd
4f⁷5d¹6s²

65
Tb
4f⁹6s²

66
Dy
4f¹⁰6s²

67
Ho
4f¹¹6s²

68
Er
4f¹²6s²

69
Tm
4f¹³6s²

70
Yb
4f¹⁴6s²

71
Lu
4f¹⁴5d¹6s²

72
Hf
5d²6s²

73
Ta
5d³6s²

74
W
5d⁴6s²

75
Re
5d⁵6s²

76
Os
5d⁶6s²

77
Ir
5d⁷6s²

78
Pt
5d⁹6s¹

79
Au
5d¹⁰6s¹

80
Hg
5d¹⁰6s²

81
Tl
6s²6p¹

82
Pb
6s²6p²

83
Bi
6s²6p³

84
Po
6s²6p⁴

85
At
6s²6p⁵

86
Rn
6s²6p⁶

87
Fr
7s¹

88
Ra
7s²

89
Ac
6d¹7s²

90
Th
6d²7s²

91
Pa
5f²6d¹7s²

92
U
5f³6d¹7s²

93
Np
5f⁴6d¹7s²

94
Pu
5f⁶6d¹7s²

95
Am
5f⁷7s²

96
Cm
5f⁷6d¹7s²

97
Bk
5f⁹7s²

98
Cf
5f¹⁰7s²

99
Es
5f¹¹7s²

100
Fm
5f¹²7s²

101
Md
5f¹³7s²

102
No
5f¹⁴7s²

103
Lr
5f¹⁴6d¹7s²

1
H
1s¹

2
He
1s²

3
Li
2s¹

4
Be
2s²

5
B
2s²2p¹

6
C
2s²2p²

7
N
2s²2p³

8
O
2s²2p⁴

9
F
2s²2p⁵

10
Ne
2s²2p⁶

11
Na
3s¹

12
Mg
3s²

13
Al
3s²3p¹

14
Si
3s²3p²

15
P
3s²3p³

16
S
3s²3p⁴

17
Cl
3s²3p⁵

18
Ar
3s²3p⁶

19
K
4s¹

20
Ca
4s²

21
Sc
3d¹4s²

22
Ti
3d²4s²

23
V
3d³4s²

24
Cr
3d⁵4s¹

25
Mn
3d⁵4s²

26
Fe
3d⁶4s²

27
Co
3d⁷4s²

28
Ni
3d⁸4s²

29
Cu
3d¹⁰4s¹

30
Zn
3d¹⁰4s²

31
Ga
4s²4p¹

32
Ge
4s²4p²

33
As
4s²4p³

34
Se
4s²4p⁴

35
Br
4s²4p⁵

36
Kr
4s²4p⁶

37
Rb
5s¹

38
Sr
5s²

39
Y
4d¹5s²

40
Zr
4d²5s²

41
Nb
4d⁴5s¹

42
Mo
4d⁵5s¹

43
Tc
4d⁵5s²

44
Ru
4d⁷5s¹

45
Rh
4d⁸5s¹

46
Pd
4d¹⁰5s⁰

47
Ag
4d¹⁰5s¹

48
Cd
4d¹⁰5s²

49
In
5s²5p¹

50
Sn
5s²5p²

51
Sb
5s²5p³

52
Te
5s²5p⁴

53
I
5s²5p⁵

54
Xe
5s²5p⁶

55
Cs
6s¹

56
Ba
6s²

57
La
5d¹6s²

58
Ce
4f¹5d¹6s²

59
Pr
4f³6s²

60
Nd
4f⁴6s²

61
Pm
4f⁵6s²

62
Sm
4f⁶6s²

63
Eu
4f⁷6s²

64
Gd
4f⁷5d¹6s²

65
Tb
4f⁹6s²

66
Dy
4f¹⁰6s²

67
Ho
4f¹¹6s²

68
Er
4f¹²6s²

69
Tm
4f¹³6s²

70
Yb
4f¹⁴6s²

71
Lu
4f¹⁴5d¹6s²

72
Hf
5d²6s²

73
Ta
5d³6s²

74
W
5d⁴6s²

75
Re
5d⁵6s²

76
Os
5d⁶6s²

77
Ir
5d⁷6s²

78
Pt
5d⁹6s¹

79
Au
5d¹⁰6s¹

80
Hg
5d¹⁰6s²

81
Tl
6s²6p¹

82
Pb
6s²6p²

83
Bi
6s²6p³

84
Po
6s²6p⁴

85
At
6s²6p⁵

86
Rn
6s²6p⁶

87
Fr
7s¹

88
Ra
7s²

89
Ac
6d¹7s²

90
Th
6d²7s²

91
Pa
5f²6d¹7s²

92
U
5f³6d¹7s²

93
Np
5f⁴6d¹7s²

94
Pu
5f⁶6d¹7s²

95
Am
5f⁷7s²

96
Cm
5f⁷6d¹7s²

97
Bk
5f⁹7s²

98
Cf
5f¹⁰7s²

99
Es
5f¹¹7s²

100
Fm
5f¹²7s²

101
Md
5f¹³7s²

102
No
5f¹⁴7s²

103
Lr
5f¹⁴6d¹7s²

1
H
1s¹

2
He
1s²

3
Li
2s¹

4
Be
2s²

5
B
2s²2p¹

6
C
2s²2p²

7
N
2s²2p³

8
O
2s²2p⁴

9
F
2s²2p⁵

10
Ne
2s²2p⁶

11
Na
3s¹

12
Mg
3s²

13
Al
3s²3p¹

14
Si
3s²3p²

15
P
3s²3p³

16
S
3s²3p⁴

17
Cl
3s²3p⁵

18
Ar
3s²3p⁶

19
K
4s¹

20
Ca
4s²

21
Sc
3d¹4s²

22
Ti
3d²4s²

23
V
3d³4s²

24
Cr
3d⁵4s¹

25
Mn
3d⁵4s²

26
Fe
3d⁶4s²

27
Co
3d⁷4s²

28
Ni
3d⁸4s²

29
Cu
3d¹⁰4s¹

30
Zn
3d¹⁰4s²

31
Ga
4s²4p¹

32
Ge
4s²4p²

33
As
4s²4p³

34
Se
4s²4p⁴

35
Br
4s²4p⁵

36
Kr
4s²4p⁶

37
Rb
5s¹

38
Sr
5s²

39
Y
4d¹5s²

40
Zr
4d²5s²

41
Nb
4d⁴5s¹

42
Mo
4d⁵5s¹

43
Tc
4d⁵5s²

44
Ru
4d⁷5s¹

45
Rh
4d⁸5s¹

46
Pd
4d¹⁰5s⁰

47
Ag
4d¹⁰5s¹

48
Cd
4d¹⁰5s²

49
In
5s²5p¹

50
Sn
5s²5p²

51
Sb
5s²5p³

52
Te
5s²5p⁴

53
I
5s²5p⁵

54
Xe
5s²5p⁶

55
Cs
6s¹

56
Ba
6s²

57
La
5d¹6s²

58
Ce
4f¹5d¹6s²

59
Pr
4f³6s²

60
Nd
4f⁴6s²

61
Pm
4f⁵6s²

62
Sm
4f⁶6s²

63
Eu
4f⁷6s²

64
Gd
4f⁷5d¹6s²

65
Tb
4f⁹6s²

66
Dy
4f¹⁰6s²

67
Ho
4f¹¹6s²

68
Er
4f¹²6s²

69
Tm
4f¹³6s²

70
Yb
4f¹⁴6s²

71
Lu
4f¹⁴5d¹6s²

72
Hf
5d²6s²

73
Ta
5d³6s²

74
W
5d⁴6s²

75
Re
5d⁵6s²

76
Os
5d⁶6s²

77
Ir
5d⁷6s²

78
Pt
5d⁹6s¹

79
Au
5d¹⁰6s¹

80
Hg
5d¹⁰6s²

81
Tl
6s²6p¹

82
Pb
6s²6p²

83
Bi
6s²6p³

84
Po
6s²6p⁴

85
At
6s²6p⁵

86
Rn
6s²6p⁶

87
Fr
7s¹

88
Ra
7s²

89
Ac
6d¹7s²

90
Th
6d²7s²

91
Pa
5f²6d¹7s²

92
U
5f³6d¹7s²

93
Np
5f⁴6d¹7s²

94
Pu
5f⁶6d¹7s²

95
Am
5f⁷7s²

96
Cm
5f⁷6d¹7s²

97
Bk
5f⁹7s²

98
Cf
5f¹⁰7s²

99
Es
5f¹¹7s²

100
Fm
5f¹²7s²

101
Md
5f¹³7s²

102
No
5f¹⁴7s²

103
Lr
5f¹⁴6d¹7s²

1
H
1s¹

2
He
1s²

3
Li
2s¹

4
Be
2s²

5
B
2s²2p¹

6
C
2s²2p²

7
N
2s²2p³

8
O
2s²2p⁴

9
F
2s²2p⁵

10
Ne
2s²2p⁶

11
Na
3s¹

12
Mg

Metals, Nonmetals, Metalloids

- Elements that border the stair case, shown in **purple** are the metalloids or semi-metals.
- There is one important exception.
- Aluminum is more metallic than not.

Main-Group Elements

s Subshell fills

Main-Group Elements

p Subshell fills

1 — Atomic number
 H — Symbol
 1s¹ — Valence-shell configuration

Transition Metals
d Subshell fills

13	14	15	16	17	18
IIIA	IVA	VA	VIA	VIIA	VIIIA
5 B 2s ² 2p ¹	6 C 2s ² 2p ²	7 N 2s ² 2p ³	8 O 2s ² 2p ⁴	9 F 2s ² 2p ⁵	10 Ne 2s ² 2p ⁶
13 Al 3s ² 3p ¹	14 Si 3s ² 3p ²	15 P 3s ² 3p ³	16 S 3s ² 3p ⁴	17 Cl 3s ² 3p ⁵	18 Ar 3s ² 3p ⁶
31 Ga 4s ² 4p ¹	32 Ge 4s ² 4p ²	33 As 4s ² 4p ³	34 Se 4s ² 4p ⁴	35 Br 4s ² 4p ⁵	36 Kr 4s ² 4p ⁶
49 In 5s ² 5p ¹	50 Sn 5s ² 5p ²	51 Sb 5s ² 5p ³	52 Te 5s ² 5p ⁴	53 I 5s ² 5p ⁵	54 Xe 5s ² 5p ⁶
81 Tl 6s ² 6p ¹	82 Pb 6s ² 6p ²	83 Bi 6s ² 6p ³	84 Po 6s ² 6p ⁴	85 At 6s ² 6p ⁵	86 Rn 6s ² 6p ⁶

Inner-Transition Metals
f Subshell fills

*Lanthanides

**Actinides

58 Ce 4f ¹ 5d ¹ 6s ²	59 Pr 4f ³ 6s ²	60 Nd 4f ⁴ 6s ²	61 Pm 4f ⁵ 6s ²	62 Sm 4f ⁶ 6s ²	63 Eu 4f ⁷ 6s ²	64 Gd 4f ⁷ 5d ¹ 6s ²	65 Tb 4f ⁹ 6s ²	66 Dy 4f ¹⁰ 6s ²	67 Ho 4f ¹¹ 6s ²	68 Er 4f ¹² 6s ²	69 Tm 4f ¹³ 6s ²	70 Yb 4f ¹⁴ 6s ²	71 Lu 4f ¹⁴ 5d ¹ 6s ²
90 Th 6d ² 7s ²	91 Pa 5f ² 6d ¹ 7s ²	92 U 5f ³ 6d ¹ 7s ²	93 Np 5f ⁴ 6d ¹ 7s ²	94 Pu 5f ⁶ 7s ²	95 Am 5f ⁷ 7s ²	96 Cm 5f ⁷ 6d ¹ 7s ²	97 Bk 5f ⁹ 7s ²	98 Cf 5f ¹⁰ 7s ²	99 Es 5f ¹¹ 7s ²	100 Fm 5f ¹² 7s ²	101 Md 5f ¹³ 7s ²	102 No 5f ¹⁴ 7s ²	103 Lr 5f ¹⁴ 6d ¹ 7s ²

Metal

Metalloid

Nonmetal

Metals, Nonmetals, Metalloids

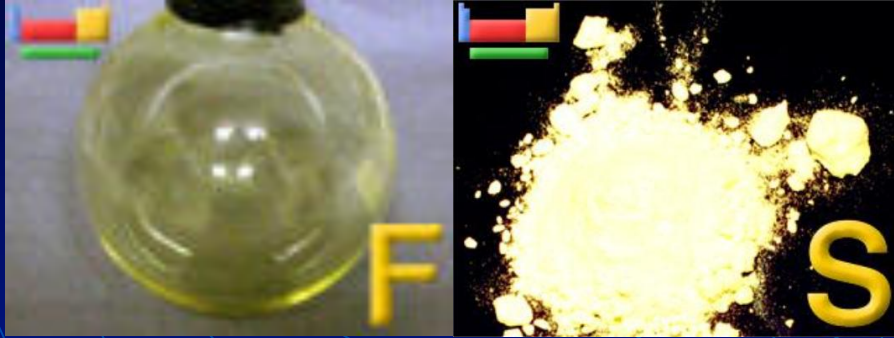
- How can you identify a metal?
- What are its properties?
- What about the less common nonmetals?
- What are their properties?
- And what the heck is a metalloid?

Metals



- Metals are lustrous (shiny), malleable, ductile, and are good conductors of heat and electricity.
- They are mostly solids at room temp.
- What is one exception?

Nonmetals

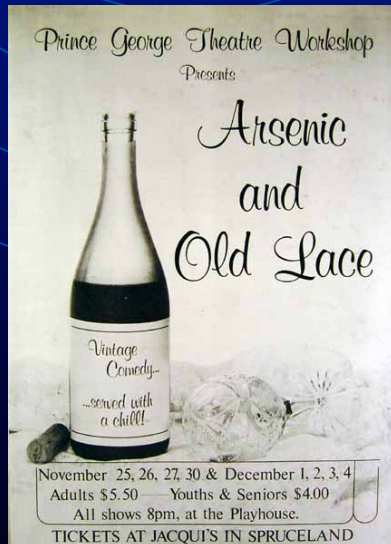


- Nonmetals are the opposite.
- They are dull, brittle, nonconductors (insulators).
- Some are solid, but many are gases, and Bromine is a liquid.



Metalloids

- Metalloids, aka semi-metals are just that.
- They have characteristics of both metals and nonmetals.
- They are shiny but brittle.
- And they are **semiconductors**.
- What is our most important semiconductor?



Periodic Trends

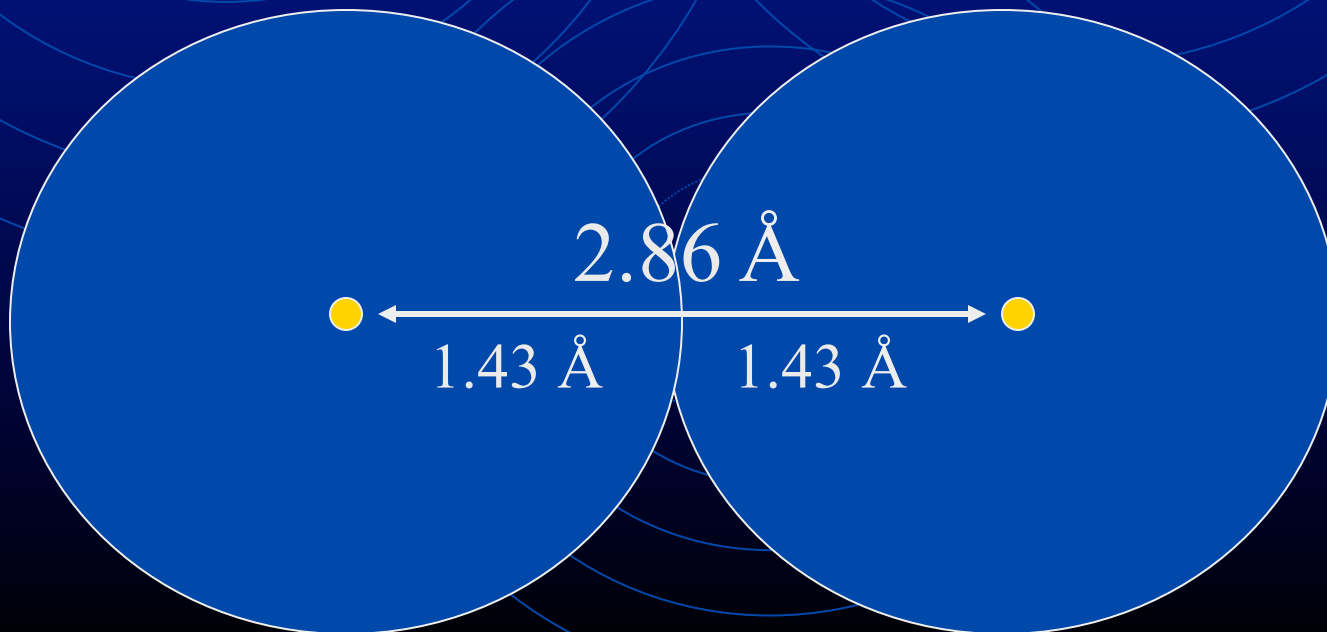
- There are several important atomic characteristics that show predictable trends that you should know.
- The first and most important is **atomic radius**.
- Radius is the distance from the center of the nucleus to the “edge” of the electron cloud.

Atomic Radius

- Since a cloud's edge is difficult to define, scientists use define **covalent radius**, or half the distance between the nuclei of 2 bonded atoms.
- Atomic radii are usually measured in picometers (pm) or **angstroms (Å)**. An angstrom is 1×10^{-10} m.

Covalent Radius

- Two Br atoms bonded together are 2.86 angstroms apart. So, the radius of each atom is 1.43 Å.



Atomic Radius

- The trend for atomic radius in a vertical column is to go from **smaller at the top to larger at the bottom** of the family.
- Why?
- With each step down the family, we add an entirely **new PEL** to the electron cloud, making the atoms larger with each step.

Atomic Radius

- The trend across a horizontal period is less obvious.
- What happens to atomic structure as we step from left to right?
- Each step adds a **proton** and an **electron** (and 1 or 2 neutrons).
- Electrons are added to existing PELs or sublevels.

Atomic Radius

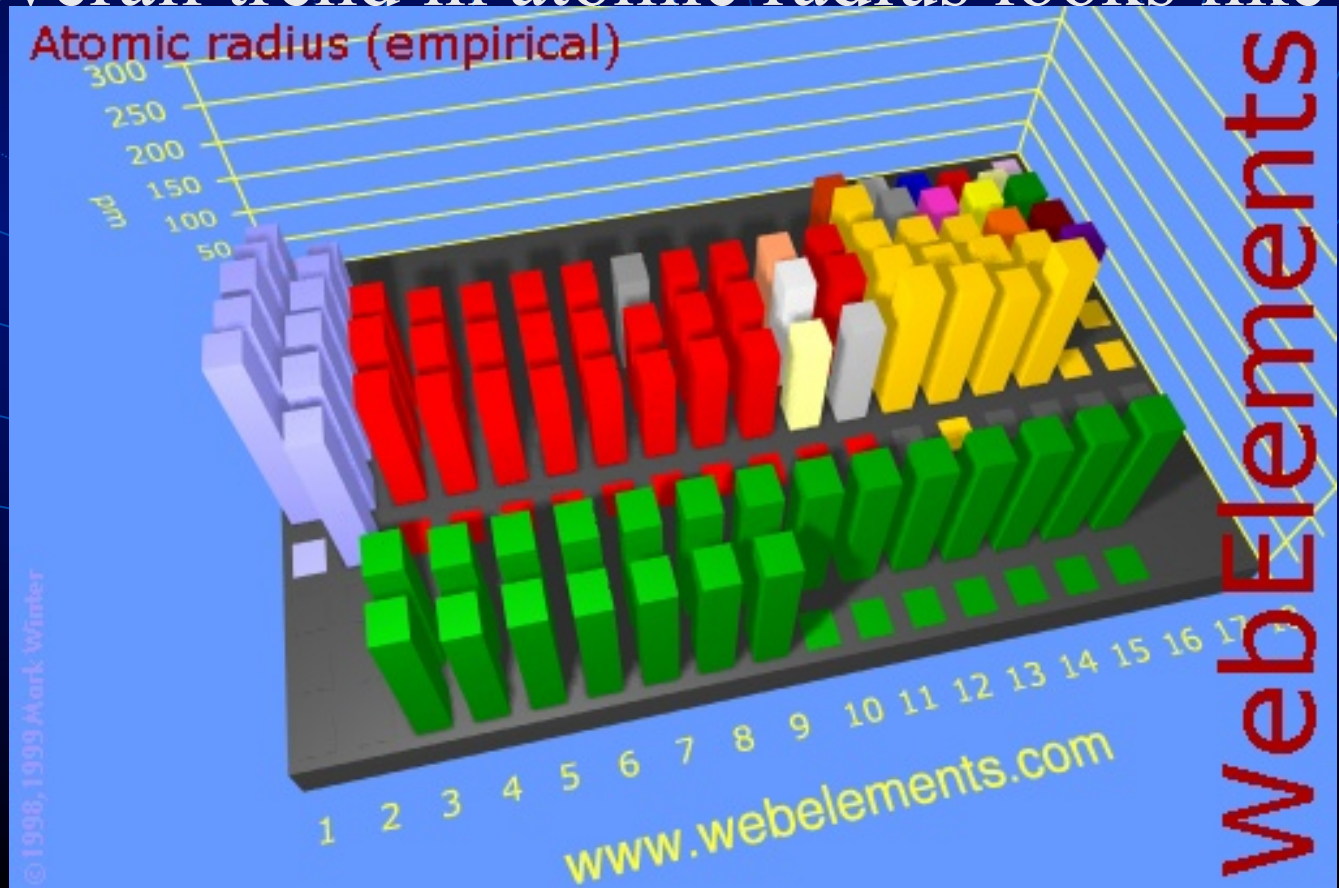
- The effect is that the more positive nucleus has a greater pull on the electron cloud.
- The **nucleus is more positive** and the **electron cloud is more negative**.
- The **increased attraction pulls the cloud in**, making atoms smaller as we move from left to right across a period.

Effective Nuclear Charge

- What keeps electrons from simply flying off into space?
- **Effective nuclear charge** is the **pull that an electron “feels”** from the nucleus.
- The closer an electron is to the nucleus, the more pull it feels.
- As effective nuclear charge increases, the electron cloud is pulled in tighter.

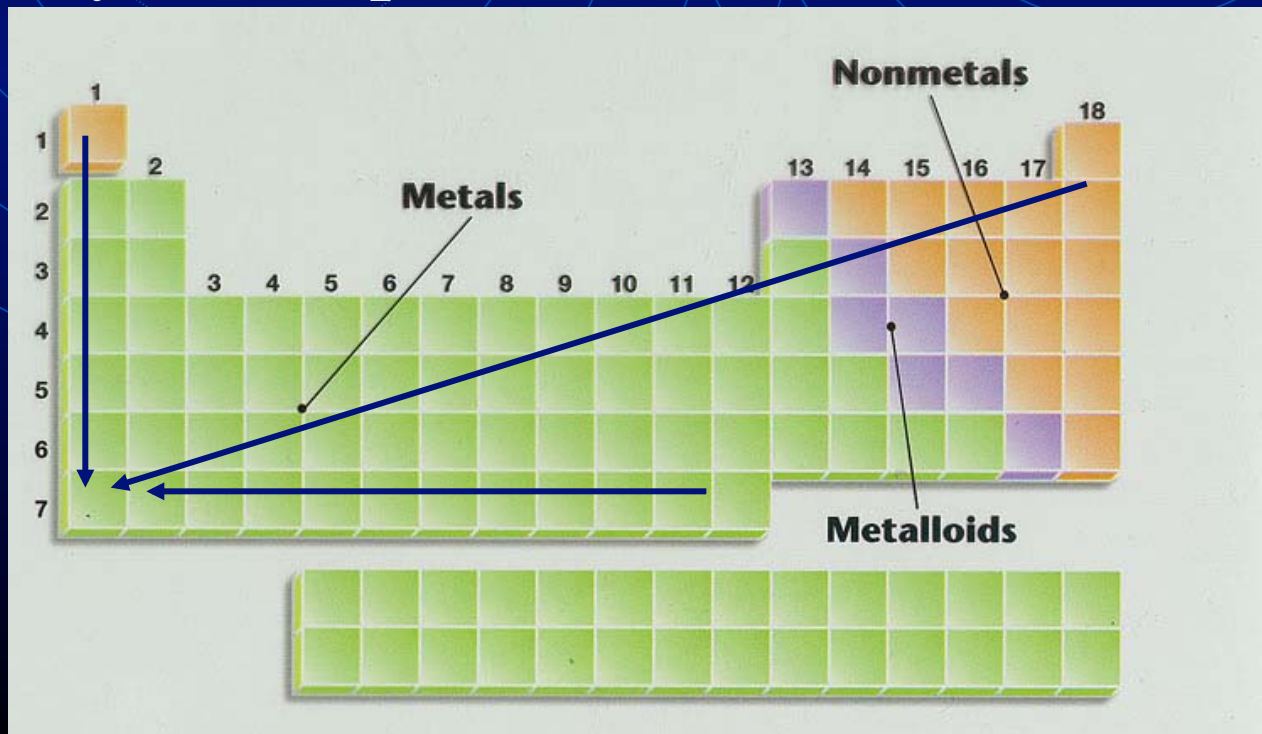
Atomic Radius

- The overall trend in atomic radius looks like this.



Atomic Radius

- Here is an animation to explain the trend.
- On your help sheet, draw arrows like this:



The Octet Rule

- The “goal” of most atoms (except H, Li and Be) is to have an **octet or group of 8 electrons** in their **valence** energy level.
- They may accomplish this by either giving electrons away or taking them.
- Metals generally give electrons, nonmetals take them from other atoms.
- Atoms that have gained or lost electrons are called **ions**.

Ions

- When an atom gains an electron, it becomes negatively charged (more electrons than protons) and is called an **anion**.
- In the same way that nonmetal atoms can gain electrons, metal atoms can lose electrons.
- They become positively charged **cations**.

Ions

- Here is a simple way to remember which is the cation and which the anion:



This is Ann Ion.

She's unhappy and
negative.



This is a cat-ion.

He's a "plussy" cat!

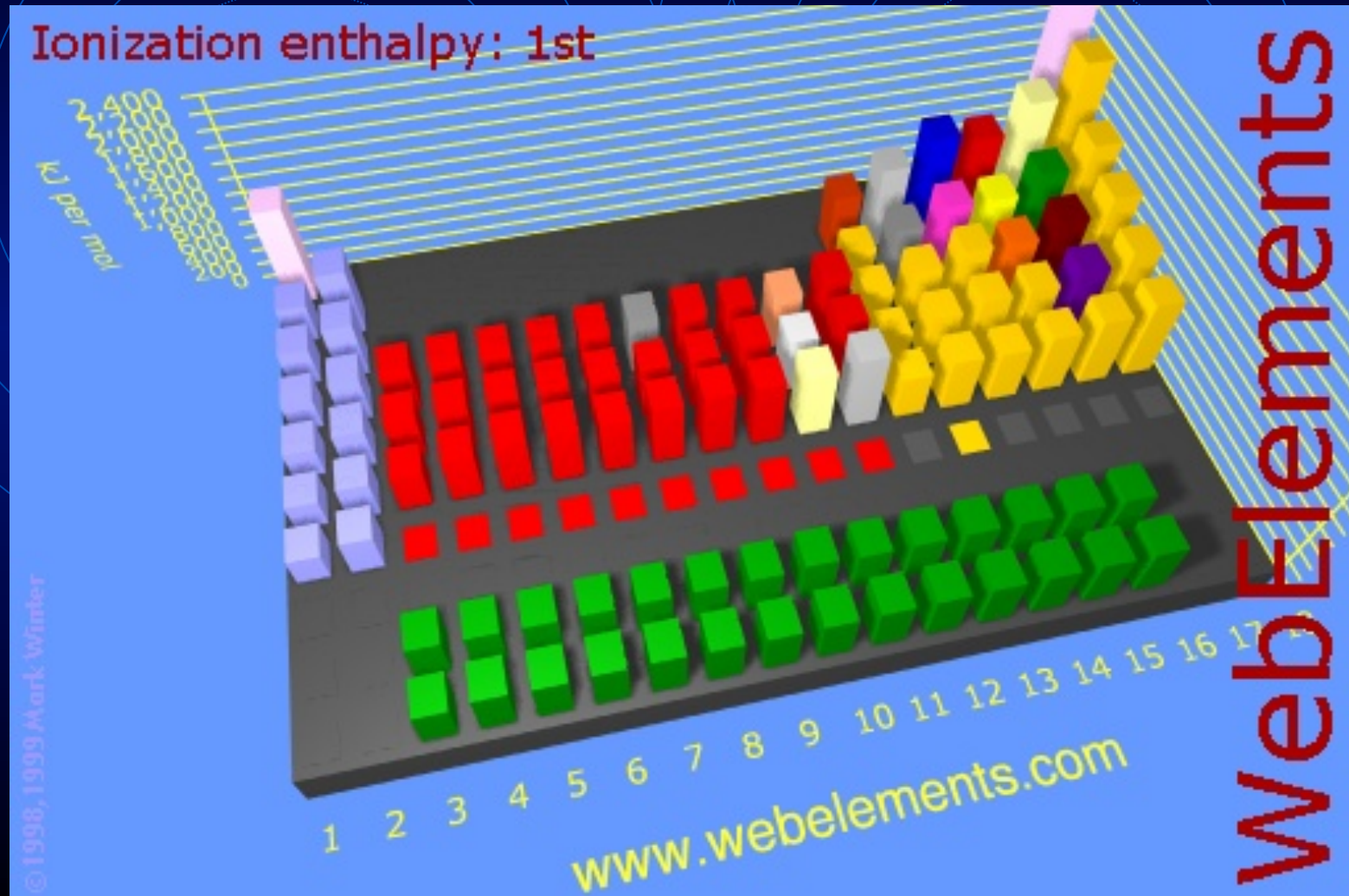
Ionization Energy

- This is the second important periodic trend.
- If an electron is given enough energy (in the form of a photon) to overcome the effective nuclear charge holding the electron in the cloud, it can leave the atom completely.
- The atom has been “ionized” or charged.
- The number of protons and electrons is no longer equal.

Ionization Energy

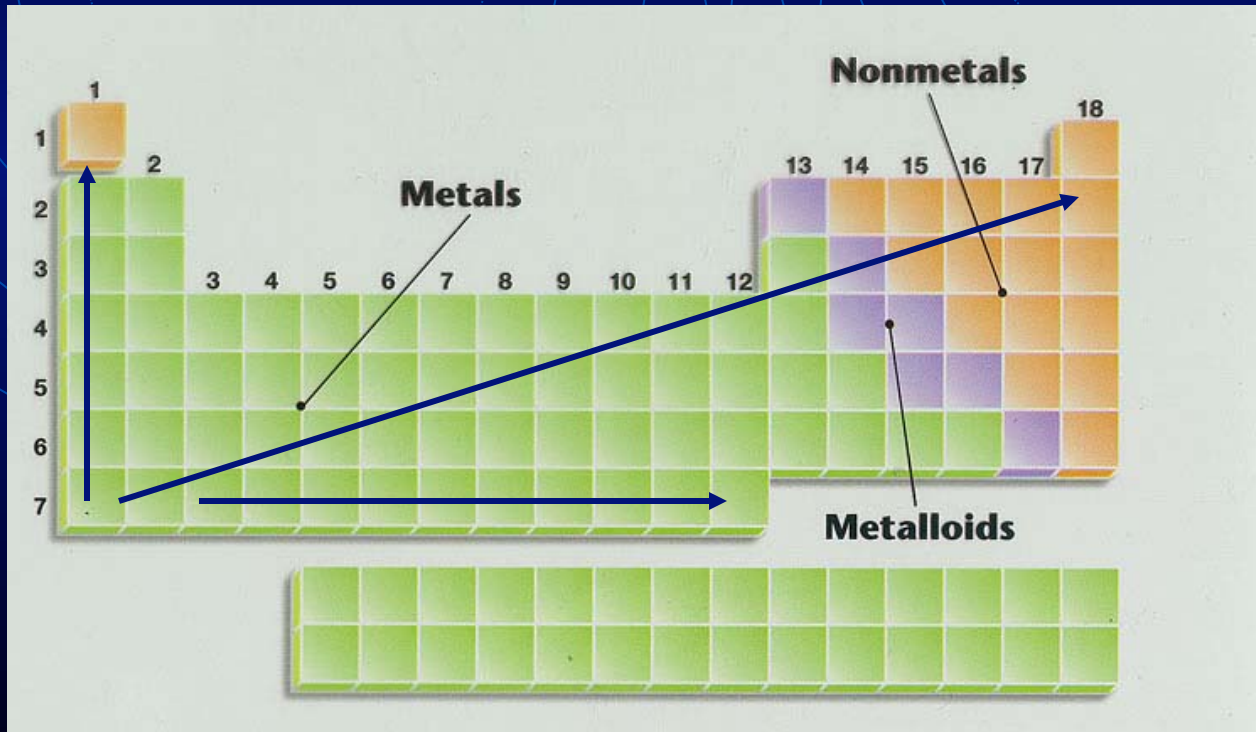
- The energy **required** to remove an electron from an atom is **ionization energy**. (measured in kilojoules, kJ)
- The larger the atom is, the easier its electrons are to remove.
- **Ionization energy and atomic radius are inversely proportional.**
- Ionization energy is always **endothermic**, that is energy is added to the atom to remove the electron.

Ionization Energy



Ionization Energy (Potential)

- Draw arrows on your help sheet like this:



Electron Affinity

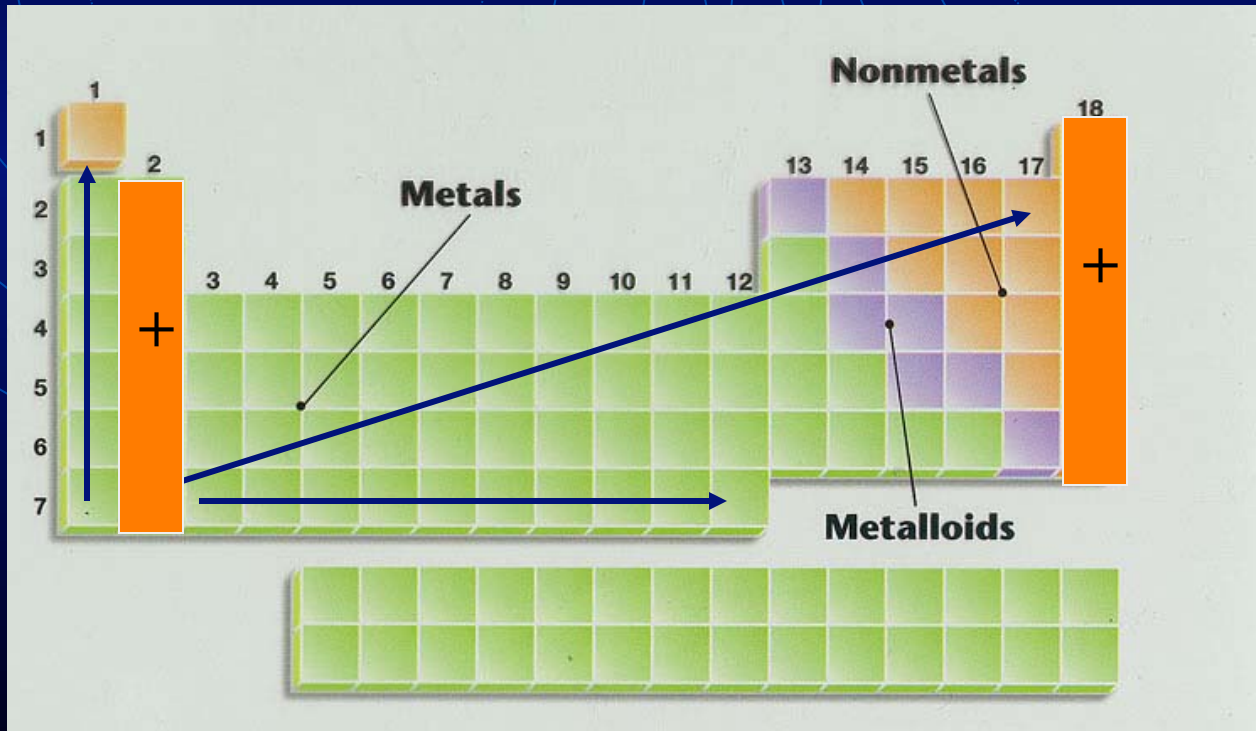
- What does the word 'affinity' mean?
- **Electron affinity** is the **energy change** that occurs when an atom **gains an electron** (also measured in kJ).
- Where ionization energy is always endothermic, electron affinity is **usually exothermic**, but not always.

Electron Affinity

- Electron affinity is **exothermic** if there is an **empty or partially empty** orbital for an electron to occupy.
- If there are **no empty spaces**, a new orbital or PEL must be created, making the process **endothermic**.
- This is true for the alkaline earth metals and the noble gases.

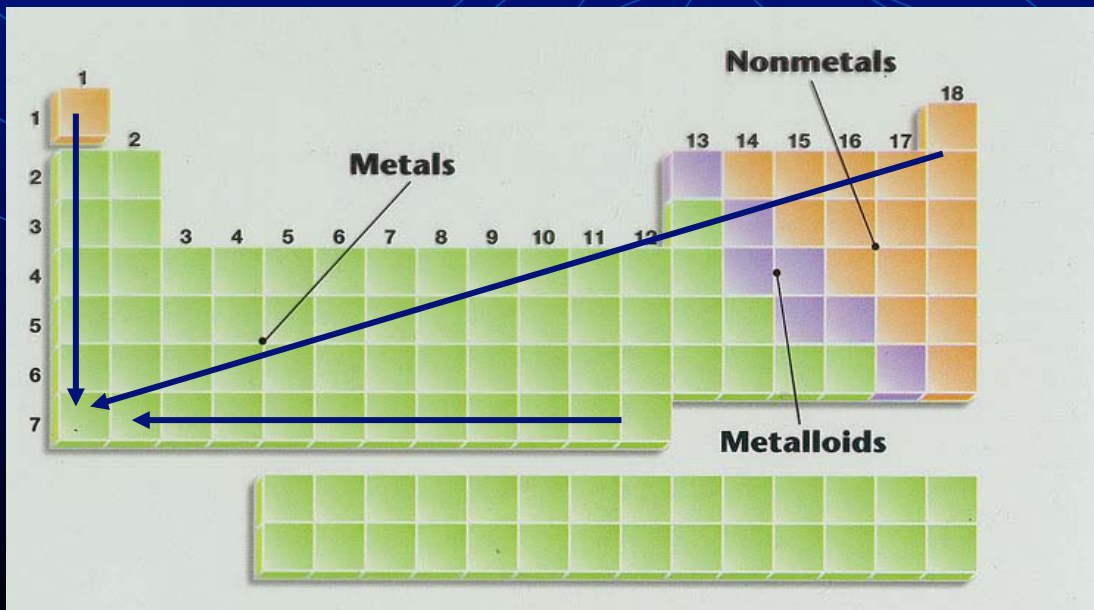
Electron Affinity

- Your help sheet should look like this:



Metallic Character

- This is simply a relative measure of how easily atoms **lose or give up electrons**.
- Your help sheet should look like this:

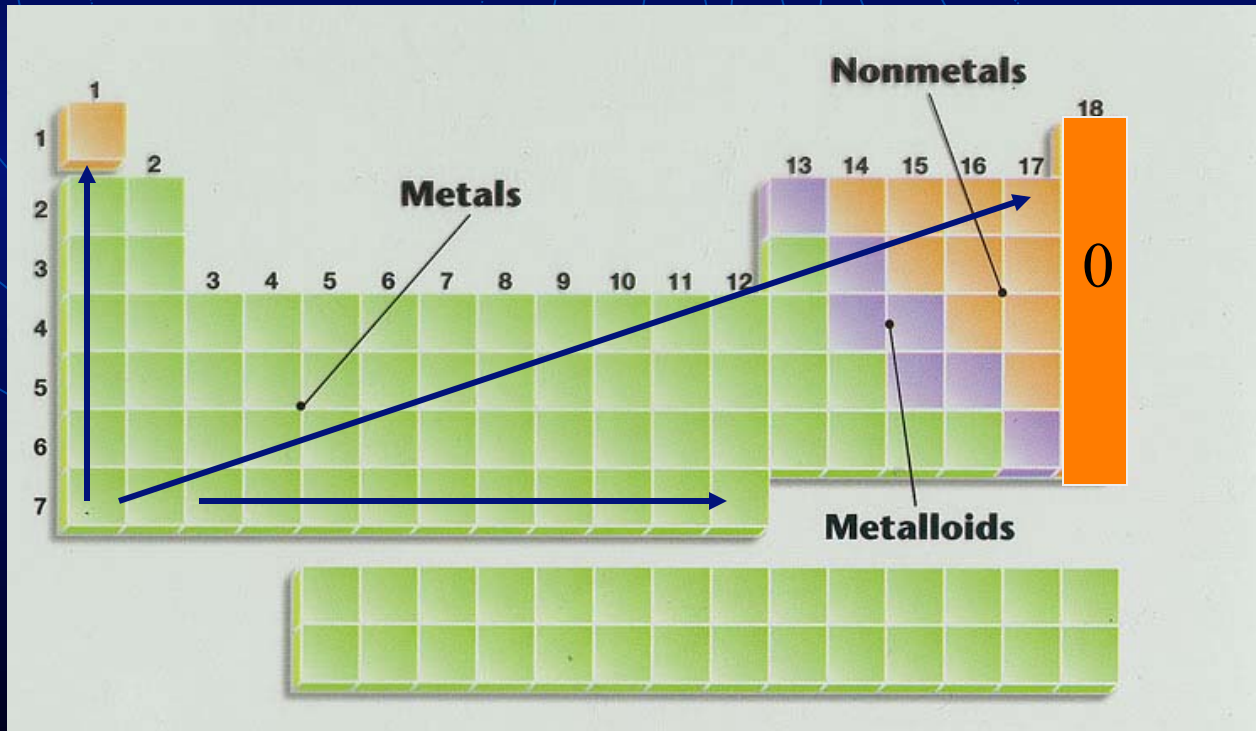


Electronegativity

- Electronegativity is a measure of an **atom's attraction for another atom's electrons**.
- It is an arbitrary scale that ranges from **0 to 4**.
- The units of electronegativity are **Paulings**.
- Generally, metals are **electron givers** and have **low electronegativities**.
- Nonmetals are **electron takers** and have **high electronegativities**.
- What about the noble gases?

Electronegativity

- Your help sheet should look like this:

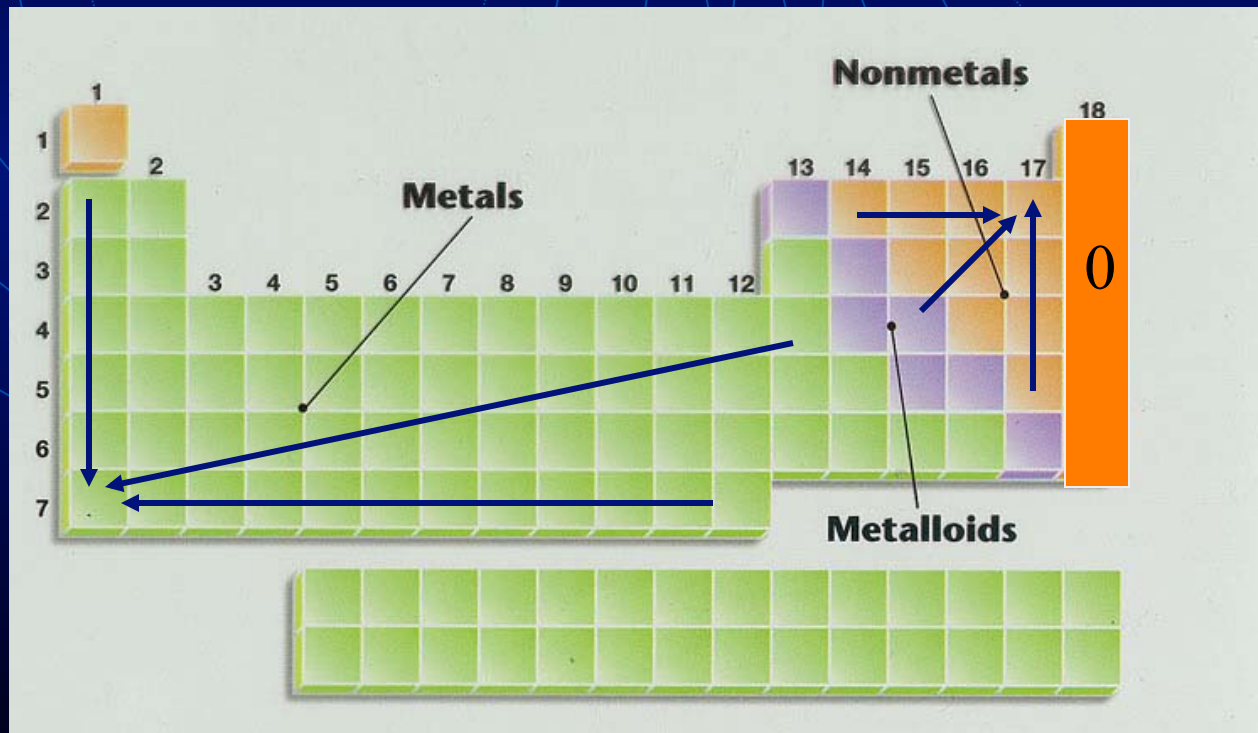


Overall Reactivity

- This ties all the previous trends together in one package.
- However, we must treat metals and nonmetals separately.
- The most reactive **metals** are the largest since they are the **best electron givers**.
- The most reactive **nonmetals** are the smallest ones, the **best electron takers**.

Overall Reactivity

- Your help sheet will look like this:



Cation Formation

Na atom

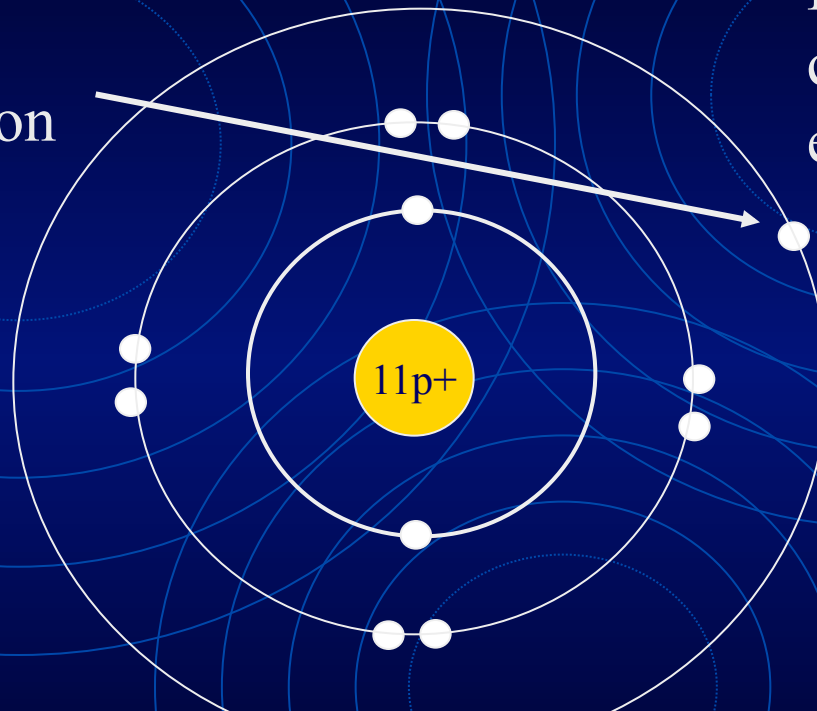
1 valence electron

Effective nuclear charge on remaining electrons increases.

Valence e-
lost in ion
formation

Remaining e- are
pulled in closer to
the nucleus. Ionic
size decreases.

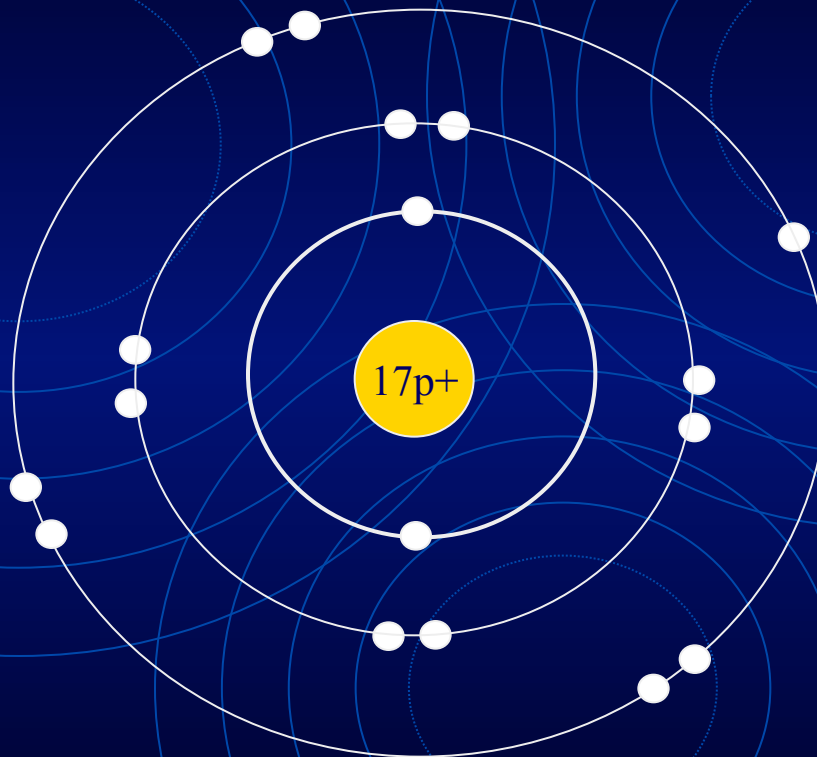
Result: a smaller
sodium cation, Na^+



Anion Formation

A chloride ion is produced. It is larger than the original atom.

Chlorine atom with 7 valence e-



One e- is added to the outer shell.

Effective nuclear charge is reduced and the e- cloud expands.