

# Periodic Relationships Among the Elements

## Chapter 8

Periodic Table of Elements

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## The Periodic Table

- The modern periodic table (PT) represents the arrangements of elements according to the building up (**Aufbau principle**), where each element has one electron more than the previous element.
- The periodic table can be classified in many different ways:
  - **Metallic character:**  
**metals**, **nonmetals**, and **metalloids**.
  - **Position in the periodic table:**  
horizontal rows (**Periods**)  
vertical columns (**Groups**)

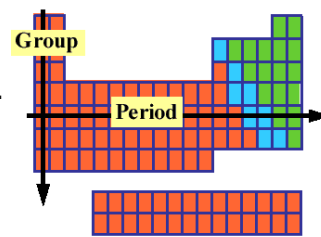


Fig. 5.1 The periodic table classification

### Classification of the Elements

1 1A		Representative elements										Zinc Cadmium Mercury										18 8A	
3 Li		Noble gases										Lanthanides										2 He	
4 Be		Transition metals										Actinides										10 Ne	
11 Na																						18 Ar	
19 K																						36 Kr	
37 Rb																						54 Xe	
55 Cs																						86 Rn	
87 Fr																						(118)	

58 Ce		Lanthanides										Actinides										71 Lu	
90 Th		Actinides										Lanthanides										103 Lr	

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### Ground State Electron Configurations of the Elements

1 1A		$ns^1$										$ns^2np^1$										18 8A	
2 2A		$ns^2$										$ns^2np^2$										2 He	
3 3A		$ns^2d^1$										$ns^2np^3$										10 Ne	
4 4A		$ns^2d^2$										$ns^2np^4$										18 Ar	
5 5A		$ns^2d^3$										$ns^2np^5$										36 Kr	
6 6A		$ns^2d^4$										$ns^2np^6$										54 Xe	
7 7A		$ns^2d^5$										$ns^2np^7$										86 Rn	
8 8A		$ns^2d^6$										$ns^2np^8$										(118)	

58 Ce		$4f$										$5f$										71 Lu	
90 Th		$5f$										$4f$										103 Lr	

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## Cations and Anions Of Representative Elements

	1A	2A																			3A	4A	5A	6A	7A	8A
1	H	He																			B	C	N	O	F	Ne
2	Li	Be																			Si	P	S	Cl	Ar	
3	Na	Mg																			Al	Ge	As	Se	Br	Kr
4	K	Ca																			Ga	Sn	Sb	Te	I	Xe
5	Rb	Sr																			In	Pb	Bi	Po	At	Rn
6	Cs	Ba																			Tl	Pb	Bi	Po	At	Rn
7	Fr	Ra																			Po	At	Rn			

88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
6s <sup>2</sup> 4f <sup>1</sup> 5d <sup>0</sup>	6s <sup>2</sup> 4f <sup>2</sup>	6s <sup>2</sup> 4f <sup>4</sup>	6s <sup>2</sup> 4f <sup>5</sup>	6s <sup>2</sup> 4f <sup>6</sup>	6s <sup>2</sup> 4f <sup>7</sup>	6s <sup>2</sup> 4f <sup>7</sup> 5d <sup>1</sup>	6s <sup>2</sup> 4f <sup>7</sup> 5d <sup>2</sup>	6s <sup>2</sup> 4f <sup>9</sup>	6s <sup>2</sup> 4f <sup>10</sup>	6s <sup>2</sup> 4f <sup>11</sup>	6s <sup>2</sup> 4f <sup>11</sup>	6s <sup>2</sup> 4f <sup>12</sup>	6s <sup>2</sup> 4f <sup>13</sup>	6s <sup>2</sup> 4f <sup>14</sup>	6s <sup>2</sup> 4f <sup>14</sup> 5d <sup>1</sup>
90	91	92	93	94	95	96	97	98	99	100	101	102	103		
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		
7s <sup>2</sup> 6d <sup>2</sup>	7s <sup>2</sup> 6d <sup>1</sup> 7p <sup>1</sup>	7s <sup>2</sup> 6d <sup>1</sup> 7p <sup>2</sup>	7s <sup>2</sup> 6d <sup>3</sup> 7p <sup>4</sup>	7s <sup>2</sup> 6d <sup>4</sup> 7p <sup>6</sup>	7s <sup>2</sup> 6d <sup>5</sup> 7p <sup>7</sup>	7s <sup>2</sup> 6d <sup>6</sup> 7p <sup>7</sup>	7s <sup>2</sup> 6d <sup>7</sup> 7p <sup>7</sup>	7s <sup>2</sup> 6d <sup>7</sup> 7p <sup>6</sup>	7s <sup>2</sup> 6d <sup>7</sup> 7p <sup>5</sup>	7s <sup>2</sup> 6d <sup>7</sup> 7p <sup>4</sup>	7s <sup>2</sup> 6d <sup>7</sup> 7p <sup>3</sup>	7s <sup>2</sup> 6d <sup>7</sup> 7p <sup>2</sup>	7s <sup>2</sup> 6d <sup>7</sup> 7p <sup>1</sup>		

## Electron Configurations of Cations and Anions Of Representative Elements

Na [Ne]3s<sup>1</sup>      Na<sup>+</sup> [Ne]  
 Ca [Ar]4s<sup>2</sup>      Ca<sup>2+</sup> [Ar]  
 Al [Ne]3s<sup>2</sup>3p<sup>1</sup>      Al<sup>3+</sup> [Ne]

Atoms lose electrons so that cation has a noble-gas outer electron configuration.

Atoms gain electrons so that anion has a noble-gas outer electron configuration.

H 1s<sup>1</sup>      H<sup>-</sup> 1s<sup>2</sup> or [He]  
 F 1s<sup>2</sup>2s<sup>2</sup>2p<sup>5</sup>      F<sup>-</sup> 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup> or [Ne]  
 O 1s<sup>2</sup>2s<sup>2</sup>2p<sup>4</sup>      O<sup>2-</sup> 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup> or [Ne]  
 N 1s<sup>2</sup>2s<sup>2</sup>2p<sup>3</sup>      N<sup>3-</sup> 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup> or [Ne]

Na<sup>+</sup>: [Ne]    Al<sup>3+</sup>: [Ne]    F<sup>-</sup>: 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup> or [Ne]

O<sup>2-</sup>: 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup> or [Ne]    N<sup>3-</sup>: 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup> or [Ne]

Na<sup>+</sup>, Al<sup>3+</sup>, F<sup>-</sup>, O<sup>2-</sup>, and N<sup>3-</sup> are all *isoelectronic* with Ne



What neutral atom is isoelectronic with H<sup>-</sup> ?

H<sup>-</sup>: 1s<sup>2</sup>    same electron configuration as He



## Periodic properties of elements

### (1) Atomic radius:

- The atomic radius for an atom is measured from the length of a bond between this atom and other one divided by 2.

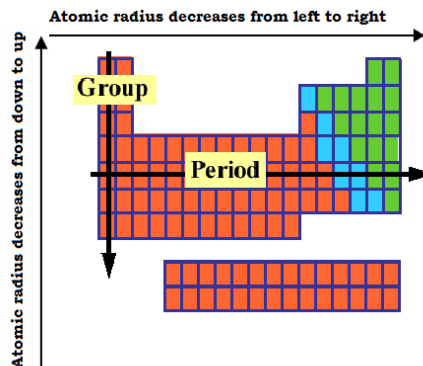
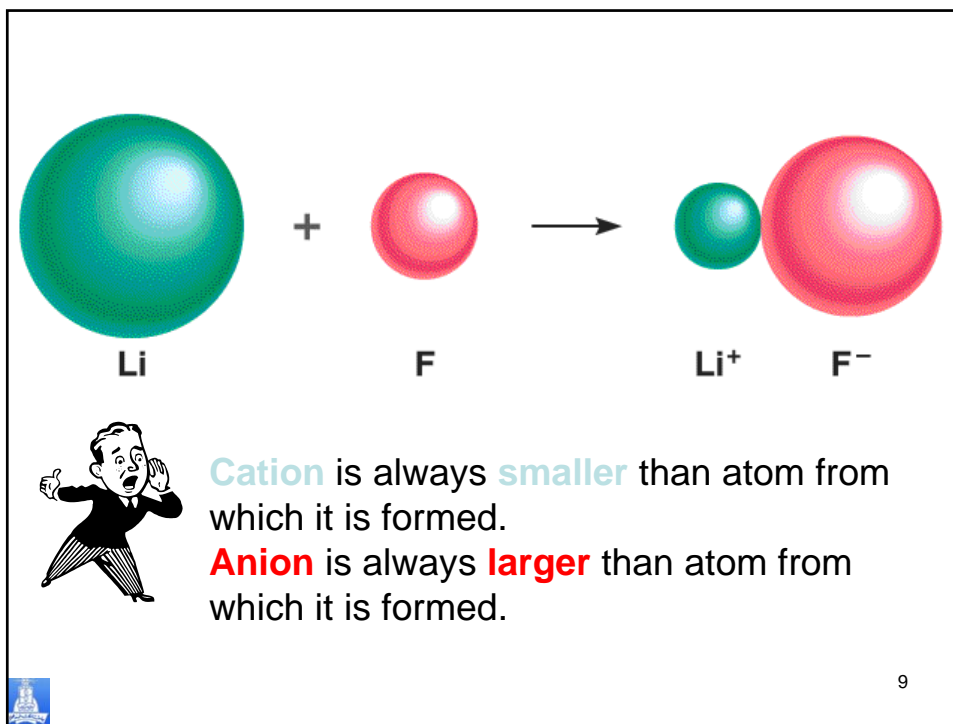


Fig. 5.3 Trends in the atomic radii within the Periodic Table.

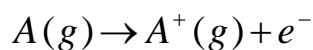




## Periodic properties of elements

### (2) Ionization energy (IE)

The energy required to remove the most loosely held electron from an isolated gaseous atom in its ground state.



- Atoms of metals with low IE because they tend to lose electrons and become positive ions in chemical reactions.
- Atoms of non-metals with high IE because they tend to accept electrons.
- The IE of noble gas atoms is high and they are stable.

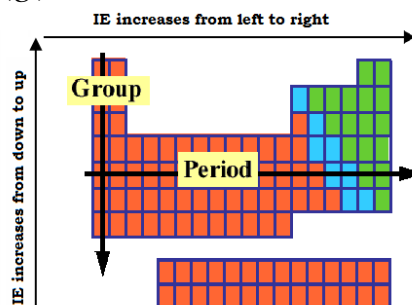
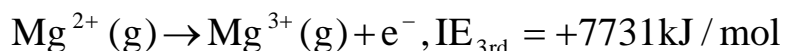
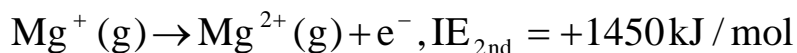
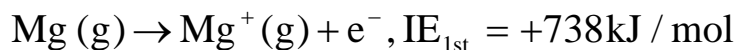


Fig. 4.10 Trends in the ionization energy within the Periodic Table.

- The second IE for an atom is higher than the first one because of increasing of the attraction of electrons by higher positive charge of the nucleus.
- For example, Mg



**Arrange the following elements according to their (a) atomic radius and (b) IE: P, N, O, F.**

(a) according to the atomic radius,  $\text{F} < \text{O} < \text{N} < \text{P}$

(b) according to the IE,  $\text{F} < \text{N} < \text{O} < \text{P}$

There is exception between O and N, because higher energy is required to remove an electron from the half-filled p orbital in nitrogen atom



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## Periodic properties of elements

### (3) Electron affinity (EA)

The energy associated with the process in which an electron is added to an atom in its ground state.

Energy is usually evolved in these processes (negative signs)

- Few elements have electron affinity
- EA Increases (the negative value) from the left to right across a period.
- \* EA increases from down to up in a group.

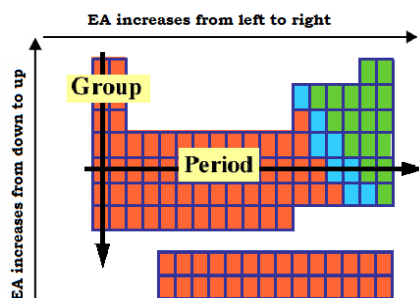


Fig.4.11 Trends in the electron affinity within the Periodic Table.



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# Periodic properties of elements

## (4) Electronegativity (EN)

- The ability of an atom to attract electrons in a molecule  
Energy is usually evolved in these processes (negative signs)

- EN across a period increases from left to right

- EN within the group increases from down to up

- EN for metals is low while it is high for non-metals

\* The fluorine is the highest electronegative element followed by oxygen.

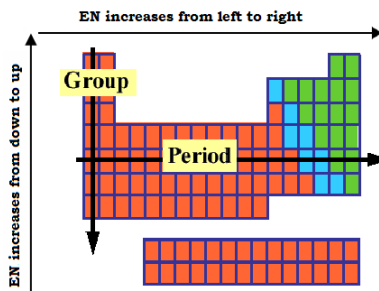


Fig. 4.12 Trends in the electronegativity within the Periodic Table.

