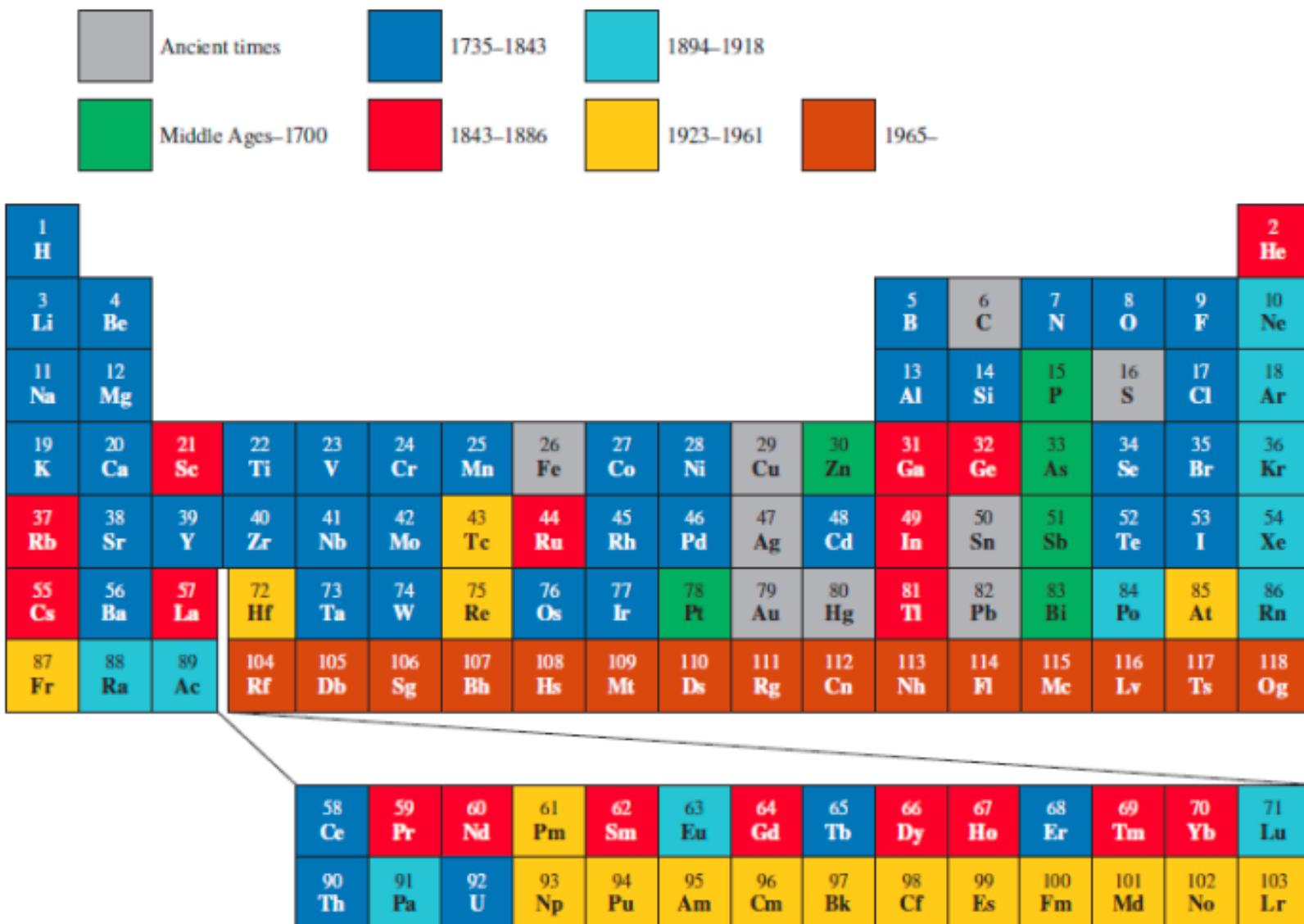


Hubungan Berkala antar Unsur

Bab 8

Kapan Unsur-unsur Ditemukan



Konfigurasi Elektron Keadaan Dasar Unsur

The diagram shows the periodic table with red annotations indicating electron configurations for each element. Red arrows point to specific subshells:

- ns¹**: Points to Hydrogen (H) at position 1.
- ns²**: Points to Helium (He) at position 2.
- d¹**: Points to Scandium (Sc) at position 3.
- d⁵**: Points to Chromium (Cr) at position 7.
- 4f**: Points to Cerium (Ce) at position 58.
- 5f**: Points to Lanthanum (La) at position 71.
- ns²np¹**: Points to Boron (B) at position 3.
- ns²np²**: Points to Carbon (C) at position 6.
- ns²np³**: Points to Nitrogen (N) at position 7.
- ns²np⁴**: Points to Oxygen (O) at position 8.
- ns²np⁵**: Points to Fluorine (F) at position 9.
- ns²np⁶**: Points to Neon (Ne) at position 10.

The periodic table lists elements from 1 to 103 with their atomic numbers and electron configurations:

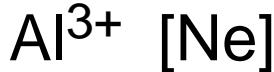
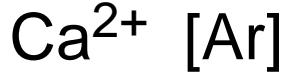
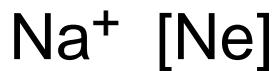
1 H	2 He	3 Li	4 Be	5 B	6 C	7 N	8 O	9 F	10 Ne				
11 Na	12 Mg	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	19 K	20 Ca				
21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn				
31 Ta	32 Ru	33 Os	34 Ir	35 Pt	36 Au	37 Hg	38 Pb	39 Bi	40 Po				
51 La	52 Ce	53 Pr	54 Nd	55 Pm	56 Sm	57 Eu	58 Gd	59 Tb	60 Dy				
61 Ho	62 Er	63 Tm	64 Yb	65 Lu	66 Lu	67 Hf	68 Er	69 Tm	70 Yb				
71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg				
81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn	87 At	88 Rn	89 At	90 Th				
104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 On	113 Nh				
114 Fl	115 Mc	116 Nh	117 Ts	118 Og									
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
60 ^{24f¹5d¹}	62 ^{24f³}	64 ^{24f⁴}	66 ^{24f³}	68 ^{24f⁶}	70 ^{24f⁷}	72 ^{24f⁷5d¹}	74 ^{24f⁹}	76 ^{24f¹⁰}	78 ^{24f¹¹}	80 ^{24f¹²}	82 ^{24f¹³}	84 ^{24f¹⁴}	86 ^{24f¹⁵5d¹}
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cf	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr
7s ² 6d ²	7s ² 5f ² 6d ¹	7s ² 5f ² 6d ¹	7s ² 5f ⁴ 6d ¹	7s ² 5f ⁶	7s ² 5f ⁷	7s ² 5f ⁷ 6d ¹	7s ² 5f ⁸	7s ² 5f ¹⁰	7s ² 5f ¹¹	7s ² 5f ¹²	7s ² 5f ¹³	7s ² 5f ¹⁴	7s ² 5f ⁴ 6d ¹

Klasifikasi Unsur

1 H	2	Representative elements			Group 12													18 He																																			
3 Li	4 Be	Noble gases			Lanthanoids													10 Ne																																			
11 Na	12 Mg	Transition metals			Actinoids													18 Ar																																			
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr																																				
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe																																				
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn																																				
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og																																				
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td>58 Ce</td><td>59 Pr</td><td>60 Nd</td><td>61 Pm</td><td>62 Sm</td><td>63 Eu</td><td>64 Gd</td><td>65 Tb</td><td>66 Dy</td><td>67 Ho</td><td>68 Er</td><td>69 Tm</td><td>70 Yb</td><td>71 Lu</td><td></td><td></td><td></td><td></td></tr> <tr> <td>90 Th</td><td>91 Pa</td><td>92 U</td><td>93 Np</td><td>94 Pu</td><td>95 Am</td><td>96 Cm</td><td>97 Bk</td><td>98 Cf</td><td>99 Es</td><td>100 Fm</td><td>101 Md</td><td>102 No</td><td>103 Lr</td><td></td><td></td><td></td><td></td></tr> </table>																		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					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				
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																																								
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																																								

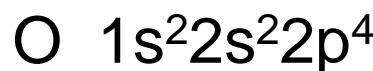
Konfigurasi Elektron Kation dan Anion

Beberapa Unsur



Atom kehilangan elektron sehingga kation mempunyai konfigurasi elektron terluar gas mulia.

Atom memperoleh elektron sehingga anion mempunyai konfigurasi elektron terluar gas mulia.



Kation dan Anion Unsur

The diagram illustrates the periodic table with red annotations indicating oxidation states and electron configurations for the first 18 elements.

Row 1:

- Hydrogen (H) has an oxidation state of +1 and an electron configuration of $1s^1$.
- Helium (He) has an oxidation state of 0 and an electron configuration of $2s^2$.

Row 2:

- Lithium (Li) has an oxidation state of +1 and an electron configuration of $2s^1$.
- Boron (B) has an oxidation state of +2 and an electron configuration of $2s^2 2p^1$.

Row 3:

- Sodium (Na) has an oxidation state of +1 and an electron configuration of $3s^1$.
- Magnesium (Mg) has an oxidation state of +2 and an electron configuration of $3s^2$.

Row 4:

- Chlorine (Cl) has an oxidation state of +3 and an electron configuration of $3s^2 3p^5$.
- Sulfur (S) has an oxidation state of +2 and an electron configuration of $3s^2 3p^4$.
- Argon (Ar) has an oxidation state of 0 and an electron configuration of $3s^2 3p^6$.

Row 5:

- Rubidium (Rb) has an oxidation state of +1 and an electron configuration of $5s^1$.
- Silver (Ag) has an oxidation state of +1 and an electron configuration of $5s^1 5p^1$.
- Xenon (Xe) has an oxidation state of 0 and an electron configuration of $5s^2 5p^6$.

Row 6:

- Cesium (Cs) has an oxidation state of +1 and an electron configuration of $6s^1$.
- Bismuth (Bi) has an oxidation state of -3 and an electron configuration of $6s^2 6p^3$.
- Radon (Rn) has an oxidation state of 0 and an electron configuration of $6s^2 6p^6$.

Row 7:

- Flerovium (Fl) has an oxidation state of +1 and an electron configuration of $7s^1$.
- Rutherfordium (Rf) has an oxidation state of +2 and an electron configuration of $7s^2 6d^1$.
- Oganesson (Og) has an oxidation state of -1 and an electron configuration of $7s^2 7p^6$.

Below the table:

58 Ce $6s^2 4f^1 5d^1$	59 Pr $6s^2 4f^3$	60 Nd $6s^2 4f^4$	61 Pm $6s^2 4f^5$	62 Sm $6s^2 4f^6$	63 Eu $6s^2 4f^7 5d^1$	64 Gd $6s^2 4f^8$	65 Tb $6s^2 4f^{10}$	66 Dy $6s^2 4f^{10}$	67 Ho $6s^2 4f^{11}$	68 Er $6s^2 4f^{12}$	69 Tm $6s^2 4f^{13}$	70 Yb $6s^2 4f^{14}$	71 Lu $6s^2 4f^{14} 5d^1$
90 Th $7s^2 6d^1$	91 Pa $7s^2 5f^2 6d^1$	92 U $7s^2 5f^3 6d^1$	93 Np $7s^2 5f^4 6d^1$	94 Pu $7s^2 5f^5$	95 Am $7s^2 5f^6$	96 Cm $7s^2 5f^7 6d^1$	97 Bk $7s^2 5f^8$	98 Cf $7s^2 5f^9 6d^1$	99 Es $7s^2 5f^{11}$	100 Fm $7s^2 5f^{12}$	101 Md $7s^2 5f^{13}$	102 No $7s^2 5f^{14}$	103 Lr $7s^2 5f^{14} 6d^1$

Isoelektronik: memiliki jumlah elektron yang sama, dan karenanya memiliki konfigurasi elektron keadaan dasar yang sama



Na⁺, Al³⁺, F⁻, O²⁻, and N³⁻ semua **isoelektronik** dengan Ne

Atom netral manakah yang isoelektronik dengan H⁻?

H⁻: 1s² konfigurasi elektron yang sama dengan He

Konfigurasi Elektron Kation Logam Transisi

Ketika kation terbentuk dari atom logam transisi, elektron selalu dikeluarkan terlebih dahulu dari orbital ns dan kemudian dari orbital $(n - 1)d$.



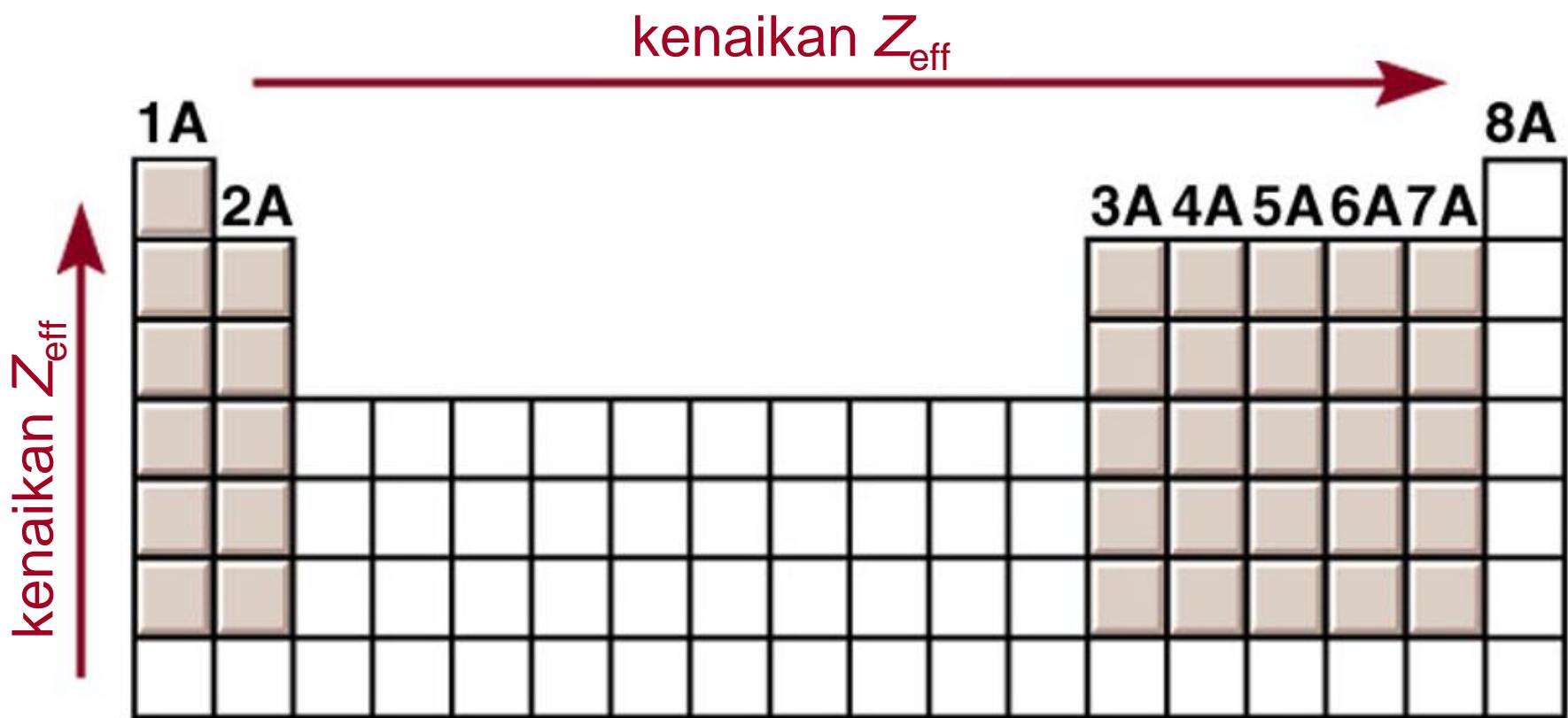
Muatan inti efektif (Z_{eff}) adalah “muatan positif” yang dirasakan oleh sebuah elektron.

$$Z_{\text{eff}} = Z - \sigma \quad 0 < \sigma < Z \quad (\sigma = \text{konstanta perisai})$$

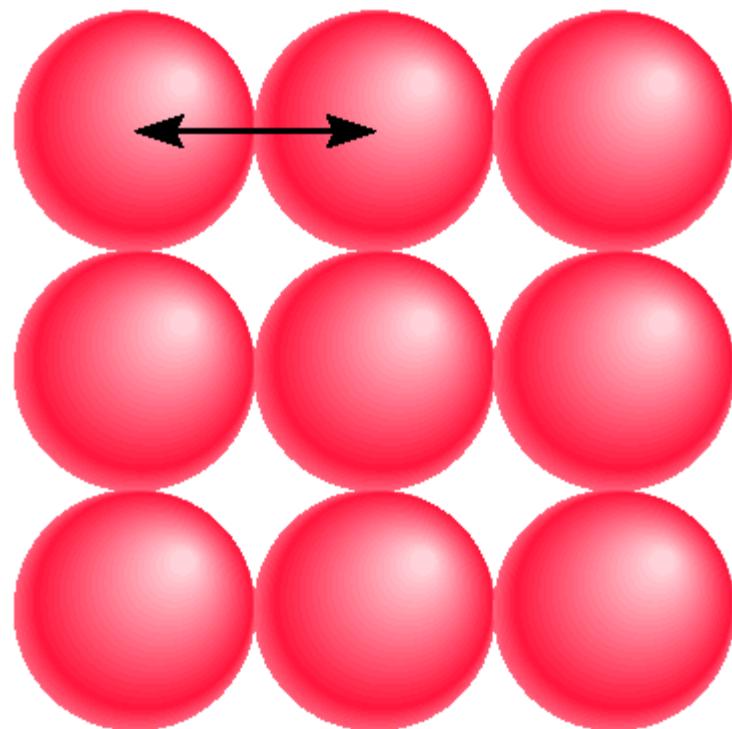
$Z_{\text{eff}} \approx Z - \text{jumlah elektron dalam atau inti}$

	<u>Z</u>	<u>inti</u>	<u>Z_{eff}</u>	<u>Radius (pm)</u>
Na	11	10	1	186
Mg	12	10	2	160
Al	13	10	3	143
Si	14	10	4	132

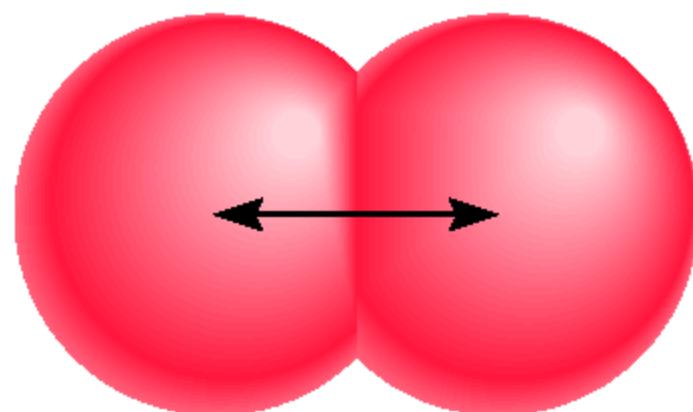
Muatan Inti Efektif (Z_{eff})



Jari-jari Atom

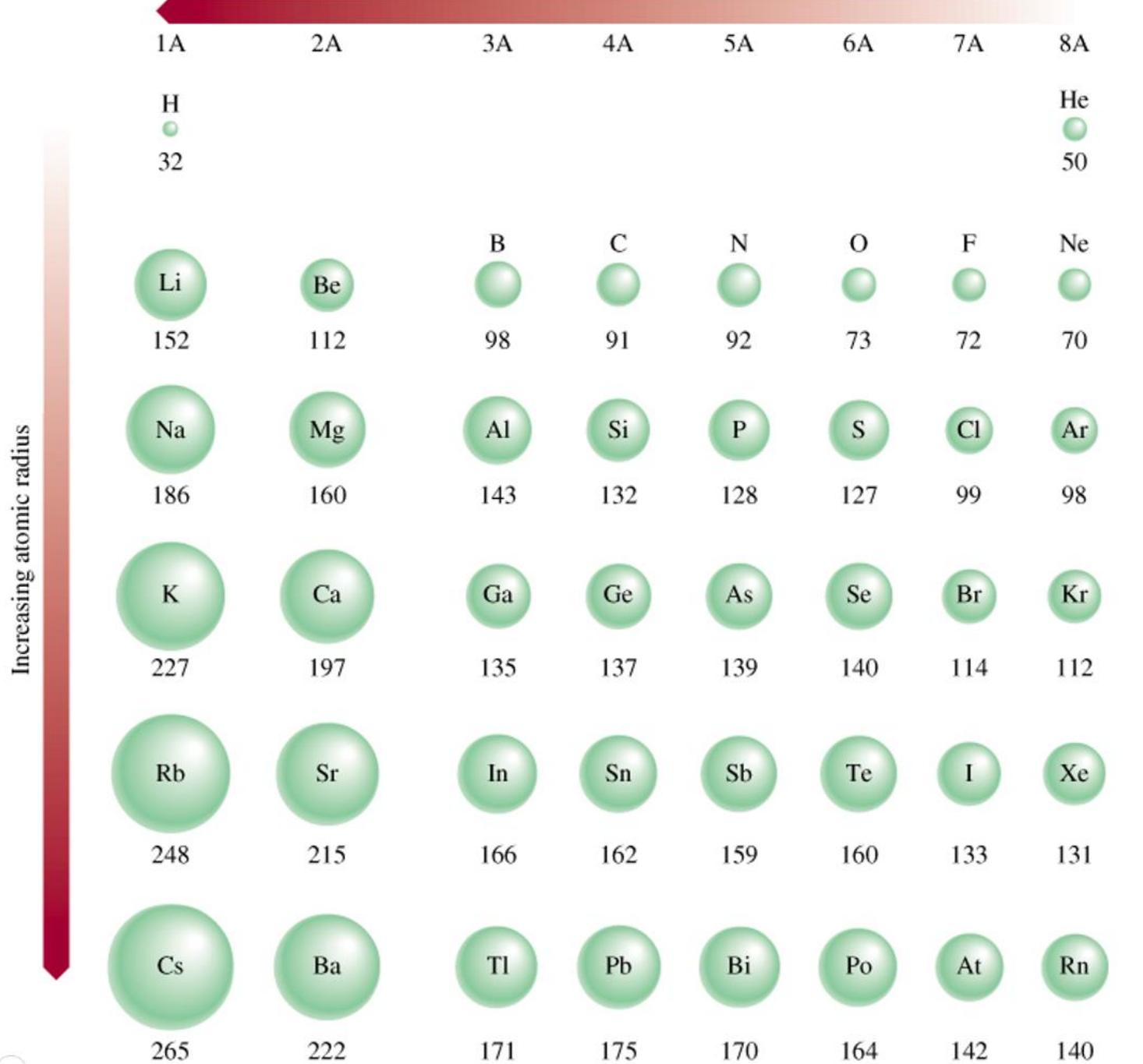


Jari-jari metalik

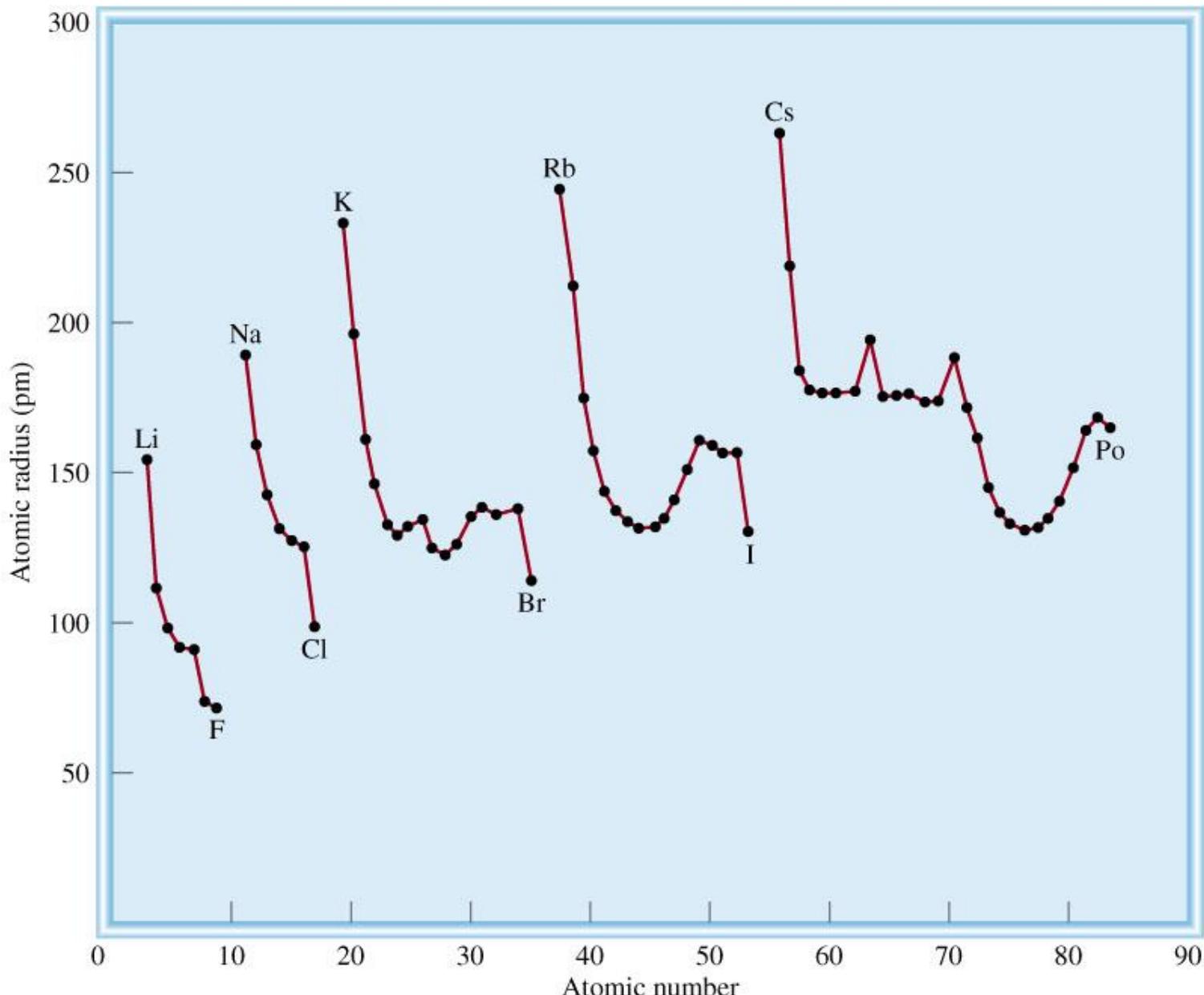


Jari-jari kovalen

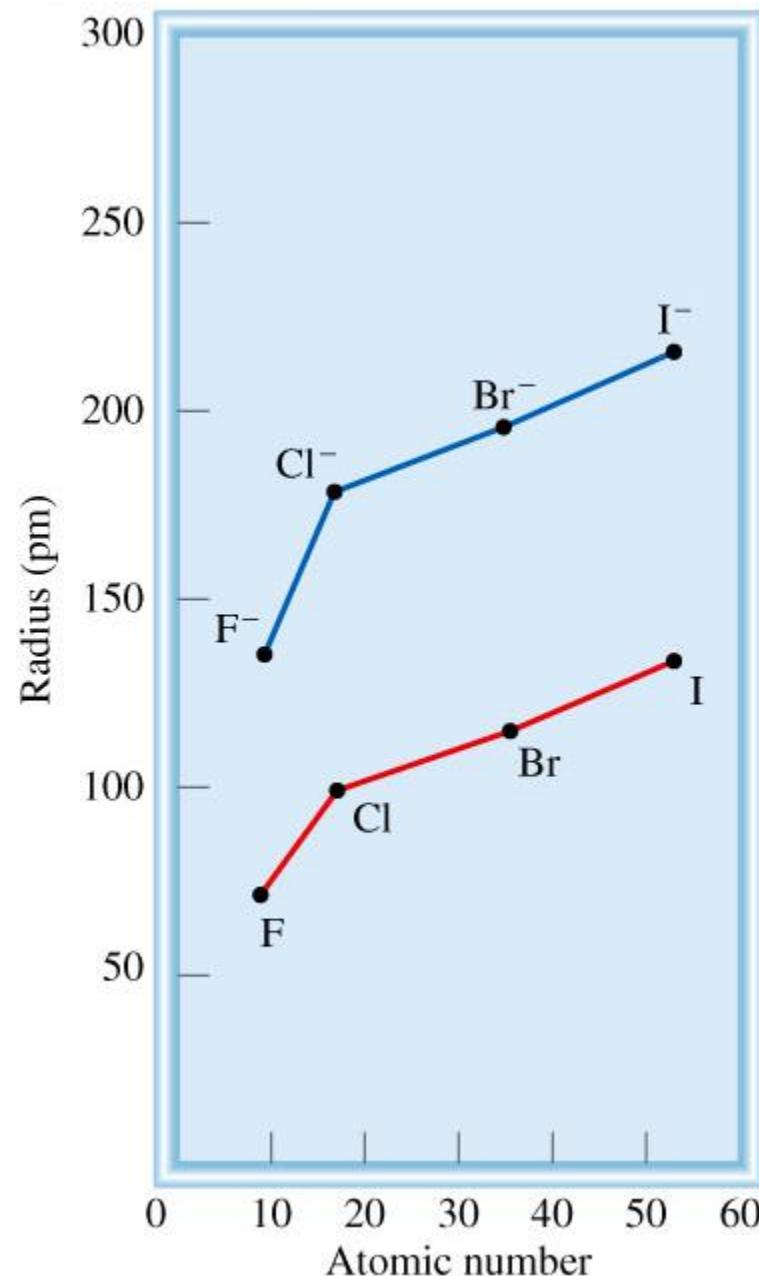
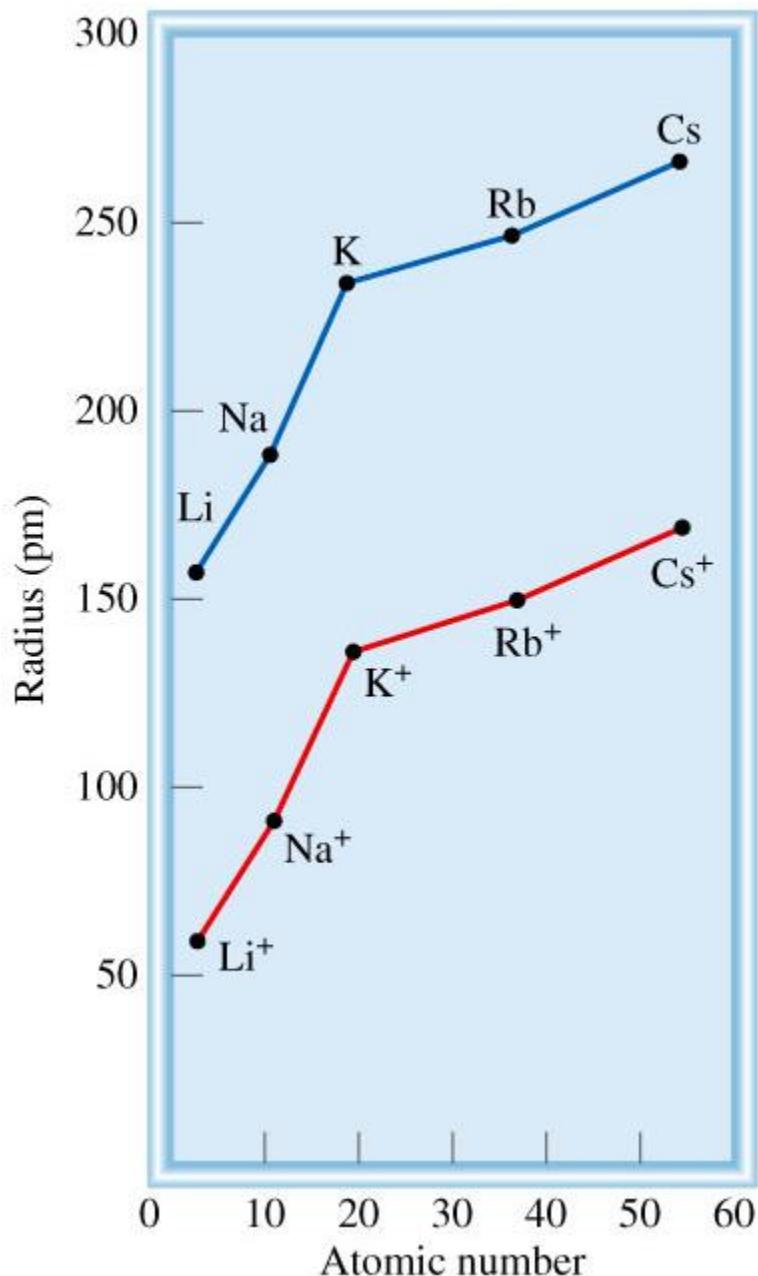
Increasing atomic radius

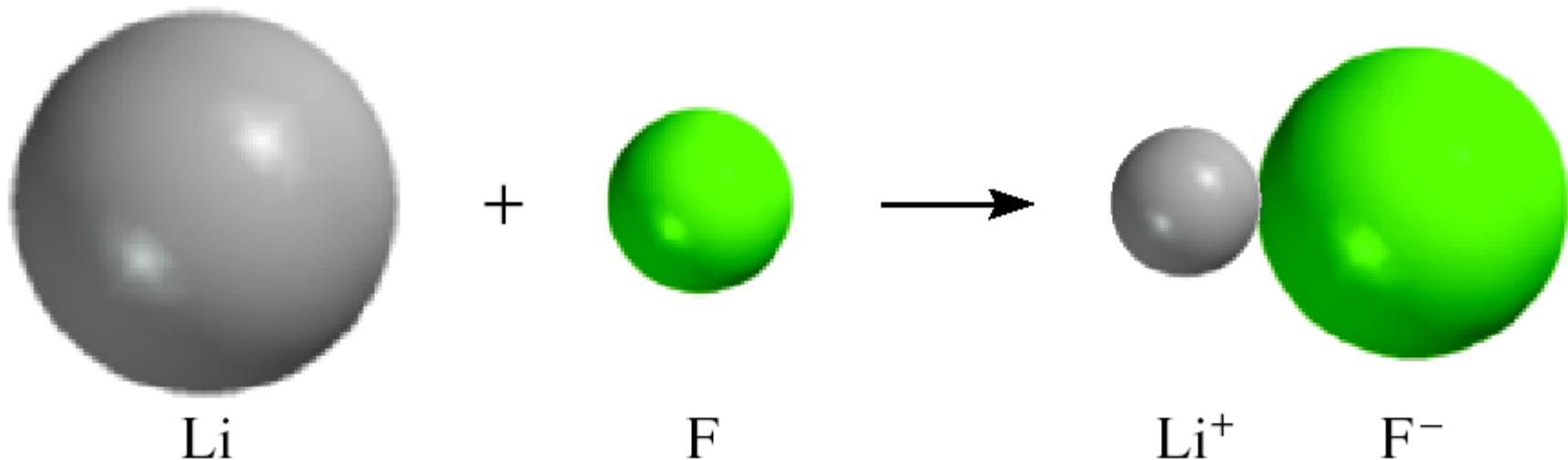


Tren Jari-jari Atom



Perbandingan Jari-jari Atom dengan Jari-jari Ionik

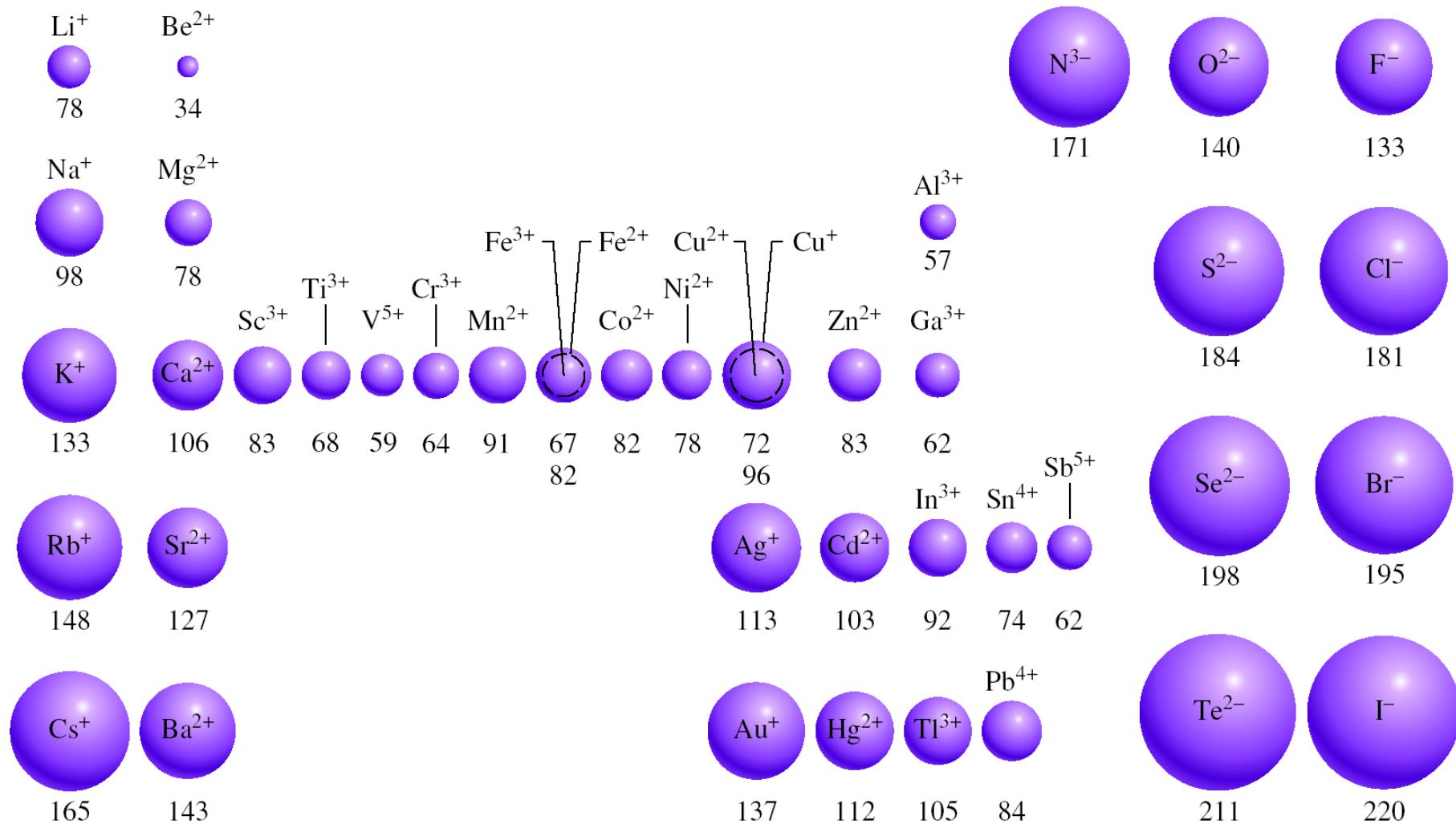




Kation selalu lebih **kecil** dari atom pembentuknya.

Anion selalu lebih **besar** dari atom pembentuknya.

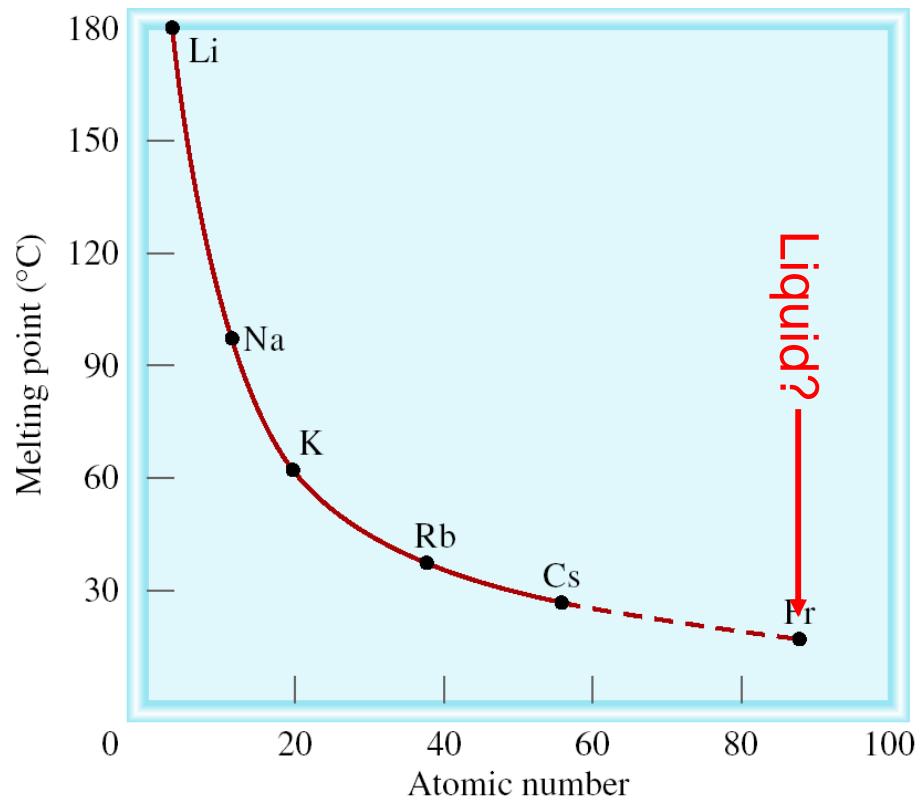
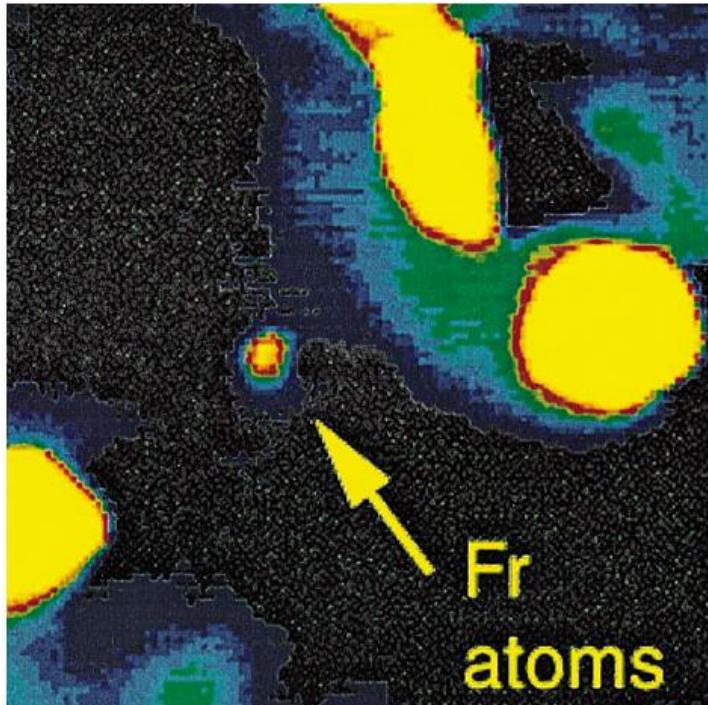
Jari-jari (dalam pm) Ion-Ion Unsur yang Dikenal



Kimia “*in Action*”: Unsur Cair ke-3?

118 unsur, 2 cairan pada 25°C – Br₂ and Hg

²²³Fr, t_{1/2} = 21 menit



Energi ionisasi adalah energi minimum (kJ/mol) yang diperlukan untuk melepaskan elektron dari atom gas dalam keadaan dasarnya.

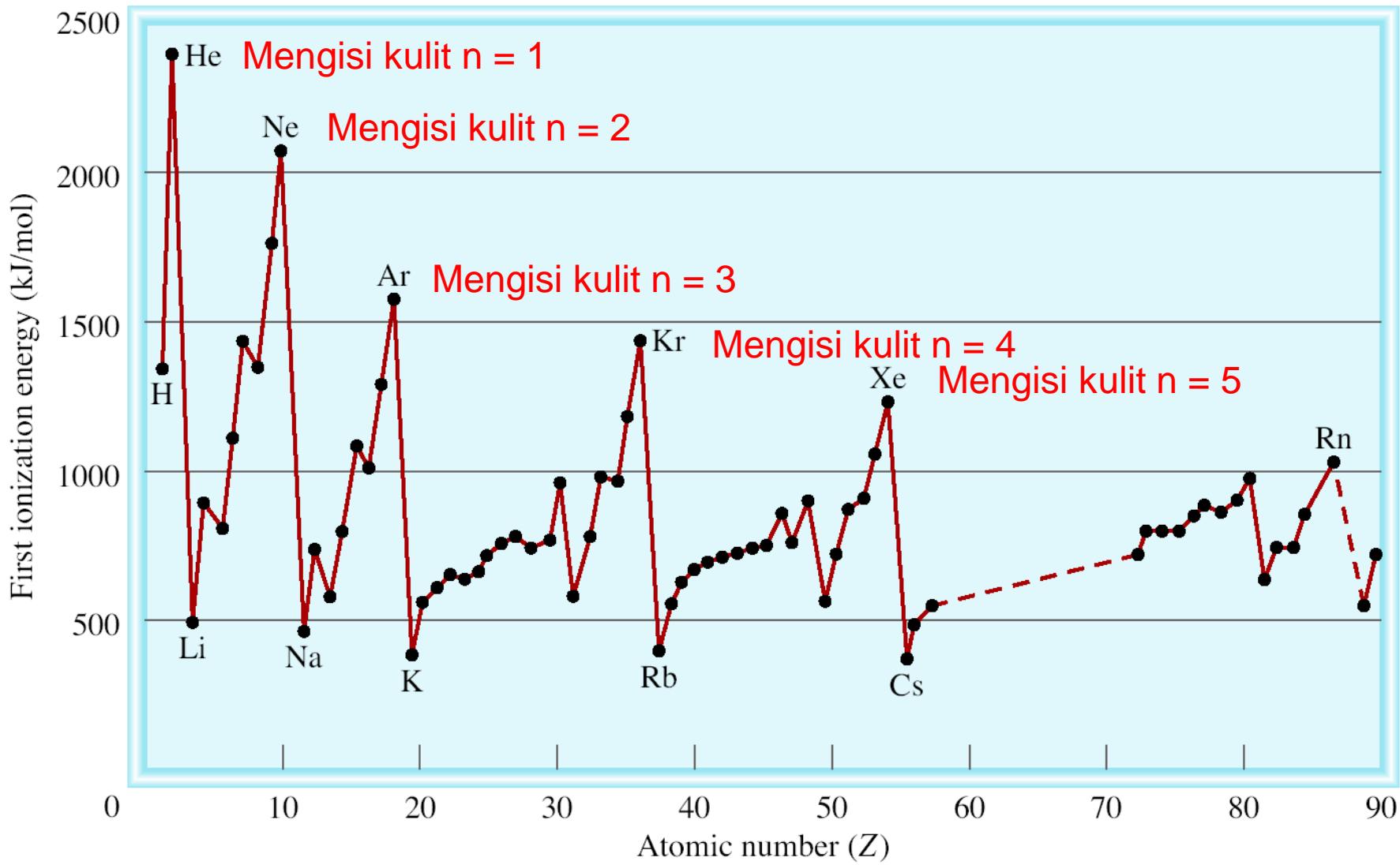


$$I_1 < I_2 < I_3$$

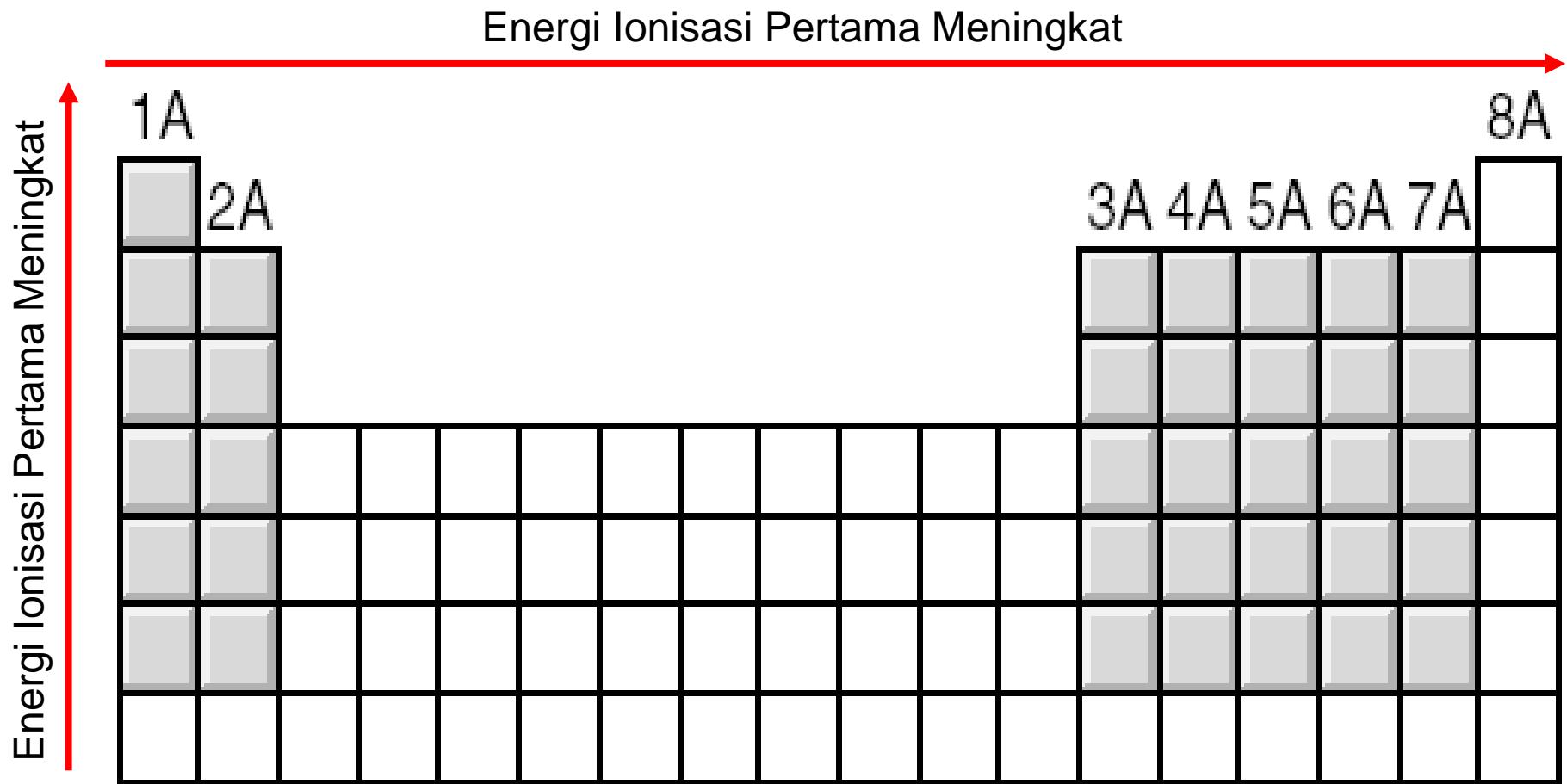
TABLE 8.2 The Ionization Energies (kJ/mol) of the First 20 Elements

Z	Element	First	Second	Third	Fourth	Fifth	Sixth
1	H	1,312					
2	He	2,373	5,251				
3	Li	520	7,300	11,815			
4	Be	899	1,757	14,850	21,005		
5	B	801	2,430	3,660	25,000	32,820	
6	C	1,086	2,350	4,620	6,220	38,000	47,261
7	N	1,400	2,860	4,580	7,500	9,400	53,000
8	O	1,314	3,390	5,300	7,470	11,000	13,000
9	F	1,680	3,370	6,050	8,400	11,000	15,200
10	Ne	2,080	3,950	6,120	9,370	12,200	15,000
11	Na	495.9	4,560	6,900	9,540	13,400	16,600
12	Mg	738.1	1,450	7,730	10,500	13,600	18,000
13	Al	577.9	1,820	2,750	11,600	14,800	18,400
14	Si	786.3	1,580	3,230	4,360	16,000	20,000
15	P	1,012	1,904	2,910	4,960	6,240	21,000
16	S	999.5	2,250	3,360	4,660	6,990	8,500
17	Cl	1,251	2,297	3,820	5,160	6,540	9,300
18	Ar	1,521	2,666	3,900	5,770	7,240	8,800
19	K	418.7	3,052	4,410	5,900	8,000	9,600
20	Ca	589.5	1,145	4,900	6,500	8,100	11,000

Variasi Energi Ionisasi Pertama dengan Nomor Atom



Tren Umum Energi Ionisasi Pertama



Afinitas elektron adalah perubahan energi negatif yang terjadi ketika elektron diterima oleh atom dalam wujud gas untuk membentuk anion.

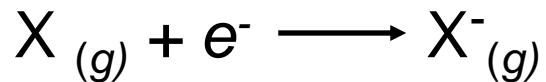
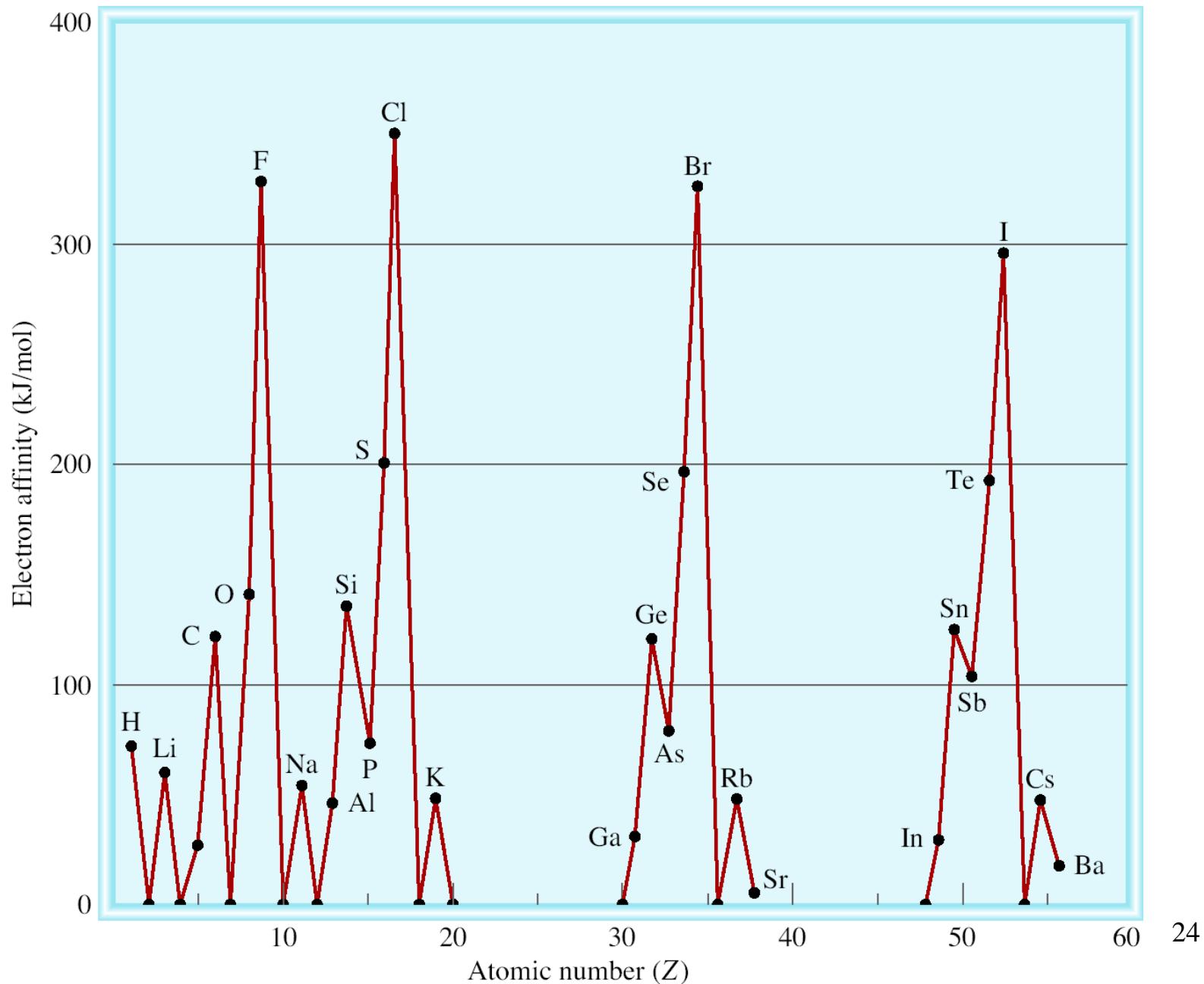


TABLE 8.3**Electron Affinities (kJ/mol) of Some Representative Elements
and the Noble Gases***

1A	2A	3A	4A	5A	6A	7A	8A
H							He
73							< 0
Li	Be	B	C	N	O	F	Ne
60	≤ 0	27	122	0	141	328	< 0
Na	Mg	Al	Si	P	S	Cl	Ar
53	≤ 0	44	134	72	200	349	< 0
K	Ca	Ga	Ge	As	Se	Br	Kr
48	2.4	29	118	77	195	325	< 0
Rb	Sr	In	Sn	Sb	Te	I	Xe
47	4.7	29	121	101	190	295	< 0
Cs	Ba	Tl	Pb	Bi	Po	At	Rn
45	14	30	110	110	?	?	< 0

*The electron affinities of the noble gases, Be, and Mg have not been determined experimentally, but are believed to be close to zero or negative.

Variasi Afinitas Elektron dengan Nomor Atom (H – Ba)

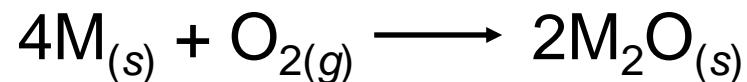
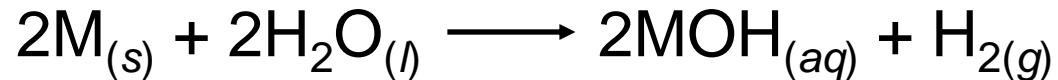


Hubungan Diagonal pada Tabel Periodik

1A	2A	3A	4A
Li	Be	B	C
Na	Mg	Al	Si

The diagram illustrates the diagonal relationship in the periodic table. Red arrows point from the elements in the first four columns of the second period (Li, Be, B, C) down to the corresponding elements in the third period (Na, Mg, Al, Si). This visualizes how the properties of these elements are related across the diagonal.

Unsur Golongan 1(ns¹, n ≥ 2)



A periodic table diagram showing the first two columns and the last five columns. The first column contains the elements Li, Na, K, Rb, and Cs. The last column contains the elements F, Cl, Br, I, and At. A red arrow labeled "kenaikan reaktivitas" points downwards from the top of the first column to the bottom of the last column.

	1																18
Li		2															
Na																	
K																	
Rb																	
Cs																	

Unsur Golongan 1 (ns^1 , $n \geq 2$)



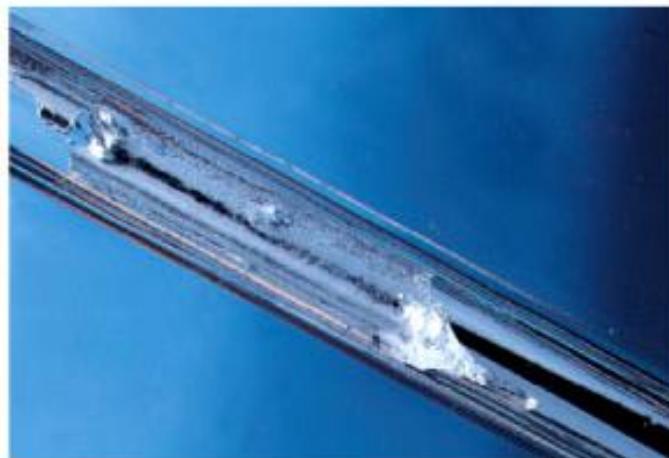
Lithium (Li)



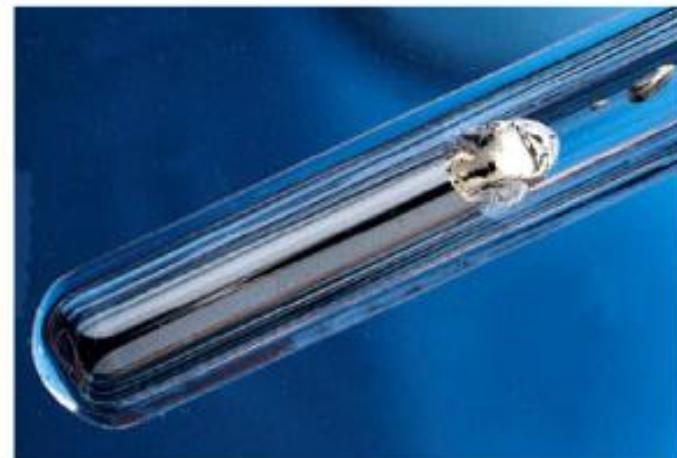
Sodium (Na)



Potassium (K)

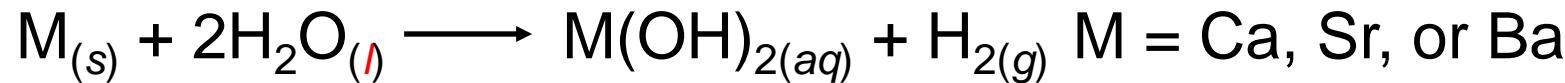
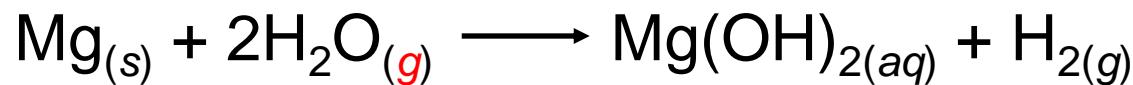
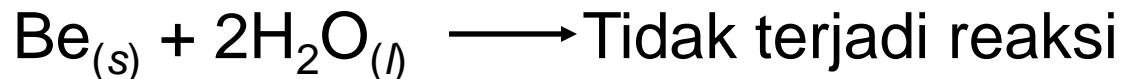


Rubidium (Rb)



Cesium (Cs)

Unsur Golongan 2 (ns^2 , $n \geq 2$)



	1															18	
kenaikan reaktivitas		2															
		Be															
		Mg															
		Ca															
		Sr															
		Ba															

Unsur Golongan 2 (ns^2 , $n \geq 2$)



Beryllium (Be)



Magnesium (Mg)



Calcium (Ca)



Strontium (Sr)

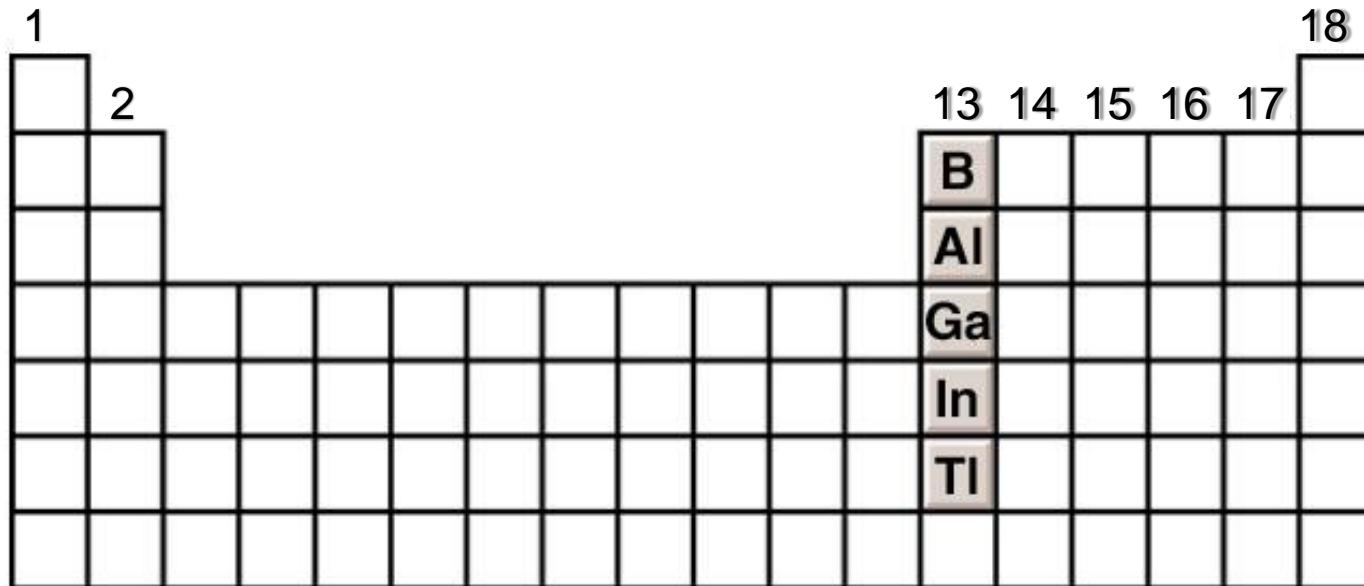
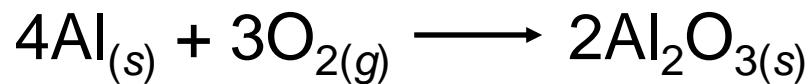


Barium (Ba)



Radium (Ra)

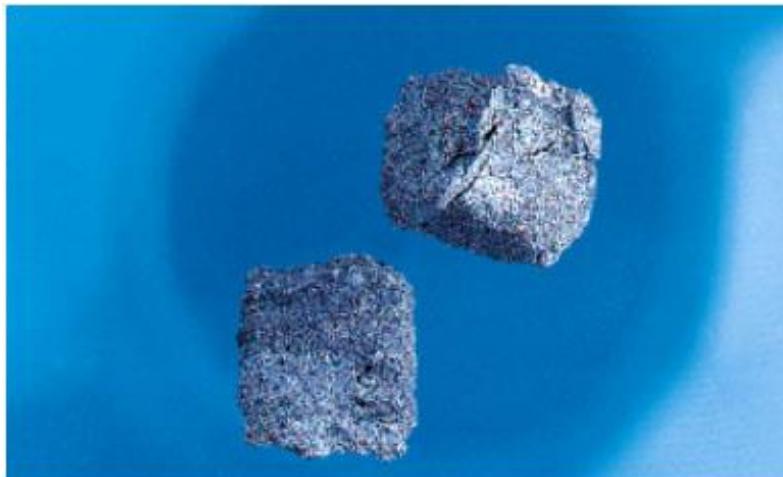
Unsur Golongan 13 (ns²np¹, n ≥ 2)



A periodic table diagram showing the first two groups of the third period. Group 1 contains elements 1 and 2. Group 13 contains elements B, Al, Ga, In, and Tl. The elements are highlighted with brown boxes.

1								18
	2							

Unsur Golongan 13 (ns^2np^1 , $n \geq 2$)



Boron (B)



Aluminum (Al)

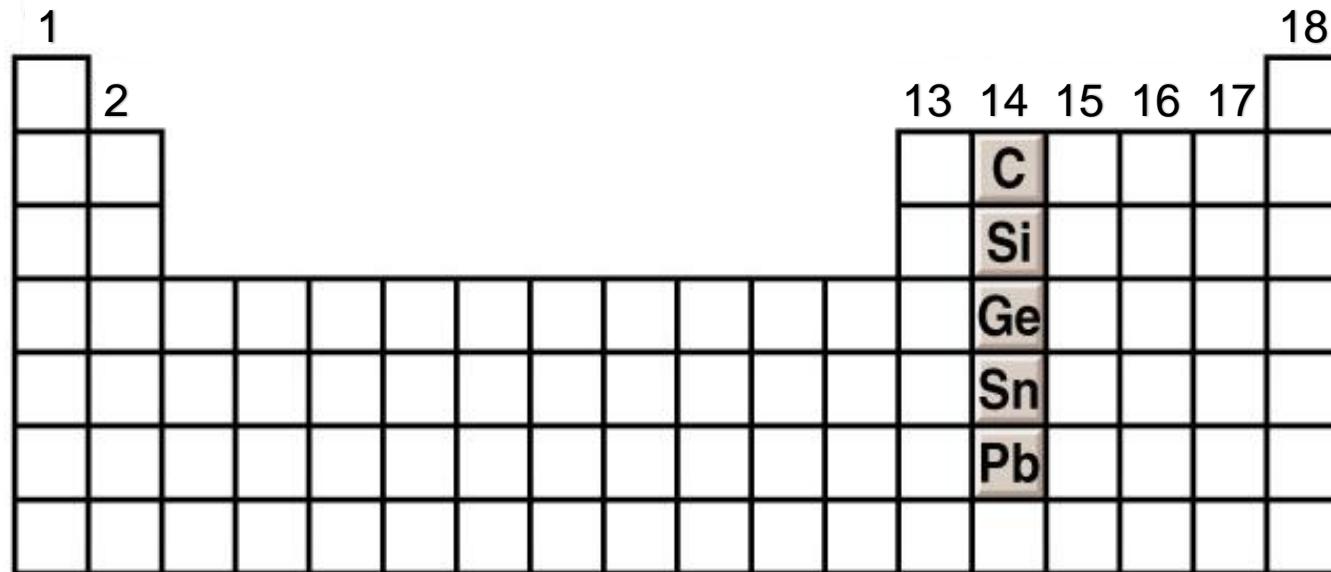
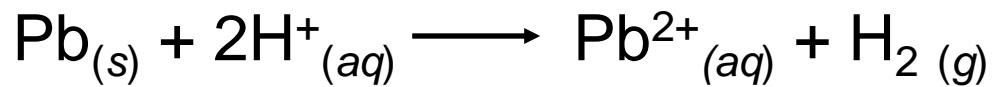
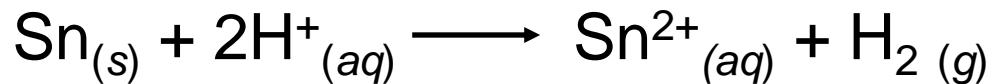


Gallium (Ga)

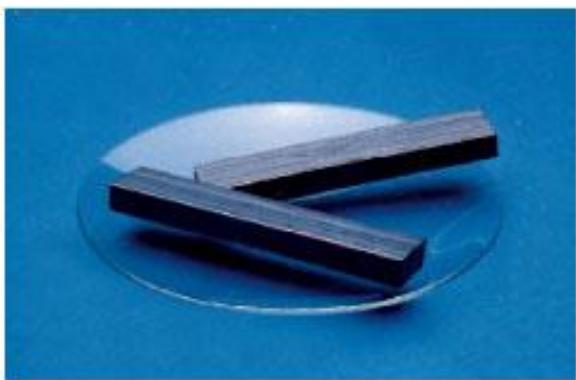


Indium (In)

Unsur Golongan 14 (ns^2np^2 , $n \geq 2$)



Unsur Golongan 14 (ns^2np^2 , $n \geq 2$)



Carbon (graphite)



Carbon (diamond)



Silicon (Si)



Germanium (Ge)

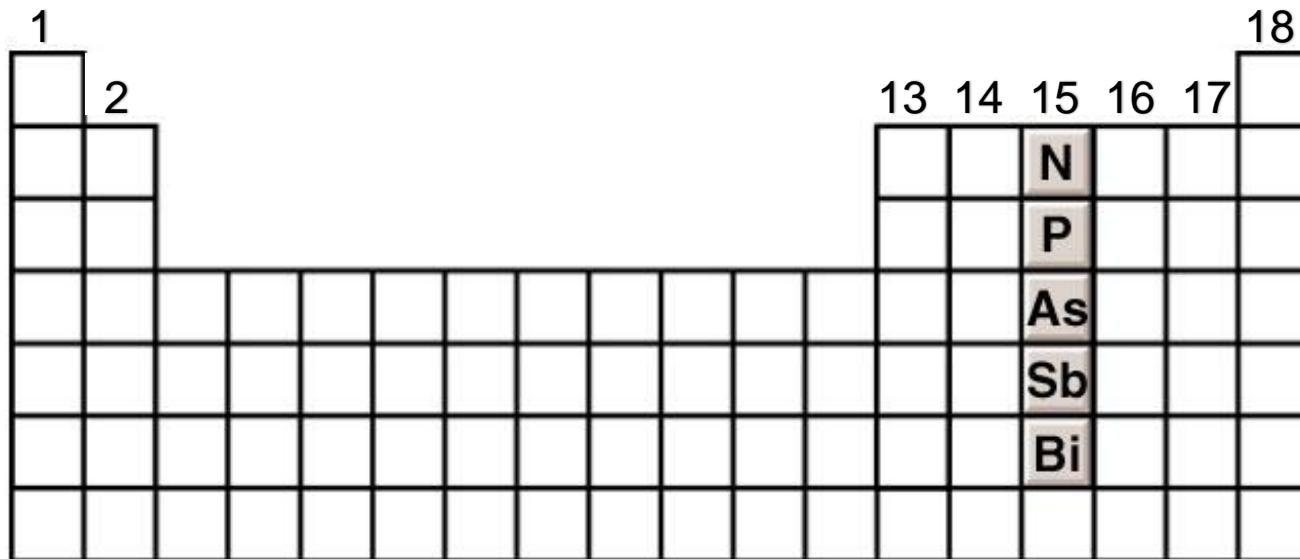
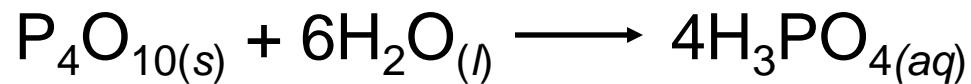
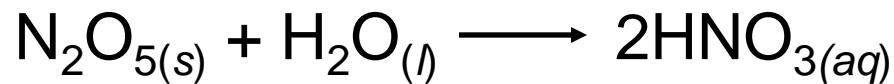


Tin (Sn)



Lead (Pb)

Unsur Golongan 15 (ns^2np^3 , $n \geq 2$)



Unsur Golongan 15 (ns^2np^3 , $n \geq 2$)



Nitrogen (N_2)



White and red phosphorus (P)



Arsenic (As)

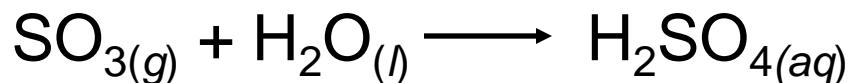


Antimony (Sb)



Bismuth (Bi)

Unsur Golongan 16 (ns^2np^4 , $n \geq 2$)



A periodic table diagram showing the first two periods. The first period contains Hydrogen (H) at position 1 and Helium (He) at position 2. The second period starts with Lithium (Li) at position 3 and ends with Argon (Ar) at position 18. The group 16 elements are highlighted in light purple: Sulfur (S) at position 16, Oxygen (O) at position 17, Nitrogen (N) at position 15, Phosphorus (P) at position 14, Arsenic (As) at position 13, Antimony (Sb) at position 16, and Bismuth (Bi) at position 18.

Unsur Golongan 16 (ns^2np^4 , $n \geq 2$)



Sulfur (S₈)

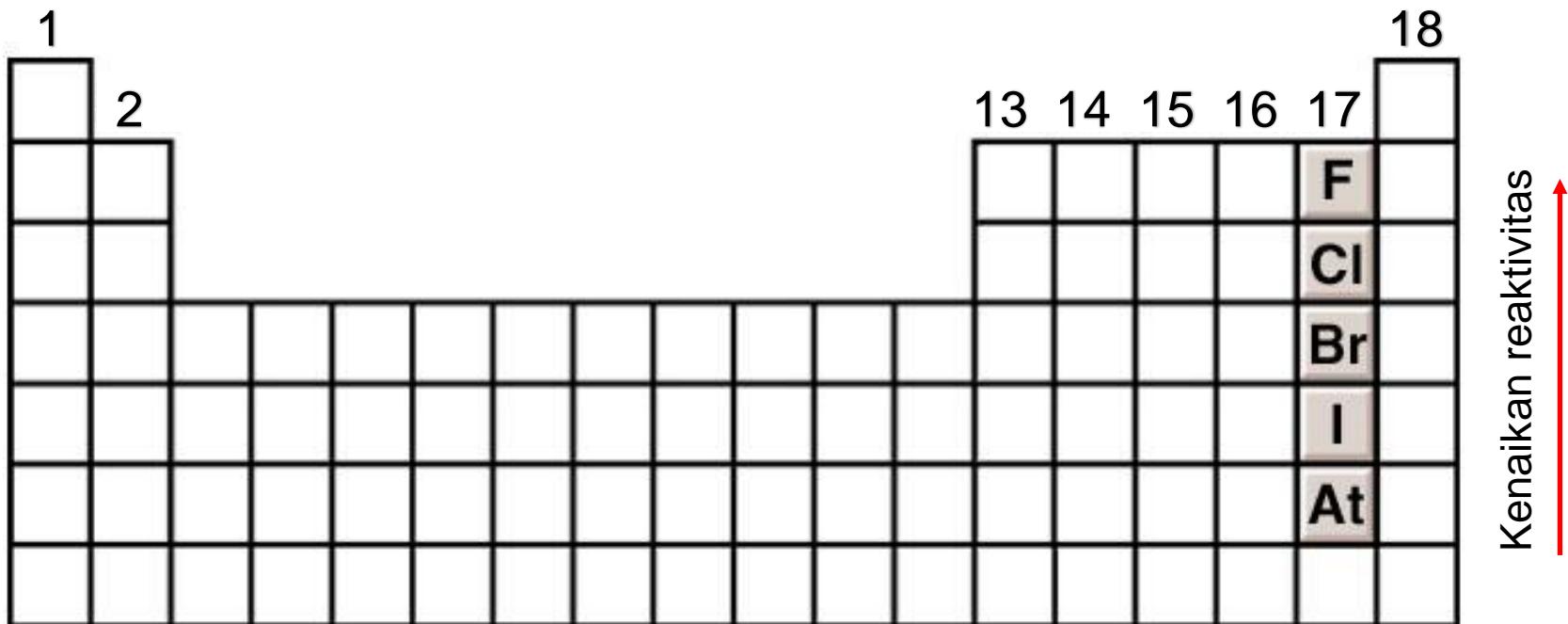
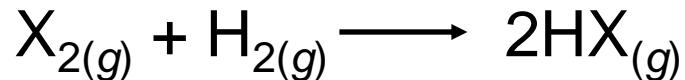
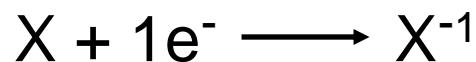


Selenium (Se₈)

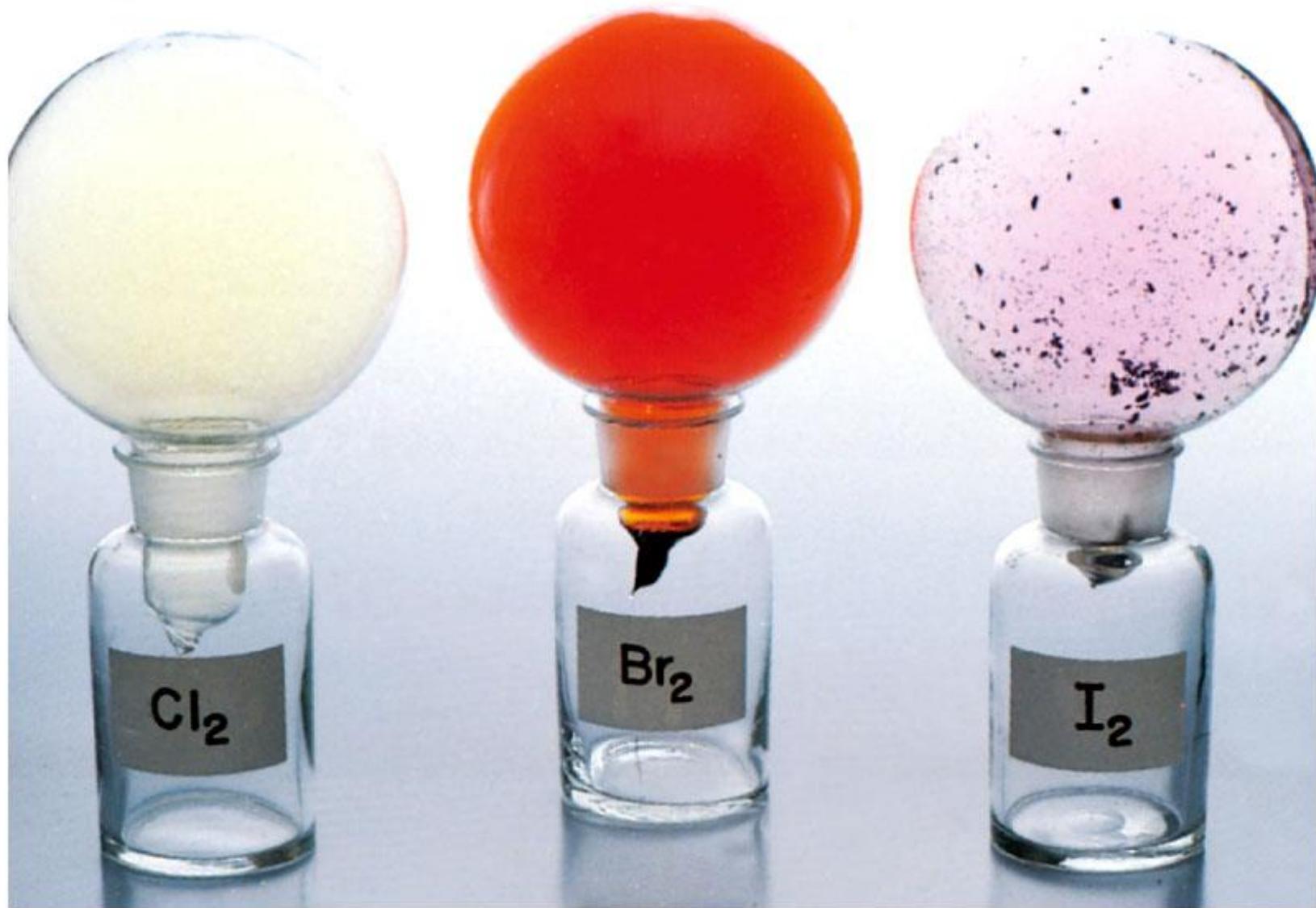


Tellurium (Te)

Unsur Golongan 17 (ns^2np^5 , $n \geq 2$)



Unsur Golongan 17 (ns^2np^5 , $n \geq 2$)

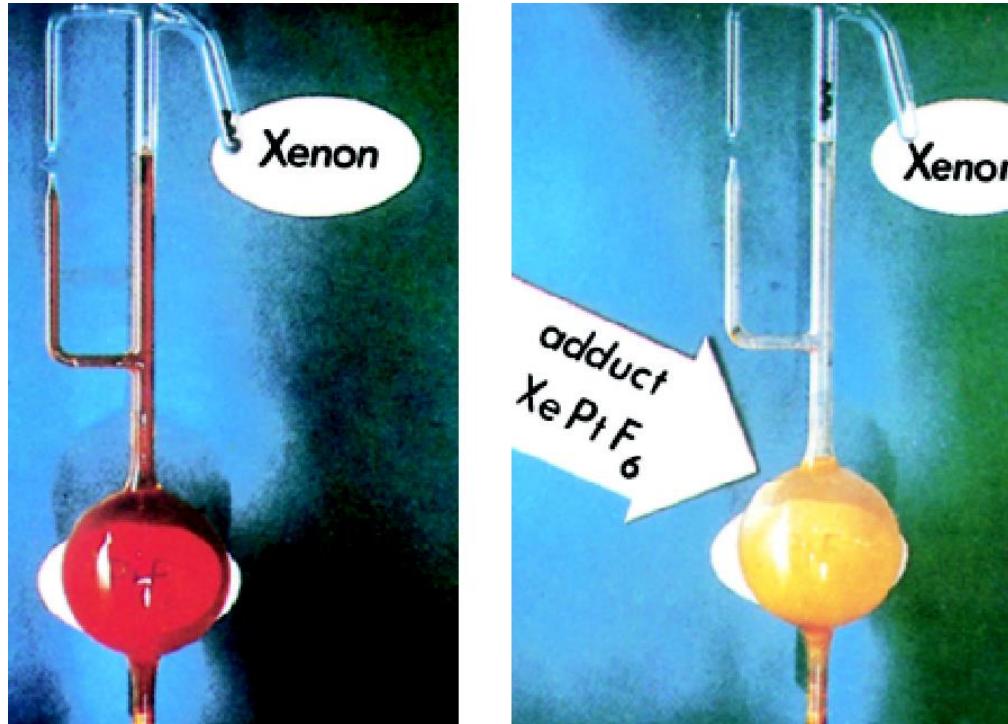


Unsur Golongan 18 (ns^2np^6 , $n \geq 2$)

Subkulit ns dan np terisi penuh.
Energi ionisasi tertinggi dari semua unsur.
Tidak ada kecenderungan untuk menerima elektron tambahan.

1	2																	18	He
																		Ne	
																		Ar	
																		Kr	
																		Xe	
																		Rn	

Senyawa Gas Mulia



Sejumlah senyawa xenon XeF_4 , XeO_3 , XeO_4 , XeOF_4 ada.

Beberapa senyawa kripton (KrF_2 , misalnya) telah dibuat.

Perbandingan Golongan 1 dan 11

Logam dalam kedua golongan ini memiliki konfigurasi elektron terluar yang serupa, dengan satu elektron berada pada orbital s terluar.

Sifat kimia sangat berbeda karena perbedaan energi ionisasi.

A periodic table diagram showing groups 1 and 11. The first column (Group 1) contains Li, Na, K, Rb, Cs, and Fr. The eleventh column (Group 11) contains Cu, Ag, and Au. All elements in both groups have one electron in their outermost s-orbital. An arrow points from the text below to the start of Group 1.

1	
2	
Li	
Na	
K	
Rb	
Cs	
Fr	
11	
Cu	
Ag	
Au	
13	
14	
15	
16	
17	
18	

Lower I_1 , more reactive

Sifat Oksida dalam Suatu Periode

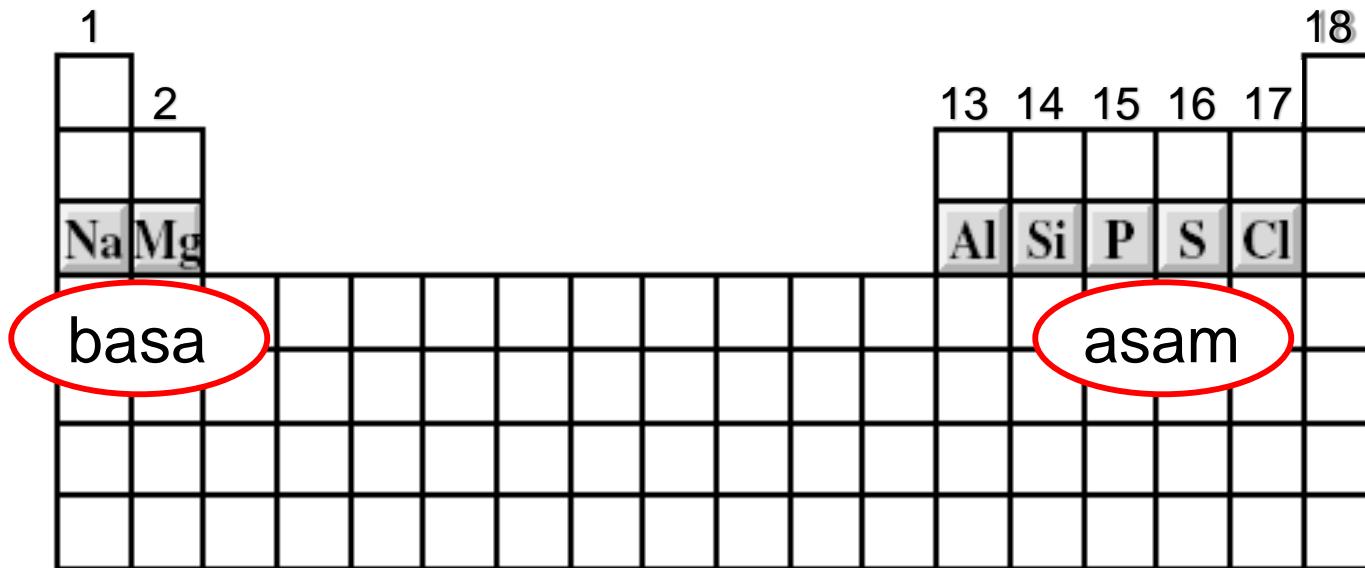
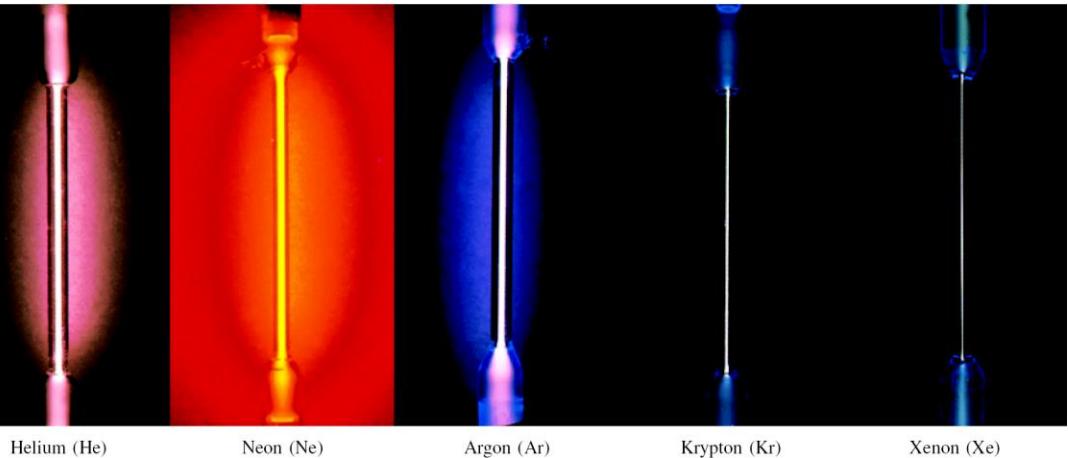


TABLE 8.4 Some Properties of Oxides of the Third-Period Elements

	Na_2O	MgO	Al_2O_3	SiO_2	P_4O_{10}	SO_3	Cl_2O_7
Type of compound	←	Ionic	→	←	Molecular	→	
Structure		←	Extensive three-dimensional	→	←	Discrete	→
						molecular units	
Melting point (°C)	1275	2800	2045	1610	580	16.8	-91.5
Boiling point (°C)	?	3600	2980	2230	?	44.8	82
Acid-base nature	Basic	Basic	Amphoteric	←	Acidic	→	

Kimia “*in Action*”: Penemuan Gas Mulia



Sir William Ramsay