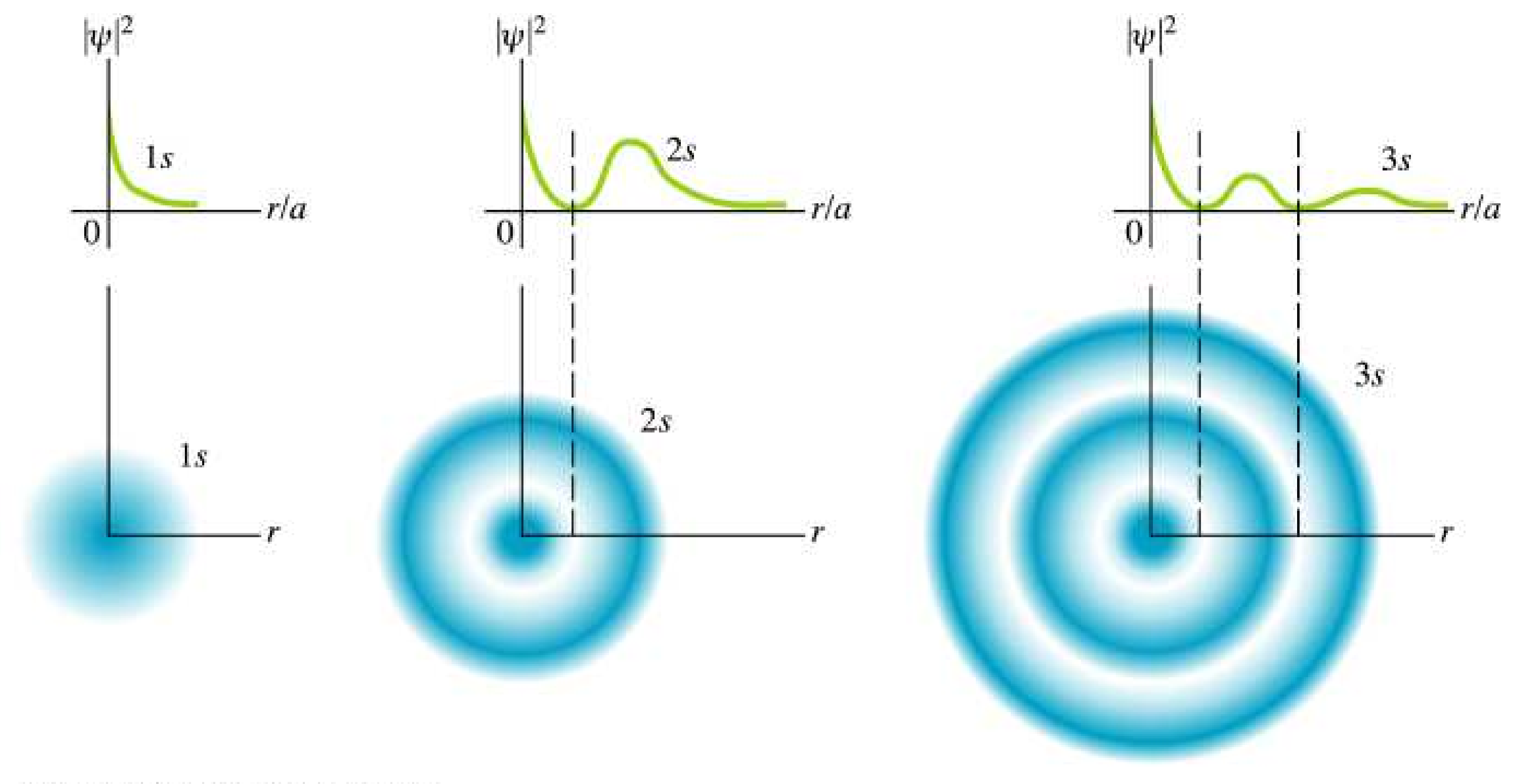
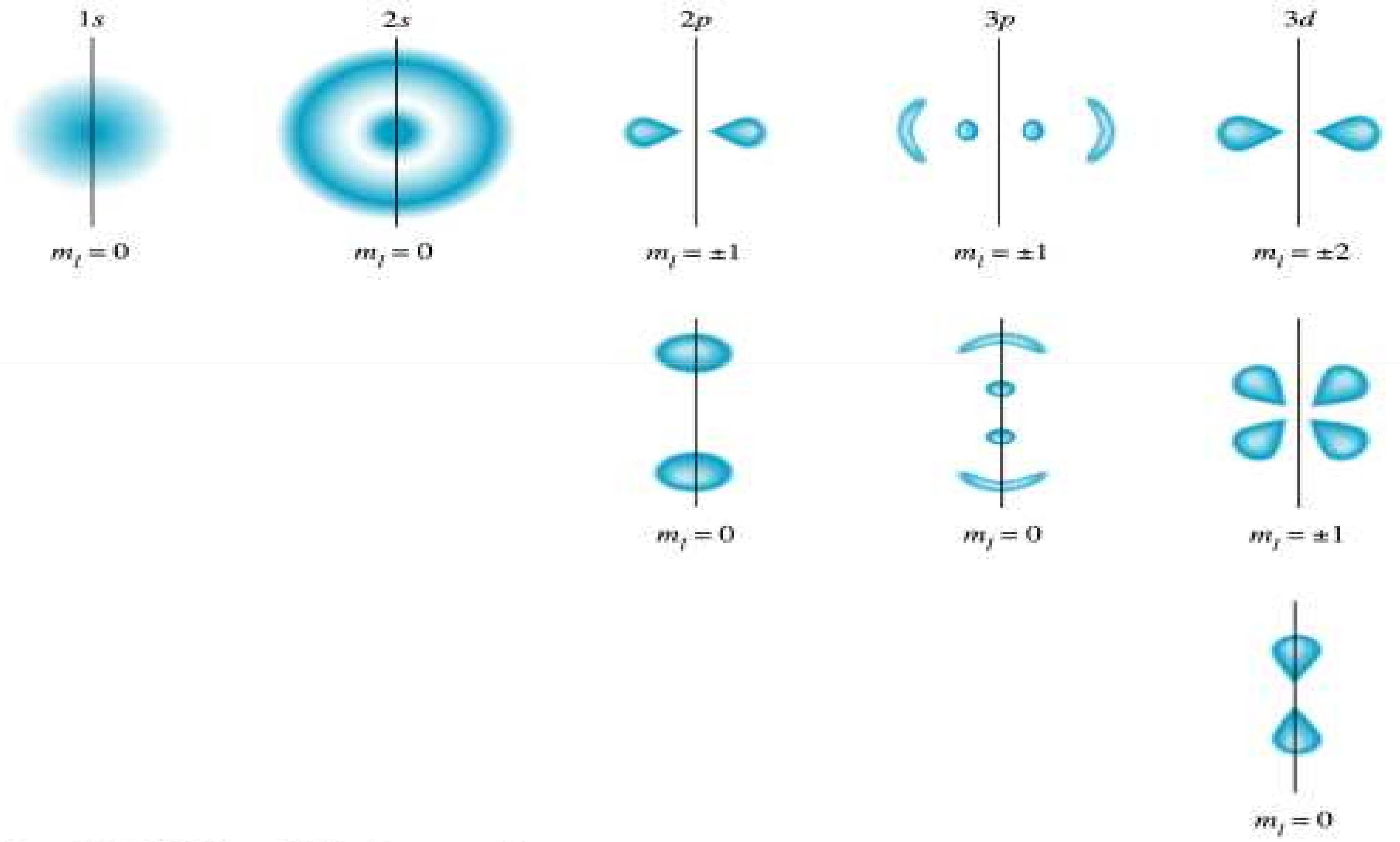
Bab.7

Atom Berelektron Banyak

Probabilitas keadaan S

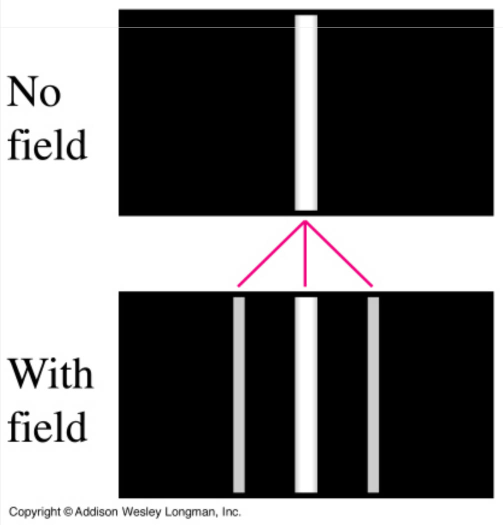


Probabilitas keadaan P



Zeeman effect

Zeeman effect ialah terpecahnya energi dari atom dan spektrum garis yang berhubungan dengannya ketika atom ditempatkan dalam medan magnet. Effect ini secara eksperimen menunjukan bahwa momentum angular terkuantisasi.



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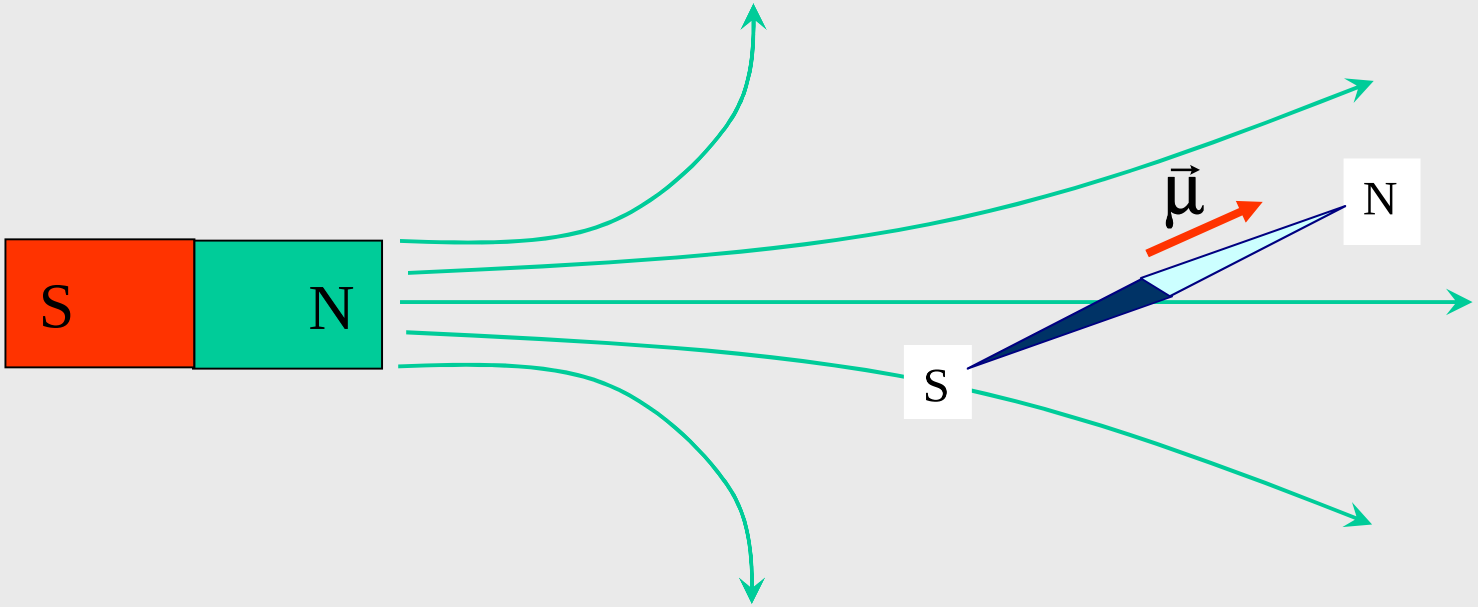
Energi potential

Energi potensial dari suatu objek didalam medan magnet bergantung pada momen magnetik dari objek dan besar medan magnet di lokasi tersebut.

$$U = -\vec{\mu} \cdot \vec{\mathbf{B}}$$



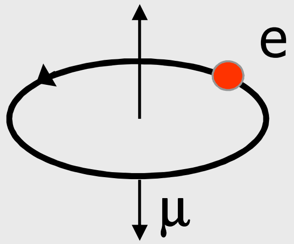
Momen magnetik dari loop arus

Momen magnetik dari suatu loop kawat yang dialiri arus listrik bergantung pada besar arus yang mengalir pada loop dan luas loop.

$$\vec{\mu} = I\vec{A}$$

Zeeman effect

orbit elektron equivalen dengan suatu loop arus yang jari jarinya r dan luas πr^2 .



Arus I rata rata ialah rata rata muatan per satuan waktu T untuk satu putaran, ialah T=2πr/v.

$$\mu = iA = \frac{-e}{T} A = \frac{-ev}{2\pi r} \pi r^2 = \frac{-e}{2m_e} \cdot m_e vr = \frac{-e}{2m_e} L$$

Zeeman effect

Bila medan **B searah sumbu** z. Interaksi energi dari atom momen magnetik dengan medan ialah:

$$U = -\mu_z B$$

dimana μ_z ialah komponen z dari vektor μ. atau:

$$\mu_z = -\frac{e}{2m} L_z$$

dan $L_z = m_l \hbar$ dengan $m_l = 0, \pm1, \pm2, \pm3 \ldots\ldots$. Jadi

$$U = -\mu_z B = m_l \frac{e\hbar}{2m} B = m_l \mu_B B$$

μ_B – Bohr magneton

Zeeman effect

Rentang harga dari m_l ialah dari *–l hingga +l* , Tingkat energi dengan harga tertentu dari bilangan kuantum orbital *l mengandung* (*2l+1*) keadaan orbital yang berbeda. Tanpa medan magnet seluruh keadaan keadaan tersebut energinya sama atau berdegenerasi(degenerate). Dengan kehadiran medan magnet energinya terpecah menjadi (*2l+1*) tingkat tingkat energi berbeda:

$$U = m_l \mu_B B \qquad \text{with} \qquad m_l = 0, \pm 1, \pm 2, \ldots$$

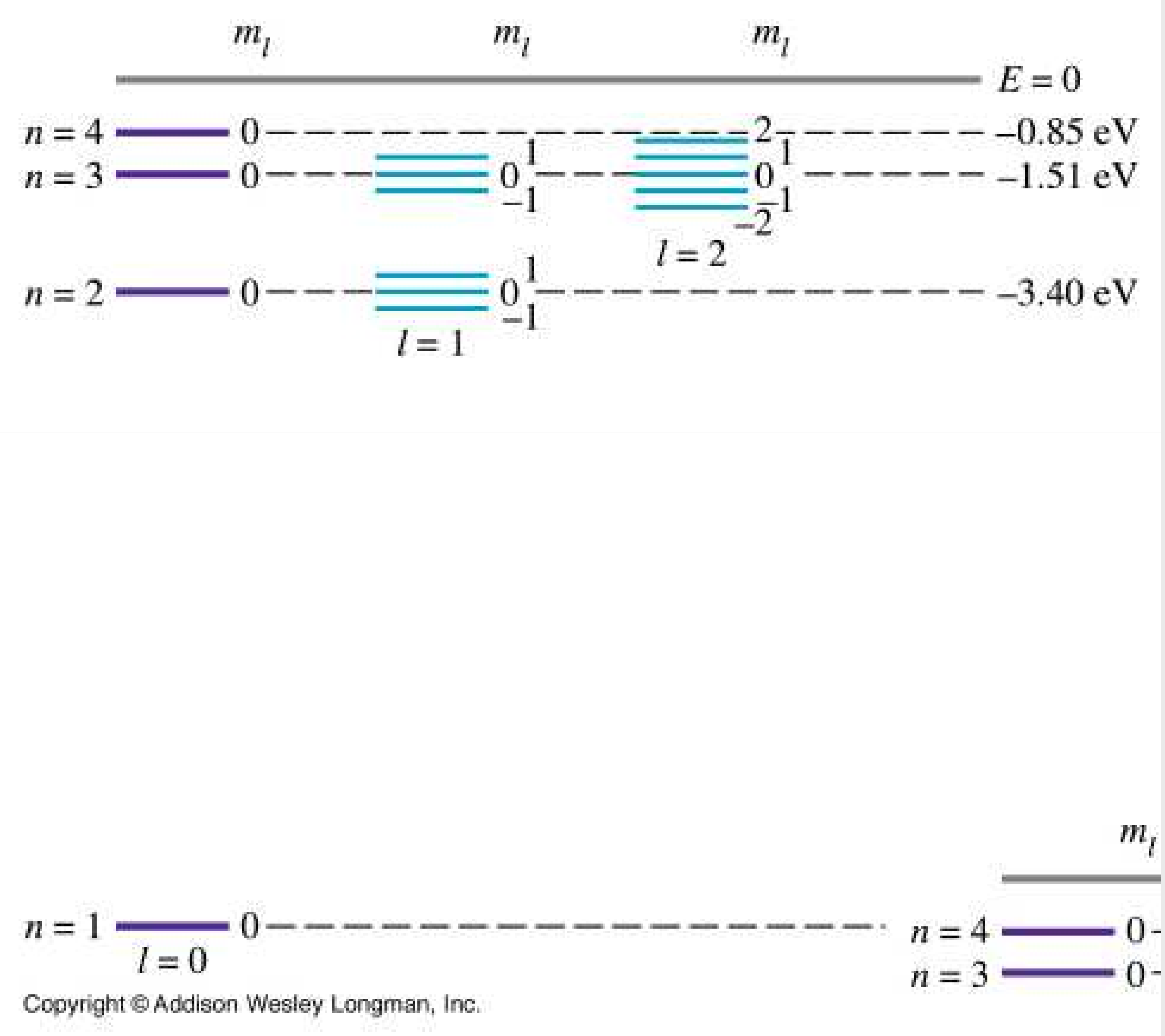
Perbedaan dua tingkat energi yang berurutan ialah

$$\Delta U = (e\hbar / 2m) B = \mu_B B$$

$$\mu_B = \frac{e\hbar}{2m_e} = 5.79 \cdot 10^{-5} \frac{eV}{T}$$

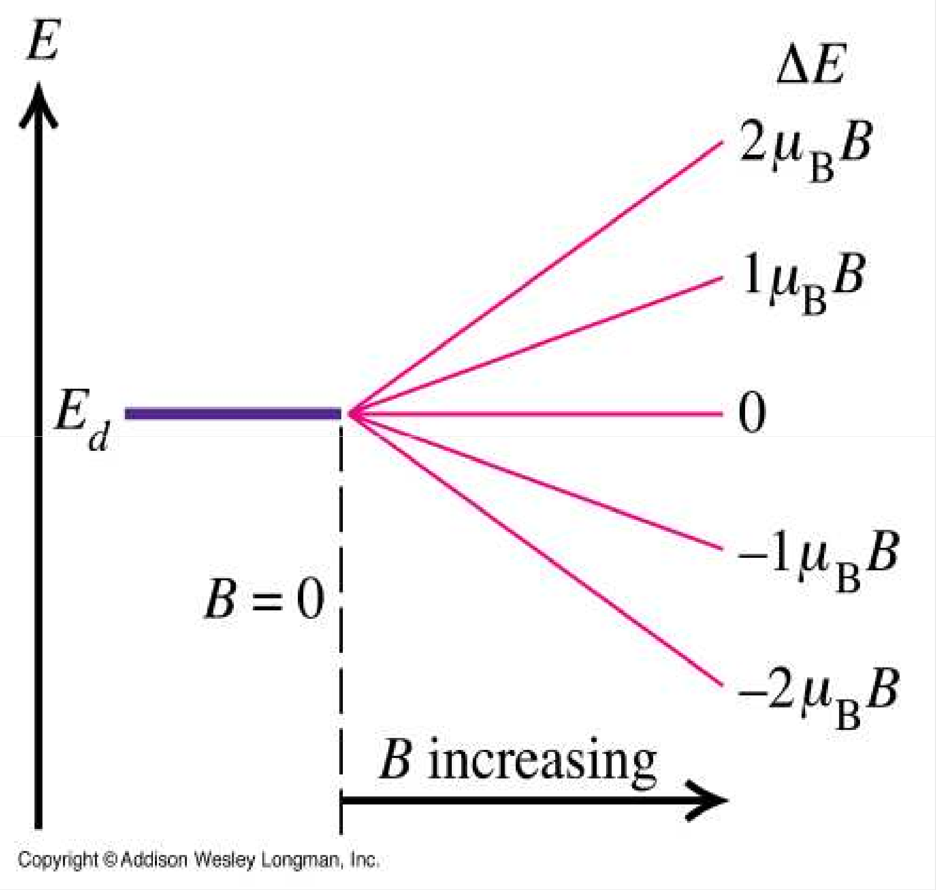
Zeeman effect

diagram energi dari hydrogen, menunjukan terpecahnya tingkat tingkat energi yang dihasilkan dari interaksi momen magnetik dari gerak elektron dalam orbital dengan medan magnet luar.



Zeeman effect

Terpecahnya tingkat tingkat energi dari keadaan d disebabkan oleh pemasangan medan magnetik, hanya diasumsikan suatu momen magnetk orbital.



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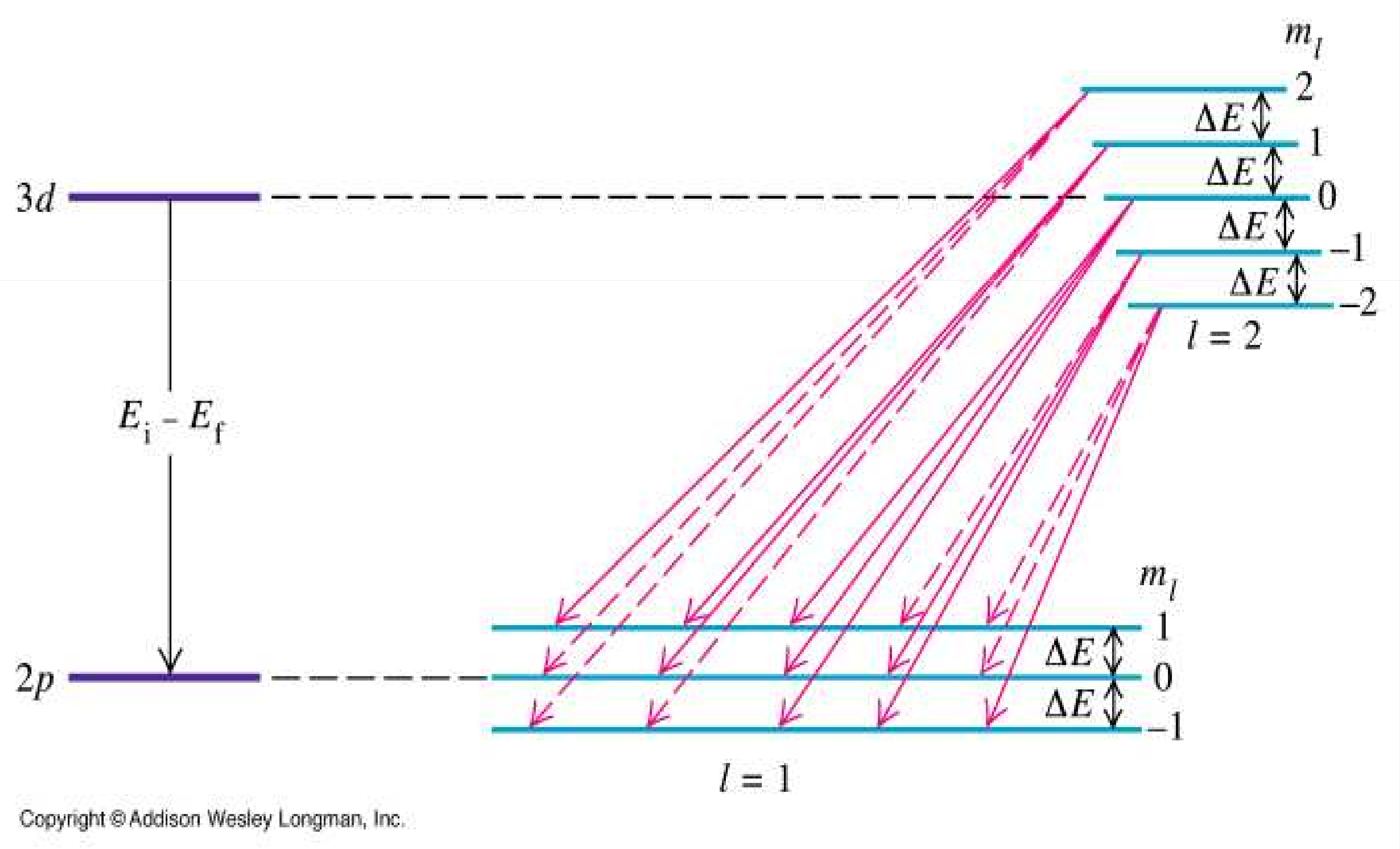
Selection rules

Photon membawa satu satuan ($\hbar$) dari momentum angular.maka
Transisi yg diijinkan: *l harus berbeda* 1 dan m_l harus berbeda 0 atau ± 1

Garis padat – Tansisi yg diijinkan;
Garis putus putus- terlarang
9 garis padat hanya memberikan 3 energi:
E_i-E_f ;
E_i-E_f +$\mu_B B$;
E_i-E_f -$\mu_B B$



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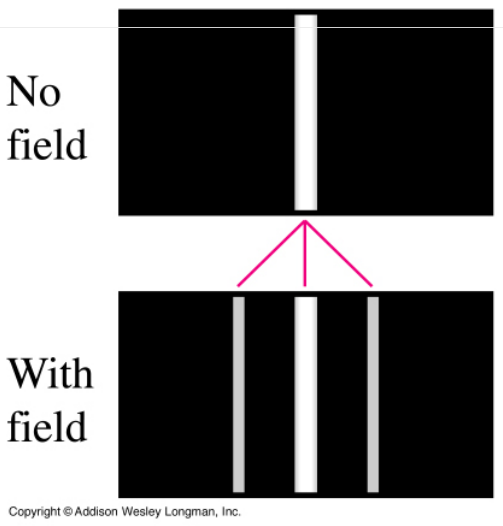
Zeeman effect

kesimpulan: garis spektrum berkaitan dengan transisi dari satu set tingkat tingkat ke set lainnya, pecah (split) dan muncul sebagai deret dari tiga spektrum garis yang letaknya sangat berdekatan menggantikan garis tunggal.



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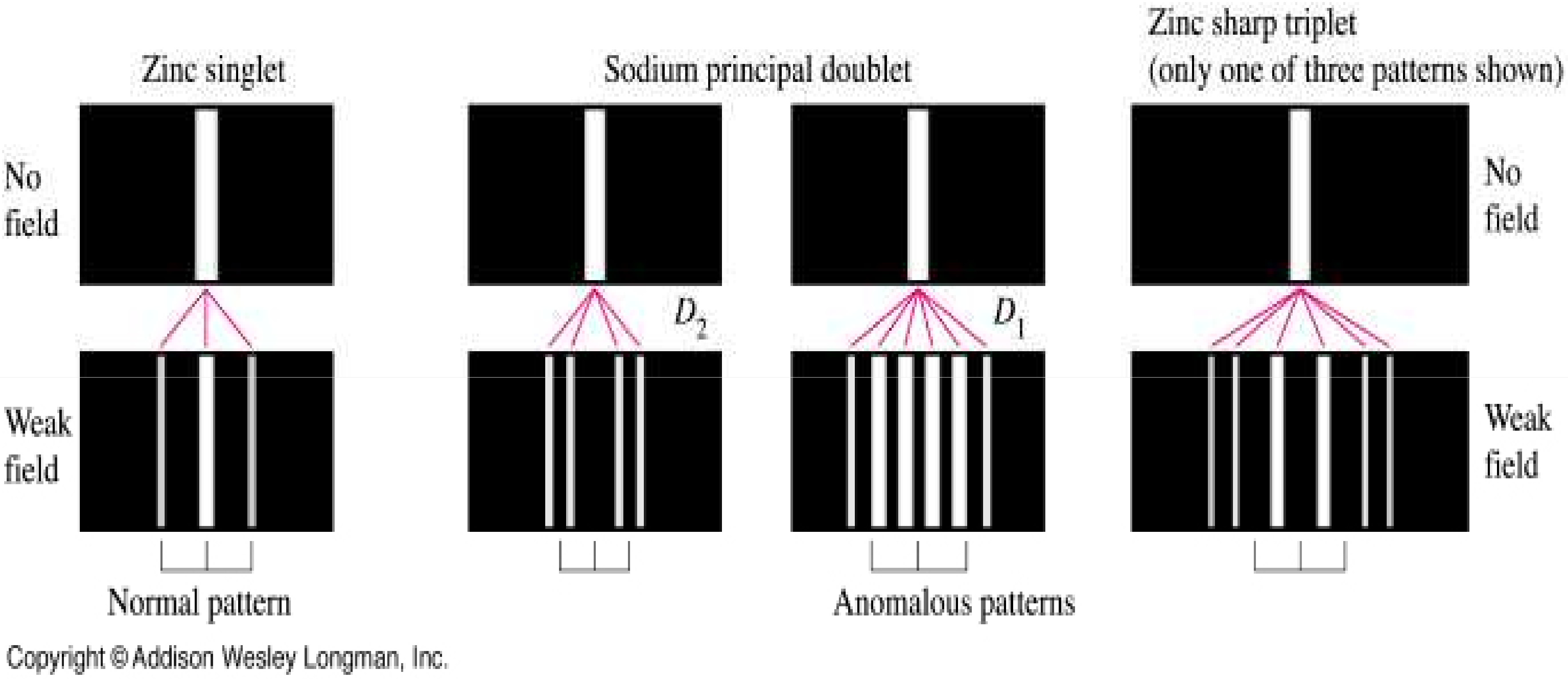
Effek Zeeman Anomalous



Momentum angular Spin dan momen magnetik

Elektron memiliki momentum angular spin L_s. Yang bebas dri momentum sudut orbitalnya. Dengan momentum ini momentum magnetik dinyatakan oleh:

$$\vec{\mu}_s = -\frac{e}{m_e}\vec{L}_s$$

$$\vec{\mu}_s = -g_e \frac{e}{2m_e}\vec{L}_s$$

dengan g_e *ialah gyromagnetic ratio*

Untuk elektron bebas $g_e=2$

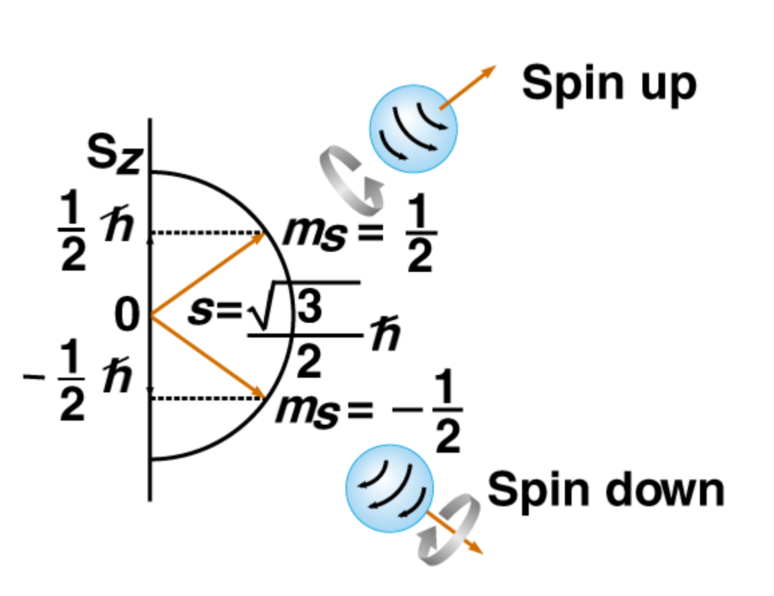
Momentum angular spin dan momen magnetik

Harga yang diperbolehkan dari momentum angular spin adalah terkuantisasi :

$$L_s = \hbar\sqrt{s(s+1)}$$

spin quantum number s = ½ → $L_s = \hbar\dfrac{\sqrt{3}}{2}$

z – component dari spin angular momentum:



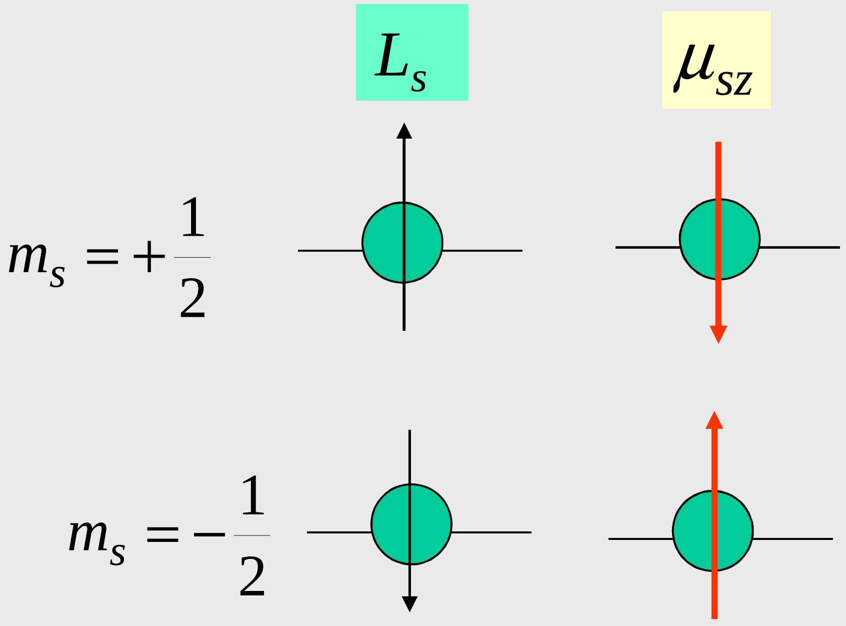
$$\boxed{L_{sz} = m_s\hbar}$$

$$m_s = \begin{cases} +\dfrac{1}{2} \\ -\dfrac{1}{2} \end{cases}$$

z- component dari momen magnetik spin

$$\mu_{sz} = -\frac{e}{m_e} L_{sz} = -\frac{e\hbar}{m_e} \cdot \left(\pm \frac{1}{2} \right)$$

$$\mu_{sz} = \mp \frac{e\hbar}{2m_e} = \mp \mu_B$$



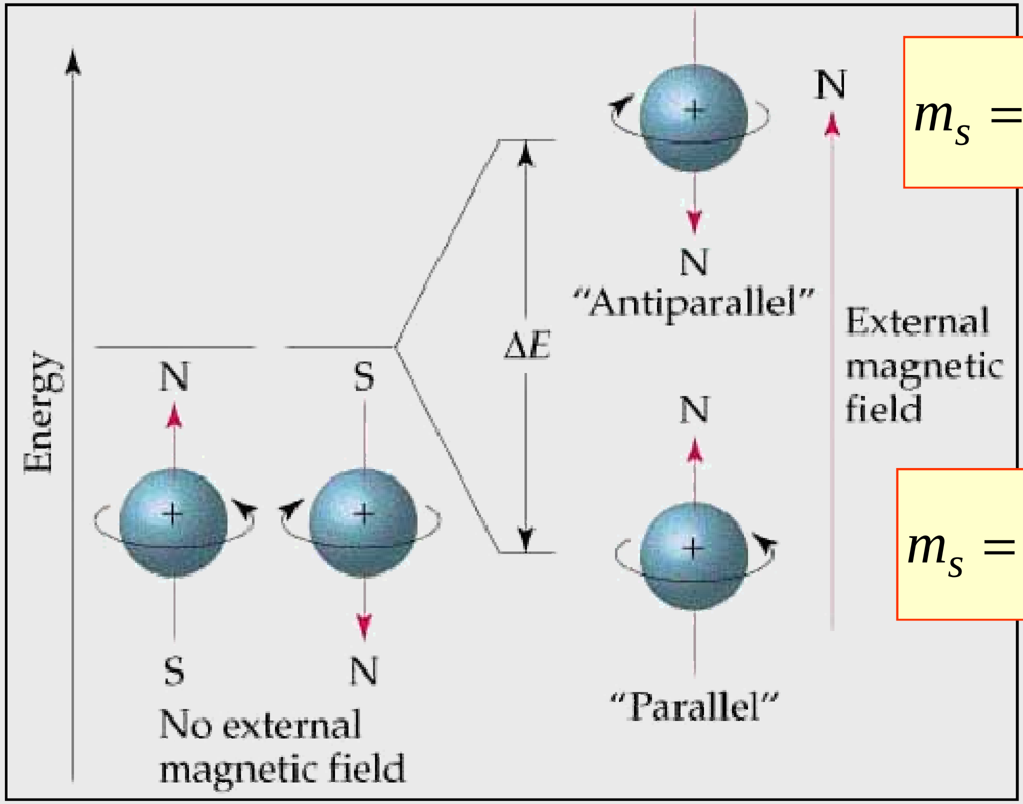
L_s μ_{sz}

$m_s = +\frac{1}{2}$

$m_s = -\frac{1}{2}$

Elektron dalam medan magnetik

$$E = E_0 - \mu_{sz} B$$



$$m_s = +\frac{1}{2}$$

$$m_s = -\frac{1}{2}$$

Untuk menandai keadaan elektron dalam atom hidrogen diperlukan 4 bilangan quantum yaitu:

name	label	magnitude
Principal quantum number	n	1, 2, 3, ...
Orbital quantum number	l	0, 1, 2, ... n-1
magnetic quantum number	m_l	od $-l$ do $+l$
Spin quantum number	m_s	± 1/2

Atom berelektron banyak dan prinsip eklusi

- Central field approximation:

  - Electron is moving in the total electric field due to the nucleus and averaged – out cloud of all the other electrons.

  - There is a corresponding spherically symmetric potential – energy function U(r).

  Solving the Schrodinger equation the same 4 quantum numbers are obtained. However wave functions are different. Energy levels depend on both *n* and *l*.

- In the ground state of a complex atom the electrons cannot all be in the lowest energy state.

  Pauli's exclusion principle states that no two electrons can occupy the same quantum – mechanical state. That is, no two electrons in an atom can have the same values of all four quantum numbers (n, l, m_l and m_s)

Shells dan orbital

n	shell	ℓ	orbital	N_{max}
1	K	0	s	2
2	L	0	s	2
	L	1	p	6
3	M	0	s	2
	M	1	p	6
	M	2	d	10
4	N	0	s	2
	N	1	p	6
	N	2	d	10
	N	3	f	14

N_{max} – *jumlah elektron maksimum yang menempati orbital*

Shells K, L, M_

n	1	2				3								
ℓ	0	0	1			0	1			2				
m_ℓ	0	0	-1	0	1	0	-1	0	1	-2	-1	0	1	2
m_s	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓
N	2	8				18								

N : jumlah keadaan yang diijinkan

↑ keadaan dengan m_s = +1/2

↓ keadaan dengan m_s = -1/2

Hund's rule – electron elektron menempati shell yang diberikan diawali dengan men set up spinnya secara paralel

carbon	↑↓	↑↓	↑	↑		$1s^2 2s^2 2p^2$
oxygen	↑↓	↑↓	↑↓	↑	↑	$1s^2 2s^2 2p^4$

Mendeleev’s Periodic Law

Susunan 65 unsur yang telah diketahui berdasarkan massa atomnya dan sifat kimianya.

Tabel periodik sekarang serupa tetapi disusun berdasarkan nomor atomnya(jumlah proton protonnya).

Unsur unsur yang terletak pada satu golongan ,memiliki sifat kimia yang sama, selain itu dapat memprediksikan sifat sifat unsur yang belum diketahui.

Table .1 Mendeleev's Predicted Properties of Germanium ("eka Silicon") and Its Actual Properties

Property	Predicted Properties of eka Silicon(E)	Actual Properties of Germanium (Ge)
atomic mass	72amu	72.61amu
appearance	gray metal	gray metal
density	5.5g/cm^3	5.32g/cm^3
molar volume	13cm^3/mol	13.65cm^3/mol
specific heat capacity	0.31J/g*K	0.32J/g*K
oxide formula	EO_2	GeO_2
oxide density	4.7g/cm^3	4.23g/cm^3
sulfide formula and solubility	ES_2; insoluble in H_2O; soluble in aqueous $(NH_4)_2S$	GeS_2; insoluble in H_2O; soluble in aqueous $(NH_4)_2S$
chloride formula (boiling point)	ECl_4; (<100^{0}C)	$GeCl_4$; (84^{0}C)
chloride density	1.9g/cm^3	1.844g/cm^3
element preparation	reduction of K_2EF_6 with sodium	reduction of K_2GeF_6 with sodium

Dari bab 6 -

Bilangan Quantum dan orbital atom

Orbital atom dicirikan oleh tiga bilangan kuantum.

n bilangan kuantum utama - integer positif

l bilangan kuantum momentum angular - integer dari 0 hinga n-1

m_l bilangan kuantum momen magnetik - integer dari -***l*** hingga +***l***

M_s bilangan kuantun spinan - + ½ atau - ½ .

The Pauli Exclusion Principle - **No two electrons in the same atom can have the same four q.n. Since the first three q.n. define the orbital, this means only two electrons can be in the same orbital and they must have opposite spins.**

Table .2 Summary of Quantum Numbers of Electrons in Atoms

Name	Symbol	Permitted Values	Property
principal	n	positive integers(1,2,3,…)	orbital energy (size)
angular momentum	l	integers from 0 to n-1	orbital shape (The l values 0, 1, 2, and 3 correspond to s, p, d, and f orbitals, respectively.)
magnetic	m_l	integers from $-l$ to 0 to $+l$	orbital orientation
spin	m_s	+1/2 or -1/2	direction of e^- spin

Faktor yang mempengaruhi energi orbital Atomik

Pengaruh muatan inti ($Z_{effective}$)

Higher nuclear charge lowers orbital energy (stabilizes the system) by increasing nucleus-electron attractions.

Pengaruh dari tolakan Elektron (Shielding)

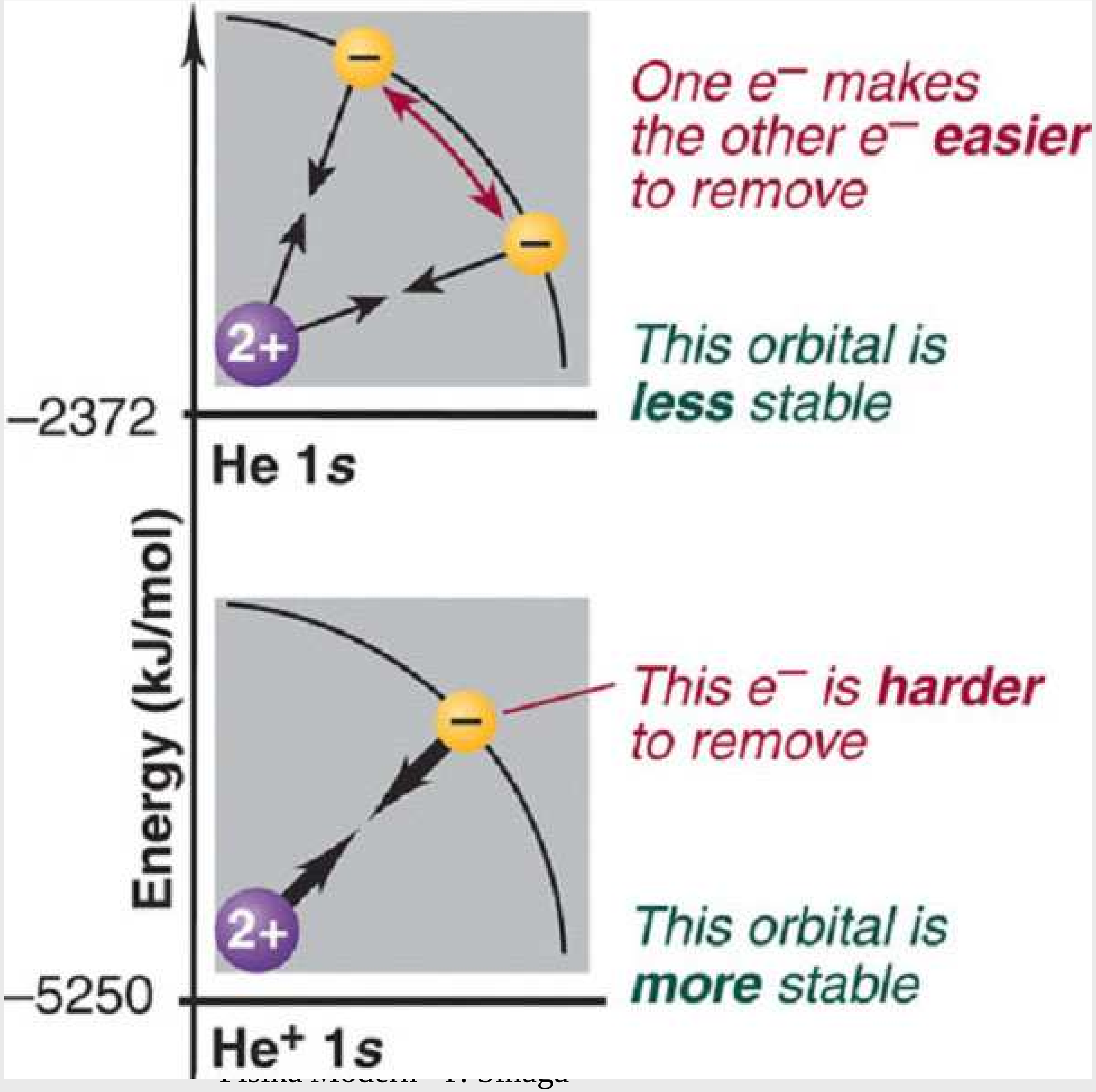
Additional electron in the same orbital (makes less stable)

An additional electron raises the orbital energy through electron-electron repulsions.

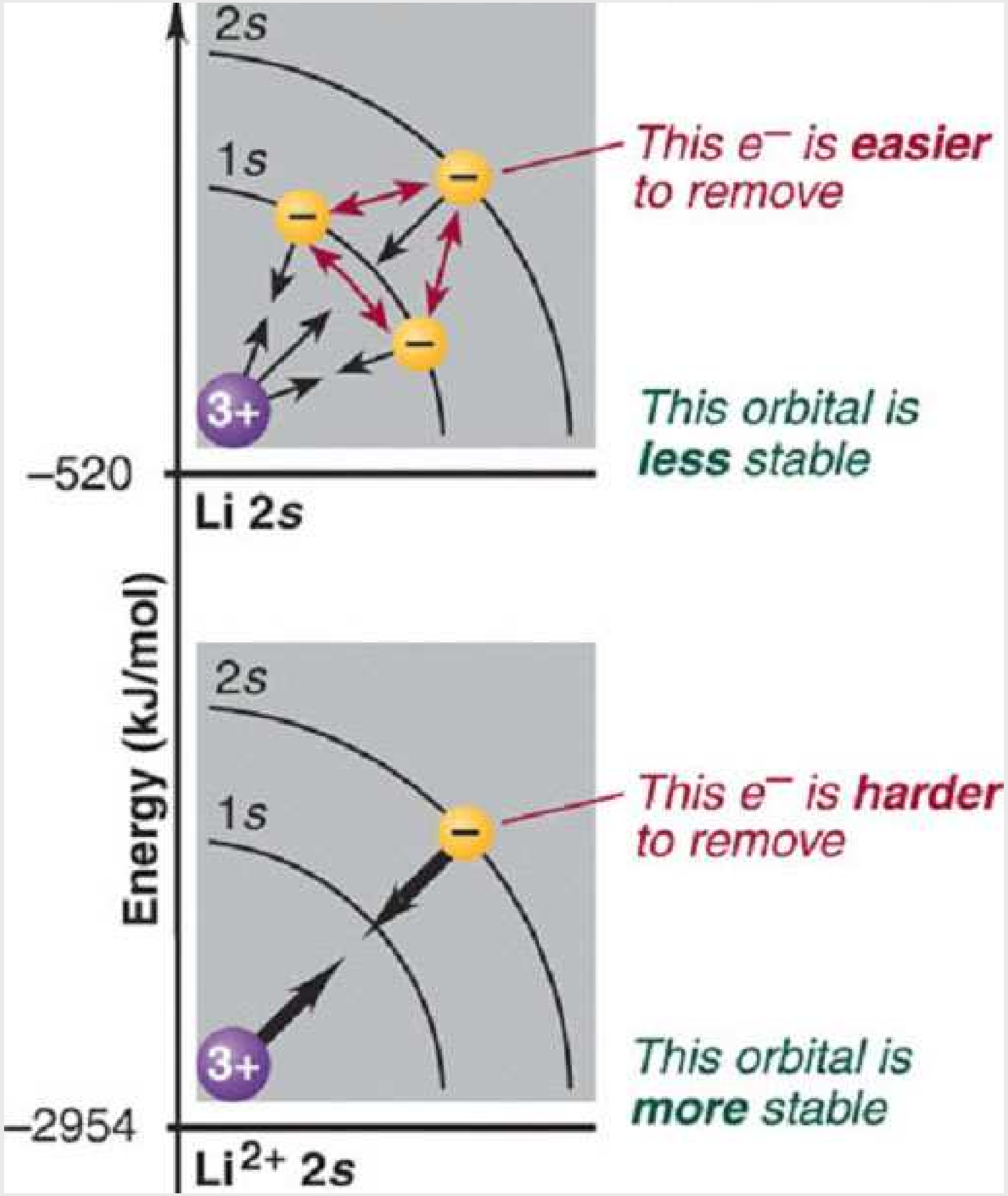
Additional electrons in inner orbitals (makes outer orbital less stable)

Inner electrons shield outer electrons more effectively than do electrons in the same sublevel.

Pengaruh dari elektron lain di orbital yang sama



Pengaruh elektron lainnya di inner orbitals



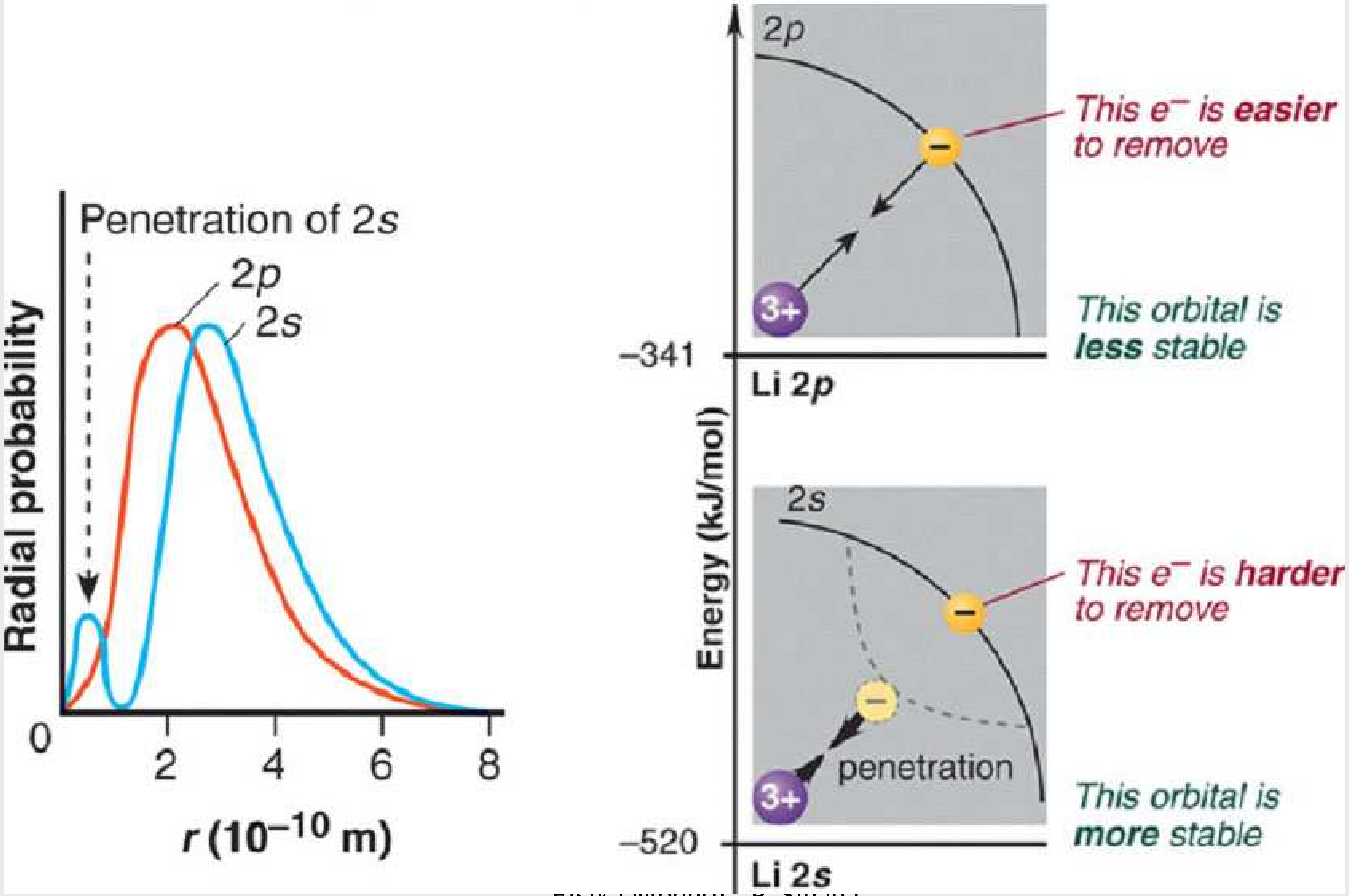
This e⁻ is **easier** to remove

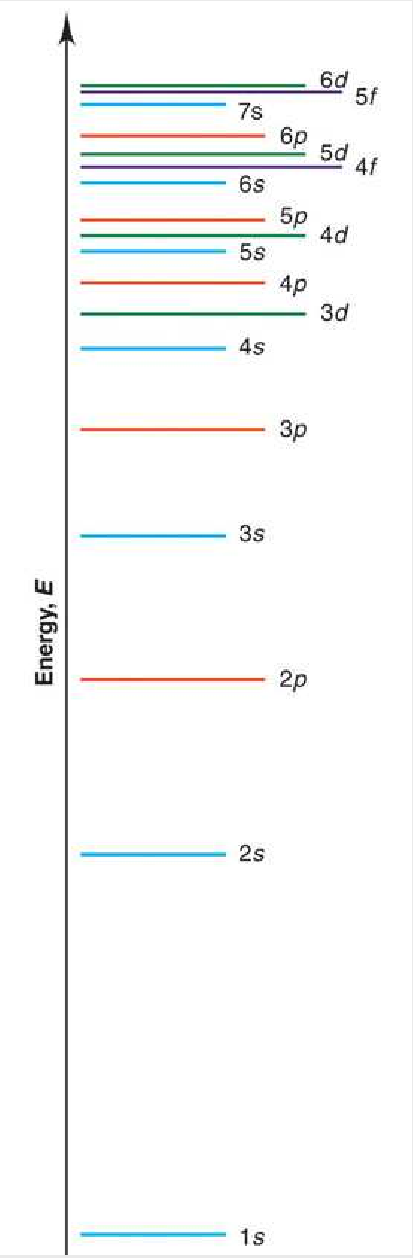
This orbital is **less** stable

This e⁻ is **harder** to remove

This orbital is **more** stable

Pengaruh bentuk orbital

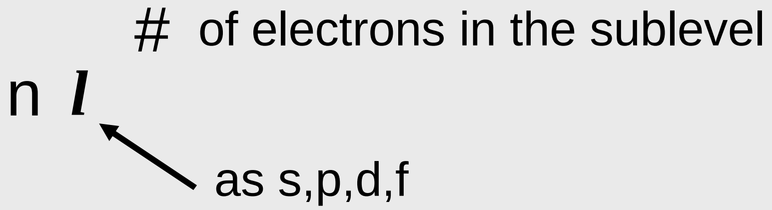




Order for filling energy sublevels with electrons

Illustrating Orbital Occupancies

The electron configuration



The orbital diagram

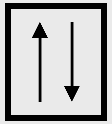
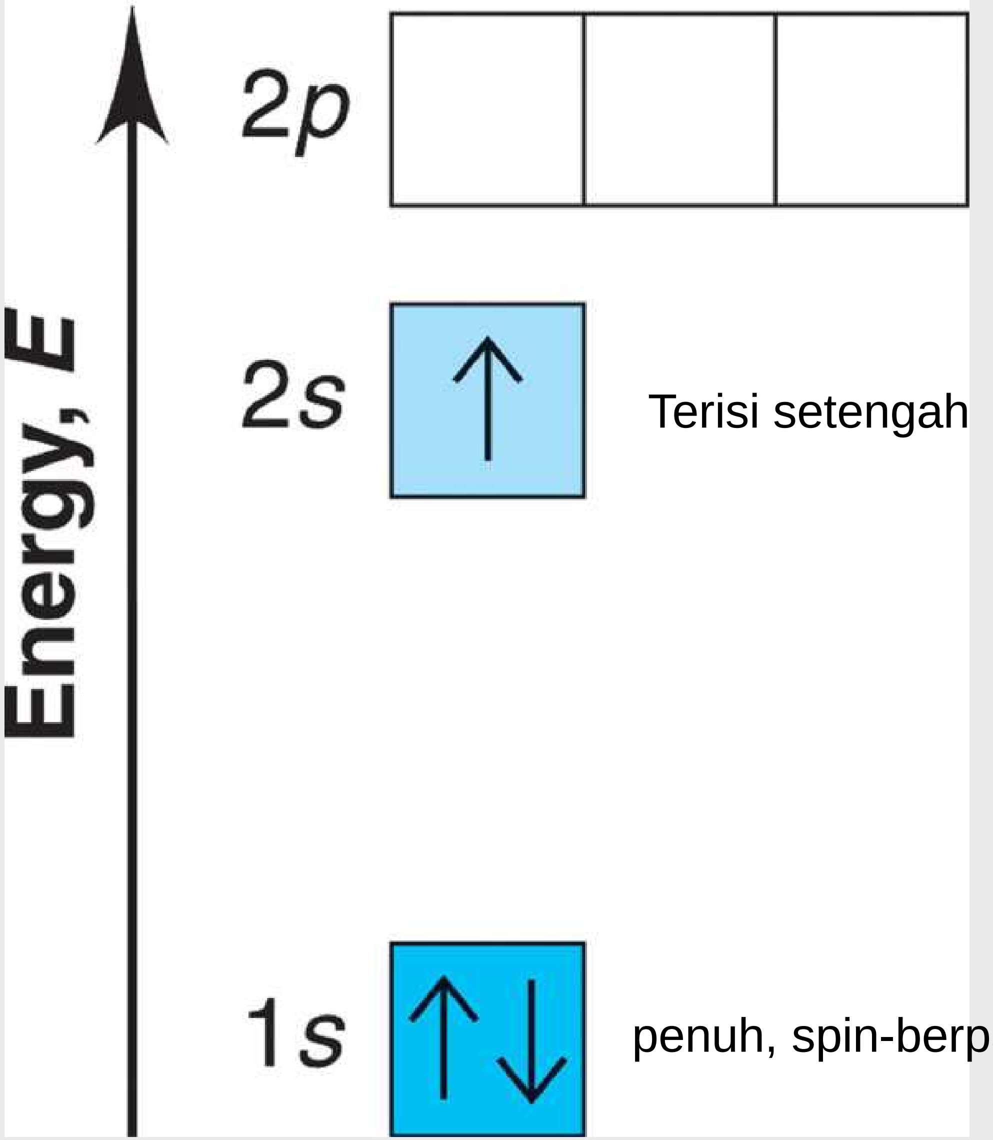


Diagram orbital vertikal untuk Li keadaan dasar



kosong

Terisi setengah

penuh, spin-berpasangan

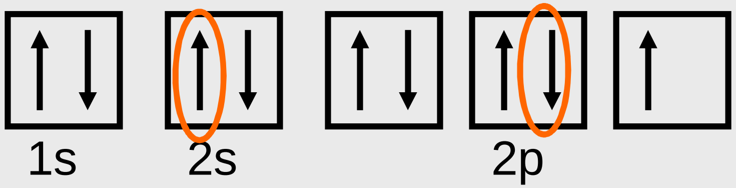
Latihan 1

Menentukan bilangan kuantum dari diagram orbital

Tuliskanlah set dari bilangan quantum untuk elektron ke 3 dan ke 8 dalam atom F .

Gunakan orbital diagram untuk menentukan elektron ke 3 dan ke 8

$_9F$



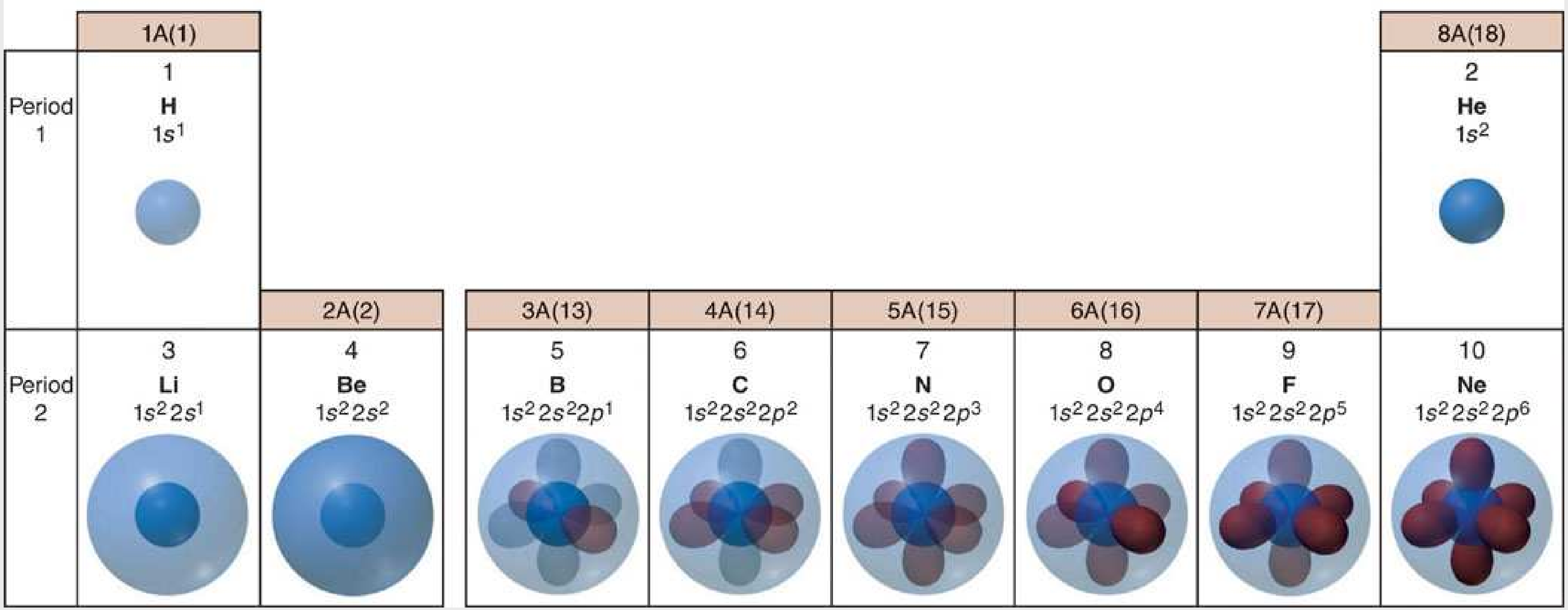
SOLUSI: Elektron ketiga bearada di orbital 2s . Bilangan kuantumnya ialah

$n = 2$ $l = 0$ $m_l = 0$ $m_s = +1/2$

Elektron ke 8 berada di orbital 2p . Bilangan kuantumnya nialah

$n = 2$ $l = 1$ $m_l = -1$ $m_s = -1/2$

Orbital occupancy for the first 10 elements, H through Ne.



	1A(1)	2A(2)	3A(13)	4A(14)	5A(15)	6A(16)	7A(17)	8A(18)
Period 1	1 **H** $1s^1$							2 **He** $1s^2$
Period 2	3 **Li** $1s^2 2s^1$	4 **Be** $1s^2 2s^2$	5 **B** $1s^2 2s^2 2p^1$	6 **C** $1s^2 2s^2 2p^2$	7 **N** $1s^2 2s^2 2p^3$	8 **O** $1s^2 2s^2 2p^4$	9 **F** $1s^2 2s^2 2p^5$	10 **Ne** $1s^2 2s^2 2p^6$

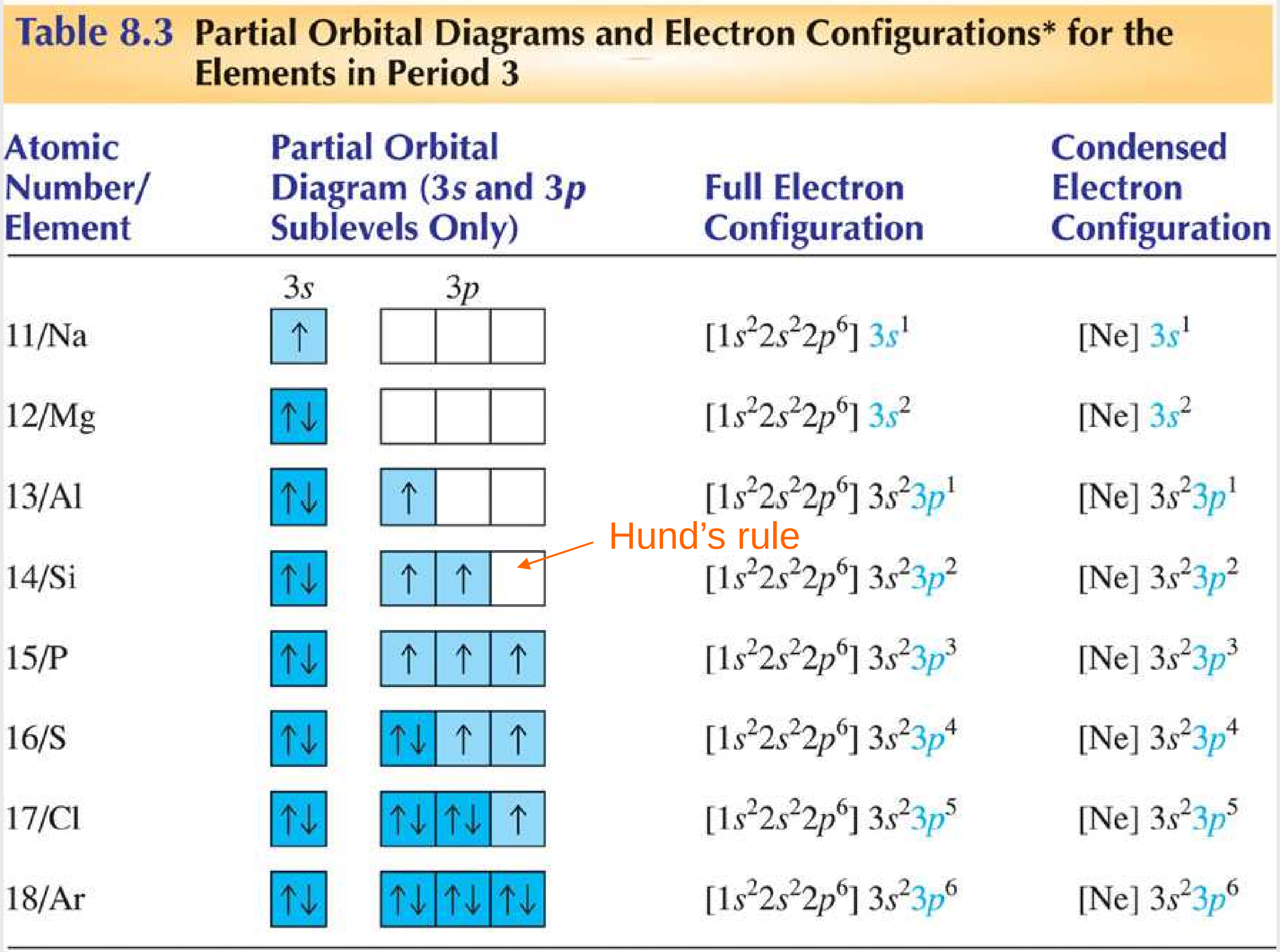
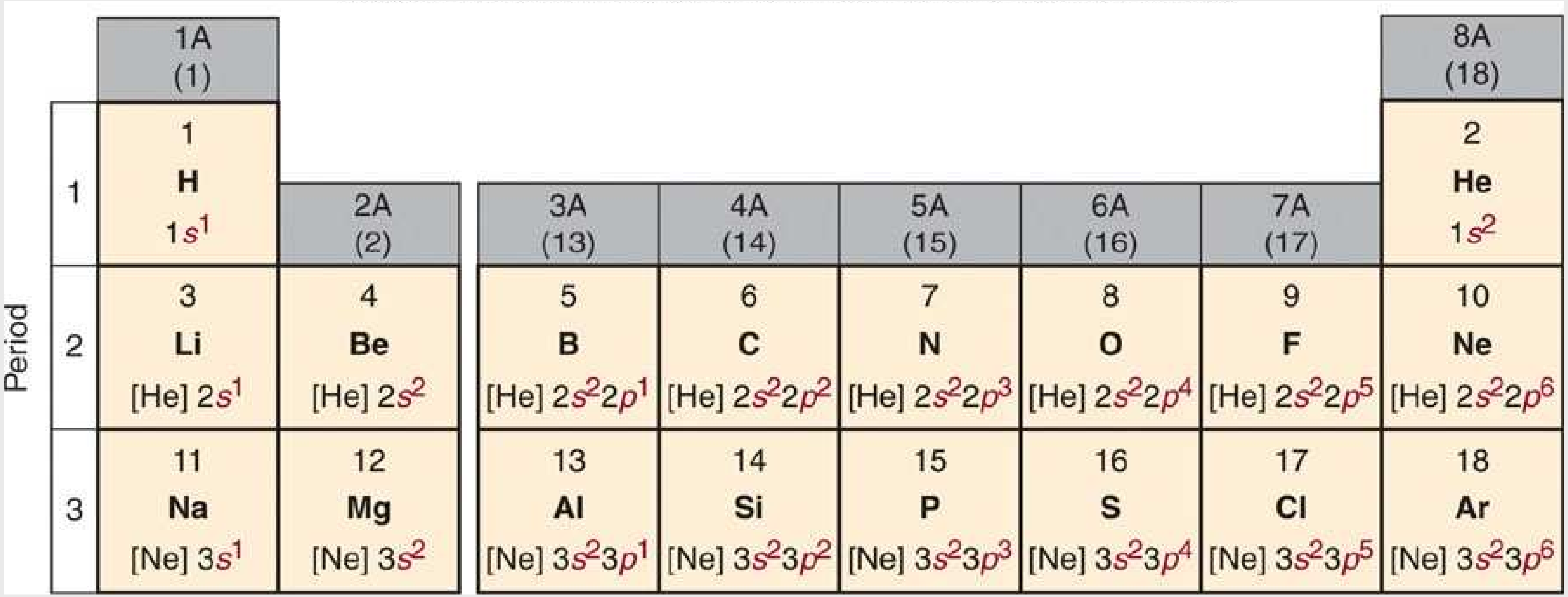


Table 8.3 Partial Orbital Diagrams and Electron Configurations* for the Elements in Period 3

Atomic Number/ Element	Partial Orbital Diagram (3*s* and 3*p* Sublevels Only)				Full Electron Configuration	Condensed Electron Configuration
	3*s*	3*p*				
11/Na	↑				$[1s^2 2s^2 2p^6]\ 3s^1$	$[\mathrm{Ne}]\ 3s^1$
12/Mg	↑↓				$[1s^2 2s^2 2p^6]\ 3s^2$	$[\mathrm{Ne}]\ 3s^2$
13/Al	↑↓	↑			$[1s^2 2s^2 2p^6]\ 3s^2 3p^1$	$[\mathrm{Ne}]\ 3s^2 3p^1$
14/Si	↑↓	↑	↑		$[1s^2 2s^2 2p^6]\ 3s^2 3p^2$	$[\mathrm{Ne}]\ 3s^2 3p^2$
15/P	↑↓	↑	↑	↑	$[1s^2 2s^2 2p^6]\ 3s^2 3p^3$	$[\mathrm{Ne}]\ 3s^2 3p^3$
16/S	↑↓	↑↓	↑	↑	$[1s^2 2s^2 2p^6]\ 3s^2 3p^4$	$[\mathrm{Ne}]\ 3s^2 3p^4$
17/Cl	↑↓	↑↓	↑↓	↑	$[1s^2 2s^2 2p^6]\ 3s^2 3p^5$	$[\mathrm{Ne}]\ 3s^2 3p^5$
18/Ar	↑↓	↑↓	↑↓	↑↓	$[1s^2 2s^2 2p^6]\ 3s^2 3p^6$	$[\mathrm{Ne}]\ 3s^2 3p^6$

Hund's rule

Condensed ground-state electron configurations in the first three periods.



Period	1A (1)	2A (2)	3A (13)	4A (14)	5A (15)	6A (16)	7A (17)	8A (18)
1	1 **H** $1s^1$							2 **He** $1s^2$
2	3 **Li** [He] $2s^1$	4 **Be** [He] $2s^2$	5 **B** [He] $2s^22p^1$	6 **C** [He] $2s^22p^2$	7 **N** [He] $2s^22p^3$	8 **O** [He] $2s^22p^4$	9 **F** [He] $2s^22p^5$	10 **Ne** [He] $2s^22p^6$
3	11 **Na** [Ne] $3s^1$	12 **Mg** [Ne] $3s^2$	13 **Al** [Ne] $3s^23p^1$	14 **Si** [Ne] $3s^23p^2$	15 **P** [Ne] $3s^23p^3$	16 **S** [Ne] $3s^23p^4$	17 **Cl** [Ne] $3s^23p^5$	18 **Ar** [Ne] $3s^23p^6$

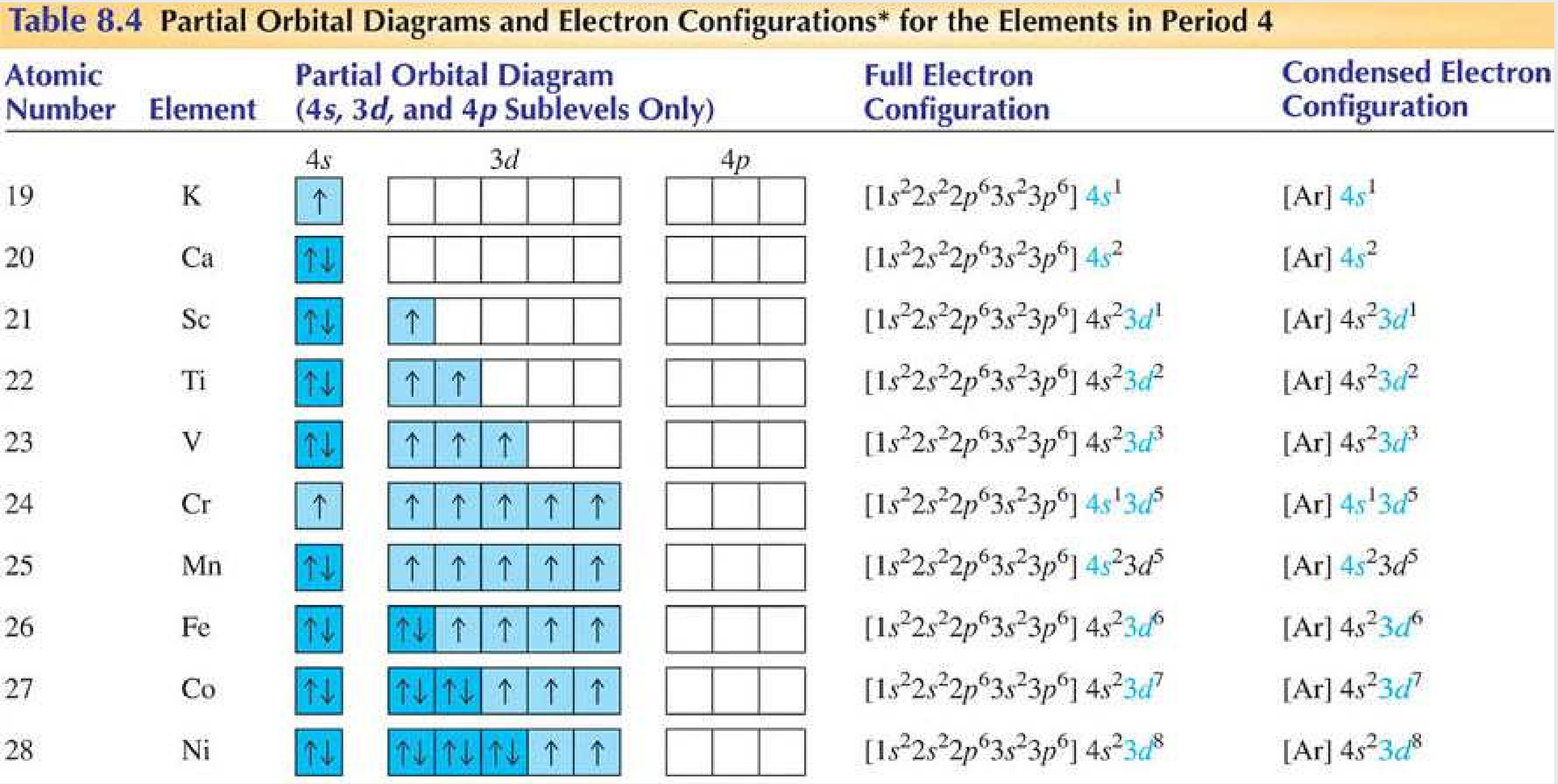


Table 8.4 Partial Orbital Diagrams and Electron Configurations* for the Elements in Period 4

Atomic Number	Element	Partial Orbital Diagram (4*s*, 3*d*, and 4*p* Sublevels Only)									Full Electron Configuration	Condensed Electron Configuration
		4*s*	3*d*					4*p*				
19	K	↑									$[1s^22s^22p^63s^23p^6]\ 4s^1$	$[\mathrm{Ar}]\ 4s^1$
20	Ca	↑↓									$[1s^22s^22p^63s^23p^6]\ 4s^2$	$[\mathrm{Ar}]\ 4s^2$
21	Sc	↑↓	↑								$[1s^22s^22p^63s^23p^6]\ 4s^23d^1$	$[\mathrm{Ar}]\ 4s^23d^1$
22	Ti	↑↓	↑	↑							$[1s^22s^22p^63s^23p^6]\ 4s^23d^2$	$[\mathrm{Ar}]\ 4s^23d^2$
23	V	↑↓	↑	↑	↑						$[1s^22s^22p^63s^23p^6]\ 4s^23d^3$	$[\mathrm{Ar}]\ 4s^23d^3$
24	Cr	↑	↑	↑	↑	↑	↑				$[1s^22s^22p^63s^23p^6]\ 4s^13d^5$	$[\mathrm{Ar}]\ 4s^13d^5$
25	Mn	↑↓	↑	↑	↑	↑	↑				$[1s^22s^22p^63s^23p^6]\ 4s^23d^5$	$[\mathrm{Ar}]\ 4s^23d^5$
26	Fe	↑↓	↑↓	↑	↑	↑	↑				$[1s^22s^22p^63s^23p^6]\ 4s^23d^6$	$[\mathrm{Ar}]\ 4s^23d^6$
27	Co	↑↓	↑↓	↑↓	↑	↑	↑				$[1s^22s^22p^63s^23p^6]\ 4s^23d^7$	$[\mathrm{Ar}]\ 4s^23d^7$
28	Ni	↑↓	↑↓	↑↓	↑↓	↑	↑				$[1s^22s^22p^63s^23p^6]\ 4s^23d^8$	$[\mathrm{Ar}]\ 4s^23d^8$

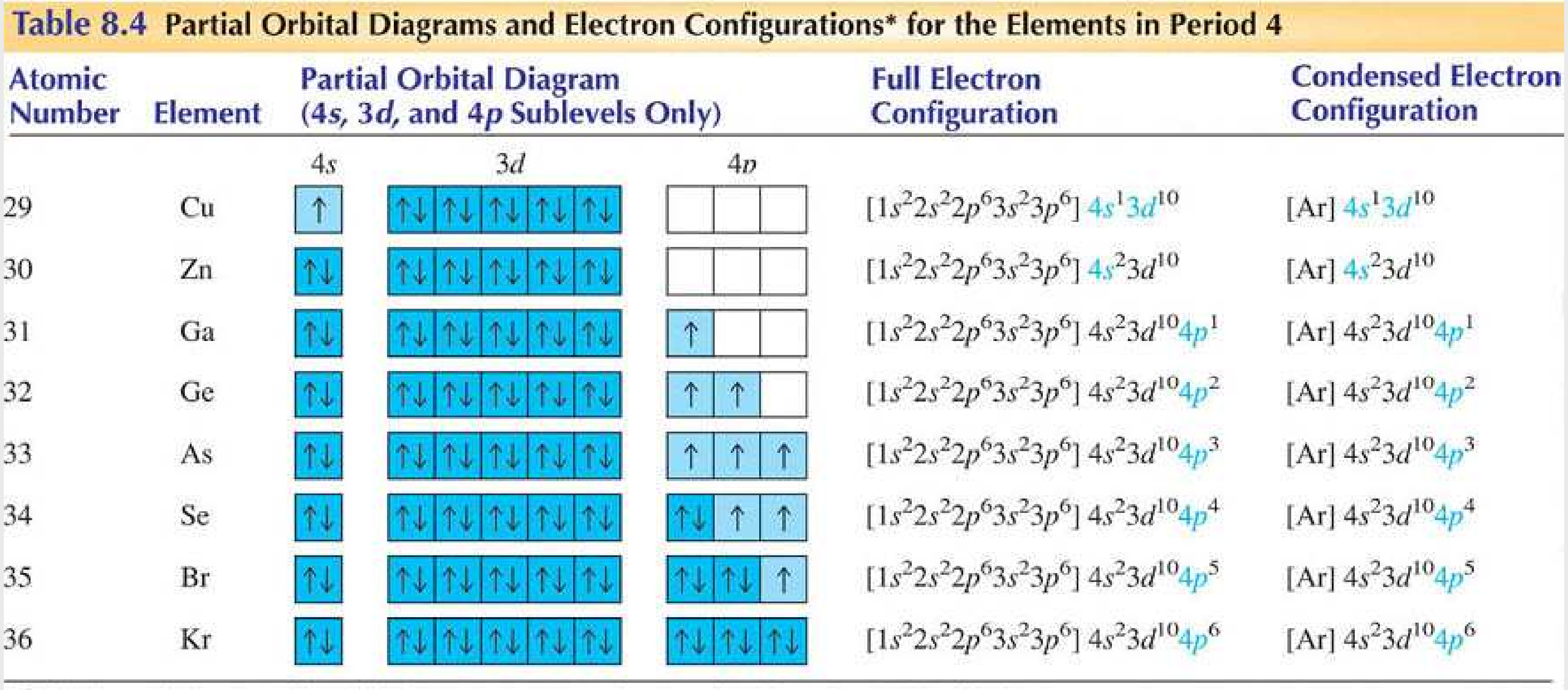
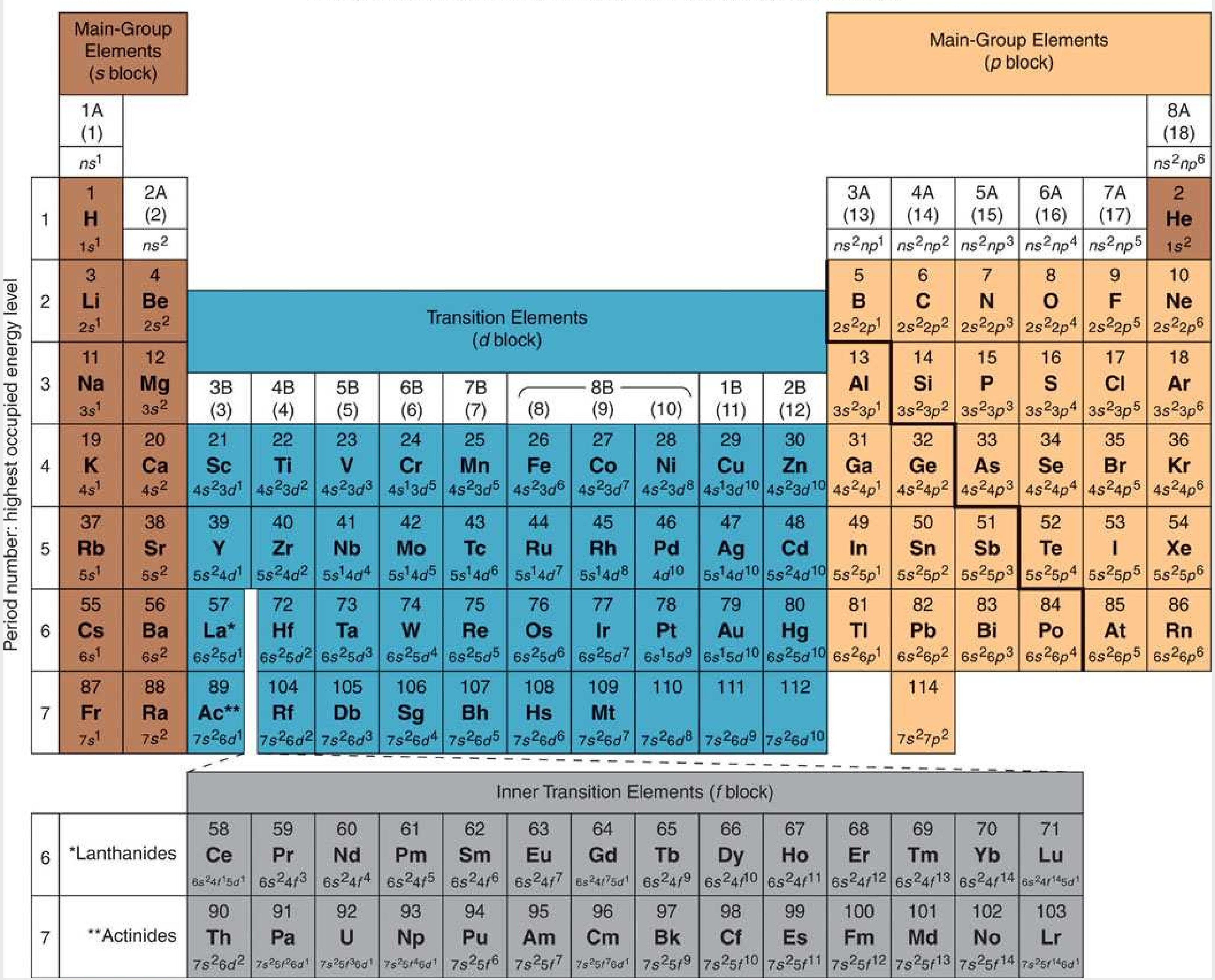


Table 8.4 Partial Orbital Diagrams and Electron Configurations* for the Elements in Period 4

Atomic Number	Element	Partial Orbital Diagram (4*s*, 3*d*, and 4*p* Sublevels Only)			Full Electron Configuration	Condensed Electron Configuration
		4*s*	3*d*	4*p*		
29	Cu	↑	↑↓ ↑↓ ↑↓ ↑↓ ↑↓	☐ ☐ ☐	$[1s^22s^22p^63s^23p^6]\ 4s^13d^{10}$	$[\mathrm{Ar}]\ 4s^13d^{10}$
30	Zn	↑↓	↑↓ ↑↓ ↑↓ ↑↓ ↑↓	☐ ☐ ☐	$[1s^22s^22p^63s^23p^6]\ 4s^23d^{10}$	$[\mathrm{Ar}]\ 4s^23d^{10}$
31	Ga	↑↓	↑↓ ↑↓ ↑↓ ↑↓ ↑↓	↑ ☐ ☐	$[1s^22s^22p^63s^23p^6]\ 4s^23d^{10}4p^1$	$[\mathrm{Ar}]\ 4s^23d^{10}4p^1$
32	Ge	↑↓	↑↓ ↑↓ ↑↓ ↑↓ ↑↓	↑ ↑ ☐	$[1s^22s^22p^63s^23p^6]\ 4s^23d^{10}4p^2$	$[\mathrm{Ar}]\ 4s^23d^{10}4p^2$
33	As	↑↓	↑↓ ↑↓ ↑↓ ↑↓ ↑↓	↑ ↑ ↑	$[1s^22s^22p^63s^23p^6]\ 4s^23d^{10}4p^3$	$[\mathrm{Ar}]\ 4s^23d^{10}4p^3$
34	Se	↑↓	↑↓ ↑↓ ↑↓ ↑↓ ↑↓	↑↓ ↑ ↑	$[1s^22s^22p^63s^23p^6]\ 4s^23d^{10}4p^4$	$[\mathrm{Ar}]\ 4s^23d^{10}4p^4$
35	Br	↑↓	↑↓ ↑↓ ↑↓ ↑↓ ↑↓	↑↓ ↑↓ ↑	$[1s^22s^22p^63s^23p^6]\ 4s^23d^{10}4p^5$	$[\mathrm{Ar}]\ 4s^23d^{10}4p^5$
36	Kr	↑↓	↑↓ ↑↓ ↑↓ ↑↓ ↑↓	↑↓ ↑↓ ↑↓	$[1s^22s^22p^63s^23p^6]\ 4s^23d^{10}4p^6$	$[\mathrm{Ar}]\ 4s^23d^{10}4p^6$

A periodic table of partial ground-state electron configurations



Main-Group Elements (*s* block)

Transition Elements (*d* block)

Main-Group Elements (*p* block)

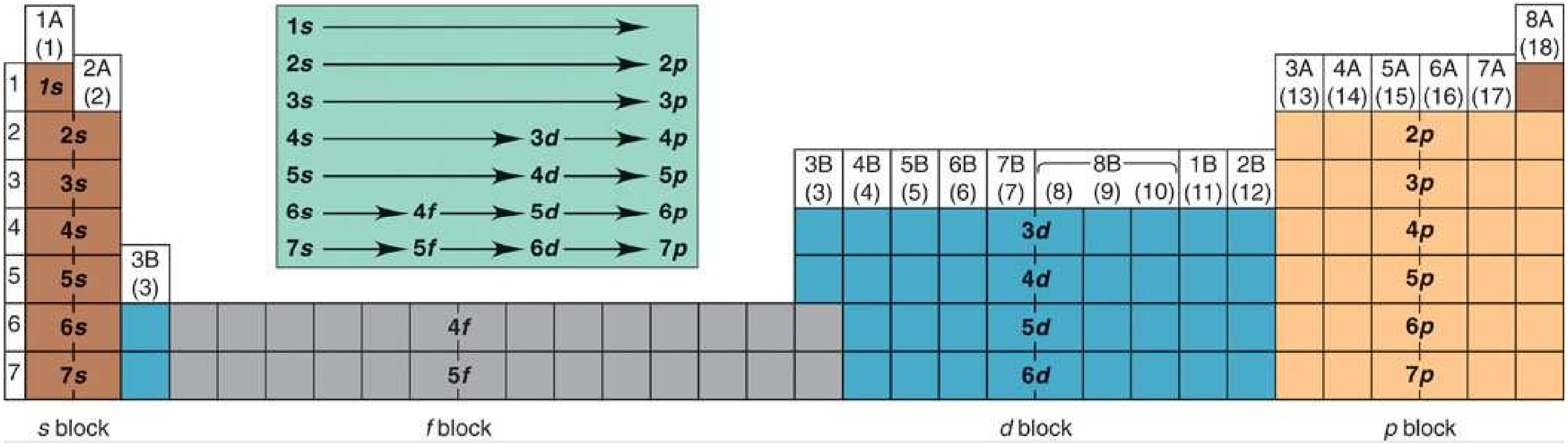
Period number: highest occupied energy level

	1A (1)	2A (2)	3B (3)	4B (4)	5B (5)	6B (6)	7B (7)	8B (8)	8B (9)	8B (10)	1B (11)	2B (12)	3A (13)	4A (14)	5A (15)	6A (16)	7A (17)	8A (18)
	ns^1	ns^2											ns^2np^1	ns^2np^2	ns^2np^3	ns^2np^4	ns^2np^5	ns^2np^6
1	1 **H** $1s^1$																	2 **He** $1s^2$
2	3 **Li** $2s^1$	4 **Be** $2s^2$											5 **B** $2s^22p^1$	6 **C** $2s^22p^2$	7 **N** $2s^22p^3$	8 **O** $2s^22p^4$	9 **F** $2s^22p^5$	10 **Ne** $2s^22p^6$
3	11 **Na** $3s^1$	12 **Mg** $3s^2$											13 **Al** $3s^23p^1$	14 **Si** $3s^23p^2$	15 **P** $3s^23p^3$	16 **S** $3s^23p^4$	17 **Cl** $3s^23p^5$	18 **Ar** $3s^23p^6$
4	19 **K** $4s^1$	20 **Ca** $4s^2$	21 **Sc** $4s^23d^1$	22 **Ti** $4s^23d^2$	23 **V** $4s^23d^3$	24 **Cr** $4s^13d^5$	25 **Mn** $4s^23d^5$	26 **Fe** $4s^23d^6$	27 **Co** $4s^23d^7$	28 **Ni** $4s^23d^8$	29 **Cu** $4s^13d^{10}$	30 **Zn** $4s^23d^{10}$	31 **Ga** $4s^24p^1$	32 **Ge** $4s^24p^2$	33 **As** $4s^24p^3$	34 **Se** $4s^24p^4$	35 **Br** $4s^24p^5$	36 **Kr** $4s^24p^6$
5	37 **Rb** $5s^1$	38 **Sr** $5s^2$	39 **Y** $5s^24d^1$	40 **Zr** $5s^24d^2$	41 **Nb** $5s^14d^4$	42 **Mo** $5s^14d^5$	43 **Tc** $5s^14d^6$	44 **Ru** $5s^14d^7$	45 **Rh** $5s^14d^8$	46 **Pd** $4d^{10}$	47 **Ag** $5s^14d^{10}$	48 **Cd** $5s^24d^{10}$	49 **In** $5s^25p^1$	50 **Sn** $5s^25p^2$	51 **Sb** $5s^25p^3$	52 **Te** $5s^25p^4$	53 **I** $5s^25p^5$	54 **Xe** $5s^25p^6$
6	55 **Cs** $6s^1$	56 **Ba** $6s^2$	57 **La*** $6s^25d^1$	72 **Hf** $6s^25d^2$	73 **Ta** $6s^25d^3$	74 **W** $6s^25d^4$	75 **Re** $6s^25d^5$	76 **Os** $6s^25d^6$	77 **Ir** $6s^25d^7$	78 **Pt** $6s^15d^9$	79 **Au** $6s^15d^{10}$	80 **Hg** $6s^25d^{10}$	81 **Tl** $6s^26p^1$	82 **Pb** $6s^26p^2$	83 **Bi** $6s^26p^3$	84 **Po** $6s^26p^4$	85 **At** $6s^26p^5$	86 **Rn** $6s^26p^6$
7	87 **Fr** $7s^1$	88 **Ra** $7s^2$	89 **Ac**** $7s^26d^1$	104 **Rf** $7s^26d^2$	105 **Db** $7s^26d^3$	106 **Sg** $7s^26d^4$	107 **Bh** $7s^26d^5$	108 **Hs** $7s^26d^6$	109 **Mt** $7s^26d^7$	110 $7s^26d^8$	111 $7s^26d^9$	112 $7s^26d^{10}$		114 $7s^27p^2$				

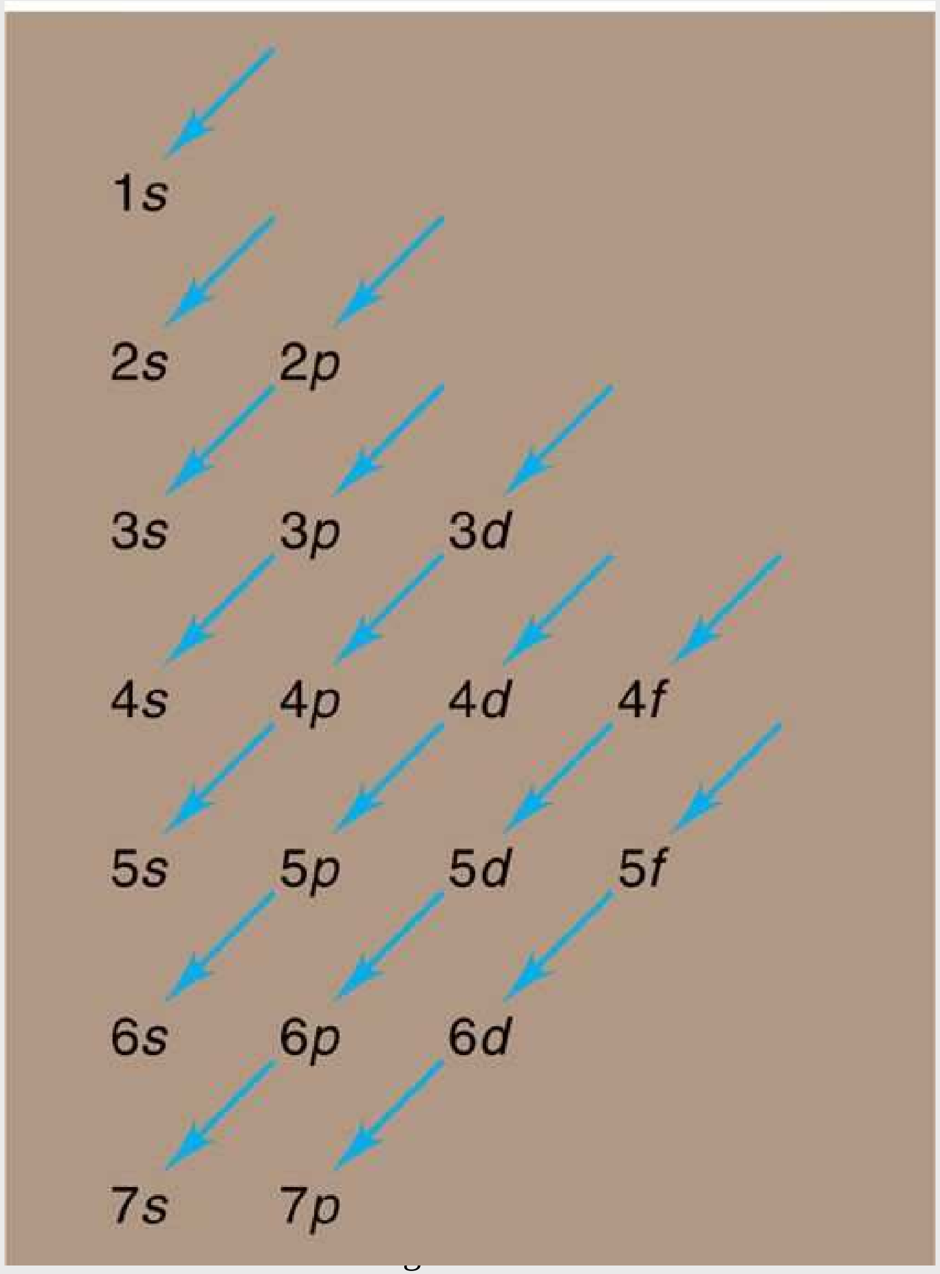
Inner Transition Elements (*f* block)

6	*Lanthanides	58 **Ce** $6s^24f^15d^1$	59 **Pr** $6s^24f^3$	60 **Nd** $6s^24f^4$	61 **Pm** $6s^24f^5$	62 **Sm** $6s^24f^6$	63 **Eu** $6s^24f^7$	64 **Gd** $6s^24f^75d^1$	65 **Tb** $6s^24f^9$	66 **Dy** $6s^24f^{10}$	67 **Ho** $6s^24f^{11}$	68 **Er** $6s^24f^{12}$	69 **Tm** $6s^24f^{13}$	70 **Yb** $6s^24f^{14}$	71 **Lu** $6s^24f^{14}5d^1$
7	**Actinides	90 **Th** $7s^26d^2$	91 **Pa** $7s^25f^26d^1$	92 **U** $7s^25f^36d^1$	93 **Np** $7s^25f^46d^1$	94 **Pu** $7s^25f^6$	95 **Am** $7s^25f^7$	96 **Cm** $7s^25f^76d^1$	97 **Bk** $7s^25f^9$	98 **Cf** $7s^25f^{10}$	99 **Es** $7s^25f^{11}$	100 **Fm** $7s^25f^{12}$	101 **Md** $7s^25f^{13}$	102 **No** $7s^25f^{14}$	103 **Lr** $7s^25f^{14}6d^1$

The relation between orbital filling and the periodic table



Pola umum untuk pengisian sublevels



Soal.2 Menentukan Konfigurasi Elkctron

Dengan menggunakan tabel periodik, tentukanlah konfigurasi lengkap, condensed electrons configurations, diagram orbital partial yang menunjukan elektron valensinya, dan jumlah inner elektron untuk unsur unsur berikut:

(a) potassium (K: Z = 19) **(b)** molybdenum (Mo: Z = 42) **(c)** lead (Pb: Z = 82)

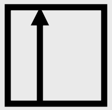
SOLUSI:

(a) untuk K (Z = 19)

full configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

condensed configuration $[Ar]\ 4s^1$

partial orbital diagram



$4s^1$

There are 18 inner electrons.

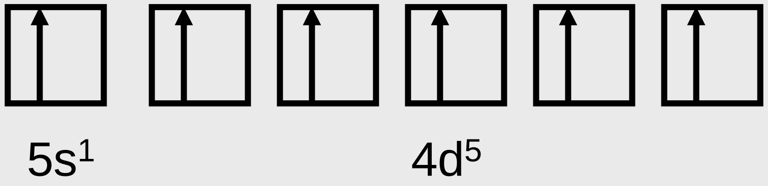
lanjutan

(b) untuk Mo (Z = 42)

full configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^1 4d^5$

condensed configuration [Kr] $5s^1 4d^5$

partial orbital diagram



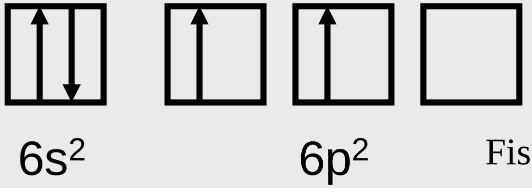
ada 36 inner electrons and 6 elektron valensi

(c) for Pb (Z = 82)

full configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{10} 6p^2$

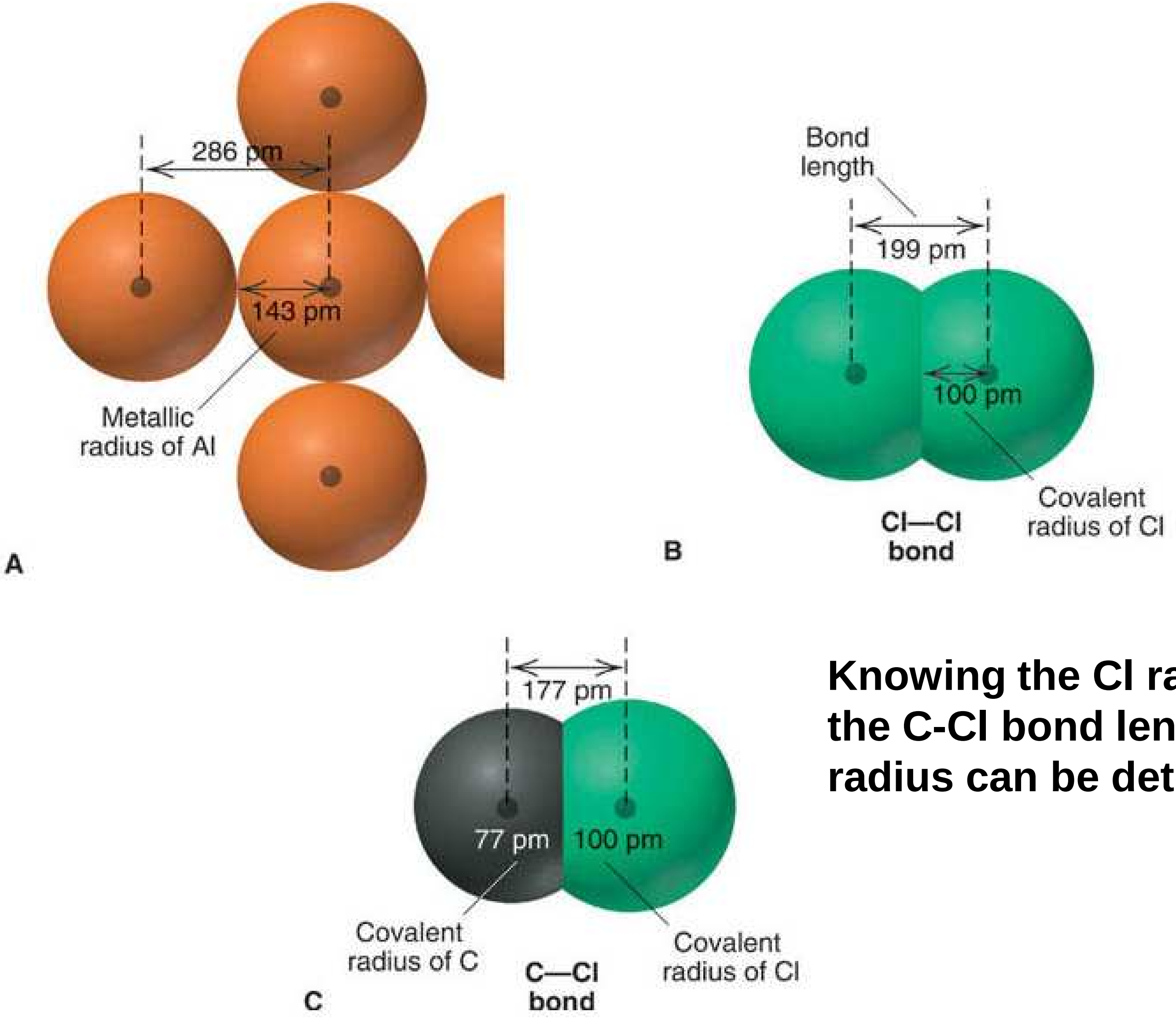
condensed configuration [Xe] $6s^2 4f^{14} 5d^{10} 6p^2$

partial orbital diagram



ada 78 inner electrons dan 4 elektron valensi.

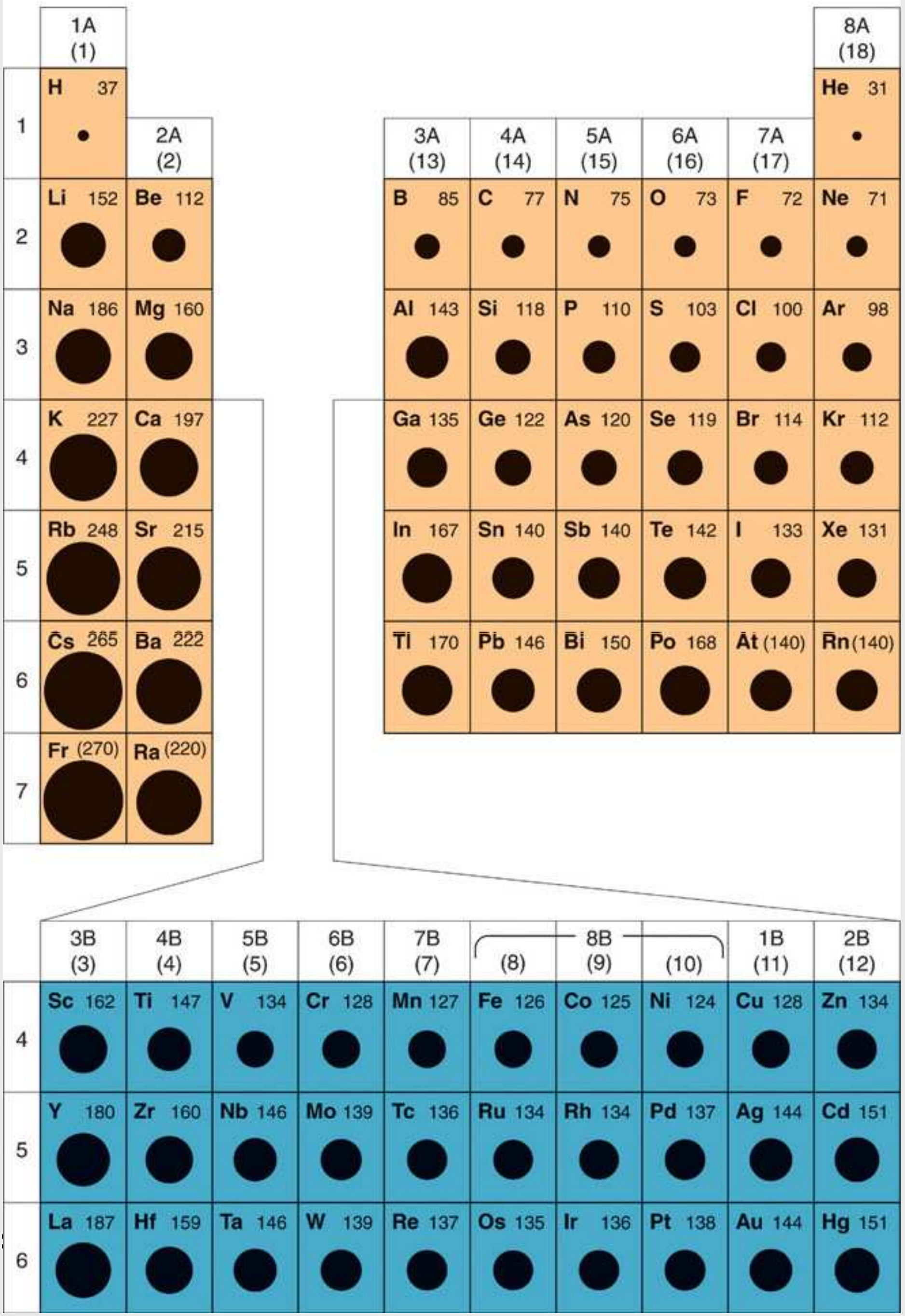
Defining metallic and covalent radii



Knowing the Cl radius and the C-Cl bond length, the C radius can be determined.

Trends dalam Tabel Periodik

Radius Atomik dari group utama dan unsur transition .

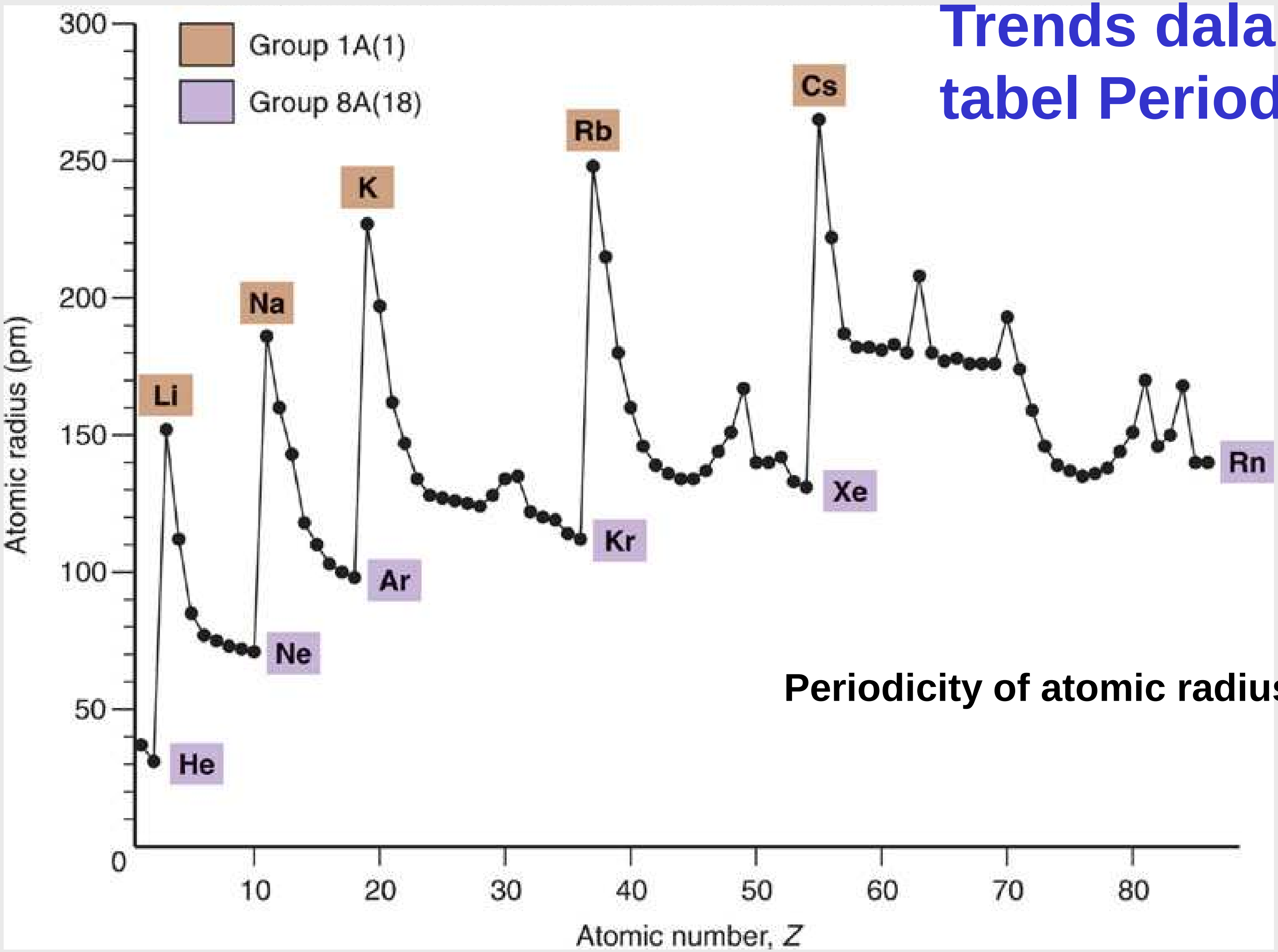


	1A (1)	2A (2)	3A (13)	4A (14)	5A (15)	6A (16)	7A (17)	8A (18)
1	H 37							He 31
2	Li 152	Be 112	B 85	C 77	N 75	O 73	F 72	Ne 71
3	Na 186	Mg 160	Al 143	Si 118	P 110	S 103	Cl 100	Ar 98
4	K 227	Ca 197	Ga 135	Ge 122	As 120	Se 119	Br 114	Kr 112
5	Rb 248	Sr 215	In 167	Sn 140	Sb 140	Te 142	I 133	Xe 131
6	Cs 265	Ba 222	Tl 170	Pb 146	Bi 150	Po 168	At (140)	Rn (140)
7	Fr (270)	Ra (220)						

	3B (3)	4B (4)	5B (5)	6B (6)	7B (7)	(8)	8B (9)	(10)	1B (11)	2B (12)
4	Sc 162	Ti 147	V 134	Cr 128	Mn 127	Fe 126	Co 125	Ni 124	Cu 128	Zn 134
5	Y 180	Zr 160	Nb 146	Mo 139	Tc 136	Ru 134	Rh 134	Pd 137	Ag 144	Cd 151
6	La 187	Hf 159	Ta 146	W 139	Re 137	Os 135	Ir 136	Pt 138	Au 144	Hg 151

Fi

Trends dalam tabel Periodik



Periodicity of atomic radius

latihan.3

Ranking Elements by Atomic Size

Gunakan tabel periodik, urutkanlah berdasarkan urutan ukuran atomnya dari yang besar hingga yang kecil:

(a) Ca, Mg, Sr **(b)** K, Ga, Ca **(c)** Br, Rb, Kr **(d)** Sr, Ca, Rb

Unsur dalam grup yang sama ukurannya membesar dari bawah keatas.

SOLUSI:

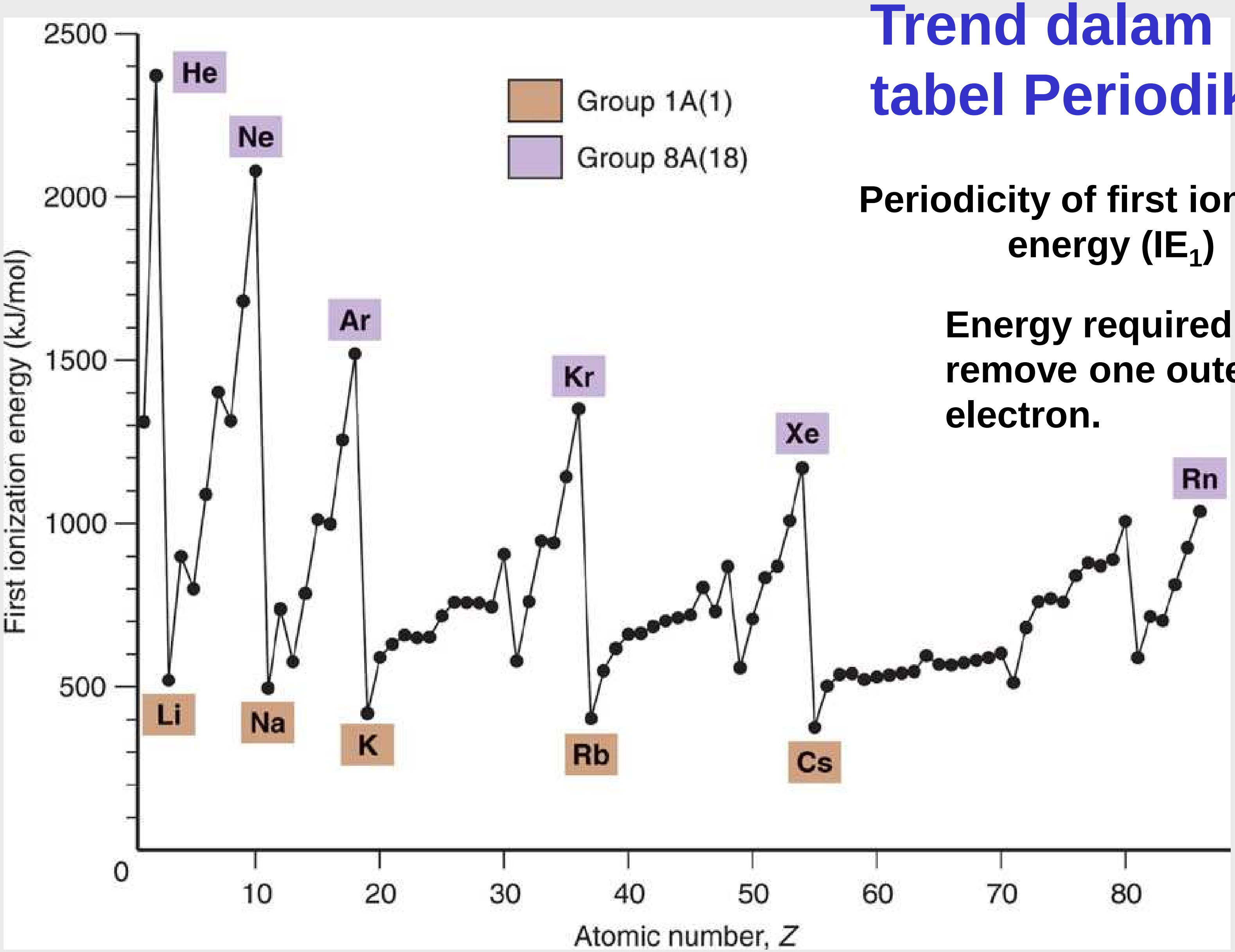
(a) Sr > Ca > Mg Unsur unsur ini ada di Group 2A(2).

(b) K > Ca > Ga Unsur ini ada di Perioda 4.

(c) Rb > Br > Kr

(d) Rb > Sr > Ca

Trend dalam tabel Periodik

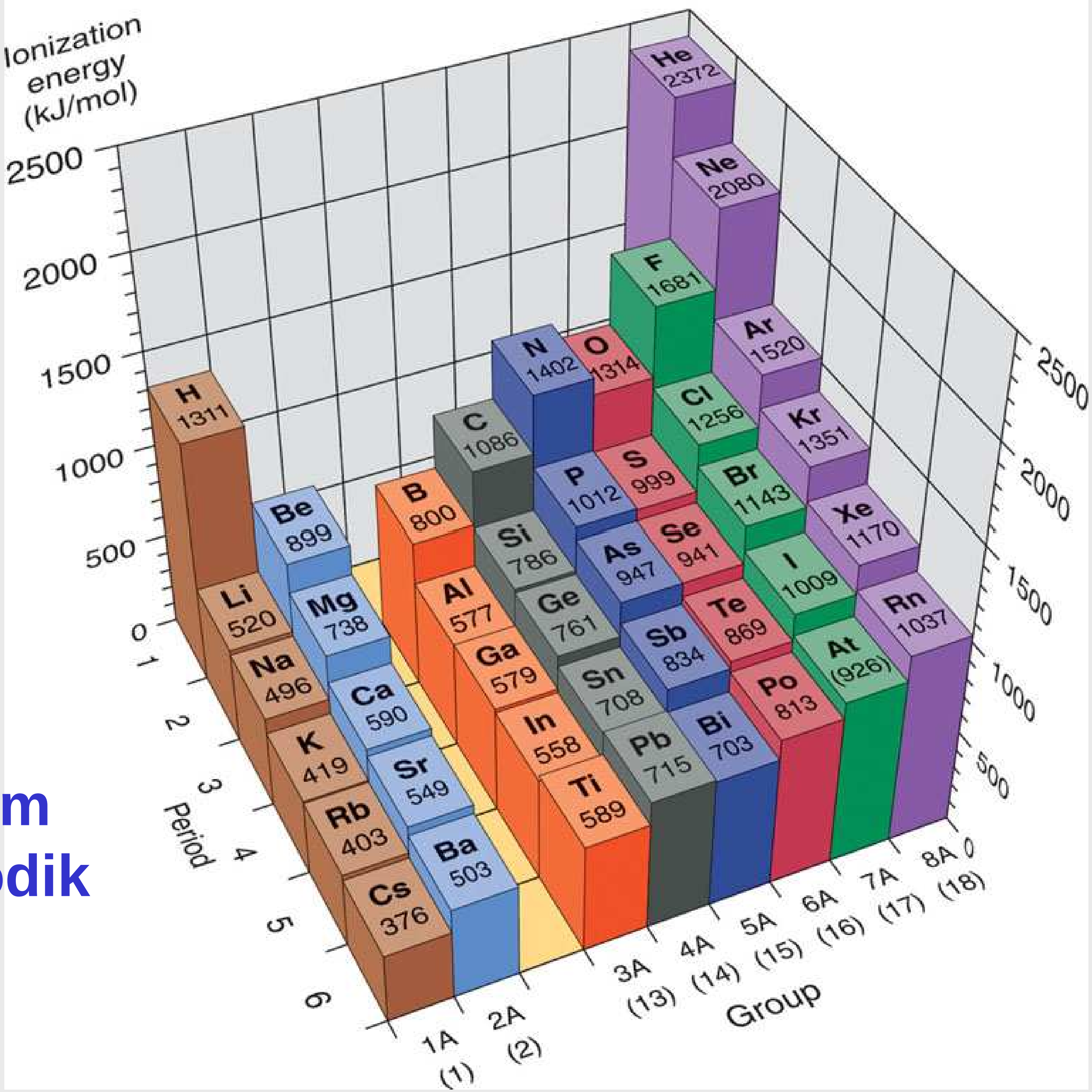


Periodicity of first ionization energy (IE_1)

Energy required to remove one outermost electron.

Energi ionisasi pertama dari unsur unsur golongan utama

Trend dalam tabel Periodik



latihan.4

Ranking energi Ionization pertama unsur

Dengan menggunakan tabel periodik,urutkanlah unsur unsur berikut berdasarkan energi ionisasinya dari yang terbesar hingga terkecil

(a) Kr, He, Ar **(b)** Sb, Te, Sn **(c)** K, Ca, Rb **(d)** I, Xe, Cs

IE dalam satu golongan meningkat dari bawah ke atas; IE dalam satu periode meningkat dari kiri kekanan.

SOLUSI:

(a) He > Ar > Kr — Group 8A(18) - IE decreases down a group.

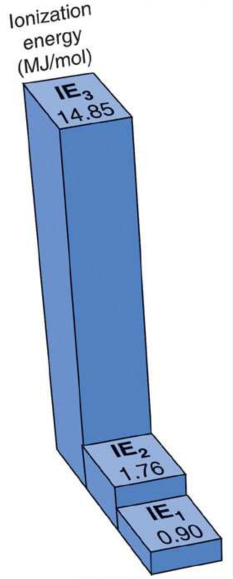
(b) Te > Sb > Sn — Unsur Perioda 5 - IE increases across a period.

(c) Ca > K > Rb — Ca sebelah kanan K; Rb sebelah bawah K.

(d) Xe > I > Cs — I sebelah kiri Xe; Cs adalah paling kiri dan terbawah di satu periode berikutnya.

Trend dalam Tabel Periodik

The first three ionization energies of beryllium (in MJ/mol)



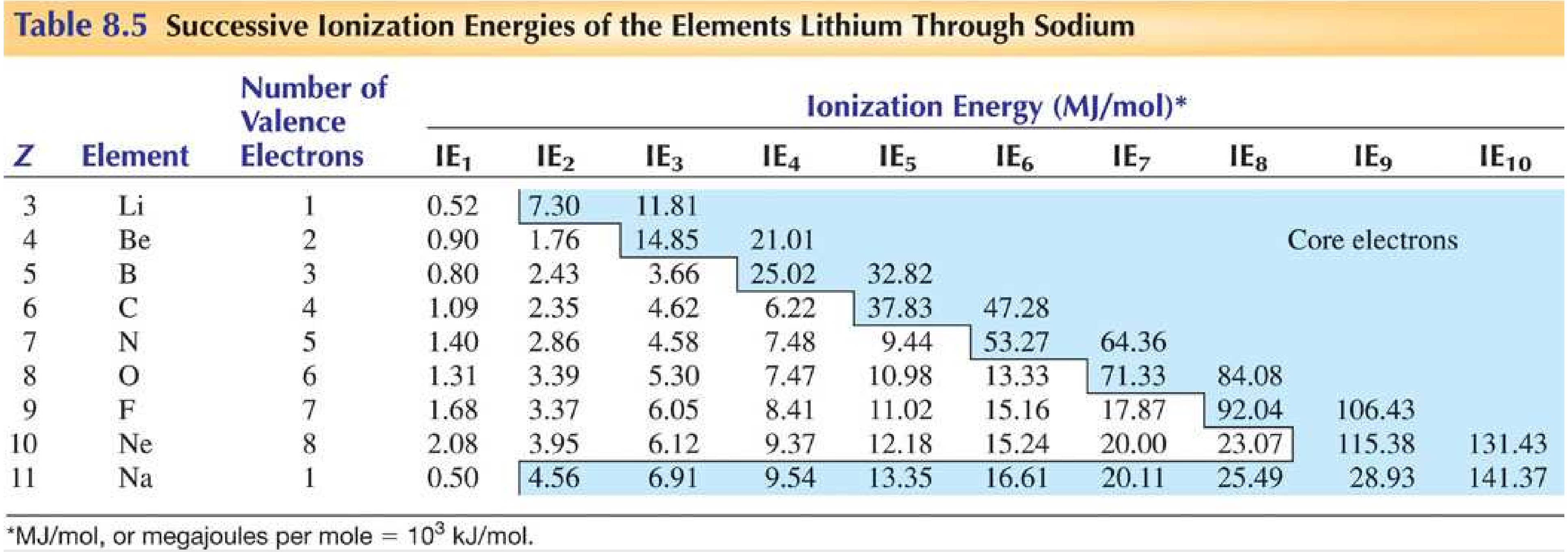


Table 8.5 Successive Ionization Energies of the Elements Lithium Through Sodium

Z	Element	Number of Valence Electrons	IE1	IE2	IE3	IE4	IE5	IE6	IE7	IE8	IE9	IE10
			Ionization Energy (MJ/mol)*									
3	Li	1	0.52	7.30	11.81							
4	Be	2	0.90	1.76	14.85	21.01				Core electrons		
5	B	3	0.80	2.43	3.66	25.02	32.82					
6	C	4	1.09	2.35	4.62	6.22	37.83	47.28				
7	N	5	1.40	2.86	4.58	7.48	9.44	53.27	64.36			
8	O	6	1.31	3.39	5.30	7.47	10.98	13.33	71.33	84.08		
9	F	7	1.68	3.37	6.05	8.41	11.02	15.16	17.87	92.04	106.43	
10	Ne	8	2.08	3.95	6.12	9.37	12.18	15.24	20.00	23.07	115.38	131.43
11	Na	1	0.50	4.56	6.91	9.54	13.35	16.61	20.11	25.49	28.93	141.37

*MJ/mol, or megajoules per mole = 10^3 kJ/mol.

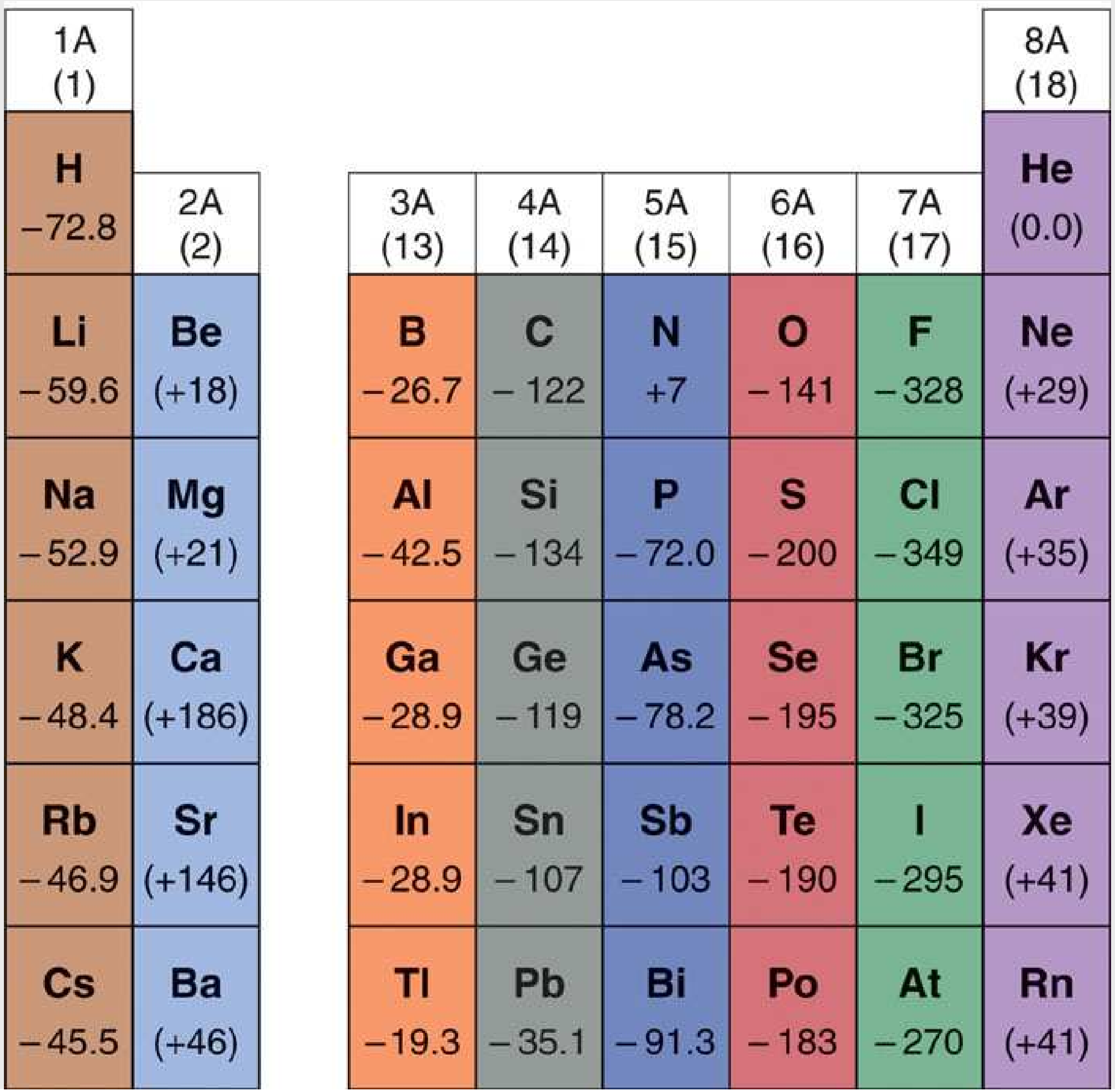
Trends in the Periodic Table

Electron affinities of the main-group elements

Electron Affinity:

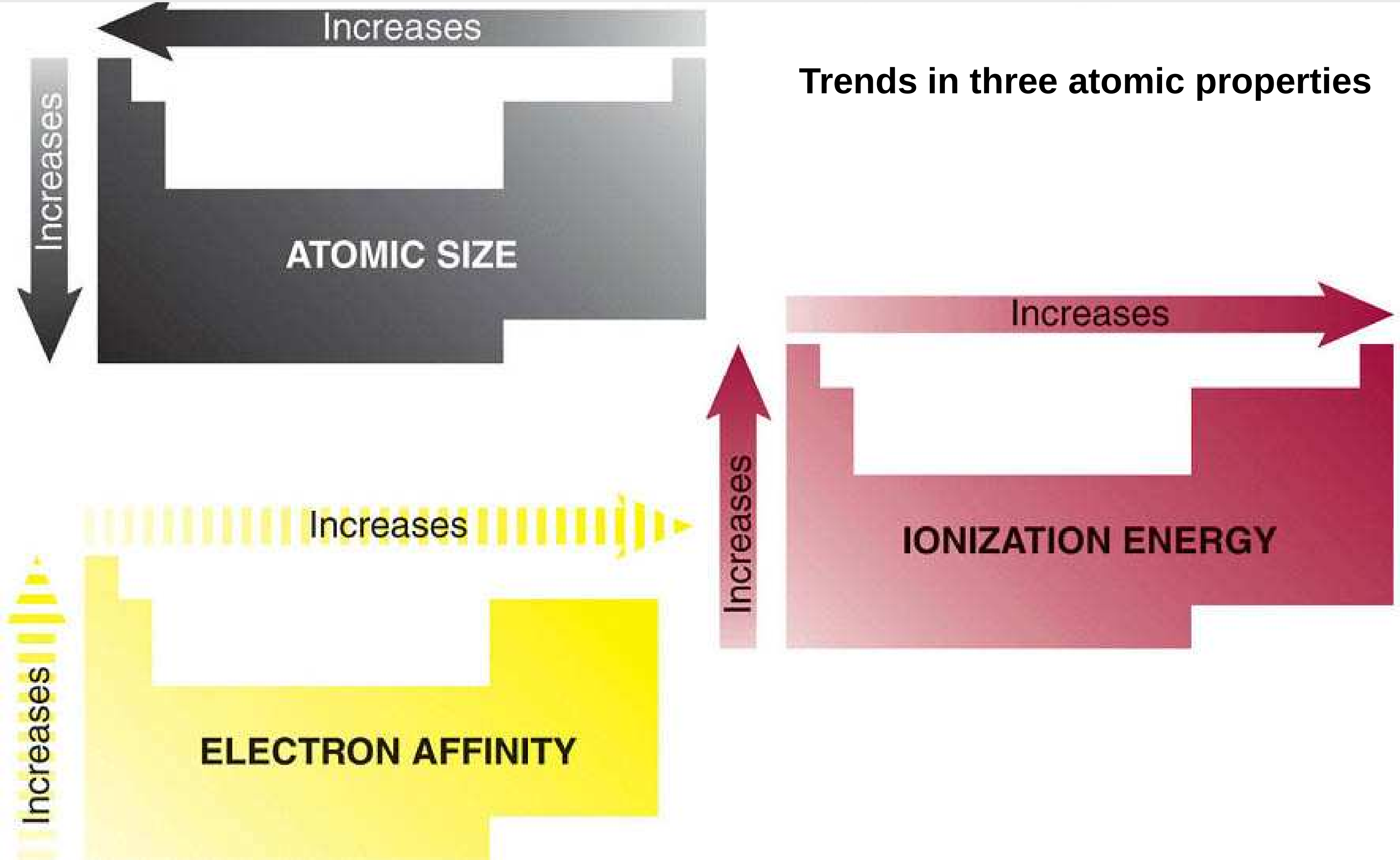
Energy change to add one electron.

In most cases, EA negative (energy released because electron attracted to nucleus

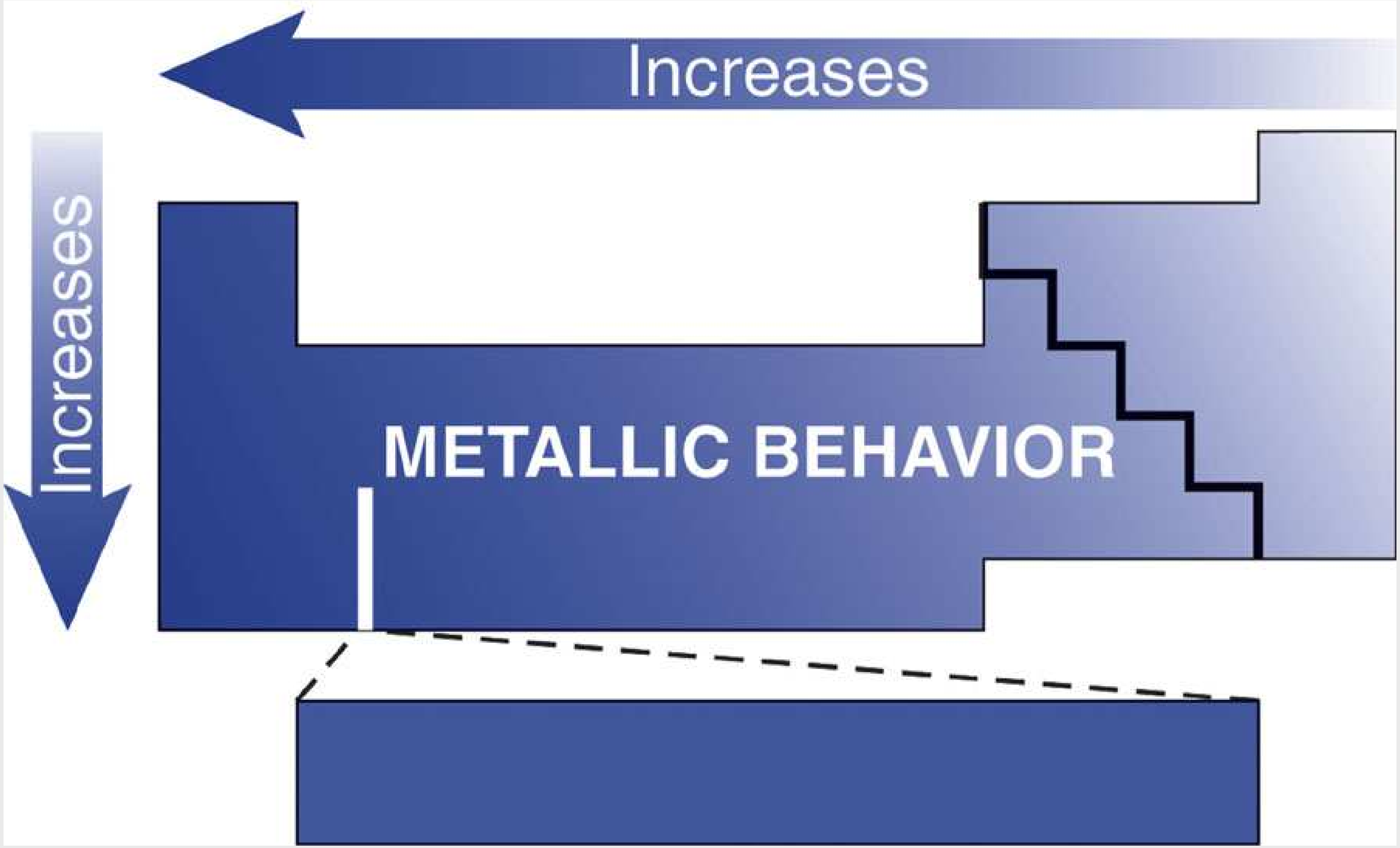


1A (1)	2A (2)	3A (13)	4A (14)	5A (15)	6A (16)	7A (17)	8A (18)
H −72.8							**He** (0.0)
Li −59.6	**Be** (+18)	**B** −26.7	**C** −122	**N** +7	**O** −141	**F** −328	**Ne** (+29)
Na −52.9	**Mg** (+21)	**Al** −42.5	**Si** −134	**P** −72.0	**S** −200	**Cl** −349	**Ar** (+35)
K −48.4	**Ca** (+186)	**Ga** −28.9	**Ge** −119	**As** −78.2	**Se** −195	**Br** −325	**Kr** (+39)
Rb −46.9	**Sr** (+146)	**In** −28.9	**Sn** −107	**Sb** −103	**Te** −190	**I** −295	**Xe** (+41)
Cs −45.5	**Ba** (+46)	**Tl** −19.3	**Pb** −35.1	**Bi** −91.3	**Po** −183	**At** −270	**Rn** (+41)

Trends in three atomic properties



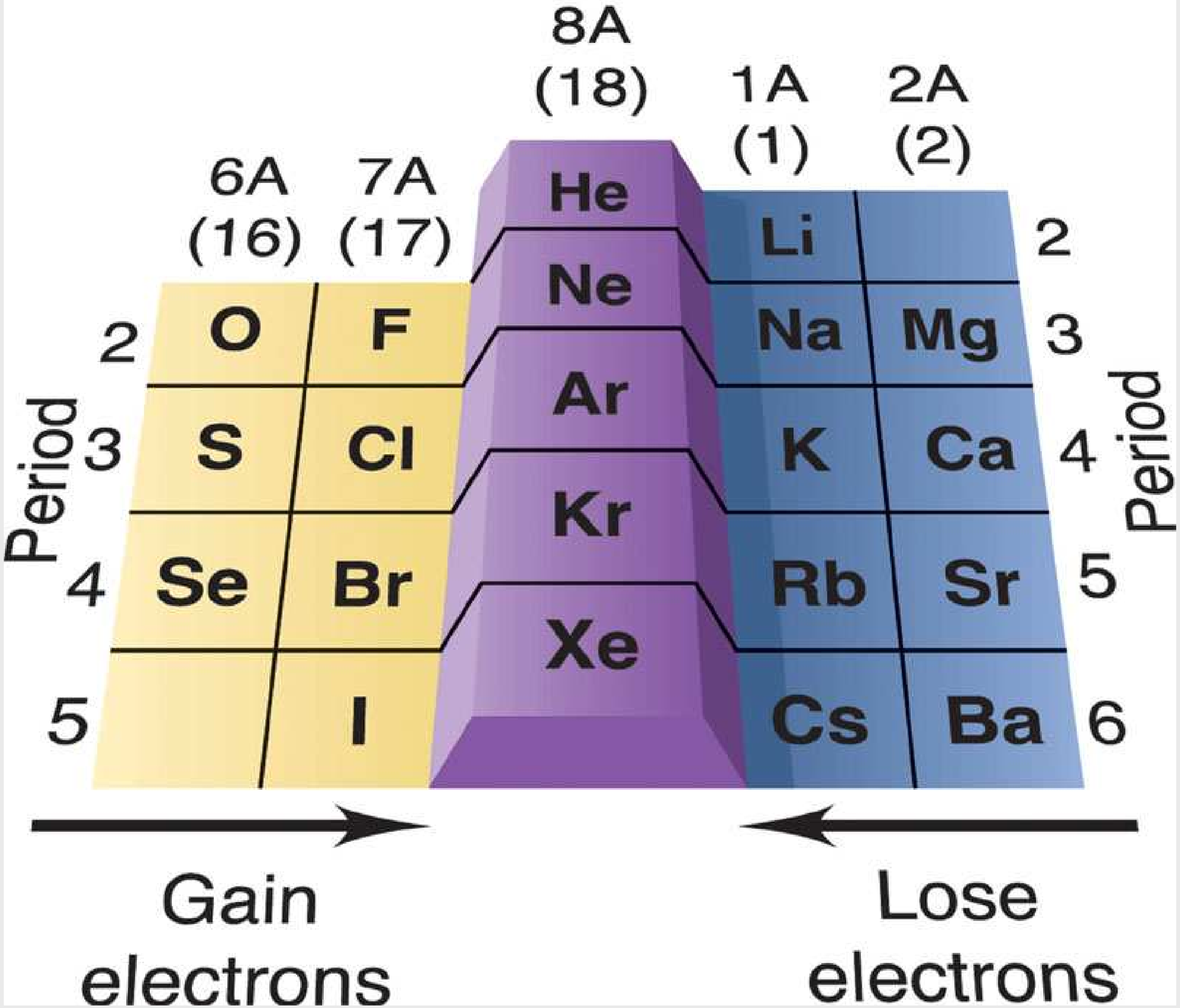
Trends in metallic behavior



Trend dalam tabel Periodik

Properties of Monatomic Ions

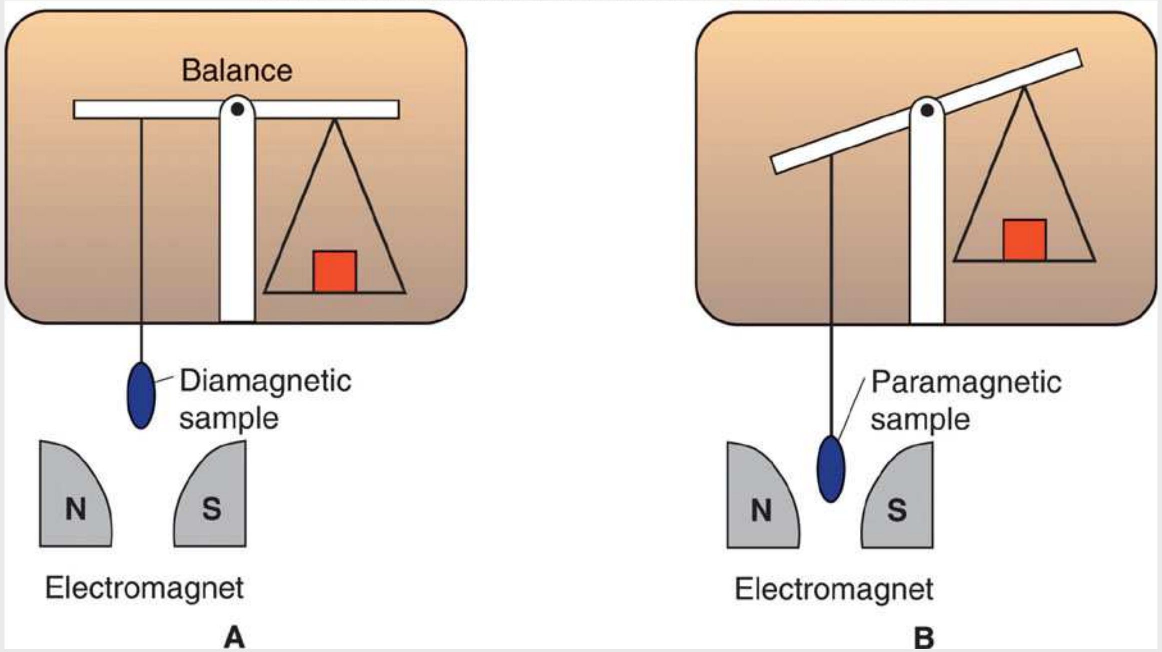
Main-group ions and the noble gas configurations



Sifat Magnetik dari ion ion logam Transisi

species dengan elektron takberpasangan paramagnetism. Akan ditarik oleh medan magnet external .

Species dengan seluruh spin elektronnya berpasangan, tidak ditarik medan magnet luar........diamagnetic



Latihan.5

Tentukanlah apakah unsur unsur berikut termasuk paramagnetik atau diamagnetik.

(a) Mn^{2+}(Z = 25) **(b)** Cr^{3+}(Z = 24) **(c)** Hg^{2+}(Z = 80)

SOLUSI:

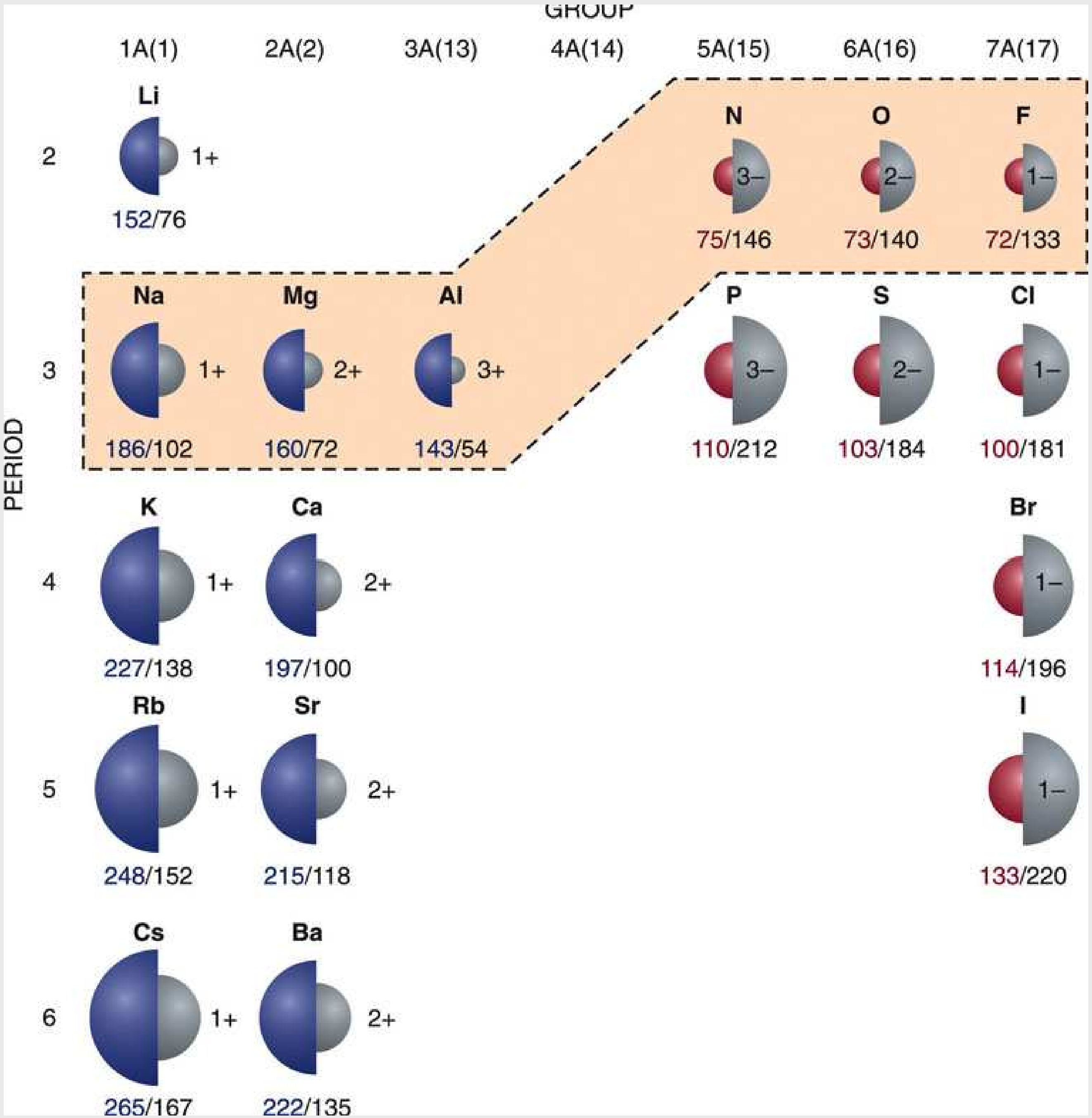
(a) Mn^{2+}(Z = 25) $Mn([Ar]4s^2 3d^5) \longrightarrow Mn^{2+}([Ar]\,3d^5) + 2e^-$ paramagnetic

(b) Cr^{3+}(Z = 24) $Cr([Ar]4s^2 3d^6) \longrightarrow Cr^{3+}([Ar]\,3d^5) + 3e^-$ paramagnetic

(c) Hg^{2+}(Z = 80) $Hg([Xe]6s^2 4f^{14} 5d^{10}) \longrightarrow Hg^{2+}([Xe]\,4f^{14} 5d^{10}) + 2e^-$

not paramagnetic (is diamagnetic)

Ionic vs. atomic radius



Latihan.6

Urutkanlah ion ion berikut berdasarkan ukurannya dari besar hingga kecil:

(a) Ca^{2+}, Sr^{2+}, Mg^{2+} **(b)** K^{+}, S^{2-}, Cl^{-} **(c)** Au^{+}, Au^{3+}

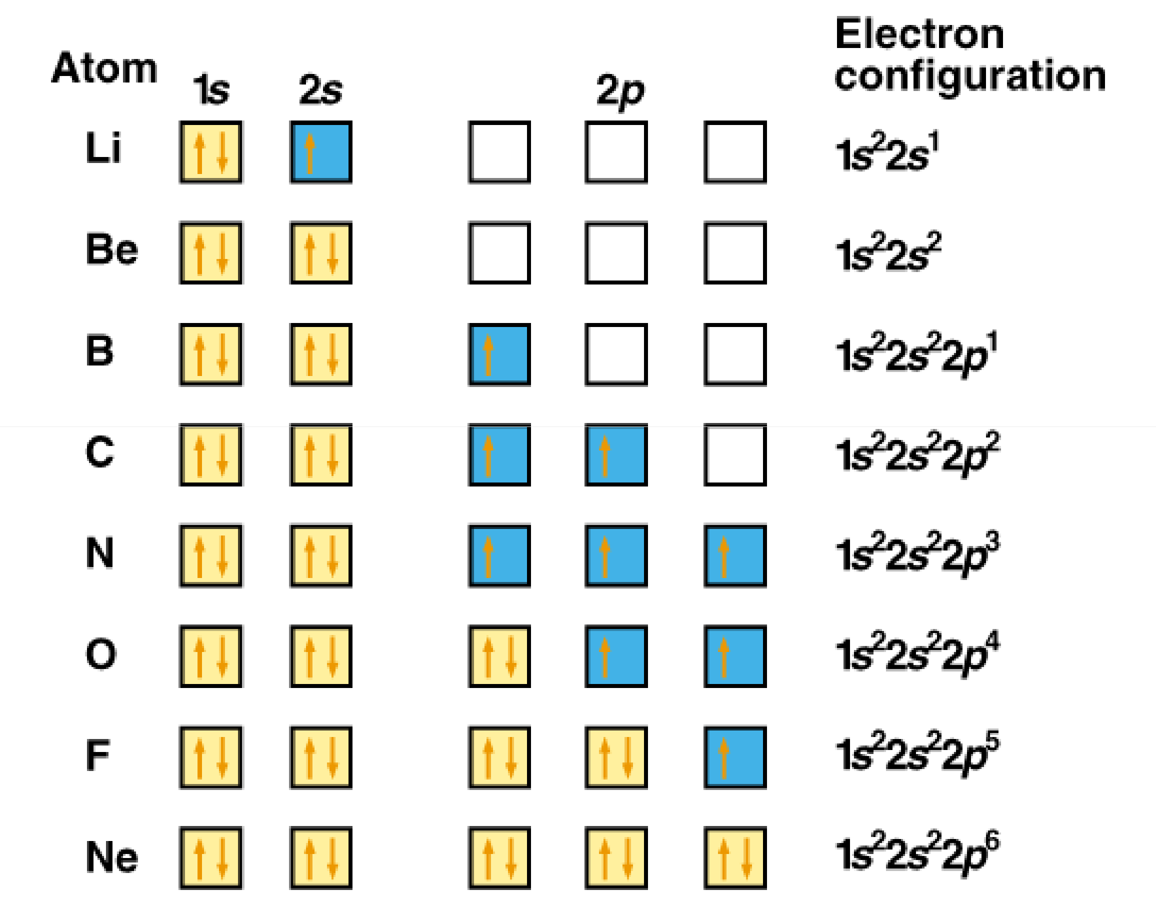
SOLUSI:

(a) $Sr^{2+} > Ca^{2+} > Mg^{2+}$

(b) $S^{2-} > Cl^{-} > K^{+}$

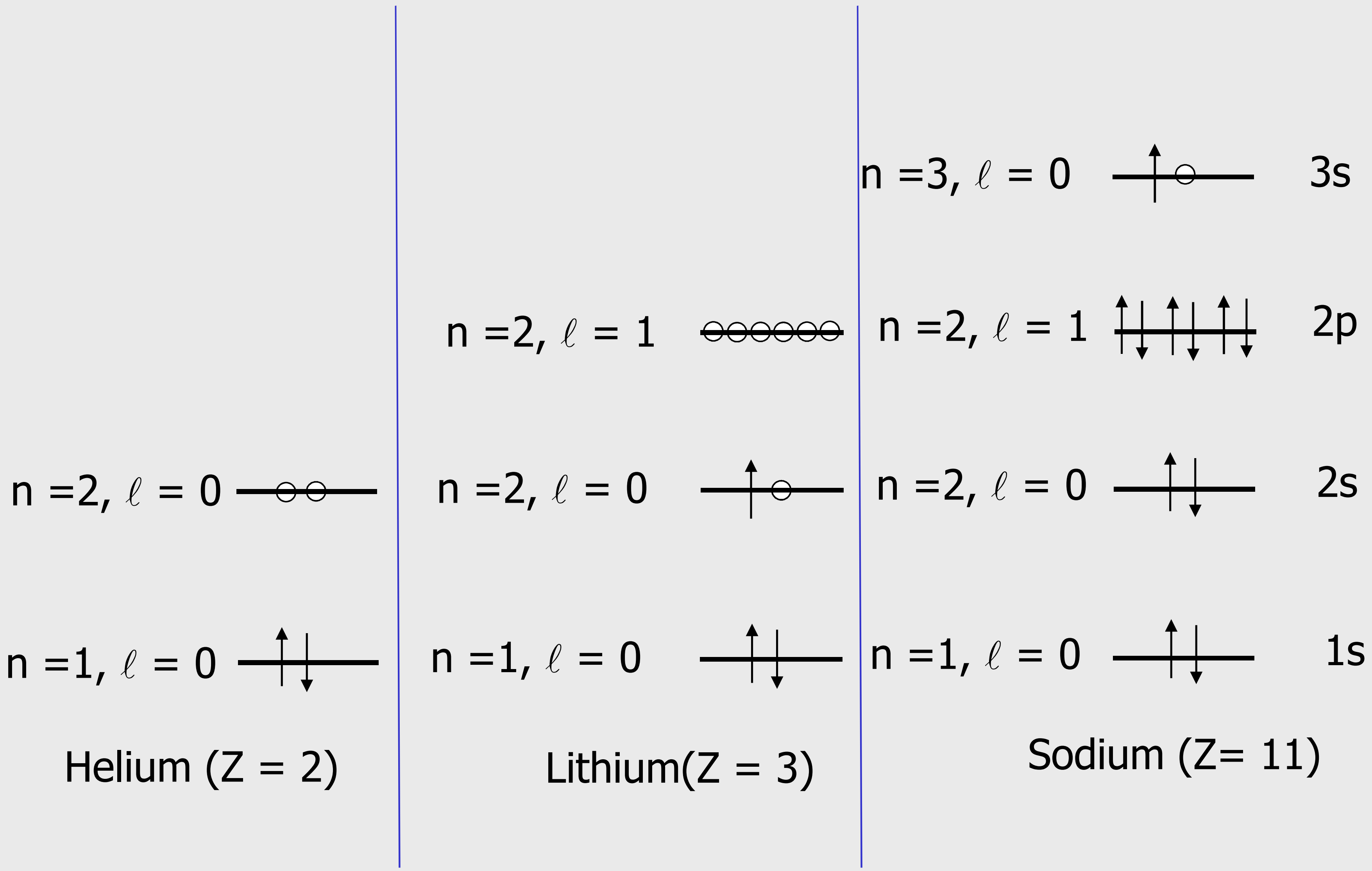
(c) $Au^{+} > Au^{3+}$

Tabel periodik unsur unsur



Atom	1s	2s	2p			Electron configuration
Li	↑↓	↑				$1s^2 2s^1$
Be	↑↓	↑↓				$1s^2 2s^2$
B	↑↓	↑↓	↑			$1s^2 2s^2 2p^1$
C	↑↓	↑↓	↑	↑		$1s^2 2s^2 2p^2$
N	↑↓	↑↓	↑	↑	↑	$1s^2 2s^2 2p^3$
O	↑↓	↑↓	↑↓	↑	↑	$1s^2 2s^2 2p^4$
F	↑↓	↑↓	↑↓	↑↓	↑	$1s^2 2s^2 2p^5$
Ne	↑↓	↑↓	↑↓	↑↓	↑↓	$1s^2 2s^2 2p^6$

Atom helium, lithium dan sodium



n =2, ℓ = 0

n =1, ℓ = 0

Helium (Z = 2)

n =2, ℓ = 1

n =2, ℓ = 0

n =1, ℓ = 0

Lithium(Z = 3)

n =3, ℓ = 0 3s

n =2, ℓ = 1 2p

n =2, ℓ = 0 2s

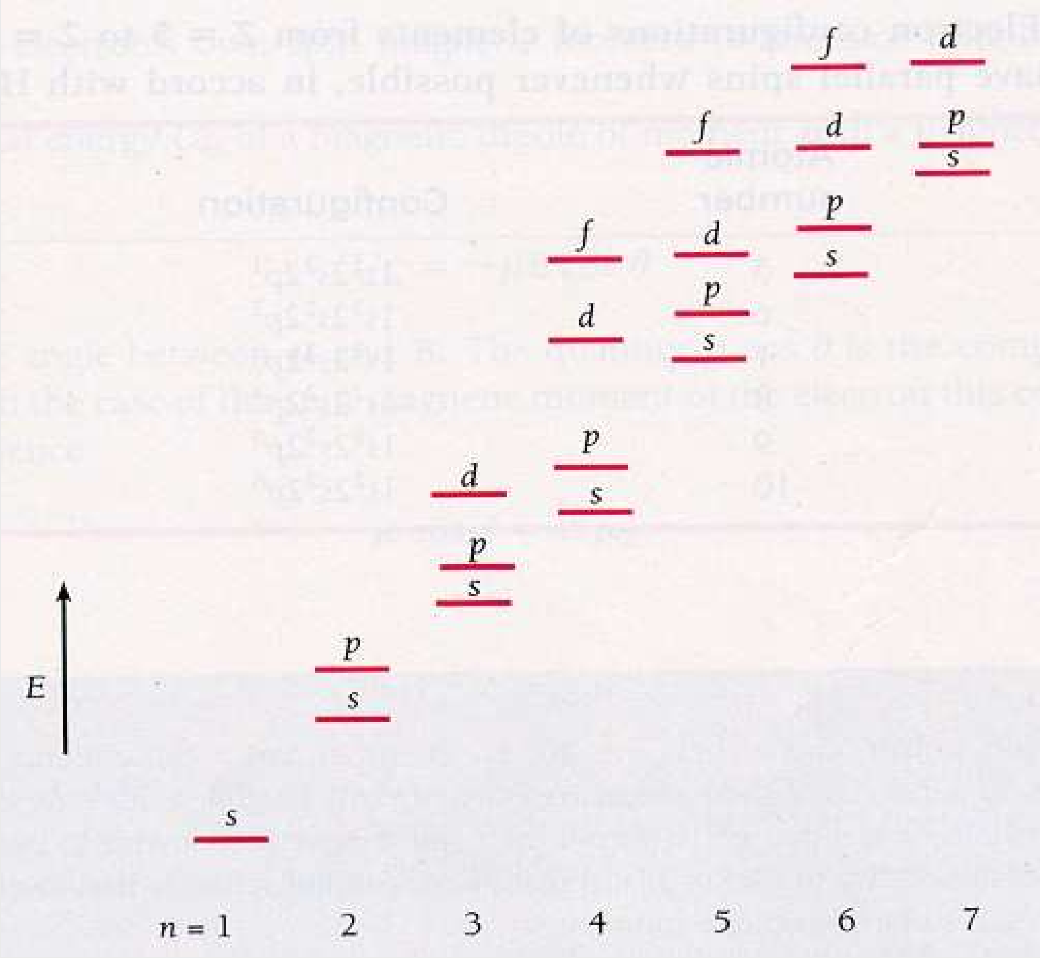
n =1, ℓ = 0 1s

Sodium (Z= 11)

Konfigurasi Elektron – the occupying of orbitals

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6\ 6s^2\ 4f^{14}$
$5d^{10}\ 6p^6\ 7s^2\ 6d^{10}\ 5f^{14}$

$K: 1s^2 \cdots 3p^6 4s^1$
$Ca: \quad 3p^6 4s^2$
$Sc: \quad 3d^1 4s^2$
$Ti: \quad 3d^2 4s^2$
$V: \quad 3d^3 4s^2$
$Cr: \quad 3d^5 4s^1$
$Mn: \quad 3d^5 4s^2$
$Cu: \quad 3d^{10} 4s^1$



Momentum angularTotal - J

$$\vec{J} = \vec{L} + \vec{L}_S$$

$$\left|\vec{J}\right| = \sqrt{j(j+1)}\hbar$$

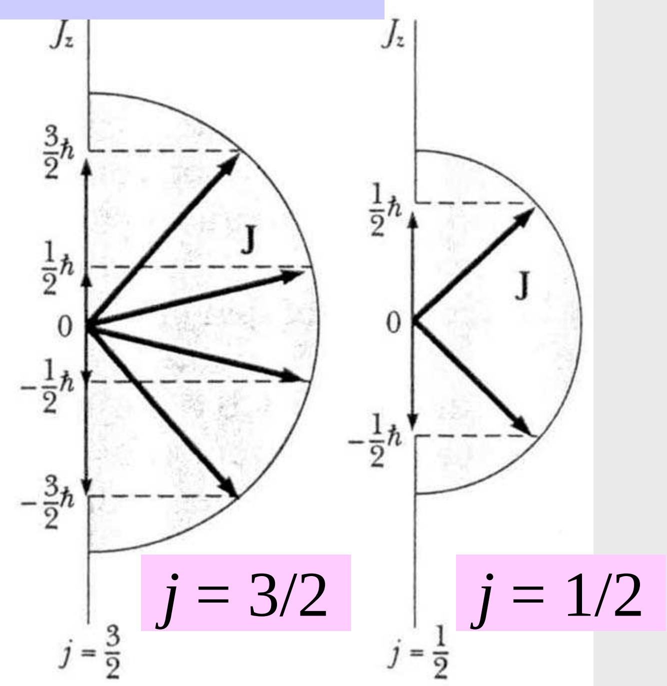
Kemungkinan dua harga j : $\boxed{j = l + s \quad \text{or} \quad j = \left|l\text{-}s\right|}$

$$J_z = m_j\hbar, \qquad m_j = -j, -j+1, \ldots, j-1, j$$

contoh: $l = 1$, $s = ½$

$$j = 1 + \tfrac{1}{2} = \tfrac{3}{2} \qquad \text{lub} \qquad j = \left|1 - \tfrac{1}{2}\right| = \tfrac{1}{2}$$

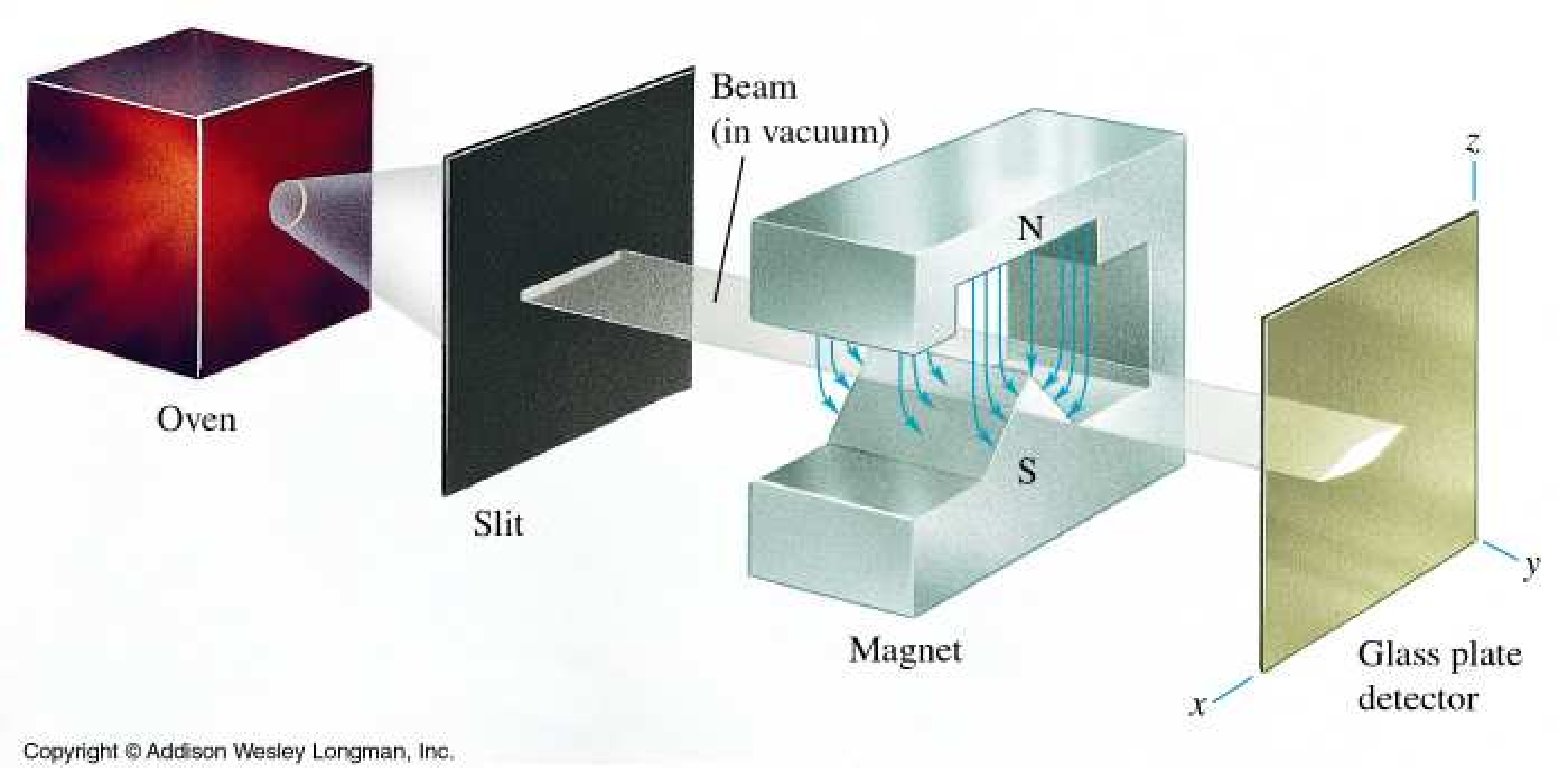
$$m_j = -\tfrac{3}{2}, -\tfrac{1}{2}, \tfrac{1}{2}, \tfrac{3}{2} \quad \text{lub} \quad m_j = -\tfrac{1}{2}, \tfrac{1}{2}$$



$j = 3/2$

$j = 1/2$

TheStern-Gerlach experiment



Diamagnetics

❑.Diamagnetics

secara total Shell dipenuhi oleh elektron. Momen magnetik Total sama dengan nol. (dalam orbital yang penuh, vektor vektor dari momentum angular orbital dan momentum angular spin mengarah kesegala arah dan saling menghilangkan).

- Noble gas
  - He, Ne, Ar…..
- molekule gas diatomik
  - H_2, N_2…..
- ikatan ionik zat padat
  - NaCl(Na+, Cl-)…
- Ikatan kovalen zat padat
  - C(diamond), Si, Ge…..
- Sebagian besar material organik

Paramagnetics

- . Paramagnetics

  Shells sebagian terisi penuh elektron

  momen magnetik Total tidak nol.

$$\mu_{ef} = g\sqrt{J(J+1)}\,\mu_B$$

Komponen dari momen magnetik disearahkan sesuai dengan arah medan magnet luar

$$\mu_{ef,H} = g\,M_J\,\mu_B$$

Fine and hyperfine structure

- terpecahnya spektrum garis sebagai hasil dari interaksi medan magnet disebut ***fine structure***.

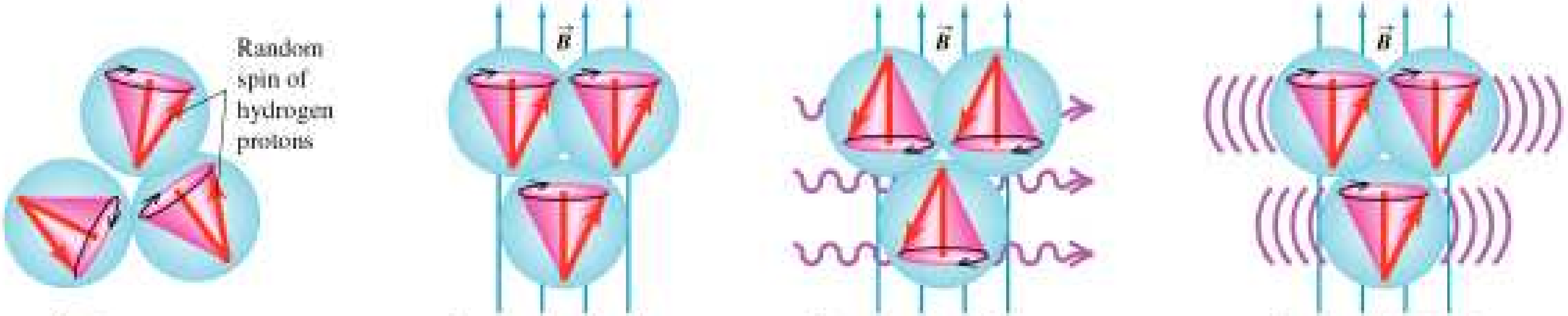
- Inti atom juga memiliki momen dipole magnetik yang berinteraksi dengan mmen magnetik total dari elektron elektron. Effek ini disebut **hyperfine structure.**

NMR (nuclear magnetic resonance)

Seperti halnya elektron, proton juga memiliki momen magnetik yaitu momentum angular orbital danmomentum angular spin.

Spin flip experiment:

Protons, the nuclei of hydrogen atoms in the tissue under study, normally have random spin orientations. In the presence of a strong magnetic field, they become aligned with a component paralell to the field. A brief radio signal flips the spins; as their components reorient paralell to the field, they emit signals that are picked up by sensitive detectors. The differing magnetic environment in various regions permits reconstruction of an image showing the types of tissue present.



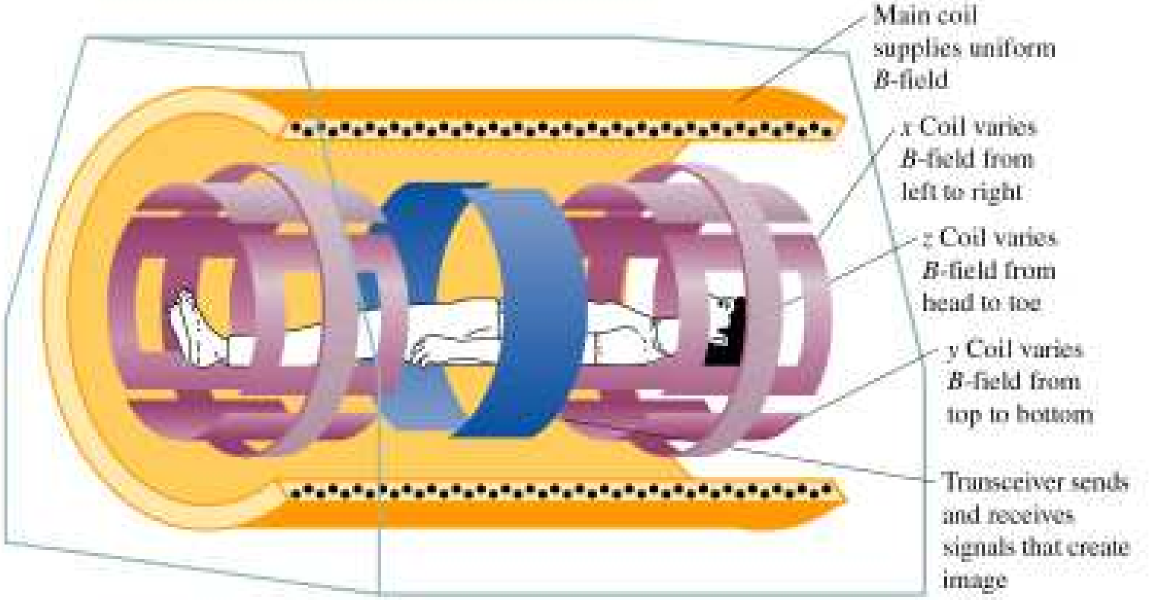
Hydrogen atoms (mostly in water)

Protons tend to align with uniform *B*-field

Resonant signal from an electromagnetic wave causes protons to flip

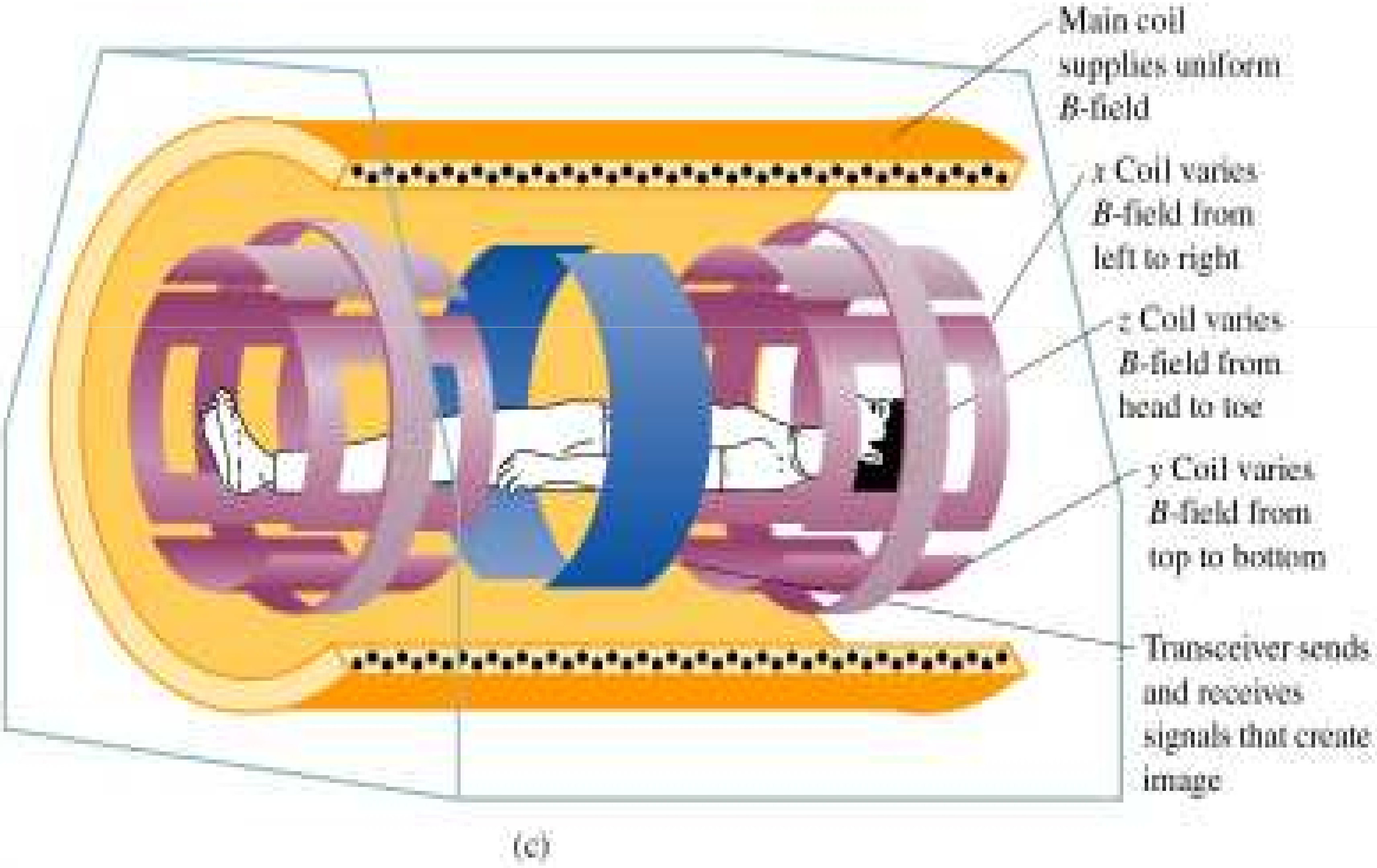
Protons emit signal as they realign with field

(a)

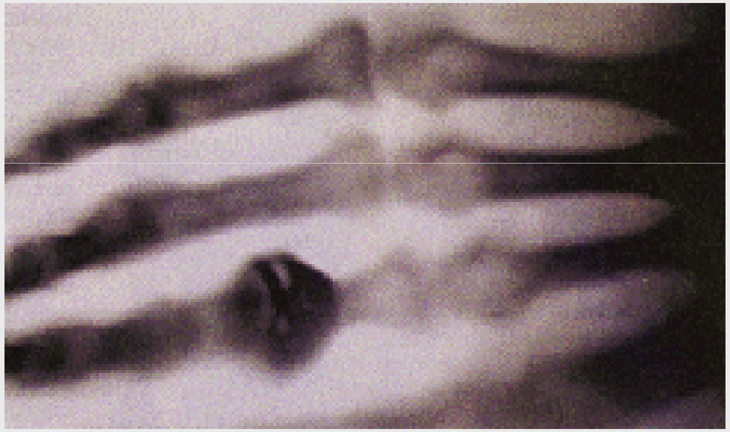


(c)

An electromagnet used for MRI imaging



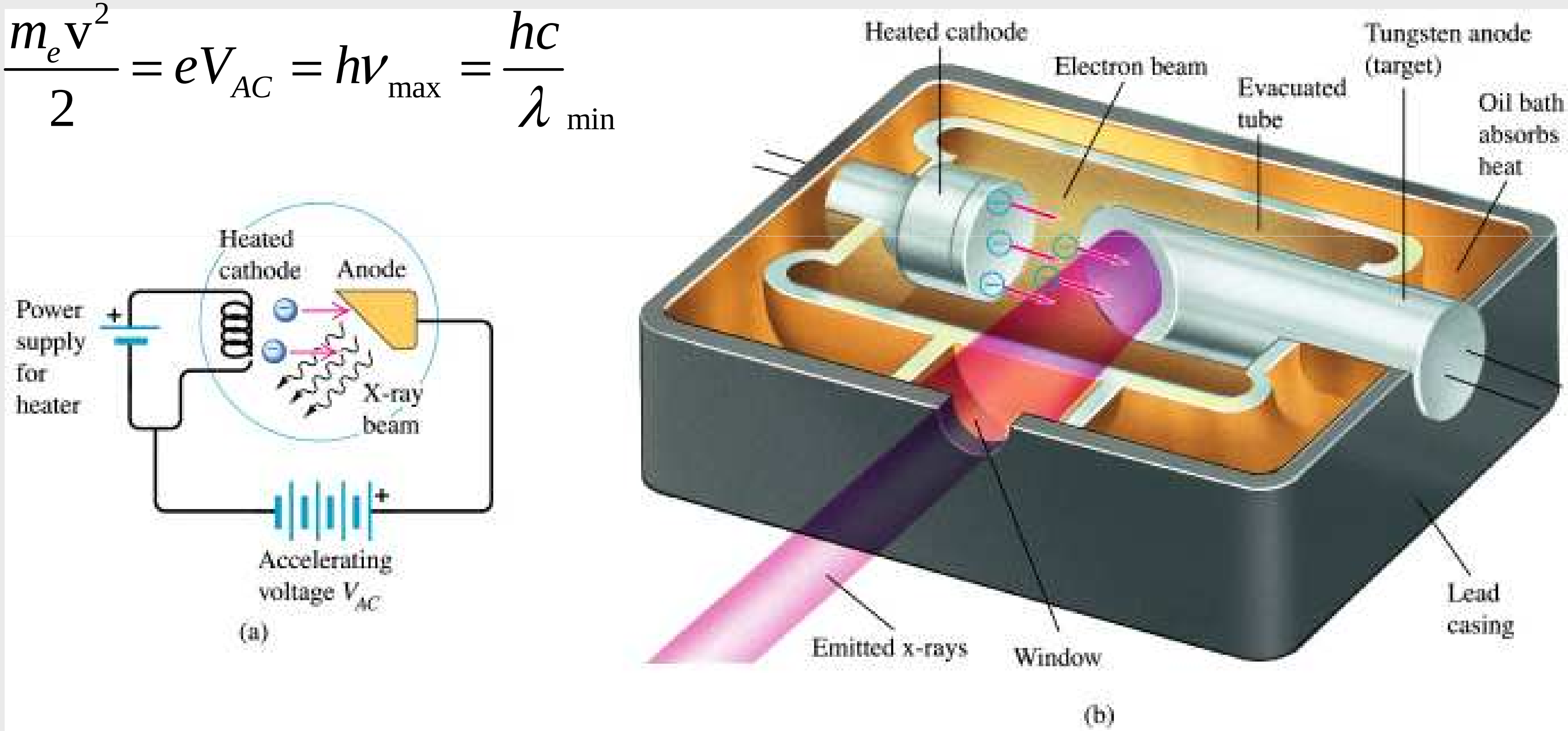
Wilhelm Roentgen 1895



Roentgen lamp

Roentgen 1895; X -ray: 10^{-12}m – 10^{-9}m

$$\frac{m_e v^2}{2} = eV_{AC} = h\nu_{\max} = \frac{hc}{\lambda_{\min}}$$



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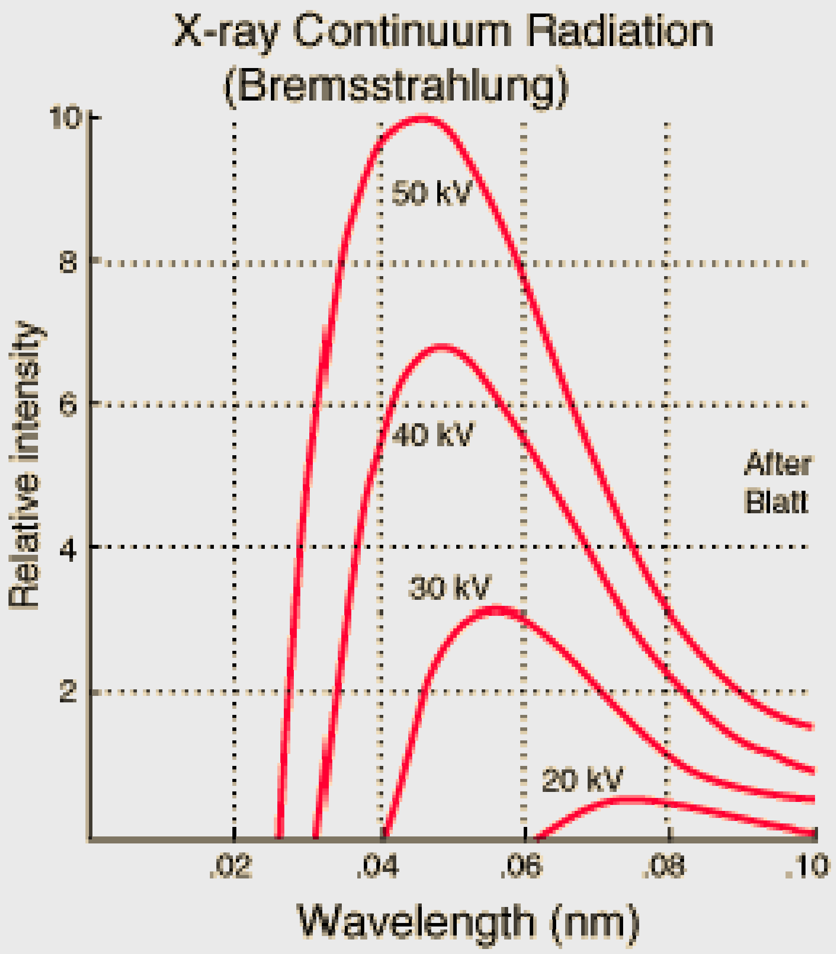
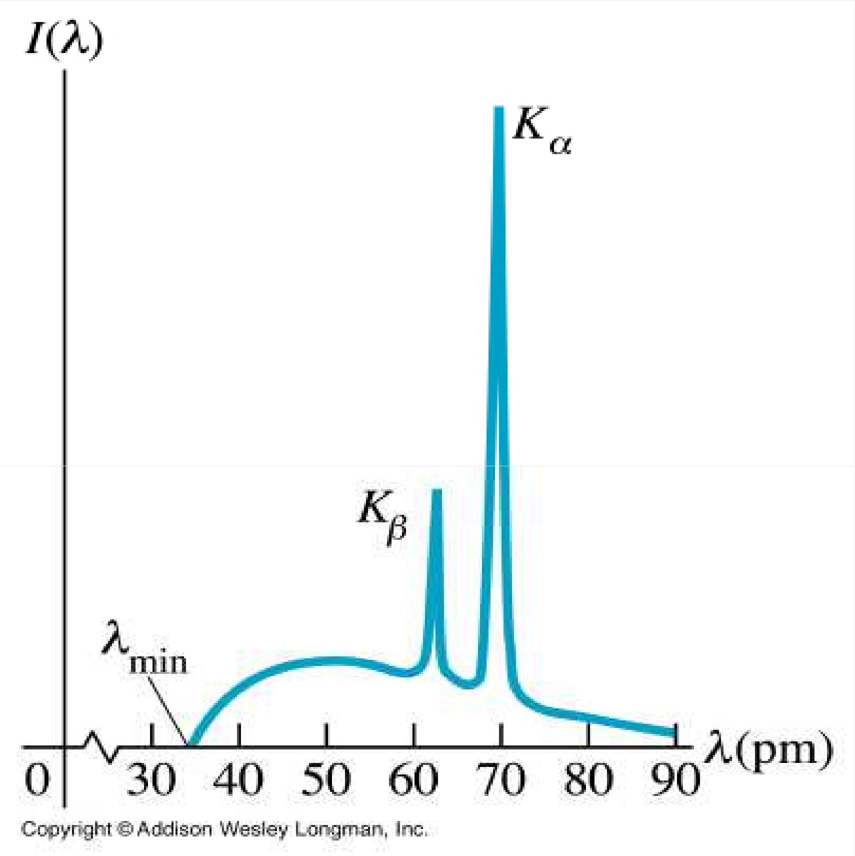
X-ray continuum spectra



$$\frac{m_e v^2}{2} = eV_{AC} = h\nu_{\max} = \frac{hc}{\lambda_{\min}}$$

$$\lambda_{\min} = \frac{hc}{eV_{AC}}$$

Spektrum X-ray dan Moseley law



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$$\lambda_{\min} = \frac{hc}{eV_{AC}}$$

The continous –spectrum radiation is nearly independent of the target material.

Sharp peaks (characteristic spectra) depend on the accelerating voltage and the target element. Frequencies of the peaks as a function of the element’s atomic number Z:

$$f = (2.48 \cdot 10^{15}\,Hz)(Z-1)^2$$

Moseley law

X-ray spectra and Moseley law - explanation

Characteristic x-ray radiation is emitted in transitions involving **the inner shells** of a complex atom.

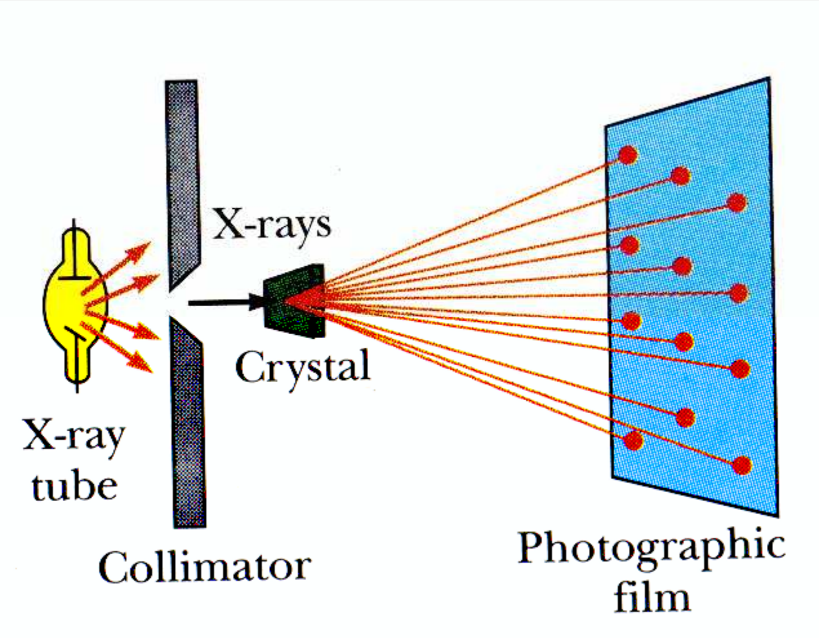
Let us assume, that due to electric field one of the two K – electrons is knocked out of the K shell. The vacancy can be filled by another electron falling in from the outer shells. K_α is the transition from n=2 to n=1. As the electron drops down it is attracted by Z protons in the nucleus screened by the one remaining electron in the K shell. The energy before (E_i) an after (E_f) transition:

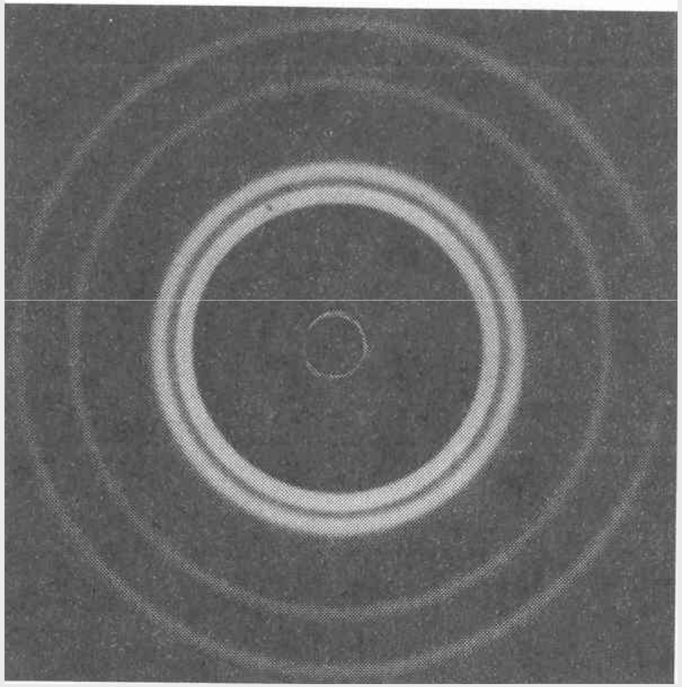
$$E_i = -(Z-1)^2(13.6eV)/2^2 \qquad E_f = -(Z-1)^2(13.6eV)$$

$$E_{K_\alpha} \approx (Z-1)^2(10.2eV)$$

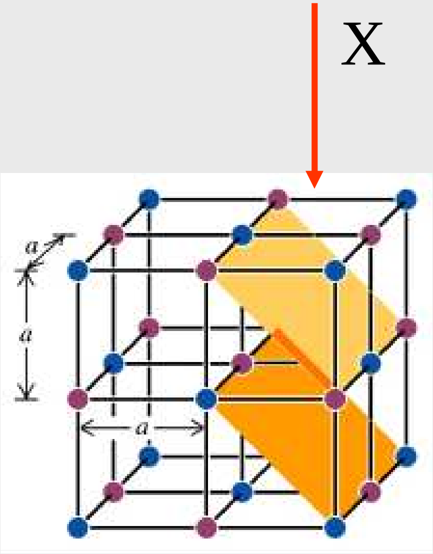
$$\boxed{f = \frac{E}{h} = (2.47\cdot 10^{15}\,Hz)(Z-1)^2}$$

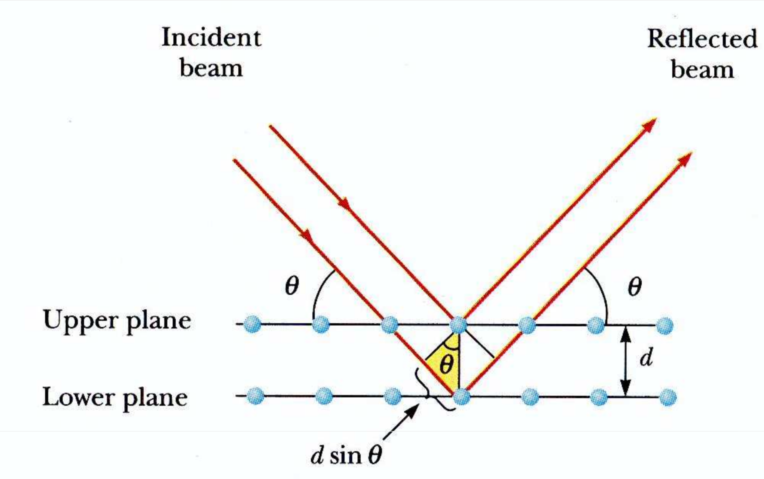
X-ray diffraction pattern

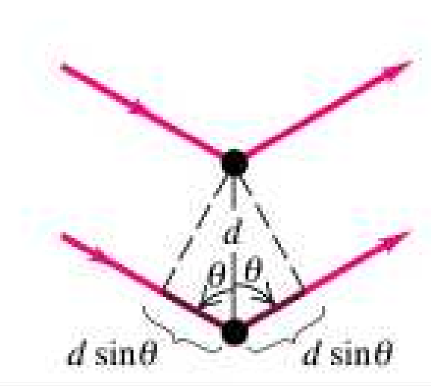




X-ray diffraction pattern







Diffraction maxima:

$$\boxed{2d\sin\theta = m\lambda}$$