

Announcements for Wednesday, 25SEP2024

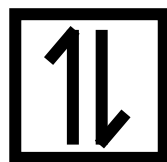
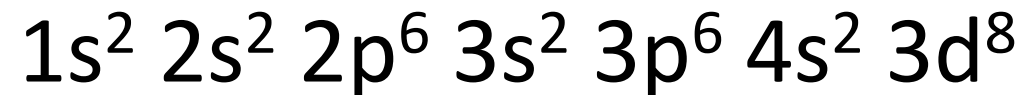
- Practice Exam 1 on Canvas
 - located under “General Course information,” “Practice Exams”
- Exam I is Tuesday, 01OCT2024, 7:45-9:05 **PM** (EDT)
 - Coverage: Chapters E-3.5; exam consists of 19 multiple-choice questions and open-ended questions; see “Other Resources” on Canvas for periodic table and formula sheet to be used on the exam
 - See Canvas announcement from Sep 25 about Exam Locations
- Exam I Calculator Policy
 - Scientific calculators and **most** graphing calculators are allowed
 - **TI-Nspire CX series & other calculators with QWERTY keyboards are NOT allowed**
- Any **TECHNICAL ISSUES** associated with eLearning (quizzes, practice assignments, etc.) must be reported to **eLearning Tech Support** (<https://techsupport.elearning.rutgers.edu>)



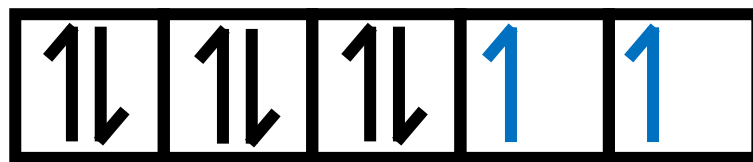
ANY GENERAL QUESTIONS? Feel free to see me after class!

Try This On Your Own

- Give the full electron configuration for nickel ($Z = 28$)
- Give the orbital diagram of the last two sublevels
- Determine the number of unpaired electrons in a nickel atom



4s



3d

2 unpaired electrons

Noble-Gas-Core Abbreviation

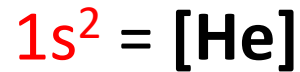
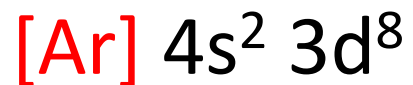
- electron configurations can be written in shorthand using Noble-Gas-Core notation

nickel (Z=28)

full electron configuration



noble-gas-core abbreviation:



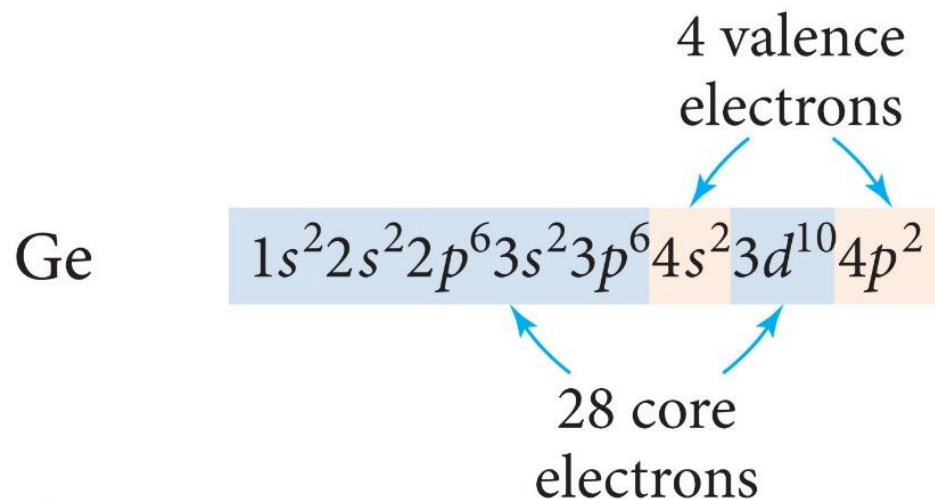
Valence vs. Core Electrons

valence electrons

- for Main Group Elements, electrons in the outermost principal energy level (i.e., highest value of n)
 - *for Transition Elements, electrons in outermost d shell are also included though they are not in outermost principal level*
 - we will be focusing primarily on MAIN GROUP ELEMENTS
- one of the most important factors in the way an atom behaves, both chemically and physically
 - largely responsible for chemical bonding

core electrons

- inner electrons in complete principal energy levels
- not responsible for bonding
 - responsible for shielding effects



Valence Electrons

Valence Electron Configurations of Elements 1A-8A

	1A							8A
1	1 H $1s^1$	2A	3A	4A	5A	6A	7A	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 $3s^2$	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 $3s^2 3p^6$

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- **Main group number** corresponds to the number of valence electrons
 - for 1A, 2A, and aluminum, group number gives charge of **cations**
 - for 7A, 6A, and 5A, (Group Number – 8) gives charge of **anions**
- length of each “block” is the maximum number of electrons the subshell can hold
 - 2 columns for s-subshell = 2 electrons
 - 6 columns for p-subshell = 6 electrons
- **period number** corresponds to the principal energy level of the valence electrons

Orbital Blocks and Electron Configurations

- the periodic table is divisible into four blocks corresponding to the filling of the four quantum sublevels (s, p, d, and f)
 - Groups 1A and 2A = s-block
 - Groups 3A – 8A = p-block
 - Groups 1B – 8B = d-block
 - inner transition groups = f-block
- the outer electron configuration can be established by tracing the elements between the previous noble gas and the element of interest
- example tellurium (Te)

Groups												18							
1A												8A							
1	2											13	14	15	16	17	18		
1	2											3A	4A	5A	6A	7A			
1	2											5	6	7	8	9	10		
1	2											2s ² 2p ¹	2s ² 2p ²	2s ² 2p ³	2s ² 2p ⁴	2s ² 2p ⁵	2s ² 2p ⁶		
3	4	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
3	4	3B	4B	5B	6B	7B	8B			1B	2B	3s ² 3p ¹	3s ² 3p ²	3s ² 3p ³	3s ² 3p ⁴	3s ² 3p ⁵	3s ² 3p ⁶		
4	5	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
4	5	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
4	5	4s ¹	4s ²	4s ² 3d ¹	4s ² 3d ²	4s ² 3d ³	4s ¹ 3d ⁵	4s ² 3d ⁵	4s ² 3d ⁶	4s ² 3d ⁷	4s ² 3d ⁸	4s ¹ 3d ¹⁰	4s ² 3d ¹⁰	4s ² 4p ¹	4s ² 4p ²	4s ² 4p ³	4s ² 4p ⁴	4s ² 4p ⁵	4s ² 4p ⁶
5	6	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
5	6	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
5	6	5s ¹	5s ²	5s ² 4d ¹	5s ² 4d ²	5s ¹ 4d ⁴	5s ¹ 4d ⁵	5s ² 4d ⁵	5s ¹ 4d ⁷	5s ¹ 4d ⁸	4d ¹⁰	5s ¹ 4d ¹⁰	5s ² 4d ¹⁰	5s ² 5p ¹	5s ² 5p ²	5s ² 5p ³	5s ² 5p ⁴	5s ² 5p ⁵	5s ² 5p ⁶
6	7	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
6	7	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
6	7	6s ¹	6s ²	6s ² 5d ¹	6s ² 5d ²	6s ² 5d ³	6s ² 5d ⁴	6s ² 5d ⁵	6s ² 5d ⁶	6s ² 5d ⁷	6s ¹ 5d ⁹	6s ¹ 5d ¹⁰	6s ² 5d ¹⁰	6s ² 6p ¹	6s ² 6p ²	6s ² 6p ³	6s ² 6p ⁴	6s ² 6p ⁵	6s ² 6p ⁶
7	8	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104
7	8	Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	**	Fl	**	Lv	**	**
7	8	7s ¹	7s ²	7s ² 6d ¹	7s ² 6d ²	7s ² 6d ³	7s ² 6d ⁴												
		Lan																	
		4f																	
		5f																	
				58	59	60	61	62	63	64	65	66	67	68	69	70	71		
				Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
				6s ² 4f ¹ 5d ¹	6s ² 4f ³	6s ² 4f ⁴	6s ² 4f ⁵	6s ² 4f ⁶	6s ² 4f ⁷	6s ² 4f ⁷ 5d ¹	6s ² 4f ⁹	6s ² 4f ¹⁰	6s ² 4f ¹¹	6s ² 4f ¹²	6s ² 4f ¹³	6s ² 4f ¹⁴	6s ² 4f ¹⁴ 6d ¹		
				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 ² 6d ²	7s ² 5f ² 6d ¹	7s ² 5f ³ 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 ⁹	7s ² 5f ¹⁰	7s ² 5f ¹¹	7s ² 5f ¹²	7s ² 5f ¹³	7s ² 5f ¹⁴	7s ² 5f ¹⁴ 6d ¹		

Write the Electron Configuration for Bismuth (Bi)

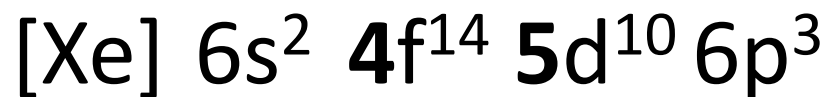
Groups
1 1A 2 2A 13 3A 14 4A 15 5A 16 6A 17 7A 18 8A

Periods
1 2 3 4 5 6 7

Legend:
 s-block elements
 p-block elements
 d-block elements
 f-block elements

1 H 1s ¹	2 He 1s ²											13 B 2s ² 2p ¹	14 C 2s ² 2p ²	15 N 2s ² 2p ³	16 O 2s ² 2p ⁴	17 F 2s ² 2p ⁵	18 Ne 2s ² 2p ⁶
3 Li 2s ¹	4 Be 2s ²											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
11 Na 3s ¹	12 Mg 3s ²	3 B 4s ² 3d ¹	4 C 4s ² 3d ²	5 N 4s ² 3d ³	6 O 4s ¹ 3d ⁵	7 Mn 4s ² 3d ⁵	8 Fe 4s ² 3d ⁶	9 Co 4s ² 3d ⁷	10 Ni 4s ² 3d ⁸	11 Cu 4s ¹ 3d ¹⁰	12 Zn 4s ² 3d ¹⁰	13 Ga 4s ² 4p ¹	14 Ge 4s ² 4p ²	15 As 4s ² 4p ³	16 Se 4s ² 4p ⁴	17 Br 4s ² 4p ⁵	18 Kr 4s ² 4p ⁶
19 K 4s ¹	20 Ca 4s ²	21 Sc 5s ² 4d ¹	22 Ti 5s ² 4d ²	23 V 5s ¹ 4d ⁴	24 Cr 5s ¹ 4d ⁵	25 Mn 5s ² 4d ⁵	26 Fe 5s ¹ 4d ⁷	27 Co 5s ¹ 4d ⁸	28 Ni 4d ¹⁰	29 Cu 5s ¹ 4d ¹⁰	30 Zn 5s ² 4d ¹⁰	31 Ga 5s ² 5p ¹	32 Ge 5s ² 5p ²	33 As 5s ² 5p ³	34 Se 5s ² 5p ⁴	35 Br 5s ² 5p ⁵	36 Kr 5s ² 5p ⁶
37 Rb 5s ¹	38 Sr 5s ²	39 Y 6s ² 5d ¹	40 Zr 6s ² 5d ²	41 Nb 6s ¹ 5d ⁴	42 Mo 6s ² 5d ⁵	43 Tc 6s ² 5d ⁵	44 Ru 6s ¹ 5d ⁷	45 Rh 6s ¹ 5d ⁸	46 Pd 4d ¹⁰	47 Ag 5s ¹ 5d ¹⁰	48 Cd 5s ² 5d ¹⁰	49 In 6s ² 6p ¹	50 Sn 6s ² 6p ²	51 Sb 6s ² 6p ³	52 Te 6s ² 6p ⁴	53 I 6s ² 6p ⁵	54 Xe 6s ² 6p ⁶
55 Cs 6s ¹	56 Ba 6s ²	57 La 6s ² 5d ¹	58 Ce 6s ² 5d ²	59 Pr 6s ² 5d ³	60 Nd 6s ² 5d ⁴	61 Pm 6s ² 5d ⁵	62 Sm 6s ² 5d ⁶	63 Eu 6s ² 5d ⁷	64 Gd 6s ¹ 5d ⁹	65 Tb 6s ¹ 5d ¹⁰	66 Dy 6s ² 5d ¹⁰	67 Ho 6s ² 6p ¹	68 Er 6s ² 6p ²	69 Tm 6s ² 6p ³	70 Yb 6s ² 6p ⁴	71 Lu 6s ² 6p ⁵	72 Hf 6s ² 6p ⁶
87 Fr 7s ¹	88 Ra 7s ²	89 Ac 7s ² 6d ¹	90 Th 7s ² 6d ²	91 Pa 7s ² 6d ³	92 U 7s ² 6d ⁴	93 Np 7s ² 6d ⁵	94 Pu 7s ² 6d ⁶	95 Am 7s ² 6d ⁷	96 Cm 7s ² 6d ⁸	97 Bk 7s ² 6d ⁹	98 Cf 7s ² 6d ¹⁰	99 Es 7s ² 6d ¹⁰	100 Fm 7s ² 6d ¹⁰	101 Md 7s ² 6d ¹⁰	102 No 7s ² 6d ¹⁰	103 Lr 7s ² 6d ¹⁰	104 Rf 7s ² 6d ¹⁰

Lanthanides
Actinides



Electron Configurations of Transition and Inner-Transition Elements

4	21 Sc $4s^2 3d^1$	22 Ti $4s^2 3d^2$	23 V $4s^2 3d^3$	24 Cr $4s^1 3d^5$	25 Mn $4s^2 3d^5$	26 Fe $4s^2 3d^6$	27 Co $4s^2 3d^7$	28 Ni $4s^2 3d^8$	29 Cu $4s^1 3d^{10}$	30 Zn $4s^2 3d^{10}$
5	39 Y $5s^2 4d^1$	40 Zr $5s^2 4d^2$	41 Nb $5s^1 4d^4$	42 Mo $5s^1 4d^5$	43 Tc $5s^2 4d^5$	44 Ru $5s^1 4d^7$	45 Rh $5s^1 4d^8$	46 Pd $4d^{10}$	47 Ag $5s^1 4d^{10}$	48 Cd $5s^2 4d^{10}$

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- many exceptions to the Aufbau principle exist in the electron configurations
- make sure you are familiar with the following irregular configurations

expected configuration	experimentally determined (i.e., actual)
Cr [Ar] $4s^2 3d^4$	[Ar] $4s^1 3d^5$
Cu [Ar] $4s^2 3d^9$	[Ar] $4s^1 3d^{10}$
Mo [Kr] $5s^2 4d^4$	[Kr] $5s^1 4d^5$
Ag [Kr] $5s^2 4d^9$	[Kr] $5s^1 4d^{10}$

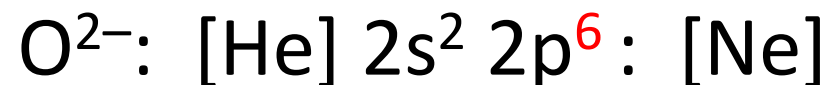
**half-filled
subshells are
energetically
favorable**

Electron Configurations of Ions

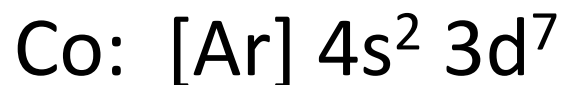
- step 1: write the electron configuration of the neutral parent atom
- step 2a: for anions, add extra electrons to lowest energy orbitals available
- step 2b: for cations, remove electrons from the outermost valence shell (i.e., orbitals having the highest value of n)
- COMMON MISTAKE! Remove n s-electrons before $n-1$ d-electrons



Noble gas configuration is achieved!
DRIVING FORCE: FULL VALENCE SHELL



Noble gas configuration is achieved!
DRIVING FORCE: FULL VALENCE SHELL



Ions from Atoms

- metals tend to form cations (*due to low ionization energies*)
- nonmetals tend to form anions (*due to negative electron affinities*)

Elements That Form Ions with Predictable Charges

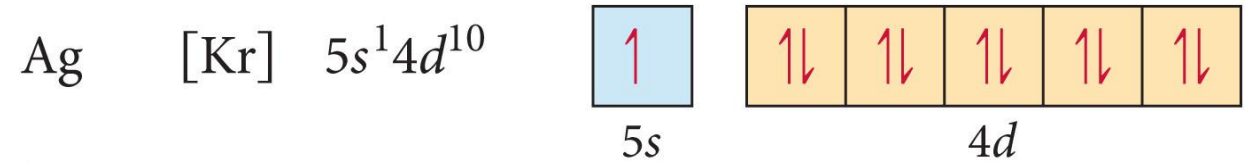
	1A	2A											3A	4A	5A	6A	7A	8A
1	Li ⁺														N ³⁻	O ²⁻	F ⁻	
2	Na ⁺	Mg ²⁺	3B	4B	5B	6B	7B	8B		1B	2B		Al ³⁺			S ²⁻	Cl ⁻	
3	K ⁺	Ca ²⁺														Se ²⁻	Br ⁻	
4	Rb ⁺	Sr ²⁺														Te ²⁻	I ⁻	
5	Cs ⁺	Ba ²⁺																

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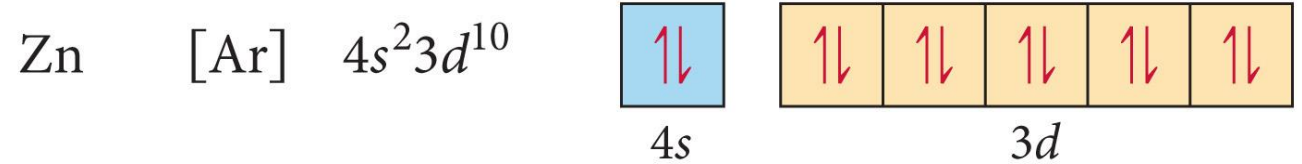
- charges of many main group elements are predictable (see above)
- charges of transition and inner-transition element ions not as predictable and also variable
- more on this in Chapter 4

Paramagnetism vs. Diamagnetism

- **paramagnetism** = a property of an atom or ion whereby it is attracted by an external magnetic field
 - comes from unpaired electrons
- **diamagnetism** = a property of an atom or ion whereby it is slightly repelled by an external magnetic field
 - all electrons are paired



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Try This On Your Own

Which of the following species has the MOST unpaired electrons?

Cu^+ , N^{2-} , Kr, Mo, Mo^+ , Fe^{3+}