


# MODULE 3-ELEMENTS ELECTRONIC STRUCTURE AND CHEMICAL PERIODICITY

REF: TEXTBOOK, CHAPTER 4, SUBSECTIONS 4.4 -  
4.7




**Key**

11	Atomic number
Na	Element symbol
Sodium	Element name
22.99	Average atomic mass*

58 <b>Ce</b> Cerium 140.12	59 <b>Pr</b> Praseodymium 140.91	60 <b>Nd</b> Neodymium 144.24	61 <b>Pm</b> Promethium (145)	62 <b>Sm</b> Samarium 150.36	63 <b>Eu</b> Europium 151.96	64 <b>Gd</b> Gadolinium 157.25	65 <b>Tb</b> Terbium 158.93	66 <b>Dy</b> Dysprosium 162.50	67 <b>Ho</b> Holmium 164.93	68 <b>Er</b> Erbium 167.26	69 <b>Tm</b> Thulium 168.93	70 <b>Yb</b> Ytterbium 173.04	71 <b>Lu</b> Lutetium 174.97
90 <b>Th</b> Thorium 232.04	91 <b>Pa</b> Protactinium 231.04	92 <b>U</b> Uranium 238.03	93 <b>Np</b> Neptunium (237)	94 <b>Pu</b> Plutonium (244)	95 <b>Am</b> Americium (243)	96 <b>Cm</b> Curium (247)	97 <b>Bk</b> Berkelium (247)	98 <b>Cf</b> Californium (251)	99 <b>Es</b> Einsteinium (252)	100 <b>Fm</b> Fermium (257)	101 <b>Md</b> Mendelevium (258)	102 <b>No</b> Nobelium (259)	103 <b>Lr</b> Lawrencium (262)



# ELECTRONIC STRUCTURE & CHEMICAL PERIODICITY

- THE PERIODIC LAW
  - THE PERIODIC TABLE
  - PERIODIC TABLE TREND
  - ELECTRON SHELLS, SUBSHELLS & ORBITALS
  - ELECTRON CONFIGURATION
  - CONDENSED ELECTRON CONFIGURATION
  - PARAMAGNETIC & DIAMAGNETIC SUBSTANCES
- 

# PERIODIC TABLE

- **PERIODIC LAW**

- WHEN ELEMENTS ARE ARRANGED IN ORDER OF INCREASING ATOMIC NUMBER, ELEMENTS WITH SIMILAR CHEMICAL BEHAVIOR OCCUR AT REGULARLY RECURRING (PERIODIC) INTERVALS.

Atomic number	1	2	3	4	...	9	10	11	12	...	17	18	19	20
Symbol	H	He	Li	Be	...	F	Ne	Na	Mg	...	Cl	Ar	K	Ca
		Unreactive gas	Soft, reactive metal			Unreactive gas		Soft, reactive metal			Unreactive gas		Soft, reactive metal	

# PERIODIC TABLE

- SYMBOLS IN THE PERIODIC TABLE ARE NOT USED IN THE NUCLEAR NOTATION FORM AS DISCUSSED PREVIOUSLY. THEY USE THE ATOMIC NUMBER AND THE ATOMIC MASS:

27

**Co**

58.93

28

**Ni**

58.69

29

**Cu**

63.55

# PERIODIC TABLE

- PERIODIC TABLE:
  - A TABULAR ARRANGEMENT OF THE ELEMENTS IN ORDER OF INCREASING ATOMIC NUMBER SUCH THAT ELEMENTS HAVING SIMILAR CHEMICAL BEHAVIOR ARE GROUPED IN VERTICAL COLUMNS.
  - TO CREATE THE PERIODIC TABLE, ELEMENTS ARE ARRANGED BY ELECTRON LEVELS.

# PERIODIC TABLE

- PERIOD - HORIZONTAL ROW OF ELEMENTS IN THE PERIODIC TABLE.
- GROUP - VERTICAL COLUMN OF ELEMENTS IN THE PERIODIC TABLE.
  - 3 WAYS TO NAME COLUMNS, US, EU, IUPAC
  - 4 GROUPS WITH NON-NUMERICAL NAMES: ALKALI METAL, ALKALINE EARTH METAL, HALOGEN, NOBLE GAS

# The Periodic Table of the Elements


1 1A																	18 8A
1 H	2 2A											13 3A	14 4A	15 5A	16 6A	17 7A	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
<div>Transition metals</div>																	
11 Na	12 Mg	3 3B	4 4B	5 5B	6 6B	7 7B	8	9	10	11 1B	12 2B	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 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
<div>period</div>																	
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	(113)	114	115	116	(117)	(118)
<div>group</div>																	
		<div>Inner Transition metals</div>															
		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		
<div>Metals</div>																	
<div>Metalloids</div>																	
<div>Nonmetals</div>																	



This is what the periodic table would look like if all atoms were added in the order of increasing electron shells

1																	2																
3	4																	5	6	7	8	9	10										
11	12																	13	14	15	16	17	18										
19	20	21																	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
37	38	39																	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86		
87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112		114		116		118		

(a)

This is a  compressed version of the periodic table with the rare earth elements separated out.

1																	2
3	4											5	6	7	8	9	10
11	12											13	14	15	16	17	18
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
87	88	89	104	105	106	107	108	109	110	111	112		114		116		118

58	59	60	61	62	63	64	65	66	67	68	69	70	71
90	91	92	93	94	95	96	97	98	99	100	101	102	103

(b)

# PERIODIC TABLE

- CLASSIFICATION BASED ON ELECTRON CONFIGURATIONS OF ELEMENTS
  - NOBEL GAS
  - REPRESENTATIVE
  - TRANSITION
  - INNER TRANSITION OR RARE EARTH ELEMENTS
- CLASSIFICATION BASED ON PHYSICAL PROPERTIES
  - METALS
  - NON-METALS

## Representative elements

elements

**S**

## Transition elements

**d** Inner transition elements

## Inner transition elements

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

**f**

p

# PERIODIC TABLE

## REPRESENTATIVE ELEMENT


- AN ELEMENT LOCATED IN THE '*s*' AREA OR THE FIRST FIVE COLUMNS OF THE '*p*' AREA OF THE PERIODIC TABLE.
- HAVE PARTIALLY OR COMPLETELY FULL '*s*' ELECTRON LEVEL.
- HAVE EMPTY OR PARTIALLY FULL '*p*' ELECTRON LEVEL.
- INCLUDES MOST COMMON ELEMENTS

# PERIODIC TABLE

- ALKALI METALS – GROUP IA
  - Li, Na, K, Rb, Cs
  - ALL HAVE ONE VALENCE ELECTRON
  - THESE ARE ALL SOFT SHINY METALS.
  - ALL ARE VERY REACTIVE WITH WATER.



# PERIODIC TABLE

- ALKALINE EARTH METALS – GROUP IIA
    - Be, Mg, Ca, Sr, Ba
    - ALL HAVE TWO VALENCE ELECTRONS.
    - SOFT, SHINY METALS.
    - ONLY MODERATELY REACTIVE WITH WATER.
- 

# PERIODIC TABLE

- HALOGEN – GROUP VIIA
  - F, Cl, Br, I, At (ASTATINE)
  - ALL HAVE 7 VALENCE ELECTRONS
  - EXIST AS DIATOMIC MOLECULES.
  - ARE VERY REACTIVE COLORED SUBSTANCES
  - GASES AT ROOM TEMPERATURE OR SLIGHTLY ABOVE ROOM TEMPERATURE.
  - Br IS LIQUID AT ROOM TEMPERATURE

# PERIODIC TABLE

- NOBEL GASES – GROUP VIIIA
  - He, Ne, Ar, Kr, Xe, Rn
  - HAVE A FULL VALENCE **SHELL** OF ELECTRONS.
  - UNREACTIVE
  - ALL GASES AT ROOM TEMPERATURE



# PERIODIC TABLE

## TRANSITION ELEMENT

- LOCATED IN THE '*d*' AREA OF THE PERIODIC TABLE
- ELECTRONS FILL THE '*D*' ENERGY LEVEL.

## INNER TRANSITION ELEMENT

- LOCATED IN THE '*f*' AREA OF THE PERIODIC TABLE
- ELECTRONS FILL THE '*f*' ENERGY LEVEL
- SERIES ARE CALLED LANTHANIDES AND ACTINIDES – ALSO KNOW AS RARE EARTH ELEMENTS

# ANOTHER COMMONLY USED SYSTEM DIVIDES THE PERIODIC TABLE INTO

1 H						2 He					
					5 B	6 C	7 N	8 O	9 F	10 Ne	
					13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
					30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
					48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
					80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
					112 —		114 —		116 —		118 —

Metal

Nonmetal

# PERIODIC TABLE – PHYSICAL PROPERTIES

## **METALS**

- HAS THE CHARACTERISTIC PROPERTIES OF
  - LUSTER (SHINE)
  - THERMAL CONDUCTIVITY
  - ELECTRICAL CONDUCTIVITY
  - MALLEABILITY – CAN BE ROLLED INTO SHEETS
  - DUCTILE – CAN BE DRAWN INTO WIRES
  - SOLIDS (EXCEPT MERCURY)
  - HIGH DENSITY
  - HIGH MELTING POINT
  - 94 METALS

# PERIODIC TABLE – PHYSICAL PROPERTIES

## NON-METALS

- CHARACTERIZED BY THE ABSENCE OF THE PROPERTIES OF LUSTER, THERMAL CONDUCTIVITY, ELECTRICAL CONDUCTIVITY, AND MALLEABILITY
  - CAN BE SOLID, LIQUID OR GASES AT ROOM TEMPERATURE
  - GENERALLY HAVE LOWER DENSITY AND LOWER MELTING POINTS THAN METALS.
  - ONLY 22 NON-METALS
  - 11 NONMETALS OCCUR NATURALLY IN THE GASEOUS STATE.
    - N, O, H, Cl, F, He, Ne, Ar, Kr, Xe, Rn
    - Br IS A LIQUID
    - C, P, S, Se, I, At, Te ETC. EXISTS AS SOLID

# LEARNING CHECK

## 1) IDENTIFY THE ELEMENT, BY GIVING ITS CHEMICAL SYMBOL

- PERIOD 4 AND GROUP IIIA
- PERIOD 2 AND GROUP IIA
- GROUP IV A AND PERIOD 5
- GROUP IA AND PERIOD 4

Ga

Be

Sn

K

## 2) IDENTIFY EACH OF THE FOLLOWING ELEMENTS BY NAME

- PERIOD 3 ALKALI METAL
- PERIOD 4 NOBLE GAS
- PERIOD 5 ALKALINE EARTH METAL
- PERIOD 2 HALOGEN

Na

Kr

Sr

F

# PERIODIC TABLE

- CHEMICAL PERIODICITY – THE VARIATION IN PROPERTIES OF ELEMENTS AS A FUNCTION OF THEIR POSITION IN THE PERIODIC TABLE.
  - BASICALLY HOW ATOMS CHANGE AS ONE TRAVELS ACROSS ROWS OR UP/DOWN COLUMNS
- WE WILL CONSIDER THREE PROPERTIES OF ELEMENTS THAT EXHIBIT CHEMICAL PERIODICITY
  - METALLIC AND NON-METALLIC CHARACTER
  - ATOMIC SIZE (ATOMIC RADIUS)
  - ELECTRONEGATIVITY

# PERIODIC TABLE TRENDS

## METALLIC CHARACTER

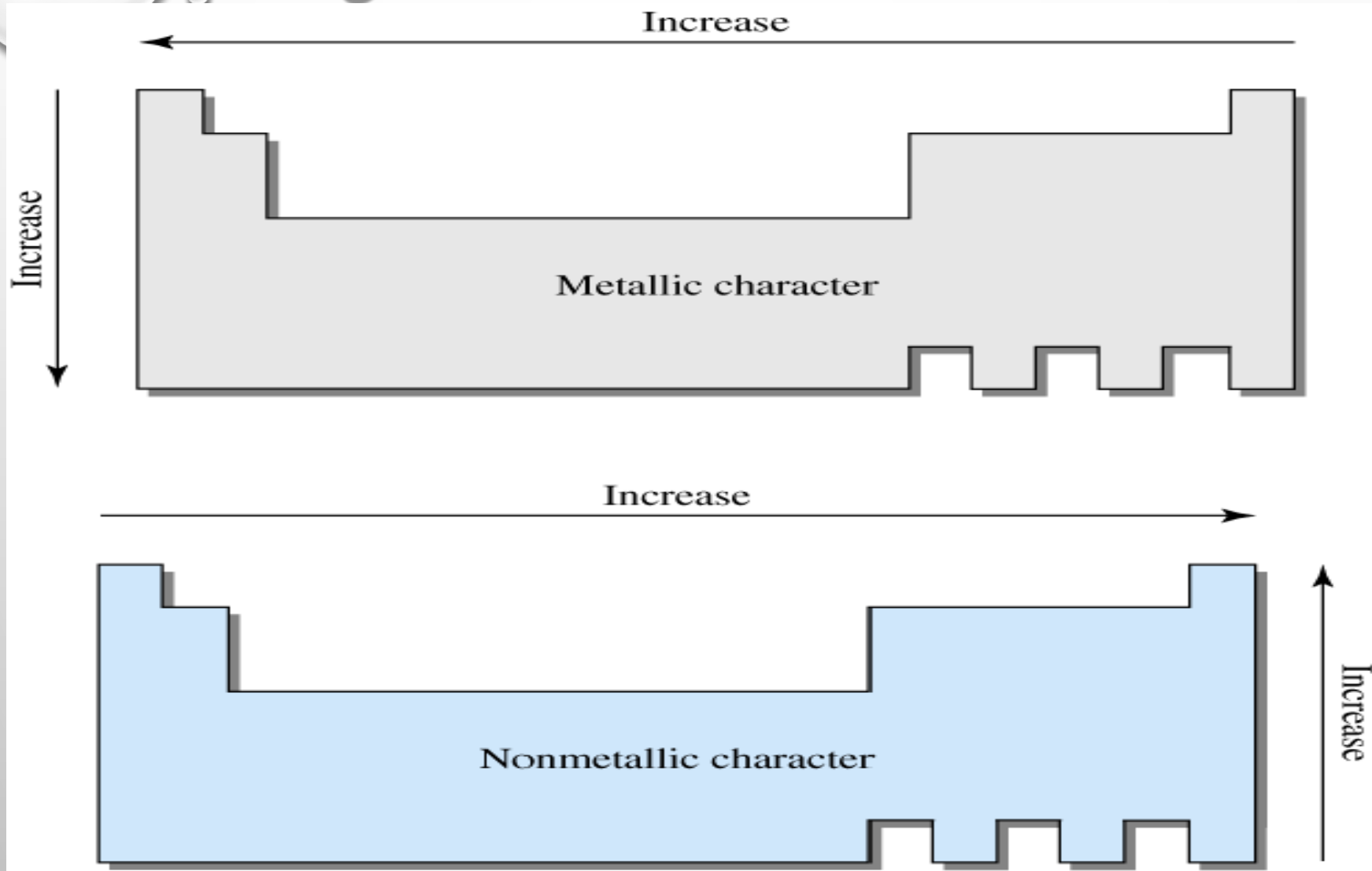
- METALLIC CHARACTER INCREASES FROM RIGHT TO LEFT WITHIN A GIVEN PERIOD (ROW) OF THE PERIODIC TABLE
- METALLIC CHARACTER INCREASES FROM TOP TO BOTTOM WITH A GROUP (COLUMN) IN THE PERIODIC TABLE.
  - E.G. Na IS MORE METALLIC THAN Mg BUT LESS METALLIC THAN K

# PERIODIC TABLE TRENDS

## NONMETALLIC CHARACTER

- NONMETALLIC CHARACTER INCREASES FROM LEFT TO RIGHT WITHIN A GIVEN PERIOD (ROW) OF THE PERIODIC TABLE.
- NONMETALLIC CHARACTER INCREASES FROM BOTTOM TO TOP WITHIN A GROUP (COLUMN) IN THE PERIODIC TABLE.
  - E.G. CHLORINE IS MORE NON-METALLIC THAN PHOSPHORUS BUT LESS NON-METALLIC THAN FLUORINE.





## Learning Check

1) USING THE PERIODIC TABLE, INDICATE WHICH MEMBER OF EACH OF THE FOLLOWING PAIRS OF ELEMENTS HAS LARGER METALLIC CHARACTER.

${}^3\text{Li}$  OR  ${}^{19}\text{K}$

K

${}^{15}\text{P}$  OR  ${}^{12}\text{Mg}$

Mg

2) USING THE PERIODIC TABLE, INDICATE WHICH MEMBER OF EACH OF THE FOLLOWING PAIRS OF ELEMENTS HAS LARGER NON-METALLIC CHARACTER

${}^5\text{B}$  OR  ${}^8\text{O}$

O

${}^9\text{F}$  OR  ${}^{53}\text{I}$

F

# PERIODIC TABLE TRENDS

- METALLOID – AN ELEMENT WITH PROPERTIES INTERMEDIATE BETWEEN THOSE OF METALS AND NONMETALS.
  - EIGHT METALLOIDS: B, Si, Ge, As, Sb, Te, Po AND At
- SEMICONDUCTOR – A METALLOID ELEMENT THAT DOES NOT CONDUCT ELECTRICAL CURRENT AT ROOM TEMPERATURE BUT DOES AT HIGHER TEMPERATURES [Si, Ge, Sb (ANTIMONY)]
  - VERY IMPORTANT IN THE ELECTRONICS INDUSTRY.

**Metalloids** reside along the stepped line which divides the metals and non-metals.

1 H						2 He						
						5 B	6 C	7 N	8 O	9 F	10 Ne	
						13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
						30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
						48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
						80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
						112 —		114 —		116 —		118 —














Metalloid

# PERIODIC TABLE TRENDS


























- NOTE:
  - INCREASING ATOMIC NUMBER DOES NOT ALWAYS EQUAL INCREASING ATOMIC MASS
    - Ar (39.95 AMU), K (39.1 AMU), Ca (40.08 AMU)
    - Co (58.93 AMU), Ni (58.69 AMU), Cu (63.55 AMU)

# PERIODIC TABLE TRENDS

- ATOMIC SIZE
  - ATOMIC RADII TEND TO DECREASE FROM LEFT TO RIGHT WITHIN A PERIOD (ROW) OF THE PERIODIC TABLE.
  - ATOMIC RADII TEND TO INCREASE IN SIZE FROM TOP TO BOTTOM WITHIN A PERIODIC TABLE GROUP.

H  37	
Li  152	Be  111
Na  186	Mg  160
K  227	Ca  197
Rb  248	Sr  215
Cs  265	Ba  217
Fr  270	Ra  220

Decreasing atomic size →

B  88	C  77	N  70	O  66	F  64	Ne
Al  143	Si  117	P  110	S  104	Cl  99	Ar
Ga  122	Ge  122	As  121	Se  117	Br  114	Kr
In  162	Sn  140	Sb  141	Te  137	I  133	Xe
Tl  171	Pb  154	Bi  152	Po  140	At  140	Rn
	114		116		118

Increasing  
atomic  
size  
↓

# PERIODIC TABLE TRENDS

- ELECTRONEGATIVITY - A MEASURE OF THE RELATIVE ATTRACTION THAT AN ATOM HAS FOR THE SHARED ELECTRONS IN A BOND.
  - THE HIGHER THE ELECTRONEGATIVITY OF AN ELEMENT, THE GREATER THE ELECTRON-ATTRACTING ABILITY OF ATOMS OF THAT ELEMENT.
    - ELECTRONEGATIVITY GENERALLY INCREASES FROM LEFT TO RIGHT WITHIN A PERIOD (ROW) OF PERIODIC TABLE.
    - FACTORS: SIZE, NUCLEAR CHARGE, NUMBER OF NON-VALENCE ELECTRONS



# Increasing electronegativity



H 2.1																	He -
Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0	Ne -
Na 0.9	Mg 1.2											Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0	Ar -
K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.8	Ni 1.8	Cu 1.8	Zn 1.6	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8	Kr -
Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.8	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.7	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5	Xe -
Cs 0.7	Ba 0.9	57-71 1.1-1.2	Hf 1.3	Ta 1.5	W 1.7	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Tl 1.8	Pb 1.8	Bi 1.9	Po 2.0	At 2.2	Rn -
Fr 0.7	Ra 0.9																



## LEARNING CHECK

- 1) USING THE PERIODIC TABLE, INDICATE WHICH MEMBER OF EACH OF THE FOLLOWING PAIRS OF ELEMENTS HAS LARGER ATOMIC RADIUS.

$_{13}\text{Al}$  OR  $_{16}\text{S}$

$_{13}\text{Al}$

$_{37}\text{Rb}$  OR  $_{3}\text{Li}$

$_{37}\text{Rb}$

- 2) USING THE PERIODIC TABLE, INDICATE WHICH MEMBER OF EACH OF THE FOLLOWING PAIRS OF ELEMENTS HAS HIGHEST ELECTRONEGATIVITY CHARACTER.

$_{7}\text{N}$  OR  $_{9}\text{F}$

F

$_{53}\text{I}$  OR  $_{17}\text{Cl}$

Cl

# ELECTRONS

- REMEMBER:

- ELECTRONS ARE THE SMALLEST OF THE THREE SUBATOMIC PARTICLES WE WILL DEAL WITH.
- THEY HAVE VERY LITTLE MASS.
- THEY RESIDE IN THE ELECTRON CLOUD THAT SURROUNDS THE NUCLEUS.
- THEIR MOVEMENT RAPIDLY ABOUT THE NUCLEUS DEFINES THE SIZE OF THE ATOM
- THE INFORMATION ABOUT THE BEHAVIOUR AND ARRANGEMENTS OF ELECTRONS WITHIN THE EXTRANUCLEAR REGION IS DERIVED FROM COMPLEX MATHEMATICAL MODEL FOR ELECTRON BEHAVIOUR CALLED **QUANTUM MECHANICS**.

# ELECTRONS

- ELECTRONS ARE THE HIGH ENERGY PART OF THE ATOM.
- THE FASTER THE ELECTRON MOVES THE MORE ENERGY IT HAS AND THE FARTHER FROM THE NUCLEUS IT TENDS TO TRAVEL.
- ELECTRONS HAVE SPIN.
- QUANTUM THEORY IS USED TO EXPLAIN THEIR ENERGY AND MOVEMENT. WHAT YOU NEED TO REMEMBER IS THAT THE ENERGY IN AN ELECTRON IS DEFINED. IT IS RESTRICTED. IT DOESN'T JUST GO EVERYWHERE.
- AN ENERGY OF ELECTRONS IS **QUANTIZED**. A QUANTIZED PROPERTY IS A PROPERTY THAT CAN HAVE ONLY CERTAIN VALUES AND NOT ALL VALUES ARE ALLOWED.

# ELECTRONS

- **ELECTRON SHELL** – A DEFINED REGION OF SPACE ABOUT A NUCLEUS THAT CONTAINS ELECTRONS WITH APPROXIMATELY THE SAME ENERGY.
- **SHELL NUMBER** – ‘n’ USED TO IDENTIFY THE ELECTRON SHELL.
  - THESE ARE NUMBERED 1-7
  - ELECTRONS IN HIGHER NUMBER SHELLS HAVE MORE ENERGY.

# ELECTRONS

HOW MANY ELECTRONS IN AN ELECTRON SHELL?

- DEPENDS –
  - NOT ALL SHELLS ARE EQUAL.
  - LOWER SHELLS HAVE LESS ELECTRONS, LESS ENERGY.
  - NUMBER OF ELECTRONS IN A SHELL FOLLOWS THE RULE  $2n^2$  WHERE 'n' IS THE ELECTRON SHELL LEVEL.
  - LOWER LEVEL SHELLS FILL BEFORE HIGHER ONES.
- SO HOW MANY ELECTRONS ARE IN SHELL 3 ?

18

# ELECTRONS – SUBSHELLS AND ORBITALS

- WITHIN A **SHELL** THERE ARE **SUBSHELLS** AND **ORBITALS**.
  - A **SUBSHELL** IS DEFINED REGION OF SPACE WITHIN AN ELECTRON **SHELL** THAT CONTAIN ELECTRONS OF THE SAME ENERGY. Ex. *s, p, d OR f*
  - NUMBER OF **SUBSHELLS** IN A SHELL = 'n', WHERE 'n' IS THE **SHELL** NUMBER.
  - **SUBSHELLS** ARE WRITTEN WITH A NUMBER, 'n', AND A LETTER.
  - THE **SUPERSCRIPT** REPRESENTS THE NUMBER OF ELECTRONS IN THE **SUBSHELL**. EX: **1s<sup>2</sup>**

# ELECTRONS – SUBSHELLS AND ORBITALS

- **SUBSHELLS**

- **SUBSHELLS** ARE WRITTEN WITH A NUMBER, 'n', AND A LETTER, *s*, *p*, *d*, *f* (ALWAYS IN LOWER CASE).
- NUMBER OF ELECTRONS PER **SUBSHELL** IS DEFINED AND INDEPENDENT OF **SHELL** NUMBER.

SUBSHELLS    ELECTRONS

- - $s = 2$
  - $p = 6$
  - $d = 10$
  - $f = 14$



# ELECTRONS – SUBSHELLS AND ORBITALS

- **ELECTRON ORBITAL** – A REGION OF SPACE WITHIN AN ELECTRON SUBSHELL WHERE AN ELECTRON WITH A SPECIFIC ENERGY IS MOST LIKELY TO BE FOUND.

- HOW MANY ORBITALS ARE IN EACH SUBSHELL?

$$s = 1$$

$$p = 3$$

$$d = 5$$

$$f = 7$$

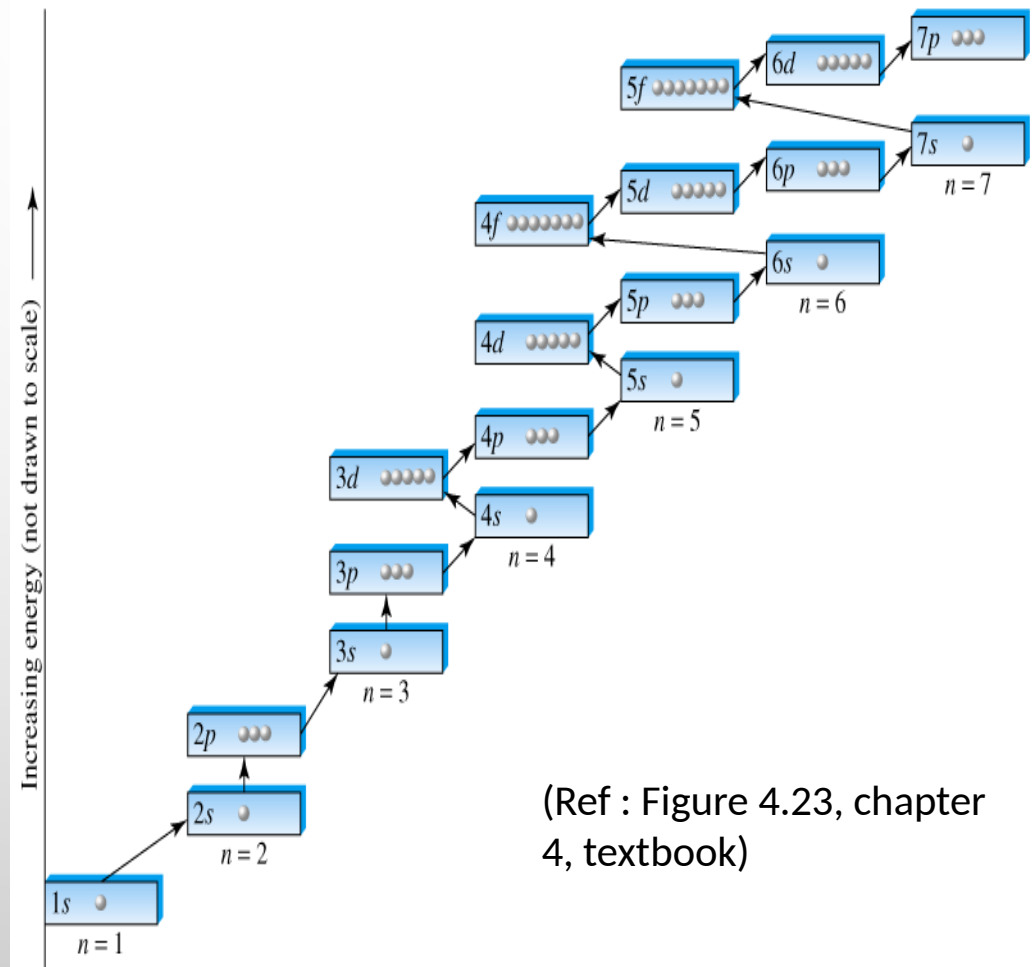
- EACH ☆✱✱✱☆✱☆☆ CAN HOLD TWO ELECTRONS.

# AUFBAU PRINCIPLE -FILLING ELECTRON SHELLS

- Electron **shells** fill according to the **Aufbau Principle**.

Electrons normally occupy electron **subshells** in an atom in order of increasing **subshell** energy.

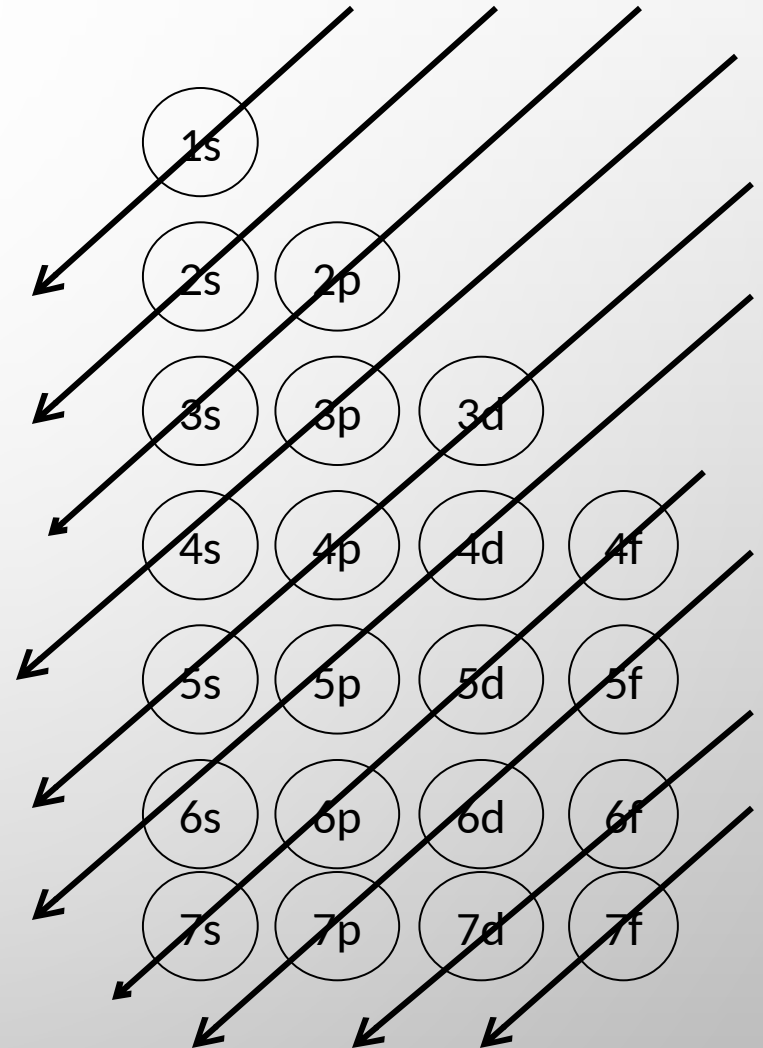
Energy of **subshells** can overlap



(Ref : Figure 4.23, chapter 4, textbook)

# FILLING ELECTRON SHELLS

*THIS IS THE AUFBAU  
DIAGRAM WHICH  
DETAILS HOW TO  
FILL THE ELECTRON  
ENERGY LEVELS.*



# OUTERMOST SHELLS AND SUBSHELLS

1s										1s
2s										
3s										
4s					3d					
5s					4d					
6s	*				5d					
7s	**				6d					

*							4f						
**							5f						

# WRITING ELECTRON CONFIGURATION

WHILE THIS MAY SEEM TEDIOUS, YOU CAN LEARN A LOT FROM THE WRITTEN ELECTRON CONFIGURATION.

THIS IS A SHORTHAND NOTATION DESIGNATING THE **SUBSHELLS** IN AN ATOM THAT ARE OCCUPIED BY ELECTRONS.

START AT THE BEGINNING AND KEEP FILLING **SUBSHELLS** UNTIL THE CORRECT NUMBER OF ELECTRON IS REPRESENTED:

- REMEMBER THE NUCLEAR NOTATION AND 'Z' IS THE NUMBER OF PROTONS WHICH EQUALS THE NUMBER OF

ELECTRONS IN A NEUTRAL ATOM		
Element	Z	Electron Configuration
Hydrogen	1	$1s^1$
Helium	2	$1s^2$
Carbon	6	$1s^2 2s^2 2p^2$
Neon	10	$1s^2 2s^2 2p^6$
Sodium	11	$1s^2 2s^2 2p^6 3s^1$

Element	z	Electron Configuration
Hydrogen	1	$1s^1$
Sodium	11	$1s^2 2s^2 2p^6 3s^1$
Potassium	19	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
Rubidium	37	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^1$
Cesium	55	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2$ $4d^{10} 5p^6 6s^1$

# Ground State Electron Configurations of the Elements

	1 1A											18 8A							
	$ns^2$												$ns^2p^1$	$ns^2p^2$	$ns^2p^3$	$ns^2p^4$	$ns^2p^5$		
1	1 H $1s^1$	2 He $1s^2$																	
2	3 Li $2s^1$	4 Be $2s^2$											5 B $2s^2p^1$	6 C $2s^2p^2$	7 N $2s^2p^3$	8 O $2s^2p^4$	9 F $2s^2p^5$	10 Ne $2s^2p^6$	
3	11 Na $3s^1$	12 Mg $3s^2$	13 Al $3s^2p^1$	14 Si $3s^2p^2$	15 P $3s^2p^3$	16 S $3s^2p^4$	17 Cl $3s^2p^5$	18 Ar $3s^2p^6$											
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 $5s^24d^5$	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 Ds $7s^26d^8$	111 Rg $7s^26d^9$	112 Cn $7s^26d^{10}$	113 Nh $7s^27p^1$	114 Fl $7s^27p^2$	115 Mc $7s^27p^3$	116 Lv $7s^27p^4$	(117)	118 Og $7s^27p^6$	

$4f$



$5f$



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 $6s^2 4f^7$	64 Gd $6s^2 4f^7 5d^1$	65 Tb $6s^2 4f^9$	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 $7s^2 6d^2$	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 $7s^2 5f^6$	95 Am $7s^2 5f^7$	96 Cm $7s^2 5f^7 6d^1$	97 Bk $7s^2 5f^9$	98 Cf $7s^2 5f^{10}$	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 $7s^2 5f^{14} 6d^1$



## CONDENSED ELECTRON CONFIGURATION

$_{11}\text{Na}$	$1s^2, 2s^2, 2p^6,$	$3s^1$
------------------	---------------------	--------

$_{10}\text{Ne}$   $1s^2, 2s^2, 2p^6$

$${}_{11}\text{Na} \quad [\text{Ne}] 3s^1$$

$_{15}\text{P}$	$1s^2, 2s^2, 2p^6, 3s^2, 3p^3$
-----------------	--------------------------------

${}_{15}\text{P}$        $[\text{Ne}] 3s^2, 3p^3$

**$53\text{I}$**        **$[\text{Kr}] 5s^2, 4d^{10}, 5p^5$**

$_{81}\text{Tl}$	$[\text{Xe}] 6s^2, 4f^{14}, 5d^{10}, 6p^1$
------------------	--

<http://www.gutenberg.org/files/55555/55555-h/55555-h.htm>، 2009Q2؛ 2009Q3؛ 2009Q4؛ 2010Q1؛ 2010Q2؛ 2010Q3؛ 2010Q4؛ 2011Q1؛ 2011Q2؛ 2011Q3؛ 2011Q4؛ 2012Q1؛ 2012Q2؛ 2012Q3؛ 2012Q4؛ 2013Q1؛ 2013Q2؛ 2013Q3؛ 2013Q4؛ 2014Q1؛ 2014Q2؛ 2014Q3؛ 2014Q4؛ 2015Q1؛ 2015Q2؛ 2015Q3؛ 2015Q4؛ 2016Q1؛ 2016Q2؛ 2016Q3؛ 2016Q4؛ 2017Q1؛ 2017Q2؛ 2017Q3؛ 2017Q4؛ 2018Q1؛ 2018Q2؛ 2018Q3؛ 2018Q4؛ 2019Q1؛ 2019Q2؛ 2019Q3؛ 2019Q4؛ 2020Q1؛ 2020Q2؛ 2020Q3؛ 2020Q4؛ 2021Q1؛ 2021Q2؛ 2021Q3؛ 2021Q4؛ 2022Q1؛ 2022Q2؛ 2022Q3؛ 2022Q4؛ 2023Q1؛ 2023Q2؛ 2023Q3؛ 2023Q4؛ 2024Q1؛ 2024Q2؛ 2024Q3؛ 2024Q4؛ 2025Q1؛ 2025Q2؛ 2025Q3؛ 2025Q4؛ 2026Q1؛ 2026Q2؛ 2026Q3؛ 2026Q4؛ 2027Q1؛ 2027Q2؛ 2027Q3؛ 2027Q4؛ 2028Q1؛ 2028Q2؛ 2028Q3؛ 2028Q4؛ 2029Q1؛ 2029Q2؛ 2029Q3؛ 2029Q4؛ 2030Q1؛ 2030Q2؛ 2030Q3؛ 2030Q4؛ 2031Q1؛ 2031Q2؛ 2031Q3؛ 2031Q4؛ 2032Q1؛ 2032Q2؛ 2032Q3؛ 2032Q4؛ 2033Q1؛ 2033Q2؛ 2033Q3؛ 2033Q4؛ 2034Q1؛ 2034Q2؛ 2034Q3؛ 2034Q4؛ 2035Q1؛ 2035Q2؛ 2035Q3؛ 2035Q4؛ 2036Q1؛ 2036Q2؛ 2036Q3؛ 2036Q4؛ 2037Q1؛ 2037Q2؛ 2037Q3؛ 2037Q4؛ 2038Q1؛ 2038Q2؛ 2038Q3؛ 2038Q4؛ 2039Q1؛ 2039Q2؛ 2039Q3؛ 2039Q4؛ 2040Q1؛ 2040Q2؛ 2040Q3؛ 2040Q4؛ 2041Q1؛ 2041Q2؛ 2041Q3؛ 2041Q4؛ 2042Q1؛ 2042Q2؛ 2042Q3؛ 2042Q4؛ 2043Q1؛ 2043Q2؛ 2043Q3؛ 2043Q4؛ 2044Q1؛ 2044Q2؛ 2044Q3؛ 2044Q4؛ 2045Q1؛ 2045Q2؛ 2045Q3؛ 2045Q4؛ 2046Q1؛ 2046Q2؛ 2046Q3؛ 2046Q4؛ 2047Q1؛ 2047Q2؛ 2047Q3؛ 2047Q4؛ 2048Q1؛ 2048Q2؛ 2048Q3؛ 2048Q4؛ 2049Q1؛ 2049Q2؛ 2049Q3؛ 2049Q4؛ 2050Q1؛ 2050Q2؛ 2050Q3؛ 2050Q4؛ 2051Q1؛ 2051Q2؛ 2051Q3؛ 2051Q4؛ 2052Q1؛ 2052Q2؛ 2052Q3؛ 2052Q4؛ 2053Q1؛ 2053Q2؛ 2053Q3؛ 2053Q4؛ 2054Q1؛ 2054Q2؛ 2054Q3؛ 2054Q4؛ 2055Q1؛ 2055Q2؛ 2055Q3؛ 2055Q4؛ 2056Q1؛ 2056Q2؛ 2056Q3؛ 2056Q4؛ 2057Q1؛ 2057Q2؛ 2057Q3؛ 2057Q4؛ 2058Q1؛ 2058Q2؛ 2058Q3؛ 2058Q4؛ 2059Q1؛ 2059Q2؛ 2059Q3؛ 2059Q4؛ 2060Q1؛ 2060Q2؛ 2060Q3؛ 2060Q4؛ 2061Q1؛ 2061Q2؛ 2061Q3؛ 2061Q4؛ 2062Q1؛ 2062Q2؛ 2062Q3؛ 2062Q4؛ 2063Q1؛ 2063Q2؛ 2063Q3؛ 2063Q4؛ 2064Q1؛ 2064Q2؛ 2064Q3؛ 2064Q4؛ 2065Q1؛ 2065Q2؛ 2065Q3؛ 2065Q4؛ 2066Q1؛ 2066Q2؛ 2066Q3؛ 2066Q4؛ 2067Q1؛ 2067Q2؛ 2067Q3؛ 2067Q4؛ 2068Q1؛ 2068Q2؛ 2068Q3؛ 2068Q4؛ 2069Q1؛ 2069Q2؛ 2069Q3؛ 2069Q4؛ 2070Q1؛ 2070Q2؛ 2070Q3؛ 2070Q4؛ 2071Q1؛ 2071Q2؛ 2071Q3؛ 2071Q4؛ 2072Q1؛ 2072Q2؛ 2072Q3؛ 2072Q4؛ 2073Q1؛ 2073Q2؛ 2073Q3؛ 2073Q4؛ 2074Q1؛ 2074Q2؛ 2074Q3؛ 2074Q4؛ 2075Q1؛ 2075Q2؛ 2075Q3؛ 2075Q4؛ 2076Q1؛ 2076Q2؛ 2076Q3؛ 2076Q4؛ 2077Q1؛ 2077Q2؛ 2077Q3؛ 2077Q4؛ 2078Q1؛ 2078Q2؛ 2078Q3؛ 2078Q4؛ 2079Q1؛ 2079Q2؛ 2079Q3؛ 2079Q4؛ 2080Q1؛ 2080Q2؛ 2080Q3؛ 2080Q4؛ 2081Q1؛ 2081Q2؛ 2081Q3؛ 2081Q4؛ 2082Q1؛ 2082Q2؛ 2082Q3؛ 2082Q4؛ 2083Q1؛ 2083Q2؛ 2083Q3؛ 2083Q4؛ 2084Q1؛ 2084Q2؛ 2084Q3؛ 2084Q4؛ 2085Q1؛ 2085Q2؛ 2085Q3؛ 2085Q4؛ 2086Q1؛ 2086Q2؛ 2086Q3؛ 2086Q4؛ 2087Q1؛ 2087Q2؛ 2087Q3؛ 2087Q4؛ 2088Q1؛ 2088Q2؛ 2088Q3؛ 2088Q4؛ 2089Q1؛ 2089Q2؛ 2089Q3؛ 2089Q4؛ 2090Q1؛ 2090Q2؛ 2090Q3؛ 2090Q4؛ 2091Q1؛ 2091Q2؛ 2091Q3؛ 2091Q4؛ 2092Q1؛ 2092Q2؛ 2092Q3؛ 2092Q4؛ 2093Q1؛ 2093Q2؛ 2093Q3؛ 2093Q4؛ 2094Q1؛ 2094Q2؛ 2094Q3؛ 2094Q4؛ 2095Q1؛ 2095Q2؛ 2095Q3؛ 2095Q4؛ 2096Q1؛ 2096Q2؛ 2096Q3؛ 2096Q4؛ 2097Q1؛ 2097Q2؛ 2097Q3؛ 2097Q4؛ 2098Q1؛ 2098Q2؛ 2098Q3؛ 2098Q4؛ 2099Q1؛ 2099Q2؛ 2099Q3؛ 2099Q4؛ 2100Q1؛ 2100Q2؛ 2100Q3؛ 2100Q4؛ 2101Q1؛ 2101Q2؛ 2101Q3؛ 2101Q4؛ 2102Q1؛ 2102Q2؛ 2102Q3؛ 2102Q4؛ 2103Q1؛ 2103Q2؛ 2103Q3؛ 2103Q4؛ 2104Q1؛ 2104Q2؛ 2104Q3؛ 2104Q4؛ 2105Q1؛ 2105Q2؛ 2105Q3؛ 2105Q4؛ 2106Q1؛ 2106Q2؛ 2106Q3؛ 2106Q4؛ 2107Q1؛ 2107Q2؛ 2107Q3؛ 2107Q4؛ 2108Q1؛ 2108Q2؛ 2108Q3؛ 2108Q4؛ 2109Q1؛ 2109Q2؛ 2109Q3؛ 2109Q4؛ 2110Q1؛ 2110Q2؛ 2110Q3؛ 2110Q4؛ 2111Q1؛ 2111Q2؛ 2111Q3؛ 2111Q4؛ 2112Q1؛ 2112Q2؛ 2112Q3؛ 2112Q4؛ 2113Q1؛ 2113Q2؛ 2113Q3؛ 2113Q4؛ 2114Q1؛ 2114Q2؛ 2114Q3؛ 2114Q4؛ 2115Q1؛ 2115Q2؛ 2115Q3؛ 2115Q4؛ 2116Q1؛ 2116Q2؛ 2116Q3؛ 2116Q4؛ 2117Q1؛ 2117Q2؛ 2117Q3؛ 2117Q4؛ 2118Q1؛ 2118Q2؛ 2118Q3؛ 2118Q4؛ 2119Q1؛ 2119Q2؛ 2119Q3؛ 2119Q4؛ 2120Q1؛ 2120Q2؛ 2120Q3؛ 2120Q4؛ 2121Q1؛ 2121Q2؛ 2121Q3؛ 2121Q4؛ 2122Q1؛ 2122Q2؛ 2122Q3؛ 2122Q4؛ 2123Q1؛ 2123Q2؛ 2123Q3؛ 2123Q4؛ 2124Q1؛ 2124Q2؛ 2124Q3؛ 2124Q4؛ 2125Q1؛ 2125Q2؛ 2125Q3؛ 2125Q4؛ 2126Q1؛ 2126Q2؛ 2126Q3؛ 2126Q4؛ 2127Q1؛ 2127Q2؛ 2127Q3؛ 2127Q4؛ 2128Q1؛ 2128Q2؛ 2128Q3؛ 2128Q4؛ 2129Q1؛ 2129Q2؛ 2129Q3؛ 2129Q4؛ 2130Q1؛ 2130Q2؛ 2130Q3؛ 2130Q4؛ 2131Q1؛ 2131Q2؛ 2131Q3؛ 2131Q4؛ 2132Q1؛ 2132Q2؛ 2132Q3؛ 2132Q4؛ 2133Q1؛ 2133Q2؛ 2133Q3؛ 2133Q4؛ 2134Q1؛ 2134Q2؛ 2134Q3؛ 2134Q4؛ 2135Q

For “d” use one less than the period

For “f” use two less than the period

## Diamagnetici

- ATOMS WHERE ALL ELECTRON **ORBITALS** ARE OCCUPIED BY PAIRS OF ELECTRONS ARE CALLED **DIAMAGNETIC ATOMS**.
- ATOMS WHERE ALL ELECTRON **ORBITALS** ARE NOT OCCUPIED BY PAIRS OF ELECTRONS ARE CALLED **PARAMAGNETIC ATOMS**.
- INTRODUCTION TO ELECTRON CONFIGURATION

<http://www.chem.latech.edu/~deddy/lectnote/chap7b.html>