### **Electrons in Atoms**

### October 27, 2014





October 29, 2014

### **ELECTRON CONFIGURATION**

## Review of Atomic Theory

• **Thomson** discovered the electron

5.2

- <u>Bohr</u> determined that the electrons travel around the nucleus according to energy; electrons with lower energy are closer to the nucleus
- <u>Quantum Mechanical Model</u> says electrons orbit the nucleus in "clouds"; there is a high probability of finding them somewhere along these paths







### Electron Cloud

- Each <u>energy level</u> in the electron cloud model can hold a limited number of electrons.
- The lowest energy level is the smallest and the closest to the nucleus and is assigned a number of one.
  - Up to seven energy levels have been detected.
    - First energy level holds a maximum of **two electrons**.
    - Second energy level is larger because it is farther away from the nucleus. It holds a maximum of <u>eight electrons</u>.
    - Third energy level is larger still and holds a maximum of <u>18 electrons</u>

### Electron Orbitals





#### Conceptual Model of Energy Levels Where n = energy level

Bohr Model of Carbon

# Organization of Electrons





- Electrons are restricted to energy levels based on the amount of <u>energy they have</u>
- Lowest energy level is assigned **#1**
- On the periodic table, each period <u>(horizontal</u> <u>row) is an energy level</u>



### Energy Sublevels

- Within each energy level, there are energy <u>sublevels</u>
- The 4 sublevels are identified by a letter and listed in increasing complexity: <u>**s**</u>, <u>**p**</u>, <u>**d**</u>, <u>**f**</u>
- The letters stand for the way the emission lines look...

= sharn	IA IIA									۱ ۱	/IIIA
	н 1s <sup>1</sup>						IIA IVA	A VA	VIA	VIIA	2 не 1s <sup>2</sup> -
= <u>principal</u>	3 Li 4 Be 2s1 2s2						5 В Б 2р1 2р	07 N 2[2p3	8 0 2p4	9 F 2p5	10 Ne 2рб
= diffuse	11Na 12Mg 3s1 3s2						13 AI 14 3p1 3t	si 15 P 52 3p3	16 s 3p4	<del>ਜਿੰ</del> ਗ 3p <sup>5</sup>	18 Ar 3p <sup>6</sup>
	1976 - Ca 45 - 152	3d <sup>1</sup> 3d <sup>2</sup>	23 V 24 Cr 3d3 3d4	25 Mn 26 Fe2 3d <sup>5</sup> 3d <sup>6</sup>	27 Co 28 Ni 1 3d7 3d8	29 Cu 30 Zn 3d9 <mark>3d10</mark>	31Ga 32 4p1 4	Ge 33 52 4p	arse 4r4	35 Br ( 4p <sup>5</sup>	36 Кл 4р <sup>6</sup>
= <u>fundamental</u>	57, 587 Sr 581   582	39 V 40 Zr 4d1 4d2	41 NB 42 Mo 4d3 4d4	43 To 4 Ru 4	45 Rh 46 Pd 4d7 4d8	47 Ag (48 Ca 4 d 9 4 d 1 0	491n 50 5p1 5t	sn 51 52 5p	5p4	53 IS 5p5	54 Xe 5p6
	55Cs 56 Ba 6s1 6s2	71 Lu 72 Hr 5d <sup>2</sup> 5d <sup>2</sup>	73 T≋ 74 W 5d3 5d4	o Rei o Ost d5 id6	77 ir 78 Pt 5d7 5d8	79 Au 80 Hg 5d <sup>9</sup> 5d <sup>1</sup> C	зіт ві 6р16;	РЫ83 Ві ⊳2 (бр.3	84Ро 6р4	<del>85 Ас</del> 6р <sup>5</sup>	36 Rn 6p6
	87 Fr 88 Ra 7s <sup>1</sup> 7s <sup>2</sup>	103Lr 104 6d <sup>2</sup> 6d <sup>2</sup>	105 106 6d <sup>3</sup> 6d <sup>4</sup>								
		57 La 5 4f <sup>1</sup> 4	8 се 59 Pr Б. If2   4f3   4	1 Na 61 Pm 62 1 <sup>4</sup> 41 <sup>5</sup> 41	5m 63 Eulor 6 4f7	9 4f <sup>9</sup> 4	бу 67 н f10 4f1	o 68Er (t 1 4f12	91m 70 4f13 4	гүр f <mark>14</mark>	
		89 Ao   91   5f <sup>1</sup>   5	0 Th 91 Pa 92 5F2   5F3   5	2 U 193 Np 194 1 <sup>4</sup> 51 <sup>5</sup> 51	Pu 95 Am 9 6 5f7 5	Cm 97 Bk 98 8 5f <sup>9</sup> 5	⊧ Cr  99Es f <sup>10</sup> 5f1	s 100 Fm1 1 5f12	01M8 10 5f1 3 5	12NG F <sup>14</sup>	



IA	IA																	VIIIA
і н 1е1												IIIA		YA	٧A	VIA	VIIA	2 Не 1-2
15. 8 11	4 Be											5	в	ь с	7 N	8 0	y F	IU Ne
2s1	2s <sup>2</sup>											2p	51	2p <sup>2</sup>	2p3	2p4	2p5	2p <sup>6</sup>
11Na 2-1	12Mg											13 Эн	AL 1	14 Si 2~ 2	15 P	16 S	17 CL 25 5	18 Ar 0- 6
35	354				20.00			24.6			21 20	기	21	304 2264	30-2	зрт	-3p⊻ as p⊭	30° 26 Ke
45	2000 102	3d1	3d2	3d3	3d4	3d5	3d6	3d7	3d8	3d9	3d10	4p	51 51	4p2	4p 8	4	4p5	4p6
87N (*	2 Sr	39 Y	40 Zr	41 N.	42 Mo	43 To	H Ru	45 R.h	46 P.d	47 Ag	48 C d	49	In	50 Sn	51	e le	53 <u> </u>	54 Xe
5s1	5s2	4d1	4d2	4d <sup>3</sup>	4d <sup>4</sup>	<b>4 </b>	-de	4d /	4d <sup>8</sup>	4d <sup>y</sup>	4d14	5p	51	5p2	5p P	5p4	5p5	5p <sup>6</sup>
55Cs	56 Ba	71 Lu	72 Hf	73 Ta	74 W	5 Re	6 Os	77 ir	78 Pt	79 Au	80 Hg	81	Т	82 Pb	83 Bi	84 Po	85 At	86 Rn
6s1	6s4	5d4	5d4	5d3	5d4	<u>(12)</u>	do.	5d7	5d8	5d9	5d14	6p	$^{1}$	6p4	6p3	6p4	6pp	бръ
B7Fr	88 Ra	103Lr	104	105	106													
7s1	7s4	6d4	6d4	6d3	6d4													

67 L	a 58 Ce	59 Pr	60 Nd	61 Pm	62Sm	63 Eu	br	D.	65 I.B	66Dy	67 Ho	68Er	69 I.M.	70 Y b
4f1	4f2	4f3 -	4r4 -	4f5 -	4f6 -	4f7	H	8	4f <sup>9</sup>	4f10	4f11	4f12	4f13	4f14
89 A	5 90 Th	91 Pa	92 U	93 No	94 Pu	95 Am	g	Cm	97Bk	98 Cf	99Es	00 Fm	10 IMB	102No
561	5f2	563	564	565	566	567	c	8	569	5f10	5f11	5612	5f13	5f14
21.5	101-	015	101	015	015	01.5	1.2	-	015	01.5	01.55	01.5	01.5	21.5



- Each sublevel contains a different # of orbitals, where the electrons are found 90% of the time
  - Orbitals are 3-D clouds that give volume to the atom
  - Pauli Exclusion Principal: Each orbital can only contain 2 electrons, which have opposing spins

Sublevel	# orbitals	Max # e-
S	1	2
р	3	6
d	5	10
f	7	14









### Locating Electrons

- There are two ways to show where the electrons are found in the atom
  - Electron configurations

5.2

– Orbital filling diagrams

Element	Total	Orbita	Electron		
	Electrons	1s 2s	2p	<b>3</b> s	Configuration
н	1	1			$1s^1$
He	2	11			$1s^{2}$
Li	3	111			$1s^2 2s^1$
Be	4	1111			$1s^2 2s^2$
в	5	1111			$1s^2 2s^2 2p^1$

### Electron Configuration





- Shorthand method for describing the <u>arrangement of electrons</u>
- Composed of the principal energy level followed by the energy sublevel and includes a superscript with the # of electrons in the sublevel

### Electron Configuration

- Electron Configuration is ordered the way you read a book: from <u>left to</u> <u>right and top to bottom</u>
- Note that d orbital is 1 energy level behind and the f orbital is 2 energy levels behind the s & p orbitals

1s	_			<b>1</b> s
2s	]			2p
3s	1			Зр
4s		3d	4p	
5s		4d		5p
	<b>*</b> 4f	5d		6р
7s	<b>*</b> 5f	6d		

4f
5f

### Electron Configuration



- Determine how many <u>electrons</u> in atom
- Fill <u>lowest energy</u> first (using Arrow Diagram)
- Stop when <u>sum of</u>
  <u>subscripts</u> is equal to electrons

The order: 1s<sup>2</sup> 2s<sup>2</sup> 2p<sup>6</sup> 3s<sup>2</sup> 3p<sup>6</sup> 4s<sup>2</sup> 3d<sup>10</sup> 4p<sup>6</sup> 5s<sup>2</sup> 4d<sup>10</sup> 5p<sup>6</sup> 6s<sup>2</sup> 4f<sup>14</sup> 5d<sup>10</sup> 6p<sup>6</sup> 7s<sup>2</sup> 5f<sup>14</sup> 6d<sup>10</sup> 7p<sup>6</sup> etc.



- Hydrogen: 1s<sup>1</sup>
- Oxygen: **1s<sup>1</sup>2s<sup>2</sup>2p<sup>4</sup>**
- Argon: 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup>3s<sup>2</sup>3p<sup>6</sup>
- Copper: 1s<sup>2</sup> 2s<sup>2</sup> 2p<sup>6</sup> 3s<sup>2</sup> 3p<sup>6</sup> 4s<sup>2</sup> 3d<sup>9</sup>