

Announcements

Monday, April 06, 2009

Exam 1 average ~72%. Key will be posted soon.

Discussion assignment 2 is now available. Reserve your topic before class next week (Monday, April 13).

Lecture 8 post and lecture 9 pre assignments due next Monday, April 13.

Atomic line spectra

A **gas lamp** is a sealed glass tube that contains a gas sample, and **glows** when a high voltage is applied to it.



Hg(g)

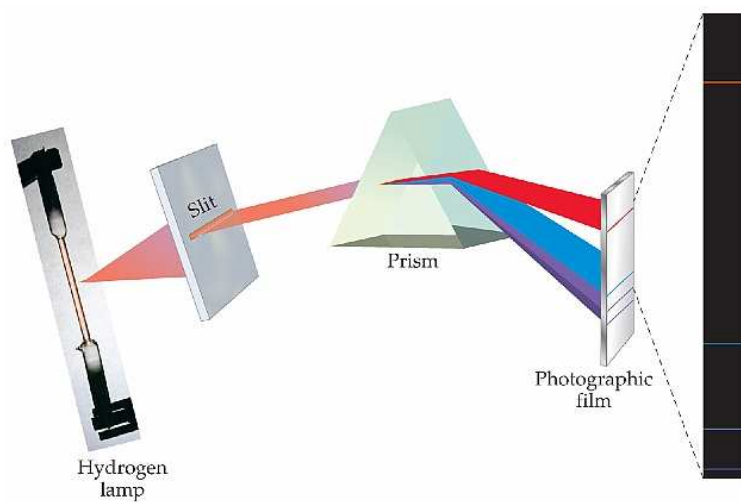


H₂(g)

Copyright © 2009 Pearson Prentice Hall, Inc.

But **only certain wavelengths** of light are given off by a gas lamp.

Compare with the continuous spectrum given off by a white light source like a light bulb.



Atomic line spectra



White-light spectrum



Hydrogen light spectrum



Helium light spectrum



Neon light spectrum

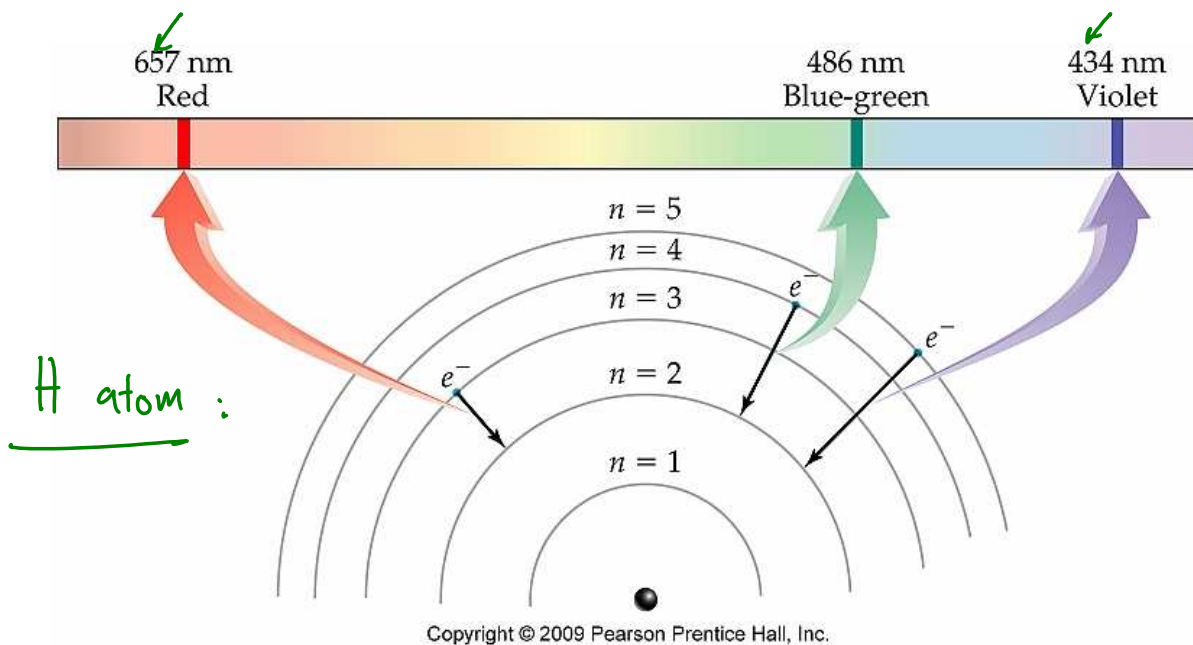
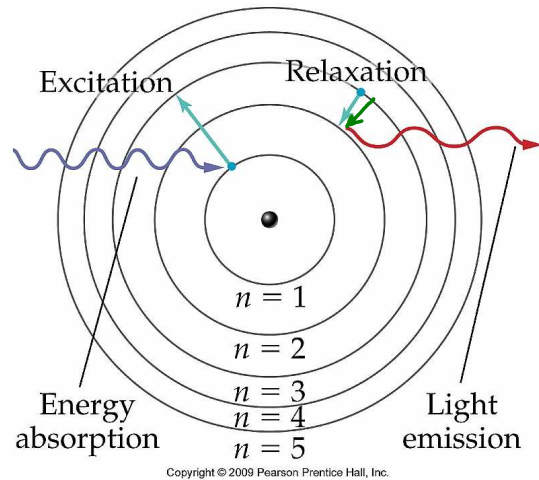
Copyright © 2009 Pearson Prentice Hall, Inc.

Bohr model

Why are only **certain** colors of light given off by a pure gas sample?

The **Bohr model** can help explain why:

- Electrons orbit in specific fixed distances from nucleus, called **shells**
- Electrons **jump** to higher, more distant orbits when they **absorb** energy (excitation)
- They **drop** down to lower orbits when they **give off** energy, usually as **light** (relaxation)



Quantum-mechanical model

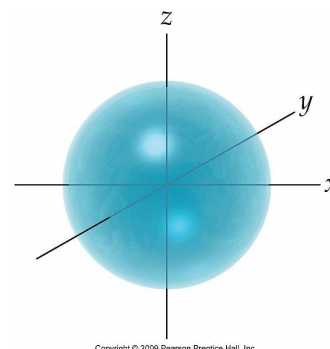
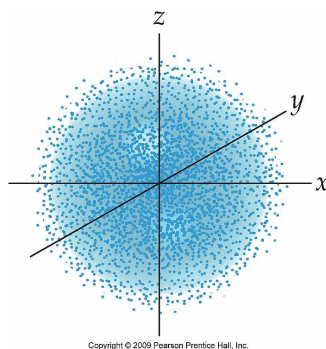
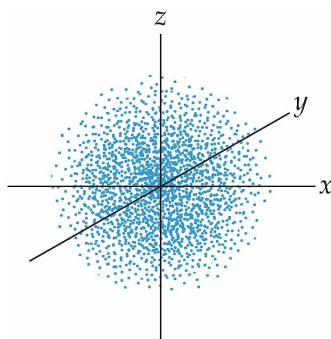
Shortcomings of the Bohr model:

- Can predict the energies of electrons in a hydrogen atom, but not for any other element
- Assumes electrons travel in single circular paths, not likely
- Does not explain periodic table behavior

Quantum mechanical model:

- Assumes electrons can act like particles or waves (supported by experimental evidence)
- Exact position or path of a single electron are impossible to predict
- But, you can predict the probability of finding an electron within a certain space:

Orbital: 3-dimensional shape that defines the **probability** of finding an electron



Shells, subshells, and orbitals

The quantum mechanical model has **shells** like the Bohr model

- $n = 1, 2, 3, 4, \dots$ (principal quantum number)
- As n increases, energy of the electron increases, and **average** distance from the nucleus increases.

But shells alone cannot explain electron behavior.

Each new row on the periodic table is a new shell, and the major sections (main group, transition, etc) each have their own **subshell**.

Each shell has n subshells:

<u>Shell</u>	<u># subshells</u>	<u>Subshell letters</u>
$n = 1$	1	1s
$n = 2$	2	2s, 2p
$n = 3$	3	3s, 3p, 3d
$n = 4$	4	4s, 4p, 4d, 4f

Electron configurations

Period	H							He
1	(1e ⁻)							(2e ⁻)
Period	Li	Be	B	C	N	O	F	Ne
2	(3e ⁻)	(4e ⁻)	(5e ⁻)	(6e ⁻)	(7e ⁻)	(8e ⁻)	(9e ⁻)	(10e ⁻)

If the elements in period 1 have their electrons in the 1s subshell, the s subshell can hold a maximum of 2 electrons.

Electron configuration: subshell^{# e⁻}

H: 1s¹

He: 1s²

Actually, **every s subshell** can hold a max of 2 electrons (including 2s, 3s, 4s, 5s, etc)

In period 2, we fill the 2nd shell (2s and 2p subshells)

Li: 1s² 2s¹

Be: 1s² 2s²

When we cross to a new section on the periodic table, a new subshell is being filled. B-Ne fill into the 2p subshell

B: 1s² 2s² 2p¹

C:

N:

O: 1s² 2s² 2p⁴

F:

Ne: 1s² 2s² 2p⁶

Electron configurations and the rest of the periodic table

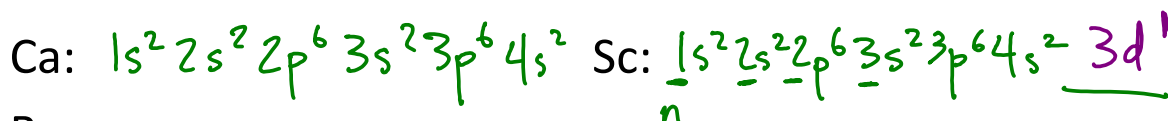
Available subshells to fill:

1s					
2s	2p				
3s	3p	3d			
4s	4p	4d	4f		
5s	5p	5d	5f		
6s	6p	6d			
7s	7p				

	<u>Subshell</u>	<u>Max # e⁻</u>
	s	2
	p	6
	d	10
	f	14

Na:

Ar:



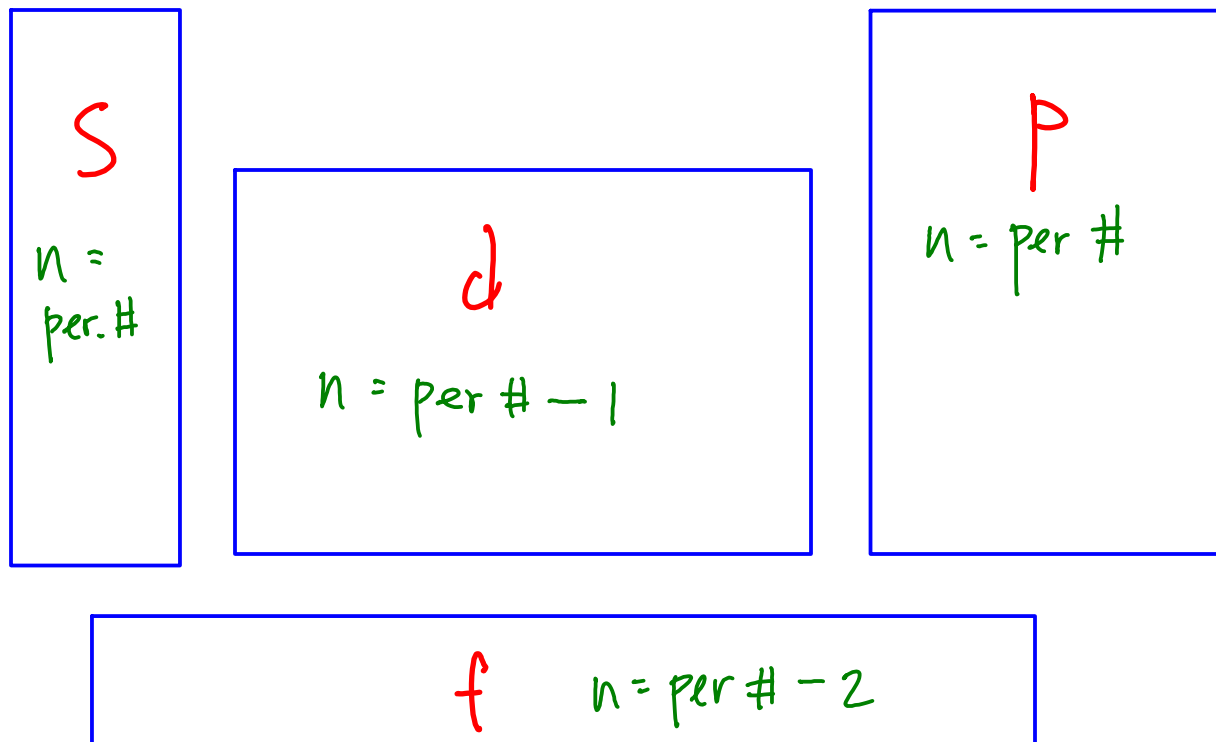
Ba:

Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
IA	IIA	IIIB	IVB	VB	VIB	VII B	VIII B	VIII B	VIII B	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA	
1 H 1.008	2 He 4.003																	
3 Li 6.939	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18	
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95	
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80	
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.96	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.4	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29	
55 Cs 132.91	56 Ba 137.33	57-70 Lanthanides	71 Lu 174.97	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89-102 Actinides	103 Lr (257)	104 Rf (261)	105 Db (262)	106 Sg (271)	107 Bh (272)	108 Hs (270)	109 Mt (276)	110 Ds (281)	111 Rg (280)	112 Uub (285)	113 Uut (284)	114 Uuq (289)	115 Uup (288)	116 Uuh (292)	117 Uuq (293)	118 Uuo (294)
		* La Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb																
		** Ac Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No																

Reference: <http://www.webelements.com>

Sections of the periodic table



Filling order (to check work only!)

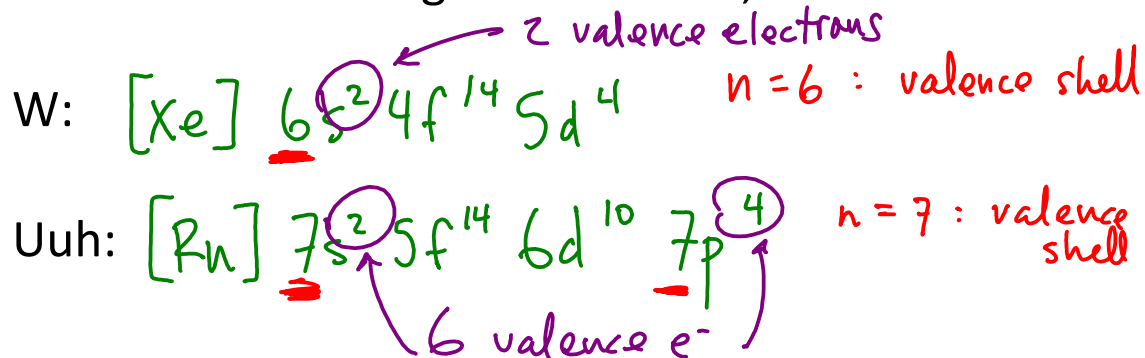
~~1s~~
~~2s 2p~~
~~3s 3p 3d~~
~~4s 4p 4d 4f~~
~~5s 5p 5d 5f~~
~~6s 6p 6d~~
~~7s 7p~~

W: $6s^2 4f^{14} 5d^4$

Abbreviated electron configurations, valence electrons

Noble gases all have full subshells

Abbreviated electron configuration starts with the nearest smaller noble gas in brackets, then continues



Valence electrons: electrons in the outermost shell
(not subshell)

4s subshell is in the $n = 4$ shell

5p subshell is in the $n = 5$ shell

The largest n number in an electron configuration is the valence shell.

Bi:

Br:

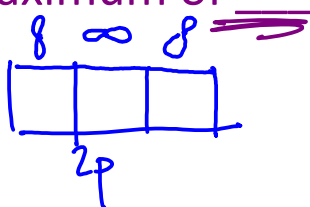
Orbital diagrams

<u>Subshell</u>	<u>Max # e⁻</u>	<u># Orbitals</u>
s	2	1
p	6	3
d	10	5
f	14	7

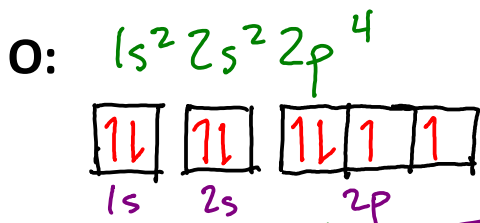
Recall, an orbital is a ... volume inside of which an e⁻ is likely to be found

If an s subshell contains a single orbital, how many orbitals are in a p subshell?

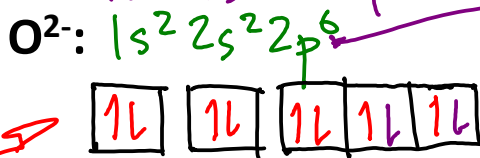
Every orbital holds a maximum of 2 electrons.



Orbital diagrams:

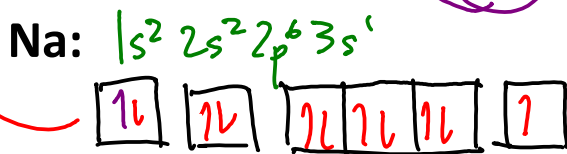


fill 1e⁻ per orbital first before pairing



2 added electrons

stable ion (same e⁻ config as Ne)



Na⁺: loses 1 extra e⁻ Ne e⁻ config