AP Chem - Unit 5 - Homework A

Key

1. Draw atomic orbital diagrams representing the ground state electron configuration for each of the following elements. How many unpaired electrons are present in each element?

   a. Na $\underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}\ \underline{\uparrow}$ — 1 unpaired
   $1s^2\ 2s^2\ 2p^6\ \ 3s^1$

   b. Co $\underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}\ \underline{\uparrow}\ \underline{\uparrow}\ \underline{\uparrow}$ — 3 unpaired
   $[Ar]\ 4s^2\ 3d^7$

   c. Kr $\underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}$ — ∅ unpaired
   $[Ar]\ 4s^2\ \ 3d^{10}\ \ 4p^6$

2. The elements Si, Ga, As, Ge, Al, Cd, S and Se are all used in the manufacture of various semiconductor devices. Write the expected electron configuration for these atoms.

Si: $[Ne]\ 3s^2 3p^2$

Al: $[Ne]\ 3s^2 3p^1$

Ga: $[Ar]\ 4s^2 3d^{10} 4p^1$

Cd: $[Kr]\ 5s^2 4d^{10}$

Ge: $[Ar]\ 4s^2 3d^{10} 4p^2$

S: $[Ne]\ 3s^2 3p^4$

As: $[Ar]\ 4s^2 3d^{10} 4p^3$

Se: $[Ar]\ 4s^2 3d^{10} 4p^4$

3. Write the expected ground state electron configuration for the following:

   a. The element with one unpaired 5p electron that forms a covalent with compound fluorine.

   I: $[Kr]\ 5s^2 4d^{10} 5p^5$ $\underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}\ \underline{\uparrow}$ ← nonmetal!

   b. The undiscovered alkaline earth metal after radium ← group 2

   X: $[Rn]\ 7s^2 5f^{14} 6d^{10} 7p^6 8s^2$

   c. The noble gas with electrons occupying 4f orbitals ← n=6

   Rn: $[Xe]\ 6s^2 4f^{14} 5d^{10} 6p^6$

   d. The first row transition metal with the most unpaired electrons. $\underline{\uparrow}\ \ \underline{\uparrow}\ \underline{\uparrow}\ \underline{\uparrow}\ \underline{\uparrow}\ \underline{\uparrow}$

Cr → exception in predicated filling order
Due to lower e^-/e^- Repulsion Cr: $[Ar]\ 4s^1\ 3d^5$ — 6 unpaired

Key

4. Consider the ground state electron configurations for Li, N, Ni, Te, Ba, and Hg. Which of these atoms would be expected to be paramagnetic, and how many unpaired electrons are present in each paramagnetic atom?

↳ Attracted to magnetic field ∴ has unpaired e's

	Paramagnetic	# unpaired e's
Li: $1s^2 2s^2 2p^6 \underline{3s^1}$	yes	1
N: $\underline{1}\ \underline{1}\ \underline{1}$ $1s^2 2s^2 2p^3$	yes	3
Ni: $\underline{1}\ \underline{1}\ \underline{1}\ \underline{1}\ \underline{1}$ [Ar] $4s^2\ 3d^8$	yes	2
Te: [Kr] $5s^2 4d^{10}$ $\underline{1}\ \underline{1}\ 1\ 1$ $5p^4$	yes	2
Ba: [Xe] $6s^2$	NO	∅
Hg: [Xe] $6s^2 4f^{14}$ $\underline{1}\ \underline{1}\ \underline{1}\ \underline{1}\ \underline{1}$ $5d^{10}$	NO	∅

5. What are the possible values for the quantum numbers n, ℓ, and m_ℓ?

$n = 1, 2, 3, 4 \ldots \infty$

$\ell = (n-1) = 0, 1, 2, 3, \ldots$

$m_\ell = -\ell \ldots -2, -1, 0, +1, +2, \ldots +\ell$

6. Which of the following sets of quantum numbers are not allowed in the hydrogen atom? For the sets of quantum numbers that are incorrect, state what is wrong in each set.

a. $n = 3, \ell = 2, m_\ell = 2$ Allowed

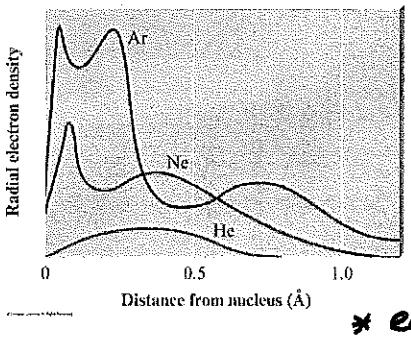
b. $n = 4, \ell = 3, m_\ell = 4$ $\ell = 3 \therefore m_\ell = -3, -2, -1, 0, 1, 2, 3$ +4 not Allowed

c. $n = 0, \ell = 0, m_\ell = 0$ n can not = 0

d. $n = 2, \ell = -1, m_\ell = 1$ ℓ can not be a negative number

KEY

7. Total radial probability distributions for the helium, neon, and argon atoms are shown in the following graph. How can one interpret the shapes of these curves in terms of electron configurations, quantum numbers and nuclear charges?



H $1s^2$

Ne $1s^2 2s^2 2p^6$

Ar $1s^2 2s^2 2p^6 3s^2 3p^6$ - Subshells are closer to nucleus because of ↑ nuclear charge

* each peak in the diagram corresponds to a subshell with different values of n.

↑ Atomic # more P^+

8. How many orbitals in an atom can have the designation 5p, 4d, n=5, n=4?

5p = 3 orbitals

4d = 5 orbitals

$\ell = n-1$

n = 5		# orbitals
ℓ = 0	s	1
ℓ = 1	p	3
ℓ = 2	d	5
ℓ = 3	f	7
ℓ = 4	g	9

/ 25 orbitals

n = 4		# orbitals
ℓ = 0	s	1
ℓ = 1	p	3
ℓ = 2	d	5
ℓ = 3	f	7

/ 16 orbitals

9. Give the max number of electrons in an atom that can have these quantum numbers:

a. $n = 4$, $\ell = n-1$

		# e
ℓ = 0	s	2
ℓ = 1	p	6
ℓ = 2	d	10
ℓ = 3	f	14

> 32 electrons

b. $n = 5$, $m_\ell = +1$

c. $n = 5$, $m_\ell = +\frac{1}{2}$

d. $n = 3$, $\ell = 2$

e. $n = 2$, $\ell = 1$

(B) n = 5, m_ℓ = +1

					# e
ℓ = 0	s	no +1			0
ℓ = 1	p	−1	0	+1	2
ℓ = 2	d	−2	−1	0 +1 +2	2
ℓ = 3	f		0	+1	2
ℓ = 4	g		0	+1	2

8e

(C) n = 5, m_ℓ = +½

From #B there are 25 orbitals ∴ 50 electrons

↑ 1e in each orbital +½, -½

½ will spin w/ +½ so 25 e's

(D) n = 3, ℓ = 2

ℓ = 0

ℓ = 1

ℓ = 2 d ↑↓ ↑↓ ↑↓ ↑↓ ↑↓

10 e's

(E) n = 2, ℓ = 1

ℓ = 0 s

ℓ = 1 p ↑↓ ↑↓ ↑↓

6 e's

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10. Find the quantum numbers for the outermost valance electron the following:

.. -2 -1 0 +1 +2 ... +½ -½

		n	l	m_l	m_s
ℓ=0 s	a. Mg $\uparrow\downarrow$ (0) [Ne] $4s^2$	4	0	0	-½
ℓ=1 p					
ℓ=2 d	b. Fe $\uparrow\downarrow$ $\uparrow\downarrow$ $\uparrow$ $\uparrow$ $\uparrow$ (-2 -1 0 +1 +2) [Ar] $4s^2 3d^6$	3	2	-2	-½
ℓ=3 f					
	c. Se $\uparrow\downarrow$ $\uparrow$ $\uparrow$ (-1 0 +1) [Ar] $4s^2 3d^{10} 4p^4$	4	1	-1	-½