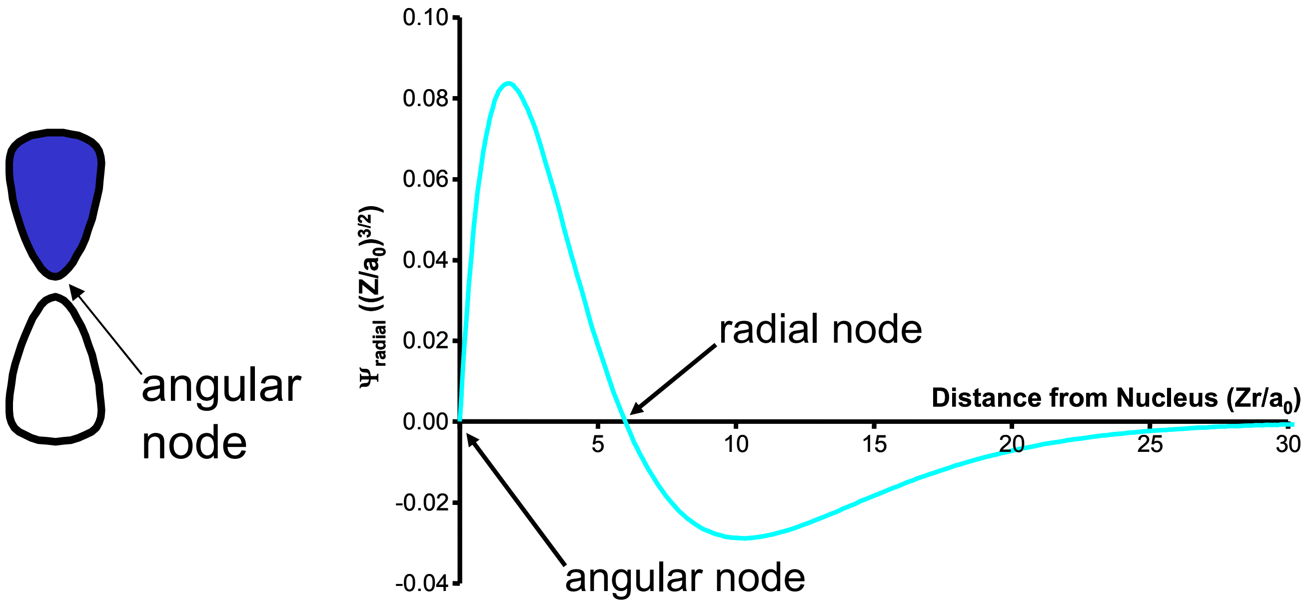
**CHEM 121**
**Spring 2006**
**Quiz 2**

Name: ______________________________________________

1a. (10 Points) The angular and radial portions of a certain orbital are shown below.




a. Clearly indicate the position of any angular nodes on the above diagrams.

b. Clearly indicate the position of any radial nodes on the above diagrams.

c. What is meaning of the shading on the portion of the wavefunction on the left?

> **The shading indicates the difference in phase for the angular portion of the wavefunction.**

d. Fill in the blanks.

> For this orbital $\ell$ = **1**.
>
> For this orbital n = **3**.
>
> The name of this orbital is **3p**.

Continued on reverse →

3. (15 Points) The electron in a hydrogen atom is excited from the ground state to an excited state where $n = 3$. Which of the following statements are true? Correct any false statements.
a. It takes more energy to ionize the electron from $n = 3$ than from the ground state.

**False. It takes less energy to ionize (remove) the electron from $n = 3$ than the ground state ($n = 1$) because some of the energy to ionize the electron from the ground state has already been paid to get to $n = 3$.**

b. The electron is farther from the nucleus on average in one of the $n = 3$ orbitals than in the ground state.

**True.**

c. The wavelength of light emitted if the electron drops from $n = 3$ to $n = 2$ is shorter than the wavelength of light emitted if the electron falls from $n = 3$ to $n = 1$.

**False. The energy difference between $n = 3$ to $n = 2$ is smaller than the energy difference between $n = 3$ to $n = 1$. Since energy is indirectly proportional to wavelength (smaller energies correspond to longer wavelengths), the wavelength of light emitted when the electron drops from $n = 3$ to $n = 2$ is longer than the wavelength of light emitted if the electron falls from $n = 3$ to $n = 1$**

d. The wavelength of light emitted when the electron returns to the ground state from $n = 3$ is the same as the wavelength of light absorbed to go from $n = 1$ to $n = 3$.

**True.**

e. The first excited state corresponds to $n = 3$.

**False. The first excited state is the one whose energy is lowest, which is the one where the electron has $n = 2$.**

4. (4 Points) Fill in the blanks.

| Name | Chemical Formula |
|---|---|
| **cobalt(III) sulfide** | $Co_2S_3$ |
| **potassium iodate** | $KIO_3$ |
| **aluminum sulfite** | $Al_2(SO_3)_3$ |
| **strontium nitride** | $Sr_3N_2$ |

5. (10 Points) Please attach problem 8-32 to this sheet.

*This problem is most easily solved by performing the stoichiometry problem first (which gives new [F⁻] and [HF]) and then the equilibrium problem.*

*$F^-$ is a weak base and it will react with an acid to give its conjugate acid, as shown below.*

**$F^-$ (aq) + $H^+$ (aq) → HF (aq)**

*This is a limiting reagent problem, so determine whether the $F^-$ or the $H^+$ is limiting.*

$$100.0\ \text{mL}\left(\frac{0.100\ \text{mmole F}^-}{1\ \text{mL}}\right)\left(\frac{1\ \text{mmole HF}}{1\ \text{mmole F}^-}\right)=10.0\ \text{mmole HF}$$

$$100.0\ \text{mL}\left(\frac{0.025\ \text{mmole H}^+}{1\ \text{mL}}\right)\left(\frac{1\ \text{mmole HF}}{1\ \text{mmole H}^+}\right)=2.5\ \text{mmole HF}$$

**Since the amount of HF formed if all of the $H^+$ reacts is smaller than if all of the $F^-$ reacts, $H^+$ is the limiting reagent. Therefore, when the reaction is complete there will no $H^+$ left and 2.5 mmole HF formed.**

*The amount of $F^-$ is the initial amount minus what reacted. The initial amount is*

$$100.0\ \text{mL}\left(\frac{0.100\ \text{mmole F}^-}{1\ \text{mL}}\right)=10.0\ \text{mmole F}^-$$

*The amount that reacted is*

$$100.0\ \text{mL}\left(\frac{0.025\ \text{mmole H}^+}{1\ \text{mL}}\right)\left(\frac{1\ \text{mmole F}^-}{1\ \text{mmole H}^+}\right)=2.5\ \text{mmole F}^-$$

*The amount of $F^-$ left is*

10.0 mmole $F^-$ - 2.5 mmole $F^-$ = 7.5 mmole $F^-$

*The concentrations of $F^-$ and HF present once the reaction is over are*

$$\frac{7.5\ \text{mmole F}^-}{200.0\text{mL}}=0.037_5\ \text{M F}^-$$

$$\frac{2.5\ \text{mmole HF}}{200.0\text{mL}}=0.012_5\ \text{M HF}$$

*Now set up the equilibrium that occurs. Note that we have a solution that contains a mixture of a weak acid and its conjugate base (or a weak base and its conjugate acid). This is potentially a buffer. Check the ratio of [F⁻] to [HF]. If this ratio is between 0.1 and 10, then we have a buffer and we can use the Henderson-Hasselbalch equation.*

$$\frac{0.037_5 \text{ M F}^-}{0.012_5 \text{ M HF}} = 3.0$$

**This ratio falls in the region where a buffer will occur. So, we can use the Henderson-Hasselbalch equation.**

$$\text{pH} = \text{pK}_\text{a} + log\left(\frac{[\text{F}^-]}{[\text{HF}]}\right)$$

**For HF $K_a = 7.2 \times 10^{-4}$. So, its $pK_a$ is $3.14_2$.**

*Substituting everything into the Henderson-Hasselbalch equation gives*

$$\text{pH} = 3.14_2 + log\left(\frac{0.037_5}{0.012_5}\right) = 3.14_2 + log(3.0_0) = 3.14_2 + 0.47_7 = 3.62$$

**The pH of the resulting solution is 3.62.**

*Note that you could have also considered the equilibrium to be*

$F^-$ (aq) + $H_2O$ (l) ⇋ HF (aq) + $OH^-$ (aq)

*and then used the Henderson-Hasselbalch equation written in terms of the fluoride ion's $pK_b$. The answer would have been the same, as it has to be.*