This exam is composed of 25 questions. Go initially through the exam and answer the questions you can answer quickly. Then go back and try the ones that are more challenging to you and/or that require calculations.

As discussed on the course syllabus, honesty and integrity are absolute essentials for this class. In fairness to others, dishonest behavior will be dealt

$$
\begin{array}{ll}
E=h v=\frac{h c}{\lambda} & h=6.626 \times 10^{-34} J S \\
1 \mathrm{~mL}=1 \mathrm{~cm}^{3} & c=2.998 \times 10^{8} \mathrm{~ms}^{-1}
\end{array}
$$ with to the full extent of University regulations.

1. Which of the following has the shortest bond length?
1) NaI
2) NaBr
3) NaCl
4) NaF
2. Which of the following has the lowest bond energy?
1) HF
2) HCl
3) HBr
4) HI
3. Which of the following has the shortest bond length?
1) $B_{2}$
2) $\mathrm{C}_{2}$
3) $\mathrm{N}_{2}$
4) $\mathrm{O}_{2}$
5) $\mathrm{F}_{2}$
4. The CO bond in the molecule $\mathrm{CH}_{3} \mathrm{OH}$ is best described as a :
1) triple bond
2) double bond
3) single bond
4) ionic bond
5) the molecule doesn't exist
5. Draw the Lewis structure for $\mathbf{O}_{2}{ }^{-}$. Draw a stable resonance structure that provides a full octet to each O . In this resonance structure, what is the bond order for the OO bond?
1) single
2) double
3) triple
6. Using the simplified molecular orbital diagram at right, predict the true bond order in $\mathbf{O}_{\mathbf{2}}{ }^{-}$.
1) single
2) double
3) 1.5
4) 2.5
5) triple

7. Draw a stable resonance structure for $\mathbf{N O}_{2}{ }^{-}$. (one that provides a full octet to each atom). In this resonance structure, what are the bond orders for the NO bonds?
1) two single
2) two double
3) two triple
4) one single, one double
5) one double, one triple
8. In the molecule $\mathbf{N O}_{2}^{-}$, the actual bond order for each NO bond is:
1) 1
2) 2
3) 3
4) 1.5
5) 1 for one bond and 2 for the other
9. In the molecule $\mathbf{N O}_{2}^{-}$, the actual charge on each O is:
1) 0
2) +1
3) -1
4) -0.5
5) -1 for one O and 0 for the other O
$\qquad$
10. Draw the Lewis structure for $\mathbf{I F}_{\mathbf{5}}$. The molecular geometry is:
1) square planar
2) square pyramidal
3) trigonal bipyramidal
4) octahedral
5) none of the above
11. The molecule $\mathbf{I F}_{\mathbf{5}}$ is:
1) polar
2) nonpolar
3) can't tell
12. In $\mathbf{I} \mathbf{F}_{5}$, what is the hybridization on $\mathbf{I}$ ?
1) $\mathrm{sp}^{3} d^{3}$
2) $s p^{3} d^{2}$
3) $\mathrm{sp}^{3} \mathrm{~d}$
4) $\mathrm{sp}^{3}$
5) $\mathrm{sp}^{2}$
13. The picture at right depicts which type of orbital hybridization?
1) sp
2) $\mathrm{sp}^{2}$
3) $\mathrm{sp}^{3}$
4) $\mathrm{sp}^{4}$

14. In the orbital hybridization above, how many atomic orbitals were used to create the resulting molecular orbitals?
1) 1
2) 2
3) 3
4) 4
5) 5
15. A molecule has $\mathrm{sp}^{3} \mathrm{~d}$ hybridization with one lone pair. The electron pair geometry of this molecule is:
1) tetrahedral
2) octahedral
3) linear
4) square pyramidal
5) trigonal bipyramidal
16. What hybrid orbitals make up the sigma bond between $\mathbf{C} 1$ and $\mathbf{C} \mathbf{2}$ in propylene, $\mathbf{C H}_{2} \mathbf{C H C H}_{3}$ ?
1) $s p \& p^{3}$
2) $s p \& p^{2}$
3) $\mathrm{sp}^{2} \& \mathrm{sp}^{3}$
4) $\mathrm{sp}^{2} \& \mathrm{sp}^{2}$
5) $\mathrm{sp}^{3} \& \mathrm{sp}^{3}$
$\qquad$
17. Which of the following molecular orbital representations correctly describes $\mathrm{N}_{2}{ }^{+}$?






(1)

(2)

(3)

(4)

(5)
18. From molecular orbital theory, the bond order in $\mathrm{N}_{2}{ }^{+}$is:
1) single
2) double
3) 0.5
4) 1.5
5) 2.5
19. Consider the molecular orbital diagram shown at right: This energy diagram best describes:
1) $\mathrm{O}_{2}$
2) $\mathrm{NO}^{-}$
3) $\mathrm{NO}^{+}$
4) $\mathrm{N}_{2}$

20. In the diagram at right, the $\pi$ bonding orbitals are best described as:
1) all O
2) all N
3) more $O$ than $N$
4) more $N$ than $O$
5) equal mixture of O and N

21. Using molecular orbital theory, what is the bond order in the anion $\mathbf{N}_{\mathbf{2}}{ }^{+}$?
1) 1
2) 1.5
3) 2
4) 2.5
5) 3
$\qquad$

## Solubility Rules for some ionic compounds in water

## Soluble Ionic Compounds

1. All sodium $\left(\mathrm{Na}^{+}\right)$, potassium $\left(\mathrm{K}^{+}\right)$, and ammonium $\left(\mathrm{NH}_{4}^{+}\right)$salts are SOLUBLE.
2. All nitrate $\left(\mathrm{NO}_{3}^{-}\right)$, acetate $\left(\mathrm{CH}_{3} \mathrm{CO}_{2}^{-}\right)$, chlorate $\left(\mathrm{ClO}_{3}^{-}\right)$, and perchlorate $\left(\mathrm{ClO}_{4}^{-}\right)$salts are SOLUBLE.
3. All chloride $\left(\mathrm{Cl}^{-}\right)$, bromide $\left(\mathrm{Br}^{-}\right)$, and iodide $\left(\mathrm{I}^{-}\right)$salts are SOLUBLE -- EXCEPT those also containing: lead, silver, or mercury (I) $\left(\mathrm{Pb}^{2+}, \mathrm{Ag}^{+}, \mathrm{Hg}_{2}{ }^{2+}\right)$ which are NOT soluble.
4. All sulfate $\left(\mathrm{SO}_{4}{ }^{2-}\right)$ salts are SOLUBLE - - EXCEPT those also containing: calcium, silver, mercury (I), strontium, barium, or lead $\left(\mathrm{Ca}^{2+}, \mathrm{Ag}^{+}, \mathrm{Hg}_{2}{ }^{2+}, \mathrm{Sr}^{2+}, \mathrm{Ba}^{2+}, \mathrm{Pb}^{2+}\right)$ which are NOT soluble.

## Not Soluble Ionic Compounds

5. Hydroxide $\left(\mathrm{OH}^{-}\right)$and oxide $\left(\mathrm{O}^{2-}\right)$ compounds are NOT SOLUBLE -- EXCEPT those also containing: sodium, potassium, or barium $\left(\mathrm{Na}^{+}, \mathrm{K}^{+}, \mathrm{Ba}^{2+}\right)$ which are soluble.
6. Sulfide ( $\mathrm{S}^{2-}$ ) salts are NOT SOLUBLE -- EXCEPT those also containing: sodium, potassium, ammonium, or barium $\left(\mathrm{Na}^{+}, \mathrm{K}^{+}, \mathrm{NH}^{+}, \mathrm{Ba}^{2+}\right)$ which are soluble.
7. Carbonate $\left(\mathrm{CO}_{3}{ }^{2-}\right)$ and phosphate $\left(\mathrm{PO}_{4}{ }^{3-}\right)$ salts are NOT SOLUBLE -- EXCEPT those also containing: sodium, potassium, or ammonium $\left(\mathrm{Na}^{+}, \mathrm{K}^{+}, \mathrm{NH}_{4}{ }^{+}\right)$, which are soluble.
8. Mixing $\mathbf{N a}_{\mathbf{2}} \mathbf{C O}_{\mathbf{3}}$ with $\mathbf{K C l}$ in water leads to precipitation of:
1) a $\mathrm{CO}_{3}{ }^{2-}$ salt
2) $\mathrm{a} \mathrm{Na}^{+}$salt
3) $\mathrm{aCl}^{-}$salt
4) everything precipitates
5) no precipitation
23. Write the balanced, net ionic equation corresponding to the unbalanced equation:

$$
\mathrm{AlCl}_{3}+\mathrm{Na}_{3} \mathrm{PO}_{4} \rightarrow \mathrm{AlPO}_{4}+\mathrm{NaCl}
$$

The coefficient in front of $\mathbf{N a}^{+}(\mathrm{aq})$ is:

1) 1
2) 2
3) 3
4) 4
5) $0\left(\mathrm{Na}^{+}\right.$doesn't occur in the net ionic equation)
$\qquad$
24. Write the balanced, net ionic equation corresponding to the unbalanced equation:

$$
\mathrm{CaCl}_{2}+\mathrm{Na}_{2} \mathrm{CO}_{3} \rightarrow \mathrm{CaCO}_{3}+\mathrm{NaCl}
$$

In the net ionic equation, the coefficient in front of $\mathbf{C a}^{2+}(\mathrm{aq})$ is:

1) 1
2) 2
3) 3
4) 4
5) $0\left(\mathrm{Ca}^{2+}\right.$ doesn't occur in the net ionic equation)
25. The correct designator for this course is:
1) Econ 3.33
2) Chem 363
3) Chem 111
4) Sports 01

PERIODIC TABLE OF THE ELEMENTS

| 1A | 2A | 3B | 4B | 5B | 6B | 7B | 8B | 8B | 8B | 1B | 2B | 3A | 4A | 5A | 6A | 7A | 8A |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{array}{\|l\|l\|} \hline 1 \\ \mathbf{H} \\ \hline 1.008 \end{array}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | He <br> 4.003 |
| $\begin{array}{\|l\|l} \mathbf{3} \\ \mathbf{L i} \\ 6.939 \end{array}$ | Be <br> 9.012 |  |  |  |  |  |  |  |  |  |  | $\begin{array}{\|l\|} \hline 5 \\ \hline \end{array}$ | ${ }^{6} \mathrm{C}$ $\begin{array}{\|l\|l\|} \hline 12.01 \\ \hline \end{array}$ | $\begin{gathered} { }^{7} \mathbf{N} \\ 14.01 \end{gathered}$ | 8 <br> 0 <br> 16.00 | $\begin{array}{\|l\|} \hline 9 \\ \mathbf{F} \\ 19.00 \\ \hline \end{array}$ | 10 <br> Ne <br> 20.18 |
| $\begin{aligned} & 11 \\ & \mathrm{Na} \\ & { }_{22}, 9 \end{aligned}$ | ${ }_{12}^{12} \mathrm{Mg}$ <br> 24.31 |  |  |  |  |  |  |  |  |  |  | $\begin{gathered} 13 \\ \text { Al } \\ 26.98 \\ \hline \end{gathered}$ | $\begin{aligned} & 14 \\ & \mathbf{S i} \\ & 28.09 \end{aligned}$ | $\begin{aligned} & 15 \\ & \mathbf{P} \end{aligned}$ $30.97$ | $\begin{array}{\|l\|l} \hline 16 \\ \mathbf{S} \\ 32.07 \\ \hline \end{array}$ | $\begin{aligned} & { }^{17} \mathbf{C l} \\ & 35.45 \end{aligned}$ | 18 <br> Ar <br> 39.95 |
| 19 K 39.10 | 20 <br> Ca <br> 40.08 | $\begin{aligned} & \mathbf{2 1}_{\mathbf{S c}} \end{aligned}$ $44.96$ | $\begin{aligned} & \hline 22 \\ & \mathbf{T i} \\ & 47.90 \end{aligned}$ | $\begin{aligned} & { }_{23}^{23} \\ & \mathbf{V} \\ & 50.94 \end{aligned}$ | $\begin{aligned} & \begin{array}{l} 24 \\ \mathbf{C r} \\ 52.00 \end{array} \\ & \hline \end{aligned}$ | $\begin{array}{\|l\|} \hline \mathbf{2 5} \\ \mathbf{M n} \\ s_{4} \end{array}$ | $26$ <br> Fe <br> 55.85 | $\begin{array}{\|l\|} \hline 27 \\ \mathbf{C o} \end{array}$ $58.93$ | $\begin{array}{\|l\|} \hline 28 \\ \mathbf{N i} \\ \text { nis } \\ 58.71 \end{array}$ | $\begin{array}{\|l\|l} \hline 29 \\ \mathbf{C u} \\ 6.55 \\ \hline \end{array}$ | $\begin{array}{\|l} 30 \\ \mathbf{Z n} \\ 60.39 \end{array}$ | $\begin{array}{\|l} 31 \\ \mathbf{G a} \end{array}$ $69,72$ | $\begin{array}{\|l\|} \hline 32 \\ \mathbf{G e} \\ \hline 72.61 \\ \hline \end{array}$ | 33 <br> As <br> 74.92 | $\begin{array}{\|l} 34 \\ \mathbf{3 4} \\ \hline \end{array}$ $78.96$ | $\begin{array}{\|l} \hline 35 \\ \mathbf{B r} \\ \hline \end{array}$ | $\begin{aligned} & \begin{array}{l} \mathbf{3 6} \\ \mathbf{K r} \\ 83.80 \end{array} \\ & \hline \end{aligned}$ |
| $\begin{array}{\|l} \hline 37 \\ \mathbf{R b} \end{array}$ $85.47$ | 38 <br> Sr <br> 87.62 | $\begin{gathered} \begin{array}{c} 39 \\ \mathbf{Y} \\ 88.91 \\ \hline \end{array} \end{gathered}$ | 40 <br> Zr <br> 91.22 | $\begin{aligned} & \mathbf{4 1}_{\mathbf{N b}} \\ & 92.91 \end{aligned}$ | $\begin{array}{\|l\|} \hline 42 \\ \text { Mo } \\ 95.94 \\ \hline \end{array}$ | $\begin{aligned} & \hline \begin{array}{l} 43 \\ \mathbf{T c} \end{array}, ~ \end{aligned}$ $(99)$ | $\begin{aligned} & 44 \\ & \mathbf{R u} \end{aligned}$ $101.1$ | $\begin{aligned} & \text { 45 } \\ & \text { Rh } \end{aligned}$ $102.9$ | $\stackrel{46}{\text { Pd }}$ <br> 106.4 | 47 <br> Ag <br> 1079 | $\begin{array}{\|l} \hline 48 \\ \mathbf{C d} \end{array}$ $112.4$ | 49 <br> In <br> 114.8 | $\begin{array}{\|l} \hline \mathbf{5 0} \\ \mathbf{S n} \\ 118.7 \\ \hline \end{array}$ | $\stackrel{51}{\mathbf{S b}}$ <br> 121.8 | $\begin{aligned} & \text { 52 } \\ & \text { Te } \end{aligned}$ $127.6$ | $\begin{array}{\|l} \hline 53 \\ \mathbf{I} \\ 126.9 \\ \hline \end{array}$ | ${ }^{54} \mathrm{Xe}$ |
| $\begin{array}{\|l} \hline 55 \\ \mathbf{C s} \\ 132.9 \\ \hline \end{array}$ | $\begin{gathered} 56 \\ \mathbf{B a} \\ 137.3 \\ \hline \end{gathered}$ | $\begin{aligned} & 57 \\ & \mathrm{La} \\ & 138.9 \end{aligned}$ | $\begin{aligned} & 72 \\ & \mathbf{H f} \\ & 178.5 \end{aligned}$ | $\begin{aligned} & 73 \\ & \mathbf{T a} \\ & 181.0 \end{aligned}$ | $\begin{gathered} 74 \\ \mathbf{W} \\ 183.8 \\ \hline \end{gathered}$ | $\begin{aligned} & 75 \\ & \mathbf{R e} \end{aligned}$ $186.2$ | $\begin{array}{\|l} \begin{array}{l} 76 \\ \text { Os } \\ 190.2 \\ \hline \end{array} \\ \hline \end{array}$ | Ir $\qquad$ | $\begin{array}{\|l} \hline 78 \\ \mathbf{P t} \\ 195.1 \\ \hline \end{array}$ | $\begin{aligned} & 79 \\ & \mathbf{A n} \mathbf{u} \\ & 197.0 \end{aligned}$ | $\begin{array}{\|l} 80 \\ \mathbf{H g} \end{array}$ $200.6$ | $\begin{array}{\|l\|} \hline 81 \\ \mathbf{T l} \\ 204.4 \\ \hline \end{array}$ | $\begin{aligned} & \mathbf{8 2} \\ & \mathbf{P b} \end{aligned}$ $\begin{array}{\|l\|} \hline 207.2 \\ \hline \end{array}$ | ${ }_{8}^{83}$ <br> 209.0 | $\begin{aligned} & \text { 84 } \\ & \text { Po } \end{aligned}$ (209) | $\begin{array}{\|l} \hline 85 \\ \mathbf{A t} \\ (210) \\ \hline\left(\begin{array}{l} \end{array}\right. \\ \hline \end{array}$ | $\begin{aligned} & \begin{array}{l} 86 \\ \mathbf{R n} \\ (222) \end{array} \\ & \hline \end{aligned}$ |
| $\begin{array}{\|l\|l} 87 \\ \mathbf{F r} \\ \hline(223) \\ \hline \end{array}$ | $88$ <br> Ra <br> 226.0 | 89 <br> Ac <br> 227.0 | $\begin{aligned} & \hline 104 \\ & \text { Unq } \end{aligned}$ (261) | $\begin{aligned} & \hline 105 \\ & \text { Unp } \\ & \hline(262) \\ & \hline \end{aligned}$ | 106 <br> Unh <br> (263) | $\begin{array}{\|l} \hline 107 \\ \text { Uns } \\ \hline 1262) \\ \hline \end{array}$ | $\begin{array}{\|l\|} \hline 108 \\ \text { Uno } \\ \hline(265) \end{array}$ | $\begin{array}{\|l\|} \hline 109 \\ \text { Une } \end{array}$ (266) |  |  |  |  |  |  |  |  |  |

