This exam is composed of 25 questions, 1 of which requires mathematics that might require a calculator.

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 in the course syllabus, honesty and integrity are absolute essentials for this class. In fairness to others, dishonest behavior will be dealt with to the full extent of University regulations.

I hereby state that all answers on this exam are my own and that I have neither gained unfairly from others nor have I assisted others in obtaining an unfair advantage on this exam.

________________________________
Signature

\[ E = h \nu = \frac{hc}{\lambda} \]
\[ E_{n-\text{atom}}^H = -\frac{R_H hc}{n^2} \]

1 mL = 1 cm³

Some common ions:
- \( \text{PO}_4^{3-} \)
- \( \text{CN}^- \)
- \( \text{CH}_3\text{CO}_2^- \)
- \( \text{NO}_2^- \)
- \( \text{NO}_3^- \)
- \( \text{CO}_3^{2-} \)
- \( \text{SO}_3^{2-} \)
- \( \text{SO}_4^{2-} \)

\[ h = 6.626 \times 10^{-34} \text{ J s} \]
\[ c = 2.9998 \times 10^8 \text{ m s}^{-1} \]
\[ N = 6.022 \times 10^{23} \text{ mol}^{-1} \]
\[ R_H = 1.097 \times 10^7 \text{ m}^{-1} \]
1. The energy level denoted “a” refers to:
   1) a bonding molecular orbital
   2) a nonbonding molecular orbital
   3) an antibonding molecular orbital
   4) an atomic orbital

2. The energy level denoted “i” refers to:
   1) sigma bonding molecular orbitals
   2) pi bonding molecular orbitals
   3) atomic orbitals
   4) sigma antibonding molecular orbitals
   5) pi antibonding molecular orbitals

3. The electrons in the orbital represented by energy level “f”:
   1) are distributed more toward X
   2) are distributed more toward Y
   3) are equally distributed between X and Y

4. If the letter designations represent energies of the orbitals, then:
   \[ a + d = \]
   1) f - e
   2) e - f
   3) e + f
   4) none of these

5. The diatomic XY is CN\(^+\). What is the overall diatomic bond order?
   1) 1.0
   2) 1.5
   3) 2.0
   4) 2.5
   5) 3.0

6. The diatomic XY is CN\(^+\). The nitrogen atomic orbitals are represented by:
   1) X
   2) Y
   3) XY
7. The picture at right depicts which type of orbital hybridization?
   1) p  2) sp  3) sp$^2$  4) sp$^3$
   5) none of the above

8. 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

9. In the molecule 2-pentene, shown at right, the carbon labeled (4) has what hybridization?
   1) sp  3) sp$^3$
   2) sp$^2$  4) sp$^4$

10. The angle describing C$_3$-C$_4$-C$_5$ (centered on carbon 4) is approximately:
    1) 109.5°  2) 120°  3) 180°  4) 90°

11. A central atom in a molecule has an octahedral electron pair geometry. What is the orbital hybridization on that atom?
    1) sp  2) sp$^2$  3) sp$^3$  4) sp$^3$d  5) sp$^3$dt$^2$

12. Trendy anti-wrinkle creams advertise the presence of “alpha hydrox” as a key component. A structure of an alpha hydroxy acid is shown at right. In this molecule, what is the hybridization at the carbonyl oxygen? Hint: all C and O atoms have complete octets.
    1) sp  2) sp$^2$  3) sp$^3$  4) sp$^3$d  5) sp$^3$d$^2$
Solubility Rules for some ionic compounds in water

**Soluble Ionic Compounds**
1. All sodium (Na⁺), potassium (K⁺), and ammonium (NH₄⁺) salts are SOLUBLE.
2. All nitrate (NO₃⁻), acetate (CH₃CO₂⁻), chlorate (ClO₃⁻), and perchlorate (ClO₄⁻) salts are SOLUBLE.
3. All chloride (Cl⁻), bromide (Br⁻), and iodide (I⁻) salts are SOLUBLE -- EXCEPT those also containing: lead, silver, or mercury (I) (Pb²⁺, Ag⁺, Hg²⁺) which are NOT soluble.
4. All sulfate (SO₄²⁻) salts are SOLUBLE -- EXCEPT those also containing: calcium, silver, mercury (I), strontium, barium, or lead (Ca²⁺, Ag⁺, Hg₂²⁺, Sr²⁺, Ba²⁺, Pb²⁺) which are NOT soluble.

**Not Soluble Ionic Compounds**
5. Hydroxide (OH⁻) and oxide (O²⁻) compounds are NOT SOLUBLE -- EXCEPT those also containing: sodium, potassium, or barium (Na⁺, K⁺, Ba²⁺) which are soluble.
6. Sulfide (S²⁻) salts are NOT SOLUBLE -- EXCEPT those also containing: sodium, potassium, ammonium, or barium (Na⁺, K⁺, NH₄⁺, Ba²⁺) which are soluble.
7. Carbonate (CO₃²⁻) and phosphate (PO₄³⁻) salts are NOT SOLUBLE -- EXCEPT those also containing: sodium, potassium, or ammonium (Na⁺, K⁺, NH₄⁺), which are soluble.

13. Mixing Ag(NO₃)₂ with MgCl₂ in water leads to precipitation of:
   1) a NO₃⁻ salt  
   2) an Ag²⁺ salt  
   3) a Mg²⁺ salt  
   4) everything precipitates  
   5) no precipitation

14. Gold can be dissolved from gold-bearing rock by treating the rock with sodium cyanide in the presence of oxygen.

   4Au (s) + 8NaCN (aq) + O₂ (g) + 2H₂O (l) → 4NaAu(CN)₂ (aq) + 4NaOH (aq)

   For this reaction, what is the oxidizing agent on the left side of the reaction?
   1) O₂  
   2) NaCN  
   3) Au  
   4) H₂O  
   5) H⁺

15. Ammonium sulfide, (NH₄)₂S, reacts with Hg(NO₃)₂ to produce HgS and NH₄NO₃.
   This reaction is best classified as:
   1) oxidation-reduction  
   2) acid-base  
   3) precipitation  
   4) gas evolving  
   5) gas evolving and precipitation
16. Consider the unbalanced reaction:

\[
\text{Ca(OH)}_2 (s) + \text{HNO}_3 (aq) \rightarrow \text{Ca(NO}_3)_2 (aq) + \text{H}_2\text{O} (l)
\]

In the balanced, net ionic equation for this reaction, the coefficient preceding \( \text{NO}_3^- \) is:

1) 1  
2) 2  
3) 3  
4) \( \text{NO}_3^- \) does not appear in the net ionic equation

17. Consider the unbalanced reaction:

\[
\text{Ca(OH)}_2 (s) + \text{HNO}_3 (aq) \rightarrow \text{Ca(NO}_3)_2 (aq) + \text{H}_2\text{O} (l)
\]

This reaction is best classified as:

1) oxidation-reduction  
2) gas evolving  
3) precipitation  
4) acid-base  
5) gas evolving and precipitation

18. Consider the following reaction that occurs within rechargeable “lead storage” batteries:

\[
\text{Pb} (s) + \text{PbO}_2 (s) + 2 \text{H}_2\text{SO}_4 (aq) \rightarrow 2 \text{PbSO}_4 (s) + 2\text{H}_2\text{O} (l)
\]

The oxidation number of Pb in \( \text{PbO}_2 \) is:

1) +1  
2) +2  
3) +3  
4) +4  
5) +5

19. In the above reaction, the reducing agent on the left side of the reaction is:

1) \( \text{Pb} (s) \)  
2) \( \text{PbO}_2 (s) \)  
3) \( \text{H}_2\text{SO}_4 \)  
4) this is not a redox reaction
20. Which reaction below is a redox reaction?

1) \( \text{NaOH (aq)} + \text{HNO}_3 (aq) \rightarrow \text{NaNO}_3 (aq) + \text{H}_2\text{O (l)} \)

2) \( \text{Na}_2\text{CO}_3 (aq) + 2 \text{HClO}_4 (aq) \rightarrow \text{CO}_2 (g) + \text{H}_2\text{O (l)} + 2\text{NaClO}_4 \)

3) \( \text{Si (s)} + 2\text{Cl}_2 (g) \rightarrow \text{SiCl}_4 (l) \)

4) \( \text{CdCl}_2 (aq) + \text{Na}_2\text{S (aq)} \rightarrow \text{CdS (s)} + 2 \text{NaCl (aq)} \)

5) None of the above

21. The net ionic equation for the reaction of zinc sulfate and sodium hydroxide is:

1) \( \text{Zn}^{2+} (aq) + 2 \text{OH}^- (aq) \rightarrow \text{Zn(OH)}_2 (s) \)

2) \( \text{Zn}^{2+} (aq) + 2 \text{OH}^- (aq) \rightarrow \text{Zn(OH)}_2 (aq) \)

3) \( \text{Zn}^{2+} (aq) + 2 \text{OH}^- (aq) \rightarrow \text{Zn(OH)}_2 (s) + \text{Na}_2\text{SO}_4 (aq) \)

4) \( \text{ZnSO}_4 (aq) + 2 \text{NaOH (aq)} \rightarrow \text{Zn(OH)}_2 (aq) + \text{Na}_2\text{SO}_4 (aq) \)

5) No net reaction occurs
22. Even though it is only slightly soluble, dissolving MgO (assume that it does dissolve) in water leads to:
   1) no change in pH of the solution
   2) a resulting acidic solution
   3) a resulting basic solution

23. You add sufficient 1 M HCl to 1.0 L of water to yield a final pH=4.0. Which statement below is true regarding the resulting solution?
   1) \([\text{OH}^-] = 10^{-14} \text{ M}\)
   2) \([\text{H}^+] = 4.0 \text{ M}\)
   3) \([\text{H}^+] = 10^4 \text{ M}\)
   4) \([\text{Cl}^-] = 0.1 \text{ mM}\)
   5) none of the above

24. Write the balanced, net ionic equation corresponding to the unbalanced equation:
   \[
   \text{AlCl}_3 + \text{Na}_3\text{PO}_4 \rightarrow \text{AlPO}_4 + \text{NaCl}
   \]
   The numerical coefficient preceding \(\text{PO}_4^{3-}\) (aq) is:
   1) 1
   2) 2
   3) 3
   4) 4
   5) 0 (\(\text{Na}^+\) doesn’t occur in the net ionic equation)

25. What is the catalog number for this class?
   1) 123
   2) 345
   3) 899
   4) 3.14159
   5) 111