This exam is composed of 25 questions on 7 pages total. 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.

\[
E = \frac{hc}{\lambda} \\
E_n^{H-atom} = -\frac{R_H hc}{n^2} \\
1 \text{ mL} = 1 \text{ cm}^3
\]

Some common ions:
- \(PO_4^{3-}\)  \(CN^-\)  \(CH_3CO_2^-\)
- \(NO_2^-\)  \(NO_3^-\)  \(CO_3^{2-}\)
- \(SO_3^{2-}\)  \(SO_4^{2-}\)

\[h = 6.626 \times 10^{-34} \text{ Js}\]
\[c = 2.9998 \times 10^8 \text{ m s}^{-1}\]
\[N = 6.022 \times 10^{23} \text{ mol}^{-1}\]
\[R_H = 1.097 \times 10^7 \text{ m}^{-1}\]
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⁺, Hg₂⁺, 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.

Identify the choice that best completes the statement or answers the question.

1. What is the hybridization of the chlorine atom in the chlorite ion, ClO₂⁻?
   a. sp²     b. sp³     c. sp³d     d. sp³d²
   **ANS:** C  **TOP:** 9.2 Valence Bond Theory

2. For which of the following molecules does the central carbon atom have sp² hybridization?
   a. Cl₂CO    b. CHCl₃    c. CS₂    d. CH₂Cl₂    e. HCN
   **ANS:** A  **TOP:** 9.2 Valence Bond Theory

3. What is the molecular geometry around a central atom that is sp³d hybridized and has one lone pair of eletrons?
   a. trigonal bipyramidal    d. tetrahedral
   b. trigonal-pyramidal    e. square-planar
   c. see-saw
   **ANS:** C  **TOP:** 9.2 Valence Bond Theory

4. Which of the following characteristics apply to SO₂?
   1. polar bonds
   2. nonpolar molecule
   3. linear molecular shape
   4. sp hybridized
   a. 1 only    d. 1, 2, and 3
   b. 1 and 2    e. 1, 2, 3, and 4
   c. 3 and 4
   **ANS:** A  **TOP:** 9.2 Valence Bond Theory
5. A molecular orbital that decreases the electron density between two nuclei is said to be .
   a. hybridized  c. antibonding  e. nonpolar
   b. bonding  d. pi-bonding
   **ANS:** C  **TOP:** 9.3 Molecular Orbital Theory

6. Which molecule will have the following valence molecular orbital level energy diagram?

   ![Energy Diagram](Image)

   a. Li₂  b. Be₂  c. B₂  d. C₂  e. N₂
   **ANS:** E  **TOP:** 9.3 Molecular Orbital Theory

7. Which picture best represents the electronic distribution in orbital “g”?

   ![Diagram](Image)

   a.  c.  e.  
   b.  d.  

   **ANS:** D

8. The diatomic AB above is NO⁺. What is the overall bond order?

   a. 1.0  b. 1.5  c. 2.0  d. 2.5  e. 3.0

   **ANS:** E
9. The picture at right depicts which type of orbital hybridization?
   a. sp  
   b. sp²  
   c. sp³  
   d. sp³d  
   e. sp³d²

   **ANS:** B

10. In the molecule 2-pentenoic acid, which most closely measures the C₃-C₄-H angle?

   ![Molecule Diagram]

   a. 90°  
   b. 109°  
   c. 120°  
   d. 145°  
   e. 180°

   **ANS:** B

11. A central atom in a molecule has octahedral electron pair geometry. What is the orbital hybridization on that atom?

   a. sp³  
   b. sp²  
   c. sp³d  
   d. sp⁴d  
   e. sp³d²

   **ANS:** E

12. An alcohol will initially react with the molecule below at which position?

   ![Molecule Diagram]

   **ANS:** A

13. Which carbon center below is most deficient in electrons?

   ![Molecule Diagram]

   **ANS:** B
14. Which of the following statements is/are correct?
   1. Water soluble ionic compounds, such as NaCl, are strong electrolytes.
   2. Some molecular compounds, such as HCl, are strong electrolytes.
   3. Some molecular compounds, such as acetic acid, are weak electrolytes.
   a. 1 only  
   b. 2 only  
   c. 3 only  
   d. 1 and 2  
   e. 1, 2, and 3
   **ANS:** E  
   **TOP:** 3.5 Ions and Molecules in Aqueous Solutions

15. Which one of the following compounds is a nonelectrolyte when dissolved in water?
   a. KI  
   b. Br₂  
   c. MgCl₂  
   d. Zn(NO₃)₂  
   e. MgBr₂
   **ANS:** B  
   **TOP:** 3.5 Ions and Molecules in Aqueous Solutions

16. A precipitate will form when aqueous nickel(II) chloride is added to an aqueous solution of
   a. NaOH  
   b. Cu(NO₃)₂  
   c. SrI₂  
   d. Na₂SO₄  
   e. NaF
   **ANS:** A  
   **TOP:** 3.6 Precipitation Reactions

17. What is the net ionic equation for the reaction of aqueous sodium hydroxide and aqueous iron(II) chloride?
   a. Na⁺(aq) + OH⁻(aq) → NaOH(s)  
   b. Na⁺(aq) + Cl⁻(aq) → NaCl(s)  
   c. Fe²⁺(aq) + 2 OH⁻(aq) → Fe(OH)₂(s)  
   d. Fe²⁺(aq) + OH⁻(aq) → FeOH⁺(s)  
   e. Fe²⁺(aq) + 2 Cl⁻(aq) → FeCl₂(s)
   **ANS:** C  
   **TOP:** 3.6 Precipitation Reactions

18. Write a balanced net ionic equation for the reaction of barium carbonate and aqueous hydrochloric acid.
   a. BaCO₃(s) + 2 H⁺(aq) → Ba²⁺(aq) + CO₃²⁻(aq) + H₂(g)  
   b. BaCO₃(s) + 2 H⁺(aq) → Ba²⁺(aq) + CO₂(g) + H₂O(l)  
   c. BaCO₃(s) + 2 HCl(aq) → BaCl₂(aq) + H₂CO₃(aq)  
   d. BaCO₃(s) + 2 H⁺(aq) → Ba²⁺(aq) + H₂CO₃(s)  
   e. BaCO₃(s) + 2 H⁺(aq) → BaO(s) + CO₂(g) + H₂(g)
   **ANS:** B  
   **TOP:** 3.8 Gas-Forming Reactions

19. Which species is oxidized in the reaction below?
   I⁻(aq) + ClO⁻(aq) → IO⁻(aq) + Cl⁻(aq)
   a. I⁻  
   b. H₂O  
   c. ClO⁻  
   d. IO⁻  
   e. none
   **ANS:** A  
   **TOP:** 3.9 Oxidation-Reduction Reactions
20. What is the oxidation number of phosphorous in PCl₃?
   a. −2 b. 0 c. +2 d. +3 e. +6
   ANS: D TOP: 3.9 Oxidation-Reduction Reactions

21. Consider the reaction
   \[ 2 \text{Na}_3\text{PO}_4 + 3 \text{Cu(NO}_3)_2 \rightarrow \text{Cu}_3\text{(PO}_4)_2 + 6 \text{NaNO}_3 \]
   This reaction is best classified as
   a. oxidation-reduction d. acid-base
   b. gas-evolving e. gas-evolving and acid-base
   c. precipitation
   ANS: C

22. Alka seltzer is a combination of citric acid, C₆H₈O₇, and NaHCO₃. They react in your glass to form C₆H₇O₇⁻, H₂O, and CO₂.
   ![Citric Acid Structure]
   What is the oxidation number of the carbon pointed to by the arrow?
   a. 3 b. 2 c. 1 d. 0 e. -1
   ANS: A

23. Mixing \text{Na}_2\text{S} with \text{BaCl}_2 in water leads to precipitation of
   a. a Cl⁻ salt d. nothing precipitates
   b. a Na²⁺ salt e. everything precipitates
   c. a Ba⁺ salt
   ANS: D

24. What is the oxidation number of vanadium in VO₄³⁻?
   a. +2 c. +5 e. +7
   b. +4 d. +6
   ANS: C

25. What course is this?
   a) Bio 152 c) Sports 01 e) Election 08
   b) Math 3.14159 d) Chem 111
   ANS: D