Multiple Choice, 2 points each

1. Which of these is least likely to have multiple bonds?
   a. HNO₃
   b. H₂CO₃
   c. H₂C₂O₄
   d. C₂H₅OH
   e. C₆H₅NO₂

2. Which of the following molecules has the highest bond polarity?
   a. C₂F₆
   b. NCl₃
   c. CO₂
   d. SCl₂

3. An ion that has a geometry similar to carbonate (CO₃²⁻) is:
   a. Nitrate (NO₃⁻)
   b. Nitrite (NO₂⁻)
   c. Phosphite (PO₃³⁻)
   d. Sulfite (SO₃²⁻)

4. Which of the following molecules will not have Trigonal Bipyramid (TBP) as its electron pair geometry?
   a. CF₄
   b. IF₃
   c. SF₄
   d. PCl₅

5. Which statement about the slow step in the mechanism for a reaction is true?
   a. It has a rate that is independent of the activation energy for the reaction.
   b. It limits the effectiveness of a catalyst.
   c. It controls the rate at which the products are produced.
   d. It almost always involves the breaking of hydrogen bonds.
   e. It determines the value of the standard enthalpy of reaction for the reaction.

6. Which of the following is not a redox reaction? (circle)
   a. Fe + O₂ → Fe₂O₃
   b. NaOH + H₂CO₃ → Na₂CO₃ + H₂O
   c. Zn + CuCl₂ → ZnCl₂ + Cu
   d. Mg + HCl → MgCl₂ + H₂

7. Rank the following compounds according to increasing solubility in water (#4 most soluble)
   a. CH₃-CH₂-CH₂-CH₃
   b. CH₃-CH₂-O-CH₂-CH₃
   c. CH₃-CH₂-OH
   d. CH₃-OH

8. For the process below at 110°C, ΔH = 3.21 kJ/mol; ΔS = 8.70 J/K mol, S₈ (rhomb) → S₈ (monocle)
   Which of the following is correct?
   a. This reaction is spontaneous at 110°C (S₈ (monoclinic) is stable).
   b. This reaction is spontaneous at 110°C (S₈ (rhombic) is stable).
   c. This reaction is nonspontaneous at 110°C (S₈ (rhombic) is stable).
d. This reaction is nonspontaneous at 110°C (S₈ (monoclinic) is stable).
e. Need more data.

9. O₂ (g) + 2H₂ (g) → 2H₂O(g)
   If the pressure is increased for this reaction at equilibrium:
   a. only the K value will change.
   b. the K value will change and the system will shift to the right.
   c. the K value will not change and the system will shift to the right.
   d. the K value will not change and the system will shift to the left.

10. Which of the following compounds lacks H-bonding?
    a. Ethanol
    b. Ammonia
    c. CHF₃ (trifluoromethane)
    d. Acetic acid(CH₃COOH)

11. Given the following substances in order of increasing acid strength, HOCl(aq) < HC₂H₂O₂(aq) < HC₂O₄⁻(aq) < HOCN(aq) < HNO₂(aq) < HCl(aq), which one of the species in the set listed below is the strongest base of that set?
    a. Cl⁻(aq)
    b. OCl⁻(aq)
    c. H₂C₂O₄(aq)
    d. NO₂⁻(aq)
    e. OCN⁻(aq)

12. (3) In the molecule shown below, what are the angles C₁-O-C₂, C₂-C₃-C₄ and C₄-N-H, respectively

   H--C₁--O--C₂--C₃=C₄=N--H
   H    H
   H    H

   C₁-O-C₂:________
   C₂-C₃-C₄:________
   C₄-N-H:________

13. (4) If 32.852 g of KMnO₄ (M. W. 158.0 g/mol) is dissolved in water to make 800 mL solution, what is its molarity?

14. (4) Calculate the [H₃O⁺] in a solution that has a pH of 11.70.

15. (6) At the stoichiometric point of the titration of 100 mL of 0.50 M NH₃ with 100 mL of 0.50 M of HCl, what is the [H₃O⁺]? (Kb₉₃ 1.8 x 10⁻⁵)
16. (6) For ammonia, $K_b$ is $1.8 \times 10^{-5}$. To make a buffered solution of pH 10.0, the ratio of NH$_4$Cl to NH$_3$ must be:

17. (5) Determine $\Delta G^\circ$ for the weak acid, HF, at 25°C. ($K_a = 7.2 \times 10^{-4}$)

18. (2) Consider the reaction $\text{HNO}_2(aq) + \text{H}_2\text{O}(l) \rightarrow \text{H}_3\text{O}^+(aq) + \text{NO}_2^-(aq)$
   Which species is the conjugate base?

19. (6) For the reaction, H$_2$ (g)+I$_2$ (g) $\rightarrow$ 2 HI(g), $K_C = 54.9$ at 699 K. A system at equilibrium contains 2.50 moles of HI and 2.12 moles of I$_2$ in a 5.00 liter vessel. How many moles of H$_2$ should there be in the container?

20. (6) The reaction, 2 NO$_2$ (g) $\rightarrow$ 2 NO(g) + O$_2$ (g), has a rate constant of 0.660 M/min at 450 °C. How long, in seconds, would it take for a sample of NO$_2$ whose concentration is initially 0.355 molar to decrease to 15.0 % of its original concentration at this temperature?

21. (6) Determine the equilibrium constant for a reaction on the basis of the following information: at 25 °C, 1.26 % of the 0.262 M solution of BrCl dissociates into Br$_2$ and Cl$_2$

22. (3) Give an example each of a strong acid, a weak acid, a strong base and a weak base
23. (4) Give Henderson Hesselbalch Equation and explain what it is used for.

24. (7) Draw an energy diagram for a two step, overall exothermic process. Indicate location of activation energies, transition states and intermediate on this diagram.

25. (6) Ka, the equilibrium constant for the dissociation of H₂O has a value of 1.8 x 10⁻¹⁶. Similarly, the Ka for the dissociation of methanol (CH₃OH) is 6.3 x 10⁻¹⁸.
   Based on this information calculate the equilibrium constant for
   \[ \text{CH}_3\text{OH} + \text{OH}^- \rightleftharpoons \text{CH}_3\text{O}^- + \text{H}_2\text{O} \]
   (Dissociation Ka equilibrium for any compound HA is \( \text{HA} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{A}^- \)).

26. (7) Draw the Lewis structure for H₂CO₃, Show dipole moments on each bond

27. (3) Recognize the hybridization of C₃, C₄ and N
   \[
   \begin{array}{c}
   \text{H} \\
   \text{H} \\
   \text{H} \\
   \text{H} \\
   \text{N} \\
   \end{array}
   \begin{array}{c}
   \text{C}_1 \quad \text{C}_2 \quad \text{C}_3 \quad \text{C}_4 \\
   \text{H} \\
   \text{H} \\
   \text{C} = \text{C} = \text{N} \\
   \text{H} \\
   \text{H} \\
   \end{array}
   \]