1. Define the following terms: (18%)
(a) isotope  (b) precision  (c) isoelectronic
(d) lattice energy  (e) electron affinity  (d) Lewis acid

2. Give the symbol, including the correct charge, for each of the following ions: (6%)
(a) permanganate ion  (b) dihydrogen phosphate ion  (c) sulfide ion
(d) nitrite ion  (e) sulfate ion  (f) perchlorate ion

3. Define redox reaction in terms of oxygen; electrons; and oxidation number? (6%)

4. A piece of nickel foil, 0.550 mm thick and 1.25 cm square, is allowed to react with fluorine, F₂, to give a nickel fluoride. (a) How many moles of nickel foil were used? (The density of nickel is 8.908 g/cm³.) (b) If you isolated 1.261 g of the nickel fluoride, what is its formula? (c) What is the percent composition by mass of the nickel fluoride? (9%)
   (atomic mass: Ni: 58.693; F: 18.9084)

5. The cancer chemotherapy agent, cisplatin, is made by the following reaction:
   \[(\text{NH}_4)_2\text{PtCl}_6(aq) + 2 \text{NH}_3(aq) \rightarrow 2 \text{NH}_4\text{Cl}(aq) + \text{Pt(NH}_3)_2\text{Cl}_2(aq)\]
   Assume that 15.5 g of \((\text{NH}_4)_2\text{PtCl}_6\) is combined with 225 ml of 0.75 M NH₃ to make cisplatin.
   (a) Which reactant is in excess and which is the limiting reactant?
   (b) How many grams of cisplatin can be formed?
   (c) After all the limiting reactant has been consumed and the maximum quantity of cisplatin has been formed, how many grams of the other reactant remain? (9%)
   (atomic weight: H: 1.0079; N: 14.0067; Cl: 35.4527; Pt: 195.08)

6. What is Heisenberg's uncertainty principle? Explain how it applies to our modern view of atomic structure. (8%)

7. Consider the ionic compound MX. How does the enthalpy of formation change if (a) the size of M⁺ increases, (b) the size of X⁻ increases, (c) the electron affinity of X decreases, or (d) the ionization energy of M decreases? (8%)
8. Sketch the phase diagram for water. Label the normal boiling point, melting point, and triple point, and show what regions of temperature and pressure are appropriate to solid, liquid, and vapor. Explain why the special properties of ice allow you to skate on ice. (8%)

9. Hydrogen and carbon monoxide react to give formaldehyde under certain conditions.

\[ H_2(g) + CO(g) \rightarrow HCHO(g) \]

The mechanism proposed for this reaction is:

Step 1 Fast, reversible: \[ H_2 \rightarrow 2 H \]
Step 2 Slow: \[ H + CO \rightarrow HCO \]
Step 3 Fast: \[ H + HCO \rightarrow HCHO \]

What rate law is derived from this mechanism? (4%)

10. The equilibrium reaction \[ N_2O_4(g) \rightarrow 2 NO_2(g) \] has been thoroughly studied. If the total pressure in a flask containing \( N_2O_4 \) and \( NO_2 \) gas at 25°C is 1.50 atm, and the value of \( K \) at this temperature is 0.148, what fraction of the \( N_2O_4 \) has dissociated to \( NO_2 \)? What happens to the fraction dissociated if the volume of the container is increased so that the total equilibrium pressure falls to 1.00 atm? (8%) \( \frac{P_{N_2O_4}}{P_{NO_2}} = \frac{P_{N_2O_4}}{P_{NO_2}} \times \frac{P_{NO_2}}{P_{N_2O_4}} \)

11. Sulfurous acid, \( H_2SO_3 \), is a weak acid capable of providing two \( H^+ \) ions.

(a) What is the pH of a 0.45 M solution of \( H_2SO_3 \)?
(b) What is the equilibrium concentration of the sulfite ion, \( SO_3^{2-} \), in the 0.45 M solution of \( H_2SO_3 \)? (8%)

\( H_2SO_3: K_a = 1.2 \times 10^{-2}, \quad K_{a2} = 6.2 \times 10^{-8} \)

12. You dissolve 1.00 mol of propanoic acid \( (CH_3CH_2CO_2H, K_a = 1.3 \times 10^{-5}) \) and 0.40 mol of \( NaOH \) in enough water to make 1.00 L of solution.

(a) Write a balanced equation to depict the reaction that can occur.
(b) How many moles of acid and of its conjugate base are present after the reaction?
(c) Calculate the pH of the solution.
(d) Does the pH increase, decrease, or remain the same if \( NaOH \) is added to the solution? (8%)