

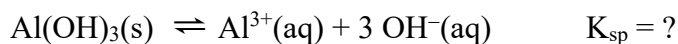
Written out problems – Show all work for partial credit.

23. Consider a galvanic cell at 25°C based on the following half-reactions:
(12 pts)



- a) Draw the cell under **standard** conditions labeling the anode, the cathode, the direction of electron flow, the concentration of ions, the electrodes, and the direction of flow of cations and anions through the salt bridge.

- b) To the standard cell above, OH^{-} is added to the aluminum compartment causing $\text{Al}(\text{OH})_3(\text{s})$ to precipitate. After precipitation of $\text{Al}(\text{OH})_3(\text{s})$ has ceased, the concentration of OH^{-} is $1.0 \times 10^{-4} \text{ M}$ and the measured cell potential is 1.82 V. Calculate the K_{sp} value for $\text{Al}(\text{OH})_3(\text{s})$.

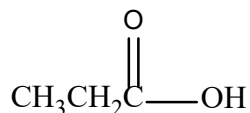


24. Consider an aqueous solution of copper nitrate, $\text{Cu}(\text{NO}_3)_2$. It took 1380 seconds using a current of 2.00 A to plate out all the copper from 25.0 mL of the copper nitrate solution. What was the original concentration of copper nitrate in the solution? Calculate the concentration in units of molarity (= mol/L).

(6 pts)

25. The boiling points of 5 organic compounds are 9.5°C , 36°C , 76°C , 117°C , and 141°C . The structures of three of the compounds are:

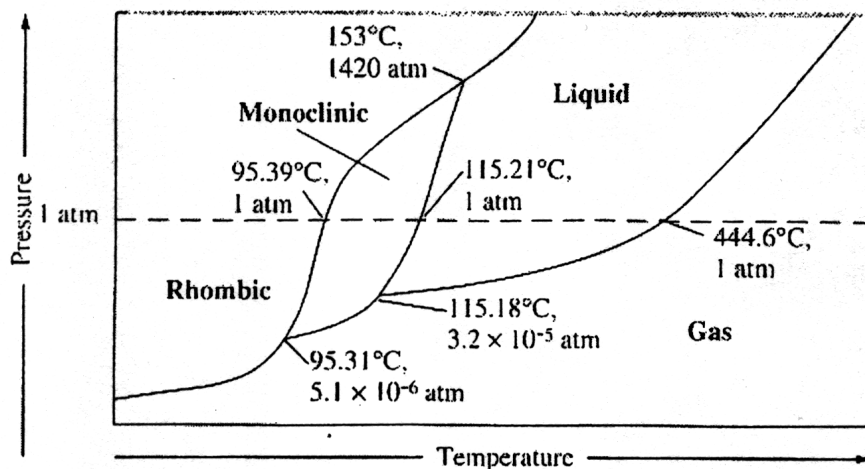
(5 pts)



The other three compounds are pentane and 2,2-dimethylpropane. Match the boiling points to the 5 compounds.

26. Sulfur exhibits two solid forms, rhombic and monoclinic. The complete phase diagram for sulfur is shown below. Consider the phase diagram when answering the following questions.

(10 pts)



- What is the normal melting point of monoclinic sulfur?
- How many triple points are in the phase diagram?
- Which is the densest phase?
- At a pressure of 1.0×10^{-5} atm, can rhombic sulfur sublime?
- The pressure on a sample of sulfur at 100°C is increased from 0 atm to 2000 atm. What phase changes will occur in this sample of sulfur as the pressure increases?

27. The following compounds can be produced in a single step reaction. Indicate which reactants (including catalysts) are necessary to make the desired products. Only major products should be produced. For the organic reactant compound, **draw the structural formula and name it.** Make sure your structural formulas contain all hydrogen atoms, e.g., butane should be drawn as $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$ or $\text{CH}_3\text{--CH}_2\text{--CH}_2\text{--CH}_3$, not C--C--C--C or line notation.

(12 pts)

a. → 2-chloropropane

b. → 2,3-dichloropentane

c. → ethane

d. $\xrightarrow{\hspace{1cm}}$ $\begin{array}{c} \text{CH}_3\text{CHCH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \\ | \\ \text{OH} \end{array}$

28. Propose a detailed mechanism for the reaction of H_2O and cyclobutene (in the presence of an H^+ catalyst).
(9 pts)

29. a. Draw the structural formula(s) for the isomer(s) of C_4H_9Cl which is/are optically active. Place an asterisk by the chiral carbon(s). Name the isomer(s).
(12 pts)
- b. Consider the reaction of toluene ($C_6H_5CH_3$) with $Cl_2(g)$ in the presence of $FeCl_3$ as the catalyst. Draw the structural formula(s) for the possible monochlorinated product(s) of this reaction. Name the product(s).
- c. Consider the reaction of toluene ($C_6H_5CH_3$) with $Cl_2(g)$ in the presence of ultraviolet light as the catalyst. Draw the structural formula(s) for the possible monochlorinated product(s) of this reaction.

30. a. Draw the molecular orbital diagram for CN. In your diagram, include the 2s and 2p MO diagrams.

(12 pts)

b. What is the bond order for the CN molecule? Is CN expected to be paramagnetic or diamagnetic?

c. Is CN^- expected to have a stronger or weaker bond than CN. Explain. Is CN^- expected to be paramagnetic or diamagnetic?

d. Is CN^+ expected to have a shorter or longer bond length than CN. Explain. Is CN^+ expected to be paramagnetic or diamagnetic?