Concentration-Time Graphs - Worksheet

1. In a solution of copper(II) chloride, the following equilibrium exists:

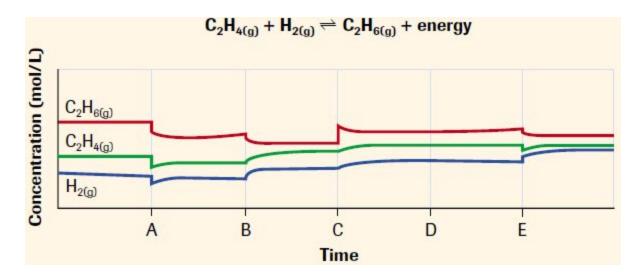$$CuCl_4^{2-}{}_{(aq)} + 4\ H_2O_{(l)} \rightleftharpoons Cu(H_2O)_4^{2+}{}_{(aq)} + 4\ Cl^{1-}$$

dark green   blue

Predict the shift in the equilibrium and draw a graph of concentration versus time for relevant reactants to communicate the shift after the following stresses are applied to the system:
   a. Hydrochloric acid is added
   b. Silver nitrate is added

2. The two oxyanions of chromium(IV) are the orange dichromate ion, $Cr_2O_7^{2-}{}_{(aq)}$, and the yellow chromate ion, $CrO_4^{2-}{}_{(aq)}$. Explain why a solution containing the following equilibrium system turns yellow when sodium hydroxide is added.

$$Cr_2O_7^{2-}{}_{(aq)} + H_2O_{(l)} \rightleftharpoons 2\ CrO_4^{2-}{}_{(aq)} + 2\ H^+{}_{(aq)}$$

orange   yellow

3. Identify the nature of the change imposed on the equilibrium system, shown below, at each of the times indicated A, B, C, D, and E.

The Haber Process

Do some research regarding the Haber Process to help you answer the following questions, take a look at the Useful Links section of the school website as a starting point:

4. What can ammonia be used for?

5. Write a balanced chemical equation for the Haber Process.

6. Examine the image to the right. Describe how Haber manipulated each of the following factors to produce an optimal yield of ammonia. Using Le Châtelier's Principle, explain which direction (forward or reverse) each change would favour.
   a. temperature
   b. pressure
   c. concentration

7. What else did Haber do to achieve a reasonable reaction rate for this process?

8. Why was the development of the Haber Process a significant factor in World War I?

$N_{2(g)}$ and $H_{2(g)}$ added to system

reaction—
chamber

500°C,
30–60 MPa,
iron(III) oxide
catalyst

$N_{2(g)}$ and $H_{2(g)}$ recycled back into system

$NH_{3(g)}$ removed from system