Show your work for all problems and be sure to box your final answer and include sensible units. No work (i.e., reasonable justification) = no credit.

1. (12 pts) Consider the following reaction at 250 K:

$$2\ ClO_2\ (aq)\ +\ 2\ OH^{1-}\ (aq) \rightarrow ClO_3^{1-}\ (aq) + ClO_2^{1-}\ (aq) + H_2O\ (l)$$

The rate equals = $\dfrac{-\ \Delta[\text{chlorine dioxide}]}{\Delta t}$

Experiment	$[ClO_2]$ M	$[OH^{1-}]$ M	Initial Rate (M/s)
1	0.100	0.100	1.80×10^{-2}
2	0.100	0.200	3.60×10^{-2}
3	0.200	0.100	1.45×10^{-1}

   a. (2 pts) How does the rate of change of [chlorine dioxide] relate to the rate of change of [chlorate]?

   b. (4 pts) Determine the rate law for this reaction. (Give rate constant info in part c.)

   c. (3 pts) Determine the value and units of the rate constant for this reaction.

   d. (3 pts) What would be the initial rate for an experiment when $[ClO_2] = 0.0705$ mol/L and $[OH^{1-}] = 0.0445$ mol/L?

2. (4 pts) The following mechanism has been proposed for the gas phase reaction of hydrogen bromide and oxygen.

   Step 1: $HBr\ (g) + O_2\ (g) \rightarrow HOOBr\ (g)$ (slow)
   Step 2: $HOOBr\ (g) + HBr\ (g) \rightarrow 2\ HOBr\ (g)$ (fast)
   Step 3: $HOBr\ (g) + HBr\ (g) \rightarrow H_2O\ (g) + Br_2\ (g)$ (fast)

   a. What is the rate law predicted by this mechanism?

   b. What is the overall order of this reaction, based on the mechanism?

3. (6 pts) 1.50 moles of chromium (III) nitrate and 2.00 moles of sodium bromide are added to 1.00 L of distilled water.

$$Cr^{3+} (aq) + 2\ Br^{1-} (aq) \leftrightarrow CrBr_2^{1+} (aq) + 15.0\ kJ$$
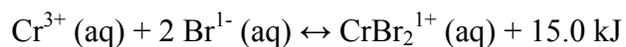
At equilibrium, the concentration of $[Cr^{3+}]$ was found to be 1.20 M. Write the expression for K_c and calculate its numerical value.

4. (6 pts) Explain in which direction (forward, reverse, or not at all) the equilibrium position in #3 will shift, and why, if:
    a. Br^{1-} is removed by precipitation.

    b. The temperature is increased.

    c. A catalyst is added.