$$8\ H^+(aq) + 4\ Cl^-(aq) + MnO_4^-(aq) \rightarrow 2\ Cl_2(g) + Mn^{3+}(aq) + 4\ H_2O(l)$$

3. $Cl_2(g)$ can be generated in the laboratory by reacting potassium permanganate with an acidified solution of sodium chloride. The net-ionic equation for the reaction is given above.

   (a) A 25.00 mL sample of 0.250 *M* NaCl reacts completely with excess $KMnO_4(aq)$. The $Cl_2(g)$ produced is dried and stored in a sealed container. At 22°C the pressure of the $Cl_2(g)$ in the container is 0.950 atm.

   (i) Calculate the number of moles of $Cl^-(aq)$ present before any reaction occurs.

   (ii) Calculate the volume, in L, of the $Cl_2(g)$ in the sealed container.

An initial-rate study was performed on the reaction system. Data for the experiment are given in the table below.

| Trial | $[Cl^-]$ | $[MnO_4^-]$ | $[H^+]$ | Rate of Disappearance of $MnO_4^-$ in $M\ s^{-1}$ |
|---|---|---|---|---|
| 1 | 0.0104 | 0.00400 | 3.00 | $2.25 \times 10^{-8}$ |
| 2 | 0.0312 | 0.00400 | 3.00 | $2.03 \times 10^{-7}$ |
| 3 | 0.0312 | 0.00200 | 3.00 | $1.02 \times 10^{-7}$ |

   (b) Using the information in the table, determine the order of the reaction with respect to each of the following. Justify your answers.

   (i) $Cl^-$

   (ii) $MnO_4^-$

   (c) The reaction is known to be third order with respect to $H^+$. Using this information and your answers to part (b) above, complete both of the following:

   (i) Write the rate law for the reaction.

   (ii) Calculate the value of the rate constant, $k$, for the reaction, including appropriate units.

   (d) Is it likely that the reaction occurs in a single elementary step? Justify your answer.

**STOP**

**If you finish before time is called, you may check your work on this part only.**
**Do not turn to the other part of the test until you are told to do so.**







**CHEMISTRY**
**Part B**
**Time—40 minutes**
**NO CALCULATORS MAY BE USED FOR PART B.**

Answer Question 4 below. The Section II score weighting for this question is 10 percent.

4. For each of the following three reactions, write a balanced equation for the reaction in part (i) and answer the question about the reaction in part (ii). In part (i), coefficients should be in terms of lowest whole numbers. Assume that solutions are aqueous unless otherwise indicated. Represent substances in solutions as ions if the substances are extensively ionized. Omit formulas for any ions or molecules that are unchanged by the reaction. You may use the empty space at the bottom of the next page for scratch work, but only equations that are written in the answer boxes provided will be scored.

EXAMPLE:

A strip of magnesium metal is added to a solution of silver(I) nitrate.

(i) Balanced equation:

$Mg + 2\ Ag^+ \longrightarrow Mg^{2+} + 2\ Ag$

(ii) Which substance is oxidized in the reaction?

Mg is oxidized.

   (a) A 0.2 *M* potassium hydroxide solution is titrated with a 0.1 *M* nitric acid solution.

(i) Balanced equation:

   (ii) What would be observed if the solution was titrated well past the equivalence point using bromthymol blue as the indicator? (Bromthymol blue is yellow in acidic solution and blue in basic solution.)



GO ON TO THE NEXT PAGE.