Colorado Regional Science Olympiad
March 3, 2001

Chemistry Lab – Answer Key

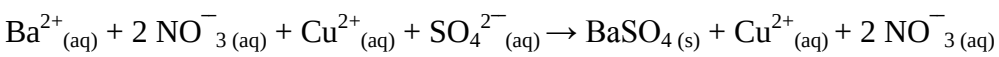
Part A. Reactions **Group #_____**

Perform each chemical reaction below by placing a few drops of each solution indicated into a cell of the microcell plate. Record your observations, and write the balanced ionic equation (be sure to indicate the phase of each component). The chemical solution concentrations are all 0.1 M.

1. Barium nitrate and copper(II) sulfate

   Observations: White Precipitate

   Balanced ionic equation:

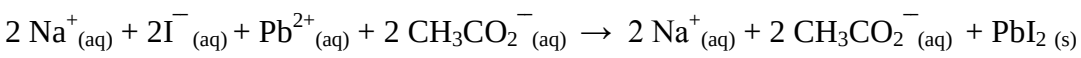


$$Ba^{2+}_{(aq)} + 2\ NO^{-}_{3\,(aq)} + Cu^{2+}_{(aq)} + SO_4{}^{2-}_{(aq)} \rightarrow BaSO_{4\,(s)} + Cu^{2+}_{(aq)} + 2\ NO^{-}_{3\,(aq)}$$

2. Sodium iodide and lead(II) acetate

   Observations: Yellow Precipitate

   Balanced ionic equation:

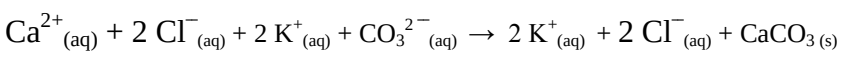


$$2\ Na^{+}_{(aq)} + 2I^{-}_{(aq)} + Pb^{2+}_{(aq)} + 2\ CH_3CO_2{}^{-}_{(aq)} \rightarrow 2\ Na^{+}_{(aq)} + 2\ CH_3CO_2{}^{-}_{(aq)} + PbI_{2\,(s)}$$

3. Calcium chloride and potassium carbonate

   Observations : White Precipitate

   Balanced ionic equation:



$$Ca^{2+}_{(aq)} + 2\ Cl^{-}_{(aq)} + 2\ K^{+}_{(aq)} + CO_3{}^{2-}_{(aq)} \rightarrow 2\ K^{+}_{(aq)} + 2\ Cl^{-}_{(aq)} + CaCO_{3\,(s)}$$

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Part B. Kinetics Procedure **Group #_____**

The purpose of this experiment is to make observations and then deductions about the kinetics of a reaction. The vial marked 'B' contains the reaction you'll be studying. The reaction mixture is a solution containing 2 drops Methylene Blue, 10 g glucose, and 8 g strong base in 300 mL water.

1. Shake your reaction vial for 3 seconds and then gently set it down. The reaction should turn blue. Immediately start your timer. Record the amount of time it takes for the solution to turn colorless again (be careful not to disturb the reaction while you wait for the color change).

   Time__15 s_____

2. Repeat step 1, but shake the vial for 30 seconds this time.

   Time__45 s_____

3. Gently set your vial in a beaker containing ice water for about 2 or 3 minutes. Remove the vial from the ice water, shake it for 3 seconds and gently place it back into the ice water. Immediately start the timer. Record the amount of time it takes for the solution to turn colorless again.

   Time___50 s_____

4. Allow your reaction vial to return to room temperature. You can hasten this event by setting the vial in a beaker containing room temperature water. Let it stand in the water bath about 4 or 5 minutes. Add water up to the second line on the vial. Shake the vial for 3 seconds and then gently set it down. Immediately start the time. Record the amount of time it takes for the reaction to turn colorless again.

   Time___45 s_____

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Part C. Kinetics Analysis **Group #_____**

I. Discuss, both in general and in reference to your reaction data, the four factors listed below that affect the rate of a reaction.

1. Concentration of the reactants

   General: Increasing the concentration caused and increase in collision frequency, which, in turn causes and increase in the rate of reaction

   Rxn: When the reaction was diluted, the reaction rate decreased; the reaction remained blue longer.

2. Physical state of the reactants

   General: In order to collide, the molecules must be fairly mobile; the freer they are to mix and contact each other, the faster the reaction will occur.

   Rxn: In solution, molecules are allowed to collide fairly readily.

3. Temperature

   General: Molecules must collide with enough energy to react. As temperature increases, the frequency and energy of collisions increase, thus, the reaction rate increases.

   Rxn: When our reaction was cooled down the reaction time increased (the reaction rate decreased).

4. Use of a catalyst

   General: A catalyst increases reaction rate by lowering the activation energy of the reaction. A catalyst is not used up in the reaction.

   Rxn: Methylene blue is the catalyst. It is not used up.

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Part C. Kinetics Analysis **Group #_____**

II. Did you observe a difference in the rate of reaction when you shook your vial for 30 seconds instead of 3 seconds. Can you explain your observation? (*Hint: colorless Methylene Blue will react with oxygen to give blue Methylene Blue)*

When you shake the vial, air mixes with the solution. The air (ie. O_2), reacts with MB. MB will keep reacting with the air and changing back to blue until all of the MB has reacted.

III. Propose a reaction mechanism to describe the kinetics of your reaction, be sure to label the rate limiting step. Use the following symbols: O_2 = oxygen, G = glucose, OH^- = base, MB_b = Methylene Blue (blue), MB_c = Methylene Blue (colorless).

$O_2 + MB_c \rightarrow MB_b$ (fast)

$G + OH^- \rightarrow G^- + H_2O$ (fast)

$MB_b + G^- \rightarrow MB_c$ + products (slow)

IV. How do you know when your reaction has reached equilibrium?

The reaction no longer changes color.

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Part D. Tie Breaker Questions **Group #_____**

These questions will graded as necessary to break ties

1. A pile of flour on your kitchen counter does not ignite with a match, but the flour dust in a mill or silo can react explosively. Explain

   The flour dust has high surface are per volume, so more contact occurs with O_2 in air. This increases the possibility for combustion to occur.

2. For the reaction $A_{(g)} \rightarrow B_{(g)}$, sketch two curves on the same set of axes that show a) the formation of product as a function of time, and b) the consumption of reactant as a function of time.

   The sketch should show that [B] starts at time and concentration = 0, and increases in concentration as time increases. While [A] starts at a high concentration and decreases as time increases.

3. How would the increase in pressure affect the rate of a gas phase reaction? Explain.

   As pressure increases, the number of molecular collisions will increase, thus the rate of the reaction increases.

4. a) Will a reaction with a catalyst yield more product?

   No, but it yields the product faster. The catalyst lowers the activation energy by providing a different mechanism for the reaction.

   b) For the reaction AB $\xrightarrow{cat}$ A + B, on the same set of axes, sketch the reaction energy diagrams for the catalyzed and uncatalyzed reactions.

   The sketch should show that the activation energy for the uncatalyzed reaction is higher then that for the catalyzed reaction.