Reaction Background

The following reactions were employed as a means of measuring specific time intervals by manipulating the concentrations of certain chemicals. This reaction is commonly known as the chameleon reaction and is given its name as it changes colour from purple to green to orange-yellow. It takes place in an aqueous environment and involves three chemicals: Dextrose ($C_6H_{12}O_6$), Potassium Permanganate ($KMnO_4$), and Potassium Hydroxide (KOH).

$$MnO_4^- + e \rightarrow MnO_4^{2-} \qquad \textit{Reaction (1)}$$

$$MnO_4^{2-} + 2H_2O + 2e \rightarrow MnO_2 + 4OH^- \qquad \textit{Reaction (2)}$$

The reactions occurring are redox reactions where potassium permanganate is reduced, and dextrose is oxidized. This causes two reactions to occur. First the permanganate ion is reduced from its oxidation state of +7, to an oxidation state of +6 (Reaction 1). Then the ion is reduced again to an oxidation state of +4 (Reaction 2). This change in oxidation state is what causes the different colours to be observed. This reaction occurs in a basic medium as the hydroxide ions allow the permanganate ion to be reduced more easily.

When measured quantities of solution A and solution B are mixed, the reaction commences. This reaction is pseudo-first order with respect to dextrose and the hydroxide ions, thus is affected by changes in KMnO4 concentration. An augmentation in the concentration of any of these constituents leads to an accelerated reaction rate, causing the colour changes to occur more rapidly.

Constraints

- The reaction vessel is a 100 mL glass beaker that is only allowed to hold **at most 60 mL** of liquid at any given point
- The injection syringe has a capacity of 12 mL but is only allowed to hold **at most 10 mL** of liquid at any given point
- The **minimum** volume of the liquid in the reaction vessel with all chemicals is 30 mL
- The reaction time should NOT exceed **2 minutes**
- No solution should contain a KOH concentration higher than **6 M**

Suggested Chemical Concentration Range

Based on data collected by UTCV, the following concentration combination is likely to make the reaction last between 50 seconds to 120 seconds:

Potassium Permanganate*: 0.0006672 M*
Dextrose: 0.009714 M
KOH: 0.08911 M - 1.337 M

Chemicals Provided

1) Potassium Permanganate (100% pure, powder)
2) Dextrose (100% pure, powder)
3) Potassium Hydroxide solution (45 wt%)

Procedure

The quantities of the chemicals and capacity of glassware specified in the procedure are <u>only for reference</u> and <u>should not be used</u> in real procedures. Please adapt the procedure with your own quantities. However, you should follow the procedure for choosing the correct type of glassware/apparatus. If you can not find appropriate glassware for the quantity of the chemicals you need, report to the lab supervisor on site before you move on.

<u>1) Preparation of Potassium Permanganate Solution</u>

Considering the low concentration of $KMnO_4$, it is recommended to make a stock solution and do a (or multiple) dilution to achieve the concentration needed.

1. Using the analytical balance and a weighing boat, measure out 1.0000 g of Potassium Permanganate($KMnO_4$). Record the actual mass of the $KMnO_4$ for later calculation.
2. Transfer the $KMnO_4$ into a 50 mL beaker, and use distilled water to rinse off the remaining solids in the weighing boat, making sure all solids are transferred to the beaker.
3. Label the flask with the dedicated labelling tape assigned to your team, and explicitly record the content, concentration (“X g $KMnO_4$/100mL”), date and your name.
4. Use approximately 20 mL of water to dissolve the $KMnO_4$ powder in the beaker, and transfer the solution into a 100 mL volumetric flask. Rinse the beaker with distilled water 3 times to make sure all $KMnO_4$ is collected in the flask. Use minimum water to avoid exceeding 100 mL
5. Fill the flask with distilled water until the water level reaches approximately 1 cm below the calibration line.
6. Cap the flask and mix the solution thoroughly by inverting it several times.
7. Use a dropper to adjust the final volume of the solution. Add distilled water drop by drop as you approach the calibration mark. Read the meniscus at eye level to ensure accuracy.

2) Preparation of Dex+KOH Solution

Note that Dextrose and KOH would react with each other when mixed thus the solution is recommended to be made "fresh"

Note that always add and dissolve Dextrose before adding the KOH

1. Calculate the required mass of the KOH and Dextrose for the stock solution. Keep in mind the final KOH solution should not exceed 6 M in KOH concentration.
2. Label a 50 mL volumetric flask with the dedicated labelling tape assigned to your team, and explicitly record the chemicals, concentration (XXXg/100 mL), date and your name.
3. Use the analytical balance, a weighing boat and an appropriate size spatula to measure out 1.0000 g of dextrose. Record the actual mass of the dextrose for later calculation.
4. Transfer the dextrose from the weighing boat to the labelled volumetric flask. Use a funnel if needed. Rinse the weighing boat with distilled water 3 times to make sure all dextrose is collected in the flask. Use minimum water to avoid exceeding 40% of the capacity of the volumetric flask.
5. Use the analytical balance and a 1 mL manual pipette to weigh the required KOH solution in a weighing boat.
6. Transfer the KOH solution from the weighing boat to the labelled volumetric flask. Use a funnel if needed. Rinse the weighing boat with distilled water 3 times to make sure all KOH is collected in the flask. Use minimum water to avoid exceeding 80% of the capacity of the volumetric flask.
7. Fill the flask with distilled water until the water level reaches approximately 1 cm below the calibration line.
8. Cap the flask and mix the solution thoroughly by inverting it several times.
9. Use a dropper to adjust the final volume of the solution. Add distilled water drop by drop as you approach the calibration mark. Read the meniscus at eye level to ensure accuracy.

3) Injection Procedure - *ex-situ* Trials (in beaker)

It's recommended to test the same concentration combination at least twice.

1. Obtain a clean and dry 100 mL beakers. Do not label them.

2. Label a clean 250 mL Erlenmeyer flask and transfer some $KMnO_4$ solution from the volumetric flask containing the $KMnO_4$ solution to the Erlenmeyer flask. The Erlenmeyer flask should not contain more than 200 mL of liquid at any given point.
3. Label a clean 50 mL beaker and transfer some KOH solution from the 100 mL flask containing the diluted KOH solution to the beaker.
4. Use a 50 mL volumetric glass pipette to transfer 50 mL of $KMnO_4$ solution from the Erlenmeyer flask into a 100 mL beaker.

<u>If you are using a 10 mL micropipette:</u>

5. Use a 5 mL glass pipette to transfer 7 mL of KOH+Dex solution into a clean **<u>15 mL</u>** Falcon tube. The falcon tube can be reused as long as it's used for the same solution of the same concentration.
6. Attach a clean 10 mL pipette tip to the micropipette. Adjust the pipette volume to slightly exceed the required volume (usually +50 µL). Use the pipette to draw liquid from the Falcon tube slowly and carefully to avoid spills. Do not insert the tip to the bottom of the falcon tube too fast. Instead, draw the liquid while you insert the pipette into the liquid.

In case of a spill of the KOH solution:

A. Make sure no one is spilled with the chemicals. If so, resort to the proper decontamination procedure outlined in the safety plan.

B. Report to the on-site lab supervisor and notify other people around the scene.

C. Use paper towel to absorb the spilled solution. If a large quantity is spilled, use the spill pad on the bench.

D. Wait for the lab supervisor before proceeding.

<u>If you are using a syringe:</u>

7. Use a 7 mL glass pipette to transfer 5 mL of KOH+Dex solution into a clean **<u>50 mL</u>** Falcon tube. The falcon tube can be reused as long as it's used for the same solution of the same concentration.
8. Attach a clean metal tip to the syringe. Draw all the liquid in the Falcon tube using the syringe. Draw more volume than you need to ensure no liquid is left in the metal tube.
9. Remove the metal tube from the syringe. The metal tube can be reused as long as it’s used to draw the same solution with the same concentration.