# CHEMISTRY

**Fermentation**

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**Aim:** To ferment a glucose solution and to monitor the mass changes involved.

**Hypothesis:** Mass loss will occur due to the expulsion of carbon dioxide

**Materials:** 100 mL conical flask with rubber stopper and delivery tube, 500 mL beaker, 50 mL beaker, large test tube, 20 mL glucose solution 10% (w/v), 1.0g dry yeast, limewater, thermometer, electronic balance.

**Method:**

1. The conical flask, stopper and delivery tube was weighed to enable the loss of mass to be calculated at the end.

2. Approximately 75 ml of glucose solution was added in the 100mL conical flask.

3. 1 g of yeast was added to the solution and the stopper and delivery tube where attached on top, plugging any holes with blue tack. The solution was weighed.

4. Limewater was poured into the 50mL beaker and put beneath the other end of the delivery tube.

5. The setup was left in a cupboard for more the 24 hours while the fermentation took place.

6. Solution was weighed and the mass loss calculated.

**Results and calculations:**

| **Item** | **Mass** |
|---|---|
| Flask & Delivery Tube | 91.5g |
| Delivery Tube | 17.11g |
| Flask | 74.39g |
| Flask & Yeast & Glucose (before) | 105.58g |
| Yeast & Glucose (before) | 31.19g |
| Delivery Tube & Flask & Yeast & Glucose (before) | 122.69g |
| Delivery Tube & Flask & Yeast & Glucose (after 20min) | 122.75g |
| Yeast & Glucose (after 20min) | 31.25g |
| Flask & Yeast & Glucose (after ≈ 24 hours) | 104.01g |
| Yeast & glucose (after ≈ 24 hours) | 29.62g |
| Lost | 1.57g |

**Discussion/Analysis:**

The hypothesis of the experiment has been approved and the aim of the experiment correctly fulfilled.

In a traditional liquid reaction, mass is conserved it is not expected that a mass change will occur, but in fermentation, carbon dioxide is produced and since this is in a gaseous form, the removal of carbon dioxide is presumed to be cause of the mass change in the experiment.

Fermentation is a process carried out in living cells as a means of obtaining energy from carbohydrates in the absence of oxygen. It is essentially, therefore, a form of anaerobic respiration. In all cases, the molecule pyruvate is formed as an intermediate product, but the final chemicals produced depend largely on the type of organism carrying out fermentation (in this case yeast). During fermentation, yeast turns sugar into ethyl alcohol and carbon dioxide, with the release of energy. The basic formula for the process of fermentation is as follows:

$$C_6H_{12}O_{6\ (glucose)} \xrightarrow{enzyme\ (yeast)} 2C_2H_5OH_{\ (ethanol)} + 2CO_{2\ (sucrose)}$$

The carbon dioxide lost was physically observed with the use of limewater. The carbon dioxide combines with calcium in lime water to form insoluble calcium carbonate, which creates a precipitate as seen in the equation:

$$Ca(OH)_{2\ (aq)} + CO_{2\ (g)} \text{---> } CaCO_{3\ (s)} + H_2O_{\ (l)}$$

Assuming this is the only reaction going on in the solution, and then only a few things can change - the amount of glucose and the amount of ethanol. The carbon dioxide is gaseous so this shouldn't change the pH of the solution itself.

From the results gathered the moles of $CO_2$ that was expelled from fermentation process is as follows:

$$\frac{1.56\ (\text{given 1 g of yeast was subtracted})}{44.011\ mol} = 0.035\ mol/g$$

Though the experiment was successfully carried out it lacked in both reliability and validity. Due to the fact that the experiment was not repeated reliability could not be judged. It would have been appropriate to compare results, either by repetition or using the results obtained by other groups to consider whether the obtained results are in par with the theory.

The mass change was due to the loss of $CO_2$, and it stopped because the ethanol content was high enough to essentially stop the metabolism of the glucose. The experiment could be considered more valid if the measurement of time was more precise. A separate set-up could be used as a control to examine the effect of concentration on the fermentation process. It is also ethanol see that yeast stops functioning above a certain ethanol concentration. It is likely that this causes the change in mass to stop.

The impact of light and temperature could also be other factors that affect the validity of the experiment. Human error may have caused variations in the measurements of each substances used. It could be improved by the use of more precise measuring tools where necessary. Likewise a more controlled environment and more importantly appropriate equipment (i.e. equipment that allowed no gas to escape so the visible reaction could be viewed in the limewater solution) would have benefited the experiment greatly.

**Conclusion:**

It can be concluded that the hypothesis can be approved of and a mass change occurred during the experiment. The results suggested that the fermentation process led to a mass loss, as presumed in the hypothesis. The setup of limewater also indicated that the mass loss occurred due to the loss of carbon dioxide ($CO_2$) with approximately 0.035 moles being lost during the fermentation reaction.