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| **Foundation Year** | **Measuring Enthalpy Changes** | **Semester 1** |

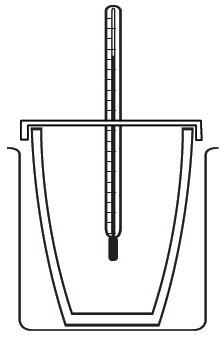
**Measuring Enthalpy Changes**

**Aim**

To determine the enthalpy changes of chemical reactions.

**Introduction**

The sum of the energy changes in making and breaking bonds results in an overall energy change in a reaction. The enthalpy, *H*, is the stored energy in a compound and if some of this stored energy is released as heat during a reaction, the surroundings will be raised in temperature (warm up). Such a reaction would be termed exothermic and the enthalpy change, Δ*H*, would be negative. However, if energy is absorbed during a reaction, then Δ*H* is positive and the surroundings are reduced in temperature (cool down).

To measure enthalpy changes you are going to use a polystyrene cup as a simple calorimeter (see below). A calorimeter is any container that is used to measure energy changes from chemical reactions.

Lid

Polystyrene cup

Thermometer

Beaker

**Skills associated with this practical**

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| --- | --- |
| **Practical Skills**   * Correct use of a top pan balance * Correct use of a measuring cylinder * Correct use of a thermometer | **Scientific Skills**   * Drawing a results table * Plotting a graph * Calculating enthalpy changes * Drawing enthalpy level diagrams |

**Signposts**

Chemistry, Conoley & Hills, 3rd Edition, Chapter 8, Page 157.

**Understanding Hazard and Minimising Risk**

You must stand up throughout the practical, and safety glasses must be worn at ALL times in the lab. You must wear a labcoat whilst you are carrying out ALL practical work. Long hair must be tied back, and trousers (jeans are OK) must be worn. Open-toed shoes and clothing revealing bare skin are not permitted.

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| Substance | Amount | Hazards | Minimising Hazards | Disposal / Spillage |
| Zinc powder | 1 g | Harmful, highly flammable. | Avoid inhalation of dust, keep away from flames. | Dispose of in zinc waste container. |
| Copper(II) sulfate (hydrated) | 2-4 g | Harmful if swallowed, irritant to eyes and skin, toxic to aquatic organisms. | Wear gloves (optional), wear safety glasses. | Wash waste solutions down the sink with copious quantities of water. |

**Procedure**

Apparatus

PER PAIR: Polystyrene cup with lid Glass beaker

-5 to 50 ºC thermometer 25 cm3 and 50 cm3 measuring cylinders

Zinc powder Copper(II) sulfate solution (0.20 mol dm-3)

Sodium hydrogencarbonate Citric acid solution (1.0 mol dm-3)

**Experiment 1: Determination of the concentration of a sodium hydroxide solution**

Zn(s) + CuSO4(aq) → ZnSO4(aq) + Cu(s) (Equation 1)

Method

1. Use a measuring cylinder to pour 50.0 cm3 of 0.20 mol dm-3 copper(II) sulfate solution into the polystyrene cup.

2. Weigh out about 1 g of powdered zinc.

3 Record the initial temperature of the solution in the cup and start your stopwatch. Record the temperature reading every 30 seconds for the next 3 minutes filling out a preprepared results table. Get your partner to take a photo of you using the thermometer for your *Skills Portfolio*.

4. Add the zinc and stir the solution gently. Continue to record the temperature every 30 seconds. The temperature will rise initially, then it will start to fall. Continue recording the temperature every 30 seconds until the solution has been cooling for at least 6 minutes.

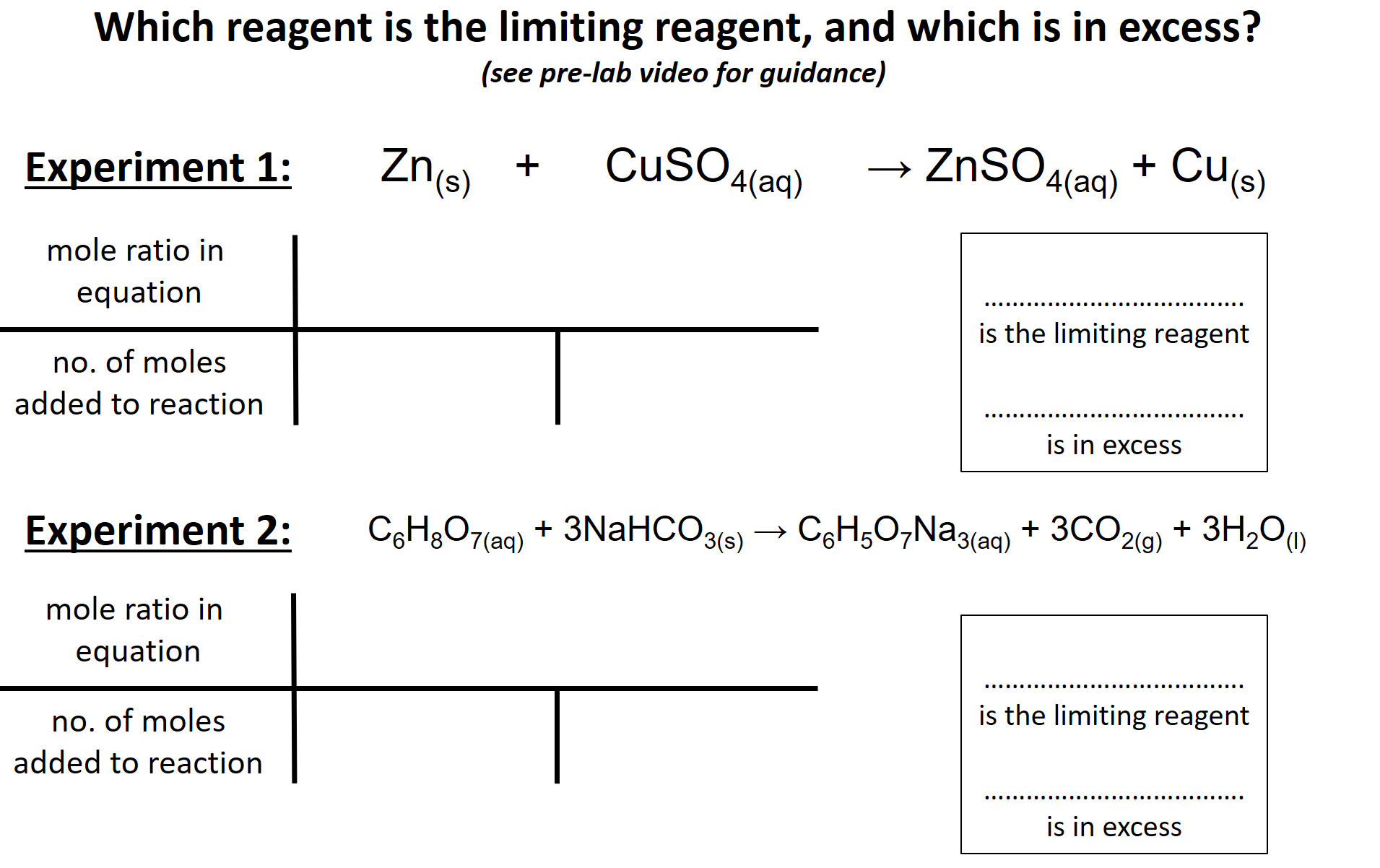
**Experiment 2: The reaction between citric acid and sodium hydrogencarbonate.**

C6H8O7(aq) + 3 NaHCO3(s) → C6H5O7Na3(aq) + 3 CO2(g) + 3 H2O(l) (Equation 2)

Method

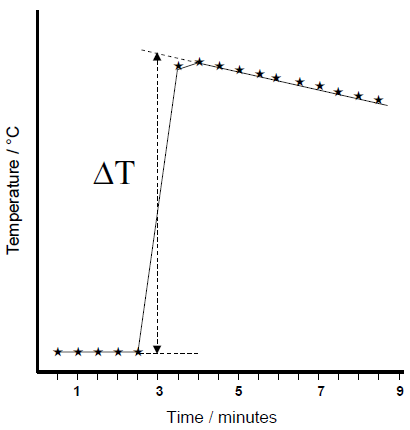
Use the same procedure as in Experiment 1 above but instead use 25.0 cm3 of 1.0 mol dm-3 citric acid and weigh out 8 g sodium hydrogencarbonate. Record your results in a new results table. This reaction will froth up, so add the powdered solid slowly enough to prevent it overflowing the cup. Keep stirring and record the maximum temperature change.

**Analysis and questions – you will be required to enter some of your your answers into Labdog**



***Processing your results***

Plot your results onto a graph similar to that shown below applying a line of best fit through the data. Extrapolate the linear sections in the graph as shown and work out the ‘corrected’ temperature change, *T*. Calculate the enthalpy change for each reaction.



**Note**: Think carefully about how to plot the graph for Experiment 2 as the data will be somewhat different from experiment one.

All of the energy transferred in these reactyions is assumed to be exchanged with the surrounding water and no energy is transferred to the air, the glass of the thermometer, or the polystyrene cup. The specific heat capacity of water, c, is approximately 4.2 J g-1 K-1, meaning that 4.2 J of energy will raise the temperature of 1 g of water by 1 K. As the solution is dilute both its density and specific heat capacity can be assumed to be that of water.

Given the relationship:

Energy transferred = mass x specific heat capacity of the solution x temperature change

***q* = *m*cΔ*T***

*....*the energy transferred, *q,* (in Joules) to the water can be determined. To calculate the enthalpy change, Δ*H*, (in kJ mol-1), the equation below can be used:

**Δ*H* = -*q* / *n*** (n = no. of moles)

**Note:** It is key to ensure that the correct sign for Δ*H* is included in the final value to show whether the reaction was exothermic (Δ*H* = -ve) or endothermic (Δ*H* = +ve).

1) For each of Experiments 1 and 2, calculate the energy transferred in the experiment. Take care with significant figures (*hint*: consider the number of significant figures available for the concentration data and the value of c).

2) Determine the enthalpy changes per mole for the reactions based on copper(II) sulfate for Experiment 1 and citric acid for Experiment 2 ensuring that you indicate whether each treaction is exothermic or endothermic by the sign of the change (‘+’ or ‘-’).

3) Draw a labelled enthalpy level diagram for the reaction in each of experiments 1 and 2.

4) Endothermic reactions tend to only be spontaneous if there is a large increase in entropy during a reaction. Examine the equation for the reaction in Experiment 2 - is there any information in the equation which gives you an indication about the entropy change during the course of this reaction?

**Make sure you show all working and check your results with a demonstrator.**

**Follow all further instructions if any are given.**

**Deadlines, Assessment and Feedback on Performance**

You are required to complete the *Skills Portfolio* document associated with this practical. This should be completed electronically with all photos inserted in the appropriate places and accompanying text typed in. The submission deadline for *Skills Portfolio*s will normally be midnight on the Sunday following the practical, although you will be given specific guidance during the practical session. Submission is via the e-submission system Turnitin which you will be able to access in the appropriate folder in the Laboratories and Coursework Blackboard course.