Lab: Mole Relationship in Chemical Reactions: Limiting and Excess Reactants

Introduction

In this lab, a single displacement reaction between aluminium metal and copper (II) chloride will be used to investigate the relationship between the limiting reactant and excess reactant.

$$2Al_{(s)} + 3CuCl_{2(aq)} \longrightarrow 2AlCl_{3(aq)} + 3Cu_{(s)}$$

The reaction occurs because the aluminium is more reactive than copper. The copper (II) chloride solution is blue due to the copper (II) ions, whilst the aluminium chloride solution is colourless.

In this experiment, you will let aluminum metal react with a copper (II) chloride dihydrate solution. After observing the results of this chemical reaction, you will determine the mass of copper (II) chloride dihydrate used and the mass of product, (i.e. copper), formed. These data will then be presented in a more useful form, i.e. the ratio of moles of copper (II) chloride dihydrate used to moles of product formed. Once mole ratio is determined, it may be converted to a whole number ratio and the numbers placed in front of the symbols for copper (II) chloride and copper. The result should be a balanced chemical equation with the atoms of the product equal in number and kind to the atoms of reactant. Stoichiometric calculations are based on the coefficients in a correctly balanced equation.

Prelab Assignment

From the introduction, formulate a statement to:

a. Experimentally determine the mole ratio between the participants in a chemical reaction.

b. Experimentally determine the coefficients in an equation for a reaction.

Materials & Apparatus

2 aluminum strips, ~ 2.00 g - 3.00 g of copper (II) chloride, 2 x 250 mL beakers, ring clamp, retort stand, hot plate, tweezers and scalpel, supply of distilled water, electronic balance, beaker tongs.

MSDS: copper (II) chloride:

Procedure

1. Prepare two data tables: qualitative and a quantitative table. Record your observations and data accurately and neatly in two suitable data tables. Take special care to record the units as an important part of each measurement. Express each measurement using the correct number of significant figures.

2. Take a dry empty beaker and place it on a balance, record the mass in the quantitative table.

3. Place ~ 2.00 g - 3.00 g of copper (II) chloride, (note if it is a hydrate), and record its full name and mass in the quantitative table. Also record qualitative observations in the qualitative table.

4. Add sufficient water to dissolve the copper (II) chloride, (~25 mL of distilled water), make qualitative observations in the qualitative table. (Stirring with a stirring rod and/or heating on a hot plate may increase the rate of dissolving, thus aid the solid to dissolve.)

5. Add *large* pieces of aluminium strip,(*why?*), and make observations, wait until the reaction is complete, as indicated by the solution becoming colourless. (*Why?*) Record qualitative observations in the qualitative table.
6. Using tweezers, slowly and carefully remove the excess unused strip of aluminium from the solution, without allowing any of the copper metal formed to be removed. Scrape off as much of the copper from the aluminium strip using a scalpel and without allowing the copper globules to be broken into finer particles. Wash off any remaining particles of copper from the aluminium strips using distilled water back into the beaker. Record qualitative observations in the qualitative table
7. Slowly and carefully decant the solution containing the copper particles to remove the aluminium chloride that is in solution. Record qualitative observations in the qualitative table. (Decant means to pour off the liquid leaving solid behind.)
8. Wash the copper residue with copious amounts of distilled water, (*Why?*), decanting the solution each time. Repeat the washing and decanting procedure 4 or 5 times. Be careful to lose as little of the solid as possible. Record qualitative observations in the qualitative table.
9. After the final washing, the solid must be dried. Place the beaker containing the copper residue on a hot plate and heat until just dry, avoid over-heating, (*Why?*).
10. Cool the beaker and copper to room temperature and then place on a weighing balance, record the mass in the quantitative table. Record qualitative observations in the qualitative table. To ensure that the sample is dry, it may be necessary to heat, cool and mass again, (to within ± 0.01 g).
Dispose of the solid as recommended by your teacher.

Data Processing & Presentation
1. Calculate the mass of the copper (II) chloride solid used. (The limiting reactant).
2. Calculate the number of moles of copper (II) chloride used, (note if it was a hydrate, then calculate the molar mass correctly).
3. Calculate the experimental mass of the copper solid formed.
4. Calculate the experimental number of moles of copper formed.
5. Determine the moles ratio: moles of Cu: moles of copper (II) chloride.
6. Convert the fractional coefficient to a whole number ratio coefficient in the reaction.
7. Determine the whole number ratio of copper (II) chloride used : copper formed
8. Write a balanced equation between the copper (II) chloride and aluminium metal. (It may be necessary to balance the remainder of the equation by inspection, after the mol: mol ratio has been used.)
9. Prepare a summary table of all the data processing.

Conclusion and Evaluation
1. Provide a valid conclusion to the prelab assignment.
2. List some of the sources of experimental error which you think may have influenced the accuracy of your results in this experiment. Wherever possible, indicate whether each error would have made your result high or low, and suggest methods of improving your procedure.

Extension
1. Determine the theoretical mass of copper that should have been formed from the moles of copper (II) chloride used by you. Show mathematical calculations in your report.
2. Calculate the percent yield of the copper.
3. Assume that gallium metal would act atom-for-atom exactly the same as aluminum in this experiment. How many grams of gallium, Ga, would have been used in the reaction if one gram of copper were produced?