*** Instructions:** Please complete the following fields, corresponding to Experiment 2 in Chemistry 1010H. If you have any questions, please contact the laboratory coordinator.*****

Name: Esther Schachter Student ID number: 0731405

Experiment Date: 08/02/22

CHEM1010H – LAB REPORT REMOTE EXPERIMENT 2 – Transformation of Copper

Question 1: Complete the following Tables using the data provided for your lab section.

Table 1: Mass measurements for copper reactions

Mass of copper wire:	0.6272
Mass of zinc solid:	1.9927
Mass of watch glass + filter paper:	37.6448
Mass of watch glass + filter paper + final recovered Cu product:	37.0850

Table 2: Observation of the reactions in the video of copper in each step of the experiment.

	Observations (wire in nitric acid):
Part A (1^{st} step)	Solution changes colour from a transparent liquid solution to a light green translucent liquid solution. Bubbles are produced in the light green solution. Dark brown gas is released from the green solution after watch glass is removed and the solution's contents are swirled.
Part A	**Observations (solution from A-1 into water):**

(2nd step)	The light green liquid copper solution is poured into transparent liquid water solution. The resulting solution changes colour from a transparent solution with the added light green translucent copper solution to a light blue, translucent solution.

Part B	**Observations (reaction of copper product with sodium hydroxide):**
	The sodium hydroxide reacts with the light blue translucent copper solution to form a dark blue opaque solution with a dark blue precipitate. Indicating a colour change, a change in transparency and the addition of a precipitate.
Part C	**Observations (formation of CuO):**
	The temperature change (heat added) induced by the hot plate changes the dark blue opaque solution with a dark blue precipitate to copper oxide, a black opaque solution with black (opaque) precipitate.
Part D	**Observations (reaction of CuO with sulphuric acid):**
	The sulphuric acid reacts with the solid copper oxide to dissolve the copper oxide from the filter paper and into the 250 mL Erlenmeyer beaker. This forms a light blue, translucent copper solution in the beaker. Indicating a colour change and change in transparency.
Part E	**Observations (reforming Copper solid):**
	The zinc solid added to the light blue translucent solution reacts to form a light blue opaque solution and the reaction produces hydrogen gas. Some pieces of the zinc solid remain unreacted in the light blue, opaque solution after the reaction. The light blue opaque solution becomes colourless and transparent (barring the zinc and copper solid precipitates remaining in the solution)

	after continuous stirring. The colourless transparent solution is filtered and rinsed with acetone, resulting in the remainder of the unreacted zinc solids and the red flakes of the copper solid.

Question 2: What type of reaction is occurring in each step? Give a brief, one sentence description/explanation for your choice.

	Type of Reaction	**Explanation**
Part A (1^{st} step)	Oxidation/reduction	This is a redox reaction since copper ($Cu_{(s)}$) is oxidized (increases oxidation number) and nitric acid ($NO_3^-{}_{(aq)}$) is reduced (decreases oxidation number).
Part A (2^{nd} step)	Bronsted-Lowry acid-base	The addition of hydrogen ions and water indicate an acid-base reaction.
Part B:	Precipitation	The presence of the copper hydroxide solid in a liquid solution of water.
Part C:	Endothermic	The addition of heat to the reaction, creating copper oxide.
Part D:	Bronsted-Lowry acid-base	The addition of hydrogen ions and water indicate an acid-base reaction.
Part E:	Oxidation/reduction	This is a redox reaction since zinc ($Zn_{(s)}$) is oxidized (increases oxidation number) and the copper ($Cu_{(s)}$) is reduced (decreases oxidation number).

Question 3 Provide a complete, balanced reaction equation for the <u>two</u> redox reactions. Indicate which species is the oxidizing agent and which is the reducing agent, in each case.

Equation 1:

1. $Cu_{(s)} \rightarrow [Cu(H_2O)_6]^{2+}_{(aq)}$

   $NO_{3(aq)}^{-} \rightarrow NO_{2(g)}$

2. $Cu_{(s)} \rightarrow [Cu(H_2O)_6]^{2+}_{(aq)}$

   $NO_{3(aq)}^{-} \rightarrow NO_{2(g)}$

3. $Cu_{(s)} + 6H_2O_{(l)} \rightarrow [Cu(H_2O)_6]^{2+}_{(aq)}$

   $NO_{3(aq)}^{-} \rightarrow NO_{2(g)} + H_2O_{(l)}$

4. $Cu_{(s)} + 6H_2O_{(l)} \rightarrow [Cu(H_2O)_6]^{2+}_{(aq)}$

   $NO_{3(aq)}^{-} + 2H^{+}_{(aq)} \rightarrow NO_{2(g)} + H_2O_{(l)}$

5. $Cu_{(s)} + 6H_2O \rightarrow [Cu(H_2O)_6]^{2+} + 2e^{-}$

   $1e^{-} + NO_{3(aq)}^{-} + 2H^{+}_{(aq)} \rightarrow NO_{2(g)} + H_2O_{(l)}$

6. $Cu_{(s)} + 6H_2O \rightarrow [Cu(H_2O)_6]^{2+} + 2e^{-}$ ×1

   $1e^{-} + NO_3^{-}{}_{(aq)} + 2H^{+}_{(aq)} \rightarrow NO_{2(g)} + H_2O_{(l)}$ ×2

7. $Cu_{(s)} + 6H_2O_{(l)} \rightarrow [Cu(H_2O)_6]^{2+} + 2e^{-}$

   $2e^{-} + 2NO_3^{-}{}_{(aq)} + 4H^{+}_{(aq)} \rightarrow 2NO_{2(g)} + 2H_2O_{(l)}$

   $Cu_{(s)} + 2NO_3^{-}{}_{(aq)} + 4H^{+}_{(aq)} + 4H_2O_{(l)} \rightarrow [Cu(H_2O)_6]^{2+} + 2NO_{2(g)}$

Equation 2:

1. $[Cu(H_2O)_6]^{2+}_{(aq)} \rightarrow Cu_{(s)}$

   $Zn_{(s)} \rightarrow Zn^{2+}_{(aq)}$

2. ↑

3. $[Cu(H_2O)_6]^{2+}_{(aq)} \rightarrow Cu_{(s)} + 6H_2O_{(l)}$

   $Zn_{(s)} \rightarrow Zn^{2+}_{(aq)}$

4. ↑

5. $2e^{-} + [Cu(H_2O)_6]^{2+}_{(aq)} \rightarrow Cu_{(s)} + 6H_2O_{(l)}$

   $Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^{-}$

6. ↑

7. $2e^{-} + [Cu(H_2O)_6]^{2+}_{(aq)} \rightarrow Cu_{(s)} + 6H_2O_{(l)}$

   $Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^{-}$

   $[Cu(H_2O)_6]^{2+}_{(aq)} + Zn_{(s)} \rightarrow Cu_{(s)} + Zn^{2+}_{(aq)} + 6H_2O_{(l)}$

Question 4: Calculate the overall percent yield (copper recovered). Show the complete calculation.

ANSWER:

37.0850 g − 37.6448 g

= −0.5598 g final recovered copper product

0.6272
−0.5598
= 0.0674

percent yield = $\frac{0.0674}{0.2323} \times 100\%$

= 0.29 × 100% = 29%

$[Cu(H_2O)_6]^{2+}_{(aq)} + Zn_{(s)} \rightarrow Cu_{(s)} + Zn^{2+}_{(aq)} + 6H_2O_{(l)}$

Cu: 1	Cu: 1
H: 12	H: 12
O: 6	O: 6
Zn: 1	Zn: 1

∴ the percent yield of copper is 29%

$[Cu(H_2O)_6]^{2+}_{(aq)}$ = 171.61 g/mol

$Zn_{(s)}$ = 65.38 g/mol

$0.6272\,g \times \frac{1}{171.61\,g/mol} = 0.0036548\,mol$

$1.9927\,g \times \frac{1}{65.38\,g/mol} = 0.03047874\,mol$

$\frac{0.03047874\,mol}{0.0036548\,mol} = 8.33937279$

−8.34 > 1

$[Cu(H_2O)_6]^{2+}_{(aq)}$: 0.0036548 mol

$Cu_{(s)}$: 63.55 g/mol

$0.0036548\,mol \times \frac{63.55\,g}{mol}$

= 0.23226246 g $Cu_{(s)}$

Question 5: What are 3 main sources of product loss (sources of experimental 'error', NOT the human errors that could be made during the experiment) for this procedure?

Give a way to improve the amount of product recovery in each case.

ANSWER:

1. The filtration of copper into the waste cylinder's solution as a source of product loss.
2. The unreacted zinc in the filtrate can be a source of error in weighing the calculations if the solids are not visible to the eye.
3. The endothermic reaction in Part C with copper oxide can be a source of error as the CuO can form fine powder and impede filtration.

Question 6: What is the overall percent yield from the procedure in the video? State the balance readings and show complete calculations for the yield.

ANSWER:

0.3517 g (copper wire)

1.8179 g (zinc solid)

42.9640 g (mass of weigh paper + watch glass + final recovered copper product

42.7147 g (mass of weigh paper + watch glass)

0.2493 g (mass of final recovered copper product)

$\%\text{ yield} = \frac{0.2493\text{ g}}{0.2605\text{ g}} \times 100\% = 95.71\% = 96\%$

$[Cu(H_2O)_6]^{2+}_{(aq)} + Zn_{(s)} \rightarrow Cu_{(s)} + Zn^{2+}_{(aq)} + 6H_2O_{(l)}$

Cu : 1
H : 12
O : 6
Zn : 1

$0.3517\text{ g} \times \frac{1}{171.61\text{ g/mol}} = 0.00204941\text{ mol}$ ZR

$1.8179\text{ g} \times \frac{1}{65.38\text{ g/mol}} = 0.02780514\text{ mol}$

$0.00204941\text{ mol} \times \frac{63.55\text{ g}}{\text{mol}}$

$= 0.13024001\text{ g Cu}_{(s)}$

$\times 2$

$= 0.26048002\text{ g}$

∴ the overall percent yield from the procedure in the video is 96%

References:

- ❖ Textbook- section or page number
- ❖ Blackboard- Chemistry 1010H
- ❑ Other (specify)

Works Cited

Chemistry: A molecular approach, 3rd Ed. [Online]; Tro, N. J.; Fridgen, T. D.; Shaw, L.; Pearson Canada: Toronto, 2019; Chapter 4, pp 109–138. (accessed 15, February 2022).

Experiment 2 – Transformation of Copper Data Set 5B [Online]; Blackboard, 2022. (accessed 15, February 2022).

Experiment 2 – Transformation of Copper: A Series of Chemical Reactions [Online]; Blackboard, 2022. (accessed 15, February 2022).