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CH201
Lab 7

Lab 7: Moles and Empirical Formula

Data:

Part A:

Data Table 1.

Item	Mass (g)
Cooled Crucible	15.772
Crucible + hydrate before heating	16.872
Crucible + anhydrous after heating	16.642
Filter Paper	0.630
Watch Glass	18.234
1st heating of watch glass, filter paper, and dried copper	19.283
2nd heating of watch glass, filter paper, and dried copper	19.273

Part B:

Data Table 2.

Item	Formula	Mass (g)	Length (cm)
Cube	Cu	144.28	2.50
Aluminum Can	Al	14.22	
Glass Slide	SiO_2	4.65	
Chalk	$CaCO_3$	4.54	
Epsom Salt	$MgSO_4 \cdot 7H_2O$	4.89	
Water	H_2O	10.58	

Calculations:

Part A:

Copper Chloride Hydrate Mass: 16.872 g - 15.772 g = 1.100 g
Water Lost Mass: 16.872 g - 16.642 g = 0.230 g
Anhydrous Copper Chloride Mass: 16.642 g - 15.772 g = 0.870 g
Copper Mass: 19.273 g - (18.234 g + 0.630 g) = 0.409 g
Chloride Mass: 0.87 g - 0.409 g = 0.461 g
Moles Water: 0.23 g / 18.015 g/mol = 0.0128 mol
Moles Copper: 0.409 g / 63.546 g/mol = 0.00644 mol
Moles Chloride: 0.461 g / 35.446 g/mol = 0.0130 mol

Mole Ratios:

Copper/Copper = 0.00644 mol / 0.00644 mol = 1
Chloride/Copper = 0.0130 mol / 0.00644 mol = 2.02 → 2
Water/Copper = 0.0128 mol / 0.00644 mol = 1.99 → 2

Part B:

Molar Mass Cu = 63.55 g/mol
Molar Mass Al = 26.98 g/mol
Molar Mass SiO_2 = 60.09 g/mol
Molar Mass $CaCO_3$ = 100.09 g/mol
Molar Mass $MgSO_4 \cdot 7H_2O$ = 246.48 g/mol

Copper Cube:

Moles Copper: 144.28 g / 63.55 g/mol = 2.2705 mol
Atoms of Copper b: 2.2795 mol * 6.022 x 10^{23} atoms/mol = 1.37 x 10^{24} atoms Cu
Atoms of Copper c: = 8.96 g/cm^3 * (2.50 cm)^3 = 140 g → 140 g / 63.55 g/mol = 2.20 mol →
2.20 mol * 6.022 X 10^{23} atoms/mol = 1.33 x 10^{24} atoms Cu

Aluminum Can:

Moles Aluminum: 14.22 g / 26.98 g/mol = 0.5270 mol
Atoms of Aluminum: 0.5270 mol * 6.022 x 10^{23} atoms/mol = 3.17 x 10^{23} atoms Al

Microscope Slide:

Moles SiO_2: 4.65 g / 60.09 g/mol = 0.077 mol SiO_2
Moles O: 0.774 mol * 2 = 0.155 mol O
Moles Si: 0.774 mol * 1 = 0.774 mol Si

Chalk:

Moles $CaCO_3$: 4.45 g / 100.09 g/mol = 0.045 mol $CaCO_3$
Moles O: .0445 mol * 3 = 0.133 mol O
Moles CO_3: 0.0445 mol * 1 = 0.0445 CO_3

Epsom Salt:

Moles $MgSO_4 \cdot 7H_2O$: 4.89 g / 246.48 g/mol = 0.020 mol $MgSO_4 \cdot 7H_2O$
Moles $MgSO_4$: 0.02 mol * 1 = 0.02 mol $MgSO_4$
Mass of H_2O: 0.0198 mol H_2O * 7 * 18.016 g/mol = 2.497 g H_2O

Water:
Moles of 10 mL H_2O: (10 mL H_2O / 0.9167 g/mL) / 18.006 g/mol = 0.61 mol H_2O
Moles of O: 0.61 mol * 1 = 0.61 mol O
Moles of H: 0.61 mol * 2 = 1.22 mol H

Results:

Part A:
Results Table 1. Moles of Copper, Chlorine, H_2O

	Mass (g)	**Moles (mol)**
Copper Chloride Hydrate	1.10	
$H_2O_{(g)}$ Removed	0.230	0.0128
Anhydrous Copper Chloride	0.870	
Copper	0.409	0.00644
Chloride	0.461	0.0130
Formula of the Copper Chloride Hydrate	$CoCl_2 \cdot 2H_2O$	

2. Copper (II) Chloride Dihydrate
3. $CoCl_2 \cdot 2H_2O_{(s)} \rightarrow CuCl_{2(s)} + 2H_2O_{(g)}$
4. $2Al_{(s)} + 3CuCl_{2(aq)} \rightarrow 2AlCl_{3(aq)} + 3Cu_{(s)}$

Part B:
Results Table 2. Direct Measurements of Matter

Item	**Molar Mass (g/mol)**	**Moles of Item**	**Calculation b. Answer & unit**	**Calculation c. Answer & Unit**
Cube	63.546	2.2705	1.367×10^{24} atoms Cu	9.23 g/cm^3
Aluminum Can	26.981	0.5270	3.174×10^{23} atoms Al	
Glass Slide	60.09	0.0774	0.155 mol O	0.774 mol Si
Chalk	100.09	0.0445	0.133 mol O	0.0445 mol CO_3
Epsom Salt	246.482	0.0198	0.0198 mol $MgSO_4$	2.497 g H_2O
Water	18.006	0.61	0.61 mol O	1.22 mol H

Discussion and Conclusion:

The purpose of this lab was to use the theoretical understanding of the law of multiple proportions and the law of definite proportions to find the empirical formula of some copper chloride hydrate compound. This was accomplished in Part A by evaporating the water from the copper chloride hydrate to make anhydrous copper chloride. Next, the anhydrous copper chloride was mixed with water and an aluminum wire placed in the solution. In this reaction, aluminum reduces copper chloride to form aluminum chloride in aqueous solution and copper as a solid metal. The copper was then separated from the aluminum wire. Each stage was massed. Through the laws of definite proportions and the masses of each stage of the reaction the empirical formula was determined through molar ratios. This experiment can be generalized to find the empirical formula of other compounds.

The empirical formula of the Copper Chloride Hydrate was determined to be $CoCl_2 \cdot 2H_2O$. It was necessary to heat the sample multiple times because there are hydrate compounds that were bound up in the sample. This method correctly identified the empirical formula of the compound. In Part B, the moles and number of atoms are reasonable when comparing the g/mol of each element or compound to the mass measured.