Stoichiometry

Purpose

From the precipitation reaction of sodium carbonate and calcium chloride, learn how to determine a chemical equilibrium equation coefficient, and how to effectively obtain the sediment, as the basis for quantitative analysis.

Equation

$Na_2CO_{3(aq)} + CaCl_{2(aq)} \rightarrow CaCO_{3(s)\downarrow} + 2NaCl_{(aq)}$

Principle

For a chemical reaction A + B $\rightarrow$ C + other products (unbalanced), if the amount of product C can be determined, then we can use a certain amount of reactant A and a different amount of reactant B. When the yield of product C does not increase with the increase in the amount of reactant B, we can know the amount of B that reacts with this certain amount of A and the ratio of A, B, and C in the reaction, and then decide The balance equation of this chemical reaction.

We can take the precipitation reaction of cadmium nitrate solution and sodium sulfide solution as an example for further explanation.

The method is described below. Ten beakers contain 1.00M Cd (NO_3) with 6.00mL solution. 1.00mL to 10.00mL volume of 1.00M Na_2S solution are added to each beaker.The resulting precipitate isdried and weighed. The expecting results of the experiment are listed below:

Precipitation reaction of 1.00M $Cd(NO_3)_2$ solution and 1.00M Na_2S solution

#	1.00M $Cd(NO_3)_2$(aq)		1.00M Na_2S(aq)		Mass of precipitate (g)
	V(mL)	(mmol)	V(mL)	(mmol)	
1	6.00	6.00	1.00	1.00	0.145
2			2.00	2.00	0.285
3			3.00	3.00	0.438
4			4.00	4.00	0.590
5			5.00	5.00	0.740
6			6.00	6.00	0.860

7			7.00	7.00	0.865
8			8.00	8.00	0.879
9			9.00	9.00	0.869
10			10.00	10.00	0.867

Comparing the data from the last two rows of Table, it can be seen that when the amount of Na_2S added is less than 6.00 mmol of $Cd(NO_3)_2$ in the beaker, the weight of the precipitate is approximately proportional to the amount of Na_2S added; When the amount of theadded Na_2S exceeds 6.00 mmol, the weight of the precipitate is almost a constantvalue. Calculate the amount of Na_2S by sediment weight, as shown in Figure 2.1. In Figure 2.1, the five-point data with the number of Na_2S less than 6.00 mmol is almost in line with the origin of the graph, and the four-point data with the number of Na_2S exceeding 6.00 mmol is almost a horizontal line. The intersection of these two straight lines falls in 0.85 g of precipitate and 6.00 mmol of Na_2S. From this, it can be seen that Na_2S reacted with 6.00 mmol $Cd(NO_3)_2$ was 6.00 mmol, and the molar ratio of the two reactants was 1:1. From the ratio of the reactants, it can be concluded that the products are CdS and $NaNO_3$. Generally, nitrates are soluble in water and most metal sulfides are insoluble in water. Therefore, the precipitate should be CdS. The equilibrium equation of this chemical reaction is:

$$Cd(NO_3)_2(aq) + Na_2S(aq) \rightarrow CdS(s) + 2NaNO_3(aq)$$

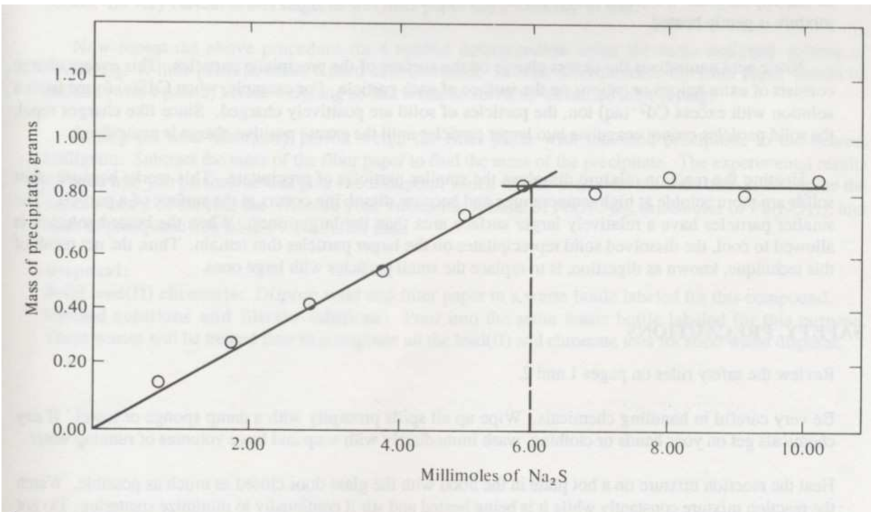

Figure 2.1. Relationship between the weight of precipitate and the amount of sodium sulfide

Procedure

In this experiment, for the precipitation reaction of $Na_2CO_{3\ (aq)}$ and $CaCl_{2\ (aq)}$, the whole class will work together to do a total of tenreactions with different $CaCl_2$ concentrations. Experiments with different ratios of reactants (as shown in the following table), each group will be designated as one of them.After the expreiments, map all the data fromthe first group to the tenth in the class (Figure 2.1) to determine the balance equation. The groups were used for the experiment numbers 1 to 10; the groups 11 to 20 were the repeated numbers from 1 to 10 respectively.If there are more experiments; the twenty-first group to the thirtieth group will be using the experiment numbers 1 to 10 again, respectively.

#	1	2	3	4	5	6	7	8	9	10
2.0 M $CaCl_2$(V), mL	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50
2.0 M Na_2CO_3 (V) , mL	3.00									

1. Take $CaCl_2$ solution of the specified volume in a 50mL beaker using a graduated cylinder.
2. Add 3.0 mL of 2M Na_2CO_3 solution to the above beaker and add 10 mL of distilled water to the solution.Stir theliquidwith a glass rod and mix well.
3. Heat the beaker for two to three minutes and stir the solution and precipitate in the beaker with a glass rod to prevent over-heatingand splattered solution.
4. Cool the beaker to room temperature.
5. Take a piece of filter paper and weigh it with the balance. Mark theweight and group number with a pencil on the edge of the filter paper.
6. Place the filter paper in a Buchi funnel, insert the funnel into a vacuum filter, and dampen the filter paper with distilled water.
7. After filtration, carefully remove the filter paper from the funnel and place it on clean towel.
8. Dry it in the oven.
9. Weigh out the precipitate.

Safety

Waste solutions and solid deposits from the experiment must be poured into the designated collection bottle or collection cylinder. Do not pour the waste into a sink or trash bin.

Data

Specified experiment number		
Experiment times	1st	2nd
2.0 M $CaCl_2$(V), mL		
2.0 M $CaCl_2$(mmol)		
2.0 M Na_2CO_3 (V) , mL		
2.0 M Na_2CO_3(mmol)		
Total mass of filter paper and precipitate(g)		
Mass of filter paper (g)		
Mass of precipitate (g)		
Mass of average (g)		

#	2.0 M Na_2CO_3 (V) , mL	2.0 M Na_2CO_3 (mmol)	2.0 M $CaCl_2$(V), mL	2.0 M $CaCl_2$(V), (mmol)	Group 1-10 Mass of precipitate (g)	Group 11-20 Mass of precipitate (g)	Group 21-30 Mass of precipitate (g)	Average (g)
1	3.00	1.50	1.00					
2			1.50					
3			2.00					
4			2.50					
5			3.00					
6			3.50					
7			4.00					
8			4.50					
9			5.00					
10			5.50					