GROUP: ……………

Surname: ....**Student Number:** ....

Partner: ....……..**Date of experiment:** ....

Experiment 2: Determination of the formula of lead iodide.

Introduction

In this experiment, you will use Job's method to determine the formula of lead iodide. The method applies to two reactants that combine to form a compound. Equimolar solutions are prepared and then mixed in varying ratios while taking care to keep the total reactant concentration the same. The maximum product in this case will be formed when the proportions of the reactants corresponds to the empirical formula of the product.

When lead nitrate solution is mixed with sodium iodide solution, lead iodide precipitates. If the number of moles of lead ions relative to the number of moles of iodide ions is varied, the amount of lead iodide that precipitate will also vary. By observing how the amount of lead iodide varies, you should be able to deduce the formula of the lead iodide. This can be done by plotting any quantitative measurement of the product against the mole fractions of the reactants, a Job's plot. The maximum meeting point of these curves indicates the empirical formula of the product. The mole fractions are on the same axis but with values for one reactant increasing left to right and those for the other reactant increasing from right to left. The height of the product will be used here.

Procedure

Apparatus and chemicals

10 x 100 mm test tubes and test tube rag, 5 mL pipette, 2 × smallest beakers, ruler, pipette filler, 0.50 M lead nitrate and 0.50 M sodium iodide, metric ruler

Caution: You will be using 5 mL calibrated measuring pipettes to measure the volumes of lead nitrate and sodium iodide solutions. Make sure you know how to correctly use these pipettes. If you are uncertain, ask your instructor.

1. Set up nine clean dry 100 mm test tubes. Use equimolar solutions of $\mathrm{Pb(NO_3)_2}$ and NaI, place them into the test tubes in mixed volume rations of 1:9 for test tube 1, then 2:8 in test tube 2, …., 9:1 in the last test tube. Refer to table 2.1.
2. Use a glass stirring rods to stir thoroughly each of the ten solutions.
3. Wait at least 20 minutes after stirring for the precipitate to settle.
4. An accurate measure of the amount of precipitate in each test tube would require filtering each solution to collect the precipitate, followed by drying and finally weighing the precipitate. For the purpose of this experiment, however, we can obtain a rough estimate of the relative amounts by simply measuring the depth of the precipitate in the bottom of the test tubes. Measure this value with your metric ruler for each test tube, recording to the nearest 0.5 mm.

Calculations and treatment of data

1. Calculate the number of moles of $\mathrm{Pb(NO_3)_2}$in each of the test tubes. n = V × M
   number of moles = volume in litres × molarity in moles/litre.
2. Calculate the number of moles of NaI in each of the test tubes.
3. Using your results from 1 and 2 above, calculate the sum of the $\mathrm{Pb(NO_3)_2}$and NaI moles in each test tube.
4. Calculate the mole fraction of iodide, X_{I^-} for each of the test tubes. This is simply (moles NaI / sum of $\mathrm{Pb(NO_3)_2}$and NaI moles). Notice that since there is one mole of $\mathrm{I^-}$ in NaI and one mole of $\mathrm{Pb^{2+}}$ in $\mathrm{Pb(NO_3)_2}$, this is also equal to

   $$X_{I^-} = \frac{\mathrm{Moles\ I^-}}{(\mathrm{moles\ \ I^- + moles\ Pb^{2+}})}$$

   for the ions in each of the solutions. In a similar manner, calculate mole fraction Pb, $X_{Pb^{2+}}$, for each of the solutions.
5. Now plot on graph paper the depth of precipitate versus mole fraction I, $X_{I^-}$and the mole fraction Pb, $X_{Pb^{2+}}$. The depth of the precipitate in millimetres should be on the vertical or y-axis and the X_{I^-} and $X_{Pb^{2+}}$ should be on the horizontal or x-axis. *Show X_{I^-} increasing left to right and $X_{Pb^{2+}}$ increasing right to left*. Make use of as much of the page of graph as possible. In other words, do not make the scales of the axes such that the graph paper is a lot smaller than the page. Be certain to label the axes precisely. Also, be sure to clearly label the graph itself, including all pertinent

information about what is being plotted so that anyone who reads the graph will be able to understand the significance of the data that has been plotted.

Discussion

In interpreting your results, remember that the amount of precipitate that you observe in each test tube will depend on the amount of the limiting reagent in that particular test tube. The maximum in the curve should occur when both are limiting.

1. At what values of X_{I^-} and $X_{Pb^{2+}}$ does the maximum in the plot occur? What is the mole ratio (Pb^{2+}/ I^-) at this maximum?
2. What is the empirical formula of the lead iodide based on your answer to question one?

Pre-lab questions

1. Calculate the volumes of NaI that must be placed in each of the ten test tubes.

   Table 2.1 showing the volumes of the reactants to be used in each test-tube

Test tube number	1	2	3	4	5	6	7	8	9
mL $Pb(NO_3)_2$	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25
mL NaI									

2. What is the total volume of each solution that you need for the experiment?

   Only collect about 10 mL more than this amount in each of the beakers.

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A friend has some questions about empirical formulas and molecular formulas. You can assume that he is good at performing the calculations. For a problem that asked him to determine the empirical formula; he came up with $C_{1.5}H_4$ as the answer. Is this answer correct? If not, what guidance would you offer your friend?

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REPORT SHEET: Determination of the formula of lead iodide

Objective/s :

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Results

Table:...

Test tube number	1	2	3	4	5	6	7	8	9
Depth of precipitate/mm									

Calculations:

Sample calculation: show the calculation steps for test tube 1 only.

Moles NaI

Moles $Pb(NO_3)_2$

Total moles

Mole fraction I^-

Mole fraction Pb^{2+}

Table 2.3 Table of results from sample calculations

Test tube number	1	2	3	4	5	6	7	8	9
Amount NaI / mol									
Amount $Pb(NO_3)_2$/ mol									
Sum of moles $NaI \& Pb(NO_3)_2$									
X_{I^-}									
$X_{Pb^{2+}}$									

NB: attach your graph paper sheet

Discussion:

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Conclusion:

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