Mr. Miller

Lead (II) Nitrate + Potassium Iodide Lab

0th Period – Chemistry

Month 00th, Year

Question/Problem

What will happen when Lead (II) Nitrate is mixed with Potassium Iodide?

Data

On the periodic table, Lead is represented by the chemical symbol Pb. It is a metal that has the ability to have multiple oxidation numbers which is why the roman numerals are needed to indicate the charge on the atom. All metals will lose their electrons and have positive charges when they form ions. Since the Roman-numeral II is written, the lead cation is represented as Pb^{+2}. Nitrate is a common polyatomic anion consisting of one Nitrogen atom and three Oxygen atoms with an overall charge of negative one. The anion is represented as NO_3^-. When ionic compounds form, they must combine in a ratio that cancels both the positive and negative charges so that a neutral compound is obtained. Since the Lead has a positive two charge, two Nitrates are needed to cancel the charge. The compound Lead (II) Nitrate is represented as $Pb(NO_3)_2$.

The chemical symbol for Potassium is K and it is located in the Alkali Metal Group on the periodic table. This means that it has a single valence electron and will lose that one electron to become a metal cation with a charge of positive one (K^+). Iodine is a halogen, which when it forms an ion will gain a single electron, giving it a negative one charge and changing the ending to *–ide* to indicate that it is the anion version of the atom (I^-). These ions will combine in a one-to-one ratio and will produce the ionic compound Potassium Iodide (KI).

At this point, the reactants in the chemical reaction have been determined and are placed on the left of the equation:

$$Pb(NO_3)_2 + KI \quad \rightarrow$$

When two ionic compounds are combined, the type of reaction that will occur is a double-replacement reaction. In a double-replacement reaction occurs, the positive ion from the first chemical will combine with the negative ion from the second chemical, while the positive ion from the second will combine with the negative from the first. Following the rules for ionic compounds, two Iodides are needed to cancel the charge on the Lead and only one Nitrate is needed to cancel the charge on the Potassium. These are the products and are placed on the right of the equation:

$$Pb(NO_3)_2 + KI \quad \rightarrow \quad PbI_2 + KNO_3$$

In order to predict exactly what will happen when the two chemicals are mixed, determining if anything noticeable will happen must be determined. The five indicators to look for in any chemical reaction are:

1) Emission of Light
2) Emission/Absorption of Energy
3) Formation of a Solid Precipitate
4) Change in Color
5) Evolution of a Gas

Since Lead is a heavy metal, it is very likely going to form a solid precipitate in a reaction. The solubility of each of the chemicals in the reaction must be determined to see if a solid will form. The first reactant contains Nitrate, which is always soluble in water, indicating the chemical is aqueous by placing (aq) after it. The second reactant has an Alkali Metal in it, which are also always soluble in water, indicating the chemical is aqueous as well. The second product contains both Nitrate and an Alkali Metal, so it is definitely aqueous as well. The first product contains Lead and Iodide. Solubility rules indicate that halide compounds tend to be soluble in water, but Lead is listed as an exception to that rule. This means that the Lead (II) Iodide product will not be soluble in water and will be a solid. The chemical equation can now be written including the solubility state of each chemical:

$$Pb(NO_3)_{2(aq)} + KI_{(aq)} \quad \rightarrow \quad PbI_{2(s)} + KNO_{3(aq)}$$

Now that the chemicals have been determined, the equation above is a skeleton equation and it is just missing the relative amounts of each substance needed to satisfy the conservation of mass and it will be an actual chemical equation. Notice how there is one Lead in the reactants as well as the products. They are balanced. The next chemical is Nitrate. There are two in the reactants and only one in the products. This means that two Potassium Nitrates can be produced using the Lead (II) Nitrate in the reactants. Now that Lead and Nitrate have been balanced, Potassium is next. There are now two in the products, so two are needed in the reactants. With two Potassium Iodides in the reactants, it balances both the Potassiums and the Iodides:

$$Pb(NO_3)_{2(aq)} + 2KI_{(aq)} \quad \rightarrow \quad PbI_{2(s)} + 2KNO_{3(aq)}$$

Given the balanced chemical equation and knowing that all of the ionic compounds will disassociate in water, a complete ionic equation can be derived by splitting each aqueous ionic compound into the individual ions:

$$Pb^{+2}_{(aq)} + 2NO_3{}^{-}_{(aq)} + 2K^{+}_{(aq)} + 2I^{-}_{(aq)} \quad \rightarrow \quad PbI_{2(s)} + 2K^{+}_{(aq)} + 2NO_3{}^{-}_{(aq)}$$

Any ions that appear on both sides of the complete ionic equation are called spectator ions and do not participate in the overall reaction. They can be crossed off and not used in the net ionic equation:

$$Pb^{+2}_{(aq)} + \cancel{2NO_3}{}^{-}_{(aq)} + \cancel{2K}^{+}_{(aq)} + 2I^{-}_{(aq)} \quad \rightarrow \quad PbI_{2(s)} + \cancel{2K}^{+}_{(aq)} + \cancel{2NO}_3{}^{-}_{(aq)}$$

The resulting equation is called the net ionic equation which shows the actual reaction taking place when the two chemicals are combined:

$$Pb^{+2}_{(aq)} + 2I^{-}_{(aq)} \quad \rightarrow \quad PbI_{2(s)}$$

Data given at the beginning of the lab says that the initial amount of Lead (II) Nitrate being used is the limiting reactant and the amount is 0.662 grams. Using this number, the exact amount of Lead (II) Iodide that should theoretically be produced is calculated using a 3-step Stoichiometric Calculation. The first step will be to convert the mass of Lead (II) Nitrate into moles of Lead (II) Nitrate. In order to do this, the molar mass must be determined for the chemical using the mass of each atom within the compound from the periodic table. The second step will be to use the balanced chemical reaction to determine the mole-ratio between Lead (II) Nitrate and Lead (II) Iodide. The last step will be using the molar mass of Lead (II) Iodide to determine the amount of it in grams that will be produced.

Step 1 = Lead has a mass of 207 g, Nitrogen has a mass of 14.0 g and Oxygen has a mass of 16.0 g.

$$Molar\ Mass\ Pb(NO_3)_2 = 1\ Pb + 2NO_3 = 1 \times 207 + 2 \times (14.0 + 3(16.0))$$
$$Molar\ Mass\ Pb(NO_3)_2 = 207 + 2 \times (14.0 + 48.0)$$
$$Molar\ Mass\ Pb(NO_3)_2 = 207 + 2 \times 62.0$$
$$Molar\ Mass\ Pb(NO_3)_2 = 207 + 124$$
$$Molar\ Mass\ Pb(NO_3)_2 = 331g$$

Step 2 = 1 mol of Lead (II) Nitrate should produce 1 mol of Lead (II) Iodide

Step 3 = Lead has a mass of 207 g, Iodide has a mass of 127 g.

$$Molar\ Mass\ PbI_2 = 1\ Pb + 2I = 1 \times 207 + 2 \times 127$$
$$Molar\ Mass\ Pb(NO_3)_2 = 207 + 254$$
$$Molar\ Mass\ Pb(NO_3)_2 = 461g$$

First the units given must be canceled out by dividing them in the next step. By doing this dimensional analysis, the units should all cancel except for the g of PbI_2:

$$g\ Pb(NO_3)_2 \left|\frac{mol\ Pb(NO_3)_2}{g\ Pb(NO_3)_2}\right|\frac{mol\ PbI_2}{mol\ Pb(NO_3)_2}\left|\frac{g\ PbI_2}{mol\ PbI_2}\right| g\ PbI_2$$

Next, the numbers calculated above will be placed in the appropriate box with the units they correspond to. Remember that the term *molar* means “pertaining to one mole”, so the number 1 goes in front of the molar masses:

$$0.662g\ Pb(NO_3)_2 \left|\frac{1mol\ Pb(NO_3)_2}{331g\ Pb(NO_3)_2}\right|\frac{1mol\ PbI_2}{1mol\ Pb(NO_3)_2}\left|\frac{461g\ PbI_2}{1mol\ PbI_2}\right| 0.922g\ PbI_2$$

This means that the theoretical yield for the amount of solid Lead (II) Iodide is 0.922 grams.

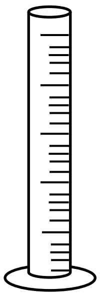
Hypothesis

If 0.662 g of Lead (II) Nitrate is reacted with excess Potassium Iodide, then a double replacement reaction should occur and a solid product of 0.922 g of Lead (II) Iodide will be produced.

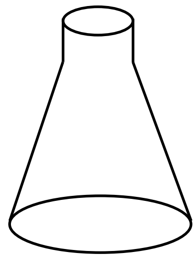
Experimental Procedure

The lab is already setup with the following items:

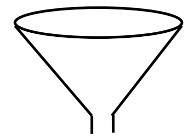
- Erlenmeyer Flasks
- Graduated Cylinders
- Funnels
- Large Bottle of Lead (II) Nitrate
- Large Bottle of Potassium Iodide
- Waste Container



Graduated Cylinder



Erlenmeyer Flask



Funnel

Steps for completion of the lab:

1. Each group obtains an Erlenmeyer flask
2. At the Lead (II) Nitrate station, use the funnel and graduated cylinder to measure approximately 10.0 mL
    a. 9.8 mL is measured
3. At the Potassium Iodide station, use the funnel and graduated cylinder to measure approximately 15.0 mL
    a. 15.2 mL is measured
4. Combine the contents of the two graduated cylinders in the Erlenmeyer flask
    a. As soon as the liquids combine, a powdery, yellow solid forms and begins to settle to the bottom
5. Discard the entire contents of the Erlenmeyer flask in the waste container at the front of the lab
6. Rinse out all glassware and place to dry at the front of the lab

Analysis

The reaction goes according to plan as a yellow solid is formed when the reactants combine. The actual amount is not collected due to the equipment available, but an actual yield of 0.750 g is given by the teacher. With the actual yield being 0.750 g of Lead (II) Iodide and the theoretical yield being 0.922 g, the percent yield for the reaction can be calculated using the following equation:

$$\%Yield = \frac{Actual\ Yield}{Theoretical\ Yield} \times 100$$

$$\%Yield = \frac{0.750\ g}{0.922\ g} \times 100$$

$$\%Yield = 81.3\%$$

Conclusion

The double replacement reaction predicted occurs and the yellow solid that is produced is Lead (II) Iodide. In conclusion, the chemical Lead (II) Iodide is an insoluble solid that is yellow in color and powdery in appearance.

The percent yield not being closer to 100% could be due to the fact that not exactly 10.0 ml and 15.0 ml of the reactants were used which would affect the 0.662 g of reactant that is used in the stoichiometric calculations. Also, with the liquid being transferred from a graduated cylinder, and then poured into the Erlenmeyer flask, not all of the liquid transfers over as very little of the liquid remains stuck to the sides of the graduated cylinder.