

Conclusion:

Lead metal was isolated from lead carbonate ore. This occurred in a two step process; first the lead carbonate was decomposed to form lead oxide, which was then reduced by carbon to form metallic lead. The percent lead composition of the original sample was 75.2%. 1.735 g of lead was isolated with 97.0% yield.

Appendix

Sample calculations

Percent lead in original sample

$$\%Pb = \frac{\text{mass of Pb isolated}}{\text{mass of PbCO}_3 \text{ sample}} \times 100\%$$

$$\%Pb = \frac{1.735 \text{ g}}{2.307 \text{ g}} \times 100\% = 75.21\%$$

Moles of PbO theoretically produced from PbCO₃ sample

$$\frac{\text{Mass of PbCO}_3}{\text{Mol wt of PbCO}_3} \left| \frac{1 \text{ mol PbCO}_3}{1 \text{ mol PbCO}_3} \right| \left| \frac{1 \text{ mol PbO}}{1 \text{ mol PbCO}_3} \right| = \text{Expected moles PbO}$$

$$\frac{2.307 \text{ g}}{267.20 \text{ g PbCO}_3} \left| \frac{1 \text{ mol PbCO}_3}{1 \text{ mol PbCO}_3} \right| \left| \frac{1 \text{ mol PbO}}{1 \text{ mol PbCO}_3} \right| = 8.634 \times 10^{-3} \text{ mol PbO} = \text{Expected moles PbO}$$

Moles of PbO actually produced

$$\frac{\text{Mass of PbO}}{\text{Mol wt of PbO}} = \text{Actual moles PbO}$$

$$\frac{1.808 \text{ g}}{223.19 \text{ g PbO}} = 8.099 \times 10^{-3} \text{ mol PbO} = \text{Actual moles PbO}$$

Percent Yield Calculation

Theoretical lead yield

$$\frac{\text{Mass of PbCO}_3}{\text{Mol wt of PbCO}_3} \left| \frac{1 \text{ mol PbCO}_3}{1 \text{ mol PbCO}_3} \right| \left| \frac{1 \text{ mol PbO}}{1 \text{ mol PbCO}_3} \right| \left| \frac{1 \text{ mol Pb}}{1 \text{ mol PbO}} \right| = \text{Theoretical moles Pb}$$

$$\frac{2.307 \text{ g}}{267.20 \text{ g PbCO}_3} \left| \frac{1 \text{ mol PbCO}_3}{1 \text{ mol PbCO}_3} \right| \left| \frac{1 \text{ mol PbO}}{1 \text{ mol PbCO}_3} \right| \left| \frac{1 \text{ mol Pb}}{1 \text{ mol PbO}} \right| = 8.634 \times 10^{-3} \text{ mol Pb} = \text{Theoretical moles Pb}$$

Actual Yield of lead

$$\frac{\text{Mass of Pb}}{\text{Mol wt of Pb}} \times \frac{1 \text{ mol Pb}}{1} = \text{Actual moles Pb}$$

$$\frac{1.735 \text{ g}}{207.19 \text{ g Pb}} \times \frac{1 \text{ mol Pb}}{1} = 8.374 \times 10^{-3} \text{ mol Pb} = \text{Actual moles Pb}$$

Percent Yield of lead

$$\% \text{Yield} = \frac{\text{Actual moles of product}}{\text{Theoretical moles of product}} \times 100\%$$

or

$$\% \text{Yield} = \frac{\text{Actual mass of product}}{\text{Theoretical mass of product}} \times 100\%$$

$$\% \text{Yield} = \frac{8.374 \times 10^{-3} \text{ mol Pb}}{8.634 \times 10^{-3} \text{ mol Pb}} \times 100\% = 97.0\%$$

Post-Lab questions

1. A lead ore contains 14.7% lead. Assuming 95% recovery, how much ore must be processed to make a 1000 kg of lead?

$$(X \text{ kg of ore}) \times (14.7\%) \times (95\%) = 1000. \text{ kg}$$

Solving for X kg of ore

$$\text{kg}(X \text{ kg of ore}) = \frac{1000. \text{ kg}}{(14.7\%) \times (95\%)} = 7160 \text{ kg}$$

since 95% has only two sig figs the answer should only have two sig figs

$$= 7.2 \times 10^3 \text{ kg}$$

Preparation of a Metal from an Ore

Abstract: Lead metal was produced from lead carbonate. The lead carbonate was first decomposed by heating to form lead oxide. The lead oxide was reduced by reaction with carbon to form lead metal. 1.735 g of lead metal were produced with a measured yield of 97.0%. The percent composition of the original lead carbonate was 75.2% lead.

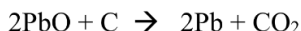
Introduction:

A metal ore contains a compound that has a particular metal as one of its constituents. In order for this metal to be isolated from the compound several chemical steps are required. In this experiment the metal ore is lead carbonate (PbCO_3). The steps necessary start with decomposing the lead carbonate to form lead oxide (PbO). This can be accomplished by heating the lead carbonate at high temperature.

The balanced chemical reaction for this step is



The lead oxide that is formed can be further reacted with carbon. This reaction will reduce the lead to form the elemental metal.



This is a redox reaction where the lead in lead oxide, oxidation number is reduced from 2 to 0, while the carbon is oxidized.

The percent composition of a substance is determined by measuring the mass of each of the constituent elements, and comparing those to the total mass of the compound. For example the percent lead in the lead carbonate sample can be determined by

$$\% \text{Pb} = \frac{\text{mass of Pb isolated}}{\text{mass of PbCO}_3 \text{ sample}} \times 100\%$$

If the sample is known to be a pure sample, the mass of the carbonate ion constituent can be determined by

$$\text{mass of CO}_3 = \text{mass of PbCO}_3 \text{ sample} - \text{mass of Pb isolated}$$

Stoichiometry can be used to determine the individual amounts of carbon and oxygen in the lead carbonate.

From the formula we know that the percent carbon of a carbonate ion is given by

$$\% \text{C} = \frac{\text{At. wt. (C)}}{\text{At. wt. (C)} + 3 \times \text{At. wt. (O)}} \times 100\% = \frac{12.011 \text{ g/mol}}{12.011 \text{ g/mol} + 3 \times 15.999 \text{ g/mol}} \times 100\%$$

$$\text{mass of carbon} = \text{mass of CO}_3 \times \% \text{C}$$

Experimental Methods

Equipment and Apparatus

Ring Stand, Balance, Clay triangle, Crucible, Hot pad, Crucible lid, Crucible tongs, Bunsen burner, 250 mL beaker

14. The lead was removed and dried with a paper towel and weigh the lead to the maximum accuracy of the balance.

Results

Decomposition of Lead Carbonate (Cerussite)

a	Mass of crucible		31.234 g
b	Mass of crucible + PbCO ₃		33.541 g
c	Mass of PbCO ₃	b-a	2.307 g
d	Mass of crucible + PbO		33.042 g
e	Mass of PbO	d-a	1.808 g
f	Mass of Recovered Lead metal (Pb)		1.735 g

Calculated results

Moles expected of PbO calc'd from mass of PbCO ₃	8.634×10^{-3}	mols
Moles of PbO measured experimentally	8.099×10^{-3}	mols
%Pb present in PbCO ₃ sample	75.21	%
Theoretical yield of Pb	8.634×10^{-3}	mols
Actual yield of Pb	8.374×10^{-3}	mols
Percent Yield	97.0	%

Observations – The white PbCO₃ compound turned yellow upon heating to form PbO. The cool yellow flame left black soot on the crucible. This was wiped off before weighing. It appears that some small pieces of carbon were stuck in the lead metal.

Discussion:

This experiment illustrated the method to isolate lead from lead carbonate ore. By isolating the lead from lead carbonate, the percent of lead in lead carbonate can be determined. This percentage of lead can be useful in identifying the particular lead ore used. Lead carbonate will have a different percentage lead than lead sulfide. If the percent composition of an ore can be determined, this would lead to clues as to what the chemical composition of the ore is.

Sources of error

There were several possible sources of error in this experiment. Loss of material during the transfer steps would reduce the yield of lead, and cause the %Pb to be lower than the actual. This can be minimized by more careful handling of the samples during transfer. Another source of error is the apparent inclusions of small pieces of carbon in the final lead sample. This carbon contamination caused the measured mass of recovered lead to be higher than the actual amount. This would cause the %Pb to be higher than the actual amount. A way to minimize this would possibly be to re-melt the lead separating the carbon pieces. Additional washing steps may also help.

Chemicals

Chemical	Formula	Mol. Wt	
Lead Carbonate	PbCO ₃	267.20 g/mol	
Carbon	C	12.011 g/mol	
DI water	H ₂ O	18.015 g/mol	

Intermediates and Products

Chemical	Formula	Mol. Wt	
Lead oxide	PbO	223.19 g/mol	
Lead	Pb	207.19 g/mol	

Procedures

1. The weight of a clean crucible without the lid was recorded to the maximum accuracy of the balance.
2. About 2.0 g of lead carbonate was added and the actual mass of the lead carbonate + the crucible was recorded to the maximum accuracy of the balance.
3. The crucible was heated with a cooler yellow flame. (a Bunsen burner flame that is oxygen poor) for 30 minutes. The crucible was 4 to 5 cm above burner so that the flames heated the sides and bottom. The material was stirred frequently with a spatula to ensure all the materials are exposed to the hot parts of the crucible. None of the material was lost from the crucible while stirring
4. After heating for 30 minutes (and color change should be observed) the crucible was placed on a hot pad to cool.
5. When the crucible had cooled the mass of the crucible and the new compound was recorded to the maximum accuracy of the balance. All the values were directly recorded in the lab notebook.
6. Approximately 1 g of powdered wood charcoal (carbon) was added to the crucible and mixed thoroughly with a spatula.
7. The lid was placed on the crucible (with the lid slightly ajar) and was heated on the hottest flame from the Bunsen burner (the amount of air entering the burner should be increased to form a hot blue flame). The cone of the flame was just reached the bottom of the crucible.
8. Heating was continued for about 15 minutes, was stirred during the last few minutes. A shiny pool of lead was visible.
9. Then the crucible was allowed to cool on the pad..
10. The contents of the crucible was poured into a 250 mL beaker half filled with DI water
11. The mixture was stirred. The lead sank and the carbon remained on top.
12. The water and carbon was decanted, leaving the lead at the bottom of the beaker
13. The washing process was repeated for several times until the lead is reasonably free of carbon