Problem 1: Carbonate rocks!

Teacher and Technician Pack

Pre-Lab answers

(Remember to give full references for any information beyond A-level that you find out)

1.Identify the principal mineral in each of the sedimentary rocks a - d below?

a) Nahcolite = sodium hydrogen carbonate
b) Limestone = calcium carbonate
c) Rhodochrosite = manganese carbonate
d) Smithsonite = zinc carbonate

2. metal carbonate → metal oxide + carbon dioxide

Group one metal carbonates; Lithium carbonate decomposes at Bunsen temperatures but other group one metal carbonates (e.g. sodium carbonate) are stable to heat.

Group two metal carbonates; The thermal stability of group two metal carbonates increases as you move down the group. Approximate decomposition temperatures are;

Carbonate	$BeCO_3$	$MgCO_3$	$CaCO_3$	$SrCO_3$	$BaCO_3$
Decomposition temperature	Unstable at room temp	400 °C	900 °C	1280 °C	1360 °C

Transition metal carbonates; Undergo thermal decomposition at Bunsen temperatures usually accompanied with a change in colour.

metal hydrogen carbonate → metal carbonate + carbon dioxide + water

Group one metal hydrogen carbonates; These are stable enough to exist as solids but do readily undergo thermal decomposition on heating

Group two hydrogen carbonates; These are so thermally unstable that they only exist in solution.

3. identify the colour changes you would expect to observe on heating a sample of each compound;

a) White (zinc carbonate) to yellow when hot / white when cold (zinc oxide)
b) Black (manganese carbonate) to dark brown (manganese oxide)
c) Green (copper carbonate) to black (copper oxide)

4.

a) lead carbonate → lead oxide + carbon dioxide
   $PbCO_3 \rightarrow PbO + CO_2$
b) Mass of CO_2 produced = 23.31 g – 22.33 g = 0.98 g
   ∴ Moles of CO_2 produced = 0.98 g ÷ 44.0 g mol^{-1} = 0.022 moles

c) If 0.022 moles of CO_2 are produced then 0.022 moles of $PbCO_3$ must have reacted. Hence there must have been 0.022 moles of $PbCO_3$ in the original sample.
mass = moles × molar mass ∴ mass of $PbCO_3$ = 0.022 moles × 267.2 g mol^{-1} = 5.95 g

d) Mass of sample heated = 23.31 g – 16.65 g = 6.66 g
Mass of $PbCO_3$ in sample = 5.95 g
∴ Percentage purity of sample = (5.95 g ÷ 6.66 g) × 100% = 89.3%

WARNING! The **products** from the reactions are not Low hazard. A crucible with a loose fitting lid should be used to minimise the generation of dust.

Using the pre-lab questions, students identify the rocks as either a metal carbonate or a metal hydrogen carbonate. Therefore, by heating a known mass of each rock sample and observing colour and mass changes, the identity of each rock can be determined.

Sample A

Mass of crucible	= 17.65 g
Mass of crucible + sample **[Low hazard]**	= 26.04 g
Mass of crucible + product **[Corrosive]**	= 26.02 g

Colour change = none

→ **Sample A is Limestone (no mass change)**

Sample B

Mass of crucible	= 17.59 g
Mass of crucible + sample **[Low hazard]**	= 22.50 g
Mass of crucible + product **[Irritant]**	= 20.66 g

Colour change = none

→ **Sample B is Nahcolite (no colour change)**

Sample C [Low hazard]

Mass of crucible	= 17.48 g
Mass of crucible + sample **[Low hazard]**	= 19.67 g
Mass of crucible + product **[Harmful]**	= 19.07 g

Colour change = white to pale yellow to white

→ **Sample C is Smithsonite (from colour changes)**

Sample D [Low hazard]

Mass of crucible	= 16.65 g
Mass of crucible + sample **[Low hazard]**	= 20.52 g
Mass of crucible + product **[Dangerous for the environment]**	= 19.22 g

Colour change = black to dark brown

→ **Sample D is Rhodochrosite (from colour changes)**

Sample C

Mass of CO_2 produced = 0.60 g

$\therefore$ Moles of CO_2 produced = 0.014 moles

$\therefore$ Moles of $ZnCO_3$ in sample = 0.014 moles

$\therefore$ Mass of $ZnCO_3$ in sample = 1.71 g

$\therefore$ **Purity of sample = 78.1%**

Sample D

Mass of CO_2 produced = 1.30 g

$\therefore$ Moles of CO_2 produced = 0.030 moles

$\therefore$ Moles of $MnCO_3$ in sample = 0.030 moles

$\therefore$ Mass of $MnCO_3$ in sample = 3.39 g

$\therefore$ **Purity of sample = 87.6%**

Equipment list

Students will need access to;

Samples of powdered rock labelled as below;

Calcium carbonate, $CaCO_3$ labelled Rock Sample A [Low hazard]
Sodium hydrogen carbonate, $NaHCO_3$ labelled Rock Sample B [Low hazard]
Zinc carbonate, $ZnCO_3$ labelled Rock Sample C [Low hazard]
Manganese carbonate, $MnCO_3$ labelled Rock Sample D [Low hazard]
An accurate balance (2 or 3 decimal point)

Each group will need;

2 × crucibles with loose fitting lids
2 × Bunsen burner, tripod, heatproof mat and pipe clay triangle
Spatulas
Tongs

Health and safety note

The products of the decomposition are not Low hazard. A crucible with a loose fitting lid is therefore required to minimise the generation of dust. The waste should be dealt with in an appropriate manner depending on amounts to be disposed of and in accordance with employer's requirements and any local rules.

Product	**From the decomposition of**	**Hazard**
Calcium oxide	Calcium carbonate	**Corrosive**
Sodium carbonate	Sodium hydrogen carbonate	**Irritant**
Manganese oxide	Manganese carbonate	**Harmful**
Zinc oxide	Zinc carbonate	**Dangerous for the environment**