VCE Chemistry Study Design 202

REVISED
2:39 pm, Apr 17, 2023

First Draft

Unit 2

How do chemical reactions shape the natural world?

SAC 5

Experiments with gases

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Quality educational content

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Background

As scientists strove to add new elements to the list of known elements in the Middle Ages, it finally dawned on some very smart individuals that they were ignoring an important possibility, that of gases. They realised that what looked like empty space actually contained particles and that those particles were not always the same.

The discovery of gases led to some challenges. How do you study something you cannot see and how do you keep a sample of a gas given the poor-quality glassware available.

Scope

You will perform a series of investigative experiments on gases over a period of 2 weeks.

For each task, you will be asked to reflect on the possible learnings from the task.

After finishing the tasks, you will answer a small number of questions under test conditions to summarise your understanding of gases.

All measurements and reflections need to be recorded in your logbook, which needs to be submitted after the short assessment at the end.

Materials

- Magnesium ribbon
- 2.0 M HCl
- 1.0 M NaOH
- 6%(v/v) H_2O_2
- Marble chips
- 100 mL gas syringe
- Large test-tubes
- Single holed stoppers
- Dried yeast
- Lime-water
- Sugar
- Universal indicator solution
- Small candle

MSDS: Given the list of reagents to be used, list safety precautions that you will need to take for these experiments.
A Material Safety Data Sheet (**MSDS**) is a document that contains information on the potential hazards (health, fire, reactivity and environmental) and how to work safely with the chemical product. It is an essential starting point for the development of a complete health and safety program. **Here a simple one to use. Use the Internet to research each chemical.**

Chemical	Health	Flammability	Reactivity	Protection Measures

Experiment 1: Production of gases

Record your observations in your logbook.

Gas 1
1. Add 10 mL of 2.0 M HCl to a large test tube.
2. Add a 2 cm piece of magnesium ribbon.
3. Test the gas produced with a lighted match (pop test).
4. What else do you notice about this reaction?

Gas 2
1. Add 10 mL of 2.0 M HCl to a test tube.
2. Add a small spatula of marble chips.
3. Test the gas produced with a lighted match.

Gas 3
1. Add 10 mL of hydrogen peroxide to a test-tube.
2. Add a small spatula of MnO_2 powder.
3. Test the gas evolved.

Questions: to be answered in your logbook

Gas 1 5 marks

1. Write a balanced equation for the reaction occurring.
2. Identify the gas released.
3. How can you test for this gas?
4. Write a balanced equation for the reaction occurring when you test the gas.
5. Describe how you could make another sample of this gas without using magnesium.

Gas 2 4 marks

1. Write a balanced equation for the reaction occurring.
2. Identify the gas released.
3. How can you test for this gas?
4. Describe how you could make another sample of this gas without using HCL or marble chips.

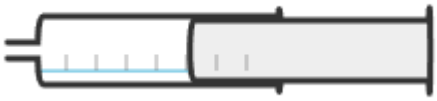
Gas 3 3 marks

1. Write a balanced equation for the reaction occurring.
2. Identify the gas released.
3. How can you test for this gas?

Experiment 2: Volume of gases

Record your measurements in your logbook.

1. Pull the plunger of a gas syringe until it is at 70 mL volume.



2. Put your finger on the nozzle.
3. Squeeze the handle as much as you can with finger still in place.
4. What is the smallest volume you can achieve?
5. Place a blob of blu-tack on the nozzle with it set on 70 mL. Record the temperature of the room.
6. Lie the gas syringe and thermometer in a tub of water at around 50 ^{0}C. Record the volume.
7. Use warmer water. Record the temperature and volume.
8. Sit the gas syringe and thermometer on a tray of ice. Record the volume and temperature.

Questions: to be answered in your logbook 3 marks

1. What property of gases is evident from steps 1 to 3 above?
2. What variables are you testing in steps 5 – 8?
3. Whose law are you testing in steps 5 – 8?

Experiment 3: Production and properties of CO_2

You have already seen that the action of acid on a carbonate will produce CO_2 gas.
There are other ways of producing CO_2

Record your observations in your logbook.

Method 2
1. Add 10 mL of lime-water to a large test-tube.

2. Use a straw to blow bubbles through the lime-water.

3. Record your observations.

Method 3
1. Add 10 mL of warm water to a test-tube. Add a teaspoon of sugar.

2. Add half a sachet of dried yeast

3. Add a single stopper and tubing to direct any gas from the test-tube into another test tube containing lime-water.

4. Sit in a warm spot and observe the lime-water over the next couple of days.

Method 4 Teacher demonstration/investigation
Test if it is possible to use an inverted funnel and plastic tubing above a Bunsen flame to direct enough combustion products through the tubing and through lime-water to turn the lime-water milky?

Questions: to be answered in your logbook 5 marks

1. Write a balanced equation for the reaction of CO_2 and lime-water.

2. Write an equation to explain how your body generates CO_2.

3. Write a balanced equation for the formation of CO_2 from glucose.

4. What is the other product formed from the sugar?

5. Write a balanced equation for the production of CO_2 when a Bunsen operates.

Properties of CO_2

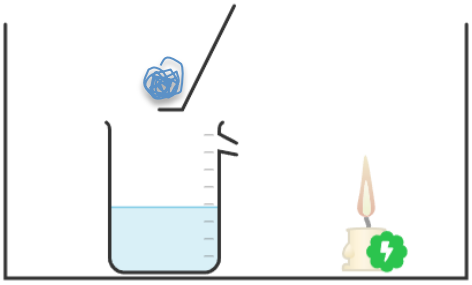
Record your observations in your logbook.

1. Density

1. Tare a sensitive balance.
2. Add 10 mL of 2.0 M HCl to a test tube.
3. Add a small spatula of calcium carbonate powder.
4. 'Pour' or direct the gas produced in the test-tube over the balance.
5. Does the balance register a mass?

2. Impact upon combustion

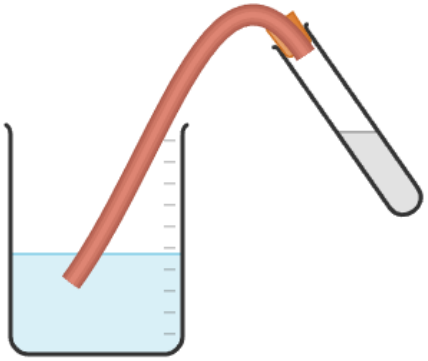
Apparatus for this experiment



1. Sit a small candle in a plastic tub. Light the candle
2. Sit a beaker containing 2.0 M HCl in the tub.
3. Add a large spatula of calcium carbonate.
4. Observe the impact on the candle flame.

3. pH

Apparatus for this experiment

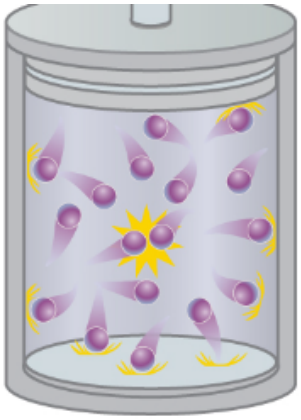


1. Add 75 mL of water to a 100 mL beaker.
2. Add 5 drops of 1.0 M NaOH.
3. Add 5 drops of universal indicator. Stir briefly
4. Add 10 mL of 2.0 M HCl to a test tube.
5. Add a small spatula of marble chips.
6. Direct the gas produced through the beaker.

Question: to be answered in your logbook

List the properties of CO_2 evident in these three experiments. 3 marks

Assessment (to be completed in your logbook under test conditions)



1. The kinetic theory postulates can be used to describe the motion of gas particles. Describe two postulates that were evident in this series of experiments. 4 marks

2. Summarise the properties of CO_2. 3 marks

3. Explain how you could use some of your data obtained to obtain an estimate of the temperature of absolute zero.

3 marks

4. **a.** Write a balanced equation for the reaction of CO_2 and water. 1 mark

b. Explain what has happened when you bubbled CO_2 through universal indicator solution.

3 marks

5. Write balanced equations for each of the following: 5 marks

a. calcium + sulfuric acid

b. sodium carbonate + sulfuric acid

c. pentane + oxygen

d. H_2CO_3 + sodium hydroxide

e. lime-water + carbon dioxide

Total **42 marks**

Teacher Guide

Title: Experiments with gases

Suited to: Unit 2: Area of Study 1

Study design reference: reflective annotations of one or more practical activities from a logbook

Key Knowledge

- CO_2, CH_4 and H_2O as three of the major gases that contribute to the natural and enhanced greenhouse effects due to their ability to absorb infrared radiation.
- the definitions of gas pressure and standard laboratory conditions (SLC) at 25 °C and 100 kPa
- calculations using the ideal gas equation ($pV = nRT$), limited to the units kPa, Pa, atm, mL, L ,°C, and K (including unit conversions)

Typical results

Experiment 1: Production of gases

Gas 1 5 marks

1. $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$
2. Hydrogen
3. Pop test. A lighted match will produce a pop in the mouth of the test-tube.
4. $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$
5. Use a different reactive metal like calcium in an acid.

Gas 2 4 marks

1. $CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$
2. CO_2
3. It will extinguish a flame.
4. Use any carbonate and any acid – CO_2 will be a product.

Gas 3 3 marks

1. $2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$
2. oxygen
3. Oxygen supports combustion.

Experiment 2: Volume of gases 3 marks

1. The density of gases is low. They can be compressed as there is space between particles.
2. Temperature is the independent variable and volume is the dependent variable.
3. Charles' Law is the relationship between gas volume and temperature.

Experiment 3: Manufacture and Properties of CO_2 5 marks

1. $Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$
2. Respiration: $C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$
3. $C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$
4. ethanol
5. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

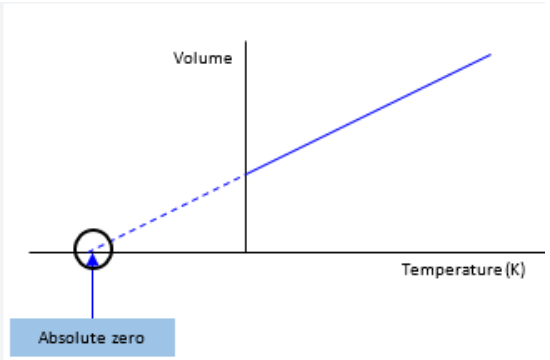
CO_2 is a dense gas. It does not support combustion and it forms an acidic solution in water.
3 marks

Assessment answers (Completed in logbooks under test conditions)

1. There is a lot of space between the particles compared to the volume of the particles themselves – gases are easily compressed.* The speed of the particles is proportional to temperature.* As the temperature of the gas syringe increases, the volume occupied by the gas increases.* The average kinetic energy of the particles is higher when the temperature rises.* The postulates can be summarised as: (1) the particles in a gas are in constant, random motion, (2) the combined volume of the particles is negligible, (3) the particles exert no forces on one another, (4) any collisions between the particles are completely elastic, and (5) the average kinetic energy of the particles is proportional to the temperature measured in kelvin.
4 marks

2. CO_2 is a dense gas*. It does not support combustion.* It forms an acidic solution in water.*
3 marks

3. If the volume and temperature values are plotted, a linear graph is produced*. If this graph is extrapolated until the volume = 0*, an estimate of absolute zero is obtained.*



3 marks

Assessment answers (continued)

4. **a.** $H_2O(l)$ + $CO_2(g)$ ⇌ $H_2CO_3(aq)$ and water. 1 mark

   b. The H_2CO_3 gradually neutralises* the NaOH. The pH decreases* and the indicator changes colour.*

   3 marks

5. Write balanced equations for each of the following: 5 marks

   a. $Ca(s) + H_2SO_4(aq) \rightarrow CaSO_4(aq) + H_2(g)$

   b. $Na_2CO_3(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + H_2O(l) + CO_2(g)$

   c. $C_5H_{12}(g) + 8O_2(g) \rightarrow 5CO_2(g) + 6H_2O(l)$

   d. $H_2CO_3(aq) + 2NaOH(aq) \rightarrow Na_2CO_3(aq) + 2H_2O(l)$

   e. $Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$

Total **42 marks**

End of VCE Chemistry Study Design 2023-2027
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