### Chapter Seven:
Isolation of pure water from sea water

### Chapter Eight:
Electrolysis of sea water

### Exercise for Chapter Seven and Eight

### Chapter Nine:
Extracting metals from their ores

### Exercise for Chapter Nine

### Chapter Ten:
Limestone, chalk and marble

### Chapter Eleven:
Chemical changes involving calcium carbonate

### Exercise for Chapter Eleven

<table>
<thead>
<tr>
<th>Date</th>
<th>Content</th>
<th>Grade</th>
<th>Correction (✓/×)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chapter Seven: Isolation of pure water from sea water</td>
<td></td>
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<td></td>
<td>Chapter Eight: Electrolysis of sea water</td>
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<td></td>
<td>Exercise for Chapter Seven and Eight</td>
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<td></td>
<td>Chapter Nine: Extracting metals from their ores</td>
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<td></td>
<td>Exercise for Chapter Nine</td>
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<td></td>
<td>Chapter Ten: Limestone, chalk and marble</td>
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<td>Exercise for Chapter Eleven</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Name: ___________________

Class:__________ ( )
Learning Objectives:
After studying this chapter, you should be able to:
- Describe how pure water can be isolated from sea water.
- Evaluate the methods of desalination.
- Describe the chemicals test to show the presence of water in a given sample.

Vocabularies
The following table show basic English terms used in this chapter. Write all their Chinese terms down in the right column.

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Distillation</td>
<td>6</td>
<td>Vapour</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Distillate</td>
<td>7</td>
<td>Desalination</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Evaporation</td>
<td>8</td>
<td>Pros and cons</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Condensation</td>
<td>9</td>
<td>Cobalt chloride paper</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Anti-bumping granules</td>
<td>10</td>
<td>Ethanol</td>
<td></td>
</tr>
</tbody>
</table>

7.1 Distillation (蒸餾)
- We have just seen how to extract common salt from sea water. How about if we want to obtain pure water from sea water instead?
- We can do this by a process called distillation.
- The following figure shows a set-up for distill sea water to get pure water.
  - If we boil the sea water, water turns into vapour which passes through the inner tube of the condenser.
  - The hot water vapour is cooled by the cold water flowing around it.
  - The water vapour condenses back to a liquid.
  - The pure water collected in the conical flask is called the distillate.

A ‘quick-fit’ set up for distillation
The process of evaporating a liquid and subsequently condensing the vapour is called distillation.

**distillation = evaporation + condensation**

### Experiment 7.1

**Title:** Obtaining pure water from sea water  
**Aim:** To obtain pure water from sea water by distillation.

**Apparatus and Chemicals:**
- Boiling tube with rubber stopper fitted with a bent glass delivery tube
- 250 cm$^3$ beaker, test tube
- Bunsen burner, heat-resistant mat and lighter, thermometer, stand and clamp
- Anti-bumping granules, sea water, ice-cold water, acidified silver nitrate solution.

**Safety precaution:** Wear safety goggles.

**Procedure:**

1. (a) Fill a test tube with sea water until it is about one-third full.  
   (b) Add a few drops of acidified silver nitrate solution to the sea water in the test tube.  
   (c) Observe what happens and record your observation in the table of result part.

2. (a) Fill a boiling tube with sea water until it is about one-third full.  
   (b) Add a few anti-bumping granules.  
   (c) Set up the apparatus as in the following figure.  
   (d) Heat the sea water gently.

3. When the liquid distils over steadily, read the temperature and record in the result part.

4. Continue heating to collect a few cm$^3$ of the distillate. Record the appearance of the distillate.

5. (a) Pour the distillate into a test tube.  
   (b) Add a few drops of acidified silver nitrate solution  
   (c) Record tour observation in the table of result part.

**Results and observations:**

<table>
<thead>
<tr>
<th>Observation / Test</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Addition of acidified silver nitrate solution to sea water before distillation</td>
<td></td>
</tr>
<tr>
<td>2. Temperature of the liquid that distils over is</td>
<td></td>
</tr>
<tr>
<td>3. Appearance of distillate obtained from distillation of sea water</td>
<td></td>
</tr>
<tr>
<td>4. Addition of acidified silver nitrate solution to distillate obtained from distillation of sea water.</td>
<td></td>
</tr>
</tbody>
</table>
Conclusions:
1. The distillate obtained by distillation of sea water (can / cannot) give an observable change when acidified silver nitrate solution is added. This shows that common salt is (present / not present) in the distillate.

2. Pure water can be obtained from sea water by ____________ .

Questions
1. What is the purpose of adding the anti-bumping granules?

2. What is the purpose of adding acidified silver nitrate solution to distillate?

Discussion
1. Instead of importing water from Guangdong province, desalination is an alternative means of providing fresh water to Hong Kong people. Discuss the pros and cons of using this alternative.

Advantages:

Disadvantages:
Experiment 7.2
Title: Testing for the presence of water in a given sample
Aim: To show the presence of water in a given sample.
Apparatus and Chemicals:
- Dry cobalt chloride test paper, watch glass, water, salt solution, ethanol, oil dry cleaning liquid, 5 droppers,
Safety precaution: Wear safety goggles. / ethanol is flammable/ dry cleaning liquid is harmful
Procedure:
1. Add a drop of water on a piece of dry cobalt (II) chloride test paper. What do you observe?
2. Repeat step 1 with the liquids in the following table in turn. Record all result in the table.

<table>
<thead>
<tr>
<th>Liquid</th>
<th>Effect on dry cobalt chloride test paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td></td>
</tr>
<tr>
<td>Salt solution</td>
<td></td>
</tr>
<tr>
<td>Ethanol</td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td></td>
</tr>
<tr>
<td>Dry cleaning liquid</td>
<td></td>
</tr>
</tbody>
</table>

Conclusions:
1. Which of the liquids give the same result as water?

1. Any liquid containing water can turn dry cobalt chloride test paper from _________ to _______________
Learning Objectives:
After studying this chapter, you should be able to:

- List the products obtained from electrolysis of sea water and describe some uses of these products.

Vocabularies
The following table show basic English terms used in this chapter. Write all their Chinese terms down in the right column.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Electrolysis</td>
<td>6. Chlorine</td>
<td></td>
</tr>
<tr>
<td>2. Electricity</td>
<td>7. Sodium hydroxide</td>
<td></td>
</tr>
<tr>
<td>3. Electrode</td>
<td>8. Sterilize</td>
<td></td>
</tr>
<tr>
<td>5. d.c. supply</td>
<td>10. Detergent</td>
<td></td>
</tr>
</tbody>
</table>

8.1 Electrolysis

- We can use chemical methods to break down a compound into simpler substances. E.g. passing electricity through water can break it down into hydrogen and oxygen.

- The process is called electrolysis (電解).

- Sea water is mainly a solution of sodium chloride in water. Water is a compound made up of hydrogen and oxygen. Hence there are four major elements in sea water: sodium, chlorine, hydrogen and oxygen.

- Passing electricity through sea water can rearrange the constituent elements to make other useful substances.

- A set-up for the electrolysis of sea water using carbon electrodes:

  Electrode connected to the positive terminal of the d.c. supply is the positive electrode (正電極) (+).

  Electrode connected to the negative terminal of the d.c. supply is the negative electrode (負電極) (−).
Experiment 8.1

Title: Electrolysis of sea water

Aim: To make useful substances by passing electricity through sea water.

Apparatus and Chemicals:
electrolytic cell, 2 carbon rods, low voltage power supply, wire and clip, 2 test tubes and
stoppers, blue litmus paper, red litmus paper, sample of sea water, wooden splint, glass rod
and lighter.

Safety precaution: Wear safety goggles.
The laboratory must be well-ventilated. Do NOT allow the electrodes to
touch each other while the power supply is switched on. Otherwise, the equipment
may be damaged.

Procedure:
1. Hold 2 small test tubes using a piece of foam rubber drilled with two holes.
2. Fill the small test tubes with one of the sea water.
3. Place the carbon electrodes inside the test tubes.
4. Press the test tubes against the bottom of the electrolytic cell and invert the set-up

5. Pour the sea water into the cell until it is about half filled.
6. a) Set up the apparatus as shown as below.
   b) Adjust the position of the tubes so that they do not touch the bottom of the cell.

7. Switch on the power supply.
8. Watch carefully to see what happens at each electrode.

Record your observations, including:
a) Any gases which are collected above the electrodes;
b) Any colour change in the solution
   c) Any solid deposit on the electrodes.
9. a) If gases are produced, wait until enough gases are collected for testing (small test tube at least two-third full)
b) Remove each test tube from the cell in turn. Stopper each tube once its rim leaves the solution.

10. Use a piece of moist blue litmus paper to test any gas collected above the positive electrode (anode +). Record your observations.

11. Use a burning splint to test any gas collected above the negative electrode (cathode -). Record your observations.

12. Use a piece of red litmus paper to test the sea water in the electrolytic cell. Record your observations.

Results and observations:

<table>
<thead>
<tr>
<th>Positive electrode (Anode)</th>
<th>Observations</th>
<th>Product</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Negative electrode (Cathode)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>The solution in the cell</th>
</tr>
</thead>
</table>

Conclusions:
1. During electrolysis of sea water, three products are formed. These are
8.2 Uses of the products obtained by the electrolysis of sea water
- Chlorine gas is formed at the positive electrode (+).
- Hydrogen gas is formed at the negative electrode (−).
- Eventually, the solution in the set-up becomes sodium hydroxide solution.
- The common uses of the products obtained by the electrolysis of sea water — hydrogen, chlorine and sodium hydroxide:

Class Practice 8.1 Making sentences:

1. Hydrogen is used to
2. Hydrogen is used as
3. Chlorine is used to
4. Chlorine is used to
5. Sodium hydroxide is used to
6. Chlorine and sodium hydroxide together are used to
A. Fill in the blanks

1. Distillation involves ____________ of a solution followed by ______________ of the vapour formed.

2. Dry cobalt (II) chloride test paper can be used to detect the presence of ______________.
   Water turns dry cobalt (II) chloride test paper from ___________ to ___________.

3. By electrolysis of sea water, the chemicals ______________, _________________ and _________________ can be produced.

B. Multiple choice questions

1. Which of the following statements about sea water is correct?
   A. It turns a dry pink cobalt chloride paper blue.
   B. It turns a dry blue cobalt chloride paper pink.
   C. It turns a moist pink cobalt chloride paper blue.
   D. It turns a moist blue cobalt chloride paper pink.

2. Electrolysis of sea water gives sodium hydroxide. Which of the following are the uses of this product?
   (1) Making soaps
   (2) Neutralizing acids
   (3) Making paper
   A. (1) and (2) only
   B. (1) and (3) only
   C. (2) and (3) only
   D. (1), (2) and (3)

3. Hydrogen is a product from electrolysis of sea water. Which of the following are the uses of hydrogen?
   (1) Manufacture of hydrochloric acid
   (2) Manufacture of nitrogenous fertilizers
   (3) Fuels for space shuttles
   A. (1) and (2) only
   B. (1) and (3) only
   C. (2) and (3) only
   D. (1), (2) and (3)

4. Hydrogen is a product from the electrolysis of sea water. Hydrogen is regarded as a clean fuel because
   A. it gives a colourless product after burning.
   B. burning hydrogen forms product that can be cleaned easily.
   C. the residue of burnt hydrogen has cleansing power.
   D. the product after burning does not cause pollution.

5. Which of the following substances is NOT one of the major products in the electrolysis of sea water?
   A. Potassium hydroxide
   B. Chlorine
   C. Hydrogen
   D. Sodium hydroxide

C. Structured questions.

1. In Hong Kong, over 80% of drinking water comes from the Dongjiang (東江), Mainland China. The river water must be treated before it is fit for drinking.
   (a) What solid materials would you expect to be present in the river water? Suggest a method to remove the solid materials from the water.
(b) Suggest a method to make the water clean and safe to drink.

(c) Desalting of sea water (removal of salt from water) was used in Hong Kong to obtain pure water in the past, but the method is no longer used. Suggest a reason for this.

2. Pure water can be obtained by distillation of sea water. The following set-up is for the distillation.

(a) What are liquid A and liquid B?

<table>
<thead>
<tr>
<th>Liquid A:</th>
<th>Liquid B:</th>
</tr>
</thead>
</table>

(b) Explain why the above method can obtain pure water from sea water.

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________

(c) Describe the reading on the thermometer (increasing, decreasing or remains unchanged) during the formation of liquid B.

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________

(d) The thermometer is filled with mercury, and a layer of nitrogen is filled above mercury. State the purposes of filling nitrogen on mercury.

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
Learning Objectives:
After studying this chapter, you should be able to:

- Describe the common methods of extraction of metals from ores.

Vocabularies
The following table shows basic English terms used in this chapter. Write all their Chinese terms down in the right column.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ores</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Minerals</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Extraction</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Aluminium</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Copper</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Lead</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Iron</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Mercury</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Silver</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Reduction</td>
<td></td>
</tr>
</tbody>
</table>

9.1 Metals in the Earth’s crust
- Metals play an important role in our lives, e.g.
  - You use metal cutlery to eat food.
  - The body frame of the bus that brings you to school is also made of metal.

Can you imagine what the world would become without metal?
- We get some metals from the ocean, but most from the Earth’s crust. About 25% of the Earth’s crust consists of metals.
- Only a few metals exist as free elements in the Earth. Most of them exist as compounds in nature.
- The individual chemical compounds that make up rocks are called minerals.
- Rocks from which we obtain metals are called ores.
- Getting a metal from its ore is called extracting the metal.

Class Practice 9.1
Conduct a library search on the extraction methods for metals in the below table. Complete last column of the table.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Name of ore</th>
<th>Extraction Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>bauxite (鋁土礦)</td>
<td></td>
</tr>
</tbody>
</table>
9.2 Extracting metals from their ores

- Common methods used to extract metals from their ores are:
  1) Physical methods
  2) Heating the ore alone
  3) Heating the ore with carbon
  4) Electrolysis of the molten ore

- Physical methods (物理方法)
  - Only metals which exist as free elements can be extracted by physical methods.
  - If the pieces of metal are large enough, we can pick them up by hand.
  - If the metal is much denser than the soil or rock mixed with it, we can wash the mixture with flowing water.
  - The flowing water carries the less dense particles away, leaving behind the metal.

- Heating the ore alone
  - We can extract mercury from cinnabar by heating it in air.
  - We can also extract silver from silver oxide by heating.

\[
\text{heat} \\
\text{silver oxide} \rightarrow \text{silver + oxygen}
\]
Heating the ore with carbon
- We can extract iron from haematite by heating it with carbon in a blast furnace (鼓風爐).

Electrolysis of the molten ore
- We can extract sodium, magnesium and aluminium by electrolyzing their molten (熔融的) ores.

Experiment 9.1 (Teacher’s Demonstration)
Title: Extracting silver from silver oxide
Aim: To extract silver from silver oxide by heating alone
Apparatus and Chemicals:
- Boiling tube, boiling tube holder, spatula, Bunsen burner and lighter, wood splint, silver oxide.
Safety precaution: Wear safety goggles.
Procedure:
1. Place 2 spatula measures of silver oxide in a dry boiling tube.
2. Heat the oxide strongly while holding a glowing splint in the boiling tube.
3. a) Observe what happens to the glowing splint.
   b) Observe the appearance of the solid that remains in the boiling tube.
   c) Record your observations.

Results and observations:

<table>
<thead>
<tr>
<th>What happens to the glowing splint</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the appearance of the solid remaining in the tube.</td>
<td></td>
</tr>
</tbody>
</table>
Discussion:
1. Based on what happens to the glowing splint, suggest what gas is produced.

2. Based on the appearance of the solid that remains after heating, suggest what the solid may be.

3. Complete the following word equation to represent the chemical change that occurs when silver oxide is heated.

\[
\text{heat} \quad \text{silver oxide} \rightarrow \quad \underline{\quad} + \quad \underline{\quad}
\]

Conclusions:
Silver can be extracted from silver oxide by ________________. Silver oxide decompose to give ______________ and ______________.

Experiment 9.2
Title: Extracting metals with carbon
Aim: To study whether carbon can be used to extract given metal oxides.

Apparatus and Chemicals:
- Crucible and lid, Bunsen burner, pipe-clay triangle, tripod mat and lighter, 50cm³ beaker, tongs, spatula, copper(II) oxide, lead (II) oxide, carbon powder

Safety precaution: Wear safety goggles. Lead (II) oxide is toxic.

Procedure:
1. Mix 3-4 spatula measures of copper(II) oxide with 2 spatula measures of carbon powder.
2. Put the mixture into a crucible.
3. Cover the mixture with several spatula of carbon powder.
4. Put a lid on the crucible. Support the crucible with a pipe-clay triangle on a tripod.
5. Heat strongly and keep red-hot for about 10 minutes.
6. Turn off the burner. Allow the mixture to cool to room temperature.
7. Tip the contents of the crucible onto a fireproof mat.
8. Examine the content for any shiny pieces of metal. Record your observations.
9. a) Repeat the experiment with lead(II) oxide in turn.
   b) Examine the content of the crucible for any shiny pieces of metal. Record your observations.
Results and observations:

<table>
<thead>
<tr>
<th></th>
<th>Any shiny pieces of metal? (✓/✗)</th>
<th>Does extraction occur? (✓/✗)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper(II) oxide</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lead(II) oxide</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Conclusions:
1. At Bunsen burner temperature, carbon can reduce oxide of ________ and oxides of ________.

Questions:
1. Write the word equations for the extraction that occur in this experiment.

2. What is the purpose of covering the reaction mixture with carbon powder in step 3?

3. Recall how iron(III) oxide is reduced to iron in a blast furnace. Can such a reaction be carried out in a school laboratory? Why?

4. What kind of metal oxide can be extracted by heating with carbon with a high temperature?

- Reduction with carbon
  - Heating metal oxide with carbon is also called “Reduction with carbon (碳還原法)’.
  - The removal of oxygen from a metal oxide is called reduction.
  - Carbon, is a reducing agent (還原剤), that can remove oxygen from a oxide.
  - Beside carbon, carbon monoxide and town gas can also be used as reducing agent.

- The availability (and hence price) of a metal depends mainly on
  - the abundance of the metal in the Earth’s crust;
  - the ease of mining its ore and the cost; and
  - the ease of extracting the metal from its ore and the cost.
A. **Concept Map**

Complete the concept map using the following words:

*Aluminium, electrolysis, haematite, heating in air, heating with carbon, mercury, ores*

```
rocks
  
  from which we obtain metals are
  
  examples
  
  cinnabar
    from which can be extracted by
  
  haematite
    from which iron can be extracted by
  
  bauxite
    from which can be extracted by
```

B. **Multiple choice questions**

1. From which of the following metal ores is lead extracted?
   - A. Haematite
   - B. Bauxite
   - C. Galena
   - D. Cinnabar

2. Aluminium can be extracted by
   - A. filtration of its ores.
   - B. fractional distillation of its molten ores.
   - C. electrolysis of its molten ores.
   - D. sublimation of its molten ores.

3. Which of the following statements is INCORRECT?
   - A. Metal oxide can be found in ores.
   - B. Malachite is an ore containing copper, carbon and oxygen.
   - C. All metals must be extracted by chemical methods (electrolysis, carbon reduction or direct heating).
   - D. Diamond is a mineral.

4. Which of the following combinations about the extraction of metals is correct?

```
<table>
<thead>
<tr>
<th>Metal to be extracted</th>
<th>Method of metal extraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Calcium</td>
<td>Heating with carbon</td>
</tr>
<tr>
<td>B. Aluminium</td>
<td>Electrolysis of its molten ore</td>
</tr>
<tr>
<td>C. Iron</td>
<td>Direct heating</td>
</tr>
<tr>
<td>D. Copper</td>
<td>Physical Method</td>
</tr>
</tbody>
</table>
```

5. Metal ores are natural resources that should be preserved. Which of the following explanations are correct?

   (1) Metals are limited in amount.
   (2) Metals are non-renewable.
   (3) Metals are expensive.

   - A. (1) and (2) only
   - B. (1) and (3) only
   - C. (2) and (3) only
   - D. (1), (2) and (3)
C. Structured questions.
1. Copper can be extracted by heating on copper(II) oxide with carbon.
   a) i) If you are supplied with a crucible with lid, a pipe-clay triangle and a tripod, try to draw a labeled diagram to illustrate how you can obtain copper from copper(II) oxide.
   
   ii) Describe the change(s) during the reaction in (i).

   iii) Write a word equation for the reaction in (i)

   iv) It is advisable to keep the crucible covered with the lid until the whole set of apparatus is cooled down. Why?

b) The experiment can be modifies as follows.

   i) What is the purpose of flushing nitrogen in the tube?

   ii) What would you observe in the test tube with limewater?
Learning Objectives:
After studying this chapter, you should be able to:

- Recognize that limestone, chalk and marble are different forms of the same compound, calcium carbonate.
- Design and perform chemical tests for calcium carbonate in a sample of limestone/chalk/marble.

Vocabularies
The following table shows basic English terms used in this chapter. Write all their Chinese terms down in the right column.

<table>
<thead>
<tr>
<th>1. Limestone</th>
<th>6. Slaked lime</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Chalk</td>
<td>7. Calcium hydroxide</td>
</tr>
<tr>
<td>4. Quicklime</td>
<td>9. Cement</td>
</tr>
<tr>
<td>5. Calcium oxide</td>
<td>10. Concrete</td>
</tr>
</tbody>
</table>

10.1 Limestone, chalk and marble
- Limestone, chalk and marble are common rocks. They have one thing in common – they all contain the same mineral.

- Chalk is the softest among them. Limestone is harder than chalk and marble is the hardest.

- Some uses of limestone:
  - Heat with shale
  - Crushed limestone
    - Used
      - In extracting iron from iron ore
      - As a material for the construction of roads and buildings
  - Powdered limestone
    - Used
      - To neutralize acidity in soil and water
      - To neutralize sulphur dioxide in flue gas from power stations
      - In making glass*
  - Quicklime (CaO)
    - Used
      - In making steel from iron
      - To neutralize acidity in soil
      - As a drying agent in industry
  - Slaked lime (Ca(OH)₂)
    - Used
      - To neutralize acidity in soil and in lakes affected by acid rain
  - Cement
    - Used
      - To make concrete*
Skeletons and shells of sea animals are made up of limestone.
- When these animals die, their skeletons or shells sink into the mud at the bottom of the oceans.
- Over millions of years, layers build up. Pressure from the top layers changes the bottom layers into chalk.
- Earth movements such as earthquakes may lift the chalk to the Earth’s surface.
- Earth movements may also cause the layers to sink further.
- Higher pressure and heat cause the chalk to turn into much harder limestone.
- Higher temperature and pressure may turn the limestone into marble.

**Experiment 10 - Design Experiment**

**Title:** What does limestone contain?
**Aim:** To design and perform chemical tests for limestone.
**Design experiment:** In your group, discuss how you will carry out the experiment by thinking of the following points.

**Apparatus and Chemicals:**
In the space provided, write down the apparatus and chemicals that you will use.

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________

**Safety precaution:**
What safety precautions, if any, need to be taken in your experiment?

________________________________________________________________________________________
Procedure:
In the space provided, write down the step-by-step procedure to carry out your experiment.

Results and observations:

<table>
<thead>
<tr>
<th></th>
<th>Testing</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flame test</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Anions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Addition of nitric acid</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Addition of acidified silver nitrate solution</td>
<td></td>
</tr>
</tbody>
</table>

Conclusions

1. Limestone contains _________ ions and ___________ ions.
2. Results of above test show that Limestone is ____________________________
Learning Objectives:
After studying this chapter, you should be able to:
- List the products of thermal decomposition of calcium carbonate.
- Express the changes in chemical reactions using word equations.
- Relate erosion of rocks to the actions of heat, water and acids on calcium carbonate.

Vocabularies
The following table show basic English terms used in this chapter. Write all their Chinese terms down in the right column.

<table>
<thead>
<tr>
<th>1. Calcium carbonate</th>
<th>5. Weathering</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Exothermic reaction</td>
<td>6. Erosion</td>
</tr>
<tr>
<td>3. Acidic</td>
<td>7. Carbonic acid</td>
</tr>
<tr>
<td>4. Alkaline</td>
<td>8. Calcium hydrogen carbonate</td>
</tr>
</tbody>
</table>

Experiment 11.1
Title: Action of heat on calcium carbonate
Aim: To study the action of heat on calcium carbonate.

Apparatus and Chemicals:
- test tubes in rack and with brush, glass rod, a small breaker, test tube holder, boiling spatula, Bunsen burner and lighter, anhydrous calcium carbonate

Safety precaution: Wear safety goggles.

Procedure:
1. Add 2 spatulas of calcium carbonate powder to a test tube. Hold the test tube with a test tube holder.
2. Heat the calcium carbonate strongly in a non-luminous Bunsen flame for 10 minutes.
3. Swirl the test tube from time to time over the tip of the fire.
4. Allow the solid to cool down for 5 minutes.
5. Record the appearance of the solid.

Discussion:
Upon heating, calcium carbonate changes to a white powder called quicklime (生石灰) (calcium oxide). Carbon dioxide is also given off.
The word equation for the change is:
Experiment 11.2
Title: Action of water on calcium oxide
Aim: To study the action of water on calcium oxide.
Apparatus and Chemicals:
Anhydrous calcium oxide, dropper, watch glass, spatula
Safety precaution: Wear safety goggles.
Procedure:
1. Put the solid obtained from experiment 10.1 onto a watch glass and add a few drops of water to the solid.
2. Touch the bottom of the watch glass. What do you feel?
3. Is there heat taken in or given out in the change?
Discussion:
When we add water to calcium oxide, calcium hydroxide forms.
The word equation for the change is:

Calcium hydroxide is often called slaked lime. It is slightly soluble in water.
The reaction, in which the heat is given out, is called exothermic reaction.

Experiment 11.3
Title: Preparation of limewater
Aim: To prepare limewater.
Apparatus and Chemicals:
Anhydrous calcium oxide, pH paper, dropper, watch glass, spatula, beaker, filter paper, stand and ring, funnel, boiling tube, glass rod, straw
Safety precaution: Wear safety goggles.
Procedure:
1. Put all the solid from experiment 10.2 into a small beaker.
2. Half fill the beaker with water and stir the mixture well for about 10 seconds.
3. Filter about 15cm³ of the liquid into a boiling tube.
4. Tip the filtrate onto a pH paper with glass rod to test its pH value. The solution is (acidic / alkaline).
5. Calcium hydroxide is slightly soluble in water. The solution of calcium hydroxide is called limewater (石灰水).

**Experiment 11.4**
**Title:** Action of carbon dioxide on limewater
**Aim:** To study the action of carbon dioxide on limewater
**Procedure:**
1. Blow into the filtrate obtained from through a straw. Record your observations.

2. Carbon dioxide turns limewater milky due to the formation of insoluble white calcium carbonate.

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Limewater is used to test for carbon dioxide gas.

**11.1 Chemical change involved calcium carbonate**

- Thermal decomposition of calcium carbonate
  
  \[
  \text{heat} \quad \text{calcium carbonate} \rightarrow \text{calcium oxide} + \text{carbon dioxide} \\
  \text{(limestone)} \quad \text{(quicklime)}
  \]

- Reaction of calcium oxide with water
  
  \[
  \text{calcium oxide} + \text{water} \rightarrow \text{calcium hydroxide} + \text{Heat} \\
  \text{(quicklime)} \quad \text{(slaked lime)}
  \]
  The solution of calcium hydroxide is called limewater.

- Reaction of calcium hydroxide with carbon dioxide
  
  \[
  \text{calcium hydroxide} + \text{carbon dioxide} \rightarrow \text{calcium carbonate} + \text{water} \\
  \text{(limewater)} \quad \text{(limestone)}
  \]

- The above changes can be summarized shown in the following:
11.2 Weathering and erosion of rocks

- Solid rock can be broken down into smaller pieces as a result of weathering (風化作用).
- The wearing away of surface materials and the movement of products of weathering from where they formed to a different location is called erosion (侵蝕作用).

The major causes of erosion are gravity, running water, waves, ice and wind.

- Chemical weathering
  When rain falls, it reacts with carbon dioxide in the air to form carbonic acid (碳酸).
  \[ \text{water} + \text{carbon dioxide} \rightarrow \text{carbonic acid} \]

  When this dilute solution of carbonic acid comes into contact with underground limestone deposits, it reacts with calcium carbonate to form soluble calcium hydrogen carbonate.
  \[ \text{calcium carbonate} + \text{carbonic acid} \rightarrow \text{calcium hydrogen carbonate} \]

  Underground limestone deposits are gradually dissolved in the same way over millions of years, creating underground holes called limestone caves.

- Weathering by temperature changes
  Changes in temperature can break rocks. This happens when rocks get hot in the daytime but cool down quickly at night.
  Most rocks are mixture of different minerals, which expand and contract to different extents. This would result in a stress, causing rocks to crack after a long time.
  Limestone also decomposes to give calcium oxide and carbon dioxide gas on heating. Due to sunshine over a long time, limestone eventually breaks down into small pieces.
B. Concept Map
Complete the concept map using the following words:

- Calcium carbonate, calcium oxide, calcium hydroxide, carbon dioxide, limestone, marble, water

B. Multiple choice questions
1. Which of the following is a correct test for carbon dioxide?
   A. It puts out a burning splint.  
   B. It turns limewater milky.  
   C. It turns blue cobalt chloride test paper pink.  
   D. It turns anhydrous copper(II) sulphate blue.

2. What is the flame colour when powdered limestone is put under a blue Bunsen flame?
   A. Lilac  
   B. Golden yellow  
   C. Orange  
   D. Brick-red

3. Which of the following tests can be used to test for the presence of carbonate ions in a compound?
   A. Put the compound into an acid and then bubble the gaseous product into sodium hydroxide  
   B. Put the compound into an acid and then bubble the gaseous product into calcium hydroxide  
   C. Put the compound into an alkali and then bubble the gaseous product into sodium hydroxide  
   D. Put the compound into an alkali and then bubble the gaseous product into calcium hydroxide

4. When carbon dioxide is bubbled into limewater, the solution turns milky. The milky colour is due to the presence of
   A. calcium.  
   B. calcium oxide.  
   C. calcium carbonate.  
   D. calcium hydroxide.
5. Which of the following rock samples would NOT react with dilute hydrochloric acid?
   A. Granite  
   B. Marble  
   C. Chalk  
   D. Limestone

6. Which of the following word equations shows correctly the reaction that occurs when calcium oxide is put into water?
   A. calcium oxide + water → calcium + water  
   B. calcium oxide + water → calcium hydroxide  
   C. calcium oxide + water → calcium oxide + hydrogen  
   D. calcium oxide + water → calcium + calcium hydroxide

7. When rainwater enters the cracks in a rock, the rock may break if temperature drops below freezing point afterwards. It is because
   A. icy water is corrosive to rocks.  
   B. water particles rub against rock particles fiercely at low temperature.  
   C. water reacts with the rock quickly at low temperature.  
   D. water may freeze and expand to widen the cracks on the rock.

C. Structured questions.
1. Calcium carbonate is a useful material in our daily lives.
   (a) Name two types of rocks that contain calcium carbonate.

   (b) Suggest a method to obtain calcium from the rocks you have stated in part (a).

   (c) How can we test the presence of carbonate in a sample of calcium carbonate? Write word equations for the reactions involved.

2. Joyce added carbon dioxide into saturated slaked lime.
   (a) What is saturated slaked lime commonly known as?

   (b) Describe the expected observations after carbon dioxide has been added to the saturated solution of slaked lime.

   (c) Joyce then filtered the white suspension produced. Name the residue.

   (d) Afterwards, the substance was added to distilled water. What was the expected observation? Explain your answer.

   (e) She added a drop of the mixture on a piece of pH paper. What was the expected observation?