Chapter

9 Chemicals in Industry

Keywords

- Alloy
- Components of glass and ceramic
- Natural polymer
- Synthetic polymer
- Natural rubber
- Vulcanised rubber
- Vulcanisation of rubber

What is an alloy?

What is superconductor alloy?

How are glass and ceramic made?

Are there different types of glass and their specific uses?

What is a polymer?

What are some examples of natural polymers and synthetic polymers?

Science Digest

Double Glazed Windows

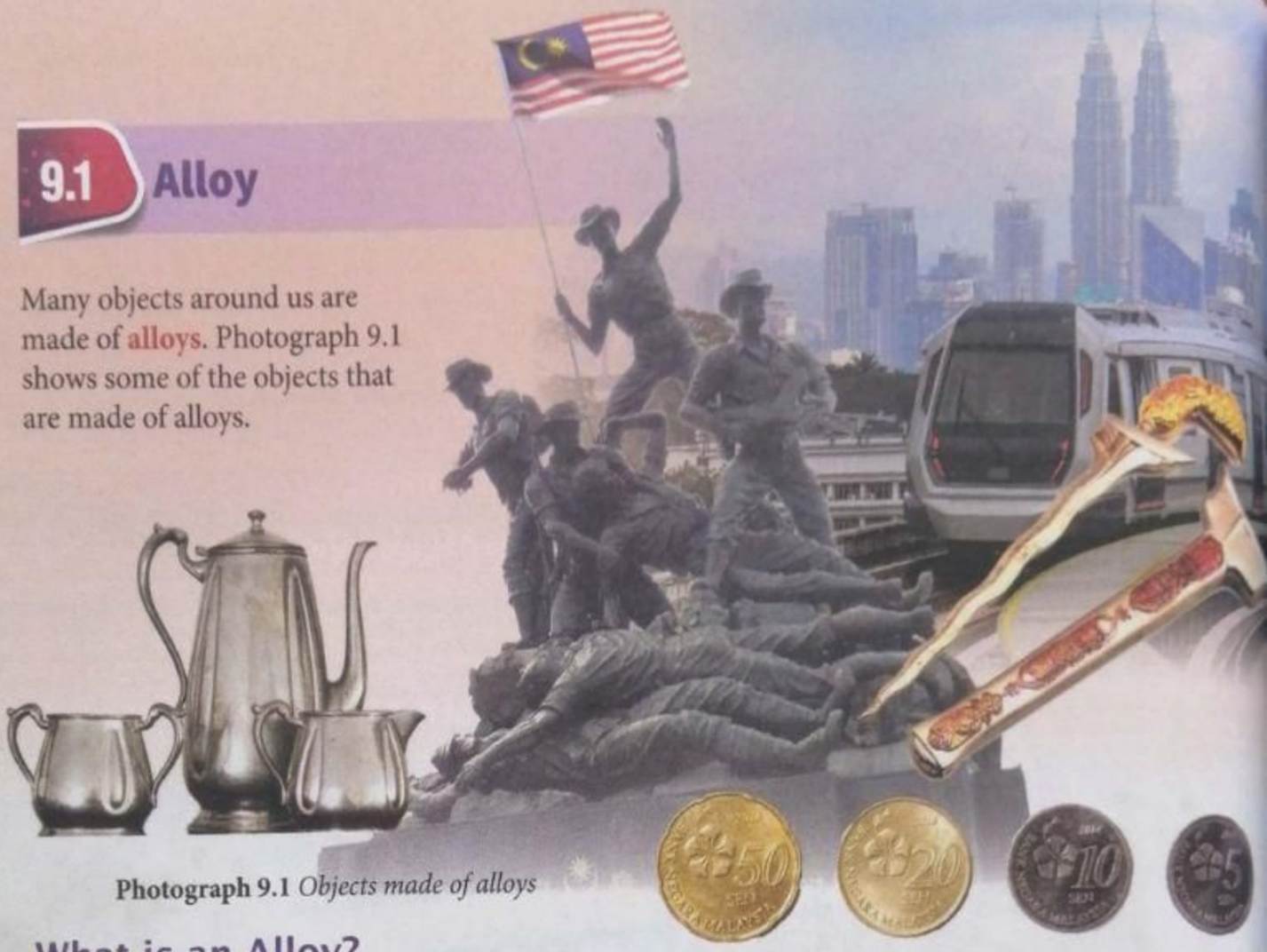
Double glazed windows consist of two layers of glass panels combined as one with empty space in between and inserted into a window frame or a door. Double glazed windows are better than windows with one glass panel because it can reduce the flow of incoming heat and cools down the space inside a building. In addition, this window is also soundproof. Double glazed windows also increase the security of the home as two glass panels are tougher to break compared to one glass panel. For safety purposes, it is better to choose a thicker glass panel or laminated glass.

You will learn about:

- alloy
- glass and ceramic
- polymer

9.1 Alloy

Many objects around us are made of **alloys**. Photograph 9.1 shows some of the objects that are made of alloys.



Photograph 9.1 *Objects made of alloys*

What is an Alloy?

An alloy is a **mixture** of several types of metals or a mixture of metal and non-metal by a certain percentage. There are several types of alloys which are commonly used in daily life such as **steel**, **pewter**, **bronze**, **brass** and **duralumin**. Table 9.1 shows the composition, properties and the uses of these alloys.

Interactive Game

Table 9.1 *Composition, properties and the uses of alloy*

Alloy	Composition	Properties	Uses
Steel	Iron 99% Carbon 1%	• Hard and strong	• Construction materials for buildings and bridges • To make frame of vehicles and railway tracks
Pewter	Tin 96% Copper 3% Antimony 1%	• Lustre • Resistant to corrosion	• To make decorative items such as photo frames
Bronze	Copper 88% Tin 12%	• Hard • Resistant to corrosion • Attractive colour	• To make monuments, metal sculptures, coins, medals and others
Brass	Copper 75% Zinc 25%	• Strong • Has shiny surface • Malleable • Gold in colour	• To make keys, door knobs, musical instruments such as trumpet
Duralumin	Aluminium 95% Copper 3% Magnesium 1% Manganese 1%	• Light • Strong • Resistant to corrosion	• To make frame of aircrafts, aeroplanes and others

Why is an alloy produced? Generally, most pure metals are soft and can corrode easily. These properties are not suitable for producing most of the things around us. Therefore, the process of forming alloys or **alloying** is done to improve the properties of pure metal.

The atoms in a pure metal are arranged orderly in layers. The layers of atoms in pure metal slide over each other easily when force is applied.

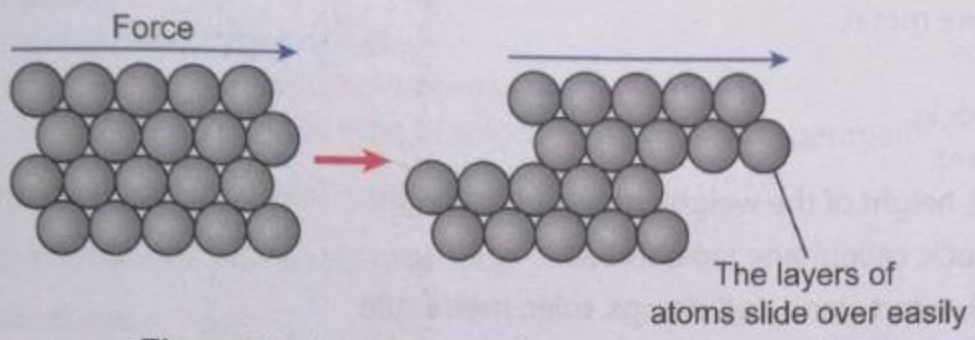


Figure 9.1 *Arrangement of atoms in a pure metal*

SCIENCE INTEGRATION WITH...

HISTORY

The first alloy found was bronze. Bronze was discovered hundreds of years back, in the prehistoric age known as the Bronze Age. During this period, bronze was used to make tools and weapons.

When one or more metal or non-metal elements are added into pure metal, the atoms from these elements make the layers of pure metal atoms difficult to slide over each other. This is because foreign atoms have different sizes. This makes alloys stronger and harder than pure metals.

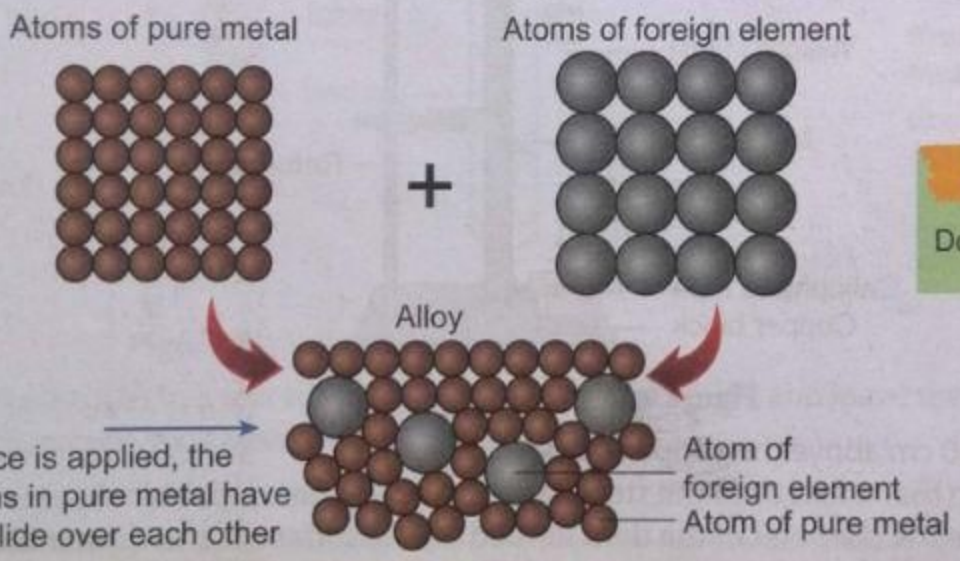


Figure 9.2 *An alloy*

Brain Teaser

Does alloy exist naturally?

The composition or percentage of the contents of each element in alloys can be altered based on its use.

Activity 9.1

Gallery Walk

Aim: To build a model of particle arrangement in pure metals and alloys.

21st Century Skills

Instructions:

1. Carry out this activity in groups.
2. Choose one type of alloy which is different from the other groups.
3. Use recycled materials to build a model of the particle arrangement in the alloy and its pure metal.
4. Present the model in front of the class.

Several properties of alloys and pure metals can be investigated through experiments in the laboratory. Let us carry out Experiment 9.1 and Experiment 9.2.

Experiment 9.1

Aim: To study the hardness of alloys compared to pure metals.

Problem statement: Is alloy harder than pure metal?

Hypothesis: Alloy is harder than pure metal.

Variables:

(a) manipulated: Types of metal blocks
(b) responding: Diameter of the dent
(c) constant: Diameter of steel ball, height of the weight, mass of the weight

Materials: Copper block, bronze block, cellophane tape, thread

Apparatus: Steel ball, weight (1 kg), retort stand and clamps, ruler, metre rule

Procedure:

1. Prepare the apparatus as shown in Figure 9.3.

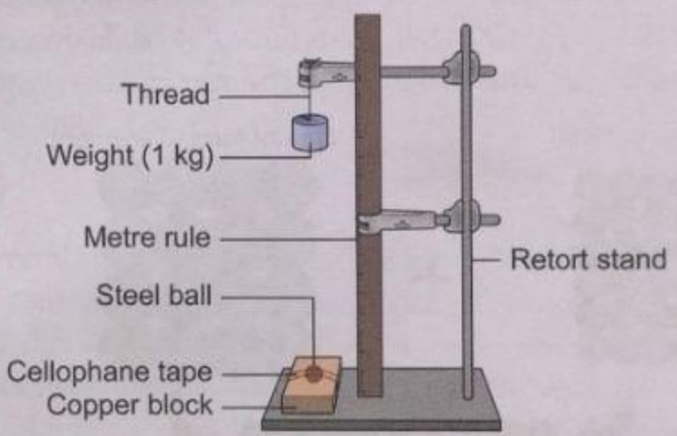


Figure 9.3 *Setup of apparatus*

2. Hang a 1 kg weight 50 cm above the copper block.
3. Release the weight so that it falls onto the steel ball attached to the copper block.
4. Observe and measure the diameter of the dent formed on the surface of the copper block using a ruler.
5. Repeat steps 2 to 4 twice on different surfaces to obtain an average diameter of the dents on the copper block.
6. Repeat steps 2 to 5 by replacing the copper block with the bronze block.

Result:

Metal block	Diameter of the dent (cm)			Average diameter (cm)
	1	2	3	
Copper				
Bronze				

Conclusion: Is the hypothesis of this experiment accepted? What is the conclusion of this experiment?

Questions:

1. Which is harder, the copper block or the bronze block?
2. Draw the arrangement of atoms in both blocks.
3. Why is the diameter of the dent for both blocks different?

Experiment 9.2

Aim: To study the resistance to corrosion of alloys as compared to pure metals.

Problem statement: Is alloy more resistant to corrosion compared to pure metal?

Hypothesis: Alloy is more resistant to corrosion than pure metal.

Variables:
(a) manipulated: Types of nails
(b) responding: The presence of brown layer on the nail
(c) constant: Size of nails, type of solution, duration of experiment

Materials: Iron nail, steel nail, water

Apparatus: Test tubes, test tube rack

Procedure:
1. Label the test tubes as *P* and *Q*.
2. Fill test tubes *P* and *Q* with 10 ml of water.
3. Put the iron nail into test tube *P* and the steel nail into test tube *Q*.

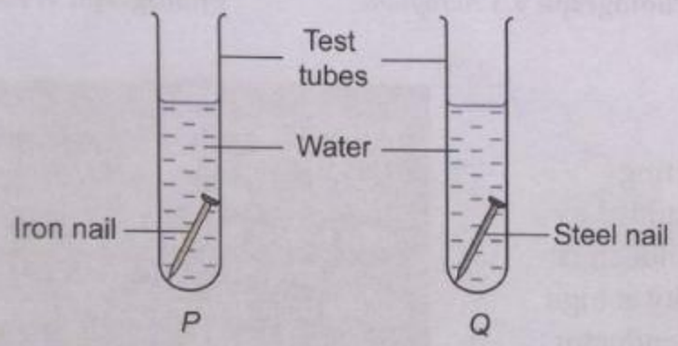


Figure 9.4 *Setup of apparatus*

Precautionary measures:
Ensure that both nails are rub using sandpaper before conducting the experiment, in order to clean the surface of the nails.

4. Place both test tubes in a test tube rack on the laboratory table and leave them for a week.
5. After a week, record your observations.

Result:

Type of nail	The presence of brown layer on the nail
Iron nail	
Steel nail	

Conclusion: Is the hypothesis of this experiment accepted? What is the conclusion of this experiment?

Questions:
1. Which nail will rust after a week?
2. Draw the arrangement of atoms in both nails.
3. Why is the resistance to corrosion for both nails different?

Besides the hardness and resistance to corrosion, what are the other properties of an alloy that distinguish it from pure metal? Discuss your answers with your teacher and friends.

The Use of Alloys in Daily Life

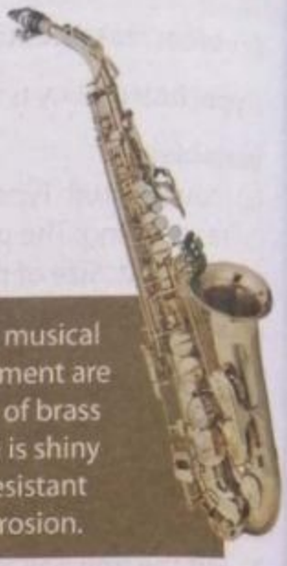
Alloys have specific uses based on their unique properties.

Steel is used for constructing skyscrapers because of its hardness and resistance to corrosion.

Photograph 9.2 *Petronas Twin Tower*

The body of an aeroplane is made of light and strong duralumin.

Photograph 9.3 *Aeroplane*



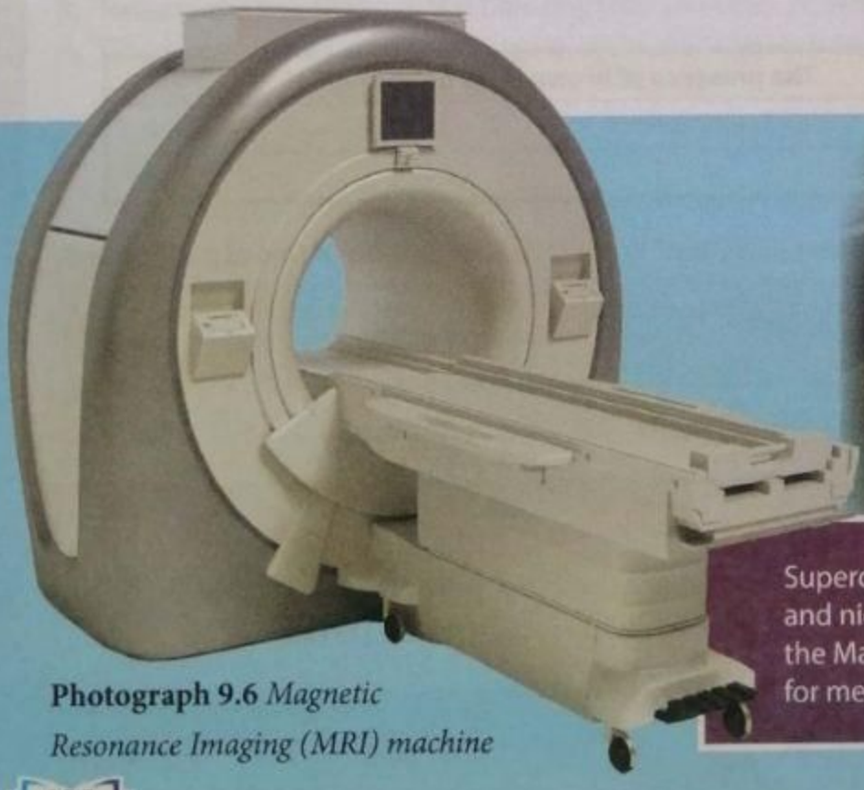
Some musical instrument are made of brass which is shiny and resistant to corrosion.

Photograph 9.4 *Saxophone*

Several types of metal elements and non-metal elements have superconducting properties at low temperature and are added to make **superconductor alloys**. Superconductors are materials that can conduct electricity at high efficiency without resistance. A superconductor is also able to resist a magnetic field causing the superconducting material to float when placed on a magnet.

Superconductor alloys are used for the construction of the railway track of a high-powered train to make sure the train moves by floating and to prevent friction between the track and the body of the train. This allows the train to move at high speed.

Photograph 9.5 *Maglev train*



Superconductor alloys such as niobium-titanium and niobium-tin are used in the construction of the Magnetic Resonance Imaging (MRI) machine for medical imaging.

Photograph 9.6 *Magnetic Resonance Imaging (MRI) machine*

FORMATIVE PRACTICE 9.1

1. Give two examples of alloy containing copper metal.
2. Draw the arrangement of atoms in an alloy and a pure metal, then relate the arrangement of the atoms to the properties of pure metal.
3. What alloy is used to make the body of an aeroplane? Explain why the alloy is chosen.

9.2 Glass and Ceramic

What is Glass?

Glass is believed to have been used since 5000 B.C. Glass is made of **silica**. Silica is a compound that contains silicon dioxide and exists naturally in sand. Pure silica melts and liquefies at around 1500°C to form glass.

Photograph 9.7 *Silica*

Photograph 9.8 *Glass bottle*

Several types of glass are made in the glass industry. Table 9.2 shows the types of glass with their composition and properties.

Table 9.2 *Types of glass with their composition and properties*

Glass	Composition	Properties
Fused silica glass	• Silica	• Resistant to heat • Chemically inert
Soda-lime glass	• Silica • Calcium carbonate • Sodium carbonate	• Low melting point • Easy to shape
Borosilicate glass	• Silica • Boron oxide • Sodium oxide • Aluminium oxide	• High resistance to heat and chemicals compared to soda-lime glass
Lead crystal glass	• Silica • Lead(II) oxide • Sodium oxide	• Low melting point • High refractive index

9.2.1

What is Ceramic?

Ceramic consists of non-metal substance that is formed from heat reaction at a very high temperature. Ceramic is made from clay. The main component in clay is **aluminium silicate**.

Ceramic can withstand high temperature and high pressure. Ceramic is also very hard, brittle, chemically inert and does not rust. In addition, ceramic is also a good insulator of heat and electricity.

Photograph 9.9 *Aluminium silicate*

Photograph 9.10 *Ceramic dishes*

Activity 9.2

Think-Pair-Share

Aim: To provide reviews from a sharing session about a visit to glass and ceramic factory, or through watching a video.

21st Century Skills

Instructions:

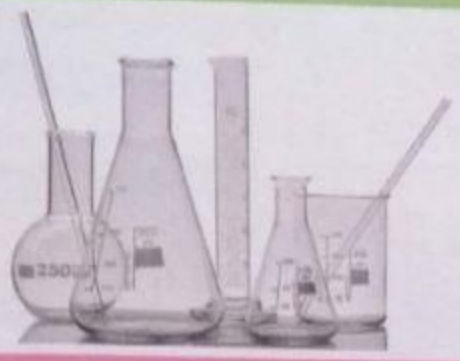
1. Participate in a sharing session or watch a video on the manufacture of glass and ceramic.
2. Gather information on the manufacture of glass and ceramic and record the information obtained in your notebook.
3. Based on the information obtained, write a review on the manufacture of glass and ceramic.

The Use of Glass and Ceramic in Daily Life

Based on the properties of glass and ceramic that we have learned, we know that glass and ceramic are used to produce many things in our daily life. Hence, this develops the glass and ceramic industry in our country.

Applications of Glass and Ceramic

Glass has unique properties that make it suitable for the manufacture of various goods. The following are some examples of applications of glass.



Laboratory apparatus such as beaker and conical flask are made of borosilicate glass because of its high resistance to heat and chemicals.

The bulb is usually made of soda-lime glass because of its resistance to heat and it is easily shaped.

The glass prism made of lead crystal glass is used to study the dispersion of light because it has high refractive index.

Transparent glass window allows light to enter the house.

Photograph 9.11 *Applications of glass*

Ceramic is used in the manufacture of various goods. The following shows some examples of applications of ceramic.

Tableware is made of ceramic because of its resistance to heat and corrosion.

Ceramic is used to make dentures because of its hardness and inert to chemicals.

Ceramic tiles used for flooring have sparkling property that make the floor look clean and nice.

Ceramic flower pots are hard and strong.

Photograph 9.12 *Applications of ceramic*

9.2.2

FORMATIVE PRACTICE 9.2

1. What is the main component in glass and ceramic?
2. State three applications of glass and ceramic.

9.3 Polymer

Did you know that all of the items shown in Photograph 9.13 are made of polymers?

Photograph 9.13 *Products from polymer*

What is a Polymer?

A **polymer** is a large molecule formed by chains of smaller molecular units. The smaller molecular unit that makes up this polymer is known as a **monomer**. Polymers can be classified into **natural polymers** and **synthetic polymers**.

Natural polymers are polymers that exist naturally.

Table 9.3 *Natural polymers*

Natural polymer	Monomer	Use
Starch	Glucose	Produces energy
Protein	Amino acid	Builds cells and body tissues
Natural rubber	Isoprene	To make rubber-based products

Synthetic polymers are man-made polymers using chemical substances.

Table 9.4 *Synthetic polymers*

Synthetic polymer	Monomer	Use
Polythene	Ethene	To make plastic bottles, plastic bags and pails
Polystyrene	Styrene	To make packing container for electrical equipment
Perspex	Methyl methacrylate	To make aeroplane mirrors, windows for vehicles
Synthetic rubber	Neoprene	To make gloves, tyres and shoe soles

Polymerisation and Depolymerisation

Polymers are produced through the process of polymerisation. **Polymerisation** is the process of joining the monomers through the formation of chemical bonds to produce a long-chain polymer. **Depolymerisation** refers to the process of splitting a long-chain polymer into its monomers through chemical reactions.

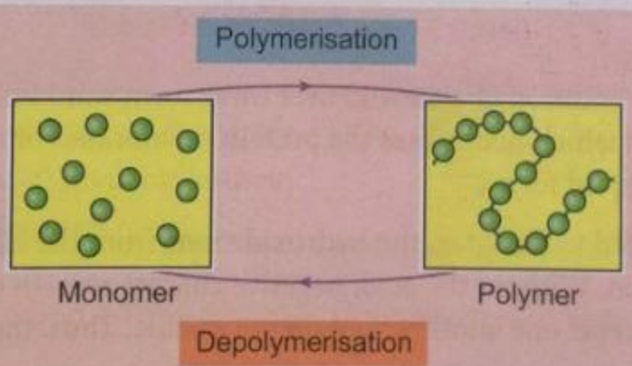


Figure 9.5 *Polymerisation and depolymerisation*

Polymerisation that involves a monomer of the same type by breaking a double bond into a single bond is known as **addition polymerisation**. Polythene is one of the example of polymers produced through the addition polymerisation from its monomer, ethene (Figure 9.6).

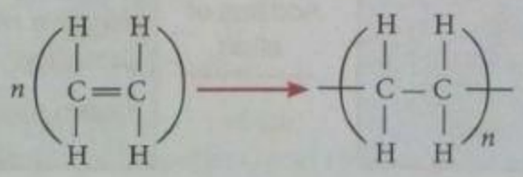


Figure 9.6 *Addition polymerisation*

9.3.1
9.3.2

Natural Rubber

The milky fluid obtained from tapped rubber trees is called latex. Latex is then processed into natural rubber. These natural polymers contribute greatly to the economic growth of our country. Natural rubber is elastic, soft, cannot withstand heat, a good electrical insulator and is not permeable to air.

The Action of Acid and Alkali on Latex

In latex, rubber molecules in the form of chains are covered with a layer of protein membrane. Negative charges surround the outer surface of the membrane. This causes the rubber molecules to repel each other. Thus, latex remains in liquid form. How can latex be converted into solid form?

When an acid is added to the latex, positively-charged hydrogen ions from the acid will neutralise the negative charges on the surface of the protein membrane. Without these negative charges, the rubber molecules will collide with one another. This will break the protein membrane and the chain of the rubber polymer is now free to coagulate to form solid lumps.

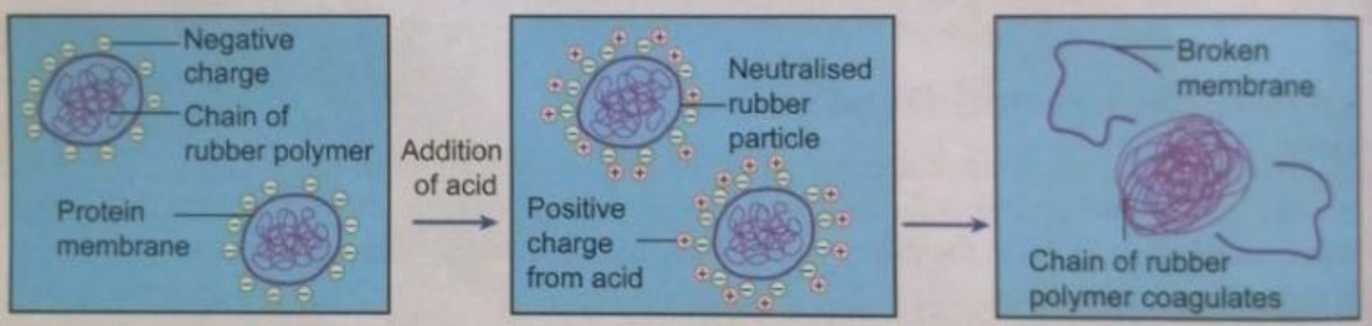


Figure 9.7 *Coagulation of latex by acid*

Latex left without the addition of acid will, over time, form solid lumps due to the action of bacteria that produces acid which neutralises the protein membranes of rubber molecules. So, how can latex be preserved in liquid form?

When an alkali is added to the latex, the hydroxide ions from the alkali will neutralise the hydrogen ions from the acid. Without the acid, negative charges remain on the protein membrane and the rubber molecules repel one another, and do not collide. Thus, the rubber molecules will remain in liquid form.

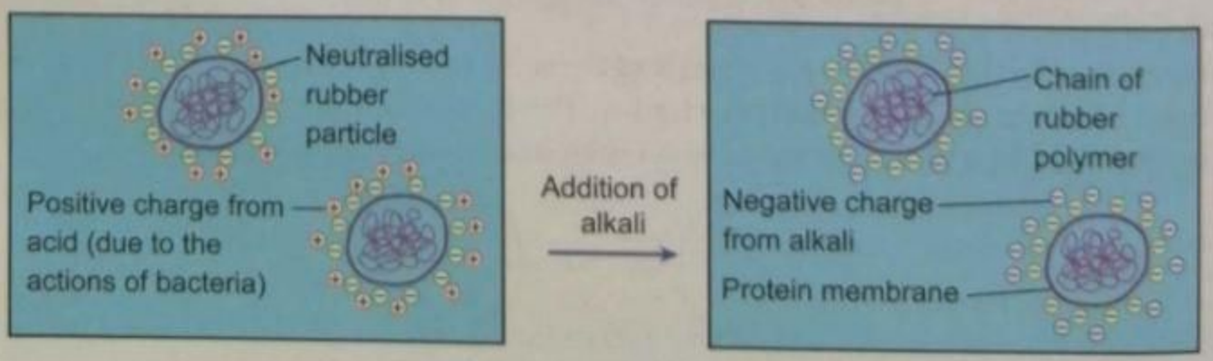


Figure 9.8 *Alkali reaction on latex*

Let us carry out Activity 9.3 and Activity 9.4 to study the properties of natural rubber.

Activity 9.3

Inquiry

Aim: To study the properties of natural rubber.

21st Century Skills

Materials: Rubber sheet, water

Apparatus: Boiling tube, retort stand and clamps, Bunsen burner

A The elasticity of natural rubber

Procedure:

1. Test the elasticity of natural rubber by stretching and twisting the rubber sheet.
2. Observe and record your observations.

Question:

Is the rubber sheet able to return to its original shape?

Photograph 9.14 *Stretching*

Photograph 9.15 *Twisting*

B The effect of heat on natural rubber

Procedure:

1. Cut a piece of natural rubber from Activity A and put it into a boiling tube containing water.
2. Heat it slowly with a Bunsen burner (Figure 9.9).
3. Test the elasticity of the rubber piece after it has cooled.

Question:

What happens to the rubber piece after heating?

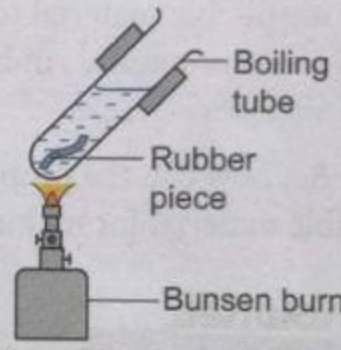


Figure 9.9 *Setup of apparatus*

Activity 9.4

Inquiry

Aim: To study the action of acid and alkali on latex.

21st Century Skills

Materials: Latex, ethanoic acid, ammonia solution

Apparatus: Beakers, droppers, glass rods

Procedure:

1. Label three beakers as *P*, *Q* and *R*. Then, add 20 ml of latex into each beaker.

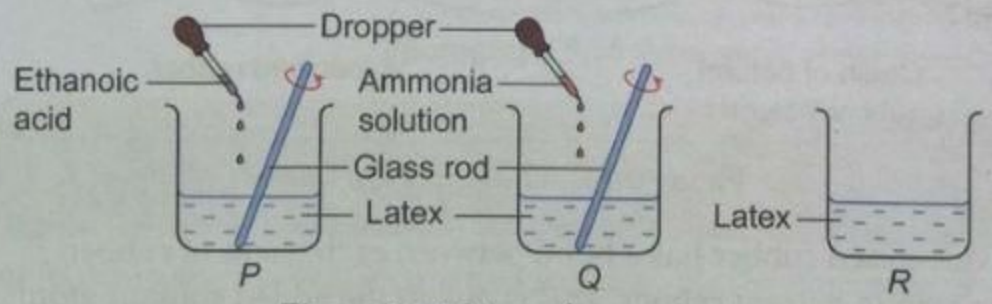


Figure 9.10 *Setup of apparatus*

Safety PRECAUTION

Wear gloves when handling ethanoic acid and ammonia solution.

2. Add 10 drops of ethanoic acid into beaker *P* and stir.
3. Add 10 drops of ammonia solution into beaker *Q* and stir.
4. Leave beaker *R* without adding acid or alkali.
5. Observe the changes occurring in all three beakers and record your observations in the table on page 196.

Observation:

Beaker	Observation
P	
Q	
R	

Questions:

1. What happens when ethanoic acid is added to latex?
2. What happens when ammonia is added to latex?
3. How can coagulation of latex be prevented?
4. Why do latex coagulate when exposed to air?

Vulcanisation of Rubber

The properties of natural rubber which is soft and not resistant to heat makes it an unsuitable material for tyres of vehicles. Due to Malaysian hot weather, tyres made of natural rubber will become soft and melt when exposed to hot road surfaces.

So, how can the properties of natural rubber be improved to make it a suitable material for making various things?

Renowned Scientist

Charles Goodyear
(1800 – 1860)

He founded the vulcanisation process in 1839. He heated a mixture of natural rubber with 1% – 3% of sulphur according to its mass.

Vulcanisation can improve the properties of rubber and make it stronger. **Vulcanisation** is a process of **heating rubber** with **sulphur**. During vulcanisation, sulphur atoms are added to the chain of natural rubber polymer molecules. The rubber obtained through this process is called **vulcanised rubber**.

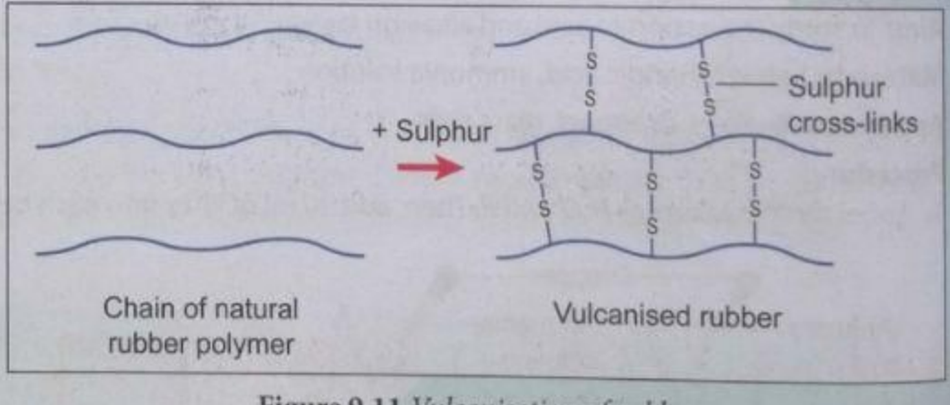


Figure 9.11 *Vulcanisation of rubber*

The molecular structure of vulcanised rubber has a bond between each chain of rubber polymer. This however, cannot be seen in natural rubber. This is due to the added sulphur atoms that produces cross-links between the rubber polymer chains. Therefore, when a force is applied, it is difficult for the chain of vulcanised rubber polymer to slide over each other. When heat is applied, the structure of vulcanised rubber molecules is difficult to break. Thus, the vulcanised rubber is harder and has high resistance to heat.

Figure 9.12 shows the properties of vulcanised rubber.

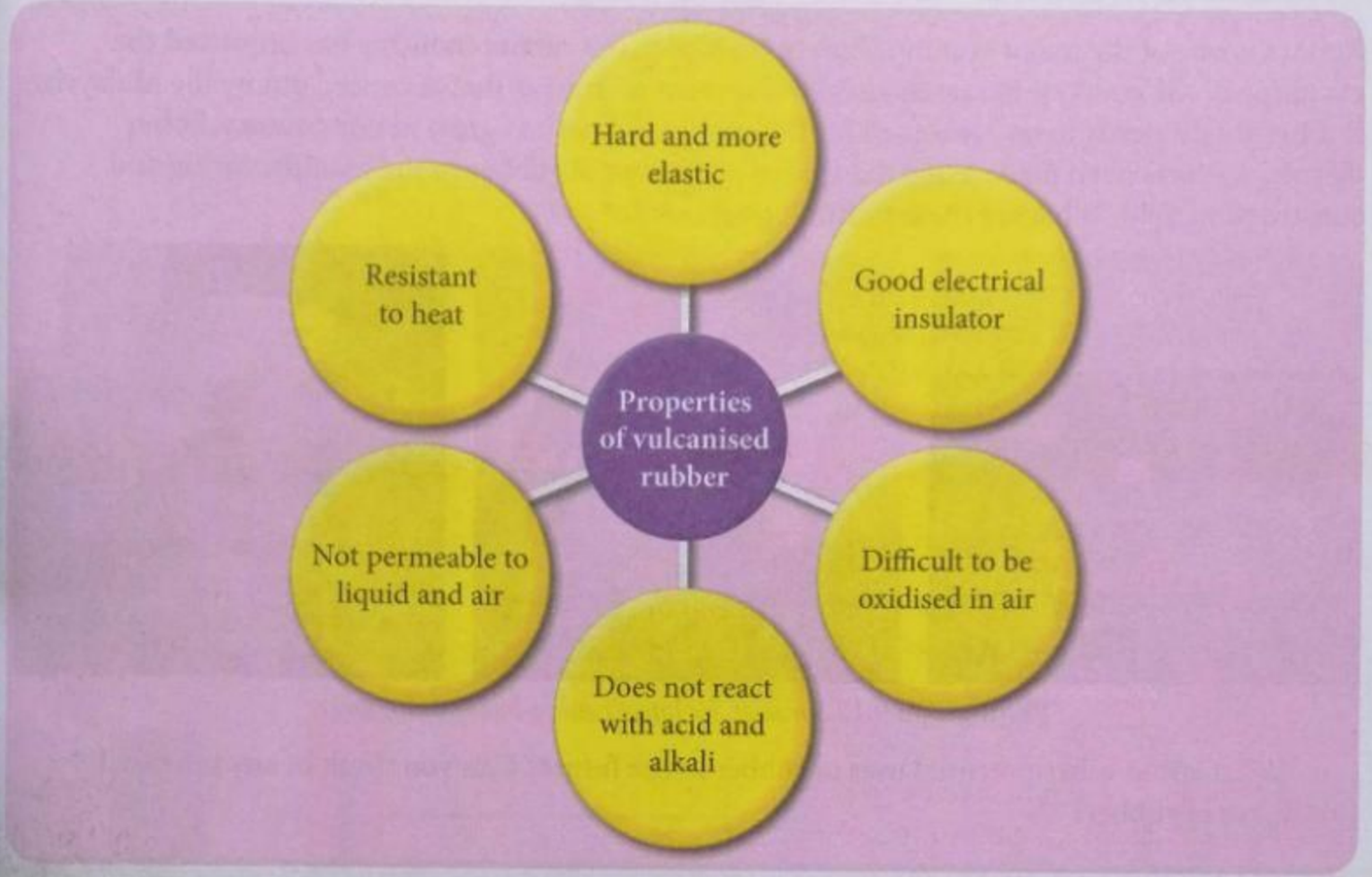


Figure 9.12 *Properties of vulcanised rubber*

Vulcanised rubber is suitable to make tyres for vehicles, rubber gloves and shoe soles.

Photograph 9.16 *Items made of vulcanised rubber*

Activity 9.5

Result Showcase

21st Century Skills

Aim: To sketch the molecular structure and describe the properties of vulcanised rubber.

Instructions:

1. Carry out this activity in groups.
2. Sketch the molecular structure of natural rubber and vulcanised rubber on a piece of flip chart paper.
3. Present your sketch to your friends in the class and describe the suitability of the properties of vulcanised rubber in producing various items.

The Latest Rubber-based Technology

Rubber is one of the major commodities of Malaysia. The rubber industry has improved the economy of the country. Research and development on rubber that is carried out by the Malaysian Rubber Board needs to be continued for the rubber industry to grow in our country. Some discoveries have been made using the special properties of rubber in the manufacturing and construction field. What are these technologies?

Cuplump Modified Asphalt (CMA) acts as the concrete asphalt for the pavement to last longer, resist heat, reduce noise and road cracks.

Getah Colour is a paint produced from latex to be used for visual arts.

The rail pad made of rubber is placed between the railway and the train's engine to reduce vibration and sound.

Photograph 9.17 *Some of the latest rubber-based technology*

What about other potential uses of rubber in the future? Can you think of any potential future use of rubber?

Activity 9.6

Result Showcase

21st Century Skills

Aim: To gather information and present the latest rubber-based technology.

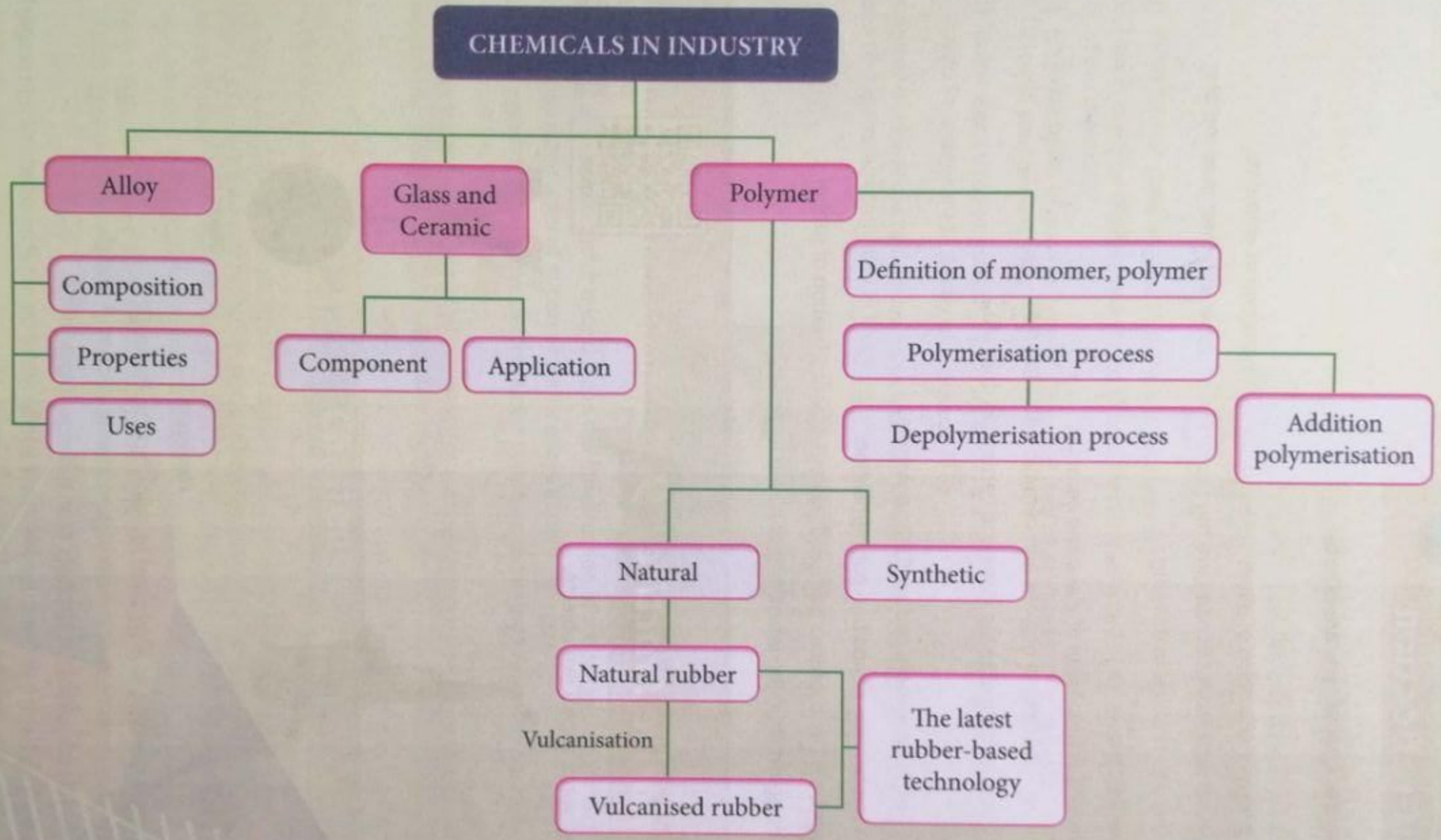
Instructions:

1. Carry out this activity in groups.
2. Using the Internet and other media, gather information about the latest rubber-based technology other than those specified in the textbook.
3. Based on the information obtained, discuss in groups on products that can be manufactured using rubber.
4. Present your ideas to the class. Your presentations must include:
   - sketches of the product
   - the manufacturing purpose
   - the special properties of the rubber in the product

FORMATIVE PRACTICE 9.3

1. Name two natural polymers and synthetic polymers and their monomers.
2. Compare the properties of natural rubber and vulcanised rubber.
3. Describe how vulcanised rubber is produced from natural rubber.

Summary


CHEMICALS IN INDUSTRY
Alloy
Composition
Properties
Uses
Glass and Ceramic
Component
Application
Polymer
Definition of monomer, polymer
Polymerisation process
Depolymerisation process
Addition polymerisation
Natural
Synthetic
Natural rubber
Vulcanisation
Vulcanised rubber
The latest rubber-based technology

Self-reflection

After studying this chapter, you are able to:

9.1 Alloy

- ☐ Define and give examples of alloys based on their composition of elements.
- ☐ Carry out an experiment to compare the properties of alloys with their pure metals.
- ☐ Justify the use of alloys in daily life.

9.2 Glass and Ceramic

- ☐ Describe the components of glass and ceramic.
- ☐ Explain the applications of glass and ceramic with examples.
- ☐ Justify the suitability of using glass and ceramic in daily life.

9.3 Polymer

- ☐ Explain natural polymers and synthetic polymers.
- ☐ Explain the process of addition polymerisation.
- ☐ Communicate the characteristics and process of vulcanisation of rubber.
- ☐ Generating ideas on the latest rubber-based technology.

Summative Practice 9

QUIZ

Objective Questions
http://bukuteksskssm.my/Science/F4/Q9

1. Photograph 1 shows two objects.

Object *P*

Object *Q*

Photograph 1

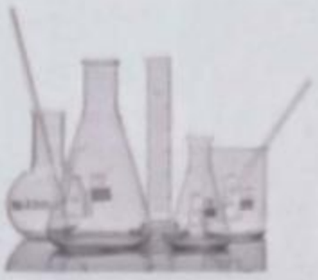
(a) What is the type of alloy used to manufacture *P* and *Q*?

(b) Give two other uses of the alloy used to manufacture *P* and *Q*.

(c) Why is a bronze block stronger than a copper block?

(d) In your opinion, can the alloy which is used to make object *P* be used to build a ship? Explain your answer.

2. Photograph 2 shows the laboratory apparatus made of glass.



Photograph 2

(a) What type of glass is used to make the products above?

(b) How is the type of glass you stated in question **2**(a) selected in the manufacture of the above products?

(c) Give examples of another type of glass that may be suitable in producing the above product. Explain your answer.

(d) Is the glass used to make the product above suitable to make drinking water containers to be used in restaurants? Justify your answer.

3. Superconductor alloys have many uses now and in the future. Photograph 3 shows one of the uses of superconductor alloy in Maglev trains.

Photograph 3

(a) How is a superconductor alloy used in the construction of the Maglev train?

(b) Give two other uses of superconductor alloys in daily life.

(c) In your opinion, can the superconductor alloy be used in the antigravity car manufacturing? Describe the process.

Mind Challenge

4. A Form 4 student found his bicycle tyre punctured on his way home from school. Then, he went to the workshop to repair his tyres. When the mechanic was repairing the tyre, the student discovered that the rubber tube of the tyre he was holding has different elasticity compared to the coagulated latex in his school laboratory.

Referring to the above statement, plan an experiment in the laboratory to study the elasticity of the two types of rubber. Your plan should include the following:

(a) aim
(b) hypothesis
(c) variables
(d) materials and apparatus
(e) procedure
(f) setup of apparatus
(g) tabulation of data