9.1: Understanding the manufacture of sulphuric acid.

A student is able to:

- list uses of sulphuric acid
- to explain industrial process in manufacture of sulphuric acid
- explain that sulphur dioxide causes environmental pollution.

a. Sulphuric Acid

(i). Uses of sulphuric acid

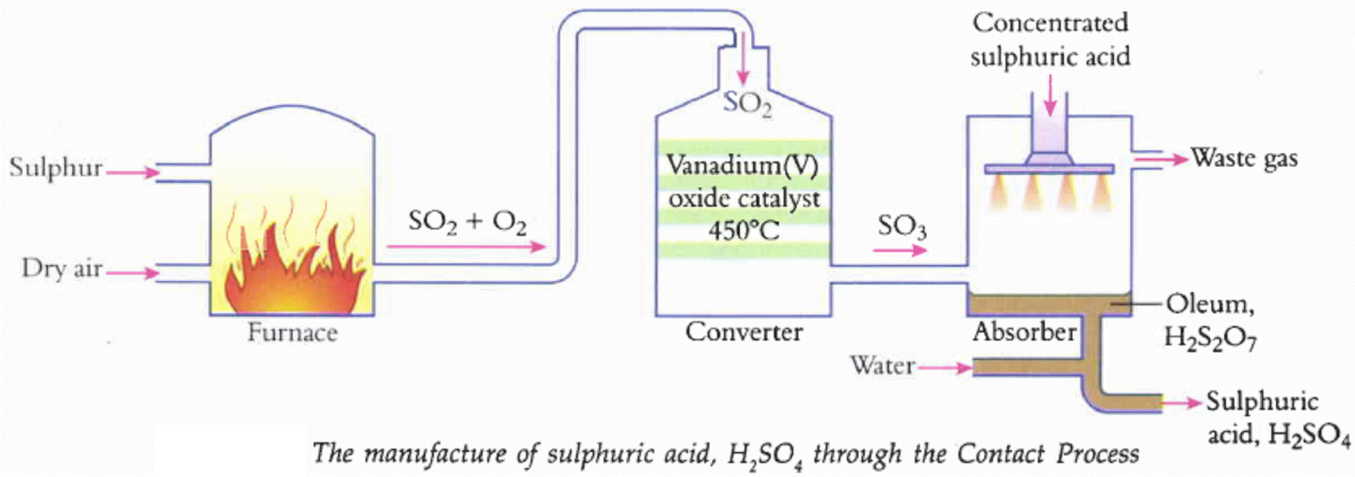
1. Sulphuric acid, H_2S0_4 is used in manufacturing of almost all products. Some of its uses are shown below:

Manufacture of detergents | Production of fertilizer | Manufacture of artificial fibers | Manufacture of paint | Leather tanning | As electrolyte in car batteries

2. Sulphuric acid, H_2S0_4 is also used to remove sulphur compounds in crude oil and to produce other chemicals.

(ii). Manufacture of sulphuric acid

1. Sulphuric acid, H_2S0_4 is manufactured in industry through **Contact Process**.
3. The raw materials used are sulphur, air and water.
4. This process consists of three stages as the diagram below:



The manufacture of sulphuric acid, H_2SO_4 through the Contact Process

Stage 1:

In the furnace, molten sulphur is burnt in dry air to produce sulphur dioxide, $S0_2$. The gas produced is purified and cooled.

$$S\ (l) + O_2\ (g) \text{--> } SO_2\ (g)$$

Stage 2:

In the converter, sulphur dioxide, $S0_2$ and excess oxygen gas, 0_2 are passed over a few plates of vanadium(V) oxide, V_20, the catalyst at 450°C to produce sulphur trioxide, SO_3

$$2S0_2\ (g) + 0_2\ (g) \text{ -- > } 2S0_3\ (g)$$

About 99.5% of the sulphur dioxide, $S0_2$ is converted into sulphur trioxide, $S0_3$ through this reversible reaction.

Stage 3:

In the absorber, the sulphur trioxide, $S0_3$ is first reacted with concentrated sulphuric acid, H_9S0_4 to form a product called oleum, $H_2S_2O_7$.

$$S0_3\ (g) + H_2S0_4\ (1) \text{- > } H_2S_20_7\ (1)$$

The oleum, $H_2S_20_7$ is then diluted with water to produce concentrated sulphuric acid, H_2S0_4 in large quantities.

$$H_2S_2Q_7\ (1) + H_2O\ (1) \text{ -- > } 2H_2SO_4\ (1)$$

The two reactions in the third stage are equivalent to adding sulphur trioxide, $S0_3$ directly to water.

$$S0_3\ (g) + H_20\ (1) \text{ -- > } H_2S0_4\ (1)$$

However, this is not done in industry because sulphur trioxide, $S0_3$ reacts too violently with water. This produces a lot of heat and a large cloud of sulphuric acid, H_2S0_4 mist. The mist is corrosive, pollutes the air and is difficult to condense.

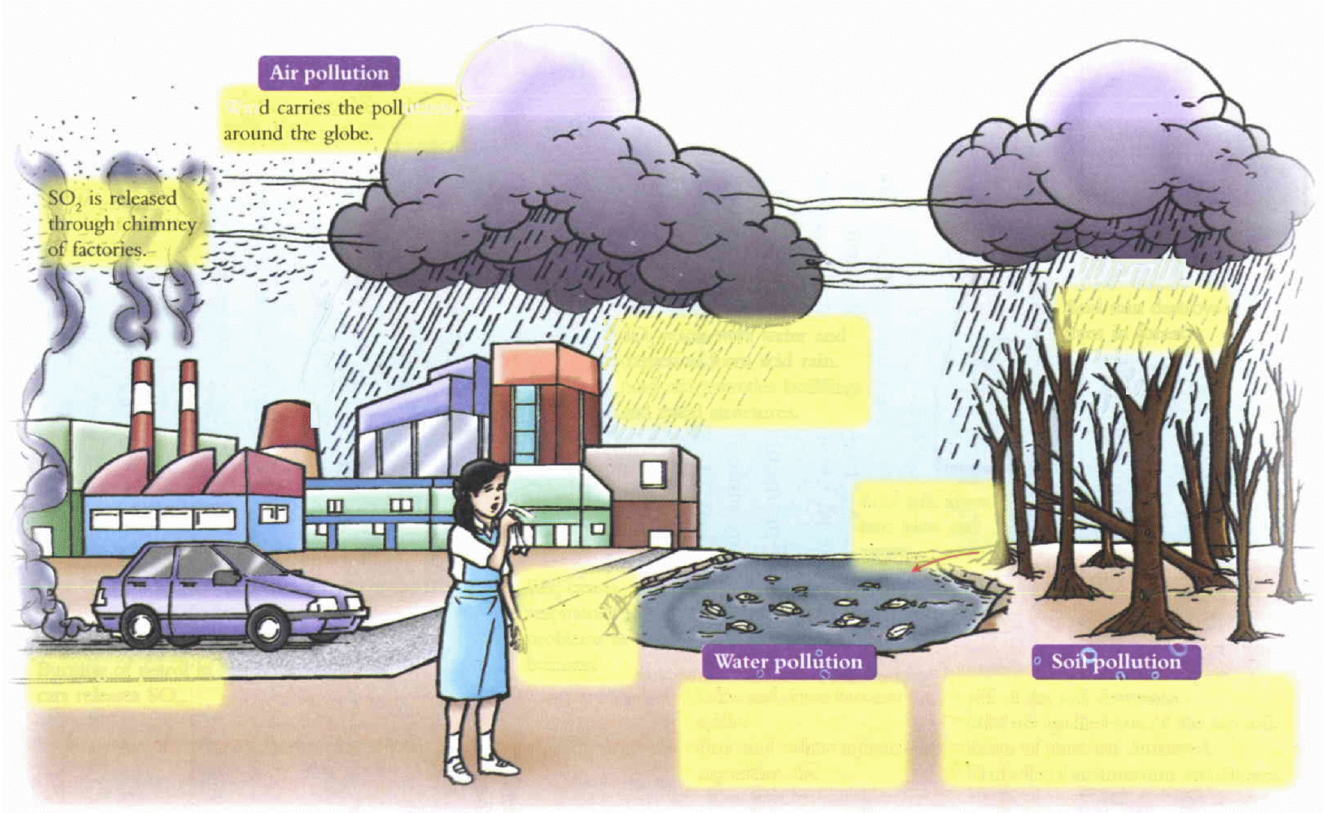
(iii). Sulphur dioxide and environmental pollution

1. Sulphur dioxide, $S0_2$ is one of the by-products of the Contact Process. It can cause environmental pollution.

2. Almost all sulphur dioxide, SO_2 in the air comes from the burning of fossil fuels containing sulphur. Inhaling sulphur dioxide, SO_2 causes coughing, chest pain, shortness of breath, bronchitis and lung diseases.

3. Sulphur dioxide, SO_2 can cause acid rain. Natural rainwater has a pH of about 5.4. Acid rain occurs when pH of the rain is between 2.4 and 5.0. This is due to the reaction of sulphur dioxide, SO_2 with rainwater.

$$2SO_2(g) + O_2(g) + 2H_2O(l) \rightarrow 2H_2SO_4(aq)$$



Quick Review A (Text Book pg. 156)

1. List eight uses of sulphuric acid, H_2SO_4.

1. to manufacture fertilisers such as calcium hydrogen phosphate, $Ca(H_2PO_4)_2$ and ammonium sulphate, $(NH_4)_2SO_4$.
2. to manufacture soaps and detergents
3. to manufacture synthetic fibres such as rayon (a type of artificial silk)
4. to manufacture pesticides
5. to manufacture dyes, paints and pigments

6. to manufacture plastics, e.g cellophane and synthetic fiber
7. to manufacture drugs and medicines
8. to manufacture explosives
9. To clean metals in a process called pickling (by removing the metal oxides from the metal surfaces before plating)
10. as an electrolyte is lead acid accumulators (car batteries)

2. Starting from sulphur, construct four chemical equations for the manufacture of sulphuric acid, H_2SO_4.

1. $S + O_2 \rightarrow SO_2$
2. $2\ SO_2 + O_2 \rightarrow 2\ SO_3$
3. $SO_3 + H_2SO_4$ (concentrated) $\rightarrow H_2S_2O_7$
4. $H_2S_2O_7 + H_2O \rightarrow 2\ H_2SO_4$

3. What is acid rain?

The rains water that produce from the reaction between sulphur dioxide with water and oxygen

4. Name three types of pollutions caused by sulphur dioxide. List their outcomes.

1. Soil pollution

Increases the acidity of the soils, making it unsuitable for plants to grow and also acid in the soil can also destroy the roots of plants

2.water pollution

increases the acidity of the rivers and lakes. This may kill aquatic life in the water.

3. Air pollution

SO_2 reacts with water and oxygen to form acid rains. Acid rain corrodes buildings and metal structures.

9.2 Synthesising the manufacture of ammonia and its salts.

A student is able to:

- list uses of ammonia
- state the properties of ammonia
- explain the industrial process in the manufacture of ammonia
- design an activity to prepare ammonium fertilizer.

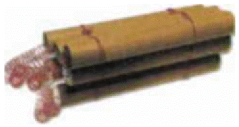
Ammonia and Its Salts

(i). Uses of ammonia

1. Most of the ammonia, NH, is used to make fertilisers. Fertilisers provide nitrogen for the healthy growth of plants.
2. Other than manufacturing fertilisers. Large quantities of ammonia, NH, are converted into nitric acid, HNO_3.
3. The acid is then used to make synthetic fibres, explosives, wood pulp, paints, varnishes, lacquers and rocket propellants.

Manufacture of fertilizers


Manufacture of synthetic fibers

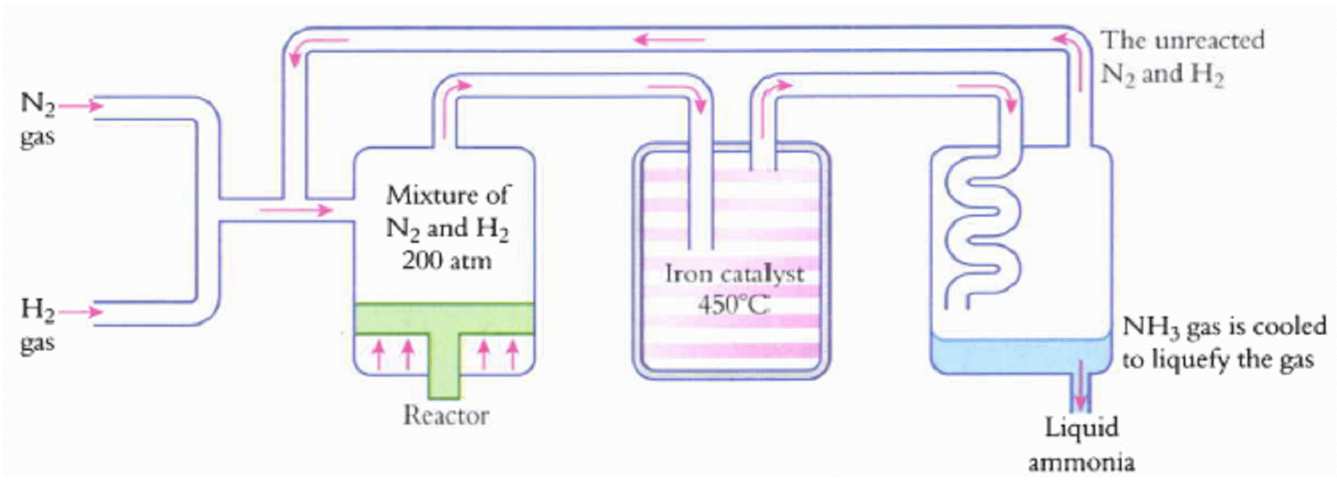

Manufacture of explosives

(ii). Manufacture of ammonia

1. Ammonia, NH_3 is manufactured in industries through Haber Process.

2. This process combines nitrogen gas, N_2 from the air with hydrogen gas, H_2 derived mainly from natural gas to form ammonia, NH_3.

3. The ratio of one volume of nitrogen gas, N_2 to three volumes of hydrogen gas, H_2 is passed through the reactor.



The manufacture of ammonia, NH_3 through the Haber Process

4. The mixture is compressed to a high pressure of 200 atmosphere at a temperature of about 450°C. It is then passed through layers of iron catalyst to speed up the rate of reaction.

$$N_2\,(g) + 3H_2\,(g) \text{ -- > } 2NH_3\,(g)$$

5. Ammonia, NH_3 formed is then liquefied and separated to get a better yield. The production of ammonia, NH_3 gives out heat.
6. The unreacted nitrogen gas, N_2 and hydrogen gas, H_2 are recycled and passed back into the reactor together with the new source of nitrogen gas, N, and hydrogen gas, H_2.

7. About 98% of nitrogen gas, N_2 and hydrogen gas, H, are converted into ammonia, NH_3.

(ii). Preparation of ammonium fertilisers

1. Ammonium fertilisers are one of the chemical fertilisers added to soil to replace the elements used up by plants. The major plant nutrients include nitrogen, phosphorus, potassium and calcium.

2. Ammonium fertilisers can be prepared from the reaction between ammonia, NH_3 and an acid.

Quick Review B (Text Book pg. 158)

1. State the uses of ammonia, NH, in our daily lives.

1. Used to make fertilisers.
[Fertilisers provide nitrogen for the healthy growth of plants.]
2. Converted into nitric acid, HNO_3.
3. To make synthetic fibres, explosives, wood pulp, paints, varnishes, lacquers and rocket propellants.

2. List five properties of ammonia, NH_3.

1. Colourless gas with a pungent smell
2. An alkaline gas that turns moist red litmus paper to blue
3. Easily liquefied into a colourless liquid at ordinary temperatures by compression
4. Very soluble in water
5. It less dense than water

3. What are the three conditions that are necessary for the manufacture of ammonia, NH in the Haber Process? Write the equation for the reaction.

1. Used iron filling as catalyst
2. Temperature : 450 °C
3. Pressure : 200 atm

$$N_2 + H_2 \rightarrow 2\ NH_3$$

9.3 Understanding alloys.

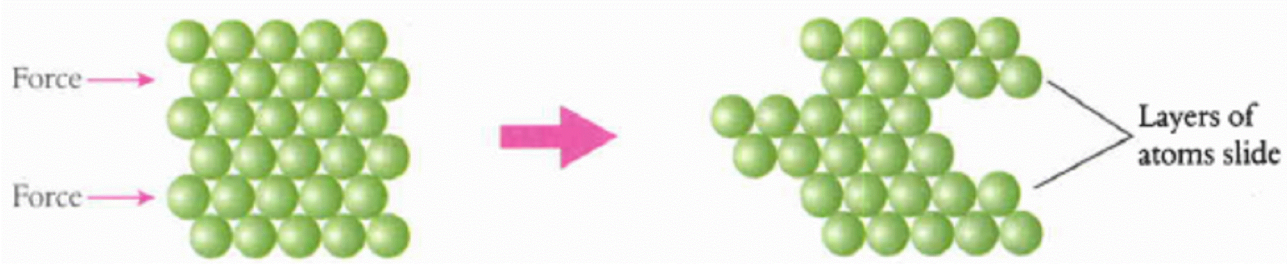
A student is able to:

- relate the arrangement of atoms in metals to their ductile and malleable properties
- state the meaning of alloy
- state the aim of making alloys
- list examples of alloys
- list compositions and properties of alloys
- relate the arrangement of atoms in alloys to their strength and hardness,
- relate properties of alloys to their uses.

Alloy

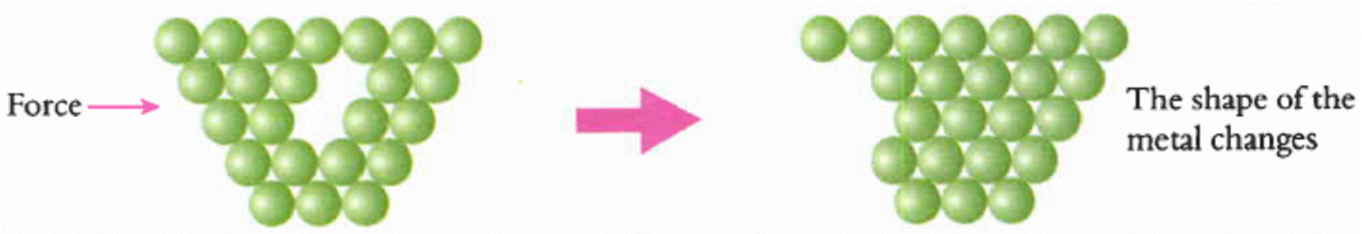
(i). Arrangement of atoms in metals

1. Most metals are solid. Pure metals are made up of the same type of atoms and are of the same size.
2. The arrangement of the atoms in metals gives the metals their ductile and malleable properties.
3. The orderly arrangement of atoms in metals enables the layers of atoms to slide on one another when force is applied, as shown in diagram below



4. Thus, metals are ductile or can be stretched.
5. There are some imperfections in the orderly arrangement of atoms in metals that allow some empty spaces in between the atoms.

6. When a metal is knocked, atoms slide. This is why metals are malleable or can be shaped.



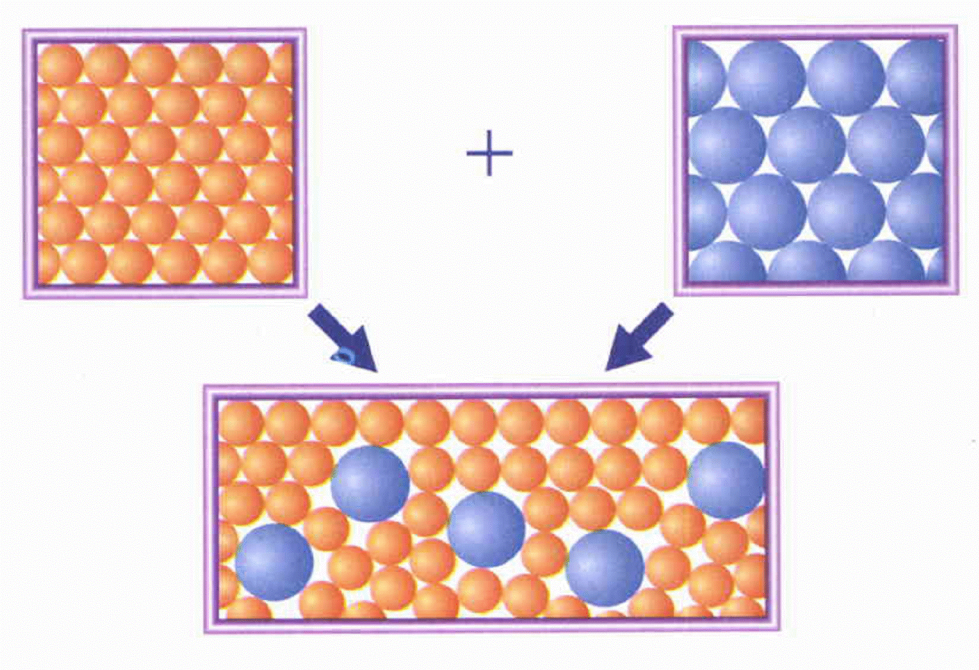
Alloy

1. An alloy is a mixture of two or more elements with a certain fixed composition in which the major component is a metal.
2. Most pure metals are weak and soft. The properties of pure metals can be improved by making them into alloys.
3. The aim of making alloys is to make them stronger, harder, resistant to corrosion, have a better furnish and lustre.
4. Alloys such as bronze, brass, steel, stainless steel, duralumin and pewter are commonly used in our daily lives.
5. The uses of each different type of alloys depend on the properties of the alloy. For example, cutlery is made of stainless steel because stainless steel is shiny and does not rust.

6. Table below shows the composition, properties and uses of some alloys.

alloy	composition	properties	uses
Bronze	90% copper and 10% tin	• Hard and strong • Does not corrode easily • Has shiny surface	• In the building of statues or monuments • In the making of medals, swords and artistic materials
Brass	70% copper and 30% zinc	• Harder than copper	• In the making of musical instruments and kitchenware
Steel	99% iron and 1% carbon	• Hard and strong	• In the construction of buildings and bridges • In the building of the body of cars and railway tracks
Stainless steel	74% iron, 8% carbon and 18% chromium	• Shiny • Strong • Does not rust	• In the making of cutlery • In the making of surgical instruments
Duralumin	93% aluminium, 3% copper, 3% magnesium and 1% manganese	• Light • Strong	• In the building of the body of aeroplanes and bullet trains
Pewter	96% tin, 3% copper and 1% antimony	• Lustre • Shiny • Strong	• In the making of souvenirs

(iii). The arrangement of atoms in alloys



1. The presence of atoms of other metals that are of different sizes disturb the orderly arrangement of atoms in the metal.
2. This reduces the layer of atoms from sliding. Thus, an alloy is stronger and harder than its pure metal.

Quick Review C (Text Book pg. 160)

1. What is an alloy?

An alloy is a mixture of two or more elements with a certain fixed composition in which the major component is a metal.

2. How does the arrangement of atoms in a metal relate to its ductile and malleable properties?

Metals are made up of the same type of atoms and are of the same size.
The orderly arrangement of atoms in metals enables the layers of atoms to slide on one another when force is applied, gives the metals their ductile and malleable properties.

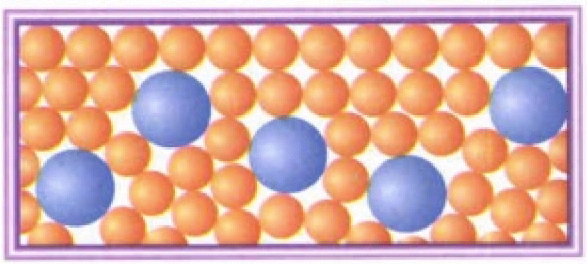
3. Why is cutlery made of stainless steel and not iron?

Cutlery made of stainless steel because it no easily to rust compare to the iron

4. Why is pure iron not used to make building materials?

Pure iron is easily to rust when the water and the air have. It will make the building will easily to decay because when pure iron is rust, it's brittle.

5. Using suitable illustrations, explain why an alloy is harder than its pure metal.



The presences of atoms of other metals that are of different sizes disturb the orderly arrangement of atoms in the metal. And also prevent layer of atom from sliding. Thus, an alloy is stronger and harder than its pure metal.

9 .4 Evaluating uses of synthetic polymers

A student is able to:

- State the meaning of polymers
- List naturally occurring polymers
- List synthetic polymers and their uses
- Identify the monomers in the synthetic polymers
- Justify uses of synthetic polymers in daily life

Polymers

1. Polymers are large molecules made up of many identical repeating sub-units called monomers which are joined together by covalent bonds.
2. Monomers are joined into chains by a process of repeated linking known as polymerisation.
3. A polymer may consists of thousands of monomers. Some polymers occur naturally. Starch, cellulose, wool, protein, silk and natural rubber are some examples of naturally occurring polymers.
4. On the other hand, synthetic polymers are man-made polymers. The monomers used are usually obtained from petroleum after going through the refining and cracking processes. Examples of synthetic polymers are polythene, polyvinyl chloride or PVC, polypropene, Perspex, nylon and terylene.

(i). Monomers in synthetic polymers

Some important synthetic polymers, their monomers and uses are shown in Table below.

Synthetic polymer	Monomer	Uses
Polythene	Ethene	Plastic bags, shopping bags, plastic containers and insulation for electrical wiring
Polypropene	Propene	Piping, bottle crates, carpets, car batteries and ropes
Polyvinyl chloride, PVC	Chloroethene	Artificial leather, water pipes and records
Perspex	Methylmethacrylate	Safety glass, reflectors, traffic signs and lens
Terylene	Hexane-l,6-diol Benzene-1,4-dicarboxylic	Clothing, sails and ropes acid
Nylon	Hexane-l,6-diamine Hexane-l,6-dioic acid	Ropes, clothing and carpets

(ii). Advantages and disadvantages use of Polymers

1. Synthetic polymers are widely used today. One of the great advantages of synthetic polymers is that they can be made to have special properties required for their uses.
2. They are relatively cheap, easy to be moulded or shaped and can also be coloured.
3. Synthetic polymers are very stable and do not corrode or decay. However, this also means that they are difficult to dispose.

4. They are not easily biodegradable. Hence, they may cause pollution, blockage of drainage systems and flash floods.

5. When they are burnt, they give out harmful and poisonous gases which have a pungent smell.
6. Although synthetic polymers pose environmental problems, we can still continue using them but in a wiser manner.
7. We should reduce, reuse and recycle synthetic polymers as much as possible. The use of biodegradable polymers should be encouraged. We should also find alternatives to synthetic polymers.

Quick Review D (Text Book pg. 164)

1. What is a polymer?

Polymers are large molecules made up of many identical repeating sub-units called monomers which are joined together by covalent bonds.

2. List two examples of naturally occurring polymers.

1. Starch
2. cellulose
3. wool
4. protein,
5. silk
6. natural rubber

3. List four examples of synthetic polymers and their uses.

No	Examples	Uses
1	Polythene	Plastic bags, shopping bags, plastic containers and insulation for electrical wiring
2	Polypropene	Piping, bottle crates, carpets, car batteries and ropes
3	Polyvinyl chloride, PVC	Artificial leather, water pipes and records
4	Perspex	Safety glass, reflectors, traffic signs and lens
	Terylene	Clothing, sails and ropes acid
	Nylon	Ropes, clothing and carpets

4. Name the monomer of polythene.

Ethene

5. Why should synthetic polymers not be disposed of by burning?

When synthetic polymers are burnt, it's give out harmful and poisonous gases which have a pungent smell.

6. State two ways to reduce pollution caused by synthetic polymers.

1. We should reduce, reuse and recycle synthetic polymers as much as possible.
2. The use of biodegradable polymers should be encouraged.

9.5 Applying uses of glass and ceramics

A student is able to:

- List uses of glass
- List uses of ceramics
- List types of glass and their properties
- State properties of ceramics

(i). Glass

1. Glass is made from sand. The major component of glass is silica, SiO_2. Among all different types of glass used in our daily lives, fused glass is the simplest glass.

2. It is mainly silica, SiO_2 Fused glass is a highly heat-resistant glass. It can be heated to an extremely high temperature and then can be plunged into icy, cold water without cracking.

3. It is expensive, yet it is still widely used because of its great purity, optical transparency, high temperature and chemical durability as well as resistance to thermal shock.

4. These properties make it appropriate to be used as laboratory glassware, lenses, telescope mirrors and optical fibres.

5. The most common glass found around the house is the soda-lime glass. It is made by heating sand with limestone, $CaC0_3$ or sodium carbonate, Na_2CO_3.

6. Soda-lime glass can be melted at a relatively low temperature. Thus, it is easy to be shaped and has a good chemical durability. It also has a high thermal expansion coefficient. It expands a lot when it is heated and contracts a lot too when it is cooled.

7. However, it does not withstand heat. Soda-lime glass is used to make flat glass, electrical bulbs, mirrors and all kinds of glass containers.

8. When boron oxide, B_20_3 is added to soda-lime glass, borosilicate glass is formed. Borosilicate glass has a lower thermal expansion coefficient. It is about three times as heat-resistant as soda-lime glass.
9. It is also more resistant to chemical attacks compared to soda-lime glass because it contains less alkali. Thus, borosilicate glass is excellent to be used in cookware, laboratory glassware and automobile headlights.

10. It is also used in glass pipelines and applications which require superior resistance to thermal shock and greater chemical durability.
11. Lead crystal glass is normally called crystal or lead glass. It is made by substituting lead oxide, PbO for calcium oxide, CaO and often for part of the silica, $Si0_2$ used in soda-lime glass.

12. Lead crystal glass is soft and easy to melt. It is more expensive than soda-lime glass. Lead crystal glass is used for the finest tableware, lead crystal glassware and art objects. Lead crystal glass is suitable for fine crystal because it is optically transparent and contains much more lead.

Ceramics

1. Clay pots, bricks, tiles and mugs are examples of ceramics. Ceramics are made from clay, for example kaolin, a hydrated aluminium silicate, $Al_20_3.2Si0_2.2H_20$.

2. When the clay is heated to a very high temperature, they undergo a series of chemical reactions and are hardened permanently to form ceramics.

3. Unlike glass, ceramics can withstand high temperature and do not melt easily. They are also very hard, brittle, chemically inert, do not corrode and have a very high melting point. They are good insulators of electricity and heat.

4. Their properties make them suitable for making abrasive, construction materials, tableware, insulators in electrical equipments and refractories.

5. The need for high performance materials has helped to speed up the development of glass and ceramics. New improved glass and ceramics like photo chromic glass, conducting glass, glass ceramic, bio ceramics and ceramic superconductors have been widely used.

Quick Review E (Text Book pg. 167)

1. What is the major component of glass?

Silica, SiO_2

2. Name four types of glass. State their properties and uses,

Name	**Properties and uses**
Fused glass	Properties : highly heat-resistant glass uses: laboratory glassware, lenses, telescope mirrors and optical fibres.
soda-lime glass	easy to be shaped and has a good chemical durability. It also has a high thermal expansion coefficient , does not withstand heat. Uses : make flat glass, electrical bulbs, mirrors and all kinds of glass containers.

soda-lime glass	a lower thermal expansion coefficient, more resistant to chemical attacks used in cookware, laboratory glassware and automobile headlights
Lead crystal glass	soft and easy to melt used for the finest tableware, lead crystal glassware and art objects

3. State five properties of ceramics.

1. can withstand high temperature and do not melt easily
2. very hard
3. brittle
4. chemically inert
5. do not corrode

very high melting point

good insulators of electricity and heat

9.6 Evaluating uses of composite materials

A student is able to:
- Describe needs to produce new materials for specific purposes,
- State the meaning of composite materials,
- List examples of composite materials and their component,
- Justify uses of composite materials,
- Generate ideas to produce advanced materials to fulfill specific needs.

Composite Materials

1. Since the old days, human beings have been using clay, wood, stones or metals as building materials.

2. These substances either corrode or decay easily. Otherwise, they are too heavy, bulky or difficult to be shaped or carved.

3. Many of our modern technologies require materials with unusual combinations of properties that cannot be met by the conventional metal alloys, ceramics and polymeric materials.

4. Therefore, continuous research and development have been done in search of new structural materials. To fulfil the needs, these building materials must have properties like low density, strong and resistance to heat and corrosion.

5. Today, many of such materials are created and used for various fields.

6. A composite material is a structural material that is formed by combining two or more different substances such as metal, alloys, glass, ceramics and polymers. The resulting material has properties that are superior than those of the original components.

7. Composite materials are created for specific application.

8. Today, many types of composite materials have been used widely. These include reinforced concrete, specific superconductor, fibre optic, fibre glass and photochromic glass.

9. Concrete is a composite material which consists of a mixture of stones, chips and sand bound together by cement. It is strong but brittle and weak in tension. Steel is strong in tension.

10. When concrete is reinforced with steel wires, steel bars or any polymer fibres, the resulting combination is a very tough material with more tensile strength.

11. This material is known as the reinforced concrete. Steel and concrete have about the same coefficient of expansion. They make very good composites and are essential for the construction of large structures like high-rise buildings, bridges and oil platforms.

12. Reinforced concrete is also relatively cheap and can be moulded into any shape.

13. Superconductors are capable of conducting electricity without any electrical resistance when they are cooled to extremely low temperature. Most of them are alloys of metal compounds or ceramics of metal oxides.

14. However, some superconductors are made from composite materials.

15. Superconductors are used in the bullet trains in Japan and medical magnetic-imaging devices like magnetic resonance imaging, MRI. They are also used in magnetic energy-storage systems, generators, transformers and computer parts.

16. Devices made from superconductors have low power dissipation, high-speed operation and high sensitivity.

17. A fibre optic cable consists of a bundle of glass or plastic threads that are surrounded by a glass cladding. Fibre optic is a composite material that is able to transmit data, voice and images in a digital format.

18. It is used to replace copper wire in long distance telephone lines, in mobile phones, video cameras and to link computers within local area networks, LAN. Fibre optic is also used in instruments for examining internal parts of the body or inspecting the interiors of manufactured structural products.

19. Fibre optic is widely used because of its low material costs, high transmission capacity, chemical stability and is less susceptible to interference.

20. Glass is hard, strong and has a relatively high density. However, it is also relatively brittle. Plastic is elastic, flexible with low density but not as strong as glass. When glass fibres are used to reinforce plastic, we get a strong composite material called fibre glass.

21. Fibre glass has high tensile strength, can be easily coloured and low in density. It can be made into thin layers, yet very strong. Fibre glass is also easily moulded and shaped. It has been used to make household products like water storage tanks, badminton rackets, small boats, skis and helmets.

22. A photo chromic glass can be produced by embedding photo chromic substances like silver chloride, AgCl crystals in glass or transparent polymers. When it is exposed to light, silver chloride, AgCl is converted to silver and the glass darkens.

23. The photo chromic glass becomes transparent again when silver is converted back to silver chloride, AgCl when the light dims. Photo chromic glass is suitable for making optical lenses, car windshields, smart energy efficient windows in buildings, information display panels, lens in cameras, optical switches and light intensity meters.

(ii) Advanced materials and the future

1. A lot of time and resources have to be invested through a series of research and tests to produce a new composite material. This is essential to fulfil the ever expanding needs especially to help Malaysia to achieve a status of developed country in year 2020.

2. With the abundant natural resources, dynamic workforce and advanced infrastructure that we have, we are certain that Malaysia will produce outstanding materials of world's standard.

3. There are so many synthetic materials being produced and used in our daily lives. Synthetic materials may have improved our standards of living but at the same time, they may cause adverse effects on human beings and the environment.

4. Therefore, it is very important to do research and development continuously.

Quick Review F (Text Book pg. 170)

1. What is meant by 'composite materials'?

A composite material is a structural material that is formed by combining two or more different substances such as metal, alloys, glass, ceramics and polymers.

2. Using a suitable example, explain how the properties of a composite material are more superior than that of its components.

1. Reinforced concrete	Concrete
concrete is reinforced with steel wires, steel bars or any polymer fibres, the resulting combination is a very tough material with more tensile strength.	mixture of stones, chips and sand bound together by cement. It is strong but brittle and weak in tension. Steel is strong in tension.
2. Fibre glass has high tensile strength, can be easily coloured and low in density. It can be made into thin layers, yet very strong. Fibre glass is also easily moulded and shaped.	Glass is hard, strong and has a relatively high density and relatively brittle. Plastic is elastic, flexible with low density but not as strong as glass.

3. State two uses of

(a) Reinforced concrete.

high-rise buildings

bridges

oil platforms.

(b) photo chromic glass.

making optical lenses,

car windshields

smart energy efficient windows in buildings

information display panels

lens in cameras

optical switches

light intensity meters.