7 Man-made Substances

Man has made many substances that help him lead a comfortable, healthy life. These are generally prepared in factories from naturally occurring substances. Man uses cement in the construction of buildings and bridges. He makes fertilisers to increase crop yield. He manufactures glass, which is used to make a range of products, from spectacles to microscopes to bulletproof windows. Man also prepares medicines to fight diseases. Let us now study these and some other man-made substances.

Cement

Cement is a grey, powdery substance manufactured from limestone, clay (aluminium silicate) and gypsum. The product is a complex material containing the silicates of calcium and aluminium. A paste of it in water sets into a hard rocky mass—a phenomenon called the setting of cement.

A paste of sand, cement and water, called mortar, is very conveniently used for joining bricks and plastering walls.

A mixture of stone chips (gravel), sand, cement and water, known as concrete, sets harder than ordinary mortar. It is used for flooring and making roads.

Concrete with steel bars and wires embedded in it, called reinforced concrete (RC), forms a very strong material. It is used for constructing roofs, bridges and pillars.

Glass

You are quite familiar with glass. It has been known for centuries for its varied uses. Glass does not melt at one temperature, rather it softens over a range of temperatures. On being softened, it can be bent and blown to different shapes. This property of glass greatly increases its utility.

There are several types of glass, depending on composition, though silica (SiO_2) is a common constituent. The different types suit different purposes. Let us acquaint ourselves with the important kinds.

Soda glass or soda-lime glass

When a mixture of soda ash (Na_2CO_3), limestone ($CaCO_3$) and sand (SiO_2) is fused, a transparent liquid is formed. On being cooled, the liquid turns into a transparent, hard material called soda glass or soda-lime glass. It is sodium calcium silicate, and its approximate composition is represented by $Na_2O \cdot CaO \cdot 5SiO_2$. The Na_2O and CaO constitute the basic part (as these are the oxides of metals) and SiO_2 constitutes the acidic part (as it is the oxide of a nonmetal).

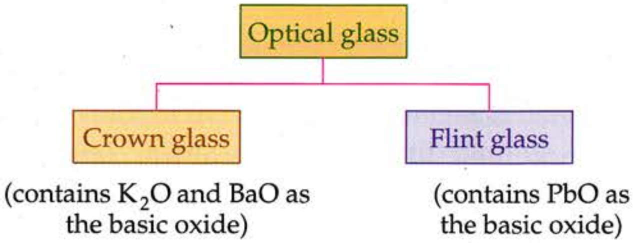
Soda glass is the cheapest of all glasses and is used for making window panes and bottles. Soda-glass bottles are easily attacked by chemicals.

Potash glass

Potash glass contains potassium in place of sodium. Compared to soda glass, it has a higher softening temperature as also a greater resistance to chemicals. So, potash glass is more suitable for making chemical apparatus—beakers, flasks, funnels, etc.

Optical glass

Optical glass is used to make lenses, prisms and components of optical instruments like telescopes and microscopes. It contains boric oxide (B_2O_3) and silica (SiO_2) as the acidic component. Optical glass can be of two types, depending on the basic component.



Crookes glass for spectacles

Glass used to make spectacles must absorb ultraviolet rays, which are harmful for the eyes. Crookes glass is useful for this purpose as it contains some compounds, which help it absorb these rays.

Lead crystal and crystal glass

Lead glass sparkles. It has a soft surface and so it can be ground and cut relatively easily. Engravings can also be made on such glass. It is, therefore, used for making decorative items. If the glass contains 24% or more of lead oxide, it is called lead crystal. If it contains less than 24% lead oxide, it is called crystal glass

Borosilicate glass

Borosilicate glass contains less alkali (K_2O or CaO) and more silica than potash glass, and some boron trioxide. It is not easily attacked by chemicals. It can stand sudden cooling or heating, and is, in fact, better than potash glass. It finds extensive use in the manufacture of laboratory apparatus.

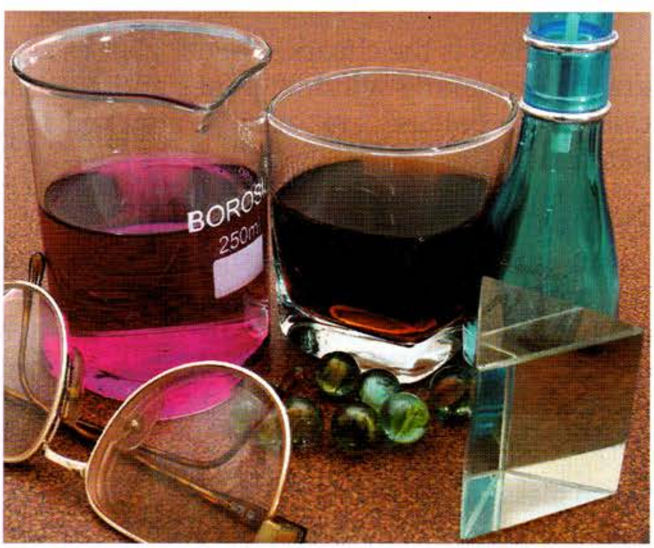


Fig. 7.1 Various things made of glass

Coloured glass

Coloured glass is manufactured by adding metals or metal oxides to the glass melt, as mentioned in Table 7.1.

Table 7.1 Substances used to make glass of different colours

Colour	Substance added to the glass melt
Red	Selenium (Se) or copper(I) oxide (Cu_2O)
Green	Chromium(III) oxide (Cr_2O_3)
Violet	Manganese(IV) oxide (MnO_2)
Blue	Copper(II) oxide (CuO) or cobalt(II) oxide (CoO)
Brown	Iron(III) oxide (Fe_2O_3)

Coloured glass is used to make artificial jewellery. It is also used to make crockery and stained-glass windows.

Milky glass

Milky glass is prepared by adding tin oxide (SnO_2), calcium phosphate ($Ca_3(PO_4)_2$) or cryolite ($AlF_3 \cdot 3NaF$) to the glass melt. All these substances are white, and so they make the glass look milky.

Glass laminates

Glass laminates are made by fixing polymer (about which you will soon learn) sheets between layers of glass. They do not shatter and are, therefore, used to make the windows and screens of cars, trains and aircraft. Specially manufactured glass laminates are used as bulletproof material.

Plastics

Plastics are highly useful materials that have been developed during the last century. Polythene (or polyethylene) carrybags, plastic bottles, soda-water crates, the body of your TV, computer or washing machine, electrical insulations and furniture foam are all plastic materials.

Plastics are cheap, light and strong. They can be moulded into different shapes—a property known as plasticity. They are not generally attacked by chemicals. For these reasons, they are ideal substitutes for wood, metals, glass and fabrics.

But, on the other hand, plastics are a great source of pollution. This is because they are not easily decomposed or degraded. So, with the increasing use of plastics, the volume of undegradable garbage is also increasing every day. When burnt, they produce poisonous gases. The use-and-throw plastic materials like carrybags and bottles block drains and sewers.

On the basis of how they behave towards heat, plastics are classified into two types—thermoplastics and thermosetting plastics. Thermoplastics retain their plasticity even after repeated heating and cooling. So they can be moulded over and over again. But thermosetting plastics, once set after being melted, cannot be moulded again.

Chemically, plastics are polymers

A single unit, called a monomer, is repeated many times over to form what is known as a polymer.

Fig. 7.2 Polymers are used to make various things.

For example, the monomer ethene is repeated thousands of times to form the polymer polythene. Teflon, which is used for coating nonstick kitchenware, is another polymer.

A class of polymers called silicones are used as lubricants and as sealing material.

Apart from the man-made polymers (also called synthetic polymers), there are natural polymers also, e.g., starch, cellulose, proteins and rubber.

Some man-made polymers are mentioned in Table 7.2.

Table 7.2 Some common man-made polymers and their uses

Polymer	Used to make
Polythene	Packaging material, carrybags, bottles
Polypropene	Bottles, crates
Polyvinyl chloride (PVC)	Pipes, insulation
Nylon (polyester)	Fibres, ropes
Teflon	Nonstick kitchenware
Vinyl rubber	Rubber, erasers
Polystyrene	Foam, Thermocole
Poly (styrene-butadiene)	Rubber, bubblegum
Bakelite	Electrical insulation, buttons
Lexan	Bulletproof glass
Melamine	Crockery
Perspex	Windows for cars, trains and aircraft
Acrylic	Knitwear

Paints

Paints can be applied on a surface to protect it from corrosion and weathering, or to give it an attractive look. Refrigerators, cars, ships, railway coaches and houses are some things that are painted. Paints are also used in works of art and signboards.

A paint contains a pigment, a vehicle and a thinner. A pigment is a white or coloured matter usually obtained from mineral sources. Zinc oxide, white lead and titanium dioxide are the commonly used white pigments. Some coloured minerals are used as coloured pigments. The pigment is mixed with a vehicle, which is an oil like linseed or soya bean oil, or a polymer. A thinner is a solvent such as turpentine or kerosene. It makes the paint more fluid so that it may be applied easily.

Luminous paints glow when exposed to light. So they are used in marking signs on roads and vehicles.

Soaps and Detergents

A detergent is a substance that can be used with water for removing dirt or cleaning. Soap is also a detergent, and has been in use for centuries. In common parlance, however, detergents are those man-made (or synthetic) substances other than soap, which are employed as cleaning agents. They are also known as soapless detergents.

Soaps

Fats are obtained from plant sources (e.g., coconut oil, palm oil and soya bean oil) as also from animal sources (e.g., milk, cheese and tallow). They are derived from glycerine and a fatty acid (i.e., an organic acid containing a large number of carbon atoms) like stearic acid, palmitic acid, oleic acid and linoleic acid. Fats, on being boiled with an aqueous solution of sodium hydroxide or potassium hydroxide, give the sodium or the potassium salts of the fatty acids, called soap, and glycerine.

$$\underset{\text{(oil)}}{\text{Fat}} + \text{NaOH} \longrightarrow \underset{\substack{\text{soap} \\ \text{(sodium salts of fatty acids*)}}}{\text{Na(Ft)}} + \text{glycerine}$$

(*More than one fatty-acid derivative is present in each oil.)

The process is called saponification. At this stage, common salt is sprinkled over the liquid to help the soap separate out. The soap is filtered, washed, mixed with dyes and perfumes, dried and cut into cakes.

Fig. 7.3 A soap and detergents

Soaps are soluble in water and produce lather with soft water. However, they form insoluble calcium and magnesium salts of fatty acids with hard water. Thus, soap becomes less effective in hard water.

Detergents

Detergents are obtained by the action of concentrated sulphuric acid on some petroleum products. They resemble soaps in action with the advantage that they do not form insoluble salts with hard water. They have, therefore, replaced soaps in the washing of clothes and linen.

Liquid detergents are specially manufactured for use as shampoos, or as cleansing agents for clothes made of silk and wool.

Many other substances are mixed with detergents to increase their efficiency, but they also add to water pollution.

Fertilisers

Just like us, plants also need nutrition for proper growth. They require potassium, calcium, magnesium, nitrogen, phosphorus and sulphur along with traces (very small amounts) of iron, manganese, copper, zinc, molybdenum and boron. Natural manures like cow dung, compost, plant roots (left in the soil during harvesting) and dry leaves are helpful in increasing the fertility of the soil. The use of some man-made chemicals, like ammonium sulphate, urea, superphosphate of lime and potassium chloride, tremendously increases the fertility of the soil. Such chemicals are called artificial fertilisers.

The trace elements mentioned are usually present in the soil. But if they are not, they are added to the soil as and when required. Nitrogen, phosphorus and potassium are the elements most required to make soil fertile. Let us now study some artificial fertilisers containing these elements, either singly or in combination.

Nitrogenous fertilisers

Plants require nitrogen for synthesising proteins. So, the following chemicals, rich in nitrogen, are used as nitrogenous fertilisers.

1. Ammonium sulphate: $(NH_4)_2SO_4$
2. Urea: $CO(NH_2)_2$
3. Calcium ammonium nitrate (CAN): A mixture of $Ca(NO_3)_2$ and NH_4NO_3
4. Diammonium phosphate (DAP): $(NH_4)_2HPO_4$
5. Potassium nitrate: KNO_3

Phosphatic fertilisers

Phosphorus, in the form of phosphate, is essential for the growth of plants. In higher classes you will learn that the phosphate ion provides energy for biochemical reactions. The following phosphatic fertilisers are commonly used.

1. Superphosphate of lime: $Ca(H_2PO_4)_2$ mixed with $CaSO_4 \cdot 2H_2O$

   (It is manufactured by the action of concentrated sulphuric acid on phosphate rocks or bones, which are mainly $Ca_3(PO_4)_2$. Gypsum, $CaSO_4 \cdot 2H_2O$, is also formed in the reaction.)
2. Diammonium phosphate (DAP): $(NH_4)_2HPO_4$ (DAP provides N as well as P to plants.)

Potassium (or potash) fertilisers

Plants need potassium for the following reasons.

(i) Potassium helps in the proper formation of roots.

(ii) It helps plants to fight diseases.

(iii) It helps in the synthesis of carbohydrates.

The following potassium fertilisers are commonly used.

1. Potassium nitrate: KNO_3
2. Potassium chloride: KCl
3. Potassium sulphate: K_2SO_4

Mixed fertilisers

Nowadays, mixed fertilisers called NPK (nitrogen, phosphorus and potassium) are commonly used. Some examples of such combinations are given in Table 7.3.

Table 7.3 Some NPK fertilisers

Element	Combination 1	Combination 2	Combination 3	Combination 4
N	Urea	CAN	Ammonium sulphate	DAP (for N and P)
P	Superphosphate of lime	Superphosphate of lime	Superphosphate of lime	
K	Potassium chloride	Potassium chloride (or nitrate)	Potassium chloride (or nitrate)	Potassium chloride

Pesticides

Many living organisms destroy crops, spread diseases and cause other harm. They are collectively known as pests. Man has manufactured chemicals, called pesticides, to kill them.

Pests include insects (like ants and cockroaches) and fungi (like the one that affects potato leaves). To kill them we use insecticides and fungicides respectively. Rodents like rats, mice and moles are also pests. They eat up grain stored in granaries and our homes. Rodenticides are used to kill rodents.

Unwanted plants in crop fields are called weeds. Weeds affect the growth of crops by consuming nutrients from the soil. They are destroyed by using herbicides. Insecticides, fungicides, herbicides and rodenticides are collectively known as pesticides. Some common examples are given below.

Insecticides:	DDT, aluminium phosphide, Gammexene
Fungicides:	Thiram, Bordeaux mixture ($CuSO_4 \cdot 5H_2O + Ca(OH)_2$)
Rodenticides:	Aluminium phosphide
Herbicides:	Benzipram, benzadox

Pesticides must be used judiciously

Pesticides not only kill pests, they harm humans and other animals too. They are not very easily degraded and some of them remain undegraded for years. DDT remains undegraded for about 40 years. So its use has been banned in many countries. Pesticide residues on crops and soil also pollute water bodies through run-offs. Hence we should not use pesticides indiscriminately.

On the other hand, we cannot stop using pesticides altogether. Even with all the pest control, the damages to crops every year is to the tune of crores of rupees. As you can imagine, in the absence of pest control, enormous amounts of food grain would be lost.

Therefore, pesticides have to be used, but judiciously.

Medicines

A drug is a substance that causes biochemical changes in the body. 'Medicine' is the term for a drug used to cure diseases. Drugs also include things like cocaine, heroin and LSD, which alter the way we think and feel, sometimes with pleasurable effects. However, they are habit-forming and extremely harmful for our mental as well as physical health. So their use is illegal.

In ancient times, man depended on plants and some minerals for medicines. The Indian *ayurvedic* system derives medicines from these sources. Similar systems prevailed in other parts of the world too.

How man-made medicines emerged

As chemistry advanced, chemists found out which chemical substance present in a plant is responsible for curing an illness. Such a substance is known as the active ingredient of the plant. The active ingredient was synthesised, tried over patients and finally marketed as a medicine. This is how medicines became available at a chemist's store. Such medicines have the advantage that they can be modified. In fact new medicines can also be developed in the laboratory. It is interesting to know how the well-known medicines aspirin and quinine were developed.

Aspirin In the beginning of the nineteenth century, the extract of the willow bark was found useful in treating fever. On chemical investigation, it was found that an organic acid was the active ingredient. The acid was named salicylic acid (*salix* is Latin for willow). By the end of the century, aspirin, a derivative of salicylic acid, was developed as a medicine. Aspirin is safer and more efficient than the willow-bark extract and is to date one of the most widely used medicines.

Quinine In the middle of the seventeenth century, it was discovered that the extract of the cinchona bark could be used for treating malaria.

During the Second World War, many countries did not have access to the cinchona bark. As a result, many people died of malaria. Then chemistry came to the rescue. Synthetic drugs containing quinine, the active ingredient of the cinchona bark, were manufactured. This saved many lives in malaria-prone areas.

Types of medicines

For convenience, medicines have been classified into several types. Let us learn about the important ones.

Analgesics Painkillers are called analgesics. Common examples are aspirin, paracetamol and morphine.

Antipyretic drugs An antipyretic drug is used when a person has a fever. (Remember that a prolonged high fever affects the brain.) Paracetamol and aspirin are commonly used antipyretic drugs.

Antimalarial drugs Antimalarial drugs are used to treat malaria. They are all quinine derivatives, e.g., chloroquine.

Antibiotics Some microorganisms like moulds produce chemicals which kill certain disease-causing bacteria. Such chemicals are called antibiotics. The first antibiotic—penicillin—was discovered by the English scientist Alexander Fleming in 1928 in the mould *Penicillium notatum*. Trials were made with penicillin in 1941. It was surprisingly successful in the treatment of various infections. It was extensively used in the Second World War to treat wounds. It is still used as an important antibiotic.

Penicillin was followed by several other antibiotics, which were effective against one or more kinds of bacteria. Some common antibiotics are streptomycin, neomycin, chloromycetin, erythromycin, ampicillin, ciprofloxacin and rifampicin.

Points to Remember

- Cement is made from limestone, clay and gypsum.
- All glasses are silicates of metals.
- There are many types of glass, e.g.,soda glass, potash glass, optical glass, Crookes glass (for spectacles), borosilicate glass, coloured glass, milky glass and glass laminates.
- Plastics are *polymers*.
- A polymer molecule is made up of a large number of a small, repeating unit called a *monomer*.
- Paints are applied on a surface to protect it from corrosion and weathering, or to give it an attractive look. A paint contains a *pigment*, a *vehicle* and a *thinner*.
- Soaps are the sodium or potassium salts of fatty acids. They are made by the saponification of fats.
- Detergents are made from some petroleum products.
- Fertilisers are chemicals that increase the fertility of the soil. They are of three types—*nitrogenous*, *phosphatic* and *potassium (or potash) fertilisers*. NPK is a mixed fertiliser.
- Chemicals used to kill destructive organisms are called *pesticides*. They include *insecticides*, *fungicides*, *rodenticides* and *herbicides*.
- In ancient times, man depended on plants and some minerals for medicines.
- In modern times, medicines are synthesised. They are of different kinds, e.g., *analgesics*, *antipyretic drugs*, *antimalarial drugs* and *antibiotics*.

Exercise

Short-Answer Questions

1. Name the substances from which cement is made.
2. What are the constituents of mortar?
3. What is the substance obtained by fusing a mixture of soda ash, limestone and sand?
4. Between soda glass and potash glass, which will you choose for making chemical apparatus?

5. Name any three kinds of glass.
6. Which glass can stand sudden heating and cooling?
7. Name the kind of plastic that can be moulded again and again.
8. Mention an important use of Teflon.
9. What is vinyl rubber—a natural polymer or a man-made polymer?
10. Name two white pigments.
11. Do detergents form insoluble salts with hard water?
12. Name a fertiliser that is nitrogenous as well as phosphatic.
13. Name the constituents of any NPK fertiliser.
14. What are the following called?
    (a) A substance, a molecule of which is made up of a large number of a small, repeating unit called a monomer
    (b) A medicine used as a painkiller
    (c) A medicine used for treating fever
15. Give one word for each of the following.
    (a) A chemical that is used to kill insects
    (b) A chemical that is used to kill fungi
    (c) A chemical that is used to kill unwanted vegetation
16. Name the mould from which penicillin was obtained.

Long-Answer Questions

1. How are soaps made?
2. Why do plants require nitrogen, phosphorus and potassium?
3. What are pests and pesticides? Name three kinds of pesticides.
4. Why should pesticides be used judiciously?
5. Narrate how aspirin was developed as a medicine.

Objective Questions

Choose the correct option.

1. Which of the following kinds of glass is used for making spectacles?
   (a) Soda glass (b) Potash glass (c) Borosilicate glass (d) Crookes glass
2. Which of the following substances uses a polymer?
   (a) Soap (b) Bubblegum (c) Glucose (d) Common salt
3. Which of the following is a nitrogenous fertiliser?
   (a) Urea (b) Potassium chloride
   (c) Superphosphate of lime (d) Potassium sulphate
4. Which of the following is an insecticide?
   (a) Soap (b) Detergent (c) Gammexene (d) Aspirin
5. Which was the first antibiotic to be discovered?
   (a) Penicillin (b) Streptomycin (c) Erythromycin (d) Ampicillin

Fill in the blanks.

1. Prisms and lenses are made of ...... glass. (soda/optical)
2. Glass of different colours is made by adding the oxides of different ...... to the glass melt. (metals/nonmetals)
3. Fats are saponified to make .... (soaps/detergents)

4. The cinchona-bark extract, used for treating malaria, contains ...... as the active ingredient. (quinine/aspirin)
5. Aspirin is an .... (analgesic/antibiotic)

Match the columns.

1. Match columns A and B to form complete sentences.

A	B
Crown glass	is used for making chemical apparatus.
Borosilicate glass	is an optical glass.
Soaps	can be moulded only once.
Thermosetting plastics	form insoluble salts with hard water.

2. Match the polymers mentioned in column A with the items mentioned in column B.

A	B
Polythene	Pipe
Nylon	Carrybag
PVC	Crockery
Melamine	Nonstick kitchenware
Teflon	Fibre

Indicate which of the following statements are true and which are false.

1. Reinforced concrete contains metal wires apart from cement and sand.
2. Glass has a sharp melting point.
3. Starch is not a polymer.
4. Pesticides are poisonous to humans also.
5. Superphosphate of lime is made from bones or phosphatic rocks.

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