



16

CHEMICAL INDUSTRIES



After completing this lesson, you will be able to:

This is 11 days lesson
(period including homework)

- Describe some metallurgical operations.
- Make a list of raw materials for Solvay process.
- Outline the basic reactions in Solvay Process
- Develop a flow sheet chart for Solvay process.
- Describe the composition of Urea.
- Develop a flow sheet diagram for the manufacturing of Urea.
- List the uses of Urea.
- Define petroleum.
- Describe the formation of Petroleum and Natural gas.
- Describe the composition of Petroleum
- Describe briefly the fractional distillation of Petroleum
- Relate the study of chemistry to careers in industry.
- Describe the link between chemistry, business and communication skills in order to promote chemical sales.
- Describe how different types of fire (wood, oil, electric) require different chemistry to put them out.
- Explain how technology impacts the production of common chemicals.
- Debate the use of synthetic fertilizers versus organic/natural fertilizers.



Reading

In grade VI you learned about metals and how important the metals are in our life...? Most of our kitchen utensils, parts of sewing machine, washing machine, parts of our car, electrical cables etc. are made of metals. Think what will happen if the base of our iron is made of plastic instead of metal...? Your mother asks you to bring dhobi soda or washing soda when she plans for her scheduled washing... Do you know the chemical name of dhobi soda...? We put fertilizer in our fields, gardens and flower pots...? Think what will happen if we don't put fertilizer to these...? Have you ever thought of how we get diesel, petrol, etc., for running our vehicles? Where from we get natural gas (Sui gas) and kerosene oil for our kitchen stoves and our factories etc.? What is coal tar? Where from it comes? In this era of high technology all of us depend too much on plastic items...? Did you ever try to know what these things are? What is the source of these things? In this chapter you will learn about how metals are extracted from their ores? How sodium carbonate or dhobi soda and sodium bicarbonate or baking soda are manufactured. How urea is manufactured and what are its important uses? What is petroleum?



TABLE 16.1: Some important ores

Metal	Name of ore	Formula
Iron	Haematite	Fe_2O_3
Iron	Magnetite	Fe_3O_4
Copper	Chalcopyrite	CuFeS_2
Aluminum	Bauxite	$\text{Al}_2\text{O}_3 \cdot x\text{H}_2\text{O}$
Sodium	Halite	NaCl
Lead	Galena	PbS
Zinc	Zinc blende	ZnS
Mercury	Cinnabar	HgS
Chromium	Chromite	$\text{FeO} \cdot \text{Cr}_2\text{O}_3$
Tin	Cassiterite	SnO_2
Silicon	Silica	SiO_2

16.1 BASIC METALLURGICAL OPERATIONS

Metals are very important for us. We use them for structural applications, cooking utensils, tools, electrical wires and many other things. However, being electropositive, almost all the metals in nature are found in the form of their compounds. The naturally occurring metallic compounds are called minerals. The debris, such as sand, rock and clay attached with the mineral is called gangue. Some important ores are given in table 16.1. An ore is a solid deposit containing a sufficiently high percentage of a mineral to make extraction of metal economically feasible. To recover and use these metals, we separate them from ores and reduce the metal ion. The process of separating a metal from its ore and preparing it for use is known as metallurgy.

The main steps in metallurgy are:

1. Crushing, grinding or pulverizing of the ore
2. Concentration of the ore
3. Extraction of metal
4. Refining of metal.

16.1.1 Concentration

After mining ore through crushing, grinding or pulverizing steps is converted into the powder. Then mineral is separated from gangue by some physical method. This process is called concentration. Some of these methods are as follows.

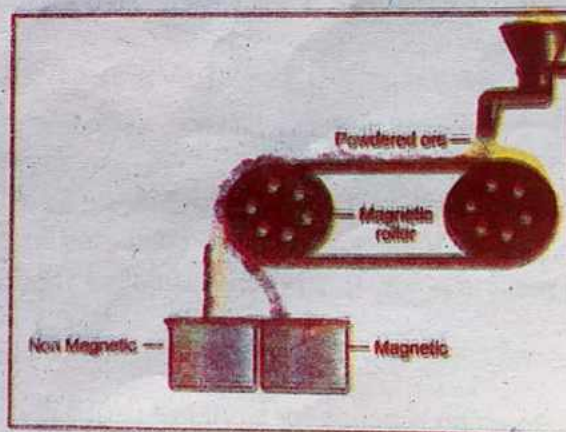


Figure 16.1: Magnetic Separator

a) Magnetic Separation:

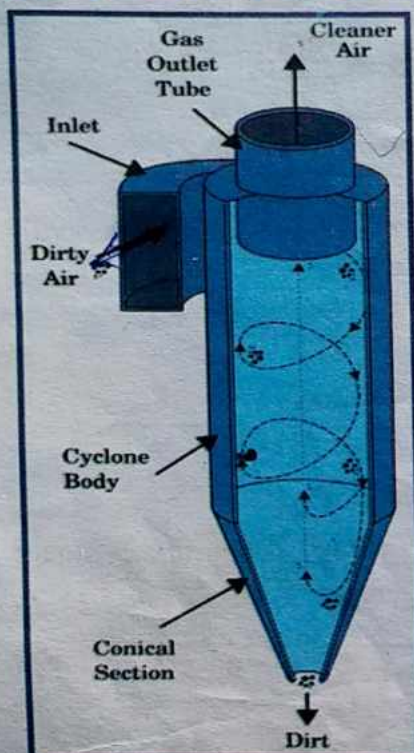


Figure 16.2 Cyclone Separator

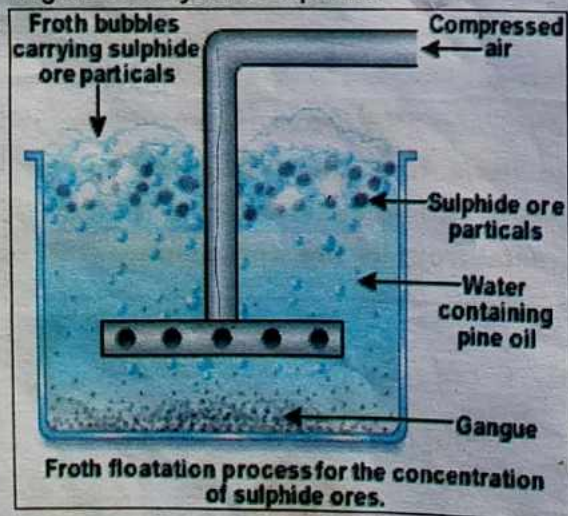
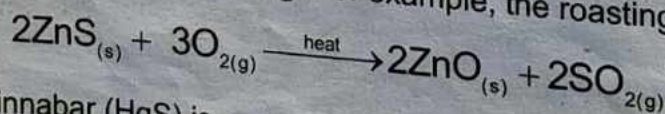


Figure 16.3 Floatation process

Some minerals are converted to oxide by heating in the air at temperature below their melting point. This process is called **roasting**. For example, the roasting for zincblende (ZnS) is



Roasting reaction for cinnabar (HgS) is



For magnetic ore, a magnet is used to remove mineral, leaving the gangue behind. The ^{powdered} ore is dropped over a moving belt. Belt moves over two wheels, one of which is magnetic. It attracts the magnetic ore, so it falls nearer to the magnetic wheel. While non-magnetic impurities fall further away, as shown in figure 16.1.

b) Cyclone Separation:

Where large density differences exist between ore and impurities, a cyclone separator is used. In this method air under high pressure is blown through the pulverized ore. The lighter gangue is blown away through the top. But the denser mineral rich particles hit the walls by centrifugal force. They fall down the funnel.

(Figure 16.2)

c) Flotation Process:

Pulverized ore is fed into a tank containing water and an oil-detergent mixture. The mixture is agitated with air. Detergents wet the mineral particles but not the silicate gangue. The mineral particles rise to the top of the mixture as a froth, from where they are skimmed off. Particles of the gangue fall down to the bottom. The copper ore is concentrated generally by flotation process. (Figure 16.3)

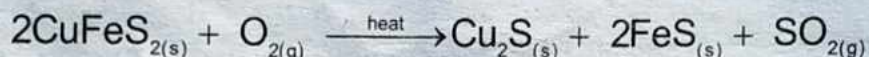
16.1.2 Extraction of Metals

After the mineral has been freed of gangue and concentrated it is passed through some chemical process to extract metal.

(a) Roasting



Roasting reaction of copper pyrite ore is



(b) Smelting

The method to reduce metal ions to free metal is called smelting.

The most common reducing agents are coke, carbon monoxide and hydrogen. Some examples are:



However, smelting of copper ore is done in two steps.

- i) **The roasted copper ore** is heated with coke and sand at about 1100°C . The materials melt and separate into two layers. The bottom layer that contains mixture of Cu_2S and FeS is called matte. While the upper layer is a silicate slag formed by the reaction of FeO and sand



ii) Bessemerization:

In this process air is blown through the molten copper matte in a Bessemer converter (Figure 16.4). Any remaining iron sulphide (FeS) is oxidized and removed as slag (FeSiO_3). In the final smelting step cuprous sulphide (Cu_2S) is oxidized to form cuprous oxide, which reacts with remaining cuprous sulphide to form metallic copper.

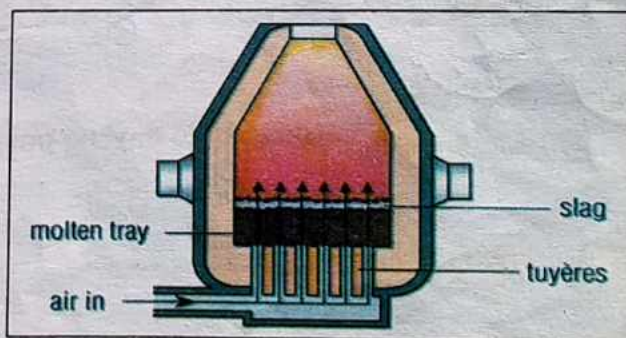


Figure 16.4 Bessemer Converter



The product, called blister copper is about 97 to 99% pure Cu, with entrapped bubbles of $\text{SO}_{2(g)}$.

Bessemerization is also used to convert pure iron into steel.

(c) Refining or purification of metals

The metal obtained as a result of smelting contains some impurities. So it must be refined. Following methods may be used.

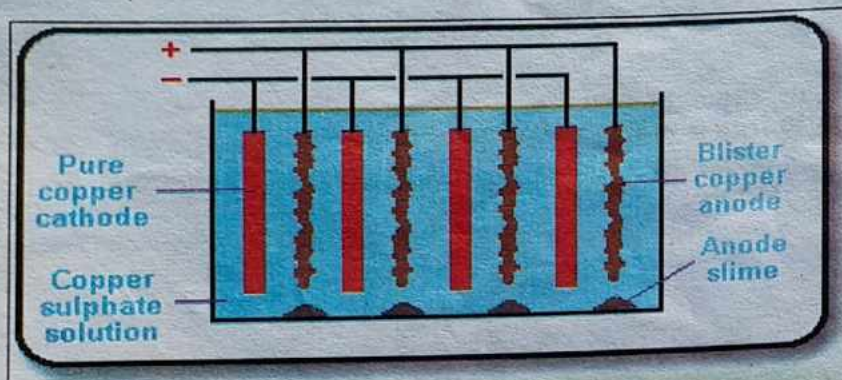
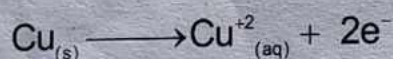
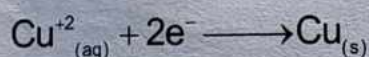
i) **Electro-refining:**

Figure 16.5: The electro refining of copper

An electrolytic cell is used in electro-refining, in which impure metal acts as the anode and a sample of pure metal acts as the cathode. For example, electrolytic refining of copper is carried out in an electrolytic tank containing acidified copper sulphate solution as electrolyte (Figure

16.5). Impure slabs of copper act as anode and pure copper sheets as cathode.

On passing electric current through the solution, impure copper dissolves forming Cu^{+2} ions. These Cu^{+2} ions gain electrons at cathode and form Cu atoms, which are deposited on the cathode. In this way pure copper is collected at cathode. The impurities like Au and Ag fall off the anode as anode mud.

Anode Reaction:**Cathode Reaction:**ii) **Distillation:**

Metals with relatively low melting points, such. As and Hg are refined by distillation.

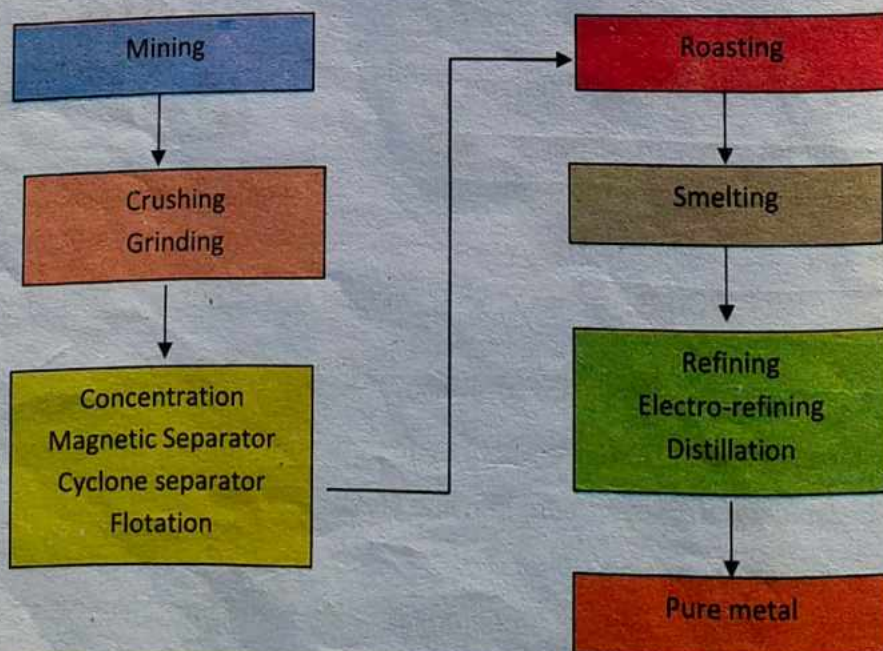


Figure 16.6: Steps in metallurgy

**Self-Assessment Exercise 16.1**

1. List important ores of iron, copper, zinc and mercury.
2. List out basic metallurgical operations.
3. List main processes used to concentrate the ore.
4. Write names of methods used in the extraction of a metal from its concentrated ores.
5. List methods used to purify metals.

16.2 SOLVAY PROCESS

Sodium carbonate (Na_2CO_3) or soda ash is an important industrial chemical. It is used in the manufacturing of glass, soaps, detergents, paper and many other important chemicals. Sodium carbonate is manufactured in a continuous process known as the **Solvay process**.

16.2.1 Raw Materials

Commercially, sodium carbonate is manufactured in a continuous process that uses:

- a) Ammonia
- b) Brine (concentrated sodium chloride solution)
- c) Lime stone as a source of carbon dioxide and slaked lime, $\text{Ca}(\text{OH})_2$

16.2.2 Basic Reactions

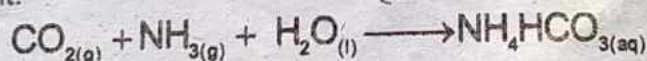
Solvay process consist of following steps

i) Preparation of ammonical brine:

Ammonical brine is prepared by dissolving ammonia gas in brine. Ammonical brine is fed into the carbonating tower.

ii) Carbonation

In the carbonating tower, carbon dioxide is passed through ammonical brine. Following reaction takes place in it.



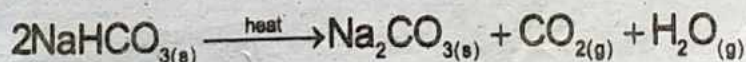
In the lower compartments of carbonating tower, the temperature of the mixture is lowered to 15°C . At this temperature, NaHCO_3 precipitates out.

iii) Filtration

Precipitates of NaHCO_3 are separated from the milky solution by filtration. It is used as baking soda.

iv) Calcinations

Sodium hydrogen carbonate is heated to get sodium carbonate

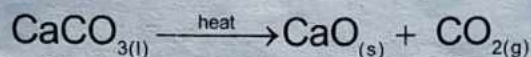


Carbon dioxide released is re-cycled in the process.

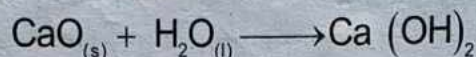


v) Preparation of carbon dioxide and slaked lime.

Carbon dioxide is produced by heating limestone in a kiln.



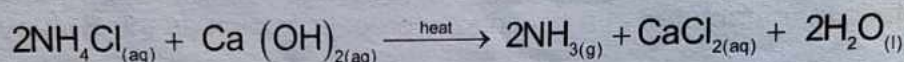
Carbondioxide is fed into the carbonating tower from the top. Equal amounts of lime (CaO) and water are mixed to produce slaked lime, Ca(OH)_2



Slaked lime is pumped to the ammonia recovery tower.

vi) Recovery of ammonia:

Solution containing ammonium chloride produced in the carbonation tower is heated with slaked lime.



Almost all the ammonia is recovered in this process. It is reused in the process.

Advantages of Solvay Process

- It is a cheap process. The raw materials are cheap and easily available.
- It is a pollution free process. No harmful products are produced.
- It consumes less fuel. This is because there is no solution to be evaporated.
- Carbon dioxide and ammonia are recovered and re-used in the process.
- It produces pure NaHCO_3 and Na_2CO_3

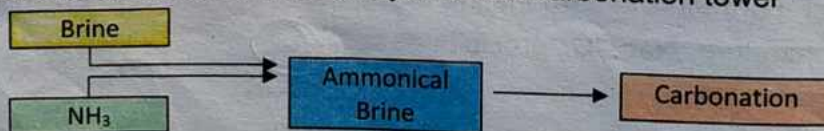


Activity 16.1

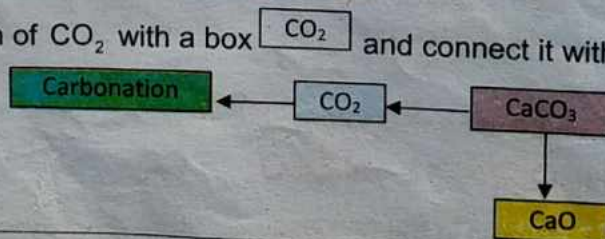
Development of flow sheet diagram of Solvay process

Carry out the following

- Represent each reactant, each product and each reaction chamber or container with one box.
- Show formation of ammoniacal brine and join it with carbonation tower

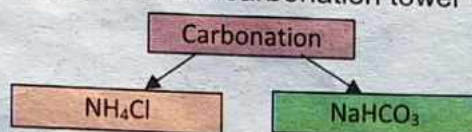


- Show the formation of CO_2 with a box CO_2 and connect it with carbonation tower.

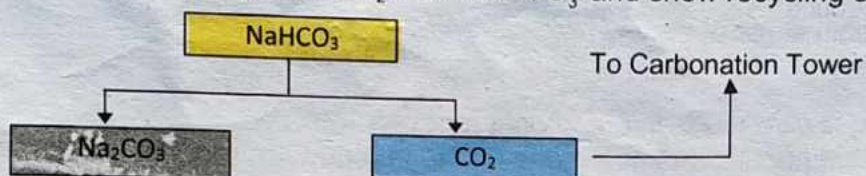




4. Show formation of two products from the carbonation tower

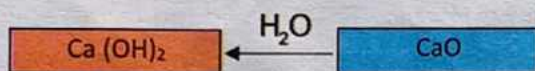


5. Show formation of Na_2CO_3 and CO_2 from NaHCO_3 and show recycling of CO_2 .

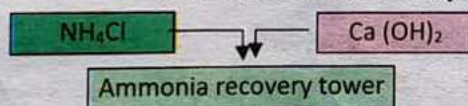


6. Show ammonia recovery:

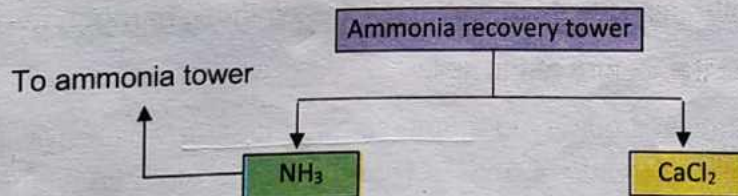
a) First show formation of $\text{Ca}(\text{OH})_2$ from CaO and H_2O .



b) Connect NH_4Cl and $\text{Ca}(\text{OH})_2$ with ammonia recovery tower.



c) Show products of ammonia recovery tower, NH_3 and CaCl_2 . Also show recycling of NH_3 .



Solution

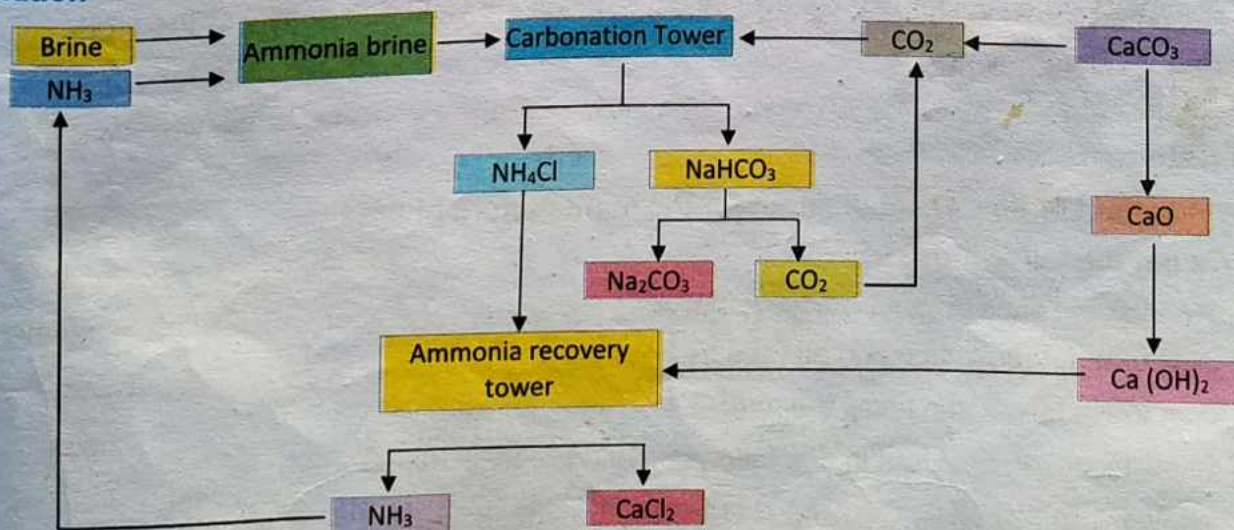


Figure 16.7 Flow sheet diagram of Solvay process



Self-Assessment Exercise 16.2

1. Make a list of raw materials of Solvay process.
2. Outline the basic reactions of Solvay process.
3. List out main steps of Solvay process.

16.3. UREA

As the world population has increased, the demand for food has increased. The world population was 3.5 billion in 1965. By 2050, it will reach 10 billion. Many people today are hungry and many more are under-nourished. Crops take nutrients from the soil, and these must be replaced before the next crop is sown. Fertilizers are the compounds which are put in the soil to provide elements essential for plant's life. They are added to the soil to make up the deficiency caused by the previous crops. Fertilizers are classified into two categories:

1. Natural fertilizers or manures derived from animals and human wastes.
2. Synthetic fertilizers i.e. urea, ammonium sulphate, ammonium phosphate, super phosphate and di-ammonium phosphate. Urea is one of the widely used fertilizer because of the following qualities:
 - i) Percentage of nitrogen is highest ^{in urea} among all the synthetic nitrogen fertilizers i.e. 46%.
 - ii) It does not affect the texture of the soil.
 - iii) In the soil it hydrolyses quickly to ammonium carbamate which eventually changes into NH_3 which decomposes into N_2 and H_2 . Nitrogen is the main constituent of proteins; it is required by the stems and leaves during the early stages of the plant development. It imparts green colour to the leaves and increases the yield and quality of the crop.



Activity 16.2

Development of flow sheet diagram for the manufacture of urea.

Carry out the following:

1. Represent each reactant, each product, reaction chamber, distillation chamber, evaporator, granulation and storage by boxes.
2. Join these boxes and show the direction of the changes or processes.
3. Show incoming of steam in distillation unit and hot air in evaporator.
4. Show release of NH_3 , CO_2 and H_2O from distillation unit.

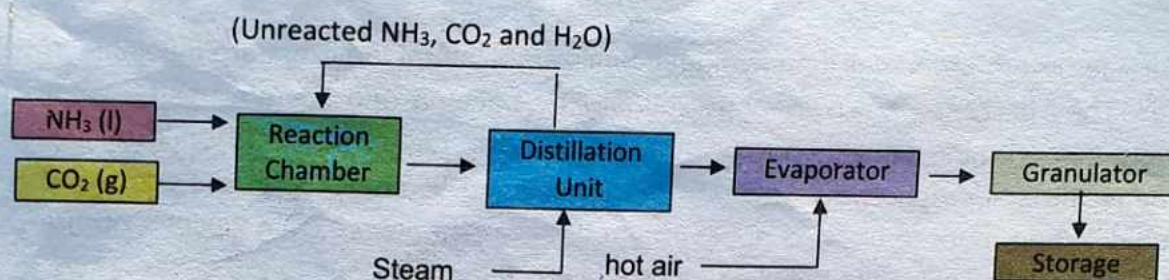
**Solution:**

Figure 16.8: Flow sheet for urea manufacturing

16.3.2 Raw materials:

The raw materials for the manufacture of urea are:

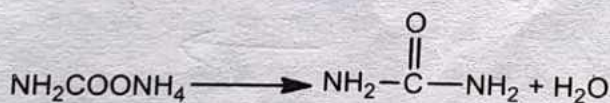
- i) Ammonia (NH_3) ii) Carbon dioxide (CO_2)

Manufacturing of urea consists of following steps.

- a) Reaction between NH_3 and CO_2 to form ammonium carbamate.



- b) Distillation of ammonium carbamate.



Urea

- c) Evaporation of liquid urea and its granulation.

The urea solution is concentrated in vacuum evaporators, which is then rapidly cooled and sent to the prilling tower. Urea prills thus produced are packed and then marketed.

Do you know**% of nitrogen in various fertilizers**

Fertilizer	Formula	Molecular mass	% age of Nitrogen
Ammonium sulphate	$(\text{NH}_4)_2\text{SO}_4$	132	21.2
Ammonium nitrate	NH_4NO_3	80	35.0
Urea	NH_2CONH_2	60	46.6

**Self-Assessment Exercise 16.3**

1. Calculate percentage of nitrogen in urea.
2. Outline the basic reactions that take place in the synthesis of urea.
3. What happens when ammonium carbamate is distilled with steam?



Society, Technology and Science

1. Natural fertilizers are better than synthetic fertilizers. Natural fertilizers are insoluble in water. They decompose slowly and gradually by bacteria and liberate useful water soluble nutrients for plants. They do not contain toxic chemicals and hence do not damage the soil crops and plants. On the other hand synthetic fertilizers are water soluble. When more fertilizer is applied than the soil can absorb, rain washes off the excess fertilizer. This is not only uneconomical but also hazardous to the environment. The dissolved nutrients flow into stream, lakes and rivers and contribute in the eutrophication of their waters. It results in over growth of water plants, algae and bad odour in these waters. A bloom of algae can spread across the surface, blocking light for other plant life in the water. When plants and algae die, bacteria multiply rapidly with so much food available. They remove the dissolved oxygen in the water. Without oxygen, fish die affecting the whole ecosystem. Nitrates in drinking water cause stomach cancer.
2. People have been preparing common chemical such as acids, alkalis, soaps, baking soda, soda ash, caustic soda etc. since centuries. But the use of technology has not only increased production of chemicals but improved quality as well. For instance, soda ash and baking soda are produced commercially by Solvay process, which is a continuous process. Soda is not handled until it is packed. Carbon dioxide and ammonia are recovered almost 100%. At the same time process is pollution free.

16.4 PETROLEUM INDUSTRY

16.4.1 Petroleum

Where the most of the energy used today come from?

Fossil fuels are energy-rich substances formed from remains of organisms. Coal, petroleum and natural gas are called fossil fuels because they were formed underground from the remains of once-living organisms. The name petroleum is derived from Latin words **petra** (rock) and **oleum** (oil). It is also called as crude oil. Petroleum or crude oil is thick dark liquid composed mostly of hydrocarbons. Natural gas, usually associated with petroleum deposits, consists mostly of methane. It also contains significant amounts of ethane, propane and butane.

16.4.2 Origin of Petroleum and Natural gas

It is believed that petroleum was formed from organisms that lived hundreds of millions of years ago. Plants and animals in the seas died. Their remains piled up. Layers of sand, rock and mud buried the dead organisms. Over time, in the absence of air, heat and pressure of sediments and bacterial effect changed the material into dark brownish viscous liquid called petroleum. It is also called crude oil. The gaseous products accumulated over the petroleum, is called as natural gas.



16.4.3 Mining of Petroleum

Petroleum is extracted by drilling holes into the earth crust where it is found. When drill is made through the rocks, natural gas comes out first with great pressure. After the gas pressure subsides, crude oil is extracted by pumps.

16.4.4 Important fractions of petroleum

The conversion of crude oil into useful products is called **refining**. These useful products are called fractions. Each fraction consists of a mixture of hydrocarbons which boil in a certain range of temperature. Petroleum is refined by fractional distillation in a tall fractionating tower. (See figure 16.9). The crude oil is heated up to 400°C under high pressure in a furnace. Then it is passed through the fractional distillation column. Its vapour rise through the column. As hot vapour move up, they condense according to their boiling points into various fractions. Compounds with highest boiling points condense first near the bottom. Compounds with lowest boiling point condense last near the top. Compounds which do not boil, collects at the bottom as residue. In this way vapour condense gradually at different levels according to their boiling points. Therefore, crude oil is separated into various fractions. Each fraction has its own specific boiling range and composition. How many fractions are obtained?

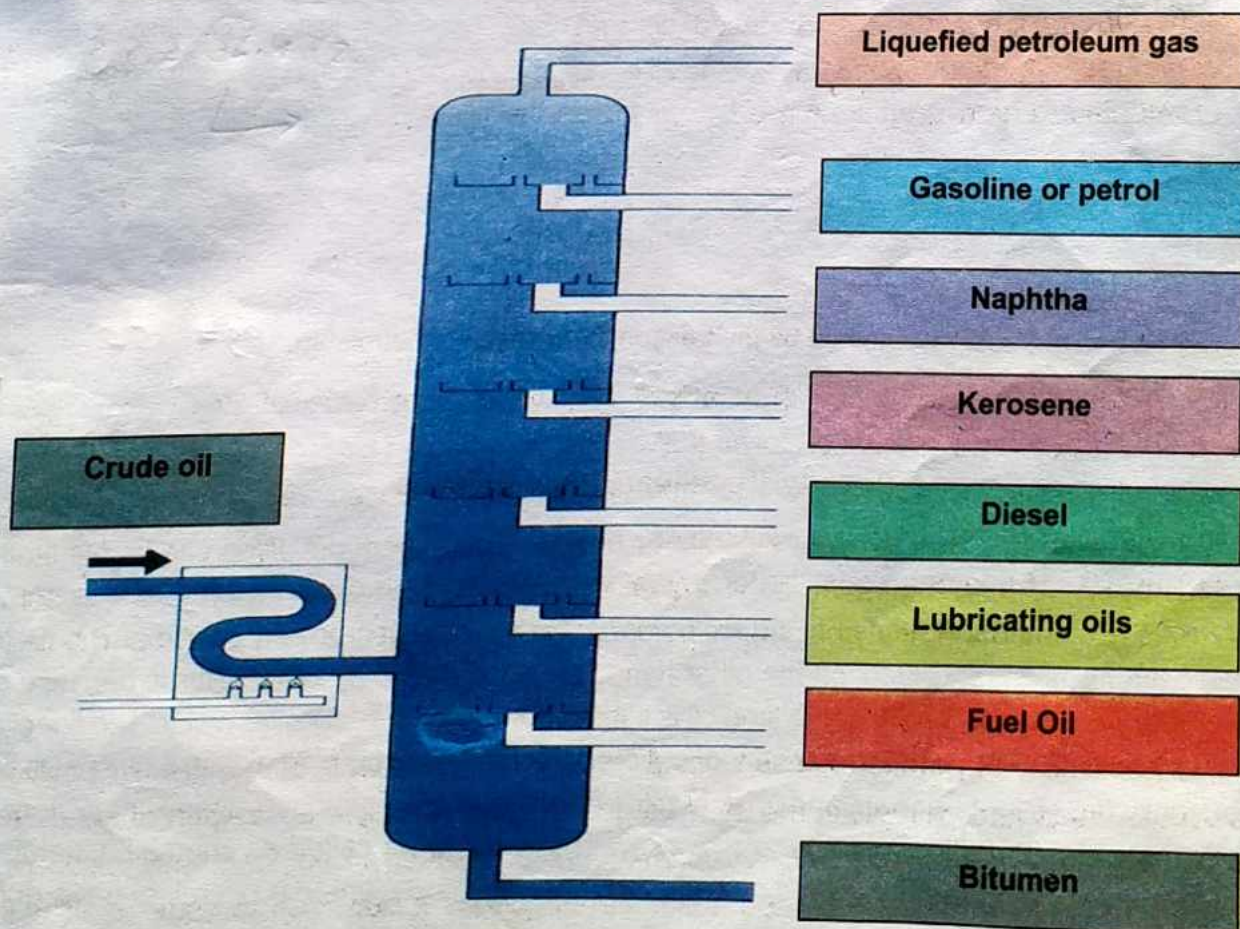


Figure 16.9: Fractional distillation of petroleum



The physical properties and uses of petroleum fractions are given in table 16.

Table 16.2: Fractions of petroleum and their uses

Fraction	Number of carbon atoms per molecule	Boiling point °C	Important uses
Liquefied petroleum gas (LPG)	1-4	Below 20	Cylinder gas for cooking
Petrol	5-10	35-70	Fuel for motor cars and vehicles
Naphtha	8-12	70-120	Chemical feedstock for making drugs, plastics and other chemicals
Kerosene	10-16	170-250	Fuel for jet planes, fuel for heating, lighting and cooking
Diesel	14-20	270-340	Fuel for buses, truck and trains.
Lubricating oil	20-50	350-500	Lubricants for machines and engines, waxes and polishes
Fuel oil	50-70	500-600	Fuel for power stations, factories and ships
Bitumen	More than 70	More than 500	Paving roads and making roofing materials



Self-Assessment Exercise 16.4

1. Define petroleum.
2. List names of fractions obtained by the fractional distillation of petroleum.
3. List one use of each petroleum fraction.
4. How is petroleum obtained?

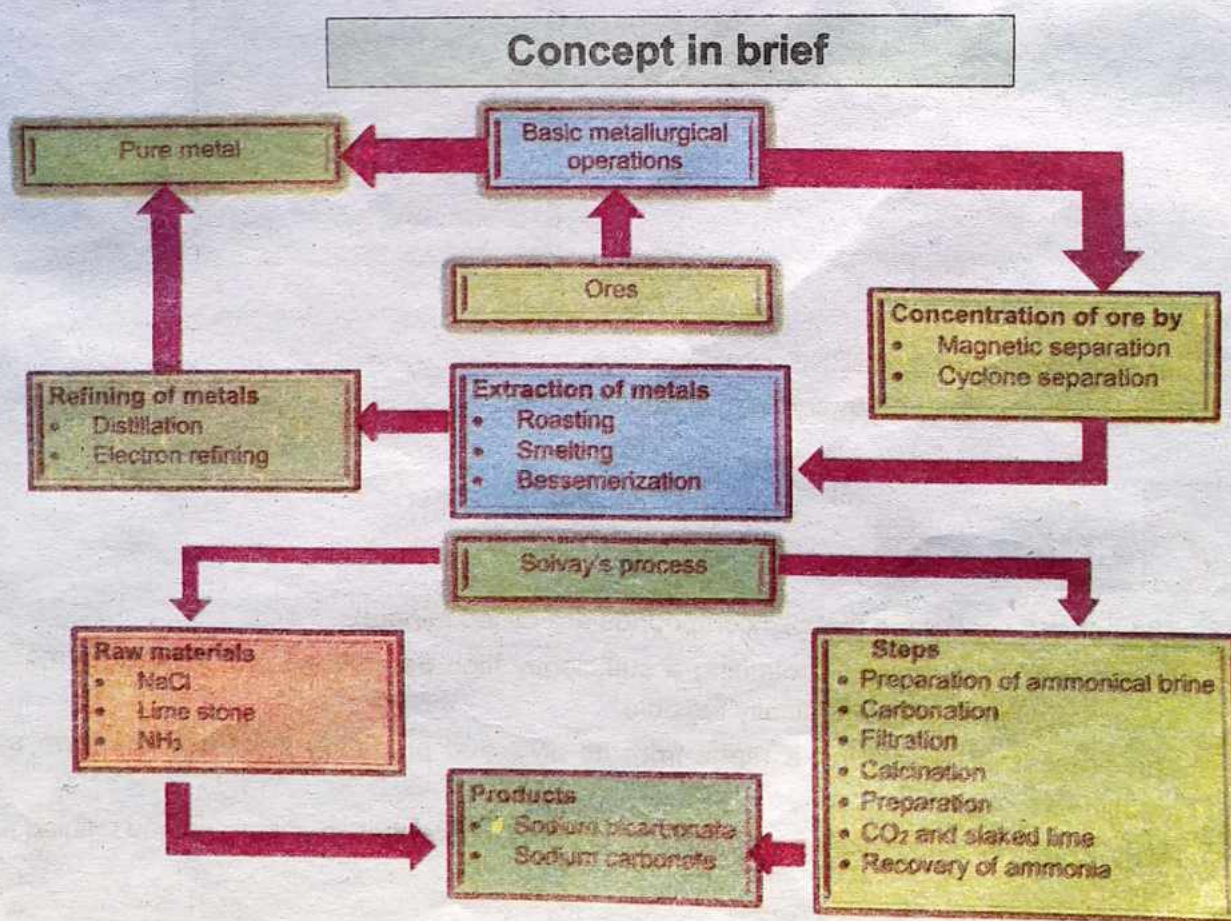
Society, Technology and Science

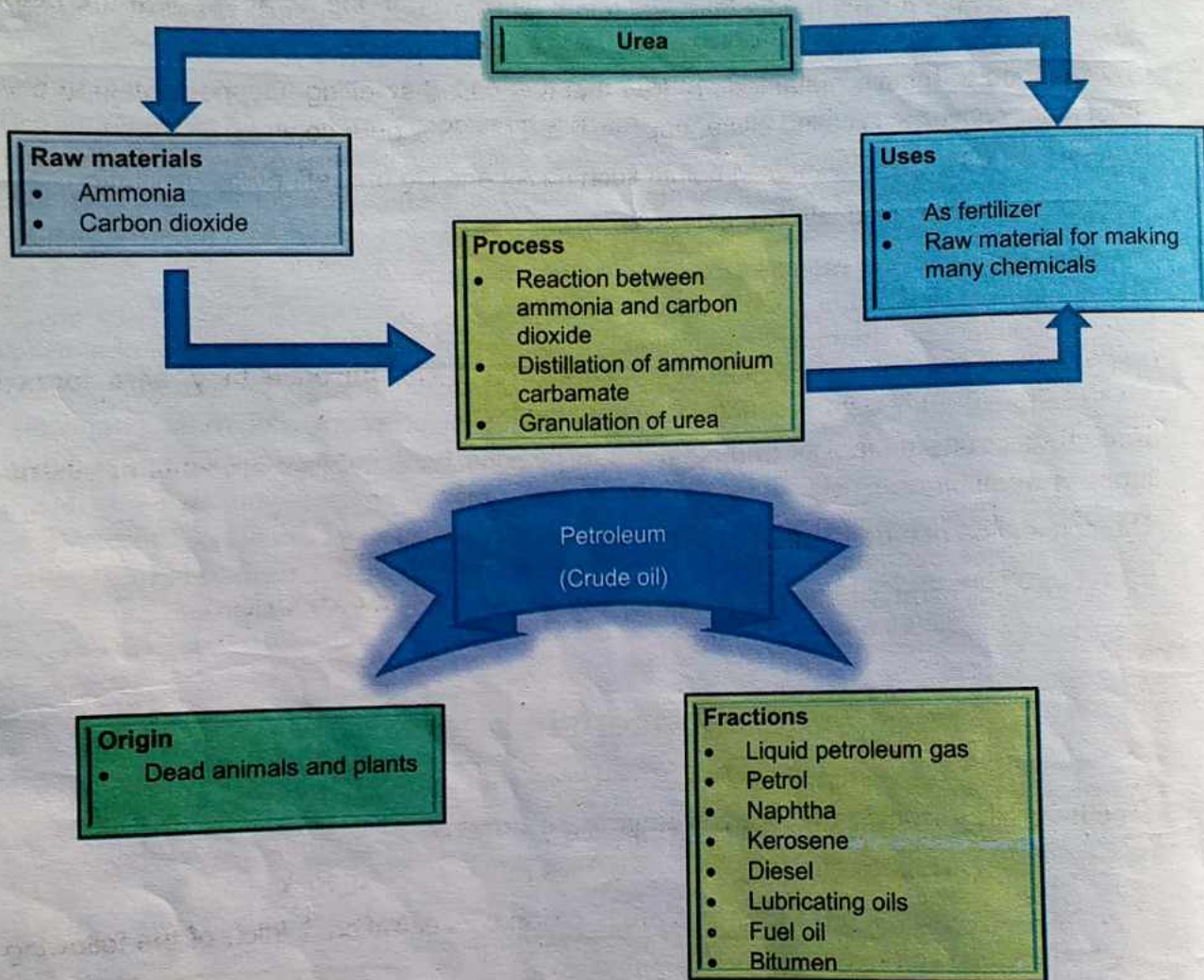
1. Wood, oil or electric fires required different techniques to put them out. Wood fire is generally extinguished by throwing water on it. Water has high heat of vaporization. So it absorbs considerable amount of heat from the fire before it vaporizes. So it gradually cools burning wood and extinguishes fire. Oil fire, on the other hand cannot be put off by water. This is because oil and water do not mix. At the same time oil is lighter than water. It floats over water. The fire also spreads with flowing water. Water cannot cut off contact between burning oil and oxygen. Oil fire is usually put off by throwing sand on it. Electric fires can only be put out by fire extinguishers.
2. A person who studies chemistry and works with chemicals is called as chemist. Chemists have opportunities in all the field of chemistry. For instance, organic chemists have good opportunities to work in industries like petroleum, petrochemical and pharmaceutical. They can research on new products, more effective medicines, new pesticides for better crops,



new ways to help people reduce environmental pollution etc. As a food chemist; you can work in food processing industry. You can discover new methods to store, improve texture and flavor of foods. In hospitals, chemists analyze blood, urine and stool samples to detect any disease, disease causing bacteria, virus, or other microorganisms. As nuclear chemist you can work in the development of new nuclear medicines besides giving chemotherapy and radiation therapy to cancer patients. As inorganic chemist you can work in chemical industries such as manufacturing cement, glass, soap and detergent, fertilizer, acids, alkalis, soda ash, dyes, explosives etc.

3. The modern application of chemical technology is a big business. Chemical firms spent billions of dollars on chemical research and development. The industrial use of chemistry brings us new medicines, lifesaving drugs, effective pesticides, germicides, fungicides, synthetic fertilizers, paints, cosmetics, artificial flavors, sweeteners, etc. These chemicals have raised our standard of living. However, besides benefits, these substances have some drawbacks and risks. It is the job of sales officer to keep you aware of such drawbacks besides explaining benefits. It is important to express benefits of chemicals in a way that everyone can understand. In order to share information he needs to develop good communication skills to promote chemical sales.





References for additional information.

- Longman Chemistry for IGCSE.
- David E. Goldberg, Fundamentals of chemistry.



Key Points

- ❖ The naturally occurring metallic compounds are called minerals.
- ❖ An ore is a solid deposit containing a sufficiently high percentage of a mineral to make extraction of metals economically feasible.
- ❖ The process of separating a metal from its ores and preparing it for use is known as metallurgy.
- ❖ Basic metallurgical operations are crushing, grinding, concentration, extraction and refining.



- ❖ The process of converting a mineral into oxide by heating in the air at temperature below their melting point is called roasting.
- ❖ The method to reduce metal ions to free metal is called smelting. Copper obtained from bessemer converter is called blister copper. It is 97% 99% pure copper.
- ❖ Metals with relatively low melting points such as As and Hg are refined by distillation.
- ❖ Fertilizers are classified into two categories
 - Natural fertilizers or manures
 - Synthetic fertilizers
- ❖ Coal, petroleum and natural gas are called fossil fuels, because they were formed underground from the remains of once-living organisms.
- ❖ Natural gas consists mostly of methane. It also contains significant amounts of ethane, propane and butane.
- ❖ The conversion of crude oil into useful products is called refining.
- ❖ Each petroleum fraction has its own specific boiling range and composition.



Review Questions

1. Select the correct answer

- i) The naturally occurring metallic compounds are called as
a) ore b) gangue ☒ c) mineral d) rock
- ii) The separation of minerals from gangue is called concentration. Which of the following methods is used for concentration?
a) smelting b) roasting c) refining ☒ d) flotation
- iii) Which of the following steps is not used in the extraction process of metals
a) roasting b) smelting ☒ c) flotation d) bessemerization
- iv) In electrolytic refining of copper, _____ is used as anode.
a) pure copper ☒ b) impure copper c) copper sulphate d) electrolytic tank
- v) Which of the followings is not a raw material for the manufacture of soda ash.
a) ammonia b) carbon monoxide c) brine d) lime stone
- vi) A mixture of Cu_2S and FeS called matte is produced in one of the metallurgical operations in the extraction of copper. The name of this operation is.
a) smelting ☒ b) roasting c) bessemerization d) electro-refining
- vii) Chemical formula of slaked lime is
a) CaCO_3 b) CaO ☒ c) Ca(OH)_2 d) CaCl_2



- viii) Calcination is the process in which sodium hydrogen carbonate is heated to get sodium carbonate. Which is not obtained in this process?
- a) CO_2 b) CO c) Na_2CO_3 d) H_2O
- ix) Percentage of nitrogen in urea is
- a) 35 b) 21.2 c) 80 d) 46.6
- x) What happens when ammonium carbamate is distilled with steam?
- a) ammonia is produced
b) carbon dioxide is released
c) urea is produced
d) urea solution is produced

2. Give short answers.

- How are urea prills produced?
- What is slaked lime? How is it produced?
- Write chemical reactions that take place during carbonation in Solvay process.
- Explain the process "Roasting" with two examples.
- Write chemical reactions that take place during urea formation.

3. Describe the following with an example

- a) roasting b) smelting c) flotation

4. Make a list of metallurgical operations.

5. How was crude oil formed?

6. State five specific products made from crude oil.

7. Outline basic reactions of Solvay process.

8. Draw flow sheet diagram of Solvay process.

9. Describe composition of urea

10. Make a list of raw materials for Solvay process.

11. Describe the composition of petroleum

12. Relate the study of chemistry to careers in industry.

13. Draw flow sheet diagram for manufacture of urea.

14. Petroleum is a mixture of several compounds, which are separated in a refinery.

- What is the name of the apparatus used for this purpose?
- What is the name of the process used in separating crude oil?
- Write name of the fraction that represents gases.
- Which fractions represent liquids with the lowest boiling points?

15. Petroleum is a source of fuels. Name two fuels which are not obtained from petroleum.

16. What has to be done to crude oil before it is useful?

**Think-Tank**

- 17 The table below lists some petroleum fractions with their approximate boiling points.

Fraction	Approximate Boiling Point/°C
P	Below 20
Q	35-70
R	170-250
S	350-500

- Name the process by which the fractions are obtained from petroleum?
 - Which fraction will contain the shortest chain molecules?
 - Which fraction will contain the longest chain molecules?
 - In what state will fraction P be at room temperature and pressure?
- 18 Should fossil fuels be burned to provide energy, or should they be used to make useful products like drugs, plastics and chemicals? Analyze this statement.
- 19 Sketch flow sheet diagram of refining of petroleum.

KEY FOR MCQS

	i	ii	iii	iv	v	vi	vii	viii	ix	x
Chapter 9	d	d	d	d	d	a	c	c	d	d
Chapter 10	c	c	d	d	a	c	d	b	c	c
Chapter 11	c	b	c	c	d	b	c	d	c	c
Chapter 12	b	c	a	b	c	d	c	d	d	a
Chapter 13	d	a	d	d	c	d	d	c	b	c
Chapter 14	c	b	c	b	b	b	d	d	b	d
Chapter 15	b	b	d	d	d	d	d	b	-	-
Chapter 16	c	d	c	b	b	b	c	b	d	d



Glossary

Acid	is a substance that can donate a proton to a base.
Alkenes	The family of hydrocarbons which contain one carbon-carbon double bond.
Alkyl group	a group of atoms that contains one less hydrogen atom than its parent alkane.
Aqueous solutions	are the mixtures in which substances are dissolved in water.
Acid rain	is formed when air pollutants dioxide are dissolved in rain water.
Acid salts	are formed by the incomplete neutralization of an acid.
Alkanes	the simplest hydrocarbons in which all carbon-carbon bonds are single.
Alkynes	unsaturated hydrocarbons with a carbon-carbon triple bond.
Amino Acids	organic compounds containing both amino and carboxyl groups.
Arrhenius Acid	a substance that produces H^+ ions in water.
Arrhenious base	a substance that produces OH^- ions in water.
Base	a substance that can accept a proton from an acid.
Bronsted lowry acid	a substance that can donate a proton.
Bronsted lowry base	a substance that can accept a proton
Carbohydrates	-polyhydroxy aldehydes or ketones.
Catenation	-linking of carbon atoms with one another to form long chains or rings of carbon atoms.
Chemical equilibrium	-a state of a chemical reaction at which rate of forward reaction equals the rate of reverse reaction.
Concentration	separation of mineral from the gangue.
Crude oil	a dark brownish viscous liquid.
Carboxyl group	the $COOH$ functional group



Destructive distillation	heating a substance in the absence of air.
Equilibrium constant	is the ratio of the product of concentration of products to the product of concentration of reactants each raised to power equal to the co-efficient in a balanced chemical equation.
Enhanced greenhouse effect	an upset in the natural balance of the concentration of greenhouse gases in the atmosphere.
Ethylene	the industrial name for ethene.
Fatty Acids	are carboxylic acids which contain three or more carbon atoms in their chain.
Functional groups	are groups of atoms in an organic molecule which give particular properties.
Fossil fuels	fuels made from the remains of decayed animal and plant matter compressed over millions of years.
Fraction	a collection of hydrocarbons that have similar molecular masses and boil at similar- temperatures.
Fractional distillation	separating a mixture on the basis of differences in boiling points.
Hard Water	water containing dissolved calcium and magnesium salts which produce scum with soap.
Hydrogenation	is addition hydrogen in alkenes and alkynes.
Hydrocarbons	compounds containing only carbon and hydrogen.
Indicators	chemicals that change colour as pH of a solution changes.
Isomer	a compound having the same molecular formula but different structures.
Law of mass action	the rate at which a substance reacts is directly proportional to its active mass and the rate at which the reaction proceeds is directly proportional to the product of the active masses of the reactants.
Lewis acid	a substance that can accept a pair of electrons.
Lewis base	a substance that can donate a pair of electron.



Lipids	any component of plant or animal tissue that is insoluble in water, but soluble in solvents of low polarity such as ether, hexane, benzene and carbon tetrachloride.
Metallurgy	is the art of extracting metals from their ores.
Mineral	a naturally occurring metallic compound.
Monosaccharides	the simple sugars that can not be hydrolyzed.
Normal salts	salt formed by the complete neutralization of an acid and a base.
Oligosaccharides	carbohydrates that on hydrolysis give 2 to 9 monosaccharide molecules.
Ore	a solid deposit containing a sufficiently high percentage of a mineral to make extraction of metal economically feasible.
Ozone	an allotropic form of oxygen that contains three oxygen atoms.
Organic Compounds	compounds containing carbon except carbon dioxide, carbon monoxide and carbonates.
Permanent hardness	in water is due to the presence of sulphates and chlorides of calcium and magnesium.
Petroleum	a dark brownish viscous liquid.
pH	is the negative logarithm of molar concentration of the hydrogen ions.
Pollutants	are substances that have adverse effect
Polysaccharides	carbohydrates that contain hundreds to thousands of monosaccharide units.
Proteins	organic compounds which on complete hydrolysis form amino acid units.
pH Scale	scale based on hydrogen ion concentration.
Refining	a process of separation of crude oil into useful fractions.
Roasting	the heating of concentrated ore in the presence of air.
Salt	an ionic compound made from the reaction of an acid and a base.
Saturated hydrocarbons	every carbon atom present in the hydrocarbon attached to four atoms.
Side groups	groups of atoms such as CH_3 group, which are attached to the main chain of carbon atoms in the molecule.



Structural formula	shows the arrangements of atoms in a molecule.
Smelting	the heating of roasted ore in presence of a reducing agent.
Soft water	produces good lather with soap.
Temporary hardness	is due to the presence of hydrogen carbonates of calcium and magnesium.
Unsaturated hydrocarbons	molecules containing only carbon and hydrogen in which at least two carbon atoms form double or a triple bond.
Universal indicator	an indicator that changes colour at each pH value.

CONTENT AUTHORS

PROF. MRS. SHAHNAZ RASHID

She obtained her Masters' degree in chemistry from Quaid-i-Azam University, Islamabad, and has over twenty eight years of teaching experience. She is serving Islamabad Model College Girls, F-10/2 Islamabad.

Along with teaching, she has been contributing her lot extensively to the promotion of chemistry. She has translated from English to Urdu Text Book of chemistry for class XI, for the National Language Authority. She has also co-authored the Text Book of chemistry for class XII for Allama Iqbal Open University, Islamabad. Besides she has been involved in writing, editing, and compering Television programs of chemistry for secondary classes.

PROF. MUHAMMAD IQTEDAR-UD-DIN

He is an alumnus of CM Boys High School Wah Cant, Gordon College Rawalpindi and Quaid-i-Azam University Islamabad. He obtained his Masters' degree in chemistry in 1979 and in 1988 he was awarded the M.Phil degree by the same Alma Mata.

In 1980, he launched himself into the teaching profession, when he joined the chemistry department of Army Burn Hall College Abbottabad. In 1982, he joined the Islamabad College for boys, G-6/3 an intuition he served as Vice Principal and acting Principal. He has served IMCB G-11/1 Islamabad as Principal for three years. He retired as Principal from Islamabad College for Boys (ICB G-6/3). On the occasion of the Silver Jubilee celebrations of I.C.B, G-6/3 he was declared the best teacher in chemistry and awarded a gold medal.

His rich experience in teaching chemistry has enabled him to serve as member, National Review Committee from 2002-2006 for finalizing text-book manuscripts in the subject of chemistry for Secondary and Higher Secondary classes, developed by various Textbook Boards. He is Managing / Co-Author of several text books.

About Authors

PROF. MRS. SHAHNAZ RASHID

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Along with teaching, she has been contributing lot extensively to the promotion of Chemistry. She has translated Textbook of Chemistry from English to Urdu for class XI, for the National Language Authority. She has also co-authored the Textbook of Chemistry for class XII for Allama Iqbal Open University, Islamabad. Besides this she has been involved in writing, editing, and comparing Television programs of Chemistry for Secondary classes.

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