14

Chemical and Nuclear Energy

You have studied in the previous lessons that energy is an essential part of our life. We all require energy in our daily life in the form of food, fuel, electricity etc. It is also needed for cooking food, running the transport system and industries. The conventional energy sources such as coal, petroleum and natural gas are being increasingly used. But we have only limited resources of conventional sources of energy (coal, petroleum, etc.) and they are depleting at a very fast rate. Therefore, scientists all over the world are trying to develop alternate sources of energy. Of the various sources of energy that would serve as alternative to conventional sources, the main sources are nuclear and solar energies. The most common forms of energy are heat, light and electricity. Other forms of energy are chemical and nuclear energy.

In this lesson we shall study in detail about chemical and nuclear energies and their various sources. We will also study about the process of combustion and the conditions necessary for it. This knowledge is useful in finding ways and means of controlling fire which some times proves to be destructive and dangerous. We will also study the types of fuels, change of chemical energy into electrical energy, and about nuclear energy.

OBJECTIVES

After completing this lesson, you will be able to :

- differentiate between chemical and nuclear energy;
- define various fossil fuels, such as coal, petroleum, biomass;
- list the important compounds of petroleum and their uses;
- define combustion and calorific value of fuel and solve problems related to calorific value;
- state the conditions necessary for combustion and describe the functioning of soda-acid fire extinguisher;
- highlight the importance of food as body fuel;
- explain the functioning of voltaic cell, its weaknesses and necessary modifications;
- explain the terms radioactivity, radioisotopes, fission and fusion;
- describe the functioning of nuclear reactor and generation of electricity therefrom;
- compare nuclear power plant with a thermal power plant;
- list some uses of nuclear energy and hazards involved in its production.

14.1 CHEMICAL ENERGY

You must have noticed that at the time of whitewashing, when water is added to quick lime, there is loud hissing sound, and the mixture almost starts boiling.

Do you know why does this happen? In this case, a chemical reaction between quick lime (CaO) and water (H_2O) takes place in which large amount of heat is liberated as follows:

$$CaO + H_2O \longrightarrow Ca(OH)_2 + \text{Heat liberated}$$

This means, there must be some stored energy in the chemicals involved in the reactions, which comes out as heat. This energy is **chemical energy**. Thus, *chemical energy is that form of energy, which the substances have by virtue of their composition and nature*. Chemical energy becomes apparent during chemical reactions when chemical energy of a substance changes into other forms such as heat, light and electricity, etc.

We shall now consider those reactions where chemical energy is converted into heat energy or *vice versa*. Such reactions are called **thermochemical reactions**. These reactions can be divided into two types – **exothermic reactions** and **endothermic reactions**.

14.1.1 Exothermic reactions

You know that burning of coal gives out large amount of heat.

The reaction can be represented as:

$$C + O_2 \longrightarrow CO_2 + \text{Heat}$$

Such chemical reactions in which heat is given out are called **exothermic reactions**.

ACTIVITY 14.1

Aim : Heat change in chemical reactions

What to do?

Take a small amount of baking soda in a test tube. Add a few drops of vinegar or lemon juice to it.

What do you observe?

You will observe that a brisk effervescence takes place and a colourless gas is evolved? Touch the bottom of the test tube. What do you feel? Does the test tube become hot? You will find that the test tube becomes hot. This shows that heat is evolved during this reaction. Hence, it is an exothermic reaction.

Similarly, addition of water to quick lime is also an exothermic reaction. Can you think of some other examples of exothermic reactions?

14.1.2 Endothermic reactions

You must have noticed that evaporation of water on a hot day is faster. Here the following transformation takes place.

$$H_2O(l) + \text{Heat} \longrightarrow H_2O(g)$$

Such reactions where heat is absorbed are called endothermic reactions.

Similarly, the decomposition of mercuric oxide (HgO) is also an endothermic reaction.

$$2HgO + Heat \longrightarrow Hg(l) + O_2(g)$$

CHECK YOUR PROGRESS 14.1

1. When carbon is burnt in the presence of oxygen what type of energy is evolved?
2. When Uranium-235 is bombarded with neutrons which type of energy will be evolved?
3. The amount of energy liberated in a chemical reaction is large or small?
4. The ability to do work is known as ____________

14.2 FUELS

You know that for cooking food we require heat energy that we get by burning wood, coal, kerosene, or liquid petroleum gas (LPG). To run vehicles we need petrol or diesel. All these provide substances that generate energy are known as **fuel**.

Fuels are chemicals, which react with an oxidizing agent. Usually the oxidizing agent is oxygen itself. Energy is released during the reaction and new chemicals are formed. *Any substance, which reacts with oxygen, or other oxidizing agent, could be used as fuel.* The best known fuels include petrol, diesel, coal and natural gas. All these fuels burn in the presence of oxygen.

Scientists have developed other fuels for special purposes. For example, a chemical called hydrazine is used as a rocket fuel. It is not burnt in oxygen, but it is oxidized by concentrated nitric acid. Other examples are the splitting of uranium in nuclear fuel reactors and the conversion of chemical energy into electrical energy in electrochemical cells. The over all changes, which take place when a fuel burns, are shown below:

$$\begin{array}{c} \text{Fuel} \\ + \\ \text{Oxidizer} \\ \text{(such as oxygen)} \end{array} \xrightarrow[\text{(burning)}]{\text{reaction}} \begin{array}{c} \text{Useful energy released} \\ + \\ \text{Chemical products} \end{array}$$

But, you should remember that every chemical, which burns is not necessarily a good fuel. The fuel must release plenty of energy when it is burnt. But there are many other important points to be considered. For most people it is probably convenience and cost that seem to be important. We prefer fuels which are safe to use and which do not produce unpleasant gases and smoke when they burn.

14.2.1 Classification of fuels

On the basis of physical states the fuels are classified into three categories:

a) **Solid:** coke, coal, wood and charcoal

b) **Liquid:** petrol, alcohol, diesel and kerosene

c) **Gas:** liquefied petroleum gas (LPG), coal gas and petrol gas

Liquid and gaseous fuels are better, as compared to solid fuels because:

- these can flow through pipes,
- can be lighted at a moment's notice,
- no ash is left,
- have high heat content, and
- their supply and distribution is easier.

14.2.2 Fossil fuels

Coal and petroleum are major fuels that are being used in large amount at present. These are known as **fossil fuels.** *The fossil fuels are carbon-containing substances that were formed from the remains of the marine organisms that lived millions of years ago, under the influence of high temperature and pressure in the interior of earth.* We have limited amount of fossil fuels. According to some estimates we would run out of fossil fuels before the middle of the twenty first century. *Fossil fuels are therefore, called depeletable or non-renewable source of energy.*

In this subsection, we will learn about the types of fossil fuels. The fossil fuels can be divided into two categories – coal and petroleum.

a) Coal

Coal may be defined as a sedimentary rock that burns. Coal deposits were formed long ago by decomposition of plant matter buried under the ground. It is a complex mixture of compounds of carbon, hydrogen and oxygen and some free carbon. It also contains small quantity of nitrogen and sulphur. Coal is important because it can also be used as a source of other fuels like coal gas and synthetic petrol.

Table 14.1 : Types of coal

Type	Carbon content
Anthracite	90%
Bituminous	80%
Lignite	70%
Peat	60%

We know that wood is the starting material for coal. Depending on the extent of carbonization, we get different varieties of coal. These forms are different in carbon contents as listed in Table 14.1.

When coal is heated strongly to a temperature of about 1273K to 1373K, in the absence of air, it decomposes into coal gas, coke, ammoniacal liquor and coal tar. This process is known as **destructive distillation**. Let us study more about these components of coal.

i) **Coal gas:** One of the most promising methods for making coal more efficient and cleaner fuel involves the conversion of coal to a gaseous form, i.e. coal gas. This process is called **coal gasification**. *Coal gas is a mixture of hydrogen, methane and carbon monoxide*. All the gases present in coal gas can burn to provide heat. Due to this, coal gas is an excellent fuel having high calorific value. It is used as a cooking gas. In the past it was used as illuminant also for lightning homes, factories and streets.

ii) **Coke:** It is used as a reducing agent in blast furnaces to extract iron from its ores. It is also used as a source of carbon in the chemical industry and as a fuel.

iii) **Ammoniacal liquor:** It is converted into ammonium sulphate by absorbing in dilute sulphuric acid. The ammonium sulphate is used as a fertilizer.

iv) **Coal tar:** It was earlier considered to be a nuisance. Even its disposal was a problem. Subsequently, it was used for surfacing roads. It has now been found to be a rich source of aromatic hydrocarbons.

b) Petroleum

The name petroleum means rock oil (*petra*: rocks; *oleum*: oil). It is called petroleum because it is found in the crust of earth trapped in rocks. It is used to describe a broad range of fossil hydrocarbons that are found as gasses, liquids and solids beneath the earth surface. *The two common forms of petroleum are crude oil and natural gas.*

i) **Crude oil:** It is a complex mixture of alkane hydrocarbons with water and earth particles. The final stage of refining involves the removal of impurities such as sulphur compounds. When a fuel containing sulphur is burnt, the sulphur in it turns into sulphur dioxide, an acidic gas. So it is to be purified or refined before it can be used for specific purposes. The process of separating crude petroleum oil into more useful fractions is called **refining**. The refining of petrol is done by the process of fractional distillation.

Refining is needed to make sure that all the oil is turned into useful products. Cracking also occurs during the refining process of petroleum. The *process of breaking bigger hydrocarbon molecules into smaller hydrocarbons molecules by heating in the presence of a catalyst is called **cracking***.

The refining of petroleum or separation of petroleum into different components is based on the fact that the different compounds of crude oil have different boiling points ranges. The fraction of petroleum having highest boiling point range is collected in the lowest part of the fractionating tower (Fig. 14.1). The fraction having lowest boiling point range is collected in the topmost part of the tower. Such a process of separation of different fractions of petroleum from crude oil is called *fractional distillation*. The various fractions obtained by the fractional distillation of crude petroleum oil and their uses are given in Table 14.2.

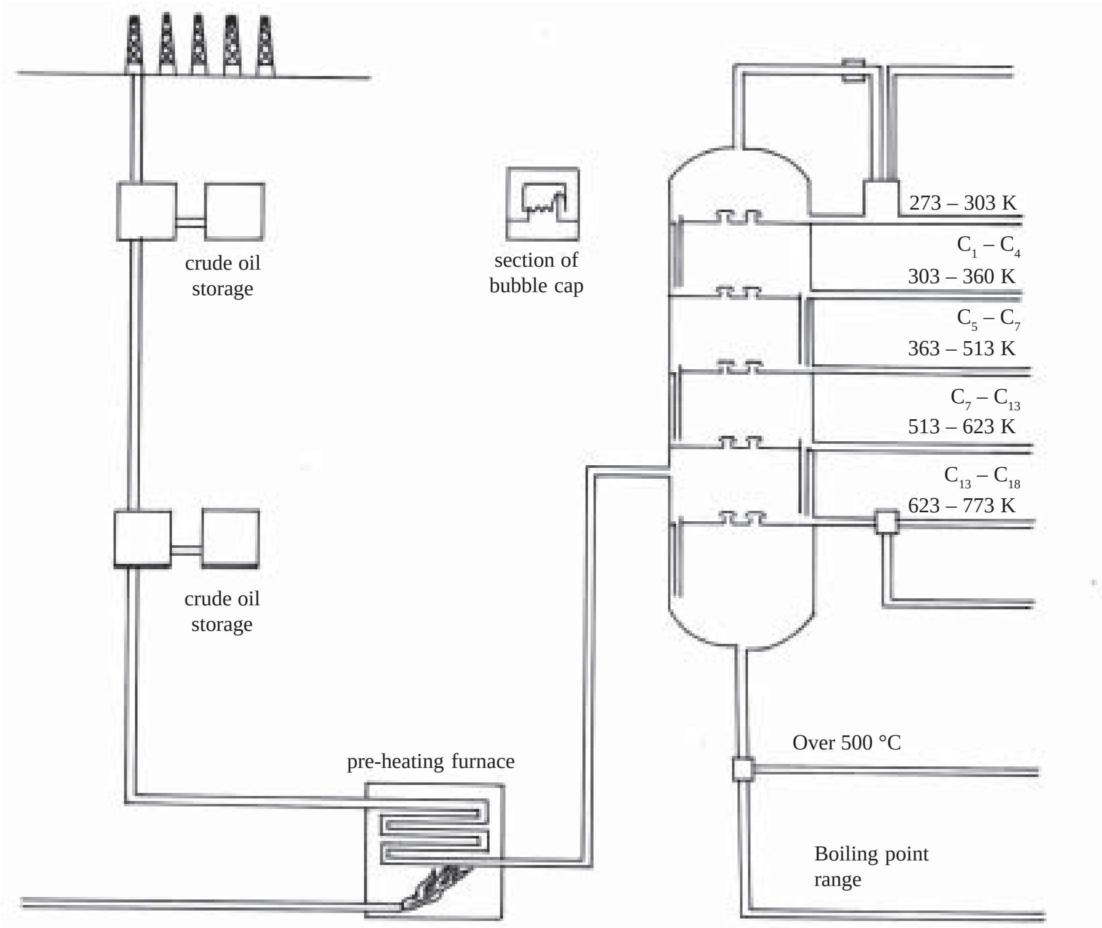


Fig. 14.1 Fractionating tower

Table 14.2 : Fractions obtained by fractional distillation of petroleum

Fraction	Approximate composition	Boiling range	Uses
Gaseous hydrocarbons	C_1-C_4	Up to 303K	As fuel gas after liquefaction, as carbon black.
Crude naphtha			
Petroleum ether	C_5-C_7	303-363K	As solvent in varnish and rubber industries, for dry cleaning
Petrol/gasoline	C_7-C_9	363-393K	As motor fuel, for dry cleaning
Benzene	C_9-C_{10}	393-423K	For dry cleaning
Kerosene oil	C_{10}-C_{13}	423-513K	Fuel for stoves, manufacture of oil gas, as an illuminant
Fuel oil Gas oil Diesel oil Furnace oil	C_{13}-C_{18}	513-623K	Fuel for diesel engine and tractors, cracking stock for gasoline
Lubricant oil Medicinal oil Motor oil Grease	C_{15}-C_{18}	Above 543K	Paint oil, transformer oil, for lubrication etc.
Paraffin wax Petroleum jelly Petroleum wax Petroleum coke	C_{18}-C_{30}	673K Upward	Ointments, candles, paraffin wax, for matches, paints, water proofing, as solid fuel, protecting paints
Heavy fuel oil and bitumen	C_{30} onward	Forms residue	Paints, road surfacing

(ii) Natural gas: Natural gas is a mixture of lightweight alkanes. The composition of natural gas depends upon the source, but a typical sample contains 80% methane, 7% ethane, 6% propane and 4% butane. Natural gas occurs deep under the crust of the earth alone or along with the petroleum deposits. Therefore, some wells dug into the earth produce only natural gas, whereas others produce natural gas as well as petroleum. In the later case, natural gas is a byproduct of petroleum. The propane and butane separated from the natural gas are usually liquefied under pressure and called as liquefied petroleum gas (LPG). It is used as domestic and industrial fuel. Compressed Natural Gas (CNG) is also used as fuel for transport as well as in industries.

CHECK YOUR PROGRESS 14.2

1. Name any two constituents of coal gas.
2. Write two examples of fossil fuels that you use in your daily life.

3. What are two main varieties of coal?
4. The boiling point of water, methyl alcohol and kerosene are 373K, 313K and 543K, respectively. If a mixture of these three liquids is separated by fractional distillation column, which component of the mixture will be collected near the bottom of the column?
5. Name any two products of the petroleum.
6. State any two uses of petroleum products.
7. Name any one hydrocarbon fraction obtained during fractional distillation of petroleum which is used as domestic fuel.

14.3 COMBUSTION

You would have seen that when coal is burnt in an *angithi* or *chulah*, it turns red hot. After some time when the *chulah* cools down, we find no coal but the ash is left. What has happened to the coal?

On burning, coal changes into carbon dioxide and ash. Hence, on burning, the composition of a substance changes, i.e. the substance changes into other substances. This is called **combustion**. Combustion may be defined *as a chemical change in the presence of oxygen in which both heat and light are produced at the same time and the composition of substance changes.*

Burning of coal, paper, candle and hydrocarbon are the examples of combustion. Chemical equations of some combustion reactions are given below:

$$C(s) + O_2(g) \xrightarrow{\text{combustion}} CO_2(g) + \text{heat} + \text{light}$$

$$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(l) + \text{heat} + \text{light}$$

It may be noted that during combustion certain chemical change should occur. If no chemical change occurs in the reaction but heat and light are produced, that reaction will not be combustion. For example, when we switch on an electric bulb it starts glowing. We get light from it. If we touch, we find that glowing bulb also produces heat. Do you think that glowing of electric bulb is a case of combustion?

No, glowing of bulb is not combustion because no chemical change occurs, i.e. no new substance is formed.

14.3.1 Conditions for combustion

Let us look at some of our day to day experiences and find out the conditions that are necessary for combustion. If we bring a burning matchstick near paper, kerosene, petrol or alcohol, they immediately catch fire and start burning, but in case of the substances like glass and stone no change is observed. Such substances that can burn are called **combustible substances**. For example, petrol, kerosene, alcohol, etc. Substances that do not burn are called **non-combustible substances**. For example, stone and glass.

Hence, we can say that *for combustion a combustible substance is required.*

We know that air contains oxygen, which is a good supporter of combustion. When we cover burning coal with vessel the supply of air is cut off, hence, the coal fire stops. We know that in *chulahs* used in the villages for cooking food, gaps are left between the logs of wood. These gaps are left for the air to enter the *chulah*. Thus, a *good supply of oxygen is necessary for burning.*

Often we find that in order to light up a pressure stove, a burning matchstick is kept for some time over the kerosene oil taken in a cup round the burner and the oil starts burning.

Let us perform an activity to prove that air is necessary for burning.

ACTIVITY 14.2

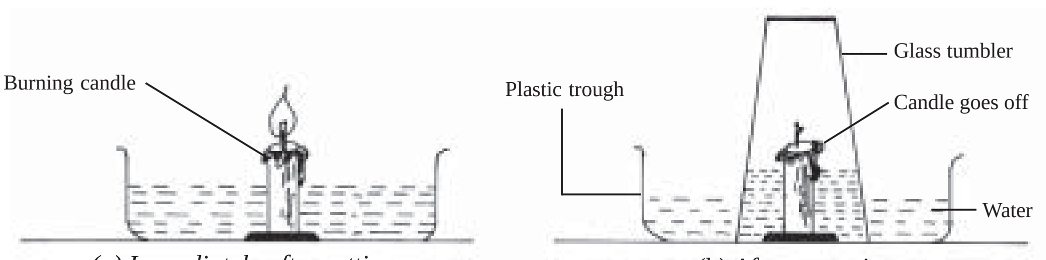
Aim : Air is necessary for burning

What is required?

A plastic trough, water, a candle, a glass tumbler, match box

What to do?

Take a candle about 8 cm long and fix it in a plastic trough. Pour water in the trough as shown in Fig. 14.2 a. Light the candle. Invert the glass tumbler over the candle.



(a) Immediately after setting up *(b) After some time*

Fig. 14.2 To show that air is necessary for burning

What do you observe?

You will see that candle continues burning for a few seconds. The flame then starts flickering and finally goes off (Fig. 14.2 b).

Why does this happen?

It is because no fresh air enters in the glass tumbler to support combustion. Thus, the activity clearly proves that air is necessary for combustion.

It is also seen that to burn coal in an *angithi* sufficient amount of heat is supplied by burning waste paper or cloth soaked in kerosene oil. Why is it so?

Whenever a substance is heated, its temperature increases till it become equal to a temperature, at which the substance starts burning. This temperature is called the **ignition temperature**. A substance cannot catch fire or burn as long as its temperature is lower than its ignition temperature. *The ignition temperature is the lowest temperature at which a substance catches fire and starts burning*.

The ignition temperatures of different substances are different. Lower the value of ignition temperature of a substance, lesser the amount of heat required to burn it.

The ignition temperature of kerosene is higher than that of petrol. So petrol catches fire immediately whereas kerosene requires more heat to start burn. Similarly the ignition temperature of coal is very high. It requires more heat to start burning.

Can you give reasons as to why a matchstick does not catch fire on its own?

Room temperature is much lower than the ignition temperature of matchstick therefore, it does not catch fire. On rubbing of matchstick against the side of the box, heat is produced due to friction. This heat raises the temperature of chemicals present on the matchstick head to its ignition temperature. Thus, the matchstick starts burning.

Hence, we find that a substance can not catch fire or burn as long as its temperature is lower than its ignition temperature. Here is a simple activity which prove that ignition temperature is necessary for combustion

ACTIVITY 14.3

Aim : Ignition temperature is necessary for combustion

What is required?

A paper cup, water and a spirit lamp

What to do?

Take a paper cup, pour water in the cup. Heat the paper cup.

What do you observe?

You will see that we *can boil the water in a paper cup without burning the paper.*

Why is it so?

It can be explained on the basis of ignition temperature of paper cup. When we heat water in a cup, the heat supplied to the paper cup is quickly transferred from the paper cup to the water, the temperature of paper cup does not reach its ignition temperature, and hence it does not burn.

Now we can say that three conditions are necessary for combustion:

- presence of a combustible substance (that burns easily e.g. fuel),
- presence of supporter of combustion (oxygen from air), and
- attainment of ignition temperature i.e. heating.

Unless all of these three conditions are fulfilled, combustion cannot take place.

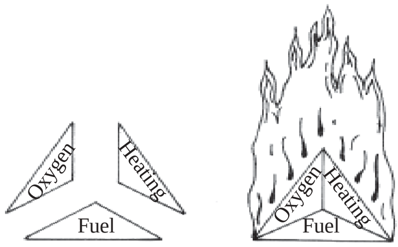


Fig. 14.3 The fire triangle

CHECK YOUR PROGRESS 14.3

1. Why does the coke not burn in air at room temperature?
2. It is said that oxygen is essential for burning. From where does this oxygen come?
3. State any one condition necessary for combustion.
4. Petrol catches fire immediately whereas kerosene does not why?

14.4 FIRE EXTINGUISHERS

We know that fire is very useful in our day to day life. However, some times it proves to be destructive, especially when it becomes uncontrollable. Therefore, it is necessary to learn the ways and means of controlling fire.

As you are aware that small fire can be extinguished by covering it with a lid. For example, coal fire or fire in frying pan is extinguished by covering it with a lid. Similarly, you would have seen that when a person catches fire than we cover him with a thick blanket and make him to roll on the ground. We often see that whenever fire spreads over a vast area, pouring water or sand puts it off. How is the fire put off by covering or pouring the water?

As you have learnt one condition of supporting combustion is air (oxygen). If we cut off the supply of air by covering fire with lid, the fire is extinguished.

The apparatus used to extinguish fire is called *fire extinguisher*. You would have seen fire extinguishers in petrol pumps, big buildings, cinema halls and other public places.

14.4.1 Principle of fire extinguisher

The principle of working of fire extinguisher is based on either of the following three conditions:

- cooling the combustible material below its ignition temperature, or
- cutting off the supply of air, or
- cooling the combustible material and at the same time cutting the supply of air.

The different types of fire extinguishers, their working principle and the nature of fire for which they are used are listed in Table 14.3.

Table 14.3 : Working principle and uses of different types of fire extinguishers

Type of fire extinguisher	Working principle	Nature of fire for which used
Dry powder extinguisher (sand and baking soda)	Cuts off supply of air	All types of fire
Baking soda sulphuric acid extinguisher (soda acid)	Cuts off supply of air	All types of fire except due to electrical and inflammable liquids
Foam type extinguisher	Cuts off supply of air	Fire due to inflammable liquids
Water	Cools the substance below the ignition temperature	All types except due to electricity and oil
Carbon tetrachloride extinguisher	Cuts off supply of air	Fire due to electricity

14.4.2 Soda acid fire extinguisher

The most common fire extinguisher is soda acid. The carbon dioxide is liberated by the action of acid on baking soda. It increases the percentage of carbon dioxide in air (CO_2 is non supporter of combustion). How does this happen?

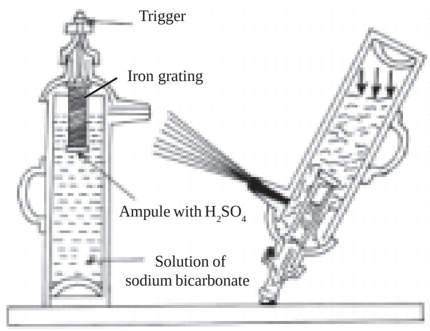


Fig. 14.4 Soda acid fire extinguisher

This type of fire extinguisher contains a bottle of sulphuric acid supported by a metallic container filled with a baking soda solution (Fig. 14.3). When the cylinder is inverted and knob struck, against the ground, the acid bottle breaks and the acid comes in the contact with the backing soda.

$$\underset{\text{baking soda}}{2NaHCO_3} + \underset{\text{sulphuric acid}}{H_2SO_4} \longrightarrow \underset{\text{sodium sulphate}}{Na_2SO_4} + \underset{\text{water}}{2H_2O} + \underset{\text{carbon dioxide}}{2CO_2}$$

As a result carbon dioxide is liberated. This increases the percentage of carbon dioxide in air. Due to this the supply of air is cut off and there, fire is extinguished. These types of extinguishers are used in cinema halls, multistorey buildings, etc.

CHECK YOUR PROGRESS 14.4

1. Name the chemicals present in a soda acid fire extinguisher.
2. Why is fire of frying pan extinguished, when it is covered with lid?
3. If fire is due to the electricity, can we use to water as fire extinguisher?
4. Name the gas evolved in soda-acid fire extinguisher.
5. Give any one condition on which principle and working of fire extinguisher is based.

14.5 BIOFUELS

The organic waste, such as wood, agricultural residues and cattle dung, are called biomass. Biomass contains carbon compounds and it is the oldest source of heat energy for domestic purposes.

Biofuels, such as firewood, dung cakes and agricultural wastes, constitute main source of energy in rural areas. A cause of concern in recent years has been the excessive consumption of firewood, which is not sustainable for long at present level of consumption. Deforestation and desertification are taking place, adversely affecting the ecology. Secondly, the age-old practice of burning dung cakes and agricultural wastes is depriving the lands of much needed humus and consequently causing loss of soil fertility. Moreover, inefficient burning of biofuels in traditional chulhas causes air pollution.

14.5.1 Smokeless chulah

In order to overcome the problems of lower energy and smoke hazards of conventional chulahs, smokeless chulahs designed scientifically are now available for use. These chulahs are designed in such a way that less amount of heat is lost to the surroundings. Thus, these chulah consume less fuels and hence, more efficient than the conventional chulahs. These are provided with a tall chimney, which help the smoke to escape into the upper atmosphere.

14.5.2 Biomass as fuel

Biomass can be used as fuel in two ways:

- By burning dry biomass like wood and cattle dung directly to produce heat.
- By converting biomass into more useful fuels, for example, wood can be converted into charcoal, which is a better fuel as compare to coal. Similarly cattle dung can be converted into biogas, which is better fuel than cattle dung.

14.6 CALORIFIC VALUE (FUEL VALUE) OF FUELS

You know heat is produced on burning of fuels. Different, fuels on burning produce different amount of heat. Various fuels have different composition and hence, different energy contents. The usefulness of the fuels is measured in terms of Calorific values. Higher the calorific value, better is the fuel.

Calorific value may be *defined as the amount of heat liberated by the complete combustion of a unit mass of fuel.* The unit of mass usually taken, for measuring the calorific value of fuel, is gram. Therefore, calorific value may be defined as the amount of heat produced by burning completely one gram of fuel. For example, by burning of one gram carbon (charcoal) produces 8137 calories of heat (or 34013 joules). Therefore, calorific value of carbon is 34013 Jg^{-1}. The calorific value is expressed in kilojoule/gram ($kJ\ g^{-1}$) because Joule is very small unit of energy. So the calorific value of carbon is 34 $kJ\ g^{-1}$.

Table 14.4 : Calorific value of some fuels

Type of fuel	Calorific value
Wood	18 $kJ\ g^{-1}$
Charcoal	35 $kJ\ g^{-1}$
Dung cake	8 $kJ\ g^{-1}$
Coal	30 $kJ\ g^{-1}$
Gasoline	34 $kJ\ g^{-1}$
Kerosene	37 $kJ\ g^{-1}$
Natural gas	50 $kJ\ g^{-1}$
Petrol	50 $kJ\ g^{-1}$
Biogas	40 $kJ\ g^{-1}$
L.P.G	50 $kJ\ g^{-1}$
Methane	55 $kJ\ g^{-1}$
Hydrogen gas	150 $kJ\ g^{-1}$

$$1\ \text{cal} = 4.18\ \text{J}$$
$$1000\ \text{J} = 1\ \text{kJ}$$

Calorific value of some fuels is listed in table 14.4.

From table 14.4 we know that the calorific value of petrol is 50 $kJ\ g^{-1}$. This means that if one gram of petrol is burnt completely, then it will produce 50 kiloJoule of heat energy.

a) **Hydrogen as fuel:** Why hydrogen is not commonly used as a fuel even though its calorific value is high. Hydrogen gas has highest calorific value, but it is not used commonly as a domestic or industrial fuel. There are two problems in using hydrogen as a fuel. Firstly, its handling is difficult and secondly, it burns with an explosion.

b) **Hydrocarbons as fuels:** Hydrocarbons contain carbon and hydrogen and are used as fuels. Since hydrogen has the highest calorific value therefore, the fuel containing higher percentage of hydrogen will have a higher calorific value than that which have a lower percentage of hydrogen in it. The calorific value of methane (CH_4) is higher than that of butane (C_4H_{10}) because percentage of hydrogen in CH_4 (25%) is higher than that in C_4H_{10} (17%). The calorific value of CH_4 is 55 $kJ\ g^{-1}$ whereas for butane it is 50 $kJ\ g^{-1}$.

c) **Wood as fuel:** Cellulose, i.e. $(C_6H_{10}O_5)_n$ is the chief constituent of wood. The percentage of oxygen in wood is quite high. The oxygen supports the combustion but does not produce heat. Therefore, wood has lower calorific value.

Out of CH_4, C_2H_6 and $C_{12}H_{22}O_{11}$, the lowest calorific value is of sugar $C_{12}H_{22}O_{11}$ because it has lower percentage of hydrogen due to the presence of oxygen. Whereas, out of CH_4, C_2H_6, C_3H_8 and H_2 the lowest calorific value is of C_3H_8 because it has lower percentage of hydrogen.

In compound A, each carbon in a molecule is bonded with three hydrogen atoms. In the molecule of another compound B, each carbon atom is bonded with one hydrogen and one oxygen atom. Can you tell which compound will have higher calorific value? Compound A will have higher calorific value because of more percentage of hydrogen.

Example 14.1 : Calorific value of LPG is 55k Jg^{-1}. Calculate the energy consumed by a family in one month if it required a cylinder containing 14.5 kg of LPG.

Solution: The calorific value of LPG is 55 k Jg^{-1}. It means one gram of LPG on burning will produce 55 kJ heat energy.

1 kg = 1000 g and 14.5 kg = 1000 x 14.5 = 14500 g

Heat energy produced by 1 g LPG = 55 kJ

So, 14500 g LPG will produce heat energy = 55 x 14500 = 797500 kJ

14.6.1 Food as fuel

We have already discussed the types of fuel required for cooking food, transport and industry. Energy is also necessary for our body to carry on the various life processes. The food, which we eat, is a kind of fuel for our body that supplies us the energy.

The food that we eat is broken down into smaller molecules of glucose during digestion. Glucose so formed is absorbed in the blood and taken to the cells throughout our body. When we breathe in air, then oxygen of the air is also absorbed by the blood and carried to all cells. This oxygen to produce CO_2 and H_2O oxidizes the glucose $C_6H_{12}O_6$ slowly and gives us energy.

When energy is released from food, some of it is transferred to a special molecule found in cells called **ATP*** (adenosine triphosphate). Thus, ATP is the energy-storing molecule in the body. To release energy ATP is converted into **ADP** (adenosine diphosphate).

$$ATP \longrightarrow ADP + phosphate + energy$$

Calorific value of some foods is given below Table 14.5.

Table 14.5 : Calorific value of some foods

Type of food	Calorific value
Carbohydrate	17 kJ g^{-1}
Fat	39 kJ g^{-1}
Protein	18 kJ g^{-1}
Apples	2.5 kJ g^{-1}
Curd	2.5 kJ g^{-1}
Bread	1.8 kJ g^{-1}
Cheese	12 kJ g^{-1}
Milk	20 kJ g^{-1}
Egg	3 kJ g^{-1}
Wheat	6.0 kJ g^{-1}
Meat	12 kJ g^{-1}
Butter	34 kJ g^{-1}
Honey	13.3 kJ g^{-1}
Hamburger	15 kJ g^{-1}
Peanuts	23 kJ g^{-1}
Potato	3 kJ g^{-1}

CHECK YOUR PROGRESS 14.5

1. Which of the following fuels has lowest calorific value?
   C_2H_6, C_2H_5OH, C_2H_4, H_2
2. Which of the following fuels has highest calorific value?
   C_2H_6, C_2H_5OH, C_2H_4, H_2
3. Hydrogen compounds are abundantly available on earth and it has a high calorific value but why this gas is not commonly used as a domestic fuel?
4. Why do the fuels like wood and alcohol have lower calorific values as compared to LPG and biogas?

*You will learn more about ATP and ADP in lesson 24 of this course.

5. How do we get energy in our body from the food?
6. Which food has higher calorific value – carbohydrate, egg, butter, peanuts and curd?

14.7 VOLTAIC AND DRY CELLS

Now we will learn about electrochemical cells. You know that cars and other automobiles are started with the help of battery. We use cells in torches, transistors and watches etc. The chemicals present in cell and batteries react to generate the electric current. The device used to generate electricity through chemical reaction is called an electrochemical cell. Let us learn about some of the commonly used electrochemical cells.

14.7.1 Voltaic cell

The first electrochemical cell was constructed by Volta in 1796. It is called **Voltaic cell**. In this cell, a strip of zinc is placed in zinc sulphate solution and a copper strip is placed in copper sulphate solution. Both the solutions are separated by a porous partition which allows the ions to pass through it, but does not allow the mixing of the two solutions. The zinc plate acts as an anode (negative electrode), while copper plate acts as cathode (positive electrode).

It is to be kept in mind that the signs of the electrodes in an electrochemical cell are opposite to that of an electrolytic cell.

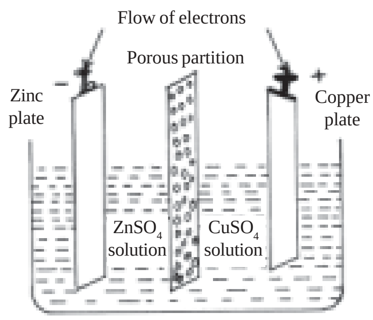


Fig. 14.5 (a) Voltaic cell

Working of a voltaic cell

When both the electrode terminals are connected by a wire then there is a flow of electrons (electric current) from zinc to copper terminal (Fig. 14.4).

Zinc metal is more reactive than copper, so it has a greater tendency to lose electron.

$$Zn \longrightarrow Zn^{2+} + 2e^- \text{ (Oxidation)}$$

These electrons flow through the wire to the copper cathode. The reaction that occurs at the copper cathode is

$$Cu^{2+} + 2\,e^- \longrightarrow Cu \text{ (Reduction)}$$

14.7.2 Daniel cell

An improvement over the voltaic cell was **Daniel cell**. Here, the zinc sulphate solution is kept in a porous pot that is suspended in a solution of copper sulphate in a copper vessel. This cell gives a more steady current. The voltage of cell is 1.1 volt.

14.7.3 Dry cell

The cell used in torch and transistor etc is called dry cell. The most common dry cell, that is, the **Leclanche cell**, is used in flashlight and transistor radios. The anode of the dry cell consists of zinc container which is in contact with manganese dioxide (MnO_2) and an electrolyte. The electrolyte consists of ammonium chloride and zinc chloride in water to which starch is added to thicken the solution to a paste like consistency so that it is less likely to leak (Fig. 14.6). A carbon rod serves as cathode, which is immersed in the electrolyte in the centre of cell.

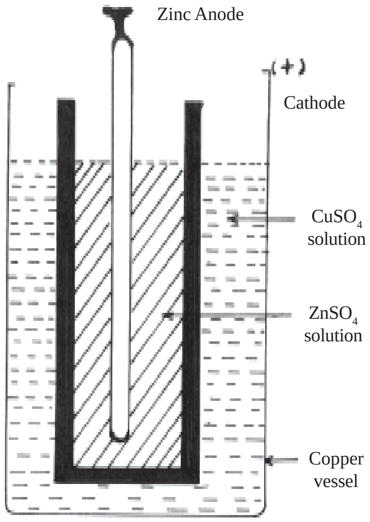


Fig. 14.5 (b) Daniel cell

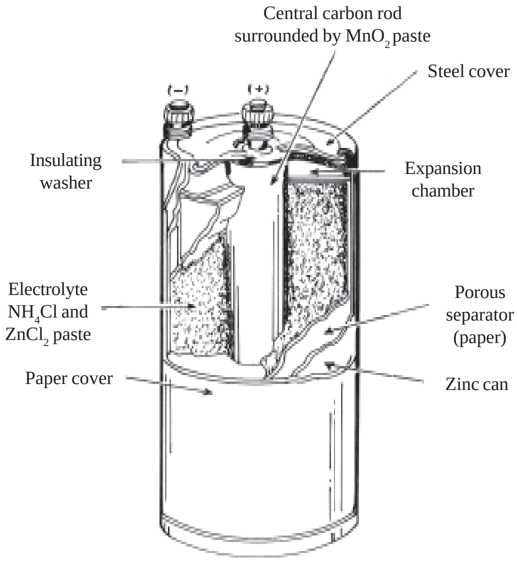


Fig. 14.6 Construction of a dry cell

The cell reactions are:

Anode : $Zn(s) \longrightarrow Zn^{2+}(aq) + 2e^-$

Cathode : $2NH_4^+(aq) + 2MnO_2(s) + 2e^- \longrightarrow Mn_2O_3(s) + 2NH_3(aq) + H_2O(l)$

Overall : $Zn(s) + 2NH_4^+(aq) + 2MnO_2(s) \longrightarrow Zn^{2+}(aq) + 2NH_3(aq) + H_2O(l) + Mn_2O_3(s)$

Actually this equation is over simplification of the complete process. The voltage produced by dry cell is about 1.5V.

CHECK YOUR PROGRESS 14.6

1. Name the materials used to make the electrodes of a voltaic cell.
2. At which electrode in a cell does reduction take place?
3. At which electrode in a cell does oxidation take place?
4. The conversion of Zn to Zn^{2+} is oxidation or reduction?
5. In which cell does chemical energy change into electrical energy – electrochemical cell or electrolytic cell?
6. Dry cell is also known as _______________
7. Name the materials used to make cathode of a dry cell.
8. Name the electrolytes used in dry cell.
9. How much voltage is produced in dry cell?
10. What precaution is adopted to prevent over mixing of the solutions of electrolytes?

14.8 NUCLEAR ENERGY – ENERGY FROM THE ATOM

You have seen that chemical reactions are accompanied by energy changes. In a chemical reaction, the composition of the nucleus of an atom does not change. But there are some reactions in which the composition of the nucleus of an atom changes. Such reactions are called nuclear reactions and the energy released during such reaction is known as **nuclear energy**. To understand the difference between chemical and nuclear energy, study the following table (14.6).

Table 14.6 : Differences between chemical and nuclear energy

Chemical energy	Nuclear energy
Chemical energy is released or absorbed due to the influence in the bond energies of the bonds in the reactants and products.	Nuclear energy is released due to the change in the composition of the nucleus of an atom.
Chemical energy is obtained when a chemical reaction takes place.	Nuclear energy is obtained when nuclear changes take place.
The amount of energy evolved is very small.	The amount of energy evolved is very large.
No harmful radiation is emitted.	Radiation emitted during nuclear changes is harmful.

Energy stored in the nucleus of an atom is known as nuclear energy. In a nuclear reaction, when the nucleus of an atom is bombarded with neutrons, it undergoes a change to form smaller fragments of new atoms. In this process, a tremendous amount of energy is evolved in the form of heat. For example, when Uranium-235 nucleus is bombarded with neutrons, it splits into two smaller nuclei and a large amount of energy is released in the form of heat.

14.8.1 Radioactivity

It has been observed that the atoms of some elements, such as radium and uranium, *spontaneously emit radiations*. Such a process is called **radioactivity**. It is a spontaneous process in which the nucleus of the atom disintegrates and the energy bearing particles or rays are emitted. *Radioactivity is a spontaneous process of disintegration or breaking up of the nucleus of an atom accompanied by the emission of energy bearing particles or rays.*

The materials which give off energy bearing rays or particles or both are called **radioactive materials.** The three main types of radiations emitted are: Alpha particles, Beta particles, Gamma rays

The characteristics and the properties of these radiations are given in Table 14.7.

Table 14.7: Characteristics of various types of radiations/particles

Characteristics and properties	Rays of alpha particles	Rays of beta particles	Gamma rays
Nature	Each particle consists of 2 protons and 2 neutrons, i.e. they are doubly-charged helium ions.	They are electrons	Electromagnetic waves similar to X-rays
Charge	Positive	Negative	No charge
Penetrating effect	Stopped by thick sheet of paper or skin	Stopped by a few millimeters thick sheet of aluminium	Not stopped
Ionization effect	High ionization power	Medium ionization power	Weak ionization power

Apart from the above properties, all three types of radioactive radiation can

(a) affect photographic plate,

(b) cause fluorescent materials like ZnS to glow,

(c) have pronounced physiological effects like

- power to kill plants seeds and human tissues,
- cause cancerous growths,
- destroy bacteria,
- can cure skin cancer and other diseases if used in controlled quantities.

14.8.2 Nuclear fission

The splitting of the nucleus of an atom into fragments that are roughly equal in mass along with the release of energy is called nuclear fission.

When a neutron strikes the nucleus of a uranium atom at an appropriate speed, it gets absorbed. Uranium nucleus on absorbing a neutron becomes highly unstable and splits into smaller atoms releasing huge amount of energy in the process.

$$^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3\,^{1}_{0}n + \text{energy}$$

During this process three neutrons are also released. These neutrons split other nuclei of the uranium. The reaction continues rapidly and is known as chain reaction (Fig. 14.7). A great deal of heat is produced in this reaction.

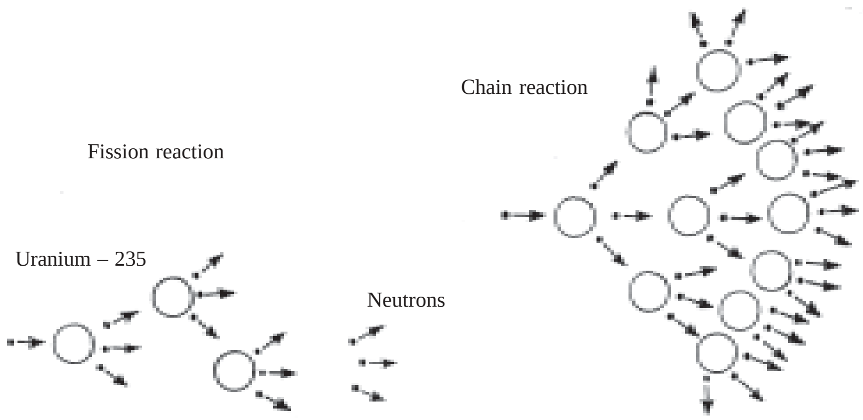


Fig. 14.7 Nuclear fission

If the chain reaction is uncontrolled, all the nuclei of uranium split in a fraction of second and this is the case of a devastating explosion, such as that of atom bombs which were dropped on Hiroshima and Nagasaki.

14.8.3 Nuclear reactors

A peaceful application of nuclear fission is the generation of electricity using heat from a controlled chain reaction in a nuclear reactor.

A nuclear reactor is an arrangement in which the energy produced (in the form of heat) in a nuclear fission can be used in a controlled manner to produce steam, which can run the turbine and produce electricity.

The main part of nuclear reactor is called the core as shown in Fig. 14.8. The reactor core is made up of the following parts:

a) **Nuclear fuel:** It is the fissionable material used in nuclear reactors to produce energy by fission process. The nuclear fuel consists of uranium, usually in the form of its oxide, U_3O_8. Naturally occurring uranium contains about 0.7% of uranium 235 isotope which is too low a concentration to sustain a chain reactions. For effective operation of reactor, uranium 235 must be enriched to a concentration of 3 or 4%.

b) **Moderator:** An important aspect of the fission process is the speed of the neutrons. Slow neutrons hit uranium-235 nuclei more efficiently than do fast ones. Because fission reactors are highly exothermic, the neutrons produced usually move with high velocities. For greater collision efficiency, neutrons must be slowed down. For this purposes a substance is used that can reduce the kinetic energy of neutrons. Such a substance is called as a moderator. A good moderator should be a nontoxic and inexpensive substance. And it should be resist conversion into radioactive substance by neutron bombardment. Graphite (C) or heavy water (D_2O) are commonly used as moderators.

c) **Control rods:** In principle, the main difference between an atomic bomb and nuclear reactor is that the chain reaction that takes place in a nuclear reactor is kept under controlled conditions at all the times. The factor limiting the rate of the reaction is the number of neutrons present. This can be controlled by lowering cadmium or boron rods between the fuel elements.

d) **Coolant:** It is the substance which is circulated in pipes to absorb the heat given off by the nuclear reactor and transfer it outside the reactor core, where it is used to produce steam to drive an electric generator. Large quantity of water is used as coolant.

e) **Shield:** To prevent the losses of heat and to protect the people operating the reactor from the radiation and heat, the entire reactor core is enclosed in a heavy steel or concrete dome, called the shield.

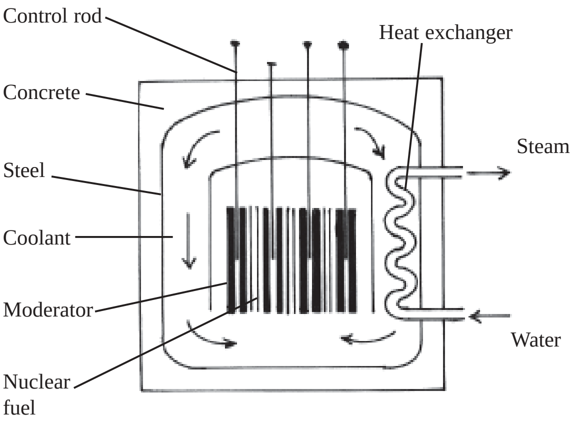


Fig. 14.8 Core of nuclear reactor

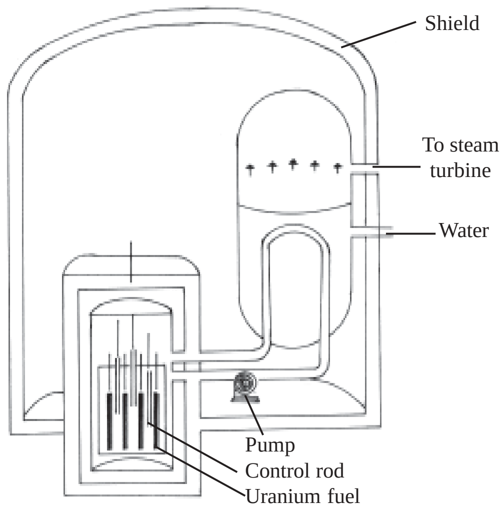


Fig. 14.9 Nuclear reactor

A complete nuclear power plant essentially consists of the four parts: reactor core, steam generator, steam turbine, and steam condensing system (Fig. 14.9).

14.8.4 Nuclear fusion

Energy is also produced when two light nuclei such as deuterium (heavy hydrogen) fuse together to form a heavy nucleus.

A process in which the nuclei of light atoms combine to form the nucleus of a heavier atom with the release of energy is called nuclear fusion.

Nuclear fusion requires very high temperature, say of the order of 4 million degree Celsius (4000000^{o}C). This is the mechanism through which the energy is produced in stars, including the sun. The hydrogen bomb also relies on this kind of reaction. Enormous amounts of energy are released during nuclear fusion. It is still not possible to control nuclear fusion to provide us with a steady supply of energy. In our country the scientists are making attempts to understand the basic process which may in future lead to controlled nuclear fusion. Some of the reactions that occur during nuclear fusion are shown below.

$$^{1}_{1}H + ^{1}_{1}H \longrightarrow ^{2}_{1}H + ^{0}_{+1}e + \text{energy}$$

$$^{2}_{1}H + ^{1}_{1}H \longrightarrow ^{3}_{2}He + \gamma + \text{energy}$$

$$^{3}_{2}He + ^{3}_{2}He \longrightarrow ^{4}_{2}He + ^{1}_{1}H + ^{1}_{1}H + \text{energy}$$

14.8.5 Uses of nuclear energy

The important uses of nuclear energy are as follows:

a) The heat produced in a nuclear reactor is used to boil the water to form steam. The steam then turns a turbine, which runs an electric generator to produce electricity.

b) Nuclear energy is now being used to run submarines and ships. Vessels driven by nuclear energy can sail for long distances without having to refill.

c) Nuclear energy in the form of bombs (atom bomb and hydrogen bomb) is used in warfare.

d) Nuclear energy is used in making radioisotopes that are used in medicine, agriculture and research.

14.8.6 Hazards of producing nuclear energy

While producing nuclear energy harmful radiations may be released which can penetrate human bodies and cause irreparable damage to cells. To prevent leakage of these dangerous and toxic radiations, nuclear reactors are covered with a thick covering of radiation absorbing substance such as lead. However, a minor fault in the design of reactors or a natural calamity striking a perfectly designed reactor, could result in the release of these extremely harmful radiations into the environment. It could pose a permanent threat to the living beings of the surrounding areas. You may be aware of the two major accidents in the nuclear power plants, one at Three Mile Island (USA) in 1979 and the other at Chernobyl (The Soviet Union) in 1986. The devastation caused in these two accidents by the release of nuclear radiations is yet to be fully assessed. Apart from possible accidents at the reactor site, there is of course, the additional danger of harmful waste matter produced at various steps of nuclear cycle, such as mining, enrichment of ore, etc. In every step of nuclear cycle a number of substance capable of emitting nuclear radiations are generated. These substances are called nuclear wastes. We have not yet been able to discover safe methods of dealing with such nuclear waste generated in nuclear power plants. It is simply being stored in strong containers. Thus, the problem of its disposal is yet to be solved.

14.8.7 Radioisotopes

An isotope that spontaneously decays into an isotope of different elements is known as radioactive isotope.

The first radioisotope of $^{17}_{8}O$ was produced by bombardment of alpha particles on ordinary nitrogen $^{14}_{7}N$ by Rutherford in 1919.

$$^{14}_{7}N + ^{4}_{2}He \longrightarrow ^{17}_{8}O + ^{1}_{1}H$$

a) Production of radioisotopes

Bombarding atoms of some elements with lighter nuclei such as protons, alpha particles or neutron produces radioisotopes. Some common examples of the production of radioisotopes are given below:

$$^{40}_{20}Ca + ^{1}_{1}H \longrightarrow ^{40}_{21}Sc + ^{1}_{0}n \quad (p, n)$$

$$^{19}_{9}Fe + ^{4}_{2}He \longrightarrow ^{22}_{10}Ne + ^{1}_{1}H \quad (\alpha, p)$$

$$^{12}_{6}C + ^{4}_{2}He \longrightarrow ^{15}_{8}O + ^{1}_{0}n \quad (\alpha, n)$$

$$^{35}_{17}Cl + ^{1}_{0}n \longrightarrow ^{36}_{17}Cl + \gamma \quad (n, \gamma)$$

$$^{37}_{17}Cl + ^{1}_{0}n \longrightarrow ^{38}_{17}Cl + \gamma \quad (n, \gamma)$$

Sometimes even heavier nuclei are used as bombarding material.

b) Applications of radioisotopes

Some important applications of radioisotopes are given below:

(i) In determining the age of fossils and old rocks.

(ii) In determining the solubility of sparingly soluble materials.

(iii) To determining the amount of an element in a sample.

(iv) Isotopes exchange reactions provide information on the mechanism of certain reactions (radioactive tracer).

(v) In industry the isotope ^{60}Co is used for γ-radiography to detect cracks/ flaws in metal plants and pipes.

(vi) The isotopes have immense use in the field of medicine. For example, ^{135}I is used to locate brain tumors and of disorders of the thyroid gland. ^{24}Na is used to locate blood clots. ^{99}Tc is used to obtain images of organs such as heart, liver and lungs. The isotopes ^{51}Cr and ^{59}Fe are used to determine the amount of total blood in a patient.

(vii) Radioactive isotopes are used in biological, fields and in agriculture. For example, ^{32}P is used to detect the deficiency of phosphetic fertilizers in the soil and ^{18}O isotope was used to determine the source of O_2 in photosynthesis.

14.9 NUCLEAR POWER PLANTS IN INDIA

India has 14 operating reactors out of which two are Boiling Water Reactors (BWR) and 12 are Pressurized Heavy Water Reactors (PHWR). Two more reactors with capacities of 500 MW are under construction at Tarapur in Maharashtra and are expected to attain criticality in 2005 and 2006, respectively. The nuclear power generation for the year 2001- 2002 was 19193 million units.

Table 14.8 : Location of Atomic power plants in India

Place	Number	Capacity
Tarapur	2	160 MW
Rajasthan	2	220 MW
	2	100 MW
Kalapakkam	2	220 MW
Narora	2	220 MW
Kakrapara	2	220 MW
Kaiga	2	220 MW

The sun is the ultimate source of energy

The ultimate source of all the energies is sun. Plants take energy from sun through the process of photosynthesis. Plants serve as food for animals. Plants and animals are fossilized to coal, petroleum and natural gas. Plants also supply wood as fuel.

CHECK YOUR PROGRESS 14.7

1. Which isotope of uranium is used in nuclear fission?
2. Name the elements produced in nuclear fission.
3. Atomic bomb is based on nuclear ________________ reaction.
4. Hydrogen bomb is based on nuclear ________________ reaction.
5. How many neutrons are emitted in a single nuclear fission?
6. What is the role of moderator in nuclear reaction?
7. What is the function of cadmium rods in a nuclear reactor?
8. State peaceful uses of nuclear energy.
9. Name the coolant used in nuclear reaction.
10. Give two examples of nuclear fuels.
11. How many operative reactors are present in India?
12. What do you mean by BWR and PHWR?

LET US REVISE

- Coal and petroleum are fossil fuels.
- The energy related to the nature and composition (atoms/molecules) of a substance is called the chemical energy.
- The chemical energy can be converted into heat energy and vice versa during chemical reactions.
- The reaction where heat is absorbed is called endothermic where as the reaction where heat is given out is called exothermic.
- Chemical energy can be converted to electrical energy and vice versa.

- Combustion is a chemical change in which heat and light are produced at the same time.
- The lowest temperature at which a substance starts burning is called ignition temperature. Ignition temperature is different for different substance.
- Substances, which burn rapidly, are called combustible substances and those, which do not burn at all, are called non-combustible substances.
- The three conditions necessary for combustion are presence of combustible substance attainment of ignition temperature continuous supply of a good supporter of combustion (generally air).
- Fire which is very useful in our daily life, is produced by combustion of substances like coal, petrol, etc.
- The instruments, which have been developed to extinguish fire, are called fire extinguishers. The working principle of different type of fire extinguishers is based either on the conditions to remove the combustible substance or to cutoff the supply of air or to cool the burning substance below its ignition temperature.
- Radioactivity is a spontaneous process of disintegration of the nucleus of an atom accompanied by the emission of energy bearing rays or particles.
- Fission is a process of splitting of the nucleus of a heavy atom into fragments that are roughly of equal masses with the release of huge amount of energy.

TERMINAL EXERCISES

A. Multiple choice type questions.

1. Which of the following variety of coal has maximum carbon content?
   (a) Anthracite
   (b) Bituminous
   (c) Lignite
   (d) Peat
2. Which of the following has highest calorific value?
   (a) Natural gas
   (b) LPG
   (c) Biogas
   (d) Hydrogen
3. Which of the following can provide maximum voltage?
   (a) Voltaic cell
   (b) Daniel cell
   (c) Dry cell
   (d) Distilled water
4. Which of the following food components has maximum calorific value?
   (a) Carbohydrates
   (b) Proteins
   (c) Fats
   (d) Mineral salts

B. Fill in the blanks.

1. The energy stored in a substance is known as ______________released in form of ______________ energy.
2. When water added in lime the heat released in form of ______________energy.
3. When heat is released and absorbed, the reactions are called______________and ______________reactions, respectively.
4. The energy released by bombarding Uranium-235 with neutrons is ______________
5. Two main products of petroleum are ______________and ______________
6. Soda acid fire extinguisher contains ______________and ______________
7. Coal gas is a mixture of ______________and ______________
8. LPG is known as ______________
9. Coke does not burn at room temperature because ______________is high.
10. The isotope of Uranium used in nuclear fission is ______________

C. Descriptive type questions.

1. Define chemical and nuclear energy.
2. With the help of examples explain exothermic and endothermic reactions.
3. Define fuel and also explain its role in every day life.
4. What is biomass? For what purpose it is usually used?
5. Explain why charcoal is a better fuel then wood?
6. Define fossil fuel. Give suitable examples.
7. Mention different types of fossil fuel.
8. Name two organic compounds obtained by distillation of coal.
9. Give the chemical composition of coal gas.
10. Name the product obtained by the distillation of petroleum that is used for making road surfaces.
11. The boiling points of substances A, B and C are 443K, 523K and 623K, respectively. On fractional distillation, which of the three compounds will be obtained at the bottom of fractional distillation column.
12. Name the two components of petroleum obtained by fractional distillation.
13. Name any one hydrocarbon fraction obtained during fractional distillation of petroleum which is used as domestic fuel.
14. What is the full form of LPG and also gives its chemical composition?
15. How does we get chemical energy in our body from the food we consume? How does this process differ from normal burning process?
16. What are three conditions necessary for combustion? Pouring water on a fire which condition of combustion is not satisfied?
17. It is very difficult to burn a heap of fresh green leaves but it catches fire easily once the leaves dry up. Why?
18. How is it possible that water can be boiled in a paper cup without burning?
19. Calorific value and ignition temperature of fuel X are 75kJ g^{-1} and 20 ^{o}C respectively and those for Y fuel are 50k J g^{-1} and 75 ^{o}C respectively. On burning the fuel Y produces

only CO_2 while fuel X produces CO_2 and CO. Which of the two is a better fuel? Give the reasons to support your answer.

20. Define ignition temperature and also explain why coke does not burn in air at room temperature?
21. Compound A has each of its carbon atom bonded with four hydrogen atoms while compound B has each carbon atom bonded with three hydrogen atoms. Which one of the two compounds will have higher calorific value?
22. An electric spark is struck between two electrodes placed near each other, inside a closed tank full of petrol. Will the petrol catch fire? Explain your answer.
23. On what principle does fire extinguisher work? Explain the working of soda- acid fire extinguisher.
24. Why is water not used to extinguish fire due to electricity?
25. Why is the crude oil sometimes called “Black Gold”?
26. Calorific value of LPG is 55kJ g^{-1}. Calculate the energy consumed by a family in one month, if it requires a cylinder containing 14.5 kg of LPG.
27. A burner consumes 1g of LPG in 55 seconds. If the calorific value of LPG be 55k Jg^{-1}, what will be the power of combustion of the burner?
28. Define nuclear fission, nuclear chain reaction and critical mass.
29. Which isotope can undergo nuclear fission?
30. What is the function of cadmium rods in a nuclear reactor?
31. Define term moderator in a nuclear reactor.
32. Name the isotopes of two different elements, which can be fissioned easily.
33. What is a nuclear reactor? Will the help of a labeled diagram describe how a nuclear power plants used as nuclear reactor to generate electricity.
34. Which fuel is used in nuclear reactor? Why can it not be used as a fuel in the form it occurs in nature?
35. State two peaceful uses of nuclear energy.
36. Explain the nuclear wastes, what are the problems inherent in their disposal.
37. Name any two type of radiations emitted during nuclear fusion. What are the measures taken to prevent the leakage of radiations from the nuclear reactors?

ANSWERS TO CHECK YOUR PROGRESS

14.1

1. Chemical energy
2. Nuclear energy
3. Small
4. Energy

14.2

1. Methane and carbon monoxide.
2. Coal and petroleum
3. Lignite and bituminous
4. Kerosene

5. Petroleum kerosene
6. Fuels, lubricants, solvents for organic compounds
7. Petroleum gas

14.3

1. The ignition temperature of coal is high
2. From air
3. Attainment of ignition temperature
4. Petrol has lower ignition temperature as compared to kerosene

14.4

1. Baking soda and sulphuric acid
2. It stops the supply of oxygen.
3. No
4. Carbon dioxide
5. Any one of the following:
   (a) Cooling below ignition temperature or
   (b) Cutting the supply of air or
   (c) Cooling the fire. and also cutting the supply of air.

14.5

1. C_2H_5OH
2. H_2
3. Problem in handling and also burn with explosion
4. Because they have higher percentage of oxygen which is a supporter of combustion
5. Metabolism (by burning the food)
6. Butter

14.6

1. Zn and Cu rods
2. Cu electrode (Cathode)
3. Zn electrode (Anode)
4. Oxidation
5. Electrochemical cell
6. Leclanche cell
7. Carbon rod.
8. $NH_4Cl + ZnCl_2$
9. 1.5 V
10. By using porous pot

14.7

1. ${}^{235}_{92}U$

2. $^{141}_{56}Ba$ and $^{92}_{36}Kr$
3. Fission
4. Fusion
5. Three
6. Graphite and D_2O
7. Slow down the speed of neutrons.
8. Nuclear reactor (to generate electricity)
9. Water
10. U_3O_8 enriched with $^{235}_{92}U$
11. 14
12. BWR: Boiling water reactor; PHWR: Pressurized heavy water reactor

GLOSSARY

Chemical energy: Energy stored within the structural unit of a substance.

Combustion: Chemical change in the presence of oxygen in which both heat and light are produced at the same time and the composition of the substance changes.

Critical mass: The minimum mass of fissionable material required generating a self-sustaining nuclear chain reaction.

Daniel cell: A galvanic cell utilizing the reduction of Cu^{2+} ion by zinc.

Dry cell: A chemical galvanic cell with a zinc anode and a graphite cathode surrounded by solid MnO_2. The electrolyte is a moist paste of NH_4Cl, $ZnCl_2$ and some inert filler.

Energy: The capacity to work or produce change.

Fission: The splitting of a heavy nucleus (mass number 7200) into lighter fragments with the release of energy. Most fission processes are initiating by bombarding the heavy nucleus with thermal electrons.

Fuel: Any substance that produces energy in the form that can be used for practical purposes.

Fusion: The process in which two light nuclei combine to produce a heavier nucleus with mass number A less than 60, with the release of energy.

Galvanic cell: A device for converting chemical energy into electrical energy.

Ignition temperature: It is the latest temperature at which a substance catches fire and starts burning.

Nuclear chain reaction: A self-starting sequence of nuclear fission reactions.

Nuclear energy: Energy stored in a nucleus of an atom.

Radioactive isotopes: An isotope that spontaneously decays to become an isotope of different elements.

Radioactivity: The spontaneous break down of an atom by emission of particles and/or radiations.