Indira Gandhi National
Open University
School of Sciences

CLT-101
GOOD LABORATORY PRACTICES

Block

3

SCIENCE LABORATORY SAFETY

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CLT-101: GOOD LABORATORY PRACTICES

LIST OF BLOCKS AND UNITS

Please remember that this programme does not have any assignment component for continuous evaluation.

BLOCK 3: SCIENCE LABORATORY SAFETY

The previous two blocks of '**Good Laboratory Practices**' course dealt with the organisation and management of a laboratory. The third block deals with another very important aspect associated with all types of laboratories. This is about the likely hazards and safety in a laboratory. It is important to learn about the hazards and the precautions and safety to be taken to prevent any accidents in the laboratory. There are five units in this block. **Unit 8**, the first unit of this block, deals with the hazards due to electricity and gas and therefore is titled as '**Electricity and Gas Hazards**'. These hazards have been given prime treatment as they are common to all the laboratories. Electricity, though very useful to mankind may be a major hazard as it can give severe shock or lead to a fire, if used carelessly. This unit discusses the possible electrical dangers, precautions to be taken to prevent the hazards, current calculation for different electrical appliances and the ways to choose a right fuse, flex or cable. This unit also deals with the gas hazards and the safety measures to be taken for the commonly used gas cylinders in the laboratory.

Fire arising out of number of reasons is another very common hazard observed in laboratories and has been dealt with in **Unit 9**, '**Fire Hazards**'. It discusses different causes of fires, classification of fires, types of fire extinguishers and their usage.

Chemical substances are used in Chemistry, Biology and Physics laboratories. The hazards due to chemical and biological substances have been dealt with in **Unit 10** named, '**Chemical and Biological Hazards**'. The United Nations classification of hazardous chemicals is given along with the symbol chart. The storage and handling of hazardous chemicals have been discussed in the unit. The unit also deals with the microbiological and other hazards which are specific to a biology laboratory. It discusses the supply, handling and disposal of biological materials.

In **Unit 11** on '**Personal Safety**', we discuss various features concerning safe laboratory work. The code of practice in a laboratory and personal protective devices are explained. A brief discussion is given on the disposal of waste materials. The sequence of actions to be followed during check-in and shut-down is also listed.

Unit 12 on '**Accidents and First Aid**' is devoted to first aid treatment that is to be provided to the victims of laboratory accidents. The need and the method for reporting an accident are discussed. The contents and the placement of the first aid box are stated.

Expected Learning Outcomes

After reading this block, you should be able to:

- describe the hazards caused by electrical fittings and the appliances in a laboratory, and the precautions to be taken there of;
- explain the possible causes of a fire hazard in a laboratory and different ways of managing it,
- state the hazards associated with different compressed gases and the first aid treatment in case of a gas hazard;
- discuss the nature of different chemicals, the possible hazards caused by them and the precautions to be taken there of;
- explain the hazards associated with a biology laboratory;
- state the features concerning code of practice in a laboratory;
- identify the contents of first aid box; and
- explain the methods of administering first aid for specific situations like electric shock, unconsciousness, chemical accidents, bleeding, burns and eye injuries.

UNIT 8

ELECTRICITY AND GAS HAZARDS

Structure

8.1 INTRODUCTION

Electricity is one of the finest gifts of science to the mankind since just a click/ tap of switch can flood the room with light or put on a fan, an air conditioner or a heater. Many electrical appliances are available to make life comfortable. In a laboratory most of the instruments and all specialised equipments and computers would be usable only with electrical power. However, electricity also presents a number of hazards. Its misuse can cause serious injury, give shock that may be fatal or start devastating fires. Most electrical accidents are caused by very old equipment or improper use – both of which are avoidable. Similarly the use of Liquefied Petroleum Gas (LPG) in laboratory is convenient for a number of purposes; but if used carelessly, it may lead to fire and other hazards. In this unit we will discuss the possible hazards due to improper use of electricity and LPG. We are going to give you some instructions to be followed for safety. The first section describes electrical hazards while the second section describes the gas hazards mainly due to LPG. In fact, the next unit deals with the fire hazards for which the misuse of electricity and LPG are also responsible to a large extent.

Expected Learning Outcomes

After studying this unit, you should be able to:

- describe the consequences of passing electric current through the body;
- state and recognise the colour code of cable and flex;
- calculate the current drawn by an electric appliance;
- select the appropriate fuse and flex;
- state all that is required for proper flex routing and making proper connections etc.;
- explain the importance and procedure of earthing;
- explain different types of dangers from electricity and related equipment;
- explain the possible hazards due to LPG and hydrogen sulphide gas; and
- list the precautions to be taken to prevent gas hazards and state the steps to be taken in case of a gas leakage in the laboratory.

8.2 ELECTRICITY HAZARDS IN THE LABORATORY

Skin's resistance to electric current might vary from 500 ohms (damp skin) to 3000 ohms (dry skin).

You've probably read about or heard of people falling onto high voltage rails or cables and surviving thousands of volts. As a contrast, you might have also had a small electric shock from the mains yourself. It does not mean that it is safe, as there are serious physiological consequences of passing an electric current through the body. You will learn about how to calculate the current in subsection 8.2.2. A current of 1 mA through the skin causes a tingling sensation. A current of 6 mA-10 mA is somewhat safe. A current beyond 10 mA is not safe, a higher current may produce muscular contraction. A current of 20-25 mA will cause sure death as it causes irregular contraction of the heart whereby it stops pumping.

CAUTION: Never touch a person suffering from electric shock until you are certain that the current has been turned off.

You will read about the first aid treatment of electric shock in Unit 12 of this block. However, if you are first on the scene of an accident where someone is in the process of being electrocuted, **YOU MUST NOT TOUCH THAT PERSON**. The first action to be taken is to isolate the victim from the electric power source.

Cut-out is a porcelain device which is put in the mains supply and horses a fuse wire. In case of excess load the fuse blows off and cuts out the main supply.

Many a times the reason behind the electrical mishap is negligence of the very fundamentals of electricity. Some of the possible causes that may lead to a shock or cause an electrical mishap are given below:

- improper wiring
- improper choice of fuse
- choosing improper wire
- deterioration in the insulation system
- accidental touches
- flash over
- break in earthing system.

Let us learn the safe ways of handling electrical equipments so as to minimise electrical accidents in the laboratory. We begin with wiring a plug.

8.2.1 Wiring a Plug

Let us consider the problem of connecting a 16 A plug, commonly known as 15 A or power plug to an electrical appliance. Do you use any old bit of wire, or any fuse that is too hard, to make the connections? Which wires are connected to which terminals?

The answers to these and other questions related to the specification or function of electrical equipment are quite simply indicated by colour codes, and there are International conventions which govern the use of colours of, for instance, electrical components, flex sheathing, fuses, etc. The systems used are practical and are now universally recognised. As most of you may be aware also, the following colour code for **cable** and **flex** is used in our country.

We use the word **'cable'** to refer to mains wiring fixed, say, to a building. It is usually made of one-strand wires and is not very flexible. **'Flex'** is the word we use to refer to the flexible mains wiring used for portable appliances and extension leads. It is usually made up of two or three multi-strand wire ropes.

Earth : Green
Live : Red
Neutral : Black

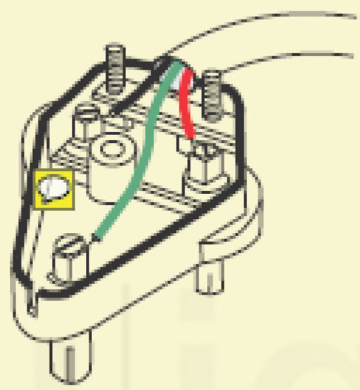


Fig. 8.1: Plug showing wire connections

These colour codes should be followed while wiring a plug. Fig. 8.1 gives a view of an ordinary 13 A plug with its top removed showing three terminals i.e., **earth(E), neutral(N)** and **live(L)** and their connections. You can see how the three wires are connected to three terminals according to the colour code. It should be ensured that the connections are tight to avoid sparking. There is an experiment (Experiment 7) in the lab course (CLTL-101) which explains how do we make cable/flex connections to a plug. Let us move on to selecting a proper fuse for a given appliance in order to learn the safe handling of electricity.

For proper wiring:

- colour code should be followed.
- connections must be tight.

8.2.2 Selection of Proper Fuse

Fuse is a safety device or a wire of metal in a cutout which may be fused by an excessive current. The current drawn by an appliance is restricted by the resistance in the circuit. In case of short circuit the resistance decreases and the current increases. This current produces heat in the circuit and can burn the equipment or the connecting wire. Therefore a fuse is provided in the circuit which blows off when the value of the current increases beyond its normal current rating and the faulty circuit is disconnected.

The fusing elements are lead-tin and tinned copper.

A short circuit is caused due to a contact of live and neutral wires without any load.

The selection of a proper fuse for a given instrument or appliance depends on the amount of current being drawn by the same. As we have discussed earlier, size of electric current is very important in relation to the effect of an electric shock on our bodies. We also need to know the size of current for each electrical appliance in the laboratory, for just as our bodies are limited to the current they can withstand, so the electrical appliances, wiring, plugs and other apparatus are limited to the current they can handle. If the flex, plug or fuse of an appliance is inappropriate to the amount of current drawn by that appliance, unnecessary damage or injury could result. Therefore, to take a decision on the fuse to be used one must know how to calculate the current drawn by an instrument.

Let us learn how to find out the current drawn by any particular appliance. First of all you should find out the power rating of the appliance. This is given in **watts** on the specification plate on most appliances. Then you would apply the formula,

$$I = W/V$$

Where I is the **current in amperes** (A) which you are trying to find out, W is the **power rating** of the appliance in **watts** (W), and V is the measure of **electromotive force** (EMF) in **volts** (V), commonly known as **voltage**. We can illustrate this by doing the following calculation.

What current does the 100 watts light bulb draw from 240 V mains?

Applying the formula given for current calculation,

$$I = W/V = 100/240 = 5/12 \text{ or } 0.42 \text{ A}$$

Fuse rating =
calculated current + 15 - 20%

i.e. a 100 watts bulb will draw 0.42 A of current from 240 V, mains. A fuse of 2 A may be chosen for this. What if the voltage drops down? It may drop to say 200 V which means it will now draw 100/200 ~ 0.5 A. Therefore fuse rating is normally kept somewhat higher than that computed by the formula.

Normally, 6 A and 16 A fuses are used for domestic purposes.

Complex equipment often contains a number of fuses of different ratings in different parts of the circuit to protect various components from damage by ensuring that a current exceeding a certain value cannot pass through them. However, for domestic purposes or even in the laboratory/institution we do not put fuses for each fan, tubelight or other appliances. Instead, the whole building's wiring in divided into a number of circuits say for each room, a block or a laboratory etc. and are individually protected by suitable fuses. The selection of fuse in such a case is done by computing the total load on the circuit. For example, a room having 2 fans of 80 W each, 6 tubelights of 40 W each will have a total load of 400 W. The fuse rating for this room will be calcualted taking the total load in consideration. Why don't you try and solve some problems based on current calculation/selection of fuse to clearly understand these concepts?

SAQ 1

Calculate the current drawn by a 2 kW geyser running on a 240 V mains. Can we run this geyser on a supply line protected by a 6 A fuse?

SAQ 2

A lecture theatre has 6 fans of 80 W each, 8 tubelights of 40 W each and 2 bulbs of 100 W each. Calculate the total load on the circuit and find the fuse needed if the working voltage is 220 V.

Thus you have learnt how to wire a plug, calculate the amount of current drawn by an appliance and thence choose an appropriate fuse. What about the kind of flex/cable to be used? Let us see next.

8.2.3 Selection of Right Flex

It is also important that the flex we choose is appropriate to the appliance used. Like fuses, the cables and flexes are also rated according to their current carrying capacity. The selection of a right flex, therefore, necessitates the knowledge of the *I=W/V* formula.

Each flex and cable is rated according to the maximum current it will safely carry. The conducting ability or the current carrying capacity of the metallic conductor depends on its cross sectional area (measured in mm^2) and therefore the diameter (in mm). However, the cables and flexes are rated in terms of maximum allowable current (in amperes) through them. This rating is given in the supplier's catalogue or is stamped on the spool or cable container. Common, general purpose flex or cable is usually covered with polyvinyl chloride (P.V.C.) for insulation and is available in a variety of ratings, e.g. 5A, 10A, 15A etc. It is dangerous to use a cable where there is a chance that it might carry current in excess of its rated value. Heat would be generated in the cable and at a certain level, the current could cause the wire to burn and melt the insulation. This is a common cause of fires. This does not mean that we use flexes/cables of very high rating. One must use the cable appropriate for a given application.

The domestic cable is usually classified in terms of its cross sectional area.

The rating of flex must be greater than the fuse protecting it.

The correct flex for a piece of electrical equipment is the one which allows the safe passage of the current drawn by the appliance. It would be uneconomic, for example, to use an expensive heavy duty heating circuit cable rated at 30A to connect a 60W reading lamp to the mains. At the opposite extreme, it would be unsafe to use a 3A lighting circuit flex as the laboratory power supply cable.

You have read about the dangers of using the wrong cable. So this is another contributory factor to electrical safety in the lab. Here are two questions to check your knowledge on this aspect. You have to tick (✓) mark the correct answer.

SAQ 3

Tick mark (✓) the correct answer in the following:

The flex/cable is rated in:

i) mm ……………..

ii) mm^2 ……………..

iii) amps ……………..

SAQ 4

Fill in the blank with an appropriate answer from the choices given:
A flex rating should be …………….. than the rating of its attendant fuse.
(greater or smaller)

You would have experienced that a number of accidents occur due to electrical wires hanging about between the doors or near the working benches etc. Some times a socket is overloaded or the plug/socket happens to be in deteriorated condition. In the next subsection we learn to make electricity safer by following a safe conduct.

In other words, you should cut a piece of cable to the right length and route it clear of,

- edges and corners – to avoid cutting.
- open floor spaces – to avoid mechanical damage.
- moving parts.
- heat sources.
- sources of moisture or corrosive substances.

Flexes must:

- be joined by proper connectors where appropriate.
- be strapped together where appropriate.
- not be strained or continually moved.

8.2.4 Safe Conduct

It is very good if you understand *I* = *W*/*V* calculations and ensure that you carefully select the appropriate fuse and flex for each appliance; but what if a trailing flex became caught up in an apparatus trolley and was cut? Or someone splashed water onto a plug, or concentrated sulphuric acid onto a flex? For example, in a laboratory where the metal mains sockets are fitted flat on a lab bench only two inches from sinks and beneath reagent bottles, the sockets are likely to be continually splashed, resulting in sparking, fusing and other possible dangers.

It becomes compulsory to follow a safe conduct if you want to avoid mishap from electricity. The safe conduct in the context of electricity includes a proper flex routing, proper use of adaptors, plugs and sockets. You will read about these in the following paragraphs.

Flex Routing

It is very important to take steps to ensure that flexes are routed safely and well clear of possible sources of danger. When connecting electrical equipment to the mains, always use a length of cable just long enough to enable the connection to be made without straining it. Avoid trailing flex over the edges of benches or across the floor where it is susceptible to mechanical damage and where anyone stepping or catching the flex could bring electrical equipment crashing to the floor. Wherever possible cables should be firmly attached to the wall or bench and two or more leads should be strapped together into neat bundles and secured. Remember that unsecured lengths of cables can place an enormous strain on the terminals and could easily pull out the earth or live connections from a plug or socket.

Adaptors

When you plug two or more appliances into a plug that makes it possible to use more than one piece of electrical equipment from a single socket. The total current drawn is the sum of the current drawn by each individual appliance. If this current is drawn from a single supply via a multiple adaptor or distribution board, you must always check that the total current drawn does not exceed the maximum safe value for the circuit. A typical example of this is during winter when room heaters and convectors are used to heat up offices and labs. Sometimes, careless people will plug the heaters into a distribution board without considering:

- the increased flex length.
- the rating of the distribution board's flex and fuse.
- the total amount of current drawn with other appliances.

Blown fuses, burnt flexes and fires are the result !

The use of a large number of plugs and adaptors in a single socket (Fig. 8.2) should be avoided as it can:

- break the socket;
- pull the wiring and socket away from the wall;
- create intermittent contact which causes superheating and can lead to fires.

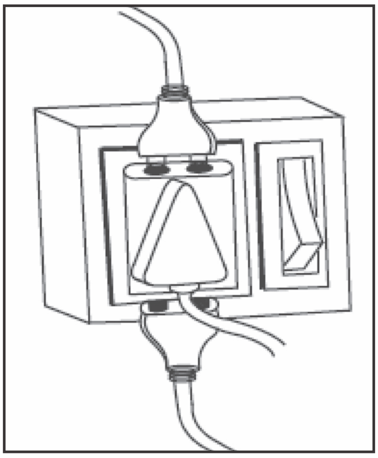


Fig. 8.2: An overloaded socket

Plug and Socket Condition

In the same way that your knowledge of flexes and fuses is wasted if you don't care to ensure that flexes and cables are routed safely and sensibly, so your ability at and knowledge of wiring plugs will be a waste of time if you do not ensure that plug tops, sockets and leads are in good repair at all times. Damage or wear to any of these could expose a user to extreme danger through short circuits, bare terminals, etc. Therefore a regular (annual) and thorough check of plugs, sockets and leads should be a standard practice in your lab. This can be done in the following manner.

> The Government of India has formulated specific legislation for safety requirements while using electricity.

Plugs – Check for:

1. Hair-line or other fractures in the plug
2. Chipped plug top
3. Worn or insecure top securing screw
4. Loose cable clamp
5. Loose connecting screws
6. Loose fuse holders

Sockets – Check for:

1. Fractures of chips
2. Faulty socket shield operation
3. Worn or insecure face-securing screws
4. Correct wiring

***Flexes/Cables* –** Check for:

1. Hairline cuts in insulation – particularly where outer sheathing has been removed
2. Brittle sheathing due to heat or corrosives

3. Frayed sheathing in fabric sheaths where the fabric becomes thin or worn so that loose threads develop
4. Twisted or damaged flex

Having learnt about the safe conduct, you can try to answer the SAQs 5 and 6. In the next subsection you will learn about another important aspect of using electrical appliances i.e. earthing. Here you will know how a piece of equipment can be earthed and what are the reasons for earthing a metal clad appliance.

SAQ 5

Three appliances draw current as follows: 8A, 5A and 2A. If they were all plugged into the same adaptor, what would be the maximum current in the adaptor? (Tick the appropriate answer.)

i) 8 A

ii) 5 A

iii) 15 A

SAQ 6

"The idea of going round checking every plug, socket and lead in the laboratory is not practical. It is too expensive in terms of time and material replace as required".

Write down the points you would make in reply to this observation.

8.2.5 Earthing

Any electrical appliance with a metal casing or with metal parts, likely to be touched by an operator is potentially dangerous. The danger is that an internal or external fault could cause the metal casing to become live and thus electrocute the operator.

Some of the electrical equipment used in your home, laboratory or workshop does not require earthing as it is fully insulated, i.e. all the parts which carry electric current are enclosed in a casing of plastic or other insulating material. When such appliances are used, normally it is impossible for your hand or other parts of your body to come into contact with the current. The appliance is thus completely safe, unless the insulator is cracked or damaged. However, larger pieces of electrical equipment are frequently encased in a metal container as part of their structure or in order to mechanically protect fragile components. All metal clad appliances must be earthed so that if any fault develops, the chasis or metal casing does not become live.

All electrical equipment that is not fully insulated should be properly earthed for safety. The correct connection of the green earth lead from the appliance to the centre terminal of the three-pin plug is generally all that is required. The end of the green cable should be attached to a terminal on the inside of the metal casing, preferably in the switch handle. When the plug is then placed into the earthed socket of the power supply there will be a direct path of earth. A screw as well as solder should always be used when earthing metal-clad equipment, because simple soldered joints are not sufficient for a reliable earth connection.

Occasionally you may have to make an earth connection other than by using the earth lead of a flex, e.g. laboratory batteries. In this or any other case you **must remember never to earth onto water pipes** – there may be plastic pipes which isolate the pipe system from earth.

Testing for Continuity

You might have observed sometimes that when all the connections in the appliance as well as the plug are made properly the appliance may still not work. This can be due to an open circuit fault. As you know that electricity flows only in a closed circuit, whenever there is a break in a circuit, say the metallic conductor in the cable may be broken or the contact is loose or lost, the current will not flow. Further, it may so happen that you have properly earthed the appliance yet it gives a shock. One must ensure that there is continuity in the connection made whether for earthing or otherwise. This can be accomplished with the help of a multimeter or you may construct a simple continuity testing device of your own. Such an instrument works on the basis of passing a small current through the earth circuit to light a torch bulb.

Earth Leakage

Earth leakage takes place when, through some fault in an appliance or its connections, electric current escapes to earth i.e. the body of the appliance becomes 'live' and may give severe shocks. A minor earth fault is called as an **earth leakage** and under these conditions the appliance continues to work and gives mild shocks. However, if there is a major earth fault the loss of current to the earth causes the fuse to blow out if the body of appliance is earthed. Increasingly, **Earth Leakage Circuit Breakers (ELCBs),** are being used to detect this loss of current as they can be sensitive to a loss of as little as 5 mA. They can be bought to fit a 16 A socket or as individual components for each experiment or appliance. ELCBs can be too sensitive; for example, if neon indicator lamps are wired from live to earth, the tripping of ELCB would take place very often. This kind of problem can be solved by rewiring the indicator lamps between live and neutral, though "**nuisance tripping**" can also be caused by slight moisture e.g. with refrigerators. A typical ELCB circuit is shown in Fig. 8.3.

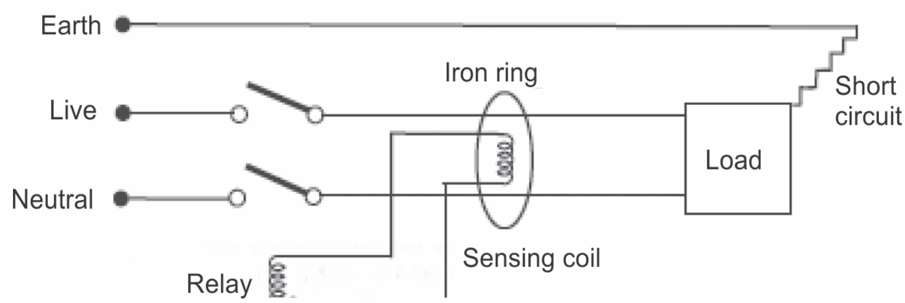


Fig. 8.3: ELCB circuit diagram

In the event of a short circuit or leakage occurring, the circuit breaker will cut off the mains power supply and will continue to break the circuit until the fault is rectified.

It can be seen that ELCBs are more sensitive than fuses and are more convenient to use. They are useful for protecting circuits supplying power tools, etc. where the risk of shock is high. However, ELCBs only protect the live conductor; for example, if the live conductor is short-circuited to earth. ELCB would not prevent a fatal shock if both neutral and live conductors were touched by someone standing on an insulated surface.

Now check your understanding of the principles of earthing electrical equipment by answering the following questions. You need only tick the answers you think are correct and compare them with ours.

SAQ 7

The purpose of earthing electrical equipment is to:

i) secure the cable to the equipment's chassis or case.

ii) complete the circuit.

iii) eliminate interference from or to adjacent equipment.

iv) keep the apparatus safe so that any electrical fault does not occur.

SAQ 8

Which of these ways would you earth an electric motor in a metal casing?

i) Connect the casing to a radiator using unshielded copper wire.

ii) Screw the earth lead of the mains cable to the casing.

iii) Tie the earth lead of the mains cable to the casing.

iv) Screw and solder the earth lead of the mains cable to the casing.

v) Solder the mains cable earth lead to the casing.

8.2.6 Other Dangers Associated with Electrical Equipments

So far, we've only discussed matters relating to mains power supply and mains appliances. There are many other potential hazards from electricity supplies and equipments. For instance, do you have any of the following in your lab?

Lead Acid Accumulators

The battery used in automobiles is also a lead acid accumulator.

These are the most common storage batteries which can deliver a heavy current when short-circuited. There are also many other hazards with these accumulators arising from

i) toxicity/corrosiveness of materials used.

ii) mass and weight.

iii) fumes.

Capacitors

These are electrical condensers having a system of electrical conductors and insulators. The simplest form consists of two parallel metal plates separated by a layer of air or some other insulatory material, such as mica. The capacitors can store, and even regain, sufficient energy to pose a threat to life. Thus you must always short circuit capacitors when they are not in use.

High Frequency Induction Heaters or Magnetic Fields

If this type of equipment is in use, large currents may be induced in any nearby metallic object or circuit, which will in turn lead to burns, damage of equipment, etc. You should consider the following as examples of only some of the articles which could cause an accident in your lab.

i) Metal rings, bracelets, watch straps, necklaces, etc.

ii) Metal plates/pins in bones

iii) Heart pacemakers

iv) Hearing aids

Static Electricity

This is produced when two substances rub together; the substances may be solids, liquids, or gases. Typical sources of static electricity are:

i) drive belts

ii) liquid/solid dispensers

iii) **Van de Graaff** generators deliberately producing static electricity

iv) plastic shoes, clothes and floors

Van de Graaff generator is an electrostatic generator used for accelerating charged particles of atomic magnitudes, e.g. protons, to high energies. It is named after R.J. Van de Graaff.

The danger is not so much in the electric potential produced as in the sparks produced. Static electricity can be prevented by

- preventing the friction
- using earthed metal containers
- wiping surfaces with dilute detergent solution
- keeping the atmosphere damp

Sparking

In ordinary domestic situations, small electrical sparks are usually not hazardous. In certain conditions which are frequently encountered in science labs, even the smallest sparks can produce dangerous results due to the presence of dust or flammable fumes and vapours. At the very least, sparks will interfere with electronic equipment such as pH meters. Typical sources of sparking in the lab are:

i) dirty switches

ii) bimetallic thermostats

iii) static sources (see above)

iv) live sockets

You can find examples of equipment designed specially to overcome the problems of sparking in refrigerators or petroleum stores. Domestic refrigerators are not spark-proof and must not be used in the lab.

SAQ 9

Against each of the following pieces of electrical apparatus, write down one associated hazard.

Apparatus	Hazard
i) Lead acid accumulator	....
ii) Capacitor	....
iii) Induction heater (High Frequency)	....
iv) Van de Graaff generator	....

8.3 GAS HAZARDS IN THE LABORATORY

As mentioned in the introduction of this unit, the gas hazards in a laboratory arise from LPG and other compressed gases. Though the use of gas for heating purposes in the laboratory is decreasing in the West, in our country it is still quite prevalent. In School Science labs **Liquefied Petroleum Gas** or **LPG** is the source of heating. Therefore, we would focus our discussion mainly to the associated hazards and safe use of this gas. Hydrogen sulphide is the other gas that is used in Chemistry laboratory and prepared in a very small scale during some specific experiments. You may be aware that in the Chemistry laboratory this gas is used for the precipitation of cations of analytical groups II and IV in quantitative analysis. Hydrogen sulphide gas in our country is still prepared in the Kipps apparatus and is available in a cylinder in most of the developed countries. Its preparation is given as a demonstration experiment in CLTL-103 course.

Let us first understand in brief about LPG, the dangers of LPG and how to make LPG safer in the laboratory.

8.3.1 How to Make LPG Safer in the Laboratory

Ethylmercaptan is used to give LPG a characteristic smell.

Liquefied petroleum gas is a colourless and odourless gas which is supplied in cylinders as a liquid under pressure. An odorant is added to give it a characteristic smell so as to detect the leaking gas. Chemically it is either commercial butane or commercial propane or a mixture of the two. The gas is slightly toxic, nonpoisonous in vapour phase but can cause suffocation in large concentration. Therefore it is advisable to know the general precautions which should be taken during the storage and use of this gas.

The following must be observed in the laboratory:

1. Stand the cylinder upright on firm base. The LPG cylinders should be kept outside the laboratory in a ventilated room.
2. A good practice in handling, loading and unloading will minimise the risk of accidental gas leakage and thus the hazard of fire.
3. The storage areas should be readily accessible. It should facilitate the quick removal of cylinders in case of an emergency.
4. A typical store room for cylinders may be constructed for eight to sixteen cylinders depending on the requirement of the lab. Do not connect all the cylinders to the feeder pipes simultaneously; two to four cylinders are sufficient.
5. Regulate the pressure of the gas to the optimum level.
6. In the laboratory ensure that all the burners connected to gas supply are in working condition and the tubing used for connection is Bureau of Indian

Standards (BIS) approved. Never use ordinary rubber tubing. **Inspect the rubber tubing for its condition and replace if needed once in a year atleast.**

7. Ensure that highly volatile liquids are never heated directly on the flame.
8. Give clear instructions to the students to close the burner knobs after the use. Also ensure that the cylinder knobs are closed after the laboratory work is over.
9. Use spark free switches.
10. A sufficient number of fire extinguishers, preferably dry powder type should be placed around the storage area and properly maintained.

Never use foam extinguishers for gas fires.

Despite the precautions taken there may be leakages and associated risks. Let us learn how to detect and manage a gas leakage.

8.3.2 Detection and Handling of Gas Leakage

If you are using a compressed gas/cylinder or have a store for it, you must have some preliminary ways and devices to indicate the leakage, if any. As you are aware, the School Science laboratories make use of LPG for heating purposes and H_2S gas for Chemistry experiments. The simplest way to detect these gases is by the smell in the first place. You have read in the previous subsection that an odorant is added to LPG for getting a characteristic smell and H_2S has a rotten egg smell. Though numerous monitoring instruments are available gas leaks may be indicated by formation of bubbles on pouring a dilute solution of soap on the suspected point of leakage. However for few gases some simple chemical procedures are also quite useful. These are beyond the scope of this course.

Hydrogen sulphide gas can be detected simply by hanging strips of lead acetate paper near cylinder or the apparatus. Blackening of paper indicates leakage.

Most of the times the leakage can be managed by simply tightening the valve or by fixing the delivery tube properly. You should attempt it only if there is no risk of exposure. If the leakage from the valve persists or leaks appear at any other position of the cylinder put on a gas mask and immediately remove the cylinder to open place and evacuate people from the vicinity. The leak ofhydrogen sulphide can be managed by passing the leaking gas into water fed scrubbing tower or by simply arranging to pass the gas through a column of water. Removing the cylinder to well ventilated area and ensuring the absence of ignition sources is sufficient. **However, all leakages eventually should be managed by the experts.**

8.3.3 Health Hazards of Gases

Exposure to the leaking gas may be unavoidable despite the precautions taken. Therefore, a knowledge about the specific health hazards from the gases and their management, in case of an exposure, is essential.

The liquefied petroleum gas forms a flammable mixture with air. Therefore it can be a fire and explosion hazard if stored or used incorrectly. It is heavier than air as a result it would normally settle down at ground level or low lying places and accumulate in depressions. While standing one may get only a faint smell of the gas. It has been reported to be the carcinogenic also. The precautionary measures are already listed in subsection 8.3.1. The best way

Carcinogenic: Causing cancer.

to deal with an emergency would be to open the windows, remove the cylinder and keep away any sparks.

The route of entry of H_2S gas is by inhalation and through eyes. The health hazards and the symptoms due to exposure of this gas are given below:

- Causes irritation of respiratory tract and eyes.
- Headache, dizziness and weakness
- At high concentration may cause unconsciousness followed by respiratory paralysis.
- For an emergency treatment the victim should be removed to a fresh air area and be given artificial respiration, if required.

Try to answer the following SAQ to assess the handling of gas leakage.

SAQ 10

If you walked into the lab one morning and there was a faint smell of gas, would you

i) ignore it?

ii) open all the windows?

iii) call the fire brigade?

Tick mark (✓) the correct answer.

8.4 SUMMARY

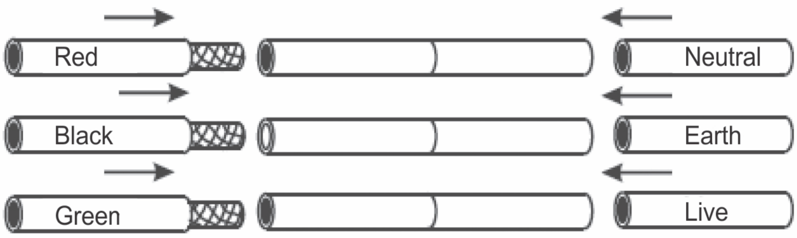
Let us summarise what all we have studied and learned about electricity and gas hazards in this unit.

Electricity beyond doubt is very useful and essential for us; but if dealt with carelessly, it can prove to be very fatal. It is compulsory for a laboratory assistant to be sure of the colour code of electric wires. The person should be able to calculate the current for different electrical appliances. To prevent any hazard from electricity, one should follow a safe conduct i.e., proper use of adaptors, plugs and also the cable and flex routing. One should keep checking every plug, socket and lead in the laboratory from wire to wire. Earthing is also very important while dealing with electricity. It is essential to learn how a piece of equipment can be earthed and also to test the connections. ELCBs are in large use for this purpose. The lab assistant should be aware of other types of dangers occurring because of electricity.

Proper precautions should be followed while handling and using the gas cylinders. We learnt how LPG can be used safely. Hydrogen sulphide gas is another commonly used gas in the laboratory. The detection, handling and health hazard of the two gases have been discussed.

8.5 TERMINAL QUESTIONS

1. Make the right connections in the following diagram by pairing off colours and electrical function. Write your answers in the blank connectors.



2. Given below are few appliances that you could use in the laboratory. What rating flexes and fuses are appropriate for them. (Assume a mains voltage of 240 V.)
   i) 200 W slide projector
   ii) 500 W incubator
   iii) 1200 W hot plate
   iv) 2 kW oven furnace
3 A salesman in electrical retail shop was overheard telling a customer "the fuse rating of an appliance connected to a distribution board doesn't really matter, because the appliance will be protected by the fuse in the distribution board". Write down some of the points you would make in reply to a remark like that.
4. You discover that a gas tap on one of the lab benches has been left half open over the weekend, and although gas has been escaping steadily, there is only a faint smell. You know that the gas used in the laboratory is more dense than air. Why does the gas concentration not appear to be high and what precautions you might take?
5. Why is a common household gas like LPG dangerous? Give three important precautions to make the use of LPG safe in laboratories.

8.6 ANSWERS

Self-Assessment Questions

1. Using the formula $I = W/V$, 1 kW = 1000 W

   I = 2000/240

   = 8.33 A

   Since the geyser draws more than 8 A of current, it should not be run on a supply line protected by 6 A fuse.
2. 6 fans of 80 W each = 80 x 6 = 480 W

   8 tubelights of 40 W each = 40 x 8 = 320 W

   2 bulbs of 100 W each = 100 x 2 = 200 W

   TOTAL = 1000 W

   So the total load = 1000 W or 1 kW

   Total current drawn = 1000/220 = 4.5 A

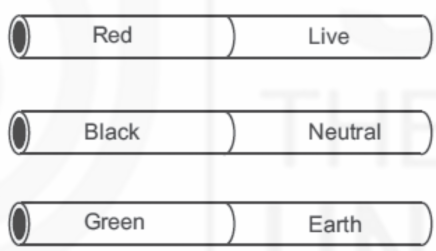
   Therefore, a 6 A fuse should be alright for the lecture theatre.
3. iii) Although it is true that the cross-sectional area and therefore the diameter of a conductor do have a bearing on its conducting ability, cable and flex are actually rated according to their maximum allowable current,

and current is measured in amps. However, domestic cable is usually classified as 1.5/2.5 mm^2 (for lighting) or 4.16 mm^2 (for power).

4. Greater – if it was less, the fuse might never blow, but the flex would burn out which would be extremely dangerous.
5. 15A. Remember that the current drawn through an adaptor is the sum of the currents drawn by each individual appliance.
6. With this philosophy, the first indication that a repair or replacement is required might be the occurrence of a serious accident or fire. The only safe way is to have regular checks at intervals of not more than a year, combined with a practice of immediate replacement or repair where a fault is observed in the meantime.
7. iv)
8. iv)
9. Any of the following hazards apply:
   i) Toxic/corrosive materials
   ii) Stored electrical energy
   iii) Induced currents in any nearby metallic object
   iv) Being left in a charged condition so that the technician dismantling it receives a shock.
10. ii) Good ventilation is all that is required.

Terminal Questions

1. Your connectors should look like this:



2. i) Flex 6A Fuse 2A $I = \frac{200}{240} = 0.8$ A

   ii) Flex 6A Fuse 3 or 5A $I = \frac{500}{240} = 2$ A

   iii) Flex 15A Fuse 10A $I = \frac{1200}{240} = 5$ A

   iv) Flex 15A Fuse 15A $I = \frac{2000}{240} = 8.3$ A

3. Here are some of the points you should make:
   i) The current drawn through a distribution board is the sum of the currents drawn by each individual appliance.

ii) It follows, therefore, that the current flowing through the distribution board fuse will be greater than that in any individual plug in the board. Therefore the fuse in the distribution board will have a higher rating than the fuses in any of the plugs.

iii) If a low power appliance, such as a reading lamp, was connected to the distribution board, it is likely that the rating of the flex for that appliance would be less than the rating of the distribution board's fuse. So if such an appliance was connected to an inappropriate fuse, there would be extreme danger. Remember that flex rating should always be greater than fuse rating.

4. Some fuel gases are heavier than air, and in an undisturbed atmosphere, they will settle out on the ground. Although only a low concentration can be detected by shifting the air about 2 m from the floor, there may be a much higher and dangerous concentration nearer to the floor. The action would be to open all windows and to create as much turbulence at floor level as possible – without generating heat or sparks (so don't switch on the lights), so that the gas mixture can be diluted to be harmless.

5. LPG is a non poisonous but toxic gas which may cause a fire hazard when gets in contact with air. The three important precautions to make the use of LPG safe in the laboratories are:

i) The LPG cylinder should be kept outside the laboratory in a ventilated room.

ii) It should be ensured to close the cylinder knobs when the laboratory work is over.

iii) Fire extinguishers should be available in the laboratory in case of an emergency.

UNIT 9

FIRE HAZARDS

Structure

9.1 INTRODUCTION

In the first unit of this block you have read about hazards due to electricity and gases in the Science laboratories. The second unit of this block deals with yet another type of common hazard which is because of fire. The consequences of fire are well known; still many do not take enough precautions and preventive measures. According to National Crime Record Bureau, a total of 20,377 cases of fire accidents were reported in the country during 2014, which caused 1,889 persons injured and 19,513 deaths. The person-in-charge of any laboratory should have a knowledge to handle a fire hazard. In case the fire spreads beyond control, the laboratory staff should know how to call the fire brigade, raise the alarm and ask for other help. In this unit, you will learn about the major causes of fire, its classification, precautions and prevention. You will also learn about the fire extinguishers. The next unit deals with hazards in handling chemicals and biological materials.

Expected Learning Outcomes

After studying this unit, you should be able to:

- ❖ explain the significance of the fire triangle;
- ❖ list common causes of fire;

- describe the purpose and use of fire alarms, escapes and barriers;
- classify different types of fires;
- list the main types of fire extinguishers;
- describe the use of different types of fire extinguishers; and
- describe how to use a fire blanket and the purpose of the buckets.

9.2 FIRE HAZARDS IN THE LABORATORY

The average Science laboratory is a particularly hazardous area when it comes to fire. Flammable liquids, liquefied gas, hazardous and reactive materials, are all either in use or in store in the laboratory. In addition, there are many sources of ignition available. Before you learn about the major causes of fire, let us see in the following subsection the factors that are required for fire to burn.

9.2.1 The Fire Triangle

Generally, a fire needs three things to burn:

Fuel – something to burn, e.g. oil

Oxygen – to maintain combustion

Ignition – something to start the fire, e.g. excessive heat, electrical spark, etc.

This principle can be depicted in the form of a triangle as shown in Fig. 9.1.

Fig. 9.1: The fire triangle

By removing any one of the three sides of the triangle, fire is prevented. For example, many fires obtain oxygen from the air where it is about 20% by volume. Fire extinguishers, e.g. sand or foam (subsection 9.4.2), prevent oxygen being available to the fuel or ignition source. Although air is the most common source of oxygen, other sources are,

- chlorates
- permanganates
- nitrates
- peroxides
- dichromates
- other oxidising agents

The essence of fire prevention is to prevent the formation of fire triangle

With air containing oxygen all around us, this consists primarily of keeping fuel and ignition sources apart.

You should watch the video programme on the concept of fire triangle available in English and Hindi languages. The title of the video programme is **"Just Break the Triangle"**. The video programme can be viewed at the study centre.

9.2.2 Causes of Fires

The potential fire risk arises from the presence of combustible solids, liquids or gases in conjunction with ignition sources. One or more class is generally found in most laboratories.

The 10 commonest causes of accidental fire are:

i) Smoking materials (matches, cigarettes, etc.)

ii) Misused/faulty electrical installations

iii) Mechanically produced heat or sparks

iv) Naked lights

v) Oxyacetylene equipment

vi) Malicious or intentional ignition

vii) Children at play

viii) Gas installations

ix) Oil installations

x) Rubbish burning

Flammable means the same as **inflammable,** i.e. likely to catch fire and their opposites are **non-flammable** and **non-inflammable**. Because "inflammable" has often been confused with "non-flammable", the word "inflammable" is hardly used. We recommend that you keep to current usage, i.e. "flammable" and "non-flammable".

And the most likely fuel sources for accidental fires are:

- Waste and rubbish
- Packing and wrapping materials
- Flammable liquids
- Electrical insulation materials

Fires are sometimes caused by the 'magnifying glass' effect of bottles and spherical flasks filled with liquid and standing in the direct rays of the sun.

Now try to do the following SAQ and check for the answer at the end of this unit.

SAQ 1

Suppose there is a beaker containing a flammable solvent and it catches fire. Keeping in mind the fire triangle, can you suggest a way this fire can be extinguished?

9.2.3 Classification of Fires

As explained in subsection 9.2.2 also, we can say that the four main sources of fire risk in the Science laboratory are:

i) flammable substances,

ii) compressed and liquefied gases,

iii) hazardous materials and reactions, and

iv) the availability of sources of ignition.

It is standard international practice to classify the main sources of fire according to their nature. In many directions and instructions on fire fighting equipment, a fire classification code is generally used to describe certain types of fires. The classification is summarised in Table 9.1 given below:

Table 9.1: Classification of fires

Fire Class	Type or Nature of Fire
A	Fires involving materials which contain carbon, e.g. wood, cloth, paper, rubber
B	Fires involving flammable liquids, e.g. petrol, oil, alcohol and many other organic solvents
C	Fires involving flammable gases, e.g. methane, propane, hydrogen, ethyne (acetylene) and butane
D	Fires involving flammable metals, e.g. sodium, potassium, calcium, magnesium and other combustible metals or their hydrides
E	Electricity and electrical appliances

After getting familiar with the general causes and types of fires, you will study in the next section about the precautions to be taken to prevent any type of fire. Before proceeding to the next section, try to answer the following SAQ.

SAQ 2

"The application of heat is needed in a large amount of scientific work and the Bunsen burner is the cheapest and most efficient way of supplying heat to any point in the science laboratory. For all its advantages, though, the Bunsen burner is a fire risk."

Write down, in a few words only, any points you can think of that could justify this statement.

9.3 PRECAUTIONS FOR FIRE PREVENTION

In the event of fire or explosion occurring there should be a prearranged plan of the necessary action to be taken. All personnel must be made aware of this and **fire drill should be carried out at least twice a year** in order to familiarise staff with these procedures. The essential procedures generally to be followed by the laboratory staff are explained in the following subsections.

9.3.1 Fire Alarms

Most modern fire alarm systems are electric and can be activated from several points throughout a building. These points usually consist of glass-covered switches which should be painted red and placed no more than 30 meters apart. Some sophisticated systems integrate alarm buttons

with a smoke detector system, and it is usual for a complete ban on smoking to be enforced in a building protected by a smoke detector system. The fire brigade should be called in case there is a need. The person-in-charge should be trained to assess the severity in case of an outbreak of fire and act accordingly.

9.3.2 Fire Escapes

When a fire breaks out in a building, it is not unusual for people to panic. Sometimes flames can spread rapidly, especially if fanned by blow of air from open or broken windows and doors, and blinding and choking smoke can soon envelop clear spaces. In such circumstances it is essential that escape routes are well known, clearly indicated and free from obstruction. Suitable escape routes are not susceptible to blockage or failure in emergencies. Similarly alarm points and assembly areas must be well indicated and accessible.

9.3.3 Fire Barriers

When a fire starts in a building it spreads quickly by:

a) **Radiation** – Intense heat radiates to neighbouring surfaces which are rapidly heated to ignition point. Materials themselves then ignite or when heated give off flammable gases and vapours.

b) **Convection** – Flames and hot gases rise by convection increasing the effects of radiation and burning the surfaces they touch. Thus ceilings quickly ignite and staircases and lift shafts often become quickest ways of spreading a fire.

Most people who die in accidental fires, die not from burning but from asphyxiation or poisoning from the fumes and smoke emitted by fire.

The spread of fire can be limited by compartmentalising the interior of a building with fire barriers such as

- fire doors
- fire retardant walls
- fire resistant floors

Fire doors are fitted with self - closing hinges and are always hung so as to open outwards towards the fire exit. They act in two additional ways in fire prevention.

i) they restrict oxygen supply to the fire.

ii) they act as smoke barriers.

Fire doors should always be kept closed and should never be obstructed.

We know that inspite of precautions taken at the work place there may be a fire outbreak. In such cases, the person-in-charge should know the use of fire extinguishers. In the next section we will study different types of fire extinguishers and their use. You can first try to answer the following SAQ.

SAQ 3

Lifts should not be used as fire escapes. Why do you think so?

9.4 EXTINGUISHING A FIRE

The techniques and equipment which you will learn about in this section relate to the standard kinds of fire fighting equipment found in buildings open to the public. This equipment is meant only to contain and extinguish small fires and is a first-aid fire fighting measure only. It does not in any way turn the user into a fireman. If for some reason you were unable to contain or extinguish a fire immediately, you would be well advised to evacuate the building and await the arrival of the fire brigade who are better able to control fire.

It is difficult for you to judge when it is best to desert the fire. Obviously if you've exhausted your extinguisher and the fire is still raging, it would be time to go. If you are using a fire hose, the decision is harder to make. Just remember that lives can easily be lost in an effort to rescue an over-zealous but unwise amateur fireman! Let us give a look at the different types of fire extinguishers in the next subsection.

9.4.1 Fire Extinguishers

You would recall the classification of fires dealt in subsection 9.2.3. Table 9.2 summaries the type of extinguisher used for different classes of fire.

Table 9.2: Summary of fire extinguishers for different types of fire

Extinguisher	Class of fire				
	A	B	C	D	E
Water	√ √	No	No	No	No
CO_2	√	√	√	No	√
Foam	√	√ √	No	No	No
Vapourising liquids: CCl_4 (carbon tetrachloride)		√			
BCF (bromochlorodifluoro methane-**halon**)	√	√ √	No		√
Dry powder	√	√	√		√
Dry sand	√	√	√	√ √	√
Fire blanket	√	√	√	√	√

This table as you can see only shows which type of fire extinguisher is to be used for what class of fire. However the laboratory staff should be trained to make use of fire extinguishers for different situations. Let us study this in the next subsection. Before proceeding, try to answer the following SAQ.

SAQ 4

Using the list given in (a) below, state the name of appropriate fire extinguishers for each of the fires mentioned in (b).

a) sand, carbon dioxide, fire blanket and water

b) i) fire involving flammable liquids and organic solvents ....

ii) fire because of burning clothing ....

iii) fire involving carbonaceous materials ....

iv) fire because of flammable and combustible metals ....

9.4.2 Use of Fire Extinguishers

We know that one type of fire extinguisher cannot serve the purpose on all kinds of fire. In this subsection you will study about the use of different types of fire extinguishers, fire buckets and fire blankets. How would you use a foam extinguisher, for instance? Would you just point it at a fire and force a jet of the extinguishing agent? Would you do the same with a water extinguisher or a carbon dioxide extinguisher?

There is no simple answer to any of these questions, but there is a technique to be learnt for each type of extinguisher. In the same way that you would use certain kinds of fire extinguisher for certain kinds of fire, you would use an appropriate technique for each kind of fire extinguisher. To do otherwise would be wasting valuable resources, probably at a time when these resources are most needed.

Remember that fire extinguishers are usually suitable only for small fires.

Use the following procedure for fire fighting:

1. Always take a position between the fire and the exit so your escape route cannot be cut off. **Fire extinguishers should always be placed close to doors and other exits** for this reason.
2. **Do not continue to fight a fire if it is dangerous to do so** or if there is a possibility that your escape route may be cut off by fire or smoke. A potentially fatal asphyxiating concentration of carbon dioxide can build up quickly if CO_2 extinguishers are operated in an enclosed space.
3. If you have to withdraw, **close doors or windows behind you,** wherever possible.

The recommended procedures for operating the different types of fire extinguishers are given below.

a) Water extinguishers

Direct the jet at the base of the flame and keep it moving across the fire. Attack a fire which is spreading vertically at its lowest point and follow the fire upwards. Concentrate the jet on any hot spots once the main fire is extinguished.

b) Carbon dioxide, Dry powder and Vapourising liquid extinguishers

Fires produced by spilled liquids should be extinguished by directing the jet or discharge horn towards the near edge of the fire and with a rapid sweeping motion drive the fire towards the far edge until all the flames are extinguished (Fig. 9.2). Other types of fire may be extinguished by directing the jet directly at the burning material. The current should be switched off first if the fire is close to electrical equipment. The controlled discharge type of extinguisher may be turned off once the fire is out, but the fire should not be left unattended as re-ignition may occur. Vapourising liquid extinguishers should not be used in a confined space if there is a danger that the fumes may be inhaled.

Fig. 9.2: Use of carbon dioxide and vapourising liquid extinguishers

A fire blanket may be used in conjunction with a carbon dioxide extinguisher, for example, for flammable liquids and other fires. The fire is first smothered with the blanket and the carbon dioxide extinguisher is used to ensure that all the flames are extinguished. Burning clothing should be extinguished by rolling the victim in the fire blanket on the floor. Fire blankets are more usually made of **glass fibre** than of **asbestos**. You will study more about fire blankets shortly.

Glass fibre is less than a quarter of a micrometer in diameter, that is woven into a cloth and impregnated with various resins.

Asbestos is a type of fibrous silicate mineral, mainly calcium magnesium silicate. It is used as a heat insulating material and for fire proof fabrics.

c) Foam extinguishers

If the burning liquid is in a container the jet should be directed at the inside edge of the vessel or at a vertical surface in order to break the jet and allow the foam to build up and spread across the surface of the liquid (Fig. 9.3). If this is not possible, the correct procedure is to stand well back (perhaps as far as 6 or 7 m) and to direct the jet with a gentle sweeping movement to allow the foam to drop down and form a layer on the surface of the liquid (Fig. 9.4). Do not aim the jet directly into the liquid as this will drive the foam under the surface where it will be ineffective in extinguishing the fire and may spread the fire by splashing the liquid on the surroundings.

Fig. 9.3: Use of foam extinguisher-I

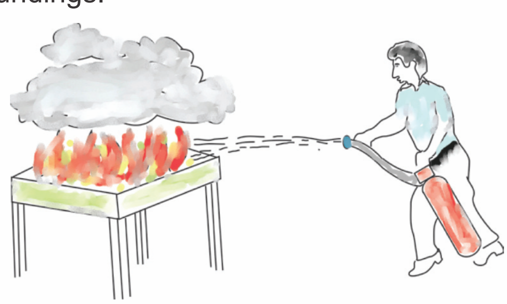


Fig. 9.4: Use of foam extinguisher-II

d) Fire Buckets

All labs should be equipped with fire buckets. The buckets are not used only for carrying water to a fire. This is one of their uses. The other way a fire bucket is used is by keeping it filled with sand and a scoop. You will find that sand can extinguish fire quickly and effectively. It is particularly useful for dealing with liquid spillage or with reactive chemicals such as alkali metals. Other advantages of sand are that it is easy to use and it is easy to clear up.

If you use sand as an extinguisher or absorber, use it liberally. Speed is important when controlling fire or dangerous spillage, but you must be careful not to throw a large quantity of sand onto the hazard in your haste. This could cause splashing which would make the hazard worse. Of course, sprinkling too little sand onto the hazard is equally useless. Quick, liberal pouring is the best method and you should aim to cover the whole area of the flames or spillage, working from the outer edge inwards. Sand buckets should be three-quarters full, and covered with a loose cardboard disc with a hole in the centre. **This sand should not be used for sand baths.**

e) Fire Blankets

We have already discussed the use of fire blankets, but it is worth noting that fire blankets are now made of glass fibre instead of asbestos, and that they are usually installed in conjunction with another type of extinguisher. The important points when using a fire blanket are to ensure that the blanket is:

1. spread out as much as possible.
2. laid as flat as possible on the burning surface.

A fire blanket should never be used on apparatus.

Remember the following in case of using fire blanket for extinguishing fire on someone's clothes:

- You must hold the blanket with the tapes wide apart.
- The bottom edge must trail on the ground.
- You must hold the blanket so that it protects your fingers from the flames, e.g. in clenched fists so that it hangs over your knuckles and forearms.
- You must wrap your arms around the casualty and pull him to the ground to avoid flames reaching the face and hair.

Knuckle: The joint connecting a finger to the rest of the hand.

Forearms: The part of the arm between elbow and wrist.

SAQ 5

Answer in **Yes** or **No** for the following questions. When using a foam fire extinguisher, do you,

1. direct the jet at the base of the flame ?
2. direct the jet at a surface adjacent to the flame to break the jet and allow the foam to settle on the burning surface ?
3. project foam so that it falls on to the surface from a distance ?
4. hold the extinguisher upside down ?

9.5 SUMMARY

Let us recall briefly what all we have learnt about fire hazards in this unit. Fire accident can happen due to a number of reasons, like, flammable liquids, faulty electrical and gas installations, etc. Three factors, fuel, ignition and oxygen are essential for fire to take place. Therefore, it is advisable to control at least one of these to prevent fire hazard.

The fires are classified into five main categories depending upon their nature. The laboratory incharge should be aware of all precautioning procedures like fire alarms, fire escapes, fire barriers etc, in case of an outbreak of fire. The staff should be trained in using different types of fire extinguishing devices like, fire extinguishers, blankets, buckets, etc. The laboratory staff should be able to judge the class of fire and act accordingly. This will help in preventing any casualty in the work place.

9.6 TERMINAL QUESTIONS

1. Imagine that the fire alarm has sounded, smoke is coming through the far end of the lab, and you are waiting for the last few people to come out of the lab. This gives you about ten seconds in which to perform one last task before leaving the lab door. Would you

   i) pack as many of your notes and belongings as possible into a brief case and carry them out?

   ii) find any fire extinguishers you can and take them with you?

   iiii) close all windows?

   iv) put your lab coat on ?

   Choose the correct answer and explain.

2. Wedging the door open is common practice in hot, stuffy weather, or when some particularly distasteful smell dominates the atmosphere. If the lab door is a fire door, do you think that wedging it open is justifiable? Briefly, write down reasons to support your judgement.

3. Bearing in mind the fire triangle, briefly state the principle behind the use of sand as an extinguisher and state for what type of fire can sand be used for.

4. Write down at least two examples for each of the following type of fire risk.

   i) carbonaceous materials

   ii) flammable liquids

   iii) hazardous materials

   iv) sources of ignition

5. What are the three general principles for fire-fighting?

9.7 ANSWERS

Self-Assessment Questions

1. The fire can be extinguished by putting a cover on the beaker and cutting off the supply of oxygen.

2. The burner is a fire risk because of

   i) its naked flame and proximity to fuel sources.

ii) difficulty in seeing whether the burner is on or off because of its invisible flame.

iii) the gas from the burner may leak and get ignited by a source of ignition.

3. Lifts are not to be used as fire escapes because a fire may cause electrical failure and jam the lift. Also the lift shaft is likely to fill with smoke and fumes.

4. i) carbon dioxide

   ii) fire blanket

   iii) water

   iv) sand

5. Yes for 2 and 3. Remember that the principle behind the foam extinguisher is to blanket the flames with a layer of foam. Method 1) would not achieve this but would probably spread the fire. Method 4) does not apply to modern extinguishers at all.

Terminal Questions

1. iii), Closing windows cuts off the oxygen supply in the same way as fire doors and thus helps to reduce the spread of the fire.

2. It is definitely a bad idea. This action defeats the main objects of a fire which are:

   i) to present a flame barrier to any fire,

   ii) to limit the oxygen supply to a fire by stopping air flow, and

   iii) to contain fumes and smoke.

3. Application of sand deprives a fire of oxygen (or its supporting medium) and prevents combustion. Sand is suitable for all types of small fires particularly those involving alkali metals.

4. i) wood, paper, timber

   ii) petrol, benzene, alcohol

   iii) sodium, potassium

   iv) excessive heat, sparks

5 i) Always position yourself between the fire and an exit.

   ii) Do not continue to fight a fire if it is dangerous to do so or your escape route is likely to be cut off by fire or smoke.

   iii) Where possible, close all doors and windows if you have to withdraw.

UNIT 10

CHEMICAL AND BIOLOGICAL HAZARDS

Structure

10.1 INTRODUCTION

You have read about the electricity, gas and fire hazards in the previous units. In this unit you will learn about two other common hazards. These are the hazards caused by chemical substances and the hazards due to biological materials. You will learn the classification handling, storage and transport of chemicals generally used in Science laboratories. A chemical hazard is likely in both Chemistry and a Biology laboratory; yet it cannot be ignored in a Physics laboratory. The additional hazards encountered in the Biology laboratories are diseases like infections and allergies. These are generally caused by handling of microorganisms. The proper handling, sterilization of apparatus and disposal of microorganisms has been discussed. We would discuss the major hazards caused by handling and working with biological materials and instruments used in handling these. Thus the hazards caused by handling chemicals, gases, electrical equipments, instruments and glassware are common for Physics, Chemistry and Biology laboratories.

Expected Learning Outcomes

After studying this unit, you should be able to:

- ❖ list the different classes of hazardous substances;
- ❖ explain handling aspects of hazardous chemical substances like, labels, packagings and use of fume cupboard;
- ❖ explain the proper and safe storage of different types of chemicals;
- ❖ explain safe methods of transport of bulk chemicals from store;
- ❖ explain the significance of personal hygiene in the prevention of chemical hazards;
- ❖ describe the principal hazards of Biology laboratory work and the ways to minimise the dangers;
- ❖ explain the necessity of using fresh needle, disinfectant and gloves while studying the blood samples;
- ❖ appreciate the need for care in handling, storage and disposal of sharps;
- ❖ outline the dangers associated with mishandling of microorganisms; and
- ❖ list the methods employed for sterilising apparatus used for microbiological experiments.

10.2 CHEMICAL HAZARDS

Chemicals are present in all laboratories. It is good to consider all chemicals toxic and flammable unless one has definite information regarding its nature. Our body also contains number of chemicals but these are very delicately controlled in terms of their nature, amount and action. Every chemical whether required in the body or not becomes harmful at a certain concentration in the body. Ideally speaking no chemical can be considered totally safe or hazard free. The nature and extent of hazard varies and more so the long time effects of many chemicals are not known. Everybody working in laboratory is advised to take precautions in handling all chemicals and minimise exposure to these.

In a laboratory, human contact with chemicals can take place in three possible ways. These are:

- direct contact from spills or by improper handling
- inhalation of the vapours, fumes or dust
- ingestion i.e. the oral route

Besides these, sometimes we can get affected indirectly also. For example, in case of an explosion one may get physically hurt – may be a fracture. On the other hand highly flammable liquids may catch fire and cause severe burns.

The hazardous materials supplied to your workplace must be labelled in accordance with Indian Motor Vehicles Rules 1988.

Storage and handling of chemical substances are two important duties of a laboratory worker. Both of these require appropriate safety measures to avoid any accident. In this section, you will learn about particularly the storage and handling aspects of hazard control. You will find out about the safe storage and handling of toxins or poisons as well as other hazardous substances.

Remember that in the laboratory where you work, there is a legal requirement for minimising or eliminating the risks of working with such substances. **Bureau of Indian Standards** (erstwhile Indian Standards Institution) also recommends classification and labelling of hazardous substances in line with the existing rules; the system is an adaptation of internationally followed procedure. Let us learn about the same in the following subsection.

10.2.1 Classification of Hazardous Chemicals

The classification of chemical hazards as recommended by the **UN Committee of Experts on the Transport of Dangerous Goods** has been widely adopted for the conveyance of hazardous chemicals for all modes of transport. Hazard types are segregated into nine basic classes represented numerically from 1 to 9. Many of these classes are further separated into divisions and subdivisions.

Hazard Identification

Each United Nations hazard class (with the exception of Class 9) has a distinctive diamond shaped label bearing a pictogram for quick hazard recognition. Fig.10.1 gives a colour chart for all the classes and subclasses. Each label has a characteristic background colour. These colours convey the nature of different chemical substances as given below:

Colour	**Nature**
Orange	Explosive
Red	Flammable
Blue	Water reactive
Yellow	Oxidiser
White	Toxic or Infectious
White or Yellow and White	Radioactive
Black and White	Corrosive

All the classes are discussed briefly in the following paragraphs.

Class-1: Explosives

These include the commercial explosives, preparations and substances used as blasting agents, ammunition, fireworks etc. Some examples are, gun powder, chlorate mixtures, nitrate mixtures, nitrocompounds, fulminates, ammunitions, fire works, detonators, gels, etc.

Class-2: Gases

A substance which has a **critical temperature** below 50°C, has a vapour pressure of more than 3 bars absolute is classified as a gas. You have read about Liquefied Petroleum Gas (LPG) and hydrogen sulphide gas in Unit 9. Gases are divided into 3 subclasses on the basis of their hazardous nature.

Critical temperature is the temperature above which a substance cannot exist as a liquid.

i) Flammable gases e.g. acetylene, LPG

ii) Toxic gases e.g. chlorine, sulphur dioxide

iii) Nonflammable nontoxic gases e.g. carbon dioxide, nitrogen, etc.

Fig. 10.1: Chart showing UN Hazard class symbols on transportation of hazardous goods

Class-3: Flammable Liquids

You have read in Unit 9, that the word flammable has the same meaning as inflammable. Flammable liquids are those liquids or mixtures of liquids or liquids containing solids in suspensions or solutions which give off flammable vapour at temperature of not more than 60.5°C. Examples of flammable liquids are petrol, alcohol, petroleum, naphtha, hexane, benzene, toluene etc.

Flammable substances are substances which

- catch fire on exposure to air without application of energy, or
- readily catch fire after brief contact with a source of ignition, or
- evolve highly flammable gases in contact with water or damp air.

Class-4: Flammable Solids

Flammable solids are substances which are flammable or liable to spontaneous combustion or emit flammable gases on contact with water. Examples are: camphor, cinema films, hay and straw, phosphorus, triethyl aluminium, sodium sulphide, alkali metals, alkali amalgams, uncoated aluminium powder, etc.

Class-5: Oxidising Substances

It includes oxidising substances and the organic peroxides. Oxidising substances are by themselves not combustible but by feeding oxygen to other substances cause or contribute to their combustion. Organic peroxides (having O-O-bond) undergo thermal decomposition leading to explosion and/or rapid burning. A few of the examples are potassium permanganate, potassium dichromate, hydrogen peroxide, peracetic acid, acetyl peroxide etc.

Class-6: Poisonous and Infectious Substances

These are the substances liable to cause death or serious injuries to health, if swallowed or inhaled or allowed to come in contact with skin. Infectious substances are those contaminated with disease inducing microorganisms. The examples of poisonous substances are pesticides, tetraethyllead and many drugs etc. The contaminated hospital wastes, strains of pathogens etc. are considered infectious substances.

Class-7: Radioactive Substances

These substances include dangerous radiations. Radium, uranium, thorium, etc. are few of the examples. The laboratories of colleges and universities use radioactive material which is responsible for the radiations emitted during the experimentations. These radiations are also hazardous and can cause severe hazards like cancers, mutations, skin problems, eye damage etc. These radiations damage cells depending upon their penetrating power.

Class-8: Corrosive Substances

These substances cause severe damage by chemical action when in contact with living tissue or in case of leakage, destroy/damage other materials. Mineral acids like hydrochloric acid and sulphuric acid and sodium hydroxide belong to this class.

Class-9: Miscellaneous Dangerous Substances

This was introduced in the United Kingdom to identify other hazardous substances and consists of a black exclamation mark on a white background.

Besides the above recognised classes for hazardous chemicals, there is another very important class of compounds which you should be aware of. These are called carcinogens. These are the substances which cause cancer. There are a number of substances which are known to induce cancer many months or years after the initial exposure. Some substances which are known or suspected carcinogens are aniline, chloroform, benzyl chloride, chromates of lead and zinc, hydrazine etc. Ninhydrin – the reagent used in biological and biochemical tests for the presence of amino acids and proteins, is also thought to be a possible carcinogen, but this has yet to be confirmed. Similarly some stains like fuchsin used in Biology laboratory also belong to this category and extreme care should be taken in their use. The examples given here are very few, however more and more substances are being shown to be carcinogenic and the fact that even quite common substances may have some carcinogenic activity emphasizes the necessity of consulting reference literature before starting work with materials when you are ignorant of their potential hazards.

Before proceeding further you can try to answer the following question based on the nature of hazardous substances.

SAQ 1

What precaution should you take while using the following chemicals. (Answer the question on the basis of the class of hazardous chemicals to which they belong)

i) Alkali metals

ii) Hydrogen peroxide

iii) Sodium hydroxide

10.2.2 Handling of Chemicals

Laboratory technicians who work in laboratories, need to be aware of the potential danger of the substances they handle. In the case of those working in chemical industry, specific provisions are made in Factories Act (1948) regarding health and safety of workers. Although your contact with reagents will be at a much lower level, as compared to those in industry, it is still necessary to pay due attention to the hazards of handling common laboratory chemicals. Before you undertake any practical work involving chemicals always be sure about safety aspects.

Labels and Packagings

In order to minimise the hazards associated with using a particular substance it is necessary to know what the precise dangers are. The label on the container provides a guide and indicates, for example, whether the substance is flammable, toxic or corrosive. Suppliers of materials to your laboratory are required by law to conform to the regulations. The regulations cover a wide range of substances including paints and solvents.

So far **as packaging** is concerned, packages need to meet three basic requirements:

i) All parts of a package must be designed to prevent leakage of the contents when handled normally.

ii) Packaging materials must not be damaged if they come into contact with their contents.

iii) Packages that are intended to be opened and closed repeatedly must be designed so that they do not leak after repeated closure.

Labelling is another important aspect in handling of chemical susbtances. A label must show:

i) the **name** of the substance. Chemicals must have their **IUPAC** (International Union of Pure and Applied Chemistry) name as well as their **trivial** name.

ii) an indication of the general **nature** of the risk. The corresponding warning symbol must be displayed if the substance is explosive, oxidising, flammable, toxic, harmful, corrosive or irritant.

iii) a **risk phrase** which underlines and explains the general nature of the risk, and a **safety phrase** which gives advice about precautions to be taken.

iv) the **name** and **address** of the manufacturer.

To illustrate, a typical label with markings as explained above is given in Fig.10.2.

Fig. 10.2: A typical label of a reagent bottle

This information may be sufficient if only small amounts of the material are being used occasionally. However, before carrying out extensive work or purifying a material, reference should be made to published sources to obtain full details of the substance's physical and chemical properties, of its particular hazards, and of the disposal procedure or first aid treatment to adopt in the event of spillage or an accident.

The Fume Cupboard

If a reaction uses or produces harmful gases, dusts or vapours, it poses a risk of inhalation. Such reactions should be carried out not on an open bench but in a **fume cupboard.** You would have read briefly about the designing part of fume cupboard in Unit 2 of this course. You might know that many laboratory operations need to be carried out in fume cupboard, e.g. working with nitrating mixtures, benzoyl chloride etc. A demonstration activity showing the use of a fume cupboard is given in CLTL-101 course (Experiment 10). A typical laboratory fume cupboard is shown in Fig.10.3.

Fig. 10.3: A typical laboratory fume cupboard

A fume cupboard is constructed to allow the normal laboratory services of gas, water and electricity to be utilised. In addition an air extraction system i.e. an exhaust fan, with a **minimum statutory air flow**, ensures that dangerous vapours are vented to the atmosphere.

Access to the fume cupboard is via **sliding panels** of safety glass. It is important to note the maximum height to which these panels can be safely raised before the air flow into the fume cupboard drops below the required rate.

SAQ 2

It used to be a common practice in some laboratories to store dangerous chemicals in fume cupboards. This practice is no more in use. Why do you think this is so?

10.2.3 Storage of Chemicals

You have read about the stores as important structures of all the laboratories in Unit 3. Storage of chemicals whether in small amount or in bulk is another important aspect of laboratory management. In this subsection we are going to discuss a few important types of hazardous substances taking into account their storage.

Poisons

It is essential that all dangerous substances, such as cyanides, are always kept under close control. Steps to ensure such control are as follows:

i) All substances of high toxicity must be kept in a locked cupboard or store and logged in and out as required.

ii) The key should be accessible only to responsible workers in the laboratory and the contents of the poison store should be checked weekly.

iii) Only the quantities required for specific experimental purposes should be issued and then stored in clearly labelled containers.

iv) No work involving poisons should be carried out without knowing the action to be taken in case of accident and the required antidotes should always be handy. It is usual to issue **antidotes** and first aid instruction when such substances are issued.

Antidote: A medicine or a remedy for preventing or counteracting the effects of poison, disease, etc.

Explosives

As defined earlier explosives release a large amount of gas and energy in a very short time. These are of four basic types:

Mixed gases: Usually the mixture is of a gas with air or hydrogen. Any flammable liquid as a vapour or aerosol will similarly create an explosive mixture although some of these mixtures may, in the strictest sense, be considered to burn very quickly, e.g. a petrol/air mixture. It would take only the smallest spark, such as the static spark of a nylon laboratory coat, to ignite this kind of mixture and anyone who witnesses that kind of accident probably wouldn't be interested in the scientific differences between an explosion and a rapid burn the devastation in the laboratory would be the same!

Flammable dust: When mixed with air, this can cause two explosions. The first generates more dust which then causes a second, more violent explosion. Ordinary dusts may also cause severe explosion when mixed with air, and this is one of the commonest causes of explosion in industrial environments, e.g. flour, wood dust, lycopodium powder. These can cause lung problems too!

Oxidiser/Reducer mixture: Mixture of strong oxidising and reducing agents invariably produces highly explosive results, e.g. gunpowder.

Unstable compounds: Such as picrates, sodamide, potassium metal, azides, acetylides, etc. The list of potentially explosive substances of an explosive mixture may be present as an impurity and is therefore "an unknown", e.g. Leclanche cells utilising manganese dioxide which can contain carbon dust as an impurity.

Flammable Liquids

Bulk supplies of all flammable liquids should be kept in a solvent store well away from main buildings. The store should be securely locked and fire warning notices should be prominently displayed on the door. Electric switches for power and lights in and around such stores should be **"spark free"** to prevent the ignition of spilled solvent vapour. For the same reason, safety lights in which the hot surface of the electric light bulb is contained within a glass cover

Winchester bottles: Amber coloured round, strong and heavy bottles used for storing liquid chemicals in laboratories.

The quantities of up to 50 dm^3 (≈ 20 winchesters) can be kept in a preparation room provided that they are stored on a fire resistant cupboard on tin fitted with retention sills. Larger quantities must be kept in a special store detatched from the main building and no more than 500 cm^3 of any one highly flammable liquid should be kept on the shelf in a laboratory.

should also be fitted. This isolation of large drums and **Winchester** bottles of flammable solvents, etc. considerably reduces the extent and likelihood of fires.

Bottles of liquids must not be placed in direct sunlight. As mentioned in the previous unit the liquid contained within the curved glass can act as a lens to focus the sunlight. Considerable increase in temperature may result in a fire. A steel bottle store is suitable for keeping small amounts of flammable liquids that are used in schools and other small laboratories. These containers should be properly labelled to indicate a fire hazard and should not be located near radiators or any naked flames. The ideal storage for bottles of flammable liquids is in a thick wooden box with a retaining sill inside a metal container.

Substances which might be unstable can be kept stable by storage in the correct environment, e.g.

- store sodium in kerosene
- store white phosphorus under water
- store silver residues in an acid condition using hydrochloric acid etc.

You must not store explosive materials such as sodamide ($NaNH_2$) and potassium metal in bulk. Your best option is to buy this kind of material in amounts which can be used in a year, because after this time it may become explosive. Another example of a substance becoming explosive if stored too long is ether. Periodic testing for its oxidising properties using potassium iodide and hydrochloric acid (giving iodine) indicates the condition of the ether. If the test proves positive, the ether must not be allowed to evaporate to dryness.

Compatibility of substances is another headache for you if you have to work out storage of substances. The basic requirement of fire prevention, i.e. separation of fuel from ignition sources (flammable substances from unstable substances), must be observed.

SAQ 3

What is the maximum amount of highly flammable liquid that you should store in a preparation room and what is the condition on which it is kept in this way?

i) 500 cm^3

ii) 5 dm^3

iii) 50 dm^3

Condition:

10.2.4 Transport of Bulk Chemicals

Ideally only sufficient concentrated acids, flammable solvents and other hazardous chemicals should be kept in the laboratory for immediate requirements. Larger amounts, e.g. 500 cm^3, one litre and two litre (Winchester) bottles, **carboys** and metal drums, should always be kept in a separate store.

Carboy: A large globular glass bottle with a narrow neck used for holding acids or other corrosive liquids.

Acid resistant trays or troughs are required for the storage of concentrated sulphuric, nitric and other acids. They are also useful for storing all liquids as the tray will contain any bottle which breaks and thus prevent harmful liquids soaking into shelves and spilling over onto other containers or onto the floor.

Never carry Winchesters by the neck as the bottle can easily slip out of your hand and smash on the floor; and don't carry these bottles in the arms or in the hands. A proper carrier must always be used for transporting Winchesters from the store or from one laboratory to another.

Carboys of concentrated acids and other liquids should be vented otherwise, the increase in pressure as the contents heat up on being brought from a cold store into a warm room is sufficient to burst the carboy. Whenever possible, carboys should be left in the bulk store.

10.2.5 Transfer from Large Containers

As with all dangerous operations, it will pay you to think what the worst possible accident may be that could result from your actions, and what would you do in this event. Thus when you decant from a large container you must expect:

a) **Drips and spillage:** Is there a fire hazard? If so, what extinguishers are available? Is there a risk of corrosion? What is the receptacle standing on, and is it stable? Are there neutralising agents? What mopping up facilities are there? Is there a sand bucket? etc.

b) **Splashes and fumes:** Similar points to (a) must be considered by you and you must also ask: Should this operation be conducted in a ventilated area? Do I need protective clothing? Is there someone nearby to give first-aid if there is a bad accident? etc. If a non-conducting fluid is being decanted from a glass or plastic container, consideration must be given to earthing containers and funnels. Sufficient static electricity could be built up to spark off a fire or explosion.

10.3 HYGIENE

We all would agree that chemical hazards can be prevented to a certain extent by maintaining a good hygiene. Hygiene in this context can be discussed in the following three categories.

Personal Safety

You would recall that there are mainly three routes through which the harmful substances can enter the human body. These are, direct contact followed by penetration, ingestion and inhalation. By keeping chemicals off the skin, through use of protective equipment, regular washing, etc. you will avoid skin sensitisation, **defatting**, dermatitis (a prescribed industrial disease) and the danger of transferring contaminants to other parts of the body such as the digestive system. A common source of skin contact is through putting coats, cases or bare arms on laboratory benches. Before leaving the laboratory you must always wash your hands after removing your laboratory coat. Here we would like to mention that sharing laboratory coats is known for transmission of disease and vermins. So we don't recommend sharing laboratory coats, even with your best friend. Neither should you wear your laboratory coat while going home.

Defatting: Removing fat.

Personal Sensitivity

There are other dangers from substances which are not so common, e.g. **mutagens,** but one aspect we have not mentioned involves you. The eyes, lungs and skin of different people can vary greatly in their sensitivity to chemicals. Also certain substances e.g., detergents, epoxy resins,

Mutagens: A substance that produces mutations (sudden change in genes.)

disinfectants, dyes, nickel and chromium salts, are more likely than others to cause dermatitis and skin trouble. Most of these disorders can be overcome by simple hygiene, e.g. the use of gloves, etc. The situation is complicated by the fact that people may suddenly become sensitised and react to very minute amounts. A common example is a bee keeper who is used to stings may suddenly have to give up bee keeping because he has been sensitised which means that he has become allergic to bee sting and the next sting might kill him.

Laboratory Hygiene

The need for continuous attention to hygiene in any type of laboratory cannot be overemphasised. Any spillage of chemicals, battery acid, blood, plasma, serum, etc. must be cleaned up at once from the bench, floor or other contaminated equipment. Traces of chemicals or other harmful materials can easily be transferred from the fingers to the lips or eyes where considerable damage may result.

After studying about the safe handling, storage and transfer of chemicals you will learn some important hazards associated with a Biology laboratory. You can proceed after answering the following SAQs.

SAQ 4

If you had to transfer benzene from a Winchester into a conical flask, would you:

i) do it by a window; or

ii) do it anywhere; or

iii) do it in a fume cupboard; or

iv) wear any protective clothing?

Tick (✓) mark the correct answer(s) in the above.

SAQ 5

Comment on the statement that only a few of the chemicals handled in a general science laboratory are harmful in one way or another.

10.4 HAZARDS IN THE BIOLOGY LABORATORY

Laboratories in the Biology department of schools, Colleges and Universities and other higher level organisation such as hospitals, veterinary establishments, pharmaceutical companies, departments of forensic sciences etc. are all concerned with the examination of living or dead organisms and animal, human and plant tissues or specimens taken from these sources. The same is true of many laboratories that monitor the output of food production factories, or that carry out environmental monitoring.

The particular hazards of Biology laboratory are infections and other diseases like, allergies due to the above mentioned reason. Infections and allergies can be caused by the ***inhalation*** and ***ingestion*** of substances in the form of fumes, fine spray or aerosol produced during pouring, stirring, centrifugation, etc. or as a dust from dried material. Infected matter can also ***penetrate*** into the body through cuts, scratches and other breaks in the surface of the skin. Other dangers in Biology laboratories come from keeping of experimental animals and the possibility of stings, bites and scratches.

You can see in the list given below some of the causes of most common dangers which you would meet in Biology laboratory work: The school laboratories may not be dealing with all that is listed. However, the exhaustive list is given for the sake of your knowledge.

1. Sharps, i.e. needles, scalpels, razors, glass, lancets, microtome blades, hypodermic needles, pins and awls.
2. Microorganisms, cultures.
3. Laboratory animals and their carcasses, bedding, litter.
4. Electrical equipment such as aquaria, water baths, incubators, ovens.
5. Heaters such as autoclaves, ovens, Bunsen burners.
6. Solvents for chromatography, histology.
7. Hazardous solutions during pipetting and handling.
8. Carcinogens such as stains, e.g. fuchsine, solvents, pesticides, preservatives, crude oil.
9. Toxicants or toxic substances, e.g. fixatives, preservatives, pesticides.
10. Radioactive tracers.
11. Intense light sources like ultraviolet.
12. Spores, pollen, plants, preservatives that cause allergies and hypersensitivity.

In this unit we want to concentrate on the first three items of the list as these relate directly to the fundamental dangers of the Biology laboratory, namely disease and infection. You will study about other items in the CLT-102 course of this programme.

10.5 LABORATORY ANIMALS

In this section, we shall deal with three important aspects concerning laboratory animals. These are supply, handling and disposal of animals.

10.5.1 Supply

Laboratory animals must be obtained from accredited dealers and by accredited dealers, we mean suppliers in the business of supplying animals for laboratory use, and not from pet shops. The animals should be sold as “pathogen-free”. Wild animals, mammals and birds, are even more likely to introduce disease and you must never allow them into the laboratory. They generally play host to a multitude of fleas, ticks, mites, skin fungi and pathogenic gut bacteria. Apart from the harm they might do to laboratory personnel, they can pass on disease to other laboratory animals.

10.5.2 Handling

The desire for survival is same whether in animals or human beings. You may be aware of the ability of even tiny animals to scratch and bite. So we won't say any more on the matter apart from reminding you of the severity with which even the smallest cuts and scratches should be treated in the Biology laboratory. You should always take normal hygiene precautions when handling animals and their cages, litter or bedding. Cages should be regularly sterilized and bedding changed. Wearing rubber gloves and washing hands afterwards, are the exercises you should not forget. You must also keep up-to-date with your anti-tetanus injections. It is important that you should consult your doctor about the time interval between two consecutive injections.

10.5.3 Disposal

Opaque bags are recommended for disposing off carcasses. You should also put freshly dissected animals and tissues into opaque plastic bags, seal them and dispose them off in the normal refuse. Animal bedding etc., is disposed off in the same way. However, if you have to dispose off any of these from an infected or diseased animal, you should **incinerate** the bags.

Incinerate: Destroy the waste material by burning.

The dangers of working in laboratories with animals will be minimised if the following precautions are taken:

1. Wash all dissection instruments in disinfectant after use.
2. Never eat seeds or parts of plants provided for study as they may have been treated with toxic fungicides. Never store foodstuffs in the same refrigerator where dissected specimens, serum, microbiological cultures or other biological materials are stored. (You should never bring food or drink into the laboratory anyway).
3. Do not let wild birds or mammals into the laboratory as they can carry and transmit diseases fatal to man. Examples of such diseases include **psittacosis** from wild birds. Monkeys and other primates may be carriers of hookworm, rabies and B-virus infection; and laboratory rats are a frequent source of salmonella poisoning. Most wild mammals are infected with fleas and other pests and can carry flukes, tapeworms and other parasites.
4. Wash the area where the dissection was performed with disinfectant. Autoclave all bacteriological and fungal cultures before disposal.
5. Always wash your hands before leaving the laboratory or after handling experimental animals or materials of biological origin.

10.5.4 Sharps

Cuts due to careless handling of sharps such as sectioning razors, microtome blades, etc. are probably the most common cause of injury in the Biology laboratory. The only real remedy is to reduce the likelihood of such injuries through appropriate and adequate training. If, for example, you cut your finger during dissection, you must regard the injury as serious because of the risk of introducing micro-organisms into the body from a contaminated instrument. Contamination is reduced by washing and sterilizing instruments after use.

Sharps are best stored in manufacturer's packaging if appropriate, although the use of plastic trays and partitioned drawers is useful. Sharps are dangerous all the time as their working surface can make contact with people or equipment – before, during and after use. Safe disposal is as important as safe storage and we recommend that you use the "post-box" method. This consists of a stout labelled box (not too big) which has a small opening or slot in the top. After use, the scalpel blade, lancet, needle or whatever, is simply posted through the slot, and when there are sufficient old sharps in the box, plaster of Paris is poured into the box. You can then throw the box away in the dustbin. This method can also be used for broken glassware.

SAQ 6

What is the major risk in handling the laboratory animals? Suggest two remedial measures.

SAQ 7

a) Complete the following sentence using the appropriate clause. "It is essential to take great care when handling sharps because

   i) they are easily damaged".

   ii) small (and large) wounds are easily inflicted and infected by idle sharps."

   iii) most sharps become blunt very easily."

b) Which of the following do you think is a good way of disposing of old needles or razor blades?

   i) post them through a slot in a stout wooden or metal box.

   ii) throw them in the wastepaper bin.

   iii) keep them in a drawer until sufficient have accumulated to make a trip to the dustbin worthwhile.

10.6 MICROORGANISMS

Great care must be taken in microbiological experiments, particularly with pathogenic (disease producing) organisms. Many microorganisms which are normally harmless, such as *E coli* in the intestines, can produce disease in a different habitat. *E coli*, for example, can cause septicaemia if it finds its way into the bloodstream. The most common sources of microorganisms are cultures, laboratory animals (including their bedding and litter), dissection material and soil. Routes of entry into the body are as follows:

Inhalation - through the nose and mouth into the respiratory system, also through the eyes via tear ducts to the nose

Ingestion - through the nose and mouth into the digestive system

Penetration - through skin injuries

In this section you will study about the precautionary measures that need to be undertaken while conducting the laboratory work using microbes.

10.6.1 Handling

You can reduce direct contact with microorganisms by careful handling and by wearing protective clothing such as rubber gloves, mask, laboratory coat, etc. Even if you entirely eliminate the likelihood of direct contact, you could still be at risk because of airborne organisms from the formation of aerosol droplets and dispersal of fungal spores. If these hazards do exist, work should be carried on in a sterile cabinet with a filtered exhaust, such as a transfer chamber i.e., a laminar flow (Fig. 10.4). In CLT-102 course you will read about general structure and functioning of a laminar flow.

Fig. 10.4: A transfer chamber inoculation

Non-pathogenic and approved cultures can be transferred in the open laboratory so long as you use correct aseptic techniques. It is important in this technique to ensure that the work bench is cleaned by spirit. It is always better if the work bench has water proof cover that can be removed and washed if spillage occurs. Spirit lamps should be used for heating the surrounding air as heating the air has germicidal effect. The wire or loop used for inoculation is sterilized and cooled before it touches the culture, otherwise sizzling occurs with aerosol droplets thrown into the air. You must take care that before lighting the flame the spirit used for wiping the working table should completely dry, as spirit is highly inflammable. When pipetting, you can avoid splashing by releasing the contents of the pipette under or onto the surface of the receiver – do not release it from a height. Keep a discard jar or tray with a disinfectant in it, on the work bench so that you can put used pipettes, loops, swabs etc. in it. You will be far safer if you regard all microorganisms as **pathogenic** because even harmless ones may be contaminated by dangerous forms.

Pathogenic: It is a medical term that describes viruses, bacteria and other types of germs causing some kind of diseases.

There are other aspects of handling microorganisms which should receive your attention. For instance, you could easily become contaminated from culture plates, therefore you should seal petri dishes with clear tape before allowing them to be examined by you or inexperienced students. If you wish to kill the microorganisms in the petri dish before they are examined (and it is possible to use killed cells for microscopic examination), you can insert a filter paper soaked in 40% methanol into the inverted dish. To avoid poisonous methanol fumes, carry out this operation in fume cupboard, and leave the dish for twelve hours.

As with other biological techniques, you should always take care to sterilize the equipment after you've used it to cut down the chances of infection. You will also ensure that infection is contained if you have a bottle of disinfectant on hand to deal with any upsets. A 10% hypochlorite solution or methylated spirit can be used. You will perform an experiment dealing with the sterilisation technique in CLTL-102 course of this programme.

10.6.2 Sterilisation of Apparatus

Containers of dangerous biological materials and the doors leading to laboratories or rooms in which work with pathogenic microorganisms is carried out should be labelled with the ***biohazard warning symbol*** (refer to subsection 10.2.1). The following methods are employed to sterilise different types of apparatus for microbiological experiments. You will study about autoclave, hot air oven and how to operate these instruments in CLT-102 course.

Glassware *(e.g.* ***petri dishes, pipettes, flasks, test-tubes and syringes****)* – Stopper the washed and dried flasks and tubes loosely with cotton wool and wrap pipettes and syringes in brown paper or metal foil before sterilising in a hot air oven at 160^{o}C for 1 hour.

Inoculating loops, mouths of culture tubes, slides, cover slips and forceps points – Dip in disinfectant, wash and pass through a flame before use.

Contaminated floors and benches*.* – Wash with 3% 'Lysol' solution or other suitable disinfectant solution.

Culture media, rubber washers and bottle caps*.* – Heat for 30 minutes under pressure in an autoclave or pressure cooker.

10.6.3 Disposal

You must always sterilize cultures and contaminated instruments and glassware before disposing them of or before washing-up. Usually, you can do this by autoclaving or soaking overnight (at least twelve hours) in a suitable disinfectant. The culture material is sterilized mainly by autoclaving.

10.7 PLANT MATERIALS

You have studied about the handling of microbial materials in subsection 10.6.1. You are aware that the Biology laboratory deals with plant materials too. A situation similar to the handling of materials can arise while working with **plant materials**. You can encounter pollens or other plant parts and products that can cause allergies, cuts and bruises. As in case of microorganisms you can reduce the risk by wearing gloves, masks and laboratory coat while working with such materials. If you are handling some known **allergens**, it is advisable to work on a fume cupboard with filtered exhaust. If such cupboard is not available in your laboratory, work in open area with proper aeration and exhaust.

Allergen: A substance that causes an allergic reaction.

SAQ 8

Here are four waste items from Microbiology and Biology laboratories and three disposal methods. Can you match a method to the waste?

Waste		*Method*
(1) Microorganism culture	(a)	Disinfect and throw in glass waste bin.
(2) Dead mouse	(b)	Autoclave
(3) Contaminated litter	(c)	Seal in opaque bag and throw away or incinerate
(4) Chipped, contaminated pipette		

10.8 SUMMARY

Let us summarise the important points that we have understood about the chemical and biological hazards in this unit.

One of the hazards very common mostly in chemical laboratories is in the storing and handling of chemicals which are toxic and explosive in nature. The hazardous chemicals are generally poisonous, explosive and flammable type. There are regulations which classify these chemicals into different categories. The precautions should be strictly followed while storing and handling them. The transport of these materials is also very important. A laboratory staff should be well aware of use of fume cupboards and other safety devices to prevent any hazard due to dangerous chemicals.

The major hazards encountered in the biological laboratory work are diseases like infections and allergies which are caused by handling live animals, dissections, plant and animal tissues, microbes etc. The infections are caused by ingestion, inhalation and penetration through cuts, scratches of the substances in the form of fumes, fine spray or aerosol produced during the work with biological materials. Precautionary measures include proper cleaning with disinfectants before and after the work, usage of masks, laboratory coats and rubber gloves during the work, safe disposal, incineration and sterilization methods etc. Sharp objects used in Biology laboratory work like razors, pins, scalpal, needles etc. can cause injury. So these should be handled properly and, after use should be properly covered and disposed off in covered boxes. Working with microbes requires special care, such as a different working area, use of disinfectants, proper handling of cultures and sterilization of the instruments.

10.9 TERMINAL QUESTIONS

1. Poisons must be kept locked and should be logged in and out of storage, and you should always lock the laboratory and laboratory room doors if they are to be left unattended at any time as additional security. If you were issuing a particularly nasty poison, such as phenol, from the poison cupboard to someone else working in the laboratory, would you consider issuing anything else with the chemical?

2. If you had to transfer a Winchester of a strong liquid oxidising agent from a cold store to a warm preparation room, would you take any extra precautions in its handling?
3. What is the minimum information you would include on the label of a beaker containing a preparation from, say, a laboratory experiment?
4. For what reasons on purely safety grounds are smoking, eating and drinking normally banned in laboratories?
5. What are the two factors you should consider while purchasing the animals for Biology laboratories?
6. What four steps would you take to minimize infection after performing a dissection?
7. List the advantages and disadvantages in using wild animals, birds or mammals for laboratory work.
8. List the precautionary measures by which you can avoid direct contact with microorganisms?
9. How many Winchesters do you think it is safe to carry in one arm:

   i) one

   ii) two, or

   iii) none?

   And would you hold them

   iv) by the neck, or

   v) at the base?
10. What action would you take before allowing microorganisms in a petri dish to be examined by inexperienced people?

10.10 ANSWERS

Self-Assessment Questions

1. i) Alkali metals - belong to Class 4 which on contact with water are liable to spontaneous combustion. They should be kept away from water (should be kept in kerosene)

   ii) Without proper knowledge should not be mixed with other chemicals for example copper, iron metal or their salts otherwise may result in combustion.

   iii) Gloves or spatula should be used to avoid any skin contact while taking out of the bottle.
2. A fume cupboard is not designed for long-term storage of hazardous chemicals. There are other ways of keeping these reagents safely so that they do not pose a danger to those using the laboratory. In addition, the "clutter" provided by containers of harmful reagents is itself a danger to safe use of the fume cupboard. Also in the toxic environment of the fume cupboard, reagent labels become unreadable and inclined to disintegrate, which only adds to the danger, as it is then impossible to identify the contents of these containers.
3. iii) So long as it is kept in a fire resistant cupboard or bin with retention sills which is suitably located.

4. iii) and iv), gloves, a laboratory coat and goggles would be required.
5. Nearly all are harmful under given appropriate circumstances. The problem is to decide which substances are the most dangerous that should be kept locked and logged.
6. The major risk in handling the laboratory animals is exposure to infected material. The two ways by which the risk of infection can be avoided are:

   i) taking hygiene precautions and using disinfectant while handling the animals,

   ii) choosing right way of disposal of animals/tissues – either in opaque bags or incineration.
7. a) – (ii). Although (i) and (iii) are true, (ii) is the real danger.

   b) – (i). From (ii) and (iii), you have the risk of hurting your feet and fingers.
8. (1) – (b); (2) – (c); (3) – (c); (4) – (a)

Terminal Questions

1. i) A special hazard warning, preferably in writing with a proper label on the container showing details of the chemical.

   ii) An antidote preparation where it is not readily available in the laboratory. In the case of phenol, we would issue some glycerol and swabs as a first-aid measure in the event of skin contact.
2. Apart from the points that we've already discussed you would need to make an outlet in the bulk liquid container which have been transferred from a cold to a warm environment to allow for expansion.
3. i) The standard warning sign as appropriate

   ii) The name of the substance

   iii) The name of the member of staff and/or student responsible

   iv) The latest date for keeping the preparation
4. Smoking presents a serious fire risk, especially near where flammable liquids are kept. Tobacco smoke can also interfere with a number of sensitive chemical and physical processes being carried out in the laboratory. The consumption of food and drink in a laboratory can lead to accidental contamination from chemicals present in that environment.
5. Laboratory animals should be – (i) Purchased from accredited dealers, i.e. suppliers in the business of supplying animals for laboratory use. (ii) The animal should be pathogen free.
6. i) Wash all instruments, sterilize them and put them away.

   ii) Ensure that any carcass or disposable material is disposed of correctly.

   iii) Wash the area where the dissection was performed with disinfectant.

   iv) Wash your hands thoroughly.
7. Advantages – None. The criteria of cost can not be an argument because diseases imported with these animals can be fatal.

   Disadvantages – You, your colleagues and animal population of your laboratory are at the risk of getting infected with diseases like rabies or salmonella poisoning.
8. The direct contact with micro-organism can be avoided by wearing protective clothing such as rubber-gloves, a laboratory coat and a mask.

9. Hopefully you will have seen this as one of few “trick” questions. The answer is (iii) since you must only carry Winchester in appropriate carrying cases held by a carrying handle; (iv) and (v) don’t apply. We hope that you weren’t caught out!

10. Seal the petri dish with clear adhesive tape. Label the petridish on the outer side of its base with the details of the date of inoculation and the name and strain of microorganism culture. After use the petri dish should be kept upside down i.e., in inverted position so that the spores fall in the lid of the petriplate and not spread out.

UNIT 11

PERSONAL SAFETY

Structure

11.1 INTRODUCTION

In the previous three Units of this block you have learnt about different types of hazards in Science laboratories. We can say that a Science laboratory can be a hazardous place and we need to observe safety precautions while working there. In this Unit, we introduce you to the fundamentals of personal safety in a laboratory. If you do not follow safe laboratory practice, your life and those of your lab inmates could be in danger.

As all concerned people need to contribute towards the laboratory safety we would begin by discussing the role of teachers and the Head of the institution in maintaining laboratory safety. We would then take up the code of behaviour of laboratory staff in terms of its need and execution. This will be followed by the discussion on the disposal of laboratory waste in terms of its classification and disposal. We would give a relatively detailed account of disposal of chemical waste. We would also take up the precautions to be followed while opening and closing of the laboratory and while shifting heavy objects in the laboratory.

Adherence to good personal safety code could lessen the occurrence or the consequences of accidents; however accidents can still happen. In the next Unit we would take up the issue of laboratory accidents and the first aid.

Expected Learning Outcomes

After studying this unit, you should be able to:

- list the duties of the teachers and the Head of the institution towards safe working conditions in a laboratory;
- recognize the necessity of personal code of behaviour in a laboratory;
- state the need for using the appropriate protective devices in a laboratory;
- explain the hazards of storing and consuming food or drinks and smoking in a laboratory;
- define unserviceable and obsolete items in the laboratory and state the methods of their disposal;
- outline the causes of chemical wastes in the laboratory and explain the methods of their disposal;
- discuss the precaution to be followed while opening and closing the laboratory; and
- explain the proper method of shifting heavy objects in the laboratory.

11.2 DUTIES OF THE TEACHERS AND THE HEAD OF THE INSTITUTION

Safety in the laboratory is the collective responsibility of the Head of the institution, teachers, laboratory staff like you and the students. It must be realised that in case any serious accident takes place in a laboratory, the Head of the institution and the teachers will have the responsibility, at the first instance, to explain the causes. We have given below some measures to be taken by the Head of the institution and teachers in ensuring safe working conditions in a laboratory.

i) Safety aspects must be taken into account while planning the laboratory buildings, the purchase of equipment, chemicals, etc. Bureau of Indian Standards, Delhi, has prescribed safety norms through many of its publications. Some of these are:

   - National Building Code of India (it includes safety codes for construction of buildings, fire, electricity, water supply, drainage, gas supply etc.)
   - Codes of safety for chemical, microbiological and radiochemical laboratories
   - Code of safety for electrical equipment and mains operated electronic equipment

   The guidelines given in these codes should be made known to the teachers and the laboratory staff through institution level training programmes.

ii) Laboratory building should be maintained in safe condition. The condition of the building, furniture, fire safety units, electrical connections and appliances, water pipes etc. may be checked at least once in a year. Any repair required must be attended to on a priority basis.

iii) At the time of purchase of gas cylinders (chlorine gas, oxygen gas) etc., if being used, the safety instruction sheets must be obtained from the dealer and preserved for use.

iv) The laboratory staff should be provided with protective clothing and other safety devices.

Immunisation: Protection against specific disease.

v) All laboratory workers must be immunised against tetanus. Additional immunization may be done if their work exposes to any special risks of infection, especially in a biology laboratory.

vi) Appropriate training must be given to lab staff in

- handling equipment, chemicals, biological specimens etc.,
- using gas cylinders and fire fighting equipment,
- shifting heavy objects,
- waste disposal, and
- giving first aid.

vii) The lab staff must be instructed to prepare a list of phone numbers and addresses of the following for use in case of any emergency:

- nearby doctors, hospitals and ambulance services
- police,
- fire service,
- electricity supply agency,
- gas supply agency,
- water supply agencies, and
- fire fighting equipment dealers.

This list should be prominently exhibited in the laboratory. An activity is included on this aspect in Experiment 12 of the laboratory course CLTL-101.

viii) The laboratory staff must be instructed to keep records of accidents occurring in the laboratory (as discussed in Sec. 12.2 of Unit 12). These records may be examined at least once in a year to plan additional safety measures for the laboratory.

11.3 CODE OF BEHAVIOUR FOR THE LABORATORY STAFF

Accidents do not happen on their own; these occur due to negligence at some level.

As mentioned above, a science laboratory is a potentially dangerous working environment. Cuts from broken glass; chemical or thermal burns; poisoning and catching infections are some of the examples of accidents that could occur in the laboratory. In order to avoid such laboratory accidents, you must follow a set of rules commonly known as **personal code of behaviour**. In addition, the conduct of laboratory staff has an educational value also. The students in the laboratory learn from what all they see from the teachers and the laboratory staff like you. Therefore, you also have a responsibility of building a positive attitude in the students towards safe working practice by following the same.

11.3.1 Code of Practice in a Laboratory

The following is a set of rules that should be followed by the people while working in a laboratory:

1. Always wear the required protective clothing.
2. Make sure that you know the positions of the main valves and switches for controlling supplies of water, gas and electricity to the laboratory.
3. Make sure that you know the locations of telephones, fire alarms, first-aid kit, fire extinguishers, and other safety equipment in the laboratory.
4. Make sure that you know how to use the fire alarms, first-aid kit, fire extinguishers, and other safety equipment available in the laboratory.
5. Never eat, drink or smoke in a laboratory. Also don't store food or drinks in a laboratory.
6. Don't look into the mouth of a test tube or flask while you are heating it or adding reagents to it. Also never point test tubes at other persons.
7. Before using flammable solvents, check that all burners are put off and that there are no naked flames. Remember to warn everyone near the fire risk area.
8. Immediately inform other laboratory staff and teachers if you discover any breakage, faulty equipment or any other defects.
9. Wipe off any spilled chemicals immediately, especially corrosive acid or alkali and mercury. Follow proper procedure for their disposal. These are described in Sec. 11.4.
10. Do not run or play around in the laboratory.
11. Make sure that you know the nature of the substances you handle. Do not handle materials or operate apparatus that you do not fully understand.
12. The apparatus not being used should be kept in cupboards.
13. Do not allow organic solvents to accumulate in the laboratory.
14. Do not smell materials, which may be toxic and never taste chemicals or eat seeds or parts of plants provided for biological studies.
15. Always use a fume cupboard for transferring highly toxic substances or for carrying out experiments, which may produce harmful gases.
16. Risky procedures should be carried out only in place set aside for the purpose and ensure that you can get assistance, if required.
17. Always label containers correctly with the full name and concentration of the contents.
18. Never try to stop or slow down a centrifuge with your hands. The speed at the outer edge may be greater than 150 kilometer per hour (or 90 kilometer per hour at least).
19. While diluting strong acids, add the concentrated acid in small amounts at a time with stirring to water. **Do not add water to concentrated acid.**
20. Always use safety bulbs when pipetting.
21. Do not charge batteries close to naked flames.
22. Always wash your hands before leaving the laboratory.
23. The passage between working benches must be kept clear so as to permit evacuation during emergency. The exits and the access to switches must also be kept clear.

> Eating, drinking or storing food in a laboratory may result in contamination by chemicals or bacteria.

> Smoking is prohibited in laboratory due to following reasons:
>
> 1. It may cause a fire accident, especially while flammable solvents are stored.
> 2. Minute particles in smoke may interfere with chemical processes or spoil electronic parts.
> 3. Hot zone of a lighted cigarette may lead to the formation of poisonous substances in presence of some chemicals.

24. Do not allow students to work in the laboratory without supervision.
25. Always exercise care while opening and closing doors of the laboratory.
26. Ensure that your footwear is adequate for the laboratory work. Open toed shoes or sandals offer no protection against injury from fallen objects or broken glass.
27. Long hair, ties and loose jewellery could be a problem during laboratory work due to possibilities of their entanglement in a moving mechanical equipment or trailing over contaminated surface on the work bench.
28. Make sure you know the emergency procedures and emergency exit routes of your laboratory.

11.3.2 Personal Protective Devices

In discussing the code of practice above, we have mentioned about using personal protective devices. These are used to minimise the risk of personal injury and damage through contact with hazardous substances. Lab coat is often used as a protective device. Sometimes gloves, aprons, goggles (safety spectacles) and safety shoes are also used as additional devices. Let us learn about some of the personal protective devices to be used in the laboratory.

It is mandatory to use lab coat while working in the laboratory. These should cover the knees and have full length sleeves.

Lab Coats

The purpose of the lab coat is to cover regular clothes to minimise contamination, hazards due to splashing of chemicals and protection against the saturation of regular clothes or skin from exposures to harmful substances. In addition, these also provide some temporary protection against fire. It is not that the material of the lab coats does not allow the hazardous substances to pass through or does not catch fire, but as these can be quickly removed, they provide additional safety from harmful exposures or flames.

The lab coat should fit well and should be buttoned up correctly at all times. Cotton lab coats are more suitable than those made from nylon as the former could absorb more liquid and offer more protection against spilled chemicals. An added advantage is that the cotton coats do not generate sparks by static electricity that might ignite highly flammable organic solvents. Nylon melts when heated and can stick to the flesh. It also dissolves in some organic solvents.

Sometimes an additional protection, such as a **rubber apron** is recommended. These should be used while working with large amounts of chromic acid, hydrofluoric acid and other highly corrosive liquids.

Safety Spectacles

You would agree that eyes are precious and we should be very careful so as to avoid any injury to them. It is therefore advisable that we should use safety goggles wherever there is even the slightest risk of splashes of chemicals or fragments of dust, glass, etc. getting into the eyes. You can get goggles that can be worn over the vision glasses. It is not advisable to use contact lenses in the laboratory. If one does use them, then in such a case it is necessary to use protective goggles while working in the laboratory.

Gloves

Gloves should also be worn when transferring toxic, radioactive and carcinogenic compounds, irritants and corrosive liquids. **The practice of wearing rubber gloves continuously for laboratory work is not recommended as the hands become very moist and sweaty.** This may lead to skin infection. Rubber gloves also make it difficult to grip wet glass and, serious accidents may result from dropped bottles or glassware.

In research laboratory, there may be need for protecting the face during certain operations. You may know that a mask is a protective covering for the face or head. While working with hazardous materials, dust masks and respirators may also be used. A dust mask may be used when transferring large quantities of powders or grinding chemicals by hand. A respirator is an apparatus for giving artificial breathing; it may be used when working with highly toxic materials.

SAQ 1

Specify the danger that could occur to a laboratory worker due to the following:

i) Looking into the mouth of a test tube during addition of chemicals.

ii) Wearing loose jewellery.

iii) Wearing open-toed shoes.

iv) Storing unused furniture in the laboratory passage.

SAQ 2

State the possible hazards caused by smoking in a lab.

11.4 DISPOSAL OF WASTE MATERIALS

In a school or college Science laboratory, chemical wastes, broken glassware, unserviceable non-consumable items, obsolete instruments, used biological specimens and radioactive materials need to be disposed off from time to time. **Many of them could be health hazards or could cause inconvenience in free movement especially during times of emergency**. Of these, the method of disposal of used biological specimens has been discussed in Unit 10 and radioactive materials, if any, are to be disposal off as per the directives of Atomic Energy Regulatory Board, Mumbai. We shall not discuss their disposal in this Unit. In this section, we shall explain the following types of laboratory waste and state the method of their disposal:

- Unserviceable non-consumable items
- Obsolete instruments and,
- Chemical wastes.

Unserviceable Non-consumable Items

The non-consumable items, which are either broken or are not in working conditions come under this category. Broken burette stands or furniture, rusted metal trays or Bunsen burners etc. are some of the examples. In addition, nonfunctional instruments like galvanometers, ammeters, refrigerators, air conditioners, deionisers, ovens, pH meters, conductometers, and computers etc. also belong to this category.

Obsolete Instruments

Laboratory instruments of old model, which may be functional but are no longer in use due to purchase of newer model become obsolete. Old model pH meters, colorimeters, computers etc. are some examples.

Chemical Wastes

Chemicals are present in all laboratories. It is advisable to consider that all chemicals are toxic and flammable unless one has definite information regarding its nature. In all laboratories chemical wastes are generated and need to be disposed off safely. Some possible reasons of generation of chemical wastes are:

- spillage of chemicals while working,
- breakage of the container of the chemical due to accidental fall,
- partial decomposition of chemicals because of improper storage,
- atmospheric action due to its moisture, carbon dioxide or oxygen content.

Let us now take up the disposal of the different types of laboratory waste.

11.4.1 Disposal of Unserviceable and Obsolete Items

In every laboratory the items become obsolete and unserviceable and the laboratory has its own procedure for the disposal of these items. However, we share here the general procedure for the purpose:

i) As a first step the Head of the Institution forms a Survey Committee for the identification and disposal of unserviceable and obsolete items in a particular Science department. Typically, the committee consists of:
   - Head of the Department (Convenor of the Committee)
   - Administrative Officer / Finance Officer of the Institution
   - One person who is an expert and has knowledge about the value of the articles to be disposed off.

ii) The Survey Committee inspects the laboratory and prepares a report of unserviceable and obsolete items indicating the original cost price and decides a reserve price for its disposal. **The reserve price is the minimum price at which the concerned item is to be sold.** The Committee has to use its judgment in fixing the reserve price. For obsolete items which are functional, the reserve price may be fixed depending on its worth. In case of nonfunctional items, reserve price can be fixed on the basis of its scrap value. In extreme cases when the concerned item is of no commercial value, the Committee may recommend writing it off, and the reserve price is taken as zero.

iii) The Committee forwards the report to the Head of the institution.

iv) The Head of the institution gives direction for the disposal of the material through open sale or auction.

v) Accordingly, the steps are taken for open sale or auction.

vi) Necessary entries are made in the stock register.

These steps are illustrated in Experiment 11 of the CLTL-101 course.

> **Scrap value:** It is the price that depends on the usable constituents of an item. The scrap value may be similar to the value fixed by a waste materials dealer.
>
> **Open Sale**: A price is fixed for each item keeping in view the reserve price.
>
> **Open auction**: Price is decided through auction keeping reserve price as minimum. The article is sold to the person offering the highest price.

11.4.2 Disposal of Chemical Wastes

As it is repeatedly being mentioned that all chemicals are dangerous; these need to be disposed off carefully. Think of a possibility that a toxic chemical waste is thrown carelessly into the dustbin. Will it not be harmful to the sweeper who cleans the dustbin and is totally unaware of it? Also flammable, volatile and water-immiscible liquid wastes thrown in the drain can cause accumulation of flammable vapours in the drainage and pose a fire hazard. While dealing with chemical waste, you should keep in mind the safety off yourself and other inmates of the laboratory. In order to dispose off chemical waste safely,

- You must be aware of the contents of the chemical waste, and its nature, (viz, harmful, toxic, flammable or corrosive - usually the reagent bottle label indicates the nature of the chemical contained in it). You would have learnt about it in the Unit 10.
- You must use adequate protective devices as mentioned in subsection 11.3.3.
- Shut off all possible sources of ignition while dealing with flammable waste, and
- Use the appropriate method of disposal of chemical waste as mentioned below.

If you need to know in more details about the disposal of a wide range of chemicals, you are advised to get the book, Hazards in Chemical Laboratory, edited by L. Bretherick (4^{th} edition published by Royal Society of Chemistry, London in 1986) for your library.

We shall deal here with the disposal of some common chemical wastes occurring in small quantities. The discussion is divided into two parts:

i) Removing the bulk of the chemical waste and, then

ii) Treating the site of spillage for removing the remaining traces of the spilled chemical.

I. Removing the Bulk of the Chemical Waste from the Spillage Site

Some of the methods used are as follows:

a) Mopping with plenty of water and running it into the drainage

b) Providing effective ventilation

c) Transferring the waste to open for evaporation

d) Emulsifying the spilled chemical, and

e) Changing the nature of the spilled chemical

Let us discuss these one by one.

a) *Mopping with plenty of water and running it into the drainage*

Mopping: Washing the floor using a bundle of yarn or sponge or cloth fastened to the end of a stick.

The disposal of chemical waste that is miscible / soluble in water and is harmless in high dilution can be done by familiar method of mopping the waste with plenty of water and running the same into the drainage.

Some of the examples of this category are: acetone, methanol, ethanol, acetic acid, ammonia (solution), hydrogen peroxide, potassium hydroxide, sodium hydroxide, oxalic acid and water soluble salts of arsenic, cadmium, lead and nickel. Although some of these chemicals could be harmful in high concentration, their effect gets minimised due to usage of plenty of water leading to their dilution.

b) *Providing effective ventillation*

Highly volatile liquid waste like, diethyl ether could be disposed off by providing effective ventillation until the liquid completely evaporates. We open the doors and windows of the lab and let the chemical evaporate off.

c) ***Transferring the waste to open for evaporation***

Spillage of moderately volatile liquids like ethyl acetate, carbon disulphide, benzene and carbon tetrachloride can be disposed off by absorbing them on sand, transferring into a bucket and then transporting to a safe open area for evaporation.

A liquid immiscible in water normally forms a separate layer with water. A typical example is a mixture of oil and water. But in presence of suitable agents like soap or detergent, two immiscible liquids form milk like homogeneous mixture known as emulsion.

The process of dispersing water immiscible liquid in water using a suitable agent such as soap or detergent is called **Emulsification**

d) ***Emulsifying the spilled chemical***

A number of common chemicals like, benzene, toluene, cyclohexane, nitrobenzene, m-dinitrobenzene, cresols, chlorobenzene and chloroform are insoluble in water and can form an emulsion. In order to dispose of the spillage of such chemicals it is scrubbed with brush in presence of soap or detergent solution. The emulsion formed in this process is run into the drainage with plenty of water.

e) ***Changing the nature of the spilled chemical***

In case of chemically reactive wastes, the chemical property of the waste could be used for its removal. Some of the examples are as given below:

i) Some water reactive waste like calcium oxide, could be disposed off by transferring it into a dry bucket, transporting to a safe area and adding a large volume of water. After completion of the reaction, the suspension obtained could be poured into the drainage.

ii) A few solid wastes that are highly reactive with water could be removed by mixing with dry sand and transferring into dry bucket(s). These are then transported to a safe open area and treated with large quantity of water added in small quantities at a time. After the reaction is complete, the mixture is decanted into the drainage. Anhydrous aluminium chloride and phthalic anhydride are two examples of this category.

   In case the product of reaction with water is highly corrosive, like with phosphorus pentachloride and phosphorus pentoxide then the process is to be carried out in an enamel or polythene container.

iii) In case of strong acids like, perchloric acid, sulphuric acid, hydrochloric acid, nitric acid, phosphoric acid etc., the site of spillage is covered with large quantities of sodium carbonate and then mopped cautiously with a large quantity of water. Similar procedure could also be followed for acetyl chloride, benzoyl chloride, chromium trioxide, chromyl chloride, tin (IV) chloride and bromine also.

iv) The spillage of aniline is mixed with sand and transferred into a suitable glass or enamel vessel and is treated with an excess of dilute hydrochloric acid (one volume of the acid and two volumes of water). It is allowed to stand for 24 hours and then run into drains with a large quantity of water.

v) The spillage of iodine in small quantities can be washed off using sodium thiosulphate or sodium metabisulphite solution.

vi) The waste sodium metal is mixed with dry sodium carbonate, transferred into a dry bucket and transported to a safe open space. The mixture is then added to a large excess of dry propan-2-ol in small lots. It is then allowed to stand for 24 hours and run into the drainage after diluting greatly with running water.

f) ***All other wastes***

For all other cases the spillage is either buried or disposed off by mixing with sand.

i) The burial of the spillage could be done by using any of the following methods:

- Mixing the spillage with sand and burying deep in the soil. Some of the examples are: iodine in large quantities, insoluble arsenic salts, picric acid and phenol.
- Sweeping the spillage with 1:1 mixture of saw dust and zinc dust and burying at an isolated site. Mercury is disposed off in this manner.

ii) Disposal by mixing with sand

Some water insoluble inorganic waste can be mixed with excess of sand and disposed of as normal garbage. Examples: Insoluble cadmium salts, lead salts and nickel salts

II. Treatment of the Spillage Site After Removal of the Bulk of the Waste

Once the bulk of the spillage is cleared we need to remove the traces of the waste left. For this, any one of the following methods may be used depending on the nature of the spillage:

a) **Ventilating the area of the spillage:** in this method the vapours of volatile wastes like, ethyl acetate, carbon disulphide and carbon tetrachloride are allowed to spread out.

b) **Washing the spillage site with water**: in case of water soluble / miscible wastes like, anhydrous aluminium chloride the spillage site is washed with a plenty of water.

c) **Washing the spillage site with water and soap/detergent:** in case of water immiscible / insoluble wastes like toluene we add soap and wash the site with plenty of water.

Some of these methods are illustrated in Experiment 12 of the CLTL-101 course.

As mentioned earlier, these methods can be used to deal with chemical wastes in school and college laboratories. In these cases the quantities of wastes are not large. However, while dealing with industrial chemical wastes, specialised methods are to be used and are not discussed here.

SAQ 3

What is the important precaution to be taken while disposing off combustible waste?

11.5 OPENING AND CLOSING THE LABORATORY

When you leave home, you ensure that all the taps are closed; the lights and other electrical appliances are put off; windows are closed; the doors are properly locked and so and so forth. Similarly, when you have to close or open the laboratory you need to be careful and follow certain procedures. Let us first lay down the instructions to be followed while opening the laboratory.

Instructions for Opening the Laboratory

At the time of opening the lab, the following need to be kept in mind:

> **Tampering the lock**: Damaging the lock with the idea of opening the door illegally.

> **Asphyxia** or suffocation is a condition in which breathing is affected. The lungs do not get sufficient supply of oxygen for breathing. If this condition continues for more than 2 to 3 minutes, brain damage followed by death could result. Asphyxia arises generally due to oxygen deficiency.

i) Check that the door locks have not been tampered with. If any tampering is detected, inform the higher authorities for necessary action.

ii) Wear lab coat and other protective devices as per the requirements.

iii) Do not enter the laboratory immediately. Allow the fumes etc. (if any) to disperse away. This is very important particularly for a Chemistry laboratory.

iv) Open the windows and doors to ensure proper ventilation and lighting; proper ventilation helps in minimising asphyxia (suffocation) and inhalation hazards.

v) Check that the animals (if any) in a biological laboratory have sufficient food and water. If not, replace them.

vi) Wipe the top of the benches with a damp cloth.

vii) Separate the waste and make arrangement for its disposal as discussed in Sec. 11.4.

viii) Personally supervise the cleaning of the garbage by the cleaning staff otherwise they could mix up wastes of different kinds and may harm themselves.

ix) Check the working condition of any instrument left overnight.

x) Check for the availability of water, electricity and gas supply for the day's work.

xi) Plan for day's activities as per the experiments to be carried out on that day.

Let us now go through the instructions to be followed while closing the lab.

Instructions for Closing the Laboratory

We need to be much more careful while closing the laboratory because the time when the lab is being closed is potentially one of the most risky times of the day. At that time after day's work, people are less alert due to tiredness and are in a hurry to go back home. We tend to take short cuts and also there are fewer people available to help in case of accidents; lighting may be poor during winter months, and so on. While closing the laboratory every day you should make a special effort to observe the main points of your personal safety code. The following are some of the actions to be performed while closing the laboratory:

i) Turn off equipment, burners, taps, etc.

ii) Replace reagent bottles to shelves and put apparatus, chemicals and other materials in proper place. Radioactive sources (if any) and poisons must be locked. Remember that the cleaning staff that would come the next day in the morning may not be aware of the hazards presented by such materials.

iii) Place any other materials in suitable containers, label them and put them safely.

iv) In a biological laboratory check aquaria, animal cages and make certain that the doors are properly closed. Ensure that the animals have sufficient food and water for the night. Check that thermostats, incubators and other equipment in continuous operation have been switched off.

v) Clear up any spilled chemicals, etc. and wipe the top of the benches with a damp cloth.

vi) Remove lab coat, safety spectacles and other protective clothing and leave them in the laboratory or in your locker. Disposable gloves should be discarded and placed in a suitable container for disposal.

vii) Make sure to wash your hands while leaving the laboratory. In fact you should wash your hands after every time you handle dangerous substances or material that carries a risk of infection.

viii) Any apparatus/ instrument to be left working overnight must be clearly indicated by a notice of the appropriate type signed by a responsible person. Leave clear **instructions to be followed in case of emergency.**

ix) Lock the laboratory and affix paper seals over the locks of the laboratory doors. The paper seals should contain the signature of responsible staff member.

SAQ 4

Why is that special efforts are required to be observed during closing the lab?

11.6 SHIFTING HEAVY OBJECTS

You may need to shift heavy objects like, gas cylinders, vacuum pumps, tables, almirahs etc. while working in the laboratory. Generally in Science laboratories the heavy objects are moved through lifting process or by using a trolley. If the heavy object is to be handled manually you must make an assessment of risks and, if the load is very heavy, split (if possible) it into smaller loads of manageable sizes. Each part should be within the lifting capability of the laboratory worker. On the other hand, if the load cannot be split arrange a trolley for the purpose. **Do not take any risk that may cause an injury.**

Manual handling: Transporting or supporting of a load by hand or bodily force.

Lifting heavy objects may cause back and other muscle strain. Back injuries are the most common type of injuries at work and, range from severe accident to mild discomfort. Remember that incorrect lifting causes the majority of back injuries. **To avoid back injuries, the back should always be kept straight and the feet apart when lifting.** The following procedure should be adopted while lifting heavy objects:

Muscle Strain: Injury caused to the muscle through forcible stretch beyond its proper length.

1. Keep feet apart. Put one foot forward and to the side of the load. Always keep the feet about a hip breadth apart when lifting as this provides a larger base and will improve your balance.
2. Bend the knees to lower the body vertically to reach the object; **keep the back straight.**
3. Grip the load tightly using the whole of your palms and not just the tips of your fingers. This reduces the chances of dropping the object.
4. Keep arms close to your body and, as straight as possible, so that you can use your whole body to carry the load.
5. Keep your chin in. This will lock your vertebrae and prevent injury to the neck.
6. Straighten your legs without jerking and let the strong muscles of the leg do the lifting.

7. The correct position for lifting objects is shown in Fig.11.1.

Fig. 11.1: Correct procedure for lifting weight

Moving Heavy Objects on a Trolley

Hernia: A protrusion (or projection) of any part of the internal organs through the structures enclosing them.

The heavy objects are shifted using a trolley, which is normally moved through pulling or pushing process. We need to take due care during these processes. In the pulling process, the whole strain is to be taken by the back muscles (Fig.11.2). Therefore, care should be taken to move the trolley with a steady speed so that it does not run on the feet and injure it. In the pushing process, load is taken by the backbone (Fig.11.3). An optimum height of push (about mid-chest height) helps in minimising the strain. Pushing at too high a level puts excess strain on stomach muscles and can cause strain of shoulder muscles or hernia. Also pushing at too low levels is ineffective.

Fig. 11.2: Pulling trolley

Fig. 11.3: Pushing trolley

11.7 SUMMARY

In this unit, we have discussed personal safety aspects of a laboratory worker in a detailed way. We started by discussing the duties of the teachers and the Head of the institution towards laboratory safety and outlined the measures to be followed for the same. We then explained the need for a personal code of behaviour for the laboratory worker and gave a list of instructions, which could serve as code of practice in a laboratory. We also discussed the importance of protective devices and described some of them.

We then described in an elaborate manner the ways of disposing of waste materials generated in a laboratory. Special emphasis was given on the disposal of chemical waste. This was followed by a discussion on the procedures to be followed while opening and closing the laboratory. In the end we described correct procedures to be followed while shifting heavy objects in the laboratory.

11.8 TERMINAL QUESTIONS

1. State two main reasons as to why the behaviour of a laboratory technician should be exemplary.
2. Why is a cotton lab coat preferable to a nylon lab coat?
3. Do you think that you are less likely to be poisoned or harmed if you just store food or drinks in the laboratory as compared to actually consuming it there?
4. What are the main causes for the occurrence of chemical waste?
5. Summarize the proper procedure for lifting a heavy object.

11.9 ANSWERS

Self-Assessment Questions

1. i) Due to vigorous chemical reaction, there may be emission of vapours or even spurting which could cause blisters on the face and even be harmful to the eyes.

   ii) Loose jewellery could get entangled in moving mechanical equipment or trail over contaminated surface.

   iii) Open-toed shoes offer no protection against injury or spillage of chemicals.

   iv) Unused furniture stored in the passage causes difficulty during emergency evacuation.
2. Burning tobacco can react with certain substances to form highly toxic compounds. Further, it could be a serious fire risk when flammable solvents are being used. In addition, the tobacco smoke can interfere with purification and, other chemical and physical processes.
3. All sources of ignition should be shut off.
4. At the end of a day's work, people are less alert due to tiredness and being in a hurry to go home; short cuts are taken to avoid working late. Further there are fewer people available to help during odd tasks such as moving gas cylinders, etc. So special efforts are required to observe personal safety code at the time of closing the lab.

Terminal Questions

1. A laboratory technician has health and safety obligations to colleagues, to students and to self. Further, the students may think that the procedure used by a laboratory technician is the correct one and they follow the same.
2. Cotton can absorb more than nylon thus giving greater protection. Nylon can produce static sparks while cotton does not. Nylon, when heated, melts and sticks to flesh.
3. No there is a risk by direct contamination of the food or drinks even by just keeping it in the laboratory.

4. The chemical wastes could occur due to breakage of a reagent bottle or spillage or partial chemical decomposition due to long storage or atmospheric action.

5. The proper procedure for lifting heavy objects consists of the following steps:

   i) Keep the feet apart (one foot forward).

   ii) Bend knees.

   iii) Grip the load completely (as close to your body as possible).

   iv) Keep arms in and straight.

   v) Keep chin in.

   vi) Straighten the legs (keeping your back as straight as possible).

UNIT 12

ACCIDENTS AND FIRST AID

Structure

12.1 INTRODUCTION

In the first three units of this block on 'Science Laboratory Safety' you have learnt about different types of hazards in Science laboratories. The previous unit dealt with the personal safety measures to be followed while working in the laboratory. Despite being aware about the hazards and taking necessary precautions while working in the laboratory the accidents can still happen. In this last unit of the Block and the course we will discuss about what to do in case an accident occurs in the laboratory.

We will start by discussing the need and the method for reporting a laboratory accident. We shall then introduce you to first aid – the immediate and temporary care given to the victim of an accident or sudden illness, first aid box, its contents and suitable location in the laboratory. We shall then describe the general features of first aid in terms of its scope and sequence of events. This would be followed by a detailed discussion on the methods of administering first aid for specific situations like electric shock, unconsciousness, chemical accidents, bleeding, burns, fractures and eye injuries etc. The contents of this unit could serve as a guide for offering first aid to those involved in laboratory accidents.

Our objective is to make you aware and also provide the necessary information that would be useful in dealing with laboratory accidents. We don't intend to make you a professional in the field we expect you to act in a responsible manner to provide precious support to the victim. **It is emphasized that for any serious injury, proper medical assistance should be sought at the earliest.**

Expected Learning Outcomes

After studying this unit, you should be able to:

- explain the need for reporting lab accidents;
- differentiate between an accident and an incident;
- state the procedure for reporting a laboratory accident;
- list the contents of a first aid box and suggest a suitable location for the first aid box in the laboratory;
- describe the general features of first aid procedure; and
- explain the first aid procedure for specific situations like electric shock, unconsciousness, chemical accidents, bleeding, shock, burns, fractures and eye injuries.

12.2 ACCIDENT REPORTING

Heinrich in 1930 defined an accident as an unplanned and uncontrolled event in which the action or reaction of an object, substance, person or radiation results in personal injury or the probability thereof. The definition has changed over time and one of the modern definitions given by Occupational Health & Safety Advisory Services defines a broader term called **incident**. According to them *an incident is referred to as a work-related event(s) in which an injury or ill health (regardless of severity) or fatality occurred, or could have occurred.* An **accident** is regarded as a particular type of incident in which an injury or illness actually occurs. A related term is called **near miss**. It is an incident in which no injury or illness occurs. Therefore, an incident can be either an accident or a near miss. Let us understand the need for reporting laboratory accidents.

Near miss: an incident in which no injury or illness occurs.

12.2.1 The Need for Reporting Accidents

All accidents (no matter how small) and, dangerous near misses should be recorded and reported. The recording of accidents ensures that all injuries are treated. The record keeping of accidents also helps in knowing about unsafe working practices and long-term trends in accidents. This can be used to take suitable measures to improve the safety in the laboratory. Further, if there is an enquiry later, great problems may arise for those involved unless the accident was recorded or reported. Hence, it is advisable to treat both minor and major accidents as serious and record all of them systematically.

It is equally important to record and report near misses, that is, the incidents where no one was injured, but could have been if circumstances were different. We analyse the reasons for the incident and possible risks. This helps us in taking suitable steps to prevent such near misses which next time may happen to be an accident. **We need not wait for an accident to occur to take preventive steps.**

12.2.2 Accident Reporting Procedure

It is advised to use incident book and accident report forms for the purposes of keeping records of accidents. The incident book is to be maintained by the laboratory Incharge. It should contain the details, as listed below, of all incidents (accidents and near misses):

1. Date, time and location of incident
2. Name of victim
3. Nature of injuries sustained or suspected
4. Description of first aid treatment given
5. Name of person who administered first aid treatment
6. Names of witnesses (if any)

There is no need to record any other information in this book and details are to be provided by the person attending on the accident victim or by any of the laboratory staff. The book is a valuable source of information to the alert laboratory Incharge.

Accident Report Forms

Accident report forms are to be used in case of serious accidents. A properly completed accident report form should contain the following information:

1. The date, time and location of the accident
2. The name, address, gender and age of the victim
3. A brief description of the accident
4. The names of witnesses (if any)
5. Details of any injuries suffered or suspected
6. A description of the first aid treatment given
7. The name of the person who administered the first aid treatment
8. A description of any further action taken, e.g. removal to hospital etc.

This form also acts a useful record of the details of the accident, which might be hard to recall at a later date. These forms are to be completed and maintained by the laboratory Incharge. A copy of this report has to be sent to the Head of the institution for information, so that suitable measures are initiated to improve working conditions in the laboratory. **An activity on the preparation of accident report is included in Experiment 13 of the CLTL-101 course.**

SAQ 1

What is meant by an incident and how is it related to an accident?

12.3 FIRST AID BOX

> The originator of first aid was Esmarch (1823-1908) of Germany. He was an expert in hospital management and military surgery. The term 'first aid' was used officially in England for the first time in 1879 by the St. John Ambulance Association.

First aid is the immediate and temporary care given to the victim of an accident or sudden illness prior to the availability of suitable medical aid. Remember that it is a temporary treatment and its purpose is to

1. help preserve life
2. prevent the victim's condition from becoming worse, and
3. promote the victim's recovery.

Any laboratory is a potentially dangerous workplace, but serious injuries are rare. It is advisable to know how to provide first aid depending on the nature of the injury. Remember that first aid is a skill that can be learnt only by proper training and practice. St. John Ambulance Association, which has Headquarters in New Delhi and has over 670 branches all over the country, is offering first aid programmes at different levels and offers certificates to those who complete the particular programme successfully. It is advisable to remember that *first aid is limited to the assistance rendered at the time of emergency with such material as may be available.* The direct responsibility of the person giving first aid ends as soon as the victim is handed over to a doctor; but he/ she should give a complete report to the doctor.

12.3.1 Placement of First Aid Box

All first aid equipment should be placed close to the sites where accidents are likely to occur. The location of first aid boxes should be such that they can be easily identified and reached during times of need. An ideal first aid system in a laboratory would have two kinds of first aid boxes to meet two kinds of needs. The first type of first aid box would be to meet emergencies and would be placed in the laboratory. It would never be locked so that it is accessible at all times. Theft of some items may be a problem but this can be overcome by:

1. Educating users; and
2. Keeping stocks to the basic minimum requirements.

A more elaborate first aid box, as a second line facility, could have contents more than the minimum requirements and the box could be locked and a responsible person put in charge of it. This could be used in times of need as a secondary support.

12.3.2 Contents of First Aid Box

The minimum contents of a first aid box are given in Table 12.1. In addition, the first aid box should carry on it the name of the person responsible for its contents, and be marked with a red cross on a green background. The phone numbers of the nearby doctors and hospitals, the replacement date of its contents *etc.* may also be typed and pasted on it.

Table 12.1: Contents of First Aid Box

Item	Quantity
Individually wrapped sterile adhesive dressings (assorted)	5
Cotton roll	1
Half ounce packets of sterilised cotton roll	3
Sterile cotton pads in sealed packets	3
Half ounce packets of gauze, plain white	3
Swab sticks	6
Triangular bandages	2
Bandage rolls of 1", 2" and 2½" width	2 each
Individually wrapped sterile unmedicated wound dressings of sizes:	
Medium (10 cm x 8 cm)	2
Large (13 cm x 9 cm)	2
Extra large (28 cm x 17.5 cm)	2
Glucose	200 g
Burnol tube	1
Dettol® / Savlon® bottle	1
Spirit bottle (100 cm^3)	1
Stainless steel spoon (padded) or Tongue depressor	1
Safety pins (assorted, rust proof)	6
Cardboard (8" to 12" length and 6" to 8" width)	1
Old news paper sheets (rolled using a rubber band)	6
Scissors (5 inch, blunt pointed)	1
Pen torch	1

An activity based on first aid box is included in Experiment 13 of the CLTL-101 course.

SAQ 2

Why is it necessary to have two types of first aid boxes in the laboratory, one unlocked and the other locked?

12.4 GENERAL FEATURES OF FIRST AID

The order of priorities in administering first aid is decided by the principal objective – to save life. Equally important is that you must not do anything that endangers the lives of others. It will not help the victim if someone is killed while attempting to rescue the person from an electrical fault or from a room filled with smoke or poisonous fumes. It is essential to keep calm and to assess the situation rapidly. Time is important and, in serious accidents, the first two or three minutes can make the difference between life and death.

12.4.1 Scope of First Aid

You must know that the scope of first aid actions spreads over the following three aspects:

- **Diagnosis**: Diagnosis of the victim involves considering the history, symptoms and signs.
  - ⇒ **History** is the information as to how the accident or illness occurred. This may be obtained either from the victim (if conscious) or from witnesses.
  - ⇒ **Symptoms** are the sensations of the victim such as shivering, feeling of cold, fainting, vomiting, thirst and pain.
  - ⇒ **Signs** are any variations from normal condition of the body such as bleeding, swelling, deformity and congestion.

In a victim, symptoms and signs are quite helpful in diagnosis.

- **Treatment**: First aid treatment is a set of actions taken to preserve life of the victim, prevent the conditions from becoming worse and promote his / her recovery.
- **Disposal**: Disposal is the arrangement made for the removal of the victim to his/her home or suitable shelter or to a hospital. A tactful message should be sent to the victim's home or relatives indicating the main details of accident and the victim's destination.

12.4.2 Sequence of Actions

The precise sequence of actions in emergency situations is governed by the circumstances. The following is the general order to be followed:

1. Quickly separate the victim from the hazard (provided it is safe to do so).
2. Ensure that the patient's breathing is maintained. If the victim isn't breathing, begin artificial respiration immediately. If the heartbeat is found to be absent, begin resuscitation (Sec. 12.6). For both of these processes, the services of a trained person are quite helpful.
3. Control serious bleeding to prevent heavy blood loss.
4. Treat for shock.
5. Treat burns and deal with localized injuries (such as cuts or foreign bodies in the eye).
6. Reassure the victim and help decrease the anxiety.
7. Do not allow people to crowd around, as fresh air is essential for the victim. Ask them to telephone for an ambulance, fire brigade, or other services, which may be required. They can also help to take care of the victim until doctor arrives; or they can help to deal with the cause of the injury, i.e. with the spilled chemicals, broken glassware, etc. or minor fire.
8. Where necessary, your last action as a first aider with any victim is either to hand him/her over to a doctor or to transfer him/her to a hospital.

Some of the terms used in this procedure are discussed in details later in this Unit. In all serious accidents, witnesses should be obtained, if possible, before searching for personal belongings of the victim.

SAQ 3

Usually there is a crowding of on-lookers in a place of accident and, laboratory accident is no exception. How can the members of the crowd be used to deal with the after effects of the accident?

12.5 FIRST AID PROCEDURE FOR ELECTRIC SHOCK

Based on Sec.12.5 - 12.10 of this unit, two activities are included in Experiment 13 of the CLTL-101 course.

The sequence of actions for a first aid procedure as described in subsection 12.4.2 is followed generally but there are certain cases when this sequence is changed. Electric shock is one such case. You would have read in Unit 8 that the main injuries that may be expected in an electrical accident are burns, asphyxia and shock. Cuts, fractures or other injuries may result from falls due to electric shock. The sequence of actions in such a case would be:

1. Do not touch the victim until you are sure that the power has been turned off or that the victim is no longer in contact with the electric current or else you may be electrocuted as well. **No attempt at rescue must be made if the victim is in contact with a high voltage electric current such as that coming from overhead electric power cables.** In case of a mains supply voltage (220-240 V), the victim can be pulled or pushed away from the source by using for example, a wooden chair, thick dry cloth, rubber or other insulating material. For this, the person administering first aid should
   - stand on a dry insulating surface such as a wooden chair when attempting this, and
   - ensure that the hands are not wet.
2. If the victim is not breathing, the artificial respiration must be given immediately. For giving artificial respiration and heart massaging, the help of a properly trained person may be taken.
3. If the victim is unconscious but is breathing, place him/her in the recovery position (as described in Sec.12.6).
4. Treat burns and other injuries. Note that burns from electrical accidents may be much deeper and larger than their surface area indicates.
5. Treat for shock (as described in Sec.12.9).
6. In cases of serious injury, call for an ambulance or a doctor.
7. Don't move the victim, if you suspect any fracture.

SAQ 4

Before beginning to administer first aid to an electric shock victim, what is the first action to be performed?

12.6 FIRST AID PROCEDURE FOR UNCONSCIOUS CASUALTIES

Fainting: A condition of temporary loss of consciousness.

Let us now discuss the first aid procedure for unconscious victims. The most common causes of unconsciousness in a laboratory accident are fainting, shock, asphyxia, poisoning and injuries to the head. Other causes include heart attack, epilepsy (fits) and diabetic coma. Unconsciousness or insensibility is due to interruption of the action of the brain through some interference with the functions of the nervous system.

The general procedure to be adopted for the first aid treatment of an unconscious victim is:

1. Remove the victim from any contaminated atmosphere. Open windows and doors. Provide enough fresh air by dispersing the crowd.
2. Turn head to one side
   - to let the secretions come out of mouth and,
   - to prevent tongue falling back and causing choking to the victim.
3. Loosen clothing about the neck, chest and waist.
4. Remove false teeth, if there, and, clear the mouth of blood, mucus etc. with a cloth to ensure that the airway is clear.
5. If breathing fails or stops, immediately give artificial respiration. If heart beat stops or pulse is not normal, apply heart massaging. For these the help of a properly trained person may be taken.
6. Control any severe bleeding.
7. Dress wounds and attend to fractures and other injuries.
8. Cover the victim with a blanket and arrange for transfer to hospital in the recovery position (discussed in Sec.12.6).
9. Keep a written record of the victim's responses and pulse rate at regular intervals.
10. Keep the victim still if s/he regains consciousness. Reassure her/him and moisten her/his lips with water but do not give any drink.
11. Do not leave an unconscious victim unattended.
12. Always ensure to inform the doctor about the unconscious state of the victim.

Let us now see how to administer first aid to those who become unconscious due to fits or diabetic coma.

Fits

Fits of various kinds may be accompanied by unconsciousness, and are usually characterized by the victim being unaware of his/her reactions. You should remember the following points in relation to fits.

1. Clear movable objects away from the vicinity of the victim; e.g. stools, chairs, bottles, *etc.*
2. Pull the patient away only if s/he is in potential danger from stairs, cables, fires, etc.
3. Never try to open the victim's mouth.
4. After the fits, allow the victim to rest.

5. Never leave the victim unattended.
6. Take a padded spoon and put the handle in between teeth to prevent tongue biting during fits.
7. Transfer the victim to safe and shady place till the help is received.

Diabetics

A diabetic patient may lapse into diabetic coma or unconsciousness, but usually the affected person is aware of the symptoms before this occurs. You can assist at any stage by giving the victim some sugar or sweets. Don't worry about creating an excess of sugar in the diabetic patient's bloodstream; **an excess of sugar is far less dangerous than lack of it**.

Sometimes it may be necessary to revive breathing and blood circulation to a person who has become unconscious due to a laboratory accident. **Resuscitation** may be helpful in such situations. Let us learn about resuscitation.

Resuscitation: An Explanation

A living person needs the support of "ABC" mentioned below:

- **A**irway – clear airway
- **B**reathing – normal breathing
- **C**irculation – proper blood circulation

> A human being cannot live for more than 3 minutes without oxygen. In case, breathing is stopped, immediate remedial measures should be taken.

In case of persons becoming unconscious, "ABC" aspects are to be taken care of by a process known as resuscitation. It involves, the following steps

I. Checking breathing and pulse
II. Opening the airway to facilitate breathing
III. Mouth-to-mouth artificial respiration for restoring breathing
IV. Heart massage for restoring blood circulation

Let us discuss these steps in details

I. Checking Breathing and Pulse

Before attempting to resuscitate a victim, it is essential that you check his / her breathing rate and pulse. You may cause problems if you attempt to resuscitate someone who is still breathing. Also, there is little point in spending a lot of time trying to restore a victim's breathing if you don't continually check that the victim's heart is beating.

1. **Breathing**: Breathing, particularly for an unconscious person, can sometimes be very shallow. Hence, it is difficult to discover whether someone is breathing or not simply by observing the rise and fall of their chest. You can try either of the following methods:
   a) Wet your lips and place them near to the victim's mouth or nose. When the victim breathes out, your lips will cool.
   b) Hold a cold piece of glass mirror, or a highly polished surface close to the victim's mouth or nose. When the victim breathes out, a small amount of condensation should form on the polished surface. However, this method is not very satisfactory.

The average rate of the pulse in a healthy adult is 72 beats per minute.

2. **Pulse**: For an unskilled person, the wrist is not the best place to feel the pulse. A weak pulse is difficult to detect and in these cases, it is easy to detect your own pulse in your fingers, mistaking it for the victim's. A suitable method is to turn the victim's head and feel the victim's pulse below the corner of her/his jaw. Four separate checks lasting 15 seconds each will give you the best indication.

   If the victim has stopped breathing, first of all we should clear the airway of the victim, so that he s/he could inhale fresh air.

II. Opening the Airway

The procedure for opening the airway is as follows:

1. Remove obstructions covering the victim's head and face. Loosen the clothing at the neck and waist.
2. Clear the mouth of any blood, vomit and loose or false teeth. You may do so using your forefinger and the middle finger after wrapping a piece of cloth on these two fingers (Fig.12.1). You may also use the handle of a padded spoon.

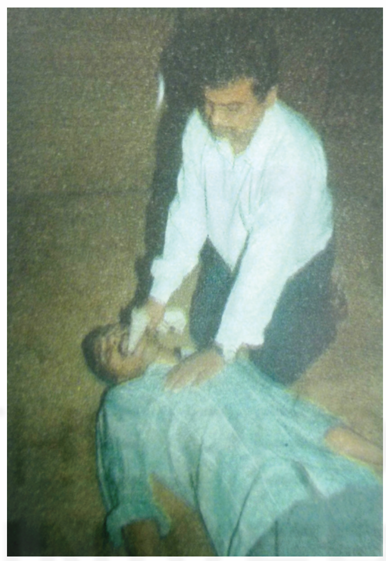
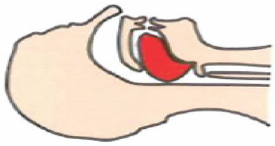


Fig. 12.1: Cleaning the mouth of the victim

3. Place one hand over the jaw and the other hand on the forehead. Lift the neck and push the forehead backwards so that the chin is up (Fig.12.2). The mouth should remain open.

Fig. 12.2: Adjustment of the chin and head

This extension of the head and neck lifts the tongue forward and clears the airway [Fig.12.3 (a) and (b)]. If the tongue does not fall forward, pull it forward with finger. In some cases, this action is sufficient to restart the victim's breathing.



(a)

(b)

Fig. 12.3: (a) In the unconscious victim lying on his/her back, the tongue may fall backwards and block the air passage; (b) If the neck is lifted and forehead is pushed backwards so that the chin is up, the tongue moves forward thus opening the air passage.

If breathing starts, place the victim in the recovery position (Fig.12.4).

Fig. 12.4: Recovery position

III. Mouth-to-Mouth Artificial Respiration

If a victim does not start breathing by the above process, artificial respiration must be started immediately to provide a supply of air into the lungs. The most important single factor is the speed with which the inflations can be given. Delay can be deadly. The mouth-to-mouth respiration is the most effective and can be used almost in all circumstances, with a few exceptions such as cyanide poisoning. The procedure for mouth to mouth respiration is as follows:

1. Pinch and compress the nose to close it.
2. Take deep breath (Fig.12.5a).
3. Place your mouth around victim's mouth, make an airtight seal and quickly breathe into victim's mouth (Fig. 12.5b).
4. Watch the victim's chest movement for its rise and fall.
5. Repeat and continue at your natural breathing rate until normal breathing is restored.

(a)

(b)

Fig. 12.5: Artificial respiration: a) Taking a deep breath pinching the nose of the victim; b) Breathing out into victim's mouth.

The pupil of the eye in a living person has the shape of a black dot at the centre of the eye. When the person is dead, the pupils dilate i.e., grow larger in size.

Sternum is indicated in Fig. 12.6a.

Closed fist: A hand with the fingers closed tightly into the palm.

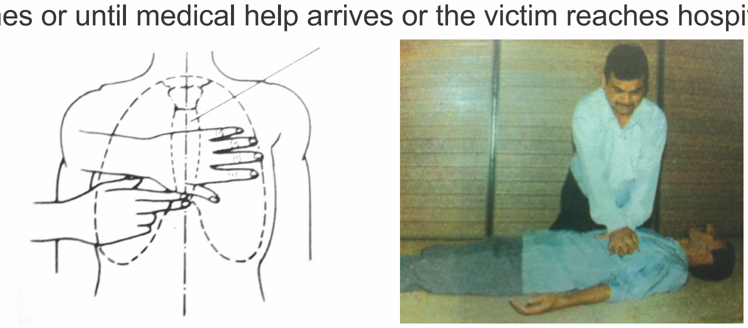
IV. Heart Massage for Restoring Circulation

In cases of breathing failure, you should check that the victim's heart is still beating. This is especially important with victims of electric shock or poisoning where heart failure is a particular hazard. This check can be carried out by feeling the pulse at the wrist or neck or by applying an ear to the victim's chest. Other symptoms are widely dilated pupils and a grey colour of the skin.

The heart massage is done as follows:

1. If a heartbeat cannot be detected, place the victim on his/her back on the floor (hard surface).
2. Strike the upper left chest forcibly in the middle of the sternum or breast bone region with a closed fist. This may result in resumption of normal heartbeat, for instance, in electric shock cases.
3. If the heart still does not beat, cardiac massage is to be given by using the procedure given below.
   a) The position for massaging is 1"-2" (or two fingers width) above the bottom end of sternum (Fig. 12.6 a).
   b) Place the heel of one hand on this point and the other hand on the top of it. Interlock the fingers to keep away from the victim's rib. Only the heel of your hand should make contact with the chest so that excess pressure may not be applied.
   c) Keep your elbows straight and lean forward.
   d) Then start pushing with the force of both your hands one above the other (Fig. 12.6 b). Apply steady smooth pressure to depress victim's sternum 1½" to 2".
   e) Then relax pressure maintaining the position of the hands.
   f) Give 15 such chest compressions and then two quick lung inflations by mouth-to-mouth breathing.
   g) Continue this process four times in a minute - namely -
      - 60 chest compressions (15 at a time for four times)
      - 8 lung inflations (2 at a time for four times)

The steps (f) and (g) are valid if there is a single person doing resuscitation. If there are two persons doing resuscitation, one may give chest massage and the other may give mouth-to-mouth breathing such that for five compressions there is one mouth-to-mouth breathing. The process of resuscitation in both the above cases, has to be continued till the heartbeat resumes or until medical help arrives or the victim reaches hospital.



(a) (b)

Fig. 12.6: Heart Massaging: a) Finding the position for massage – placing a hand at a distance of about two fingers (1"-2") above the bottom end of sternum; b) Applying the pressure on the chest – note the leaning position of the person providing first-aid and his straight elbow on the victim's chest. His fingers are interlocked and pressure is applied through the heels of the hands.

SAQ 5

What are the purposes of resuscitation?

12.7 FIRST AID PROCEDURES FOR CHEMICAL ACCIDENTS

There are three general procedures to be followed for chemical accidents and all are based on the principle of diluting the hazardous chemicals as quickly as possible. The procedures relate to the three routes of entry of the chemical into the body as mentioned in Unit 10.

These are:

- Ingestion: through the oral route
- Inhalation: of the vapours, fumes or dust
- Dermal exposure: direct skin contact by spills or by improper handling

Let us deal with each one of these separately.

Ingestion

The standard treatment for this type of exposure is as follows:

1. Make the victim to spit out as much of the ingested material as possible and then wash the mouth thoroughly a number of times with water. Do not let the victim swallow the chemical.
2. If the chemical has been swallowed, give large drinks of water or milk to dilute the chemical in the stomach.
3. Do not induce vomiting as this may result in further damage to the delicate tissues of the upper food passages, if the substance is corrosive.
4. Transport the victim to hospital. Wherever possible, the following information should accompany the victim:
   a) the identity of the ingested chemical,
   b) the approximate amount and concentration of the chemical consumed,
   c) brief details of the treatment already given.

Antidote:
Any substance that gives relief from the effect of a harmful material.

Experiments with cyanides and other highly toxic substances should never be carried out without having sufficient amounts of the specific antidote (amyl nitrite), immediately available and a specially trained first aid provider.

Amyl nitrite capsules have a shelf – life of two years and can explode if not kept cool. Cyanide salts are usually forbidden in schools.

Safe laboratory practice, e.g. never pipetting by mouth, never eating in the laboratory, always washing hands after working with chemicals, *etc.* should minimise ingestion accidents.

Inhalation

This route of entry of toxic substances into the body is the most dangerous and requires the most immediate response. Most poisonous gases, such as chlorine, hydrogen sulphide, ammonia and hydrogen cyanide, are detectable by their odour or by their irritating effect on the nose, throat, etc. Do not ignore these initial warning signs as the nose quickly becomes insensitive to smell. For example, hydrogen sulphide has strong smell of rotten eggs but because of the paralysing effect of the gas, it seems to be odorless when highly concentrated. Therefore, one may inhale a large amount of the gas without realizing it.

Remember also that poisoning by inhalation does not just happen with gases – it can happen with vapours also, e.g. phosphorus pentachloride. Other substances, like dust and spores, e.g. some of those encountered in the biology lab, may produce severe allergic reactions, which require the same treatment as gas hazards.

The standard procedure in gas based accidents is as follows:

1. Remove the victim from the danger area, provided this can be done without putting yourself in danger.
2. Loosen the victim's clothing and administer oxygen if it is available.
3. If breathing is stopped, apply artificial respiration through a properly trained person.
4. Transport the victim to hospital if the situation needs it. Give details of the gas inhaled and of the treatment given.

Procedures for Treatment of Chemical Burns

Accidental splashing of chemicals onto the skin can produce burns as a result of the corrosive nature of the substance involved. It can also cause skin disorders such as dermatitis. Examples of chemicals that could cause burns are as follows: phenol, bromine, strong acids especially concentrated sulphuric acid, nitric acid, strong bases like sodium hydroxide and potassium hydroxide etc. The standard first aid treatment for chemical burns is the same as that for dealing with splashes of poisons or other potentially hazardous chemicals on the skin.

The procedure is as follows:

1. The first step in such a situation is to remove the chemical at the earliest.
2. Remove contaminated clothes, longer they stay on the skin, greater the damage.
3. Remove rings, watches and other ornaments in the affected area as these may trap the chemicals and increase the damage.
4. Drench the affected area with large amounts of running water. Continue for at least five minutes or until you are satisfied that the chemical is no more in contact with the skin.
5. Chemicals known to be insoluble in water can be removed with soap under a running tap. In cases where the water supply is limited, it is best to wipe as much of the acid or other corrosive liquid from the skin quickly as possible with clean cloth before using the little water which is available to wash the affected area.
6. Take care that the washings do not go onto the unaffected portion of the skin. Save yourself also.
7. **Avoid using neutralising solutions. These generate heat, which increases damage.**
8. If the victim is seriously injured or if the burn was caused by splashes of hydrogen fluoride or other extremely dangerous substances, arrange immediate transportation to the nearest doctor.

Immediate and plentiful dilution is the most desirable action for many "skin contact" accidents with chemicals – particularly for concentrated sulphuric or nitric acids. In fact, water alone, is increasingly recommended for all types of burns.

Don't underestimate the penetration effects of the chemicals for example phenol can kill through penetration. The effects of burns from bromine, phenol or sodium are considerably reduced and the accompanying pain of the injury is lessened by applying an antidote as given in Table 12.2.

Table 12.2: Antidotes for Some Chemical Reagents

Chemical	Antidote
Bromine	Wash with 2 *M* ammonia solution, keep the affected part dipped in sodium bisulphite solution.
Phenol	Apply ethanol or glycol on a cotton wool pad.
Sodium	Apply ethanol on a cotton wool pad.

"2 *M*" stands for 2 molar solution.

In case the corrosive chemical falls in the eyes i.e. it is a case of an ocular burn.

- Remove the contact lens, if it is there, as the chemical can get in between the lens and cornea and cause damage. Do not let the patient rub her/his eyes.
- Wash the eyes with gently running water from the tap, an eyewash bottle or eye wash station for 10 to 15 minutes.
- Open the eyelids and ensure that water drenches the eyeball.
- **All eye injuries must be seen by a doctor preferably within an hour.**

Eye wash station

Acute and Chronic Effects of the Chemicals

The effects of accidents due to chemicals are severe and immediate on the human body. These effects are called **acute effects** and can be noticed without difficulty. However, due to poor lab practice or an unsafe system of work there can be gradual poisoning by a chemical. This also has harmful effects. The harmful effects due to long term exposure to a chemical are called **chronic effects**. These effects generally go unnoticed or are attributed to the wrong causes. It may be hard to trace the real cause of these chronic or long term effects. In some cases, final results could be much worse than the immediate results. For instance, consider the effects of ingested alcohol:

Acute effect: Severe and immediate effect.

Chronic effect: The effect due to prolonged exposure

- Acute effect – drunkenness and vomiting
- Chronic effect – addiction, liver damage, etc.

Safe laboratory practice will also minimize the chronic effects. An example of good practice is ventilating the lab in the morning; this will minimize immediate poisoning or suffocation (acute effect) and longer term poisoning (chronic effect) due to inhalation hazards.

SAQ 6

Are these four steps for dealing with a gas-affected victim in the correct order?

If not, put them in the correct order by indicating the respective numbers within brackets:

1. Apply artificial respiration if breathing has stopped.
2. Loosen the victim's clothing and give oxygen, if available.
3. Remove the victim from the danger area, if possible.
4. Transport the victim to hospital, if the situation so requires.

SAQ 7

What is the purpose of applying an antidote to a chemical burn?

12.8 CONTROLLING BLEEDING

The accidents involving cuts and sometimes falls are accompanied by bleeding. The nature of bleeding would depend on the severity of the accident. In this section, we will discuss methods of dealing with three types of bleeding:

1. Severe bleeding
2. Moderate and mild bleeding
3. Internal bleeding

The first of these, severe bleeding, must be attended to urgently. You would recall that controlling bleeding was the third step in the general procedure for first aid. You need to use your judgment here. If a large artery is cut, stopping bleeding would be the first life saving measure that needs to be undertaken. The second type of bleeding would usually be dealt with in the later stages of the general procedure under localized injuries. The third type of bleeding cannot directly be dealt with by the first aid provider for this you would need medical help. While treating a patient, you should ask him or her when he/she last had an anti-tetanus injection. **All technicians especially those working with soil or animals should have anti-tetanus injections every five years.**

Wounds are cuts in the skin which cause bleeding and can be either external or internal. Both categories are potentially dangerous as, in addition to the loss of blood, they may allow germs to enter the body that could cause infection.

Severe Bleeding

In case of severe bleeding, follow the steps given below:

1. The bleeding can be controlled by the following means:
   a) Apply direct pressure on the wound for 5-15 minutes with a clean pad of cloth. If a clean cloth is not available, use fingers or bare hands. Press the sides of large wounds gently but firmly together. If it is not possible to apply pressure directly on the wound, apply indirect pressure at an appropriate point on any artery between the heart and the wound. This treatment prevents blood reaching the wound and is the method, which must be applied immediately in any accident in which an artery has been cut. Indirect pressure may also be applied around the wound using a ring bandage. The technique may be used if pieces of glass or metal are in the flesh.
   b) Wherever possible, lay the victim down with the head lower than the rest of the body and – provided an underlying fracture is not suspected – raise the injured part and support it. This has the effect of increasing the blood supply to the brain. If the injured part is raised above the

heart, the pressure effect of having to flow uphill will also reduce blood loss from the wound.

2. Carefully remove any foreign bodies that can easily be picked out of the wound.
3. Apply a dressing directly over the wound and press it down firmly. Cover it with a pad of soft material and bind it with a firm bandage to keep the dressing and pad in position.
4. Immobilize the injured part using a sling or, in the case of a lower limb, by padding and tying it to the other leg.
5. Call an ambulance and carefully transport the victim to the hospital.

Dressing is a covering applied to wound or an injured part.

Dressing a Wound

A wound should be cleaned first and covered with a protective dressing. The main purpose of the dressing is to:

1. prevent infection,
2. control bleeding,
3. absorb any discharge from the wound, and
4. reduce further injury.

Sling: A sling is used to afford support and rest to an upper limb such as arm, wrist, chest etc. Arm sling (Fig.12.7), for example, is a wide piece of cloth looped from the neck under an injured arm for support.

The main types of first aid dressing for surface wounds are sterile adhesive pads such as 'Band-Aid', and the prepared standard gauze dressings covered with a pad of cotton wool which are supplied sealed in paper or plastic covers to keep them sterile. 'Bandaging' is a skill, which is obtained only by practice, and it is outside the scope of this course to turn you into a bandaging expert. However, it is necessary for you to know the essentials about the use of first aid dressings.

Slight Bleeding

Many a times, the bleeding stops on its own or is easily controlled by applying local pressure. The procedure for first aid treatment for wounds having slight bleeding is as follows:

1. Reassure the victim and keep him/her still.
2. Wash the wound in running water. Dry the skin with swabs of cotton wool, using each swab only once and wiping away from the wound.
3. Apply a dressing with a pad if required and bandage firmly. It is convenient to use an adhesive dressing.
4. If you don't suspect that a bone is broken then you may raise the injured part and support it in this position with a sling or by resting it on something of a convenient height such as a table or laboratory stool. You can support the area with a pad of old newspaper or plain wood or cardboard.

Fig. 12.7: Victim with an arm sling.

Internal Bleeding

If the patient's condition becomes worse without any external injury, one possible cause is internal bleeding. You cannot do much in such a case; you can try to reassure the victim and call for a doctor immediately. Internal bleeding should always be suspected after when a violent blow has been sustained and the person is in a state of shock.

However, one common type of internal bleeding that you can treat is a nosebleed. In case of a nosebleed,

1. the victim must be made to sit upright with his/her head slightly forward,
2. pinch his/her nose just below the hard part for about 10 minutes,
3. tell the victim to breathe through mouth,
4. do not attempt to plug the nose, and
5. seek the medical help immediately.

This procedure should be followed in all cases, though persistent bleeding from the nose should receive professional medical attention.

SAQ 8

List four steps you would take to give first aid treatment for a severe bleeding.

12.9 FIRST AID TREATMENT FOR SHOCK

All accidents are accompanied by a certain amount of shock that can be seen in terms of shivering, giddiness or excessive sweating etc. It is due to the changes in the system of blood circulation. Shock may arise due to

- loss of blood caused by injury or
- fall in blood pressure without loss of blood.

Shock may also be present even in cases where one suffers from severe and sudden fear, without any physical injury. In some laboratory accidents, such as explosions or burns from splashes of concentrated sulphuric acid, the effects of shock may be more serious than the injuries themselves. Shock varies a lot in its severity and can be fatal. Sometimes the effects are delayed and shock may not be observed until some time after the accident.

The chief symptoms of shock are as follows:

- Extensive sweating
- Paleness, cold skin and rapid breathing
- An increased pulse rate or a weak pulse
- Trembling, faintness, blurred vision, giddiness
- A feeling of sickness and vomiting
- Anxiety

If the victim is seriously injured, it is advisable to get him/her immediately to the hospital. Do not waste time as sometimes immediate blood transfusion may be required to save the life.

In other cases, the following treatment should be given:

1. Make the victim lie or sit down, if necessary, and deal with the injury or cause of shock. If the person is feeling cold wrap her/him in a blanket, but

do not use hot water bottles or electric fires as these draw blood from the vital organs to the skin.

2. Loosen ties, belts or other tight clothing at the neck, chest and waist.

3. Raise the victim's legs, if possible, to bring more blood back into the brain. If the person is sitting down, e.g., after fainting, it may be more convenient to get her/him to lower his/her head between the knees.
4. Keep the person still and reassure her/him.
5. Do not move the person unnecessarily.
6. If the injured person complains of thirst, moisten her/his lips with water. Remember, a seriously injured person may require an anesthetic immediately on arrival at hospital; so, do not give her/him anything to drink until you are satisfied that any injury is only trivial, e.g. faintness or dizziness.
7. Do not allow the victim to drink alcohol and never give tea, coffee or any other liquid to a person who is unconscious or is suspected of having internal injuries. If the patient has anything in her/his digestive system such as tea, either the anesthetic, if administered later at the hospital, may be refused or it could cause vomiting. In either case, it makes the surgery, if required, quite difficult.

SAQ 9

"The best thing for shock is a warm cup of sweet tea" is a common advice generally offered by the onlookers. If you had time to give a reply, what points would you raise?

12.10 FIRST AID TREATMENT OF LOCALIZED INJURIES

So far, we have seen main life-saving functions of first aid. Let us discuss the task of controlling some other injuries so that they do not pose a major threat to the victim while professional medical aid is sought.

12.10.1 Burns

There are two types of burns, which we need to discuss. These are the chemical burns and thermal burns. Of these the chemical burns have already been discussed in Sec. 12.7; so we shall discuss thermal burns, i.e. burns due to high temperature. Two common injuries due to thermal burns are:

i) Dry burns from flames or from picking up hot glassware or metals
ii) Blisters from steam, boiling water or other hot liquids.

Direct contact with the source of heat causes tissue damage. In addition there is a considerable danger from shock that is directly related to the extent of the injury.

The aims of the first aid treatment of thermal burns are:

- to reduce the local effects of heat,
- to relieve pain,
- to prevent infection of the affected area,
- to replace fluid loss and thereby reduce shock, and
- to remove a severely injured victim to hospital as quickly as possible.

The procedure to be followed is as follows:

1. Cool the injury as rapidly as possible and reduce pain by immersing the affected part in cold water or holding it under a running tap.
2. Remove rings, bracelets, boots or anything else of a pressing nature before swelling occurs. Don't pull away clothing that has been burnt and is sticking to the skin.
3. Cover the wound with a dry, sterile dressing.
4. Give small volumes of cold drinks at frequent intervals to a badly burnt conscious victim to counteract the effect of fluid loss. However, before giving liquids it must be made sure that a surgery is not necessary.
5. Reassure the victim.
6. Badly burnt or blistered victims must be taken to hospital as quickly as possible. Any burn injury in which more than 10% of the body surface is burnt is considered as very severe and immediate hospital treatment is vital. For example, the surface area of your head or back represents about 11% of the total surface area of your body.

Do not prick any blisters that form, and do not touch the affected area as this can increase the risk of infection. For very minor burns, apply 'Burnol'. If severe burns are there, do not apply lotions or ointment.

12.10.2 Fractures

Any broken or cracked bone is referred to as a fracture. The general symptoms of a fracture are as follows:

- Sensitivity when gentle pressure is applied to the affected area and localized pain, which increases if the injured part is moved. Some fractures such as those of the wrist or fingers produce little pain and the victim may feel that s/he has only bruised or strained the affected area.
- Swelling occurs as a result of blood loss into the surrounding tissues and may mask other symptoms.
- If a deformity or unnatural movement is observed, wherever possible the injured and uninjured limbs should be compared.
- Shock.

Bruise: Bleeding beneath the surface of the unbroken skin.

It is not our intention to introduce you to many types of fracture that can occur or all the ways a first aid provider might deal with them. The essential thing we wish to bring to your notice is that **if a victim with a fracture is moved without first taking steps to immobilize the fractured limb there may be**

serious complications.

The recommended action in any accident in which a fracture is suspected is to keep the victim still and not to move her/him unless it is necessary to separate her/him from some other hazard which could endanger her/his life. Remember that any movement can cause further injury and the part should be immobilized by means of a body bandage or by the use of splint and bandages.

Splint: A thin, rigid strip of wood, metal *etc*. used to keep a broken bone in place. It can be improvised by flat wood or news papers.

The best general treatment for a fracture is to

1. cover the victim with a blanket
2. keep the victim warm
3. send for an ambulance
4. treat for shock and do not give any drinks.

12.10.3 Eye Injuries

The eyes are a particularly vulnerable part of the body. Safety glasses, goggles or a face shield are a 'must' for any experiment where there is any danger of splashes of chemicals, broken glass or particles of metal entering the eye. Eye injuries are common occurrences, particularly where power tools are used. However, the use of safety goggles will prevent nearly all accidents of this kind. Injuries are usually caused by

1. entry of a foreign body in the eye, or
2. chemical splashes into the eye.

In either case, initial first aid treatment is through the use of tap water.

Splashes of chemicals or of corrosive liquids in the eye must be treated immediately as any delay may result in permanent damage to the sight. Strong alkalis are particularly dangerous. The aim of first aid treatment is to dilute and eliminate the chemical as quickly as possible and then to get the victim to hospital for urgent treatment.

The standard first aid procedure is as follows:

1. Hold the eye open or get the victim to blink repeatedly while washing the eye with clear, fresh tap water for several minutes.
2. Place a clean dressing over the eye.
3. Arrange immediate transport to the hospital. All eye injuries caused by the action of chemicals require urgent medical treatment. In some cases, the effects of the injury may not develop for some time.

Foreign bodies, such as a piece of sand, grit or an eyelash, may be removed from the eye using the corner of a clean handkerchief. All eye injuries resulting from solid objects should receive urgent skilled medical attention.

Grit: Hard particles of sand or stone.

SAQ 10

Write down the four steps you would take on discovering a suspected fracture.

12.11 SUMMARY

Accidents in laboratories, by and large, occur due to unsafe work practice. The accidents may result in harm to someone and / or damage to equipment and premises. In this unit, we have given a series of guidelines for offering first aid treatment for specific situations like electric shock, unconsciousness, chemical accidents, bleeding, burns, fractures and eye injuries. Due care must be shown while using these procedures. Wherever necessary, the victim should be provided with skilled medical attention at the earliest.

12.12 TERMINAL QUESTIONS

1. Differentiate between incident book and accident report form.
2. If an electric shock victim is in contact with high voltage electric current such as that coming from overhead electric power cable, what is the method to be used in separating the victim from the hazard?
3. Assume that you have given the required first aid to an unconscious victim. You are waiting for proper medical assistance. In this situation, what would you record in writing?
4. State the first aid procedure to be followed in dealing with a victim who has swallowed some poisonous chemical while pipetting.
5. Name any five sources of vapour, gas or dust that could cause poisoning by inhalation.
6. Suggest three methods of checking whether the victim's heart is beating or not.
7. What are the main purposes of first aid dressing?
8. What is the first step in the first aid treatment of shock?
9. The five aims of first aid treatment for thermal burns are
   i) to reduce the local effect of heat
   ii) to relieve pain
   iii) to prevent infection at the site of the burn
   iv) to replace lost fluid
   v) to reduce shock

What are the five steps to be taken to achieve these aims?

12.13 ANSWERS

Self-Assessment Questions

1. According to Occupational Health & Safety Advisory Services *an incident is referred to as a work-related event(s) in which an injury or ill health (regardless of severity) or fatality occurred, or could have occurred.* An **accident** is regarded as a particular type of incident in which an injury or illness actually occurs.
2. One of the first aid boxes containing minimum content is to be kept in unlocked condition in order to cater for emergency usage. It must be within easy reach. The other first aid box with contents above the minimum

requirements should be kept locked and, a responsible person put in charge of it. The second box serves as a support in times of need.

3. The members of the crowd can be used to contact ambulance, fire service, doctor etc. A person can be asked to take care of the accident victim until doctor arrives. They can also be used to clear up the spilled chemicals, or broken glassware or extinguish the fire (if it is only a small one) etc.

4. The power supply has to be turned off or it should be made certain that the victim is no longer in contact with the power supply.

5. Resuscitation helps to clear the airway, restore respiration and restart circulation.

6. (3) (2) (1) (4).

7. The antidote helps in lessening the pain of the injury by removing or neutralising the substance. Also, it helps in reducing the effects of burns.

8. (a) Control bleeding.

   (b) Remove foreign bodies, unless they are deeply embedded

   (c) Apply a dressing directly over the wound.

   (d) Immobilize the injured part of the body.

9. If the victim has to undergo an operation using an anesthetic, tea or any fluid in the digestive system would result in the refusal of the anesthetic or vomiting. In either case, the chances of the patient undergoing a smooth operation are considerably diminished by fluids. If a victim is thirsty, only her / his lips need to be moistened with water.

10. a) Do not move the victim unless absolutely necessary.

    b) Immobilize the fractured part by use of a body bandage or splint.

    c) Treat for shock.

    d) Call for professional medical aid, and remember – don’t give any drinks.

Terminal Questions

1. Incident book contains details of all accidents and ‘near misses’. The book is a valuable source of information to the alert laboratory Incharge who also maintains it. The entries in the incident book are to be made by the person attending on the accident victim or by any of the laboratory staff. Accident report forms are to be used in case of serious accidents. These forms are to be prepared and maintained by the laboratory Incharge and a copy of each filled-in form may have to be sent to the Head of the institution who could initiate measures to improve safe working conditions in the laboratory.

2. The victim can be pulled or pushed, using a wooden chair, thick dry cloth, rubber or other insulating material. The person administering first aid should stand on a dry insulating surface such as a wooden chair.

3. The victim’s responses and pulse rate are to be recorded at regular intervals.

4. a) Tell the victim to spit out as much of the chemical as possible and to wash the mouth repeatedly with water.

   b) Give large drinks of water or milk to dilute the poison.

   c) Don’t induce vomiting as this may cause further damage.

5. Chlorine, hydrogen sulphide, ammonia, hydrogen cyanide and phosphorus pentachloride could cause poisoning by inhalation.

6. The heartbeat can be checked by feeling the pulse at the wrist or neck or by applying an ear to the victim's chest.

7. (i) Prevention of infection (ii) controlling bleeding

   (iii) absorbing any discharge (iv) reducing further injury.

8. Where ever possible, ensure that the victim is lying down (with the legs raised) or sitting down (with the head lowered between the knees), and protected from the cold by using a blanket wrapped underneath; but do not use hot water bottles or electric fires as these draw blood from the vital organs to the skin.

9. i) Reduce the local effects of heat by immersing the affected part in water. Use gently running water, or a full bucket or bowl. Speed is essential.

   ii) Relieve pain by removing anything that might cause swelling by pressing, but do not pull away clothing that has been burnt and is sticking on to the skin.

   iii) Cover the injury with a dry, sterile dressing.

   iv) Counteract the effect of fluid loss by giving small volume of cold drinks if the victim is conscious, and if operation is not necessary.

   v) Reassure the victim.