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NATIONAL OPEN UNIVERSITY OF NIGERIA

PHY 131

HAZARDS IN LABORATORY AND LABORATORY SAFETY

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INTRODUCTION

This course is about the likely hazards and ways of ensuring safety in a laboratory. It is important to learn about these hazards and the precautions to be taken to prevent any accidents in the laboratory. There are six units in this course. The Unit 1 of this course 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. In this Unit, we also discuss 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 2, 'Fire Hazards'. It discusses different causes of fires, classification of fires, types of fire extinguishers and their usage.

Unit 3 named, 'Radiation and Chemical 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. This unit also discusses some of the very common radiation hazards which could occur in laboratories where radioactive materials are used.

Unit 4, 'Hazards in Biology Laboratory', deals with the microbiological and other hazards which are specific to a biology laboratory. It discusses the supply, handling and disposed of biological materials.

In Unit 5 on 'Personal Safety', we discuss various features concerning safe laboratory work. The obligations of the teachers and the Head of the Institution towards maintaining laboratory safety are stressed. 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 of laboratories is also listed.

Unit 6 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.

OBJECTIVES

After reading this course, 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,
- describe the hazards caused by radiations,
- 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,
- appreciate the need for observing safe laboratory practice,
- state the features concerning code of practice in a laboratory,
- identify the contents of a 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 1 ELECTRICITY AND GAS HAZARDS

CONTENTS

1.0 INTRODUCTION

Electricity is one of the finest gifts of science to the mankind since just a flick 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 equipment 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 worn out equipment or improper use - both of which are avoidable. For instance, according to National Crime Records Bureau, there have been 3502 and 3861 accidental deaths in our country due to electric shock during 1994 and 1995, respectively.

Similarly the use of LPG in laboratory is convenient for a number of purposes; but if used carelessly, it may lead to fire and other hazards. Besides LPG, other compressed gases also need careful handling and may pose a potential danger in the event of misuse. In this unit we will discuss the possible hazards due to improper use of electricity, LPG and other compressed gases. You are going to study some instructions to be followed for safety. The first section describes electrical hazards while the second section describes the gas hazards. 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.

2.0 OBJECTIVES

After studying this unit, you should be able to:

- describe the consequences of passing electric current through human 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,
- describe high and low pressure gas hazards, and
- list the precautions to be taken to prevent gas hazards and steps to be taken in case of a gas leakage in the laboratory.

3.0 MAIN CONTENT

3.1 Electricity Hazards in the Laboratory

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 because it only needs a few milliamperes (mA) across the heart to stop it. There are serious physiological consequences of passing an electric current through the body. You will learn about how to calculate the current in subsection 3.1.2. A current of 1 mA is recognised as the threshold of perception i.e., a 1mA current through the skin causes a tingling sensation. A current of 6 mA -10 mA is the let-go-current. A current beyond 10 mA is not safe, a higher current may produce muscular contraction which does not allow even to throw away the current carrying object. A current of 20-25 mA will cause sure death as it causes irregular contraction of the heart whereby it stops pumping.

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

From now on, you know just what to expect if you ignore electrical

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

safety. You will read about the first aid treatment of electric shock in

this course. 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. In other words, switch off the power either at the nearest appropriate mains socket or at the nearest **cut-out** or master switch.

Many a times the reason behind the electrical mishap is due to 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.

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

- improper wiring
- improper choice of fuse
- choosing wire of improper rating
- deterioration in the insulation system
- accidental touches
- break in earthing system
- improper operation/use of unconventional tools

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

3.1.1 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.

earth	**green**
live	**red**
neutral	**black**

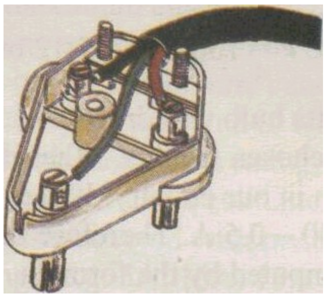


Fig. 1.1: Plug showing wire connections

The above mentioned colour codes should be followed while wiring a plug. Fig. 1.1 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. Let us move on to selecting a proper fuse for a given appliance in order to learn the safe handling of electricity.

> 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.

> For proper wiring: (i) colour code should be followed; (ii) connections must be tight.

3.1.2 Selection of Proper Fuse

Fuse is a safety device or a wire of metal in a cut-out 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 e

> 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, untold 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,

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

Fuse rating = calculated current 15-20%

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

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; a common phenomenon in our country. 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.

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 is divided into a number of circuits say for each room, a block or a laboratory etc. and is 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 tube lights of 40 W each will have a total load of 400 W. The fuse rating for this room will be calculated 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.

SELF ASSESSMENT EXERCISE 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?

____

____

SELF ASSESSMENT EXERCISE 2

A lecture theatre has 6 fans of 80 W each, 8 tube lights 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 hence choose an appropriate fuse. What about the kind of flex/cable to be used? Let us see below.

3.1.3 Selection of Proper 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.

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

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") 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. Commonly, general purpose flex or cable is usually covered with PVC (poly-vinyl chloride -a polymer) for insulation and is available in a variety of ratings, e.g. 5 A, 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.

In addition to the information you have read on cables and flexes, you should remember that if a cable *is* coiled, its maximum allowable current will be reduced due to its decreased ability to dissipate heat, and also due to the build up of heat caused by induction.

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 extensive heavy duly 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.

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

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 the correct answer.

SELF ASSESSMENT EXERCISE 3

The flex/cable is rated in

(i) mm …….......
(ii) mm^2 or …….......
(iii) amps …….......

SELF ASSESSMENT EXERCISE 4

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.

3.1.4 Safe Conduct

Of course, it's 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. This includes a proper flex routing, proper use of adaptors, plugs and sockets. You will read about these in the following paragraphs.

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

Flexes must

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

Flex Routing

You can see that your labour will have been in vain unless you 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. 1.2) 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.

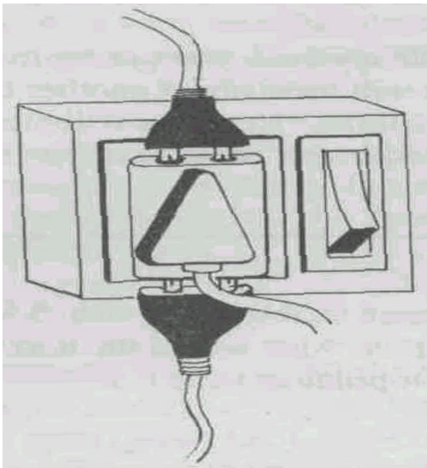


Fig. 1.2: An overloaded socket.

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.

Plugs

Check for:

(1) Hair-line or other fractures in body
(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) Mechanical distortion to flex - twisted, worn

Having learnt about the safe conduct, you can try to answer the Self Assessment Exercise 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 the reasons for earthing a metal clad appliance are.

SELF ASSESSMENT EXERCISE 5

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

(i) 8 A
(ii) 5 A
(iii) 15 A

SELF ASSESSMENT EXERCISE 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.

3.1.5 Earthing

Any electrical appliance with a metal casing or with metal pans, 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 may 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 may 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 equipment 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. 1.3.

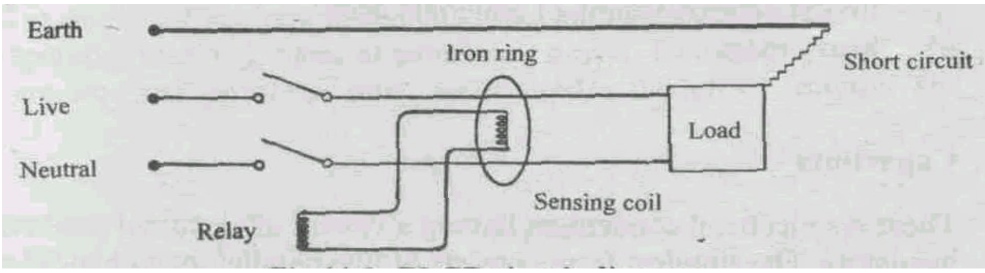


Fig. 1.3: ELCB circuit diagram

In the event of 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, then, 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.

SELF ASSESSMENT EXERCISE 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.

SELF ASSESSMENT EXERCISE 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.

3.1.6 Other Dangers Associated with Electrical Equipment

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

Lead Acid Accumulators

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) heavy mass
(iii) fumes

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

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 insulating 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 are rubbed 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 for 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 catastrophic 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.

SELF ASSESSMENT EXERCISE 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 (HF)	____________________
(iv)	Van de Graaff generator	____________________

3.2 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 the following subsection we are going to discuss 'how to make LPG safer' and in the next subsection we shall deal with the hazards and precautions associated with other compressed gases.

3.2.1 How to Make LPG Safer in the Laboratory

The following must be observed in the laboratory:

1. The LPG cylinders should be kept outside the laboratory in a ventilated room.
2. 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.
3. Regulate the pressure of the gas to the optimum level.
4. In the laboratory ensure that all the burners connected to gas supply are in working condition and the tubing used for

connection is ISI approved. Never use ordinary rubber tubing. **Inspect the rubber tubing for its condition and replace if needed once in a year at least.**

5. Ensure that highly volatile liquids are never heated directly on the flame.
6. 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.
7. Use spark free switches.

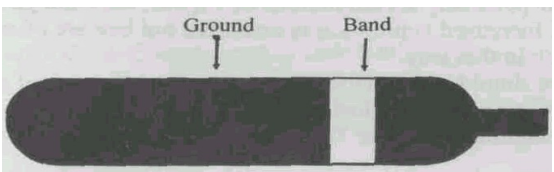
3.2.2 High Pressure Gas Hazards

When we consider the dangers of compressed gas in the lab, there are three main sources of danger as follows:

(1) Sudden release of high pressure gas
(2) Gas cylinders as unstable heavy objects
(3) Inherent dangers of the contents of gas cylinders

It is advisable to know as to what general precautions should be taken when handling gases, or even to know the dangers of particular gases. None of this knowledge is of much use to you if you don't actually know what gas is inside the cylinder. The main indication is given on the shoulder of a cylinder where the name and chemical formula of the gas should appear. A secondary indication of the gas or its nature is given by colour coding (Fig. 1.4) as follows:

(i) Ground colours - covering the entire cylinder body
(ii) Colour bands - on the shoulder of the cylinder.



A red band indicates a flammable gas.
A yellow band indicates a toxic gas.
A red band above **a yellow band** indicates a flammable toxic gas.
A black band indicates a nonflammable nontoxic gas.

Fig. 1.4: Gas cylinder with colour coding

The ground colours tell you what the gas is, and the bands tell you something about the nature of the gas. Table 1.1 summarises the important markings which should be learnt by heart.

In addition to the colour codes, flammable gases are usually indicated by cylinders being fitted with a left-hand thread. Of course this indication is only of use when fitting a valve and regulator to a cylinder. However, you need to know which way to turn when removing the valve unit.

The contents of compressed gas cylinders can range from highly flammable substances, such as hydrogen, propane and ethyne (acetylene), to toxic gases, such as chlorine, sulphur dioxide, carbon monoxide etc., and to comparatively inert substances like argon, carbon dioxide, and nitrogen. The standard symbols used for the flammable and toxic gases are shown in Fig. 3.6 of Unit-3. These gases can cause the following types of hazards in the event of a leakage.

Table 1.1: Gas cylinder colour codes

Gas	**Colour of Cylinder**	**Colour of bands (if any)**
Air (not for breathing)	Grey	-
Ammonia	Black	Red and golden
Argon	Blue	-
Carbon dioxide	Black	-
Carbon monoxide	Red	Golden yellow
Chlorine	Yellow	-
Ethyne (acetylene)	Maroon	-
Hydrogen	Red	-
Helium	Brown	-
Nitrogen	Grey	Black
Oxygen (industrial)	Black	-
Oxygen (medical)	Black	White
Sulphur dioxide	Green	Yellow
Any toxic gas mixture	Purple	Yellow
Any flammable gas	Purple	Red

(1) **Oxygen displacement:** leading to **asphyxiation** of staff or laboratory animals.

(2) **Fire and explosion:** oxygen or hydrogen enriched atmospheres can explode into fireballs moving with great force. Ignition can be by the slightest spark, e.g. from a light switch (spark free switches are available where this is a particular hazard).

(3) **Toxicity:** gases may be toxic even cause burns and irritation by skin contact.

> **Asphyxiation**: Oxygen deficiency caused by gases, heavier than air such as carbon dioxide, methane etc. Due to this, lungs do not get sufficient supply of oxygen,

These hazards can be minimised by following certain precautions, given below.

(1) **Ventilation:** it is a good practice to ventilate a laboratory as soon as it is opened to disperse any accumulations of vapour, dust and gas. In any emergency, increased ventilation is essential; but beware of exposing others to risk in this way.

(2) **Respirators** should be available where there is a real risk of gas hazards.

(3) Where there is a risk **of explosion** due to gas, elimination of ignition sources is essential. This can be done by practising the following measures:
   - (a) use of spark-free electrical switches
   - (b) banning of all electric motors
   - (c) elimination of all sources of sparking from impact/friction
   - (d) a thorough warning sign system
   - (e) no experiments/work with flame

(4) Large cylinders may weigh as much as 85 kg and should always be clamped vertically, Fig. 1.5, to prevent them toppling over or laid horizontally on the floor and fixed to prevent rolling. Damage could cause the base of valve stem, Fig. 1.6, to shear off and sudden release of pressure can propel a heavy gas cylinder across the room or through brick walls like a shell because compressed gas cylinders have gases stored under very high pressures.

Keep the cylinder key on or attached to the cylinder for emergency switch off.

(5) The gas cylinders may be stored in open but should be protected from water, to avoid rusting and from extreme temperatures. These should not be heated beyond ~50°C.

(6) Care must be taken while moving cylinders, avoid dragging, rolling or sliding them. The use of a cylinder trolley is recommended.

(7) The valve protection cap should not be removed if the gas is not to be used. Stiff cylinder valves must be opened carefully with hand pressure and not forced with hammers or wrenches with excessive leverage.

(8) When the gas has to be passed through a liquid always use a check valve or a trap to prevent back suction of the liquid into the cylinder.

(9) Always employ cylinders of suitable size so that the gas exhausts within a reasonable period of time.

(10) Oil or grease must never be used on lines, releasing valves or other equipment for oxygen cylinders as this can cause explosions.

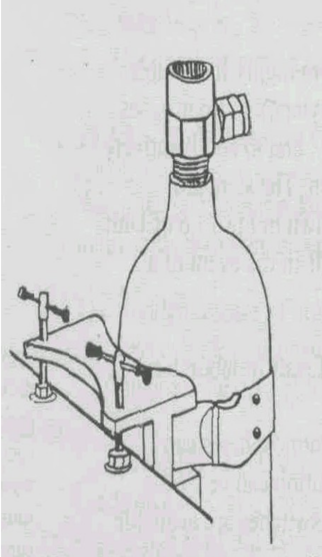


Fig. 1.5: Clamping a gas cylinder vertically

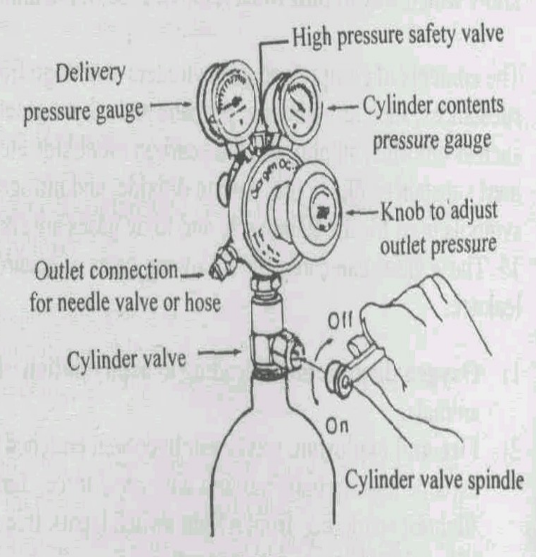


Fig. 1.6: Valve and valve stem

Despite the precautions taken there may be leakages and associated risks. Let us learn how to detect and manage a gas leakage. But before that try to answer the following Exercises.

SELF ASSESSMENT EXERCISE 10

What is the main danger when a gas cylinder falls?

____

____

SELF ASSESSMENT EXERCISE 11

What force should you use to turn the valve of a gas cylinder? (Tick mark the correct answer).

(i) light finger pressure
(ii) firm hand pressure
(iii) strike with a hammer

3.2.3 Detection and Handling of Gas Leakage

If you are using a toxic gas or have a store for it you must have some devices to indicate the leakage, if any. Though numerous monitoring instruments are available for this purpose, 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 the following simple chemical procedures are also quite useful.

The source of leakage in a chlorine cylinder can be located by the use of ammonia. You may take a glass rod/stick and wrap a strip of filter paper/cloth on one end of it and soak into liquid ammonia or ammonium hydroxide. Take this chlorine detection device to a possible leakage point. Formation of dense white clouds (due to reaction of ammonia and chlorine) indicate the leakage source. Similarly hydrogen sulphide gas (H_2S) can be detected simply by hanging strips of lead acetate paper near the place of work. Blackening of paper indicates leakage. You may be aware that in the chemistry laboratory H_2S gas is used for the precipitation of cations of analytical groups II and IV in quantitative analysis.

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 leaks of chlorine, ammonia or hydrogen 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. Leaking oxygen poses a fire hazard if the concentration becomes 3-4% more than the normal, while hydrogen being flammable poses an explosion risk. Removing the cylinder to well ventilated area and ensuring the absence of ignition sources is sufficient. Leaking nitrogen and carbon dioxide cylinders should be removed to open spaces to avoid exposure, else these do not pose much of threat. **However, all leakages eventually should be managed by the experts.**

Exposure to the leaking gas may be inevitable despite the precautions taken. Therefore, knowledge about the specific health hazards from the gases and their management, in case of an exposure, is essential. The health hazard data of some commonly used gases is summarised in Table 1.2.

Several times, we need to evacuate glass apparatus in the lab. This creates a low pressure inside the apparatus. These apparatus under low pressure are also potentially hazardous. Let us see in the next subsection how do we minimise this risk.

3.2.4 Low Pressure Gas Hazards

Safety screens and wire-mesh guards should be placed round evacuated glassware (Fig. 1.7) and safety goggles or a face shield must be worn

> **Implosion**: Bursting inward due to low pressure. During implosion, the pressure exerted on the walls by the atmosphere is far more than inside the vessel.

against the possibility **of implosion.** This particularly applies when large desiccators or Buchner funnels are being evacuated. Take care when connecting thin-walled glassware to a vacuum line or filter pump. The rule is, don't do so unless it is designed to withstand low pressures. Glassware should be examined for flaws before it is evacuated. If a crack occurred in a vessel which was partially evacuated, the effect of this enormous force compressing the weakened flask would cause it to implode (i.e. to explode inwards) propelling fragments of broken glass in all directions.

Table 1.2: Health hazard data of commonly used compressed gases

S.No.	Name of the gas	Routes of entry	Effects of exposure/symptoms	Emergency treatment
1.	Hydrogen	Skin, inhalation	• Can cause dizziness, unconsciousness or even death. • Contact with eyes or skin causes stiffness.	• Inhalation- if victim is unconsious, move to fresh air and apply resuscitation method (Unit 16). • Eyes and skin- soak the skin in lukewarm water.
2.	Nitrogen	Inhalation, eyes and skin	• Can cause asphyxiation • Dizziness, unconsiousness, even death can result. • Liquid nitrogen causes frost bite, burns in skin and eyes.	• Inhalation- remove the victim to fresh air area. • Artificial respiration if required. • Eyes- treat by liquid. • Skin- soak in lukewarm water. • Immediate medical aid.
3.	Ammonia	Inhalation, skin or eyes	• 700 ppm causes eye irritation leading to permanent injury. • 5000 ppm may cause death. • Caustic burns on skin. (ppm : parts per million; namely 1 mg in 1 litre of air)	• Inhalation- remove victim to fresh air area and give artificial respiration or oxygen. • Skin and eyes- wash effected area with plenty of water for 15 min., seek medical aid.
4.	Chlorine	Inhalation, ingestion, skin and eyes	• Eye irritation, restlessness, sneezing, copious excitement. • Respiratory distress and violent coughing due to high concentration. • Suffocation may lead to death.	• Inhalation- remove victim to fresh air area, support respiration, give oxygen. • Eyes- flush with large amount of water for at least 15 minutes. • Seek medical aid.
5.	Carbon dioxide	Inhalation, skin and eyes	• Causes increased respiration rate, headache, subtle physiological changes for ~ 5% concentration and prolonged exposures. • Higher concentration can cause unconsciousness and death. • Solid causes cold contact burns. • Liquid or cold gas-injury to eye and skin.	• Inhalation- move victim to fresh air area. • Skin- treat burns. • Eyes- irrigate with plenty of water for 15 minutes. • Seek medical aid.
6.	Oxygen	Inhalation, skin and eyes	• Inhalation of 100% causes nausea, dizziness, irritation of lungs, pulmonary edema, pneumonia and collapse. • Liquid causes frostbite of eyes and skin.	• Inhalation- recovery is rapid after reduction of O_2 pressure, immediate sedation, convulsive therapy and rest. • Eyes- soak in lukewarm water, treat frostbite burns.
7.	Hydrogen sulphide	Inhalation, eyes	• Causes irritation of respiratory tract and eyes, • Headache, dizziness and weakness • At high concentration may cause unconsciousness followed by respiratory paralysis.	• Remove the victim to fresh air area, • Artificial respiration, if required.

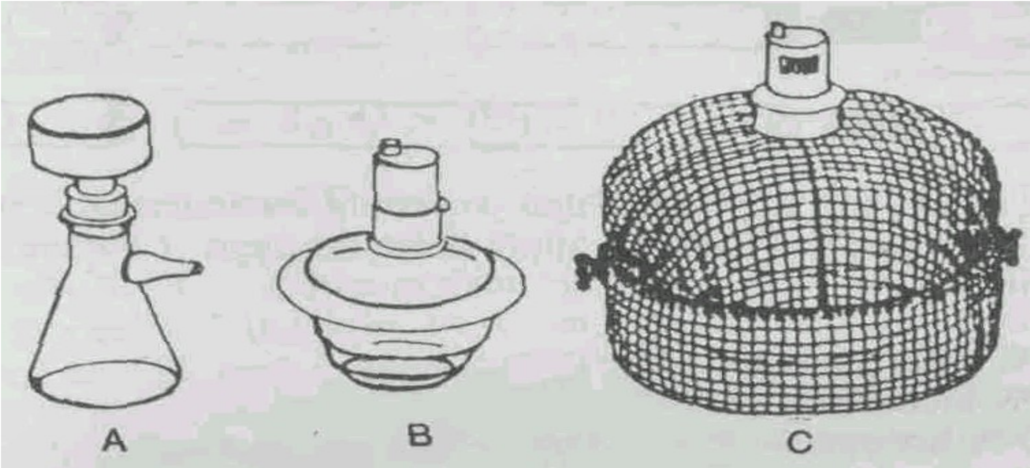


Fig. 1.7: (a) Buchner funnel (b) Vacuum desiccator (c) Protective wire-mesh guard

4.0 CONCLUSION

Electricity is one of the finest gifts of science to the mankind but its misuse is injurious to life. Similarly the use of gas in laboratory or at home is convenient for a number of purposes; but if used carelessly, it may lead to fire and other hazards. So both, electricity and compressed gases, need careful handling.

There are serious physiological consequences of passing an electric current through the body. A current beyond 10mA is not safe and a current of 20-25 mA will cause sure death as it causes irregular contraction of the heart whereby it stops working. 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 but firstly isolate the victim from the electric power source means switch off the power. There are many causes that may lead to shock or cause an electrical mishap. But colour code for cable and flex should be followed and should be ensured that the connections are tight to avoid sparking.

A fuse should be selected properly and provided in the electrical circuit. It should be such that it blows off when the value of current increases beyond its normal current rating and the faulty circuit is disconnected.

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. Each flex and cable is rated according to the maximum current it will safely carry. The conducting ability of the metallic conductor depends on its cross-sectional area and therefore the diameter. Always ensure that flexes are routed safely and well clear of sources of danger.

The use of a large number of plugs and adaptors in a single socket 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.

All electrical equipment that is not fully insulated should be properly earthed for safety. 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 (Earth leakage circuit breakers) are in large use for this purpose. The lab assistant should be aware of other types of potential hazards arising from like lead acid accumulators, capacitors and static electricity etc.

Gas hazards in a laboratory arise from LPG and other compressed gases. Proper precautions should be followed while handling and using the cylinders of these gases. It should be aware that what gas is inside the cylinder and the danger of the gas. Proper precautions should be followed while handling and using these cylinders. The laboratory personnel should be aware of the colour code of the cylinders used which is specific for a particular gas. Knowledge of gas leak detection and handling and the emergency treatment in the event of an exposure is essential for every laboratory staff. Some simple procedures are made use of to detect the gas leakage like, use of ammonia for chlorine, lead acetate for hydrogen sulphide etc.

5.0 SUMMARY

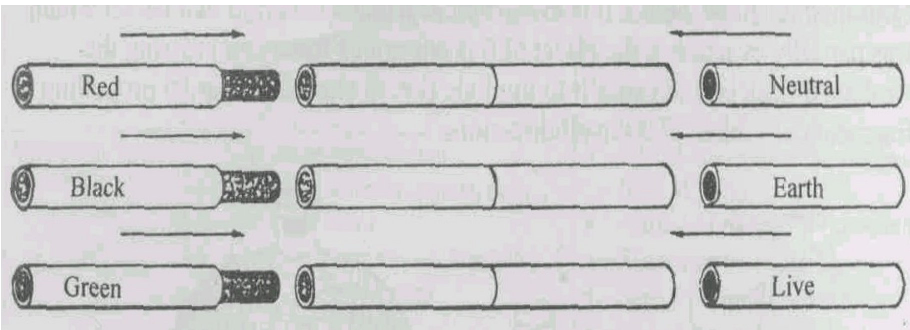
Let us summarise what all we have studied and learned about electricity and gas hazards in this unit.

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.

We learnt how LPG can be used safely. Pressurised gas cylinders are widely used in all labs and many cylinders contain toxic or flammable gases. Proper precautions should be followed while handling and using these cylinders. The laboratory personnel should be aware of the colour code of the cylinders used which is specific for a particular gas. Knowledge of gas leak detection and handling and the emergency treatment in the event of an exposure is essential for every laboratory staff. Some simple procedures are made use of to detect the gas leakage like, use of ammonia for chlorine, lead acetate for hydrogen sulphide etc. The possible health hazards of different gases and the emergency treatment in case of an eventuality have been given in a tabular form. The use of goggles should be made as a precautionary measure in case of a possible implosion in evacuated glass apparatus.

6.0 TUTOR MARKED ASSIGNMENT

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 240V.)

   (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. 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, or
   (iii) call the fire brigade?

5. 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 lab is denser than air. Why does the gas concentration not appear to be high and what precautions might you take?

ANSWERS SELF-ASSESSMENT EXERCISES

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

   $$I = 2000/240 = 8.33 \text{ A}$$

   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 × 6 W = 480 W
   8 tube lights of 40 W each = 40 × 8 W = 320 W
   2 bulbs of 100 W each = 100 × 2 W = 200 W
   Total = 1000W
   So the total load = 1000 W or 1 kW
   Total current drawn = 1000/220 W = 4.5 A

   Therefore, a 6 A fuse should be alright for the lecture theatre.

3. 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. If the top valve is knocked off, the cylinder behaves like a rocket due to the rush of a gas.

11. Firm hand pressure. Never strike with a hammer.

7.0 REFERENCES/FURTHER READINGS

Certificate Programme in Laboratory Techniques (CPLT) , a certificate programme, School of Sciences, Indira Gandhi National Open University (IGNOU), New Delhi, India

Electrical Hazards and accidents: Their cause and prevention, by Greenwald E.K. (Editor), published by John Wiley & Sons. New York

UNIT 2 FIRE HAZARDS

CONTENTS

1.0 INTRODUCTION

In the first Unit of this course, you learnt about hazards due to electricity and gases in the science laboratories. The second unit 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. The person-in-charge of any laboratory should have 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 chemical and radioactive materials.

2.0 OBJECTIVES

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.

3.0 MAIN CONTENT

3.1 Fire Hazards in the Laboratory

The average science laboratory is a particularly hazardous area when it comes to fire. Flammable liquids, compressed and liquefied gases, 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.

3.1.1 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. 2.1.

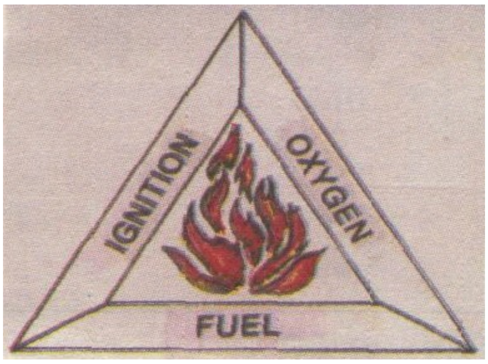


Fig. 2.1: The fire triangle

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 2.4.2), 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.

3.1.2 Causes of Fire

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

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.

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

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

SELF ASSESSMENT EXRCISE 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?

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3.1.3 Classification of Fires

As explained earlier 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 the table given below.

Table 2.1: Classification of fires

Class of fire	Type or nature of fire
A	Type involving materials which contains 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 next section, try to answer the following SELF ASSESSMENT EXERCISE.

SELF ASSESSMENT EXERCISE 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.

3.2 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.

3.2.1 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 sited no more than 30 metres 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.

3.2.2 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.

3.2.3 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 hafts often become quickest ways of spreading a 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.

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

SELF ASSESSMENT EXERCISE 3

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

We know that in spite 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.

3.3 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.

3.3.1 Fire Extinguishers

You would recall the classification of fires dealt in subsection 3.1.3. Table 2.2 summaries the type of extinguisher used for different classes of fire.

Table 2.2: 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	√	√	√	√	√

Halon is a halogenated hydrocarbon used as an extinguishing medium.

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 that try to answer the following SELF ASSESSMENT EXERCISE.

SELF ASSESSMENT EXERCISE 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

3.3.2 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. The difference between knowing what fire extinguisher to use and how to use it, and not knowing this information could be the difference between life and death for someone. However, 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. 2.2). 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.

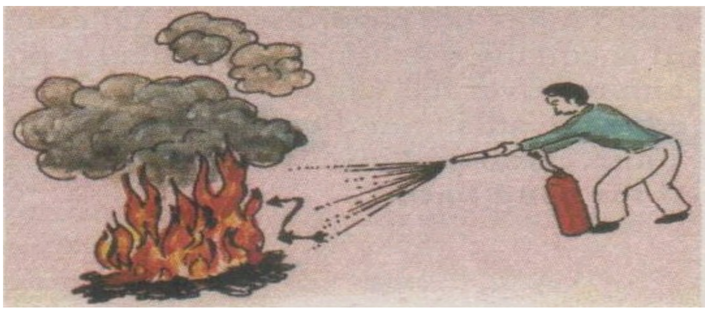

Fig. 2.2: Use of carbon dioxide and vapourising liquid extinguishers

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 that of

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.

asbestos. You will study more about fire blankets shortly.

(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. 2.3). 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. 2.4). 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. 2.3: Use of foam extinguisher-I **Fig.2.4: Use of foam extinguisher-II**

(d) Fire Buckets

All labs should be equipped with a fire bucket. 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.

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.

SELF ASSESSMENT EXERCISE 5

Tick the correct answer/s. When using a foam fire extinguisher, do you

(i) direct the jet at the base of the flame ?
(ii) direct the jet at a surface adjacent to the flame to break the jet and allow the foam to settle on the burning surface ?
(iii) project foam so that it falls on to the surface from a distance ?
(iv) hold the extinguisher upside down ?

4.0 CONCLUSION

In science laboratory, there are many sources of ignition available. A number of precautions and preventive measures are required to handle a fire hazard. 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. In the event of fire occurring, there should be prearranged plan of the necessary action to be taken. Therefore, the person-in-charge of any laboratory should have knowledge to handle a fire by following procedures like fire alarms, fire escapes, fire barriers etc. The laboratory staff should be trained in using different types of fire extinguishing devices like water, CO2, Foam, Dry sand, Fire blanket, Dry powder etc.

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 to prevent any casualty.

5.0 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 in charge 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.

6.0 TUTOR MARKED ASSIGNMENT

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?
(iii) 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 (iii) hazardous materials (ii) flammable liquids (iv) sources of ignition

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

ANSWERS SELF-ASSESSMENT EXERCISES

1. The fire can be extinguished by putting a cover on the breaker 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. (ii) and iii). Remember that the principle behind the foam extinguisher is to blanket the flames with a layer of foam. Method i) would not achieve this but would probably spread the fire. Method (iv) does not apply to modern extinguishers at all.

7.0 REFERENCE/FURTHER READINGS

Certificate Programme in Laboratory Techniques (CPLT) , a certificate programme, School of Sciences, Indira Gandhi National Open University (IGNOU), New Delhi, India

Fire and Explosion Hazards Handbook of Industrial Chemicals, by Tatyana A.D. and Nicholas P.C., Published by Noyes publication, New Jeresey.

UNIT 3 RADIATION AND CHEMICAL HAZARDS

CONTENTS

1.0 INTRODUCTION

You read about the fire hazards, general precautions and remedial measures in case of an outbreak of fire in the previous Unit. In this Unit, you will learn about two other common hazards. These are the hazards because of radiation and chemical substances i.e., substances hazardous to health. The radiation hazard is generally common in a physics laboratory; however, it is equally important for a biology or chemistry technician who has to handle radioactive isotopes, used as tracers. On the other hand a chemical hazard is more likely in chemistry or a biology laboratory; yet it cannot be ignored in a physics laboratory. Therefore proper attention should be given by all the staff working in a laboratory to these hazards.
In the next unit you will study about the hazards in a biology laboratory.

2.0 OBJECTIVES

After studying this unit, you should be able to:

- categorise different radiations into ionising and nonionising types,
- explain the effects of radiations and the precautions to be taken in their use,
- 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, and
- explain the significance of personal hygiene in the prevention of chemical hazards.

3.0 MAIN CONTENT

3.1 Radiation Hazards

We are sure that you would have studied about electromagnetic radiation during your studies at the school. You would recall that in electromagnetic radiation, the electric and magnetic components oscillate in mutually perpendicular directions as well as to that of the direction of propagation, Fig. 3.1. It is characterised by parameters like

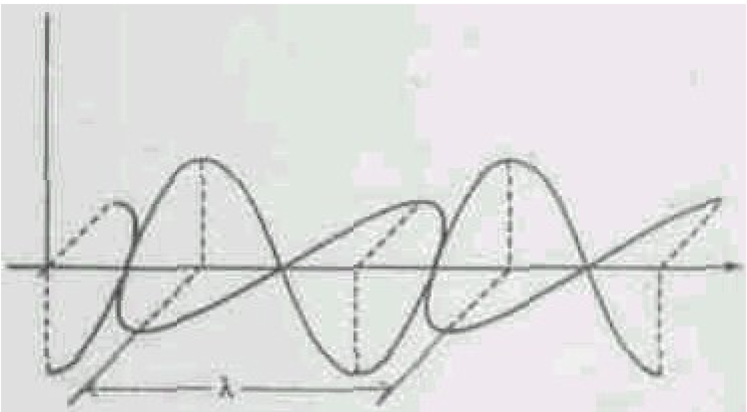

Fig. 3.1: Representation of an electromagnetic radiation

- wave length (λ) which is the distance between two crests or troughs and
- frequency (ν) which is the number of waves per second.

The energy of radiation is given by the formula:

$$E = h\nu = h\frac{c}{\lambda};\ h \text{ is Planck's constant and } c \text{ is velocity of light.}$$

The wavelength of a radiation can be as small as less than a picometre (10^{-12} m) or as high as a kilometre (km) or even more. As we see from the formula, the energy of radiation will decrease with increase in its wavelength. The hazardous nature of the radiation is manifested on its interaction with matter. On the basis of interaction with matter, radiations may be divided into two broad groups - **ionising** and **nonionising.** The nonionising radiations cannot change the nature of atom, but can be highly hazardous. They include ultraviolet and infrared radiations, ultrasonics, light (e.g. from lasers) and microwaves. The ionising radiation changes the atomic structure of a substance and can be classified into three major types - alpha (α), beta (β) and gamma (γ). The International Ionising Radiation symbol is used to indicate the presence of intermittent or continuous ionising radiation, Fig.3.2. It is usually black, on a yellow background.

The energy of the radiations absorbed when these ionising rays pass through living organisms can cause immense damage. The radiations affect human beings in a number of ways. They can cause cancer, genetic mutations, skin reddening etc. Cells which divide, such as those which produce the red blood corpuscles, are particularly susceptible. Effects on reproductive cells are cumulative and genetic damage may result. You must therefore exercise great care when using, storing or disposing of such materials.

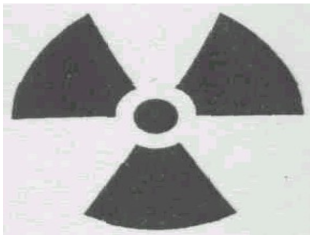

Fig. 3.2: Symbol for ionising radiation

3.1.1 Ionising Radiations

The three types of ionising radiations mentioned above penetrate matter to different extent. Table 3.1 summarises the nature, ionising power and penetration of the three ionising radiations.

Table 3.1: Radiation summary

Rays	Nature	Relative ionising power	Typical Penetration
Alpha (α)	A stream of positively charged (α) particles, nuclei of helium atoms	Most ionising	A few cm of air, a piece of card or foil.
Beta (β)	A stream of negatively charged (β) particles, electrons	Not as ionising	Can penetrate aluminium sheet. Stopped by a thin layer of lead.
Gamma (γ)	A stream of very high energy photons, high energy electromagnetic radiation	Least ionising	Penetrates all substances to some extent. 10 mm of lead halves intensity.

It should be noted that some apparatus not normally associated with ionising radiation can in fact produce it, e.g. high voltage rectifiers and electron microscopes.

Precautionary Measures Against Ionising Radiations

The following guidelines are suggested for experiments using low activity radioactive materials:

(1) Avoid skin contact by:

(a) wearing protective gloves (disposable polythene gloves over a rubber pair are convenient) and a lab coat.

(b) transferring chemicals in a fume cupboard or in a manipulator glove box (Fig.3.3) with a spatula or forceps.

(c) using safety bulbs (Fig. 3.4) when pipetting radioactive substances. Do not lick any labels.

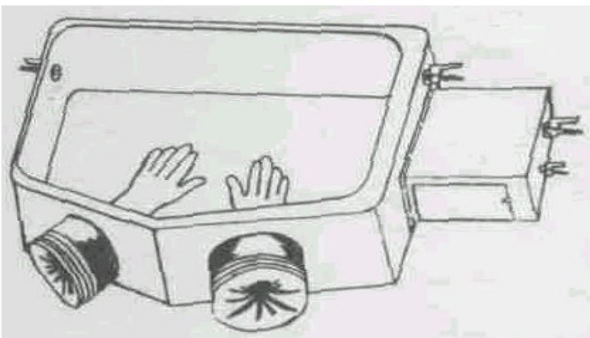

Fig. 3.3: An isolation or manipulator glove box

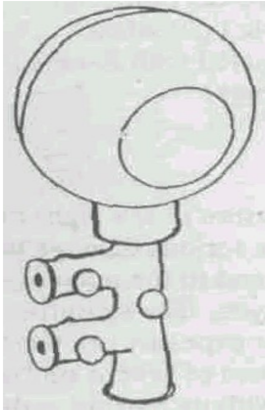

Fig. 3.4: A pipette filler

(2) Confine any work with radioactive materials to one area of the laboratory such as a fume cupboard and always set up warning signs.

(3) Glassware to be used for radioactive materials should be kept solely for this purpose and stored separately to guard against accidental contamination.

(4) All bottles containing radioactive material should be labelled with the recognised symbol.

(5) The person getting the radioactive material issued should put his signature along with full name and also the date and issuing time in the register.

(6) Check the quantities of radioactive substances at the end of any work and account for all the material which has been used.

(7) Return all sources and radioactive materials to a securely locked and suitably shielded cupboard in the stores. This cupboard should be properly labelled and used solely for storing radioactive materials. A special notebook should be kept for logging these radioactive sources in and out of storage. It should also indicate the type and serial number of the source.

(8) Always wash your hands thoroughly using disposable towels after working with radioactive materials and then monitor with a Geiger counter to ensure that no radioactivity remains on the skin.

Geiger counter is a special device used for measuring radioactivity.

(9) Use plenty of water if disposing of permitted quantities (up to 100 g) of uranium or thorium salts.

The radioactive materials used in industry are frequently more than a million times stronger than the demonstration materials in schools and colleges. Extensive lead or steel shielding is required and specialised equipment and techniques are needed to work with such materials. The laboratories have to obtain permission and guidelines from an Atomic Energy Regulatory Board.

SELF ASSESSMENT EXERCISE 1

Explain the method of maintaining log book entry for radioactive substances.

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3.1.2 Nonionising Radiations

As stated earlier the radiation hazards are not limited to ionising radiations from radioactive materials. There are a number of other radiation sources in the laboratories which are potentially hazardous. Let us learn about these in brief.

Ultraviolet Radiations

The ultraviolet (UV) light has higher energy than visible light. Hydrogen lamps, deuterium lamps and other sources of ultra-violet are used for a variety of purposes in physical, chemical and biological laboratories. These applications include spectroscopy, the sterilisation of instruments, the initiation of chemical reactions and other substances which fluoresce when irradiated with UV light in chromatography and other separation techniques. Ultraviolet sources may be recognised by their intense pale blue illumination, for example mercury vapour lamps and high voltage sparks and arc emitted at the time of welding.

Fluoresce: Emitting visible light when irradiated with X-rays or UV rays.

Exposure to UV light can cause serious damage to the skin and to the outer layers of the eyes. The symptoms after slight exposure are the same as those of severe sunburn, but with increasing exposure, intense pain, irritation and watering of the eyes take place. One may start feeling as if one has sand in one's eyes and can even lead to temporary loss of vision. Conjunctivitis frequently occurs some time after exposure and may last for several days.

Precautions

The following precautions should be taken while using UV lamps:

(1) UV lamps must always be properly shielded.
(2) Wear approved goggles when working with or close to the source.
(3) As a minimum precaution, view through **pyrex glass** as this material absorbs UV light and is thus largely opaque to radiation of this wavelength.
(4) Protect your skin with thick cloth or by suitable barrier cream if necessary.
(5) Ensure good ventilation to guard against the dangers of inhaling ozone, which can be produced by the effect of UV on the oxygen in the air.

Lasers

Laser light is an extremely intense form of electromagnetic radiation and its name is acronym for **light amplification by stimulated emission of radiation.** Lasers are used widely in industry and research laboratories. Their dangers stem from the enormous concentration of the energy of the laser into a very small area. These extremely short, concentrated pulses of light can cause severe eye damage. Both the cornea and the retina may be affected and permanent blind spots can be produced at the points where the lens of the eye brings the rays to a focus, thereby destroying the tissues at the back of the eye. This focussing effect of the lens of the eye increases the intensity of the laser light by a factor of about a million (10^6), so low energy laser light can also be dangerous. In practice, the maximum safety value is set at one-tenth of this figure. Additional dangers in the use of the laser stem from the very high voltages required to operate its source.

Precautions

The following must always be observed while dealing with lasers.

(1) Never look along a laser beam or expose any part of your skin to it.
(2) Beware of reflected laser radiation. (Any surface which reflects light will also reflect a laser.)
(3) Block out any reflected laser light with opaque matt grey screens.
(4) Always wear the correct type of goggles for the particular laser being used. A helium-neon laser, for example, gives a red beam, and some lasers generate radiation in the ultraviolet and infrared regions of the spectrum as well as producing visible light.
(5) Never operate lasers in the dark. The room should always be brightly lit to avoid enlargement of the pupil of the eye.
(6) Warning notices should be set up and the working area should be fenced off.
(7) The laser source should be fixed rigidly to a bench so that the direction of the beam is not altered by accidental movement.
(8) Never align a laser while it is switched on. This alignment should be carried out optically before turning on the source.
(9) Keep laser instruments in a securely locked store room when they are not in use.

Based on your knowledge on ultraviolet radiation and lasers, you can try to answer the following Self Assessment Exercise in the given spaces.

SELF ASSESSMENT EXERCISE 2

i. Which of the following are sources of ultraviolet radiation?
   (a) the sun
   (b) tungsten filament lamp
   (c) quartz-halogen lamp
   (d) mercury vapour lamp
   (e) hydrogen lamp
   (f) sparks from a cutting wheel
   (g) high voltage arcs or sparks

ii. Which part of the body would be most harmed by exposure to UV radiation?

SELF ASSESSMENT EXERCISE 3

A laser beam is dangerous because

(i) it is very hot,
(ii) it is of high energy, or
(iii) it concentrates a lot of energy into a small area.

Other visible light hazards

Ordinary, visible light can present a hazard under certain conditions. You can burn paper by focussing the sun's rays using a small magnifying lens. The same effect can occur with the eye's lens on the back of the eyeball (the retina), and this usually happens when we are viewing an eclipse. The result can be total blindness or at least partial blindness. Similar dangers can occur when using daylight to illuminate a microscope slide.

Never look at the sun directly or indirectly through a pinhole, lens, filter or any other optical instrument.

The source of the danger is the sudden and intense illumination of a human eye by the sun. The accidents occur because it is difficult to ensure that a filter is going to absorb sufficient light to make it safe to view a sudden appearance of the sun, such as an eclipse, directly. The absorbent powers of a filter won't be discovered until it is too late, and the time-honoured method of using smoked glass is much unreliable. You can imagine how much worse the damage would be to the human eye if an eclipse was viewed through any optical instrument, e.g. binoculars, reflecting devices on microscopes, etc.

The only safe way to view an eclipse is to look at an image of the sun projected onto a screen. This means that a laboratory or classroom would have to be turned into a projection room, i.e. blacked out with a screen and an optical system need only be a 1 cm hole in a blind to admit the required light and a plain mirror to direct the light onto the screen, Fig. 3.5.

Microwaves

The microwave region of the electromagnetic spectrum is increasingly used for a variety of purposes for example, for rapid heating. The particular microwave ovens have been known to leak dangerous amounts of microwave energy when the doors are not properly shut.

The hazards of microwaves depend on the power of the source. For instance, the low energy microwave transmitters used in educational labs do not present a danger, whereas microwave ovens do. The danger zone is in the immediate vicinity of the microwave source and the hazard is primarily due to the invisible nature and ability of the body, particularly the eyes, to absorb microwaves without any sensation. This easy absorption of radiation by body and the high thermal effects of microwaves can cause severe damage to internal organs, and anyone who has a metal plate, steel implant, heart pacemaker or other such aids can suffer severe injury from microwave radiation.

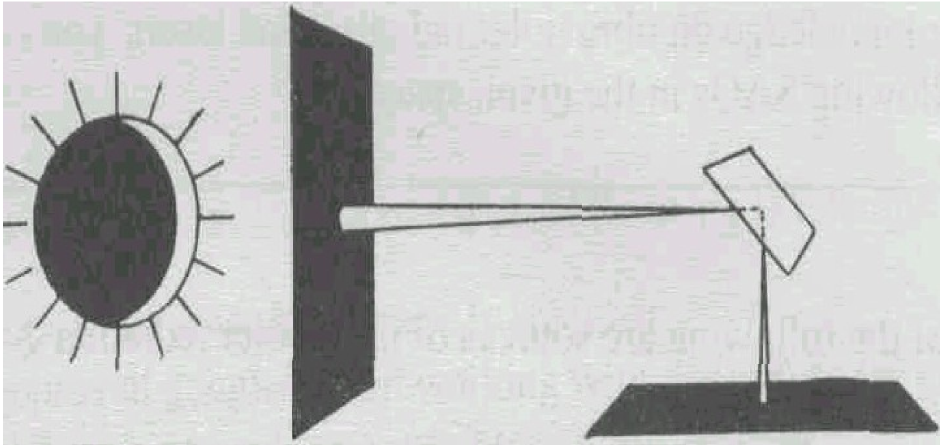

Fig. 3.5: Safe way to view an eclipse

The hazards from this source in the lab can be kept at a low level by ensuring that microwave devices which operate at significant power levels are manufactured to the country's standard specifications and are maintained according to the manufacturer's recommendations.

We hope that after reading about radiation hazards you would have understood the dangers and precautions to be taken while working with radioactive materials. You should try to implement the good practices in lab to prevent any type of casualties. The next section of this unit deals with another type of common hazard i.e. the chemical hazard, where you will study the classification, storing and handling of different types of hazardous substances. Before proceeding try to answer the following Exercises. You have to tick the right answer.

SELF ASSESSMENT EXERCISE 4

Tick the right answer in the following:

(a) The main danger of microwaves is due to
  (i) their general heating effect
  (ii) the fact that they are invisible
  (iii) the fact that there is insufficient research into their real dangers

(b) What part of the body is most susceptible to absorbing this kind of energy?
  (i) the hands
  (ii) hair
  (iii) the eyes

(c) The area of greatest danger of microwave is
  (i) in the immediate vicinity of the source

(ii) up to 20 m from the source

3.2 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. One is advised to exercise caution in handling all chemicals and minimise exposure to them.

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.

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 learn about the safe storage and handling of toxins or poisons as well as other hazardous substances. Remember that in the lab where you work, there is a legal requirement for minimising or eliminating the risks of working with such substances.

3.3 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.

3.3.1 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. 3.6 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 (highly volatile) is classified as a gas.

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

Different types of gases and their hazards have been explained with examples in Unit 1. Gases are divided into 3 subclasses on the basis of their hazardous nature.

(i) Flammable gases e.g. acetylene, liquefied petroleum gas (LPG)
(ii) Toxic gases e.g. chlorine, sulphur dioxide
(iii) Nonflammable nontoxic gases e.g. carbon dioxide, nitrogen, etc.

Class-3 Flammable Liquids

As mentioned in Unit 2, 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.

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.

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-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, 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 micro-organisms. The examples of poisonous substances are pesticides, tetraethyl lead and many drugs etc. The contaminated hospital wastes, strains of pathogens etc. are considered infectious substances.

Class-7 Radioactive Substances

These substances have been discussed in detail in the Sec. 3.2 of this unit. Radium, uranium, thorium, etc. are few of the examples.

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, sodium hydroxide belong to this class.

Class-9 Miscellaneous Dangerous Substances

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

Besides these 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. 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.

SELF ASSESSMENT EXERCISE 5

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

____

____

Handling of Chemicals

Laboratory technicians, who work in laboratories, need to be aware of the potential danger of the substances they handle. 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 lab 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 become worn out after repeated closure.

Labelling is another important aspect in handling of chemical substances. 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.

Fig. 3.6: Chart showing UN Hazard class symbols on transportation of hazardous goods

(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 is given in Fig. 3.7.

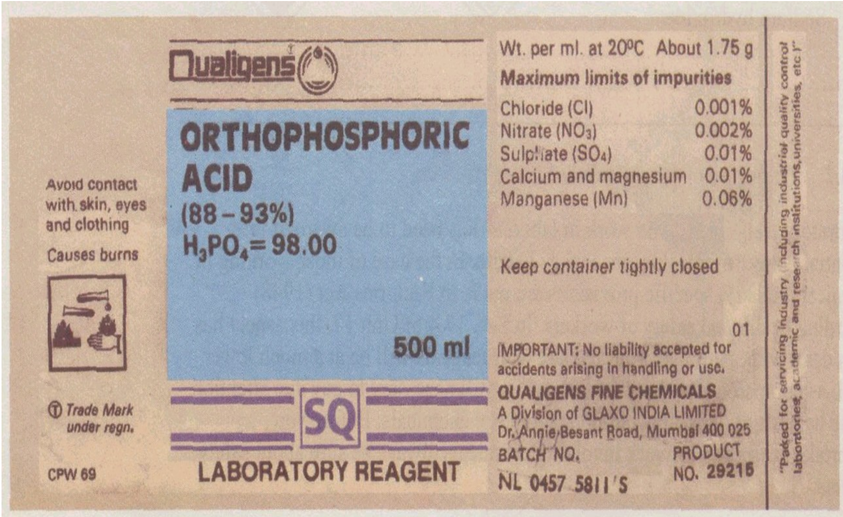

Fig. 13.7: A typical label of a reagent bottle

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 hazards associated with a few of common chemicals are listed at the end of the unit as **Annexure.** Table I summarises hazardous properties of some chemicals encountered in the laboratory and Table II summarises the chemicals which give violent reaction when mixed with some other substances i.e. the incompatible chemical substances.

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 1 of this course. You may be knowing that many laboratory operations need to be carried out in fume cupboard, e.g. working with nitrating mixtures etc. A typical laboratory fume cupboard is shown in Fig.3.8.

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.

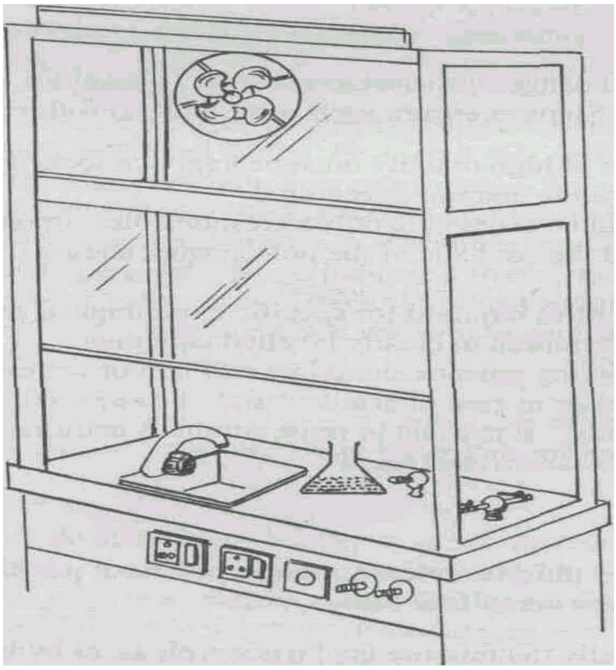

Fig. 3.8: A typical laboratory fume cupboard

SELF ASSESSMENT EXERCISE 6

It used to be a common practice in some laboratories to store dangerous chemicals in fume cupboards. This practice is now frowned on. Why do you think this is so?

3.3.2 Storage of Chemicals

You have read about the stores as important structures of all the labs in Unit 2. 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 strict 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.

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 lab 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, they can cause lung problems too!

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

Unstable compounds - Such as 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 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 temperature increases can be obtained which 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 labs. 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.

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.

> 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.

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.

SELF ASSESSMENT EXERCISE 7

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

SELF ASSESSMENT EXERCISE 8

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 dm3
(iii) 50 dm^3

Condition:

3.3.3 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, 1 litre and 2 litre (Winchester) bottles, carboys and metal drums, should always be kept in a separate store.

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 lab 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 and liquids transferred as required using a carboy siphon, Fig. 3.9.

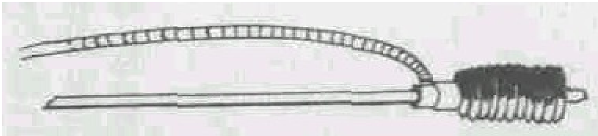

Fig. 3.9: A carboy siphon

SELF ASSESSMENT EXERCISE 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?

3.3.4 Transfer from Large Containers

As with all dangerous operations, it will say 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.

SELF ASSESSMENT EXERCISE 10

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

(i) do it near a window;

(ii) do it anywhere;
(iii) do it in a fume cupboard; or
(iv) wear any protective clothing?
(Tick the correct answer(s))

3.4 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 (an 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 lab coats is known for transmission of disease and vermins. So we don't recommend sharing lab coats, even with your best friend. Neither should you wear your lab coat while going home.

Defatting:	Removing fat.
Vermins:	Any kind of unpleasant, biting insect e.g. flea, louse that lives on the body of man and animals.
Mutagens:	A substance that produces mutations (sudden change in genes)

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, 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.

Lab 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.

4.0 CONCLUSION

In this Unit, you have learnt about two other common hazards. These are the hazards because of radiation and chemical substances i.e., substances hazardous to health.

The energy of radiation is given by the formula:

$$E = h\nu = h\frac{c}{\lambda};\ h \text{ is Planck's constant and } c \text{ is velocity of light.}$$

The wavelength of a radiation can be as small as less than a picometre (10^{-12} m) or as high as a kilometre (km) or even more. The energy of radiation will decrease with increase in its wavelength.

The hazardous nature of the radiation is manifested on its interaction with matter. On the basis of interaction with matter, radiations may be divided into two broad groups - **ionising** and **nonionising.** The nonionising radiations cannot change the nature of atom, but can be highly hazardous. They include ultraviolet and infrared radiations, ultrasonics, light (e.g. from lasers) and microwaves.

The ionising radiation changes the atomic structure of a substance and can be classified into three major types - alpha (α), beta (β) and gamma (γ). These radiations damage cells depending upon their penetration power.

Use of goggles and gloves and proper storage are few of the precautionary measures to be taken to avoid any radiation hazard.

On the other hand a chemical hazard is more likely in chemistry or a biology laboratory; yet it cannot be ignored in a physics laboratory.

There are three possible ways of contacting with chemicals in a laboratory are (i) inhalation of the fumes, dust and vapours, (ii) ingestion and (iii) direct contact with spills. But sometimes, they affected indirectly also.

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 to be done carefully. Therefore proper attention should be given to these hazards by all the staff working in a laboratory.

5.0 SUMMARY

Let us summarise the important points that we have understood about the radiation and chemical hazards in this unit. The radiations, causing severe hazards like cancers, mutations, some skin problems are divided into ionising and nonionising types. The examples of nonionising radiations are ultraviolet, lasers etc. which are responsible for eye and skin damages mainly, α, β and γ radiations are the main in ionising type. These radiations damage cells depending upon their penetration power. Use of goggles and gloves and proper storage are few of the precautionary measures to be taken to avoid any radiation hazard.
Another hazard 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 to be done carefully. A laboratory staff should be well aware of use of fume cupboards and other safety devices to prevent any hazard due to dangerous chemicals.

6.0 TUTOR MARKED ASSIGNMENT

1. Which of the following gives the best protection against UV radiation?
   Explain.
   (i) air (ii) glass (iii) fabric (iv) metal

2. Would you say that low power lasers such as those used in schools and colleges
   (i) are harmless because they are low power instruments, or
   (ii) could damage the eye?

3. 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 lab, would you consider issuing anything else with the chemical?

4. 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?

5. What is the minimum information you would include on the label of a beaker containing a preparation from, say, a laboratory experiment?

6. For what reasons on purely safety grounds are smoking, eating and drinking normally banned in laboratories?

ANSWERS SELF-ASSESSMENT EXERCISE

i. You must have a special log book for this which records:
- date and time of withdrawal
- type and serial number of source
- name of user and signature
- date and time of replacement
- name and signature of person accepting returns

ii. (a) (i) The sun is a UV source (but we are protected from the worst effects of the harmful wavelengths by the earth's atmosphere), (ii) and iii) are not UV sources, (iv) This is a UV source (and can be harmful), (v) As iv. (vi). This is not a UV source. (vii) UV is usually emitted from high voltage arcing or sparking. (The danger will depend on the power of the source, e.g. the spark of a motor car's spark plug is insignificant as a UV hazard, whereas the high voltage continuous arcs and sparks used in emission spectroscopy or arc welding can present a considerable hazard.)

(b) The eyes and the skin.

iii. (iii)

iv. (a) (i) however ii) and iii) are also applicable..
(b) (iii)
(c) (i)

v. (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, hydrogen peroxide should not be mixed with other chemicals - for example copper, iron metal or their salts - otherwise, it may result in combustion,
(iii) Gloves or spatula should be used to avoid any skin contact while taking out of the bottle.

vi. 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.

vii. Nearly all are harmful given appropriate circumstances. The problem is to decide which substances are the most dangerous that should be kept locked and logged.

viii. (iii); so long as it is kept in a fire resistant cupboard or bin with retention sills which is suitably located.

ix. Hopefully you will have seen this as one of few "tricky" 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!

x. (iii) and iv), gloves, a lab coat and goggles would be required.

ANNEXURE

Table I: Hazardous properties of some common chemicals

Name of compound	Boiling point	Hazardous properties
Benzene	80°C	Extremely flammable. Vapour very poisonous with the danger of cumulative effects. Poisons by skin absorption. Causes kidney and liver damage and can destroy bone marrow and thus cause severe anaemia and other blood disorders. Carcinogens are often present as impurities in benzene. Use of benzene as a solvent should be banned.
Chlorine	-34°C	Toxic gas. Irritating to the eyes, skin and respiratory system. Can cause conjunctivitis and severe lung damage.
Formalin [an aqueous solution containing approx. 40% of methanal (formaldehyde) and 11-14% of methanol]	96°C	Flammable. Poisonous by inhalation and by swallowing. Causes burns and severely irritates the eyes, skin and respiratory system . Can cause ulceration and cracking of the skin.
Propanone (acetone)	56°C	Highly flammable. Forms explosive mixtures with air. Vapour irritates eyes and can produce cataracts. Inhalation may cause dizziness and coma.
Tetrachloromethane	77°C	Poisonous vapour. Inhalation causes headache, mental confusion, depression, fatigue, nausea, vomiting and coma. Repeated contact with the liquid can produce dermatitis. Taken by mouth, can damage the liver, kidneys, heart and nervous system. Small doses may be fatal. Can induce cancer.
Methanol	65°C	Highly flammable. Poisonous by inhalation, swallowing and skin absorption. Inhalation causes dizziness, nausea, cramps, headache and vomiting. If swallowed, liquid can damage the central nervous system and cause blindness (some methanol and unpleasant smelling substances such as pyridine are added to ethanol in methylated spirit to denature the alcohol and make it unfit for drinking. Can also injure kidneys , liver and heart. Unconsciousness might develop some hours after taking methanol and death may follow.

Note: Some hazards may develop in a material on standing or when the substance is treated with a particular chemical. Ethoxyethane (ether), for example, slowly forms explosive peroxides on standing in the presence of light and air. These peroxides have a higher boiling point than ether and therefore form a dangerous residue during distillation. The presence of peroxides may be detected by the liberation of iodine when a sample of the ether is added to aqueous potassium iodide solution. Peroxides may be destroyed by shaking ether with iron (II) sulphate solution. The distilled material is then stored in dark glass bottles containing a small coil of clean copper wire. The bottles should be almost filled with the liquid as this limits the amount of air and oxygen in contact with ether.

Table II: List of some incompatible chemical substances

Substance	Violent reaction when mixed with:
Alkali metals, e.g. potassium or sodium	water, acids, carbon dioxide, tetrachloromethane and other chlorinated hydrocarbons.
Aluminium (especially in powdered form)	chlorates, nitrates.
Ammonia	chlorine, bromine or iodine; calcium hypochlorite; mercury.
Ammonium nitrate	metal powders, sulphur, chlorates, powdered organic compounds.
Chlorates	metal powders, sulphur, ammonium salts, finely divided organic compounds or other combustible materials, sulphuric acid, picrates.
Chlorine	ammonia, ethyne (acetylene), hydrogen, finely divided metals.
Chromic acid	ethanoic (acetic) acid, glycerol, napthalene, alcohol and other flammable liquids.
Copper	ethyne (acetylene), hydrogen peroxide.
Ethanoic (acetic) acid	chromic acid, nitric acid, glycol and other hydroxy compounds, manganates, peroxides and perchloric acid.
Ethyne (acetylene)	chlorine, bromine and iodine; copper, silver or mercury.
Hydrocarbons	chlorine, bromine and iodine; copper, silver or mercury.
Hydrogen peroxide	copper, chromium, iron and many other metals or their salts; any flammable liquid or combustible material.
Hydrogen sulphide	fuming nitric acid.
Iodine	ammonia (gaseous or aqueous solution), ethyne.
Mercury	ethyne, ammonia.
Nitric (V) acid (conc.)	ethanoic acid, alcohols, propanone (acetone), phenylamine (aniline), hydrogen sulphide, flammable liquids or solids, chromic acid.
Oxygen	grease, oil, hydrogen and any other highly flammable materials.
Potassium manganate (permanganate)	glycol, glycerol, sulphuric acid, benzaldehyde.
Propanone (acetone)	mixtures of concentrated nitric and sulphuric acid.
Sodium nitrate (nitrate)	ammonium nitrate.
Sulphuric acid	chlorates, perchlorates, permanganates; water (dilute the acid by adding acid to water and not by reverse method).

7.0 REFERENCE/FURTHER READINGS

Certificate Programme in Laboratory Techniques (CPLT), a certificate programme, School of Sciences, Indira Gandhi National Open University (IGNOU), New Delhi, India

Hazardous Materials Characterisation: Evaluation Methods, Procedures and Considerations, by Donald A. Shafer, Published by John Wiley & Sons. Inc, New Jeresy.

UNIT 4 HAZARDS IN BIOLOGY LABORATORY

CONTENTS

1.0 INTRODUCTION

In any science laboratory you work with chemicals, gases, electrical equipments, glassware, instruments etc. In case you are working in a biology laboratory handling the plants, animals, dissections, micro-organism and, disposal of used materials are essential exercises. The hazards caused by handling chemicals, gases, electrical equipments, instruments and glassware are common for physics, chemistry and biology labs. The additional hazards encountered in the biology laboratories are diseases like infections and allergies.

In earlier Units, we discussed the hazards due to chemicals, gas and electricity. In this Unit, you are going to learn the major hazards caused by handling and working with biological materials (plant and animal tissues, live and dead animals, and microbes) and instruments used in handling these. It is possible that the hazards you encounter in your particular laboratory are not covered in this unit. In such a case you can discuss the problem with your lab Incharge. However, we have highlighted the important problems in this Unit.

2.0 OBJECTIVES

After studying this unit, you should be able to:

- state the principal hazards of biology lab work,

- describe the ways to minimize these 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, i.e. pointed objects such as scalpel, blades, razors, needles, pins etc.,
- outline the dangers associated with mishandling of microorganisms and need to seal cultures if they are to be handled by inexperienced people, and
- list the methods employed for sterilizing apparatus used for microbiological experiments.

3.0 MAIN CONTENT

3.1 Hazards in the 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 lab are infections and other diseases. Along with these, common hazards of chemistry laboratories are also present. 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 labs 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 lab work:

1. Sharps, i.e. needles, scalpels, razors, glass, lancets, microtome blades, hypodermic needles, pins and awls.
2. Micro-organisms, cultures.
3. Lab 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 rays.
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 lab, namely disease and infection. You will study about other items in the other units of this course or in other course of this programme.

3.2 Lab Animals

In this section, we shall deal with three important aspects concerning lab animals.

3.2.1 Supply of Animals

Lab animals must be obtained from accredited dealers and by accredited dealers, we mean suppliers in the business of supplying animals for lab 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 lab. 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 lab personnel they can pass on disease to other lab animals.

3.2.2 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 lab. 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.

3.2.3 Disposal

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

The dangers of working in labs 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 lab 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 lab 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 lab or after handling experimental animals or materials of biological origin.

SELF ASSESSMENT EXERCISE 1

What is the major risk in handling the lab animals? Suggest two preventive measures.

3.3 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 lab. The only real remedy is to reduce the likelihood of such injuries through appropriate and adequate training of the work. 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.

SELF ASSESSMENT EXERCISE 2

(i) Complete the following sentence using the appropriate clause from the options given below. "It is essential to take great care when handling sharps because ……..
   (1) they are easily damaged",
   (2) small (and large) wounds are easily inflicted and infected by idle sharps."
   (3) most sharps become blunt very easily."

(ii) Which of the following do you think is a good way of disposing of old needles or razor blades.
   (1) post them through a slot in a stout wooden or metal box.
   (2) throw them in the wastepaper bin.
   (3) keep them in a drawer until sufficient have accumulated to make a trip to the dustbin worthwhile.

3.4 Blood Sampling

In blood sampling, the skin is deliberately punctured in order to take a blood sample for analysis. If this is done carelessly, it is easy for microorganisms either to enter the blood stream of the donor from the lancet used, or from the donor's blood to enter the environment and contaminate it. The most common serious diseases transmitted are viral hepatitis and AIDS. Both of these diseases can be transmitted through small cuts. Therefore, you should always use fresh and sterilized needle to prick the fingertip for the blood sample. Disposal of the needle should be done in the same way as for the sharps. Rubber gloves should be used while taking and handling the blood samples.

SELF ASSESSMENT EXERCISE 3

Why should one be careful while studying blood sample?

3.4 Micro-organisms

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, lab 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

You will in this section study about the precautionary measures that need to be undertaken while conducting the lab work using microbes.

3.5.1 Handling

You can reduce direct contact with microorganisms by careful handling and by wearing protective clothing such as rubber gloves, mask, lab 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. 4.1).

Fig. 4.1: A transfer chamber

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. (You should not wear gloves while working near a burner or a spirit lamp. When pipetting, you can avoid splashing by releasing the contents of the pipette under or onto the surface of the receiver - don't 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.

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% methanal into the inverted dish. To avoid poisonous methanal 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.

A similar situation can be while working with **plant materials.** You can encounter pollens or other plant parts and products that can cause allergies, cuts and burises. As in case of microorganisms you can reduce the risk by wearing gloves, masks and lab 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 lab, work in open area with proper aeration and exhaust.

SELF ASSESSMENT EXERCISE 4

What action would you take before allowing microorganisms in a petri dish to be examined by inexperienced people?

3.6 Sterilization of Apparatus for Microbiology Experiments

Containers of dangerous biological materials and the doors leading to laboratories or rooms in which work with pathogenic micro-organisms is carried out should be labelled with the *biohazard warning symbol.* The following methods are employed to sterilize different types of apparatus for microbiological experiments.

Glassware (e.g. petri dishes, pipettes, flasks, test-tubes and syringes) -Stopper the washed and dried flasks and tubes loosely and wrap pipettes and syringes in brown paper or metal foil before sterilizing in a hot air oven at 120°C for few hours.

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.

3.6.1 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.

SELF ASSESSMENT EXERCISE 5

Here are four waste items from microbiology and biology labs and three disposal methods. Can you match a method to the waste?

	Waste		Method
(1)	Micro-organism 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
(4)	Chipped, contaminated pipette.		Incinerate

4.0 CONCLUSION

In a biology laboratory handling the plants, animals, dissections, micro-organism and, disposal of used materials are essential exercises. The hazards encountered in the biology laboratories are diseases like infections and allergies caused by the inhalation and ingestion of substances in the form of fumes, fine spray or aerosol produced during the work with biological materials.

While studying the blood samples, every time a fresh needle, gloves and disinfectant should be used for pricking the finger tip for the blood. The precautionary measures are proper cleaning with disinfectants before and after the work, usage of masks, lab coats and rubber gloves during the work, safe disposal, incineration and sterilization methods etc. Special care such as a different working area, use of disinfectants, proper handling of cultures and sterilization of the instruments should be taken on working with microbes.

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5.0 SUMMARY

In this unit you have studied the following:

- The major hazards encountered in the biological lab 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.
- While studying the blood samples, every time a fresh needle, gloves and disinfectant should be used for pricking the finger tip for the blood.
- Precautionary measures include proper cleaning with disinfectants before and after the work, usage of masks, lab coats and rubber gloves during the work, safe disposal, incineration and sterilization methods etc.
- Sharp objects used in biology lab 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 of 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. The cells should be killed before the disposal of cultures.

6.0 TUTOR MARKED ASSIGNMENT

1. What are the two factors you should consider while purchasing the animals for biology labs?
2. What four steps would you take to minimize infection after performing a dissection?
3. List the advantages and disadvantages in using wild animals, birds or mammals for lab work.
4. List the precautionary measures by which you can avoid direct contact with micro-organisms?

ANSWERS SELF-ASSESSMENT EXERCISES

1. The major risk in handling the lab 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.

2. (i) - (2). Although (1) and (3) are true, (2) is the real danger.
(ii) - (1). From (2) and (3), you have the risk of hurting your feet and -fingers.

3. It is very important to be careful while studying blood samples because the serious diseases like viral hepatitis and AIDS can be transmitted through blood via small cuts in your hand.

4. Seal the Petri dish with clear adhesive tape. Label the Petri dish 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 Petri plate and not spread out.

5. (1)-(b); (2)-(c); (3)-(c); (4)-(a)

7.0 REFERENCES/FURTHER READINGS

Certificate Programme in Laboratory Techniques (CPLT), a certificate programme, School of Sciences, Indira Gandhi National Open University (IGNOU), New Delhi, India

UNIT 5 PERSONAL SAFETY

CONTENTS

1.0 INTRODUCTION

In Unit 4, you have learnt about the major hazards caused by handling and working with biological materials (plant and animal tissues, live and dead animals and microbes) and the instruments used in handling them. Now, as you know that the additional hazards encountered in the biology laboratories are diseases like infections and allergies.

In the present Unit, we introduce you to the fundamentals of personal safety code in a laboratory. If you do not have safe laboratory practice, your life and those of your lab inmates could be in danger. A good personal safety code could lessen the occurrence or the consequences of accidents. Besides the personal safety code, we shall discuss the procedure for checking in, shutting down and lifting.

2.0 OBJECTIVES

After studying this unit, you should be able to:

- list the obligations of the teachers and the Head of the institution towards safe working conditions in a laboratory,

- state the need for wearing the appropriate protective clothing in a laboratory,
- recognize the necessity for personal code of behaviour in a laboratory,
- explain the hazards of storing and consuming food or drink and smoking in a laboratory,
- state the methods of disposal of waste materials in a laboratory,
- discuss the check-in and shut-down sequences in a laboratory, and explain the method of lifting objects in a laboratory.

3.0 MAIN CONTENT

3.1 Obligations of the Teachers and the Head of the Institution Towards Maintaining Laboratory Safety

Safety in laboratory work is the collective responsibility of the Head of the Institution, teachers, lab 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.

(ii) Lab building should be maintained in safe condition. Once in a year at least, condition of the building, furniture, fire safety units, electrical connections and appliances, water pipes etc. may be checked. Any repairs must be attended to.

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

(iv) The lab staff are to be provided with protective clothing.

(v) All laboratory workers must be immunised against tetanus. Additional immunisation may be done if their work exposes to special risks of infection.

vi) Appropriate training must be given to lab staff in

- handling equipment, chemicals, biological specimens etc.,
- using gas cylinders and fire fighting equipment,
- moving load,
- waste disposal, and
- administering first aid.

(vi) The lab staff must be instructed to prepare a list of phone numbers and addresses of the following for use during emergency:

- nearby doctors, hospitals and ambulance services
- police
- Fire Service Authority (Fire Service may also offer help for rescue operations during building collapse, explosion, drowning, gas leakage etc.)
- electricity supply agency
- gas supply agency
- water supply agencies
- fire fighting equipment dealers

This list should be prominently exhibited in the laboratory.

(viii) The lab staff must be instructed to keep records of accidents (as discussed in Sec. 6.2 of Unit 6). The records of accidents may be examined once in a year to plan protective measures.

3.2 Code of Behaviour for the Laboratory Staff

Let us discuss the need for a code of behaviour in Science lab of an educational institution.

3.2.1 Need for Code of Behaviour

A laboratory is a potentially dangerous working environment. Cuts from broken glass, chemical or thermal burns and poisoning are three examples of lab accidents that could occur. In order to avoid such lab accidents, you must follow a set of rules commonly known as **personal code of behaviour.** When you work as an assistant or technician in an educational lab, you have to consider the educational element of your conduct. The students around you learn from what all they see from the teachers and the laboratory staff like you; you also have a responsibility of building in students a positive attitude to safe working practice and an awareness of potential dangers. You may also appreciate that such an educational element is not necessarily associated with the code of behaviour of laboratory staff working in industry. Hence, the lab staff in educational institutions should practise personal safety code both for avoiding the accidents and for the educational value that it offers to the students learning in the lab.

3.2.2 Code of Practice in a Laboratory

The following is a set of rules you should follow while working in a laboratory:

1. Always wear the required protective clothing.
2. Make sure you know the positions of the main valves or 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 and that you know how to use them.
4. Never eat, drink or smoke in a laboratory. Also don't store food or drink in a laboratory. 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:
   (i) It may cause a fire accident, especially while flammable solvents are stored.
   (ii) Minute particles in smoke may interfere with or spoil purity, chemical processes and electronic parts.
   (iii) Hot zone of a lighted cigarette may help in the formation of poisonous substances in presence of some chemicals.
5. Don't look into the mouth of a test tube or flask while you are heating it or adding reagents. Never point test tubes at other persons.

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

No smoking sign

6. Before using flammable solvents, check that all Bunsen burners are put out and that there are no naked flames. Remember to warn everyone near the fire risk area.
7. Inform other lab staff and teachers regarding any breakage, faulty equipment and any other defects immediately.
8. Wipe off any spilled chemicals immediately, especially corrosive acid or alkali and mercury.

9. Do not run or play about in laboratories.
10. Make sure you know the nature of the substances you handle. Do not handle materials or operate apparatus that you do not fully understand.
11. Keep in cupboards the apparatus that is not immediately used. Do not allow organic solvents to accumulate in the laboratory.
12. Do not sniff materials that may be toxic and never taste chemicals or eat seeds or parts of plants provided for biological studies.
13. Always use a fume cupboard for transferring highly toxic substances or for carrying out experiments that may produce harmful gases. Operations considered hazardous should be carried out only in rooms set aside for the purpose and ensure that you can get assistance, if required.

> In Sec. 4.3 of Unit 4 of this course, you would have read in detail about how to handle hazardous chemicals.

14. Always label containers correctly with the full name and concentration of the contents.
15. Never try to stop or slow down a centrifuge with your hands. The speed at the outer edge may be greater than 150 kilometre per hour (or 90 kilometre per hour at least).
16. While diluting strong acids, add the acid in small amounts at a time with stirring, to water. Do not add water to acid.
17. Always use safety bulbs when pipetting.
18. Do not charge batteries close to naked flames.
19. Always wash your hands before leaving the laboratory.
20. Passage between benches must be kept clear to permit evacuation during emergency. The exits and the access to switches must be kept clear. Storage of materials behind and above benches must be avoided.
21. Do not allow undergraduate students work in labs without supervisory staff.
22. Always exercise care when opening and closing doors of the laboratory.
23. Ensure that your footwear is adequate for the lab work. Open toed shoes or sandals offer no protection against injury.

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 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.

24. Long hair, ties and loose jewellery could be a problem during laboratory work due to possibilities of entanglement in a moving mechanical equipment or trailing over contaminated surface on the work bench.
25. Make sure you know the emergency procedures and emergency exit routes of your laboratory.
26. Ensure that the doorways and emergency exits are not obstructed with trolleys, furniture, etc.

3.2.3 Personal Protective Devices

We shall now discuss the details of protective devices required for safety in a laboratory. The aim of protective devices is 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.

Lab coats

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 also melts when heated and can stick to the flesh. It also dissolves in some organic solvents.

Safety spectacles

Safety spectacles need to be used where there is the slightest risk of splashes of chemicals or fragments of dust, glass, etc. getting into the eyes.

Gloves

Gloves should 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. Skin infection may result. Rubber gloves also make it difficult to grip wet glass and, serious accidents may result from dropped bottles or glassware.

Aprons

Additional protection, such as a rubber apron is recommended for work with appreciable amounts of chromic acid, hydrofluoric acid and other highly corrosive liquids.

SELF ASSESSMENT EXERCISE 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.

SELF ASSESSMENT EXERCISE 2

State the possible hazards caused by smoking in a lab.

3.3 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 of from time to time. **Many of them could be health hazards or could cause inconvenience for free movement especially during times of emergency.** Of these, the method of disposal of used biological specimens has been discussed in Unit 4. In this section, we shall explain the terms:

- unserviceable items,
- obsolete instruments, and
- chemical wastes.

We shall also state the methods of disposal of all these three categories of waste materials.

Unserviceable non-consumable items

The non-consumable items that are broken or are in non-functional status come under this category.

Examples:
(i) broken burette stands or furniture, rusted metal trays or bunsen burners, etc.
(ii) non-functional instruments like galvanometers, ammeters, refrigerators, air conditioners, deionisers, ovens etc.

Obsolete instruments

Old model instruments which are functional but not used due to purchase of latest model belong to this category.

Examples:
Old model pHmeters, colorimeters, computers etc.

Chemical wastes

The chemical wastes may occur in the following cases:

- breakage of the container caused by accidental fall
- partial decomposition because of
    - improper storage
    - atmospheric action due to its moisture, carbon dioxide or oxygen content.

3.3.1 Disposal of Unserviceable and Obsolete Items

Every institution may have evolved its own procedure for the same. Generally the following procedure is used for the disposal of unserviceable and obsolete items:

(i) The Head of the Institution forms a Survey Committee for the disposal of unserviceable and obsolete items in a particular science department. The following may be the members of the Committee:

- Head of the Department (Convenor of the Committee)
- Administrative Officer/Finance Officer of the Institution
- One person having expert knowledge regarding the value of the articles to be disposed of.

(ii) The Survey Committee inspects the laboratory and prepares a list of unserviceable and obsolete items-indicating the original cost price and reserve price. **The reserve price is the minimum price at which the concerned item is to be sold.** The Committee has to use its judgement in fixing the reserve price. For obsolete

> 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.

items which are functional, the reserve price may be fixed depending on its worth. In case of non-functional items, reserve price can be fixed on the basis of its scrap value. In extreme case, the Committee may recommend writing off the items, if the concerned item is of no commercial value and the reserve price is taken as zero.

(iii) The Committee prepares a report and forwards it to the Head of the Institution.

> Sale: A price is fixed for each item keeping in view the reserve price.

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

(v)

> Open auction: Price is decided through auction keeping reserve price as minimum. The article is sold to the person offering the highest price.

The steps are taken for open sale or auction.

(vi) Necessary entries are made in the stock register.

These steps are illustrated in Exercise 14, of the practical component of this course.

3.3.2 Disposal of Chemical Wastes

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

While dealing with chemical waste, you should keep in mind the safety of yourself and other inmates of the laboratory. Consider that a toxic waste is thrown carelessly into the dust bin. Will it not be harmful to the sweeper who cleans the dust bin? Also flammable, volatile and water-immiscible liquid wastes can cause accumulation of flammable vapours in the drainage. In order to dispose of 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 read about it in Unit 3),
- you must use adequate protective devices as mentioned in Subsection 5.3.3,
- **shut off all possible source of ignition while dealing with flammable waste, and**
- use the appropriate method as mentioned below.

We shall discuss various methods of

(I) first removing the bulk of the chemical waste and, then
(II) treating the site of spillage for removing its traces.

We shall limit our discussion to the disposal of chemical wastes occurring in small quantities.

I Removing the bulk of the chemical waste from the spillage site

The following are some of the methods used:

(a) For water soluble/miscible solid and liquid wastes

The familiar method of mopping the waste with plenty of water and running the same into the drainage could be done for miscible/soluble waste substances which are

- harmless in high dilution or
- non-reactive with water.

Although some of these could be harmful in high concentration, their effect gets minimised due to usage of plenty of water. Examples: 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.

(b) For highly volatile liquid wastes

Highly volatile liquid waste could be disposed of by effective ventillation until the liquid completely evaporates. Example: Diethyl ether.

(c) For moderately volatile liquid wastes

Spillage of moderately volatile liquids could be absorbed on sand, shovelled into bucket(s) and transported to a safe open area for evaporation. Examples: Ethyl acetate, carbon disulphide, benzene and carbon tetrachloride.

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 a milk like homogeneous mixture known as emulsion. **Emulsification** is the process of dispersing water immiscible liquid in water using a suitable agent such as soap or detergent.

(d) For water immiscible/insoluble liquid/solid wastes which can be emulsified

The spillage of water immiscible/insoluble liquids/solids could be scrubbed with brush in presence of soap or detergent solution. The emulsion is to be run into the drainage with plenty of water. Examples: Benzene, toluene, cyclohexane, nitrobenzene, m-dinitrobenzene, cresols, chlorobenzene and chloroform.

(e) For chemically reactive wastes

The chemical property of the waste could be used in its removal in a number of ways as given below:

(i) Some water-reactive waste could be disposed of 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 could be poured into the drainage. (Example: Calcium oxide).
(ii) A few solid wastes, which are highly reactive with water, could be removed by mixing with dry sand, shovelled into dry bucket(s), 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. (Examples: Anhydrous aluminium chloride and phthalic anhydride).

(iii) Where the product of reaction with water is highly corrosive, then (ii) is to be carried out in an enamel or polythene container. (Examples: Phosphorus pentachloride and phosphorus pentoxide),

(iv) The site of spillage is to be covered with sodium carbonate liberally and then mopped cautiously with a large quantity of water. (Examples: Perchloric acid, sulphuric acid, hydrochloric acid, nitric acid, phosphoric acid, acetyl chloride, benzoyl chloride, chromium trioxide, chromyl chloride, tin (IV) chloride and bromine).

(v) The spillage is mixed with sand and shovelled into a suitable glass or enamel vessel for treatment with an excess of dilute hydrochloric acid (one volume of the acid and two volumes of water) allowed to stand for 24 hours and then run into drains with a large volume of water. (Example: Aniline).

(vi) Small quantities of spillage can be washed off using sodium thiosuiphate or sodium metabisulphite solution. (Example: Iodine in small quantities).

(vii) The waste may be mixed with dry sodium carbonate, shovelled into a dry bucket and transported to a safe open space. The mixture may be added a little at a time to a large excess of dry propan-2-ol, allowed to stand for 24 hours and run into the drainage diluting greatly with running water. (Example: Sodium metal).

(viii) The spillage is to be treated with excess of sodium hypochlorite solution, mopped up into a bucket, allowed to stand for 24 hours, diluted greatly with water and then run into the drainage. (Example: Potassium cyanide).

(f) For all other wastes

(i) Burial

The spillage could be buried using any of the following methods:

- The spillage could be mixed with sand and buried deep. Examples: Iodine in large quantities, insoluble arsenic salts, picric acid and phenol.
- The spillage could be swept with 1:1 mixture of saw dust and zinc dust and buried at an isolated site. Example: Mercury.

(ii) Mixing with sand and disposal as waste

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

In order to remove the final traces of the spillage, any one of the following methods may be used depending on the nature of the spillage:

(a) The spilled area is to be ventilated to dispel the vapours in case of easily volatile wastes. (Examples: Ethyl acetate, carbon disulphide and carbon tetrachloride).
(b) The spillage site is to be washed with water in case of water soluble/miscible wastes. (Example: Anhydrous aluminium chloride).
(c) The site of spillage is to be washed thoroughly with water and soap/detergent in case of water immiscible/insoluble wastes. (Examples: Acetic anhydride and toluene).

Some of these methods are illustrated in Exercise 5 of the practical component of this 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. While dealing with industrial chemical wastes, specialised methods are to be used. We illustrate with an example the consequences of unplanned dumping of industrial chemical wastes that affected small children of an elementary school.

Case Study: Disposal of Toxic Chemicals in Love Canal

In 1940, Hooker Chemicals, a chemical manufacturing company, operating at Niagara Falls, New York, purchased an abandoned canal called Love canal for disposing of its wastes. Approximately 19,000 tonnes of chemical waste was packed into 55 gallon steel drums and dumped in the canal. In 1953, the company covered one of its dumpsites by dirt and, sold it to the Board of Education of Niagara Falls. An elementary school and playground were made on this site. In 1973, due to heavy rains, the area turned into muddy swamp. It was contaminated with poisonous chemicals which floated about in the playgrounds and even entered the basement of nearby houses. Soon, children and adults of nearby area suffered illness such as severe headache, skin sores, rectal bleeding, liver malfunctions and epilepsy. Later miscarriages and birth defects were also reported. The investigations showed that the chemicals in the swamp were due to leakage in the drums that were buried by the Hooker company decades earlier.

The above example illustrates how dumpsites of hazardous wastes become permanently unfit for living purposes.

Rectal bleeding: Loss of blood from the portion of the large intestine which ends at the anus.

Miscarriage: Abortion

SELF ASSESSMENT EXERCISE 3

Why is it necessary to devise proper methods for the disposal of chemical, biological and radioactive wastes?

SELF ASSESSMENT EXERCISE 4

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

3.4 Check-In and Shut-Down Sequences

The procedures for opening and closing a laboratory are to be carefully followed. Let us first note down some instructions for checking in a laboratory.

Check-in Sequences

'Check-in' means opening and entering the lab for starting the day's work.

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

(i) Ensure that the door locks have not been tampered. If any tampering is detected, inform the higher authorities.

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

(ii) Wear lab coat and other protective clothing as per requirement.
(iii) Arrange for proper ventilation and lighting; proper ventilation helps in minimising asphyxia and inhalation hazards.

> 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.

(iv) Ensure that the animals in a biological laboratory' have sufficient food and water.
(v) Wipe the top of the benches with a damp cloth.
(vi) Classify the waste and make arrangement for its disposal. Personally supervise the cleaning of the garbage by the cleaners; otherwise they could mess up wastes of different kinds.
(vii) Check the working condition of any instrument left overnight.
(viii) Check for the availability of water, electricity and gas supply for the day's work.
(ix) Plan for day's activity as per the experiments to be carried out on that day.

Let us now go through some of the features of shut-down.

Shut-down Sequences

In some respects, the time when the lab is being shut down is potentially one of the most dangerous periods of the day. For example, at the end of a day's work, people are less alert due to tiredness and thinking about getting home; short cuts are taken to avoid working late. There are fewer people available to help during awkward tasks, such as moving gas cylinders, or in case of accidents; lighting may be poor during winter months, and so on. During your daily shut-down sequence, therefore, you should be making a special effort to observe the main points of your personal safety code. The following are some, of the actions to be performed during shut-down:

(i) Turn off equipment, Bunsen burners, taps, etc.
(ii) Replace reagent bottles in the shelves and put away apparatus, chemicals and other materials. Radioactive sources and poisons must be locked away. Remember that the cleaners may not be aware of the hazards presented by such materials.
(iii) Place any other materials in suitable containers, label them and put them away safely.
(iv) In a biological laboratory check aquaria, animal cages and make certain the doors are secure. Ensure that the animals have sufficient food and water. 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.
(vii) The hands should always be washed when leaving the laboratory or after handling dangerous substances or material which carries a risk of infection.
(viii) Any apparatus left overnight must be clearly indicated by a notice of the appropriate type signed by a responsible person. Instructions should be left concerning action in case of emergency
(ix) Affix paper seals over the locks of the laboratory doors. The paper seals should contain the signature of responsible staff member.

SELF ASSESSMENT EXERCISE 5

Why is that special efforts are required to be observed during lab shut-down time?

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3.5 Shifting Load

When a load has to be shifted, you have to take a number of simple steps to prevent back and other muscle strain:

- If the load is to be manually handled, an assessment of risks should be made.
- The load should be split down into manageable sizes.
- Each part should be within the lifting capability of the lab worker.

Muscle strain: Injury caused to the muscle through forcible stretch beyond its proper length. **Manual handling**: Transporting or supporting of a load by hand or bodily force.

Generally in Science lab situations, objects are moved through lifting process or using a trolley. Remember that the majority of back injuries are caused by incorrect lifting. Back injuries are the most common cause of injury at work and, range from severe accident to mild discomfort. To avoid back injuries, the back should always be kept straight and the feet apart when lifting.

The following procedure should be adopted:

1. 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. Always keep the back straight.
3. Grip the load securely 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.
   The correct position for lifting objects is shown in Fig. 5.1.

Fig. 5.1: Correct lifting procedure

Moving loads on a trolley

Loads on a trolley, are normally moved through pulling or pushing process. During the pulling process, the whole strain is to be taken by the back muscles (Fig.5.2). Care should be taken to move the trolley with a steady speed that it does not run on and injure the feet. During pushing process, an optimum height of push (about mid-chest height) helps in minimising the strain. The push load is taken by the backbone (Fig. 5.3). Pushing at too high a level puts excess strain on stomach muscles and can cause strain of shoulder muscles and hernia. Also pushing at too low a level is ineffective.

Fig. 15.2: Pulling load

Fig. 15.3: Pushing load

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

4.0 CONCLUSION

In the beginning of this unit, we have discussed the measures to be taken to ensure safe working condition in a laboratory. The fundamentals of personal safety code in a laboratory are also discussed. A list of instructions one should follow while working in a laboratory is also given which could serve as code of practice in a laboratory. A brief mention of protective devices required for safety in a laboratory is made. In this unit, you have also learnt elaborately about the methods of disposal of all the three categories of waste materials. The three categories of waste materials are:

- Unserviceable non-consumable items
- Obsolete instruments
- Chemical waste.

Finally, you have studied about the procedure to be used for check-in, shut-down and lifting objects.

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5.0 SUMMARY

In this unit, we have discussed safety aspects in a detailed way. We explained the need for a personal code of behaviour and then gave a list of instructions which could serve as code of practice in a laboratory. We stated a few protective devices. We described in an elaborate manner the ways of disposing of waste materials. We discussed the check-in and shut-down sequences. Finally we described the procedure to be used in lifting objects.

6.0 TUTOR MARKED ASSIGNMENT

1. State two main reasons as to why the behaviour of a laboratory technician be exemplary.

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2. Why is a cotton lab coat preferable to a nylon coat?

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3. Do you think that you are less likely to be poisoned or harmed if you just store food or drink in the lab as compared to actually consuming it?

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4. What are the main causes for the occurrence of chemical waste?

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5. Summarize the proper procedure for lifting.

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ANSWERS SELF-ASSESSMENT EXERCISES

1. (i) Due to vigorous chemical reaction, there may be emission of vapours or
even spurting which could cause blisters in the face and even be harmful to the eyes.
(ii) Loose jewellery could get entangled in a 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. It could be a serious fire risk when flammable solvents are being used. The tobacco smoke can interfere with purification and, other chemical and physical processes.
3. Improper disposal of waste materials could cause serious environmental problems.
4. All sources of ignition should be shut off.
5. At the end of a day's work, people are less alert due to tiredness and thinking about getting home; short cuts are taken to avoid working late. 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 during shut-down sequences.

7.0 REFERENCE/FURTHER READINGS

Certificate Programme in Laboratory Techniques (CPLT), a certificate programme, School of Sciences, Indira Gandhi National Open University (IGNOU), New Delhi, India

UNIT 6 ACCIDENTS AND FIRST AID

CONTENTS

1.0 INTRODUCTION

In this Unit, we shall discuss the need and the method for reporting an accident. We shall explain the choice of locating the first aid box and state its contents. You will also learn about the general features of first aid procedure and then discuss the methods of administering first aid for specific situations like electric shock, unconsciousness, chemical accidents, bleeding, burns, fractures and eye injuries. This unit could serve as a guide for offering first aid to those involved in laboratory accidents. For any serious injury, proper medical assistance should be sought at the earliest.

2.0 OBJECTIVES

After studying this unit, you should be able to:

- explain the need for reporting lab accidents,
- state the accident reporting procedure,
- list the contents of a first aid box,
- 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.

3.0 MAIN CONTENT

3.1 Accident Reporting

To start with, let us explain two closely related words, accident and incident.
Accident is an unexpected or unplanned event. It may cause

(i) harm to someone and /or
(ii) damage to equipment or premises.

Accidents are the result of unsafe systems of work. The 'near misses of accidents' also need to be recognised, although systems of work would never be changed until an accident occurred.

Near misses of accidents: Accidents prevented just before occurrence.

The word 'incident' includes a wide range of happenings-anything from an individual fainting to natural disasters like floods, earth quake etc. and to man-made disasters like fire, industrial disasters etc. You may note that incidents include accidents also.

3.1.1 The Need for Reporting Accidents

All accidents (no matter how trivial) and, dangerous near misses should be recorded. The recording of accidents ensures that all injuries are treated. The record keeping of accidents helps in knowing about unsafe working practices and long-term trends in accidents. It helps in tightening safety aspects in a lab. Further if there is a subsequent enquiry, considerable problems may arise for those concerned 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.

3.1.2 Accident Reporting Procedure

It is better 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 lab in-charge. It should contain details of all accidents and "near misses" as given below:

(1) Date, time and location of incident
(2) Name of casualty
(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 lab staff. The book is a valuable source of information to the alert lab in-charge.

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 and age of the casualty
(3) A description of the accident
(4) The names of any witnesses
(5) Details of any injuries suffered or suspected
(6) A description of the first aid treatment given
(7) The name of the person who gave the first aid treatment
(8) A description of any further action taken, e.g. removal to hospital

This form is also a useful record containing details concerning the accident which might be hard to recall at a later date. These forms are to be completed and maintained by the lab in-charge. A copy of this report has to be sent to the Head of the institution for information, so that the Head could initiate measures to improve safe working conditions in the lab.

SELF ASSESSMENT EXERCISE 1

What are the main features of an accident?

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3.2 First Aid Box

Before we discuss the location and contents of first aid box, we shall explain the term, first aid.

3.2.1 What is First Aid?

First-aid is the immediate and temporary care given to the victim of an accident or sudden illness. 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 lab 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 which can be learnt only by proper training and practice. 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.

3.2.2 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.

> 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.

An ideal first aid system would have two kinds of first aid box to meet two kinds of need. The first type of first aid box would be to meet emergencies and would be placed in the lab. It would never be locked so that it is accessible at all times. Theft could become 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 above the minimum requirements and hence the box could always be locked and a responsible person put in charge of it. This could be used in times of need as secondary support.

3.2.3 Contents of First Aid Box

The minimum contents of a first aid box are given in Table 6.1. 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 near-by doctors and hospitals, the replacement date of its contents etc. may also be typed and pasted to it.

Table 6.1: 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 grams
Burnol tube	1
Dettol bottle	1
Spirit bottle (100 ml)	1
Stainless steel spoon (padded) or Tongue depresser	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 (5inch, blunt pointed)	1
Pen torch	1

SELF ASSESSMENT EXERCISE 2

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

3.3 General Features of First Aid Procedure

The order of priorities in administering first aid is decided by the principal objective - to save life. Equally important, you must not do anything which endangers the lives of others. It will not help the victim if you are 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.

3.3.1 Scope of First Aid

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

* Diagnosis:
  Diagnosis of the casualty 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 casualty (if conscious) or from witnesses.
  - Symptoms are the sensations of the casualty 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 casualty, symptoms and signs are quite helpful in diagnosis.

* Treatment:
  First aid treatment is a set of actions taken to preserve life of the casualty, prevent the conditions from becoming worse and promote his/her recovery.

* Disposal:
  Disposal is the arrangement made for the removal of the casualty to his/her home or suitable shelter or to hospital. A tactful message should be sent to the casualty's home or relatives indicating the main details of accident and the casualty's destination.

3.3.1 Sequence of Actions

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

(1) Quickly remove 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. 6.6). For both 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 casualty and help lessen the anxiety.
(7) Do not allow people to crowd around as fresh air is essential. Get them to telephone for an ambulance, summon the fire brigade, or other services which may be required. They can also help to care for 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 fire (provided it is only a small one).
(8) Where necessary, your last action with any casualty is either
    (a) to hand him/her over to a doctor or
    (b) to transfer him/her to a hospital.

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

SELF ASSESSMENT EXERCISE 3

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

3.4 First Aid Procedure for Electric Shock

Although the procedure described earlier is usually followed, there are occasions when other matters have to be considered and therefore the procedure altered. Electric shock is one such occasion.
You would have read in Unit 1 that the main injuries which may be expected in an electrical accident are bums, asphyxia and shock. Cuts, fractures or other injuries may result from falls due to electric shock. The sequence of actions to be taken is:

(1) Do not touch the casualty until you are certain that the power has been turned off or that the casualty 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. With a mains supply voltage (220-240 V), the victim can be pulled or pushed clear using for example, 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 when attempting this and,
   - ensure that the hands are not wet.

(2) If the victim is not breathing, the artificial respiration must be applied immediately. For administering artificial respiration and heart massaging, the help of a properly trained person may be taken.

(3) If the victim is unconscious but breathing, place him in the recovery position.

(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.

(6) In cases of serious injury, send for an ambulance or doctor.

(7) Don't move the victim, if you suspect any fracture.

SELF ASSESSMENT EXERCISE 4

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

3.5 First Aid Procedure for Unconscious Casualties

Let us now discuss the first aid procedure for unconscious casualties. The 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 diabetics. Unconsciousness or insensibility is due to interruption of the action of the brain through some interference with the functions of the nervous system.

Fainting: A condition of temporary loss of consciousness.

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

(1) Remove the casualty 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 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 and, clear the mouth of blood, mucus etc. with a cloth to ensure that the airway is clear.
(5) If breathing fails or stops, apply artificial respiration immediately. If heart beat stops or pulse is not normal, apply heart massaging.
(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. 6.6).
(9) Keep a written record of the casualty's responses and pulse rate at regular intervals.
(10) Keep the casualty still if he/she regains consciousness. Reassure him/her and moisten his/her lips with water but do not give any drink.
(11) Do not leave an unconscious casualty unattended.
(12) Always ensure to inform the doctor about the unconscious state of the casualty.

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

Fits

Fits of various kinds may be accompanied by unconsciousness, and are usually characterized by the casualty 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 casualty; e.g. stools, chairs, bottles, etc.
(2) Pull the patient away only if he/she is in potential danger from stairs, cables, fires, etc.
(3) Never try to open the casualty's mouth.
(4) After the fits, allow the casualty to rest.
(5) Never leave the casualty unattended.
(6) Take a padded spoon and put the handle in between teeth to prevent tongue-biting during fits.
(7) Transfer the casualty to safe and shady place till the help is received.

Diabetes

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 casualty some sugar or sweets. Don't worry about creating an excess of sugar in the diabetic'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.

Resuscitation - An Explanation

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

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

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

You are aware that respiration or breathing is the method by which

- oxygen passes from the air into our blood, and
- waste carbon dioxide is removed via our lungs.

Circulation is the method by which

- blood transports oxygen and nutrients to various parts of the body, and
- wastes are carried from the tissues.

The heart is the pump which makes circulation possible. In case of persons becoming unconscious, "ABC" aspects are to be taken care of by a process known as resuscitation.

Resuscitation is the process of

(i) clearing the airway,
(ii) restarting breathing and
(iii) restoring blood circulation.

Checking Breathing and Pulse

Before attempting to resuscitate a casualty, it is essential that you check his/her breathing rate and pulse. You can 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 casualty'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. Either of the following methods is suitable:

   (a) Wet your lips and place them near to the casualty's mouth or nose. When the casualty breathes out, your lips will cool.
   (b) Hold a cold piece of glass mirror, or a highly polished surface close to the casualty's mouth or nose. When the casualty breathes out, a small amount of condensation should form on the polished surface. This method is least satisfactory.

(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 pulse in your fingers, mistaking it for the casualty's. A suitable method is to turn the casualty's head and feel the casualty's pulse below the corner of his/her jaw. Four

separate checks lasting 15 seconds each will give you the best indication.

Opening the Airway

If a casualty has stopped breathing, first of all we should clear the airway of the victim, so that he/she could inhale fresh air. The procedure is as follows:

(1) Remove obvious obstructions covering the casualty'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.6.1). You may use the handle of a padded spoon.

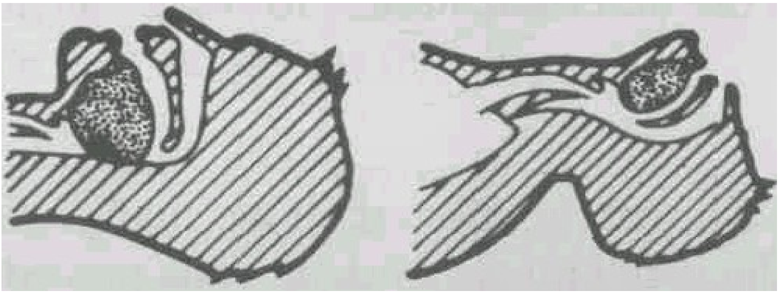
The average rate of the pulse in a healthy adult is 72 beats per minute.

Fig. 6.1: 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. 6.2). The mouth should remain open.

Fig. 6.2: Adjustment of the chin and head.

This extension of the head and neck lifts the tongue forward clear of the airway (Fig. 6.3 (a. and (b)). If the tongue does not fall forward, pull it forward with finger. In some cases, it is sufficient to restart the casualty's breathing.



(a) (b)

Fig.6.3: (a) In the unconscious casualty 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 him (or her) in the recovery position (Fig. 6.4).

Fig. 6.4: Recovery position

Mouth-to-Mouth Artificial Respiration

If a casualty does not start breathing by the above process, artificial respiration must be started immediately to get 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 fatal. The mouth-to-mouth is the most effective and can be used almost in all circumstances, with a few exceptions such as cyanide poisoning. The procedure is as follows:

(1) Pinch and compress the nose to close it.
(2) Take deep breath (Fig.6.5a).

(3) Place your mouth around victim's mouth, make an airtight seal and quickly breathe into victim's mouth; if required, a thin cloth may be placed over the patient's mouth (Fig. 6.5b).
(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.

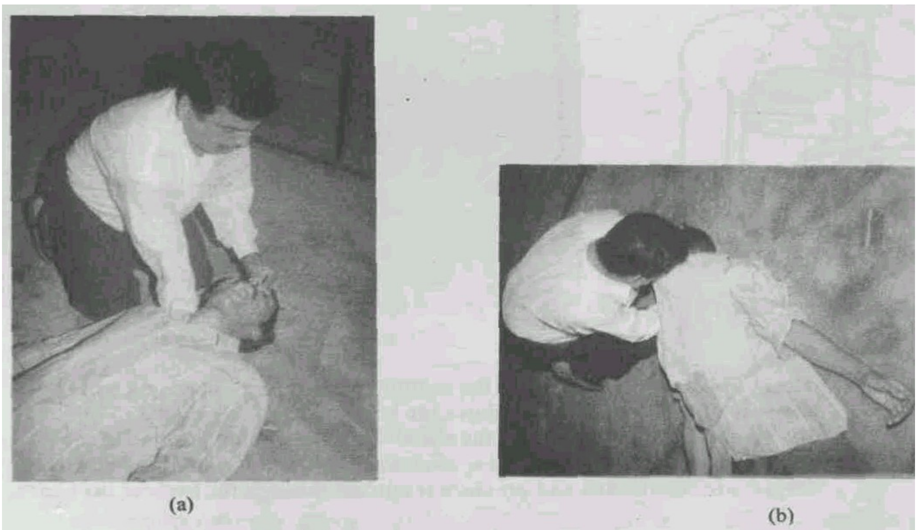


Fig. 6.5: Artificial respiration (a) Tailing a deep breath pinching the nose of the victim (b) breathing out into casualty's mouth.

Heart Massage for Restoring Circulation

In cases of breathing failure, you should check that the casualty'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 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.

The heart massage is done as follows:

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

(1) If a heart beat cannot be detected, place the casualty 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 heart beat, for instance, in electric shock cases.

Sternum is indicated in Fig. 6.6a.

(3) If the heart still does not beat, cardiac massage is to be given by using the procedure given below.
(4) The position for massaging is 1-2" (or two finger width) above the bottom end of sternum (Fig. 6.6a).
(5) 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.
(6) Keep your elbows straight and lean forward.
(7) Then start pushing with the force of both your hands one above the other (Fig. 16.6b). Apply steady smooth pressure to depress victim's sternum l'/2"to2".

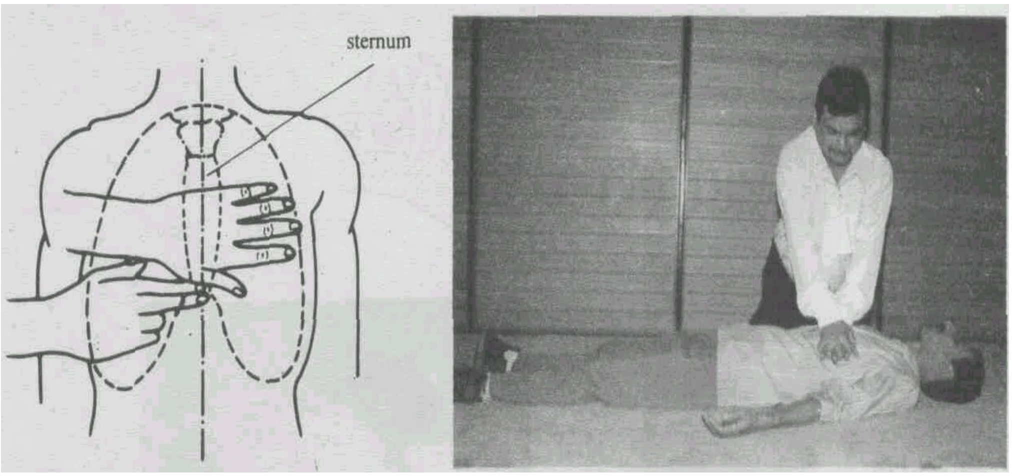


Fig. 6.6: Heart Massaging: (a) Finding the position for massage - placing a hand at a distance of two fingers (1-2") above the bottom end of sternum, (b) Applying the pressure on the chest - note the leaning position of the person providing first-aid and his straight elbow on the victim's chest. His fingers are interlocked and pressure is applied through the heels of the hands.

(8) Then relax pressure maintaining the position of the hands.
(9) Give 15 such chest compressions and then two quick lung inflations by mouth-to-mouth breathing.
(10) 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 (9) and (10) 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 heart beat resumes or until medical help arrives or the casualty reaches hospital.

SELF ASSESSMENT EXERCISE 5

What are the purposes of resuscitation?

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3.6 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.
These are:

(1) through the digestive system - ingestion;
(2) through the lungs - inhalation; and
(3) through the skin - corrosion, irritation, penetration.

Let us deal with each of these ones separately.

Ingestion

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

(1) Tell the casualty to spit out as much of the material as possible and then wash the mouth thoroughly a number of times with water. Do not let the victim swallow.
(2) If the substance 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 casualty to hospital. Wherever possible, the following information should accompany the casualty:

    (a) the identity of the poison,

(b) the approximate amount and concentration of the chemical consumed, and
(c) brief details of the treatment already given.

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

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

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

Inhalation

This route of toxic substances into the body is the most dangerous. It 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 is almost as toxic as hydrogen cyanide, but because of the paralysing effect of the gas, it seems to be odourless when highly concentrated.

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

Table 1.2 of Unit 1 gives the health hazard data and the emergency treatments for some of the compressed gases. Generally the standard procedure in gas based accidents is as follows:

(1) Remove the casualty from the danger area, provided this can be done without danger to you.
(2) Loosen the casualty's clothing and administer oxygen if this is available.
(3) If breathing is stopped, apply artificial respiration through a properly trained person. Do not use the mouth-to-mouth method if the gas responsible is hydrogen cyanide. A capsule of amyl nitrite should be broken and held under the nose of a victim who

has inhaled hydrogen cyanide. Again immediate medical attention must be obtained.

> Amyl nitrite capsules have a shelf-life of two years and can explode if not kept cool.

(4) Transport the casualty to hospital if the situation needs it. Give details of the gas responsible 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 which could cause bums are as follows: phenol, bromine, strong acids (especially concentrated sulphuric acid, nitric acid), strong bases (sodium hydroxide (caustic soda) 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) Drench the affected area with large amounts of running water. Continue for at least five minutes or until you are satisfied that the chemical does not remain in contact with the skin. 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 as possible of the acid or other corrosive liquid from the skin quickly with clean cloth before using the little water which is available to wash the affected area.
(2) Carefully remove all contaminated clothing.
(3) The effects of burns from acids, alkalis, bromine, phenol or sodium are considerably reduced and the accompanying pain is lessened by applying an antidote (Table 6.2) to remove or neutralize the substances.
(4) If the casualty 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; phenol can kill through penetration.

Table 6.2: Antidotes for Some Chemical Reagents

Chemical	**Antidote**
Acids like HNO_3, H_2SO_4, HCl	Wash with 10% sodium bicarbonate solution (which leaves no residue on clothes), then apply Vaseline or a soothing cream.
Alkalides, e.g., NaOH, KOH, etc.	Wash with 1% acetic acid, then apply Vaseline or a soothing cream.
Bromine	Wash with 2 M ammonia, keep the affected part dipped in sodium bisulphite solution.
Phenol	Apply ethanol or glycerol on a cotton wool pad.
Sodium	Apply ethanol on a cotton wool pad.

* "2 M" stands for 2 molar solution.

Acute and Chronic Effects

The effects of accidents due to chemicals are severe and immediate on the human body. These effects are called acute effects and can be traced without difficulty. Frequently, poor lab practice or an unsafe system of work will lead to gradual poisoning. At first, effects may go unnoticed; or the effects may be attributed to the wrong cause. 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 - drunkenness and vomiting
- Chronic effect - addiction, liver damage, etc.

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

SELF ASSESSMENT EXERCISE 6

Are these four steps for dealing with a gas-affected casualty in the correct order? If not, put them in the best order by indicating the respective numbers within brackets:

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

Acute effect - Severe and immediate effect. Chronic effect - The effect which remains for a long time.

SELF ASSESSMENT EXERCISE 7

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

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3.7 Controlling Bleeding

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. Although it is the third step in the general procedure for first aid, you must exercise some judgement here. Where a large artery is cut, stopping bleeding would be the first life - saving measure you would take. The second type of bleeding would usually be dealt with in the latter stages of the general procedure under localized injuries. The third type of bleeding cannot directly be dealt with by the first aider. 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.

Severe Bleeding

In case of severe bleeding, use the following steps:

(1) Control bleeding by the following means:

(a) Apply direct pressure on the wound for 5-15 minutes with a clean pad of cloth. If this 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 from reaching the wound and is the method which must be applied immediately in any accident in which an artery has been severed. Indirect pressure may also be applied around the wound using a ring bandage for example. 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 flow uphill will also reduce blood loss from the wound.

(2) Carefully remove any foreign bodies which 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.

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

(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.

Sling: A sling is used to afford support and rest to an upper limb such as arm, wrist, chest etc. Arm sling (Fig. 6.7), for example, is a wide piece of cloth looped from the neck under an injured arm for support.

(5) Send for an ambulance and carefully transport the casualty to hospital.

Fig. 6.7: Casualty with an arm sling.

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 which could cause infection.

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

(1) prevent infection,
(2) control bleeding,
(3) absorb any discharge, and
(4) reduce further injury.

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 only obtained 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

Frequently, the bleeding stops of its own accord or is easily controlled by local pressure. The procedure for first aid treatment is as follows:

(1) Reassure the casualty 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. Frequently an adhesive dressing is more convenient.
(4) Provided a broken bone is not suspected, 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.

Internal Bleeding

There is little that you can do for most internal bleeding other than treating for shock and calling for a doctor immediately. If the patient's condition becomes worse without any external injury, one possible cause is internal bleeding. Internal bleeding should always be suspected

after a violent blow has been sustained and shock symptoms become apparent.
However, one common type of internal bleeding that you can treat is a nosebleed. For nosebleed,

(1) the casualty must be made to sit upright with his/her head slightly forward,
(2) his/her nose pinched just below the hard part for 10 minutes,
(3) tell the casualty 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.

SELF ASSESSMENT EXERCISE 8

List four steps you would take in giving first aid treatment for a severe bleeding.

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3.8 First Aid Treatment for Shock

Some degree of shock is produced in most accidents. Shock is associated with changes in the system of blood circulation varying from temporary weakness to complete failure. Shock may arise due to:

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

Shock may be present even in cases where the victim simply suffers from severe and sudden fear, but no 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 enormously in its severity and can be fatal. Sometimes the effects are delayed and shock may not be apparent until some time after the accident.

The chief symptoms of shock are as follows:

- Profuse 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 to the hospital at once. Do not waste time, as an immediate blood transfusion may be required if his/her life is to be saved.
In other cases, the following treatment should be given:

(1) Lie or sit the victim down, if necessary, and deal with the injury or cause of shock. Protect the casualty against cold by wrapping him/her in a blanket, but do not use hot water bottles or electric fires as this draws 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 casualty's legs, if possible, to bring more blood back into the brain. If the casualty is sitting down, e.g., after fainting, it may be more convenient to get him/her to lower his/her head between the knees.
(4) Keep the casualty still and reassure him/her.
(5) Do not move the casualty unnecessarily.
(6) If the casualty complains of thirst, moisten his/her lips with water. Remember, a seriously injured person may require an anaesthetic immediately on arrival at hospital; so, do not give him/her anything to drink until you are satisfied that any injury is only trivial, e.g. faintness or dizziness. 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 his/her digestive system such as tea, either the anaesthetic, if administered later at the hospital, may be refused or it could cause vomiting. In either case, it makes a smooth surgical operation quite difficult.

SELF ASSESSMENT EXERCISE 9

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

3.9 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 casualty while professional medical aid is sought.

3.9.1 Burns

There are two types of burns which we are to discuss:

(1) Chemical
(2) Thermal

Chemical burns have already been discussed in Sec. 6.7; so we shall discuss thermal burns, i.e. burns due to high temperature. Two common thermal burn injuries are given below:

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

Scald: A burn caused by hot liquids or gases.

Tissue damage results from direct contact with the source of heat. There is also considerable danger from shock which 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 casualty to hospital as quickly as possible.
The procedure 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 on to the skin.
(3) Cover the wound with a dry, sterile dressing.
(4) Give small cold drinks at frequent intervals to a badly burnt conscious casualty to counteract the effect of fluid loss; it must be made sure that operation is not necessary.

(5) Reassure the casualty.
(6) Badly burnt or scalded casualties must be taken to hospital as quickly as possible. Any injury in which more than 10% of the body surface is burnt is regarded 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 which form, and do not touch the affected area as this can increase the risk of infection. If severe burns are there, do not apply lotions or ointment.

3.9.2 Fractures

It is not our intention to introduce you to many types of fractures that can occur or all the ways a first aider might deal with them. The essential thing is that you know that complications can arise from moving a casualty with a fracture without first taking steps to immobilize the fractured part.
Any broken or cracked bone is referred to as a fracture. The general symptoms of a fracture are as follows:

- Tenderness 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 of fingers produce little pain and the casualty may feel that he/she has only bruised or strained the affected area.

> Bruise: Bleeding beneath the surface of the unbroken skin.

- Swelling occurs as a result of blood loss into the surrounding tissues and may mask other symptoms.
- Deformity or unnatural movement; wherever possible the injured and uninjured parts should be compared.
- Shock.

The recommended action in any accident in which a fracture is suspected is to keep the casualty still and not to move him/her unless it is necessary to separate him/her from some other hazard which could endanger his/her 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 is to:

(1) cover the casualty with a blanket
(2) keep the casualty warm
(3) send for an ambulance
(4) Treat for shock and do not give any drinks.

3.9.3 Eye Injuries

The eyes are a particularly vulnerable part of your 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 concerned. 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, or
(2) chemical splashes.

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 casualty to hospital for urgent treatment.

The first aid procedure is as follows:

(1) Hold the eye open or get the casualty 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 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 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.

SELF ASSESSMENT EXERCISE 10

Can you write down the four steps you would take on discovering a suspected fracture?

4.0 CONCLUSION

You have learnt about the need and the method for reporting an accident. Now, you know about the term first aid and the choice of locating the first aid box and state its contents. In this unit, a list of a series of guidelines for offering first aid treatment for specific situations like electric shock, unconsciousness, chemical accidents, bleeding, burns, fractures and eye injuries is also discussed. Due care must be shown while using these procedures. Wherever necessary, the victim should be provided with skilled medical attention at the earliest. For any serious injury, proper medical assistance should be sought at the earliest.

5.0 SUMMARY

Accidents in laboratories, by and large, occur due to unsafe work practice. The accidents may result in harm to some one and/or damage to equipment and premises. In this unit, we have listed 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.

6.0 TUTOR MARKED ASSIGNMENT

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 casualty. 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 casualty who has swallowed some poisonous material while pipetting.

5. Name any five sources of vapour, gas or dust which could cause poisoning by inhalation.

6. State the liquids/cream that you would apply to a casualty with (i) acid burn and (ii) alkali burn.

7. Suggest three methods of checking whether the casualty's heart beats.

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8. What are the main purposes of first aid dressing?

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9. What is the first step in the first aid treatment of shock?

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10. 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 of the burn
    (iv) to replace lost fluid
    (v) to reduce shock

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

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ANSWERS SELF-ASSESSMENT EXERCISES

1. An accident is an unexpected or unplanned event that causes harm or hurt to someone and/or damage to equipment or premises. Accident occurs due to unsafe systems of work.
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 casualty 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 anaesthetic, tea or any fluid in the digestive system would result in the refusal of the anaesthetic or vomiting. In either case, the chances of the patient undergoing a smooth operation are considerably diminished by fluids. If a casualty is thirsty, only his/her lips need to be moistened with water.
10. (a) Do not move the casualty 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.

7.0 REFERENCE/FURTHER READINGS

Certificate Programme in Laboratory Techniques (CPLT), a certificate programme, School of Sciences, Indira Gandhi National Open University (IGNOU), New Delhi, India