INCREASING ACCESS TO SECONDARY SCHOOL LEVEL EDUCATION THROUGH THE PRODUCTION OF QUALITY LEARNING MATERIALS

JUNIOR SECONDARY LEVEL

PHYSICS

Module 5:
Magnetism and Electricity

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JUNIOR SECONDARY LEVEL SCIENCE - PHYSICS

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➤ **MODULE 5 – Magnetism and Electricity**

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MODULE 5

MAGNETISM AND ELECTRICITY

INTRODUCTION

This is the last Module of the physics component of this programme. It is about magnetism and electricity. You will first learn about magnets, their properties and their applications in various devices. Then we introduce you to a very practical area namely electricity, including the safe use of electrical energy in the home.

OBJECTIVES

After completing this Module you should be able to

- state the properties of magnets
- distinguish between temporary and permanent magnets
- explain the working of an electromagnet
- list some uses of electromagnets
- describe how electricity can be generated
- distinguish between direct and alternating currents
- discuss ways of making use of electricity in the home safer
- perform simple calculations on electrical power

5.1 ABOUT MAGNETS

I am sure you must have played with magnets at one time or another. Magnets contain oxides of iron. Magnets appear quite strange at first. They attract certain objects, for example, an iron nail or a pin made of steel. This implies a magnetic force. The iron nail and the pin are said to be magnetic. On the other hand, if you bring a magnet near a piece of copper wire, wood or plastic, these are not attracted. They are non-magnetic.

✍ ***Before proceeding further, complete the following activity.***

Activity 1

Give four examples of
(i) magnetic materials
(ii) non-magnetic materials

(i) Magnetic Materials	(ii) Non Magnetic Materials

You will find the answers at the end of the Module.

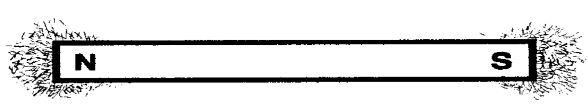
We can now proceed to a simple investigation.

INVESTIGATION 1: Effect of a magnet on iron filings

For this investigation you will require the materials indicated. **You should record your answers in the space provided.**	**Materials needed -** • A bar magnet • Iron filings **Method**: *Dip a bar magnet into iron filings. Then remove it.* *Record your observations.* …………………………………………………………… …………………………………………………………… …………………………………………………………… …………………………………………………………… …………………………………………………………… …………………………………………………………… …………………………………………………………… …………………………………………………………… ……………………………………………………………

I am sure that you saw the iron filings being attracted to the magnet.

You should also have noticed that the iron filings gather in large clusters around the ends of the magnet. More iron filings are attracted at the ends. The magnet will look like this



The ends of the magnet are called the poles.

5.1.1 POLES OF A MAGNET

A magnet normally has two poles - the north pole and the south pole.

Before proceeding further, complete the following activity.

Activity 2

(a) *In a bar magnet, its power to attract magnetic materials appears to be concentrated in regions near the ends of the magnet.*
How are the regions called?

……………………………………………………………………

(b) *Name the materials of which magnets are made.*

……………………………………………………………………

You will find the answers at the end of the Module.

At this stage you will find it useful to investigate further about the poles of a magnet. Let's proceed with the following investigation.

INVESTIGATION 2: Poles of a Magnet

For this investigation you will require the materials indicated. **You should record your answers in the space provided.**	**Materials needed -** • A bar magnet • Fine thread **Method**: *Suspend a bar magnet horizontally by a fine thread arranged to form a stirrup.* *Record your observations.* *Mark the poles of the magnet.*

You must have found that in (a) the bar magnet performs rotary oscillations and eventually it comes to rest in a North – South direction.

As for (b), I am sure that you marked the pole pointing north as N (north seeking or simply the north pole). The other pole pointing south is marked as S (South seeking or simply the south pole). Thus as pointed out earlier the magnet has a north pole (N) and a south pole (S).

As we noted earlier magnetic forces are concentrated at the poles.

Let's undertake the following simple investigation to find out more about the nature of those magnetic forces.

INVESTIGATION 3: Nature of magnetic forces

For this investigation you will require the materials indicated. **You should record your answers in the space provided.**	**Materials needed -** • 2 bar magnets X, Y • A cardboard placed on a table **Method:** *Place the bar magnet X on the cardboard.* *(i) Now place bar magnet Y on the cardboard and bring the N Pole of Y close to the N Pole of X.* ***Result*** …………………………………………………………… ………………………………………………… *(ii) Bring the S Pole of Y close to the S Pole of X.* ***Result*** …………………………………………………………… ………………………………………………… *(iii) Bring the N Pole of Y close to the S Pole of X.* ***Result*** …………………………………………………………… …………………………………………………………… *(iv) Bring the S Pole of Y close to the N Pole of X.* ***Result*** …………………………………………………………… ………………………………………………… *(v) What generalisation can you make?* …………………………………………………………… ……………………………………………………………

You must have observed that:

(i) a North Pole repels another North Pole.

(ii) a South Pole repels another South Pole.

(iii) a North Pole attracts a South Pole.

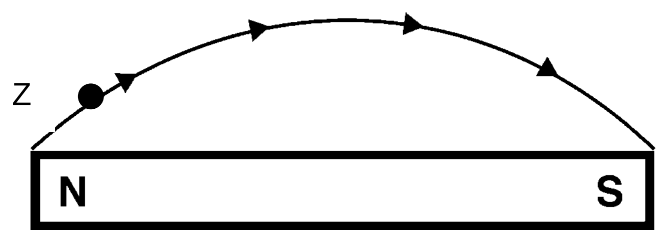
(iv) a South Pole attracts a North Pole.

Thus we can generalise that LIKE POLES REPEL UNLIKE POLES ATTRACT. This statement is referred to as the 'Law of Magnetic Poles'.

5.1.2 LINES OF FORCE

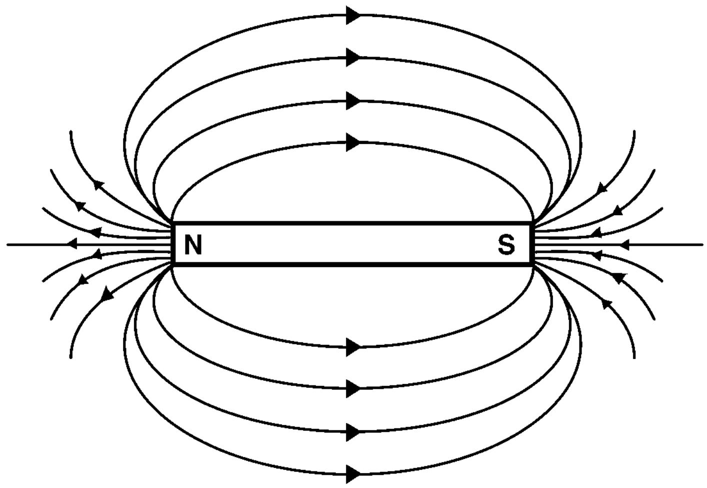
We have just seen that like poles repel and unlike poles attract.

Now let us consider a 'free' or 'isolated' north pole (Z). If it were placed near the N Pole of a bar magnet it would be repelled by the N of the magnet and attracted by the S of the magnet. The path that Z would follow is called a line of force or a magnetic line of force. See diagram below:



This can be repeated using slightly different positions of Z near the north pole.

You will note a pattern is formed. This pattern of magnetic lines of force is called magnetic field. It is important to remember that a magnetic line of force has a direction - given by the direction of the arrow.



✍ ***Before proceeding further, complete the following activity.***

Activity 3

Lines of force around a magnet

Consider each of the five statements below. Write TRUE or FALSE as appropriate.

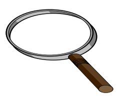
1. *A magnetic line of force starts at a N Pole and ends at a S Pole.*
   ………………………………………………………..
2. *A collection of lines of force associated with a magnet constitute its magnetic field.*
   ………………………………………………………..
3. *A magnetic field has a pattern of lines of force.*
   ………………………………………………………..
4. *In a magnetic field, the lines of force always cross one another.*
   ………………………………………………………..
5. *Magnetic lines of force have no direction.*
   …………………………………………………………..

You will find the answers at the end of the Module.

5.1.3 MAGNETIC FIELD PATTERN OF A BAR MAGNET

As we mentioned earlier, the lines of force for a magnet produce a pattern which we call magnetic field.

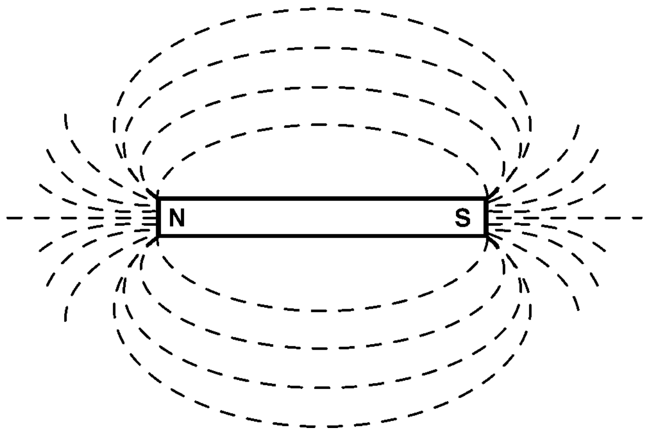
Let's now find out more about the magnetic field of a bar magnet through the following investigation.



INVESTIGATION 4: Magnetic field of a bar magnet

For this investigation you will require the materials indicated. **You should record your answers in the space provided.**	**Materials needed -** • A bar magnet • Iron filings • A cardboard **Method:** *Place a bar magnet horizontally on the table. Support a cardboard on the magnet so that the magnet is in the middle of the cardboard. Sprinkle iron filings on the cardboard.* *Tap the cardboard gently a few times.* *Describe what you see.* ……………………………………………………………… ……………………………………………………………… ……………………………………………………………… ………………………………………………………………

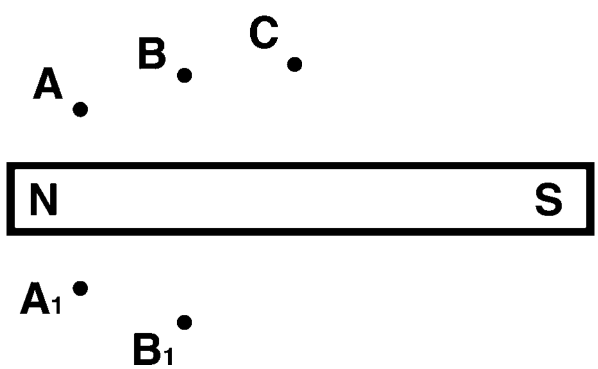
I am sure you noticed that the iron filings form a pattern about the magnet. The pattern gives the magnetic field of the magnet. See diagram below.



5.1.4 USING A COMPASS NEEDLE

A compass needle is often used to plot the magnetic lines of force and hence the magnetic field pattern of a magnet. Let's see how this is done.

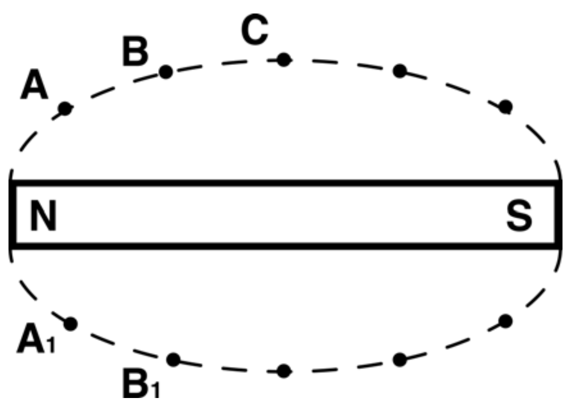
The magnet is placed on a sheet of paper (on the table).



A compass needle is placed relative to position A as shown. The head of the needle is marked B. The compass needle is moved to B so that the tail is now pointing towards B. The head is marked as C. We continue in this manner.

We repeat on the other side at positions A_1, B_1 etc.

We join up each set of points. This will give the following pattern.



✍ ***Before proceeding further, complete the following activity.***

Activity 4

The Compass Needle

Read carefully each statement below. Insert True or False as appropriate

(a) *The compass needle has a very light magnet pivoted horizontally* ☐

(b) *When no magnets occur near a compass needle, its light magnet points in the north-south direction.* ☐

(c) *We cannot use a compass needle to find out the pattern of lines of force in a magnetic field.* ☐

(d) *When a compass needle is placed near a magnet, it shows a deflection.* ☐

(e) *The compass needle is used in ships and airplanes to indicate direction.* ☐

You will find the answers at the end of the Module.

5.2 STATIC ELECTRICITY

In Module 2, we learnt about electrons and protons. You will recall an electron has a negative change (-1) while protons has a positive change (+1).

Here we shall look at charges at rest or static charges.

Let's start with a simple investigation.

INVESTIGATION 5

For this investigation you will require the materials indicated. **You should record your answers in the space provided.**	**Materials needed -** • Polythene strip • Soft cloth • Small pieces of paper **Method:** *(a) Rub the polythene strip with a soft cloth.* (b) *Hold it above some small pieces of paper* *What happens to the pieces of paper?* ………………………………………………………… ………………………………………………………… ………………………………………………………… ………………………………………………………… ………………………………………………………… ………………………………………………………… ………………………………………………………… ………………………………………………………… ………………………………………………………… ………………………………………………………… ………………………………………………………… …………………………………………………………

You must have noted that the small pieces of paper are attracted by the polythene strip. This can be explained as follows:

When the polythene rod is rubbed with the soft cloth, some electrons from the soft cloth are transferred to the polythene strip.

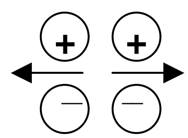
The polythene strip has thus an excess of electrons and hence a negative charge. The polythene strip has been charged negatively by friction (by rubbing). The negatively charged rod can thus attract small pieces of paper.

Similarly when a glass rod is rubbed with silk, some electrons are transferred from glass to silk. The glass thus gets positively charged by friction.

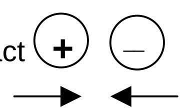
5.2.1 LAW OF ELECTROSTATICS

According to this law,

Like charges always repel



Unlike charges always attract



5.2.2 LIGHTENING AND THUNDERSTORM

Have you ever seen flashes of lightening? It normally occurs just before or during a thunderstorm.

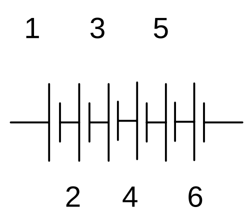
Lightening is a natural phenomenon. In fact electric charge often builds up in the clouds as a result of friction from winds. When the charge is sufficiently big, the molecules in the air are said to be 'ionised'. Under these circumstances the big charge flows from the cloud to the earth as lightening. We often refer to lightening as a natural discharge between clouds and the earth.

5.3 ELECTRIC CURRENT

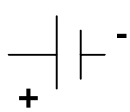
What is an electric current?

An electric current can be regarded as a flow of charge. It is measured in Amperes (A) by an instrument called an ammeter. We shall denote an electric current by 'I'.

We can obtain an electric current from a dry cell (for example the one used in a torch). A torch uses dry cells. These dry cells provide an electric current which lights the bulb. The current provided by these cells is referred to as a direct current (d.c). It always flows in one direction from the positive terminal to the negative terminal. An arrangement of cells as shown is referred to as a battery.



A battery of six cells

Thus cells and batteries provide direct current. Please note that the symbol for one cell is 

In your house, the electric current you use for lighting or heating is different. This electricity is referred to as 'Mains" electricity - which provides an electric current whose direction is not constant as in the case of a direct current. In fact the current provided by the mains changes its direction many times in a second. In other words the direction 'alternates'. This current is called an alternative current (a.c.)

5.3.1 ELECTRIC CHARGE

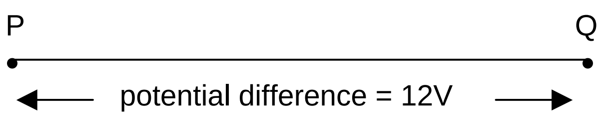
Electric charge is measured in Coulombs. It is calculated as:

Charge in Coulombs	=	Current in amperes	x	Time in seconds

5.3.2 VOLTAGE OR POTENTIAL DIFFERENCE

The voltage or potential difference is measured in Volts. The potential difference between 2 points A and B in volts means the work done in joules to transfer a charge of 1 coulomb from A to B.

Consider the following example where the potential difference between P and Q is 12 volts.



This means 12J of work is done to transfer a charge of 1 coulomb from P to Q.

Before proceeding further, complete the following activity.

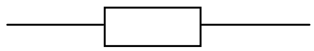
<u>Activity 5</u>

The potential difference between P and Q is 10 volts. How much work is done to transfer 5 coulombs of charge from P to Q

You will find the answer at the end of the Module.

5.4 RESISTANCE

The resistance of a conductor refers to its ability to resist the flow of charge. Resistance is measured in Ohms (Ω). It is denoted by R and its

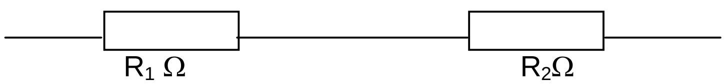
symbol is  or 

Resistances can be combined in :

(i) Series (that is one after another)
(ii) Parallel

5.4.1 SERIES ARRANGEMENT

When two resistances $R_1\,\Omega$ and $R_2\Omega$ are connected in series,



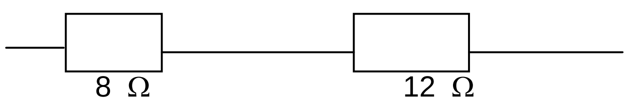
The combined resistance, $R = (R_1 + R_2)\ \Omega$

Before proceeding further, complete the following activity.

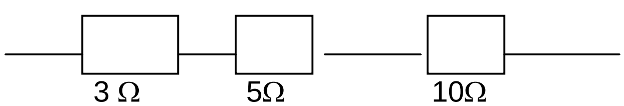
<u>Activity 6</u>

What is combined resistance in each case?

(i)



(ii)



You will find the answers at the end of the Module.

5.4.2 PARALLEL ARRANGEMENT OF RESISTANCES

When 2 resistances R_1, and R_2 are arranged in parallel,

the combined resistance R is given by

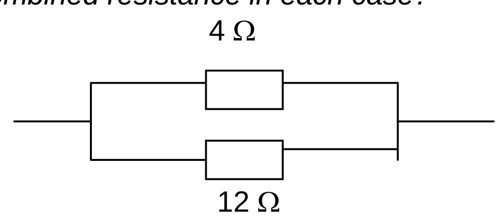
$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

Before proceeding further, complete the following activity.

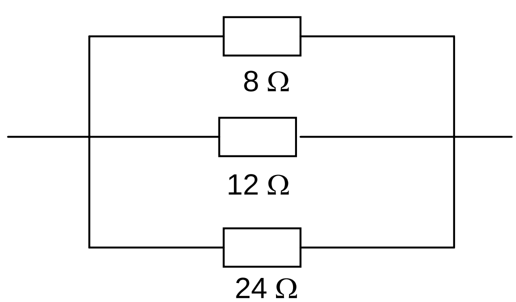
Activity 7

What is the combined resistance in each case?

(i)



(ii)



You will find the answers at the end of the Module.

So far we have explained the meaning of

- electric current (I)
- potential difference (V)
- resistance (R)

At this stage, it is useful to know that these three quantities are related by the formula

$V = IR$

In fact the expression

$$V = IR$$

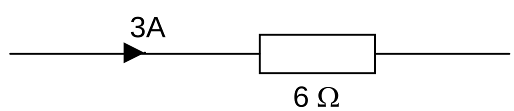
Is known as Ohm's law. This relationship was established by the German physicist G.S.Ohm.

You will find this expression useful in simple calculations.

Before proceeding further, complete the following activity.

Activity 8

A current of 3A passes through a resistance of 6 Ω as shown. What is



the potential difference across the 6 Ω?

You will find the answers at the end of the Module.

5.5 EFFECTS OF AN ELECTRIC CURRENT

You will recall we introduced you to magnets, their properties and magnetic field at the beginning of this Module. Then you learnt about electric current, potential difference and resistance. Now it is useful to study about the magnetic field that is set up when an electric current flows.

First let's investigate the magnetic field pattern due to an electric current flowing through a copper wire.

INVESTIGATION 6: Magnetic field due to an electric current

For this investigation, you will require the materials indicated. **You should record your answers in the space provided.**	**Materials needed -** • A metal wire • A cell (or battery) • A switch (or key) • Electrical connection • A small compass needle • A cardboard • Iron filings **Method**: (a) *Place the metal wire vertically through the horizontal cardboard, use the electrical connection (copper wires) to complete the circuit through a switch and the cell. Place the compass needle near the wire. Switch on the current.* (b) *Switch off the current.* (c) *Remove the compass needle. Sprinkle iron filings on the cardboard. Switch on the current. Tap gently the cardboard.*

	Record your observations ……………………………………………………………… ……………………………………………………………… ……………………………………………………………… ……………………………………………………………… ………………………………………………………………

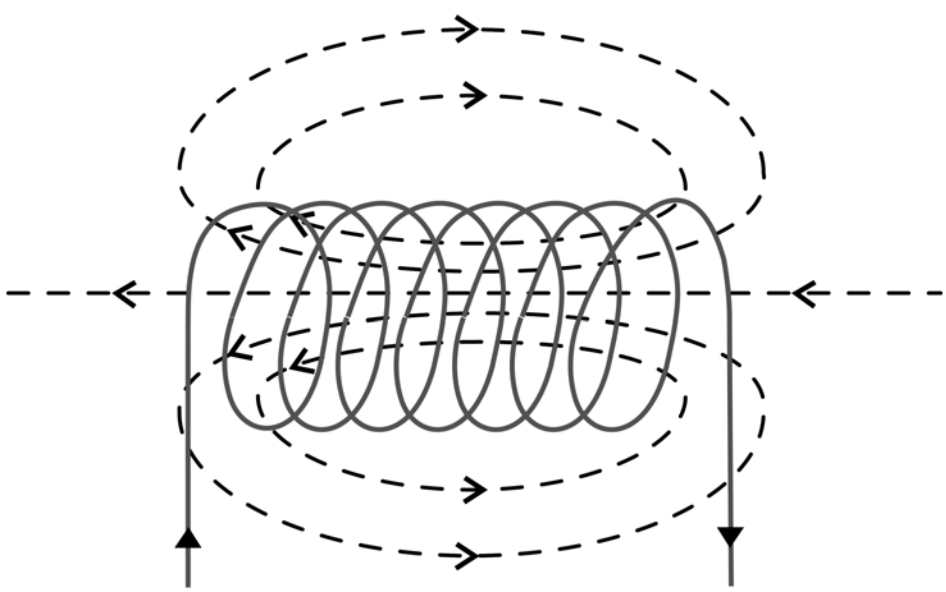
I am sure that in (a) you noticed the compass needle showing a deflection.

In (b) the deflection is cancelled.

In (c) the final observation should be a circular pattern around the wire. This pattern is the magnetic field pattern due to a current flowing through a wire.

We have just learnt that an electric current gives rise to a magnetic field. Thus an electric current has a **magnetic effect**.

A similar effect is observed when an electric current flows through a **solenoid.** A solenoid is just a coil of several turns of insulated copper wire. The following pattern illustrates the magnetic field set up as the electric current flows through the solenoid.



✍ ***Before proceeding further, complete the following activity.***

Activity 9

An insulated copper wire is made into a number of turns (called a solenoid). If this were connected to a battery, the solenoid would carry a current. Sketch the solenoid and draw the magnetic field.

Do not forget to include

(i) direction of current
(ii) direction of lines of force in the resulting magnetic field

You will find the answer at the end of the Module.

So far we have considered the magnetic effect of an electric current. Apart from a magnetic effect, an electric current also has a **heating effect**.

- When an electric current passes through a wire, the wire becomes hot. Heat is produced. Electrical energy is converted into heat.
- When we use an electric iron, an electric current flows through the heating element. Electrical energy is converted into heat.
- Similarly when we put on a kettle full of water, electrical energy is changed into heat energy.
- In winter, when we put on the electric heater, electrical energy is converted into heat energy.

There are many other such examples that illustrate that electrical energy can be converted into heat energy.

✍ ***Before proceeding further, complete the following activity.***

Activity 10

We have learnt that electrical energy can be converted into HEAT energy.

(a) *How is this effect of an electric current called?*

……………………………………………………………………………

(b) *Give a few examples of the above effect.*

1st ……………………………………………………………

2nd …………………………………………………………….

3rd ……………………………………………………….

4th ……………………………………………………

(c) How does it arise?

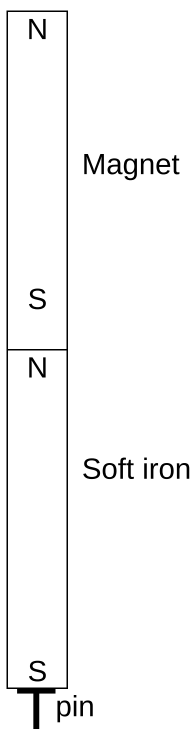
……………………………………………………………………………

You will find the answers at the end of the Module.

5.6 MAGNETIC INDUCTION

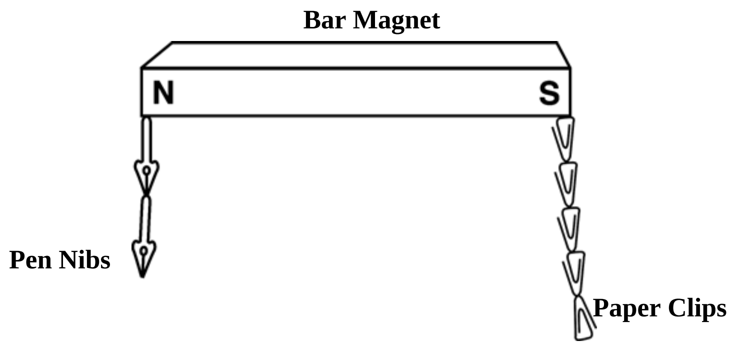
When a pin made of iron or steel is brought near the pole of a magnet, it is attracted to the magnet. It itself becomes a magnet. We say that the pin has induced magnetism. The process of inducing magnetism in the pin is called magnetic induction. Instead of a pin, we can use a soft-iron bar, AB.

The end A is attracted. A north pole is induced at A and a south pole at B. Thus the soft iron becomes an induced magnet. It can in turn attract other magnetic materials such as a pin made of iron or steel.



5.6.1 MAGNETIC PROPERTIES OF IRON AND STEEL

Although steel contains iron, its magnetic properties are quite different from iron. We shall refer to our earlier knowledge on induced magnetism to illustrate this. We can use steel pen nibs and iron paper clips together with a magnet. The pen nibs and paper clips are brought near the magnet. One of each is added successively as shown. The successive pen nibs and paper clips are attracted by induced magnetism. A stage is reached when the pen nibs and the paper clips are no longer attracted. The induced magnetism is too weak. The diagram below illustrates this situation.



What do you deduce?

This simple experiment shows that the iron paper clips are more easily magnetised than the steel nibs.

Now if we just detach the first paper clip from the magnet, all the other paper clips fall down.

On the other hand if we detach the first steel nib from the magnet, the other nibs do not fall down.

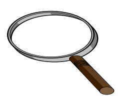
What do you deduce?

Steel nibs retain the magnetism but iron paper clips do not. The magnetism induced on the iron is temporary while that on the steel nibs is permanent.

To conclude we can say that steel is more difficult to magnetise than iron, but steel retains its magnetism longer. Steel is often referred to as a hard magnetic material while iron is referred to as a soft magnetic material.

In fact steel is commonly used for making permanent magnets while iron is used for temporary magnets.

The following investigation about magnetic properties of iron and steel will improve your understanding about magnetic properties of iron and steel.



INVESTIGATION 7: Comparison of iron and steel

For this investigation you will require the materials indicated. **You should record your answers in the space provided.** →	**Materials needed -** • A bar magnet • Pins of iron • Pins of steel (the pins should be similar) **Method**: *(a) Support the magnet horizontally. Below one end (say N pole) put an iron pin vertically. At the lower end of the pin put another iron pin. Continue in this way and count up the maximum number of pins which form a chain below the pole.* *(b) Repeat the steps in (a) at the other pole (South) of the magnet, using pins of steel in this case. Count up the corresponding number of pins.* *Record your results.*

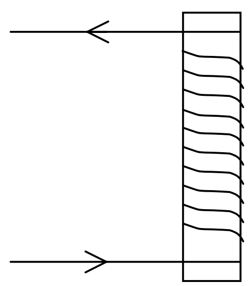
I am sure you found out that the chain of pins of iron is longer than that of steel.

The iron pins are magnetised more easily than those of steel.

5.6.2 AN ELECTROMAGNET

You will recall that iron is easily magnetised and iron can be used for making temporary magnets. Moreover we learnt that an electric current has a magnetic effect.

We can now look at how a direct electric current passing through a coil of copper wire wound on an iron rod can act as a magnet. The iron rod acts as a magnet as long as the current is flowing. This can be illustrated using the diagram below.



If the current is switched off, the iron is no longer a magnet. Such a magnet is called an electromagnet.

You realise that it is quite easy and simple to make an electromagnet. The following investigation will make it clearer.

INVESTIGATION 8: Making a model electromagnet

For this investigation you will require the materials indicated.

Materials needed -

- A solenoid (A coil with a large number of turns of copper wire)
- A rod of iron
- Pins of iron
- A battery (torch cells)
- Electrical connections
- A switch

Method:

(a) *Connect the solenoid to a battery through a switch using electrical connecting wires.*

(b) *Place a rod of iron in the solenoid.*

(c) *Switch on the current. Place pins of iron near one end of the rod.*
What do you observe?

……………………………………………………………

……………………………………………………………

………………………………………………………

(d) *Now switch off the current. What do you observe?*

……………………………………………………………

……………………………………………………………

………………………………………………………

You should record your answers in the space provided.

In (a) you observed the iron pins being attracted to the end of the rod. In (b) the pins fall off as they are no longer attracted.

Uses of electromagnets

There are numerous uses of electromagnets. In some cases they are used for lifting large quantities of magnetic materials and transferring them to another place. Another application is in the electric bell. A telephone earpiece also contains an electromagnet. Thus electromagnets are useful components of a number of devices.

Can you think of other examples?

✍ ***Before proceeding further, complete the following activity.***

Activity 11

Magnetic properties of iron and steel

*For **each** of the following, select between **iron** and **steel***

(a) Is easy to be magnetised.
……………………………………………………………….

(b) Once it is magnetised, it loses its magnetism easily.
……………………………………………………………….

(c) Is difficult to be magnetised.
……………………………………………………………….

(d) Once it is magnetised, it retains its magnetism i.e. does not lose it easily.
……………………………………………………………….

(e) Is suitable as material for permanent magnets.
……………………………………………………………….

(f) Is good as material for temporary magnets.
……………………………………………………………….

(g) Is suitable for use as an electromagnet (this is magnetised when an electric current flows in a solenoid around it; but the moment the current is switched off, it loses its magnetism.
…………………………………………………………………….

You will find the answers at the end of the Module.

5.7 AN ELECTRIC MOTOR

An electric motor is an important component of many electric devices we use in the home. These include electric mixers, washing machines and vacuum cleaners. Other examples include electric trains and lifts. Even in the car the working of the windscreen wipers depends upon an electric motor. The working of all the above devices is governed by the "**motor effect**".

"A wire carrying an electric current in a magnetic field experiences a force. If the wire is free to move then the wire moves."

In all electric motors, an electric current flows through a coil that is situated in a magnetic field. The coil rotates as a current flows.

✍ ***Before proceeding further, complete the following activity.***

Activity 12

The Electric Motor

(a) *What is an electric motor?*

………………………………………………………………………………………

…………………………………………………………………………

(b) *How can a simple electric motor be made? Illustrate with a sketch.*

You will find the answers at the end of the Module.

5.8 THE ELECTRIC GENERATOR

In an electric motor, we apply an electric current in a coil situated in a magnetic field to obtain mechanical energy (due to rotation of coil). The electric generator does the reverse – i.e. we rotate a coil in a magnetic field to generate an electric current.

✍ ***Before proceeding further, complete the following activity.***

Activity 13

(a) Show the alterations which have to be made to the model electric motor (in activity 12) in order to convert it into a simple generator.

(b) How is electricity generated using a dynamo?

You will find the answers at the end of the Module.

5.9 USE OF ELECTRICITY IN THE HOME – MAINS ELECTRICITY

You will recall that we mentioned earlier in this Module that electricity in our homes comes from the 'MAINS' – as alternating current. Let's now look at the safe use of electricity in the home.

5.9.1 THE DOMESTIC WIRING SYSTEM

The electricity comes to our homes through cables. In our home the wiring system has three wires. These are:

(i) The live (L) wire
(ii) The neutral (N) wire
(iii) The earth wire (E) wire

The Live wire

The live wire is at high voltage (about 240V) and hence dangerous.

It is brown in colour. Previously it was red.

The neutral wire

The neutral wire is at zero volt. It is coloured blue. Previously it was black

The earth wire

The earth wire is in fact a safety device. This is important especially for an electric appliance having a metal frame or metal stand. It helps to avoid electric shocks in case there is a fault or the live wire touches the casing of the appliance. It is coloured yellow with green strips or green with yellow strips.

5.9.2 OTHER FEATURES OF THE DOMESTIC WIRING SYSTEM

A careful study of the domestic wiring system reveals the following features:

- switches
- fuses

A switch

A switch is a device that helps to make or break the circuit. Thus you can use it to put an appliance on or off. It is useful to remember that all switches are placed in the live wire – the brown one. This ensures that the appliance is not connected to the live wire when the switch is in the "off" position.

A fuse

A fuse is a safety device that controls the maximum safe current flowing in a circuit. It the current exceeds the maximum safe value, the fuse wire gets over heated and melts. Thus it breaks the circuit. Fuses are always placed in the live wire This ensures that the appliance will not become live after the fuse has blown or melted.

It is also important to choose the fuse properly. The rating of the fuse must be such that it is just above the normal current flowing in the circuit - for example if a circuit takes a current of 11 A, then a suitable fuse rating will be 13A.

Other features include fused plugs and circuit breakers. Some appliances such as vacuum cleaners, hairdryers and food mixers have double insulation. The appliance is enclosed in a plastic case.

✍ ***Before proceeding further, complete the following activity.***

Activity 14

(a) Explain

(i) direct current
……………………………………………………………………………………

(ii) alternating current
……………………………………………………………………………………

(b) Explain carefully why it is important to place all switches and fuses in the live wire and not in the neutral wire
…………………………………………………………………………
…………………………………………………………………………
…………………………………………………………………………

You will find the answers at the end of the Module.

5.9.3 SAFE USE OF ELECTRICITY IN THE HOME

In the last 2 decades there has been an increase in the use of electric domestic appliances. These include:

- electric irons
- heaters
- air conditioners
- ovens
- washing machines
- cookers

There are many more! You may also may think of computers, printers, drilling machines, and lawn mowers.

✍ ***Before proceeding further, complete the following activity.***

Activity 15

Name some domestic appliances which make use of electric energy.

(a) In the kitchen

………………………………………………………………………………………
…………………………………………………………

(b) In other places in the home

………………………………………………………………………………………
………………………………………………………………………………………

You will find the answers at the end of the Module.

The increase in the use of an increasing number of appliance may increase the risks of accidents unless we are aware of the dangers and safety precautions are taken. This is what we see discuss in the next section.

Safety precautions

Inadequate knowledge of electricity and the associated features can be dangerous.

Let's recapitulate the important features we have considered so far. You will recall:

(i) all fuses and switches must be placed in the live wire
(ii) all appliances with a metal part must be earthed
(iii) circuit breakers are important

(iv) fuses should have a rating that is just above the normal current taken by the circuit.

In addition to the above, electrical faults often develop in appliances or circuits. These can cause fire, electric shocks or even electrocution to users. The dangers may be due to one or more of the following:

- damaged insulation
- overheating of cables
- damp conditions

Damaged insulation

You will recall there are 3 wires (L, N and E) in our domestic wiring system. The two wires that complete the circuit from the electricity supply to the appliance and back to the supply are the Neutral and the Live wires. They are insulated from one another by rubber or plastic. These insulating materials often deteriorate with time. The insulation often gets worn out. The result is that the live wire may become exposed which can in turn lead to electric shock.

Overheating of cables

Overheating of cables can occur if an excessive current flows. This can occur when insulation of the L and N wires are worn out and they touch each other. A **'short circuit'** is then said to occur. A big current flows producing a large amount of heat. This can melt the wire or even start a fire.

Damp conditions

Damp conditions often lead to serious accidents. It is dangerous to change a light bulb with wet hands or put on a switch with wet hands. An electric current can flow more easily through the hand when it is wet.

At this stage, you will find it useful to carry out an investigation. It is about the dangers associated with electricity.

INVESTIGATION 9: Dangers associated with electricity

You should record your answers in the space provided.	**Method**: *Make a survey, in a few homes, concerning dangers to which users of electric energy are exposed.*

I am sure you found out one or more of the following:

- At connections of wires, the insulation may show signs of being damaged.
- Overheating of certain electric devices e.g. the electric iron or electric shower.
- Damp plugs/sockets.
- Electrical connections getting worn out and not renewed/replaced.
- Sockets are sometimes low and within reach of children. While playing they may insert metal objects in the sockets and get electric shocks.
- Lack of earthing in the case of an electric oven, refrigerator etc.

✍ ***Before proceeding further, complete the following activity.***

Activity 16

Consider each statement below. Think well over each one and put a tick or a cross.

Suitable fuses serve to control the current flowing in a circuit ☐

1. *The circuit breaker is a safety device that functions automatically.* ☐
2. *The circuit breaker switches off the main current in the home when a serious fault occurs in electric connections/devices in the home.* ☐
3. *Double insulation provides greater safety than single insulation.* ☐
4. *Earthing is a safety measure for a night lamp.* ☐
5. *Earthing is a safety measure for a refrigerator with a metal frame.* ☐

You will find the answers at the end of the Module.

5.10 CONSERVATION OF ELECTRIC ENERGY

Most of our energy sources are limited, for example, petroleum reserves are being gradually depleted. The cost of electric energy is increasing. Our monthly electricity bill is quite high. There is an urgent need to avoid wastage of electric energy and reduce our electricity bills!

Before proceeding further, complete the following activity.

Activity 17

(a) *Why should electric energy NOT be wasted*?

……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………

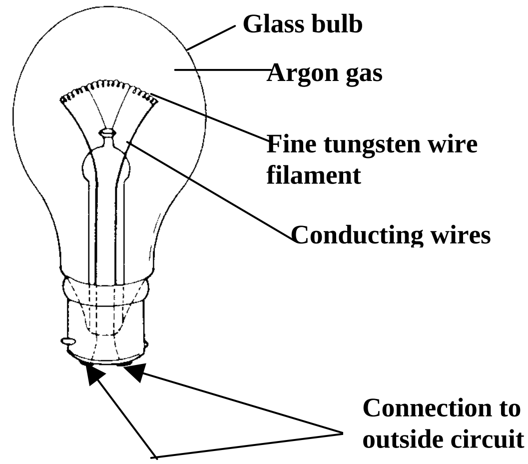
(b) Make a list of the ways in which wastage of electric energy is avoided.

……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………

You will find the answers at the end of the Module.

5.10.1 WORKING OF A SIMPLE LIGHT BULB

The light bulb is the simplest electric appliance. It's useful to examine how it works. A simple light bulb consists of a coil of thin tungsten wire enclosed in a glass bulb. The glass bulb is filled with an inert gas, argon.



Connections to lamp

When you switch on the current, the filament becomes very hot (about 2500^0C). At this high temperature, a proportion of the electrical energy is converted into light energy. Some electrical energy is also converted into heat. This is why the bulb becomes warm after a few minutes.

Why is tungsten used for the filament?

Tungsten is suitable for the filament because it has a high melting point.

Why is the bulb filled with argon?

Argon in unreactive. Thus it allows the bulb to operate without 'burning' the tungsten.

5.11 ELECTRICAL POWER

The term “power” is not new to us. We came across it in Module 3. We are going to apply it to electricity.

✍ ***Before proceeding further, complete the following activity.***

Activity 18

(a) Define power and state the unit for power

……………………………………………………………………………………

…………………………………………………………………………………..

(b) In motor vehicles small bulbs are often marked "6W12V".

(i) What does "6W" stand for?

……………………………………………………………………………………

…………………………………………………………………………………..

(ii) What does "12V" represent?

……………………………………………………………………………………

……………………………………………………………………………………

You will find the answers at the end of the Module. .

The watt value of electric bulbs

We just considered the case of a small bulb marked 6W12V. In the home we have bulbs marked 40W240V or 60W240V etc. It is useful to remember that

Power = Voltage x Current

✍ ***Before proceeding further, complete the following activity.***

Activity 19

(a) *An electric heater has a power of 40W. It operates at 240V. What is the current it takes when in normal use?*

…………………………………………………………………………………
…………………………………………………………………………………
…………………………………………………………………………………

(b) *What is the resistance of the heater?*

…………………………………………………………………………………
…………………………………………………………………………………
…………………………………………………………………………………

You will find the answers at the end of the Module.

✍ ***Before proceeding further, complete the following activity.***

Activity 20

An electric oven has a power of 2 KW. How much heat does it produce in 5 minutes?

……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………

You will find the answer at the end of the Module

The Kilowatt hour

At this stage, it is useful to note that the cost of electricity is based on the number of kilowatthour (KWh) used. In fact,

Number of KWh = Number of KW x Number of hours

Once we know the number of KWh, we can calculate the cost of energy - using the cost of 1 KWh.

Before proceeding further, complete the following activity.

Activity 21

Bearing in mind that 1 KW = 1000 W and that 1 hr = 3600 sec, how much energy (in Joule) is represented by 1 Kilo Watt hour (symbol KWh)?

……………………………………………………………………………………………
……………………………………………………………………………..
……………………………………………………………………………………………
……………………………………………………………………………..

You will find the answers at the end of the Module.

! POINTS TO REMEMBER

- A magnet has 2 poles: N and S.
- The poles are near the ends of the magnet.
- Unlike poles attract, like poles repel.
- A magnet has a magnetic field (with lines of force).
    - Friction between two bodies often produce electric charges
    - Unlike charges attract, like charges repel
    - Ohm's law, $V = IR$
- An electric current has magnetic effect. It also has heating effect.
- Iron is good for temporary magnets.
- Steel is good for permanent magnets.
- The electric motor converts electrical energy into mechanical energy (rotational energy).
- The generator or dynamo converts mechanical energy into electrical.
- In both motor and dynamo there are coils and a magnetic field.
- In the home electric supply is of alternating type (and NOT direct). It has many uses.
- Electricity is hazardous and necessitates precautions. Safety devices and measures are important.
- Electric energy has to be conserved.
- Electrical power is in Watt. It is the product of voltage and current.
- Electrical energy can be measured in KWh

ANSWERS TO ACTIVITIES

Activity 1

(i) Magnetic	(ii) Non Magnetic
Iron	Wood
Steel	Plastic
Cobalt	Lead
Nickel	Aluminium

Activity 2

(a) Poles of the magnet
(b) Iron
Steel

Activity 3

1. True
2. True
3. True
4. False
5. False

Activity 4

(a) True
(b) True
(c) False
(d) True
(e) True

Activity 5

Energy = Coulombs x volts
= 5 x 10
= 50 J

Activity 6

(i) R = 8 + 12 = 20 Ω
(ii) R = 3 + 5 + 10 = 18 Ω

Activity 7

(i) $\frac{1}{R} = \frac{1}{4} + \frac{1}{12} = \frac{3+1}{12} = \frac{4}{12}$

$\frac{1}{R} = \frac{4}{12}$ i.e $\frac{1}{3}$

$\therefore$ R = 3 Ω

(ii) $\frac{1}{R} = \frac{1}{8} + \frac{1}{12} + \frac{1}{24}$

$= \frac{3+2+1}{24} = \frac{6}{24} = \frac{1}{4}$

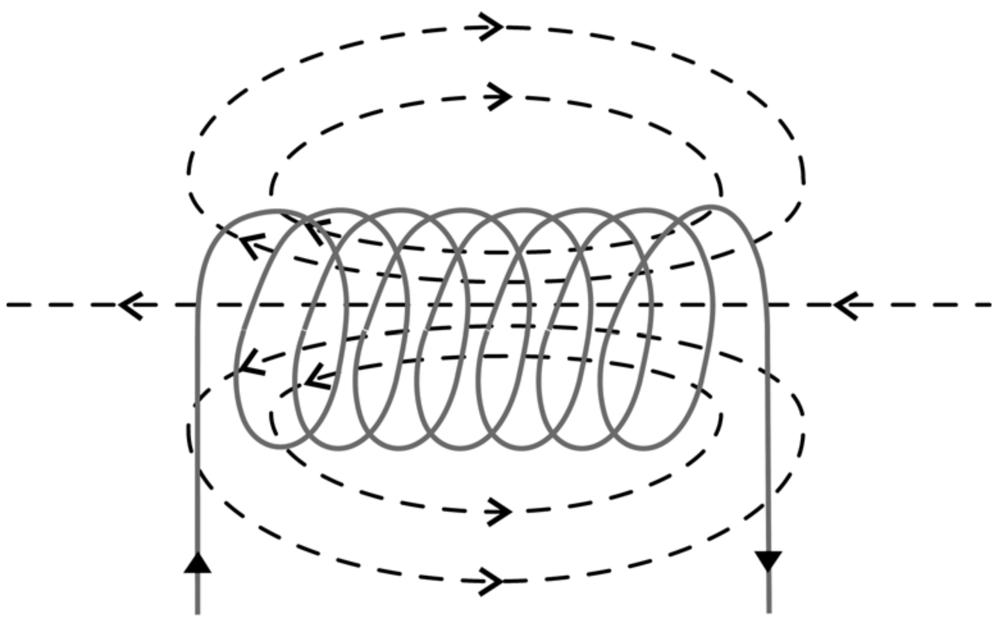
$\therefore$ R = 4 Ω

Activity 8

Using V = IR and replacing

We have
V = 3 x 6
= 18 volts

Activity 9



Activity 10

(a) The heating effect of an electric current.
(b) 1^{st} Electric iron
2^{nd} Electric oven
3^{rd} Electric boiler
4^{th} Electric grill
(c) Work done in overcoming electrical resistance is converted into heat.

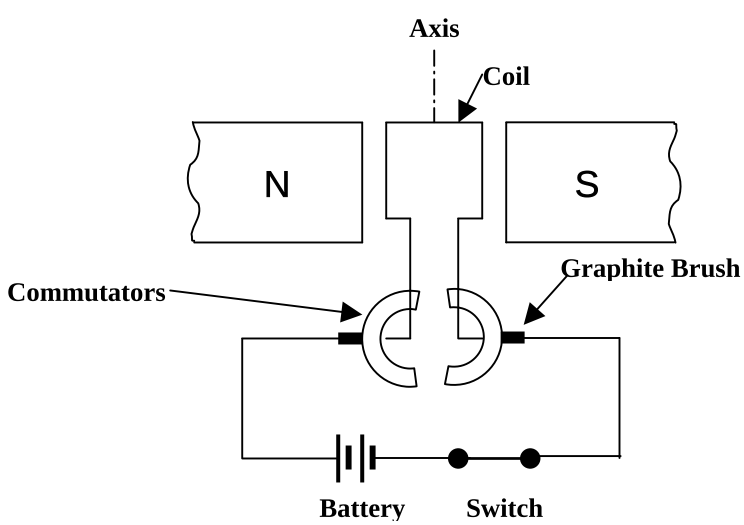
Activity 11

a. iron
b. iron
c. steel
d. steel
e. steel
f. iron
g. iron

Activity 12

(a) It is a device which converts electrical energy into mechanical energy. In fact, a rectangular coil carries a current. The coil occurs in a magnetic field. The coil rotates about an axis.

(b)



When the current is switched on, the coil rotates about the axis.
The 2 ends of the coil are connected to 2 half rings or commutators.

Activity 13

(a) The battery is replaced by a lamp. The coil is made to rotate in a magnetic field.
Mechanical energy is converted into electrical energy. This causes the lamp to light.

(b) A series of coils are made to rotate rapidly in a magnetic field. Electrical energy is generated.

Activity 14

(a) (i) A current which flows in one direction only.
(ii) A current which keeps on changing direction.

(b) In order to 'protect' the electrical device from damage which would result from excessive current.

Activity 15

(a) The refrigerator
The electric kettle
The electric grinder/mixer
The electric grill/oven
The microwave

(b) The electric iron
The hairdryer
The fan
The electric brush
The vacuum cleaner
The electric bath (water heater)
The electric bulb/tube
The door-bell

Activity 16

1. ☑
2. ☑
3. ☑
4. ☑
5. ☒
6. ☑

Activity 17

(a) 1. Electric energy is very costly
2. Most of our energy sources are limited

(b) 1. Switching off electric lamps/tubes/devices when not required
2. Using low power electric devices as far as possible
3. Using gas cooker instead of the electric cooker.

Activity 18

(a) Power is the rate of doing work <u>or</u> of using energy
The unit of power is the WATT (which is the Joule/Second)

(b) (I) Each of the bulbs uses energy at the rate of 6 J/S

(ii) Each such bulb functions at a potential difference of 12 volts.

Activity 19

(a) Power = Voltage x current
Replacing in the above formula,
We have:

$$40 = 240 \times \text{current}$$

$$\text{Current} = \frac{40}{240} \text{ amp} = \frac{1}{6} \text{ A}$$

(b) Voltage = Current x Resistance
Replacing in the formula, we have:

$$240 = \frac{1}{6} \times R$$

$$R = 240 \times 6$$

$$= 1440\ \Omega$$

Activity 20

2 KW = 2000 W
5 mins = 5 x 60 sec = 300 sec
Heat (Energy) = watt x sec
= 2000 x 300
= 600000 J
or 600 KJ

Activity 21

1 KW = 1000W
1 KW used for 1 sec, corresponds to energy of 1000 J
1 KW used for 3600 sec,
corresponds to energy of 1000 x 3600 J
= 3600000 J