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Ohm's Law — Current, Voltage and Resistance

What is modern atomic theory ?

According to this theory the central part of the atom is called *nucleus* and contains *protons* and *neutrons.* A proton is a positively charged particle and neutron has no charge. Thus, nucleus of an atom bears positive charge. The neutron is electrically neutral *i.e.* it carries no charge though it is as heavy as proton. The protons and neutrons are very closely held together with tremendous forces.

The nucleus is surrounded by a number of tiny particles called *electrons.* The electrons are spinning around themselves and also are revolving round the nucleus in orbits or shells. The electrons carry the smallest negative charge and have a negligible mass. The mass of electron is approximately 1/1840 that of a proton, but it is three times the diameter of the proton.

Under ordinary conditions, the number of protons is equal to the number of electrons in an atom. Therefore, an atom is electrically neutral as a whole. This explains why a body does not exhibit any charge under ordinary conditions.

Electrons have negative charge exactly equal in magnitude to the positive charge of the protons.

The electrons are kept in the atom by the attraction exerted on them by the positive nucleus. In fact, the electrons can be regarded as arranged and revolving in successive orbits or levels around the nucleus. The electrons in each orbit or level are associated with a definite amount of energy. Thus the orbits are referred to as energy levels. The energy levels are denoted by the letters *K, L, M, N, O, P,* etc. The *K* level is nearest to the nucleus.

To remove the electron from its orbit, some definite amount of energy is required. To remove the electrons from the first orbit, the energy required is maximum and to remove the electrons from the outermost orbit the energy required is minimum.

The number of electrons that can be accommodated in any orbit or level is given by the formula $2N^2$, where N is the number of orbit or level.

Therefore, K level or first orbit has $2 \times 1^2 = 2$ electrons
L level or second orbit has $2 \times 2^2 = 8$ electrons
M level or third orbit has $2 \times 3^2 = 18$ electrons
N level or fourth orbit has $2 \times 4^2 = 32$ electrons

and so on. But there is some limitation to the above formula that the outermost orbit of any atom cannot have more than 8 electrons and the last but one orbit of the atom cannot have more than 18 electrons. The electrons in the outermost orbit of an atom are called valence electrons.

What are valence electrons ?

The electrons in the outermost incomplete orbit, called the valence orbit or the valence ring, are called the *valence electrons.* The number of valence electrons is always less than 8. If electrons are added to the valence orbit to bring the total to 8, the atom becomes stable. In case of Helium, Neon, Argon and Radon and outermost orbit is complete and hence these atoms are stable and, therefore, inert.

It is the valence electrons that determine most of the properties of the elements and form bonds to hold the material together. The valence electrons are comparatively loosely bound to the rest of the atom and they may be removed by various means *e.g.* by applying electrical voltage to the material.

What is the difference between elements and compounds?

Elements are composed of molecules containing atoms of one kind only. Compounds are composed of molecules containing atoms of different kinds. An element is defined as a substance that can neither be broken up into other substances nor can be created by ordinary chemical means. The elements which are found in nature are gold, silver, copper, aluminium, mercury, hydrogen, oxygen etc.

A substance that is composed of combination of elements is called a *compound e.g.* water is a compound having symbol H_2O which means it is composed of two elements, namely, hydrogen (2 parts) and oxygen (1 part).

Why some materials behave as conductors, some insulators and some semi-conductors ?

In conductors *e.g.* silver, copper, aluminium etc. there are free electrons which move about haphazardly in all directions from atom to atom but when a certain electrical pressure or voltage is applied to such metals at the two ends, the electrons move only in one direction. The movement of electrons in a conductor in one direction is known as the *electric current*. The direction of motion of electrons is opposite to the direction of conventional current, *i.e.* electrons move from a point at lower potential to a point at higher potential whereas the electric current flows from a point at higher potential to a point at lower potential.

In insulators *e.g.* glass, mica, porcelain etc. The electrons are rigidly held to their atoms or are very closely bound to the nucleus and it is difficult to remove the electrons from the atoms. In insulators a very large potential difference is required to detach their electrons and even then the number of electrons detached and set drifting is comparatively small.

In semi-conductors like germanium, uranium, selenium etc., if a potential difference is applied across the ends of the material a partial flow of electrons takes place, *i.e.* some of them can be detached from the atom and some of them cannot be detached and hence the conduction is partial. Hence the properties of semi-conductors are in between those of conductors and insulators.

Define electric current and what is its unit of measurement.

The rate of flow of electrons or electricity is known as current.

It is measured in amperes.

i.e. Electric current = Rate of flow of electrons.

$$= \frac{\text{Quantity of electricity passed during a given time}}{\text{Time}}$$

or $$I = \frac{Q}{t} \text{ Amperes or coulombs/sec.}$$

What is the velocity of electric current ?

The velocity of electric current (flow of electrons) is equal to the velocity of light, *i.e.* 1,87,000 miles per sec.

What is the unit of quantity of electricity ?

Coulomb is the unit of quantity of electricity (Q) and is defined as the quantity of electricity passed in one second by a flow of current of one ampere. One coulomb is approximately equal to 628×10^{16} electrons. When the flow of electrons in a wire is at the rate of 628×10^{16} electrons per sec past any fixed point, a current of one ampere is said to have flown through that point.

Define the International Ampere.

It is defined as the current, which when passed through a solution of silver nitrate ($AgNo_3$) will deposit silver at the rate of 0.00111800 grams per second. It is slightly less than the practical unit of current, *i.e.* ampere.

1 International ampere = 0.999835 absolute ampere.

Define Potential Difference.

It is the force which causes the electric current to flow in a closed circuit. It is also called E.M.F. (Electromotive Force). It is measured in Volts.

The volt may be defined as the potential difference which when applied to the ends of a resistance of one ohm produces a current of one ampere.

The current strength depends upon the potential difference. No potential difference means no current.

Define resistance and its unit of measurement.

Resistance may be defined as that property of a substance which opposes the flow of an electric current through it. It is measured in ohms.

One ohm resistance is that resistance, when one ampere current is passed through it for one second, an energy equivalent to one joule is expended.

What is the difference between E.M.F. and P.D. ?

The E.M.F. is the pressure or voltage which causes an electric current to flow in a circuit.

The P.D. is the voltage measured between any two points of a circuit when the current is actually flowing through the circuit.

What is terminal voltage ?

It is the electric pressure between two conductors which is available at the terminal points where the load is required to be connected.

What are the factors on which resistance of a conductor depends ?

(*i*) *Length :* The longer the wire, greater is its resistance.

(*ii*) *Cross-sectional area :* Thicker is the wire, smaller is its resistance, *i.e.* resistance is inversally proportional to the cross-sectional area of the conductor.

(*iii*) *Material :* The resistance of a conductor depends upon its material *e.g.* silver in a better conductor than copper.

(*iv*) *Temperature :* Metals and their alloys increase in resistance with the rise in temperature upto 100ºC temperature. But the resistance of carbon, silicon, insulators and electrolytes decreases with the rise in temperature and so they have negative temperature coefficient of resistance.

From (*i*) and (*ii*), we have

$$R \propto \frac{1}{a}$$

or $$R = \rho\, l/a$$

where ρ (rho) is called the resistivity or specific resistance of the material and is a constant.

Define specific resistance or resistivity ?

Since $R = \rho\, l/a$

$\therefore$ $\rho = \dfrac{R.a}{l}$

If $a = 1\ \text{m}^2$ and $l = 1$ m

Then $\rho = R$

Therefore, specific resistance is the resistance of a material having unit length and unit cross-sectional area.

Or

Specific resistance is the resistance between the opposite faces of a unit cube.

Define Ohm's Law.

The ratio of potential difference applied across the ends of a conductor and the current flowing through it remains constant, provided physical conditions like temperature and pressure of the conductor remain the same.

i.e. $$\frac{V}{I} = \text{constant} = R$$

where R is known as the resistance of the conductor.

The three forms of Ohm's law are

$$I = V/R$$
$$V = IR$$
$$R = V/I$$

where V is measured in volts, I in amperes and R in ohms.

What is the difference between conductors and insulators ?

Conductors are those materials which offer least resistance to the flow of electric current *e.g.* silver, copper, aluminium etc.

Insulators are those materials which offer such a high resistance that they allow practically no current to flow through them *e.g.* wood, rubber, paper, mica, porcelain, bakelite, polyvinyl chloride (P.V.C.) etc.

Define conductance.

Conductance is the property of a material by virtue of which it allows the passage of current through it easily. It is reciprocal of resistance. Its unit is mho (Ω) and is represented by G.

$$G = \frac{1}{R} = \frac{1}{\frac{\rho l}{a}} = \frac{1}{\rho} \cdot \frac{a}{l}$$

$$= K.\frac{a}{l} \qquad \text{where} \qquad K = \frac{1}{\rho}$$

when k is known as conductivity or specific conductance.

Define the term conductivity.

Conductivity is defined as the conductance between the opposite faces of a unit cube and is the reciprocal of the resistivity or specific resistance.

The unit of measurement of conductivity is mho per metre.

Define temperature coefficient of resistance.

It is defined as the ratio of increase in resistance per degree centigrade rise in temperature to the original resistance. It is represented by letter α (alpha).

What is the shape of Resistance/Temperature graph ?

For pure metals and alloys the Resistance/Temperature graph is practically a straight line, within ordinary limits of temperature, say 0ºC to 100ºC.

What is the formula to find out the resistance of a material at *t*ºC when its resistance at 0ºC is known ?

The formula is

$$R_t = R_o\,(1 + \alpha_o\, t)$$

where R_t = resistance at tºC

R_o = resistance at 0ºC

α_o = temperature coefficient of resistance per ºC at 0ºC.

α_o may be defined as the ratio of increase in resistance for 1ºC rise in temperature to the resistance at 0ºC.

The value of α_o for copper is 0.00428 per ºC at 0ºC.

What is the formula to find out the resistance of a material at *T*ºC when its resistance at *t*°C is known?

The formula is $R_T = R_t \{1 + \alpha_o\,(T - t)\}$

where R_T = resistance at TºC

R_t = resistance at tºC

TºC = higher temperature

tºC = lower temperature

α_t = temperature coefficient of resistance per ºC at tºC.

What is the relation between α_o and a_t ?

The relation between α_o and α_t is as under

$$\alpha_t = \frac{\alpha_o}{1 + \alpha_o\, t}$$

What is the effect of temperature on resistivity ?

The resistivity or specific resistance of a metallic conductor increases with the rise in temperature. The relation between ρ_t and ρ_o within normal ranges of temperature is given by :

$$\rho_t = \rho_o\,(1 + \alpha_o\, t)$$

where ρ_t = resistivity at tºC

ρ_o = resistivity at 0ºC.

What is the effect of strain on resistance of metallic conductors ?

When a metallic conductor is strained, its resistance changes due to the change in length and cross-sectional area of the conductor. This effect is made use of in the manufacture of *strain gauges* which are used for the measurement of stresses.

What are the uses of low resistivity materials ?

Silver, copper, aluminium, steel etc. are some examples of low resistivity materials. Low resistivity materials are used in all such application where the power loss and voltage drop should be low *e.g.*

in house wiring, as conductor for power transmission and distribution, in the windings of motors, generators and transformers.

Copper and aluminium are the examples of commercially accepted low resistivity materials. Silver has lower resistivity than copper but due to high cost it is not used as a conductor material.

What properties a low resistivity material should possess?

A low resistivity material should possess the following properties in addition to possessing a low value of resistivity :

(*i*) *Low resistance temperature coefficient :* This means that the change of resistance with change in temperature should be low. This is necessary to avoid variation in voltage drop and power loss, in the transmission lines and windings of electrical machines with changes in temperature.

(*ii*) *Sufficient mechanical strength.* To withstand mechanical stresses in over-head line conductors, used for transmission and distribution of electric power, produced due to wind and their own weight and mechanical stresses produced in conducting materials used for the windings of motors, generators and transformers when they are loaded, the conducting material should possess sufficient mechanical strength.

(*iii*) *Ductility :* Different sizes and shapes of conductors are required for different applications. To fulfil this requirement the conducting material should be ductile enough to enable it to be drawn into different sizes and shapes.

(*iv*) *Solderability :* Conductors are required to be joined very often. The joint should offer minimum contact resistance. The solderability is also considered as a required property while selecting the conducting material.

(*v*) *Resistance to corrosion :* Conducting material should be such that it is not corroded or rusted when used without insulation in outdoor atmosphere.

What are the high resistivity materials ?

High resistivity materials are generally alloys of different materials *e.g.* Nichrome, Tungsten Manganin, Constantan, Platinum etc. Such materials are used in such applications where a large value of resistance is required *e.g.* elements of heating devices, starters of electric motors, filaments of incandescent lamps, loading resistances, rheostats and resistances for measuring instruments.

What is the drawback if a low resistivity material is used for making the elements of heating devices ?

The length of the wire would be too large which would increase, to a large extent, the overall size of the equipment.

What properties a high resistivity material should possess ?

A high resistivity material, in addition to possessing a high value of resistivity, should also possess the following additional properties :

(*i*) Low resistance temperature coefficient.
(*ii*) High melting point.
(*iii*) No tendency for oxidation.
(*iv*) Ductility.
(*v*) High mechanical strength.

What is the composition, maximum working temperature and field of applications of Constantan, Manganin, Nichrome, Platinum and Tungsten ?

Alloy	*Composition*	*Max. Working Temperature*	*Field of Application*
Constantan or Eureka	60% copper, 40% nickel,	400–450°C	Resistance elements for loading rheostats, starters for electric motors, resistance boxes and thermocouples.
Manganin	86%, copper 12% manganese 2% nickel	upto 60°C	Resistance boxes, standard resistances and shunts.
Nichrome	75% nickel,, 25% chromium	upto 1000°C	Heating elements, of heater, electric iron, furnaces.
Platinum	Greyish white metal	upto 800°C	Heating elements in ovens, furnaces, thermocouples, as contact material.
Tungsten	Silver white hard metal	upto 2000°C	Filament lamps, valve electrodes.

What is the significance of stranded conductors ?

A conductor of large cross-section becomes rigid in construction and is liable to kink and breaks while handling. To avoid such happenings, conductors are made of a number of thin wires bunched together called strands. Stranded conductors are flexible and can be coiled very easily. The stranded conductor has no tendency to break through the insulation.

Generally, stranding is done in opposite direction for successive layers, *i.e.* if wires of one layer are twisted in left-hand direction, the next layer of wire will be twisted in the right hand direction and so on. The conductors usually have a central wire or strand around which successive layers of strands are wound. The centre wire is not counted as a layer.

What does a conductor size 7/2.24 signify ?

It signifies that there are seven wires in the stranded conductor and the diameter of each wire is 2.24 millimetres.

What is meant by superconductivity ?

A state of material in which it has zero resistivity is called superconductivity *e.g.* mercury becomes superconducting at approximately 4.5°K (–268.5°C) and lead at 7.22°K. The temperature at which there is transition from *normal state to super conducting* state is called transition temperature, T_c.

What are the applications of superconducting materials?

(*i*) *Power Cable.* A 220 kV cable with super-conducting material will enable transmission of power over very long distances using a diameter of a few centimetres without any significant power loss or drop in voltage.

(*ii*) *Electrical Machines.* By using super-conducting materials it is possible to manufacture electrical generators and transformers in exceptionally small size having an efficiency of 99.99%.

(*iii*) *Electromagnet.* Super-conducting solenoids have been made which do not produce any heat during operation. However, superconductivity can be destroyed if the magnetic field exceeds a critical value.

What is the significance of A.C.S.R. Conductor ?

A.C.S.R. conductor means aluminium conductor, steel reinforced. It is cheaper than copper conductor. It possesses good mechanical strength and high tensile strength in addition to good conductivity. Galvanised steel wires are used as cores to take the mechanical stress and to increase the tensile strength, the aluminium conductors in the form of strands are twisted over the steel wire. Load is carried by steel wire and current is transmitted by aluminium. The ratio of cross-section of the two metals is between 1 : 6 to 1 : 4. These conductors are used for long distance high voltage overhead power transmission lines.

What are the important applications of elasticity ?

A few important applications of electricity are as under :

(*i*) *Lighting.* For lighting purposes in houses, industries, workshops, offices, institutions and street lighting in which electrical energy is converted into light by utilising the illuminating effect of electricity.

(*ii*) *Heating.* For domestic heating purposes electricity is used in the form of room-heaters, heaters, hot plates, ovens, geysers, electric iron etc. In industry, electricity is used for heating ovens, furnaces, boilers etc. In most of the electric heating appliances, electrical energy is converted into heat by passing electric current through a wire of high resistance.

(*iii*) *Electric Motors.* Electricity is used for running motors of domestic appliances *e.g.* ceiling fans, table fans, air cooler, washing machine, refrigerator, hair drier, mixer etc. In industrial applications electricity is used for running the electric motors of cranes, lifts, concrete mixer, tube-wells, lathe machines etc.

(*iv*) *Electroplating.* Electricity is used for the process of electroplating, *i.e.* coating a layer of superior metal over the surface of inferior metal *e.g.* tin plating of utensils, nickel plating of vehicles, and watch cases etc.

(*v*) *Welding.* Electricity is used for welding of metals through welding transformers and welding generators.

(*vi*) *Electronics.* Electricity is used for electronic equipments *e.g.* T.V. sets, radio sets, transistor sets, oscilloscopes, computers, amplifiers etc.

(*vii*) *Miscellaneous applications of electricity :*

(*a*) Battery charging
(*b*) Telephones
(*c*) Electric traction
(*d*) Tape records, record players etc.
(*e*) Theatres
(*f*) Sound system
(*g*) For operating relays.

What are the various types of energies ?

The various types of energies are :

(*a*) Mechanical energy
(*b*) Heat energy
(*c*) Light energy
(*d*) Chemical energy
(*e*) Sound energy
(*f*) Electrical energy.

What are the advantages of electrical energy over other types of energy ?

Electrical energy has virtually established in superiority over other forms of energy due to the following reasons :

(*a*) *Convenient form.* It can be easily converted into other forms of energy *i.e.* light, heat, sound etc.

(*b*) It is cleaner
(*c*) It is cheaper
(*d*) More efficient
(*e*) No fumes or poisonous gases
(*f*) Easy in handling, *i.e.* more easily controllable.

What are the various effects of electricity ?

When electric current passes through a circuit, it may produce any one or more of the following effects :

(*a*) Thermal or heating effect.
(*b*) Luminous or lighting effect
(*c*) Magnetic effect.
(*d*) Chemical effect.

What is meant by communication and how it is done ?

Communication means the method of talk between two persons who are away from each other. The two persons may be in the same city or they may be in different towns or countries. Communication is done by wireless system or by telephone lines.

In case of aeroplanes communications is done by wireless system by which the aeroplane keeps itself in contact with ground during its flight period to intimate the condition of flight and difficulties, if any, to the ground. The pilot is to observe the instructions given to him from ground for all operations of flight, *i.e.* while taking-off, during flight period and while landing.

What is an electric circuit ?

Electric circuit is a complete path for the flow of electric current and the circuit is completed with the help of electric wires.

What are different types of electric circuits ?

There are three types of electric circuits?

(*a*) Open circuit, *i.e.* when there is a break in the closed circuit.

(*b*) Closed circuit, *i.e.* when there is no break in the circuit and current flows in the circuit through some resistance.

(*c*) Short circuit, *i.e.* when the two wires of supply (+ve and –ve or phase and neutral) come in contact with each other without any resistance in the circuit.

What is a D.C. series circuit ?

A D.C. series circuit is that in which the resistances are connected end to end, so that they form only one path for the flow of electric current. In a series circuit the current through all the resistances, connected in series, remains the same but the voltage across each resistance is different.

What is the law of resistances in series ?

When a number of resistances are connected in series, their total or equivalent resistance is given by the arithmetic sum of the individual resistances.

i.e. $$R = R_1 + R_2 + R_3$$

where R_1, R_2 and R_3 are the individual resistances in series and R in their total resistance.

What is a D.C. parallel circuit ?

A D.C. parallel circuit is that in which a number of resistances are connected in such a way that the starting ends of all the resistances are joined together and finishing ends of all the resistances are joined together. In a parallel circuit the voltage across each resistance is the same but the currents through them differ from each other.

What is the law of resistances in parallel ?

When a number of resistances are connected in parallel, the reciprocal of the total or equivalent resistance is given by the arithmetic sum of the reciprocals of their individual resistances.

i.e. $$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

where R_1, R_2, R_3 are the individual resistances in parallel and R is their total or equivalent resistance.

When there are only two resistances connected in parallel then the total resistance R is given by the formula :

$$R = \frac{\text{Their product}}{\text{Their sum}} \left[\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} \text{ or } R = \frac{R_1 R_2}{R_1 + R_2}\right]$$

How the current is distributed in parallel circuits ?

When a number of resistances are connected in parallel, the current divides itself in the reverse ratio of resistances.

If two resistances R_1 and R_2 are connected in parallel across a supply and I_1 and I_2 are the respective currents in them, then

$$I_1 : I_2 = \frac{1}{R_1} : \frac{1}{R_2}$$

What is the theory of shunt ?

A shunt is essentially a low resistance of predetermined value which is connected in parallel with the ammeter to extend its range. A 0—1 ampere ammeter may be made to read currents upto 5 A, 10A etc. by connected shunts of proper value and proper scale calibration. The shunt may be connected internally or externally.

What is potential divider ?

A high resistance connected across supply mains to get a variable voltage from a constant voltage supply is called a potential divider.

What is a voltage multiplier ?

Voltage multipliers are high non-inductive resistances (made essentially from material having low temperature coefficient of resistance) which are connected in series with the voltmeter so that it may be able to measure voltages of higher ranges.

Define Kirchhoff's Laws ?

There are two laws which are the extension of Ohm's Law. Complicated circuits which cannot be solved by applying Ohm's law can be solved by applying Kirchhoff's Laws.

Kirchhoff's First Law. In any network of wires carrying current, the sum of the incoming currents towards any point is equal to the sum of the outgoing currents going away from that point.

Or

The algebraic sum of all the currents meeting at a point is zero.

Kirchhoff's Second Law. In any closed circuit or mesh the algebraic sum of the *IR* products is equal to the resultant E.M.F. of the circuit.

What are the rules to follow while solving networks by applying Kirchhoff's Laws ?

The following three rules are to be followed :

(*i*) The battery e.m.f. which causes current to flow in clockwise direction in a closed circuit should be taken as positive e.m.f. and the battery e.m.f. which causes current to flow in anti-clockwise direction in a closed circuit should be taken as negative e.m.f.

(*ii*) The resistive drops (*IR* drops) in a mesh are taken as positive which are due to the flow of current in the clockwise direction.

(*iii*) The resistive drops in a mesh are considered as negative which are due to the flow of current in anticlockwise direction.

What are different types of electric conductors ?

(*i*) Electronic or metallic conductors such as silver, copper, aluminium, carbon, graphite etc. When current is passed through these conductors, there is no chemical and physical change except rise in temperature.

(*ii*) Electrolyte or Ionic Conductors such as HCl, H_2SO_4, KOH, $AgNO_3$ and conduction in such conductors is accompanied by chemical reaction.

What is the effect of temperature on the insulation resistance of the insulating materials ?

It decreases rapidly with the increase in temperature.

What is the effect of strain on resistance of metallic conductors ?

There is change in resistance due to change in length and cross-sectional area of the conductor.

Fill in the blanks with appropriate words

1. All matter is essentially .... in nature.

2. Matter is anything that .... space and has ....

3. Matter is made of extremely small particals called ....

4. .... is the smallest partical of an element.

5. The nucleus is formed of sub-atomic particles called .... and ....

6. Neutron is as heavy as ....

7. Electrons are .... charged.

8. The rate of flow of electrons is called ....

9. .... is the unit for measurement of quantity of electricity.

10. One coulomb is approximately equal to .... electrons.

11. The potential of earth is referred to as ....

12. The resistance between the opposite faces of a unit cube of a material is called ....

13. Conductance or specific conductance is the reciprocal of ....

14. The unit of conductance is ....

15. Silver is used for contact surfaces of switchgear because it requires low .... surface

16. Copper can be easily and efficiently jointed by soldering and ....

17. Hard copper is .... ductile.

18. The resistivity of aluminium is .... times of that of copper.

19. Paper is made from .... or plant fibre.

20. Mica is fire proof, does not absorb water and its electric strength is ....

21. Porcelain is .... to heat

22. Temperature coefficient of carbon is ....

23. Insulation resistance of the insulators dercreases rapidly with the .... in temperature.

24. Tungsten is a .... hard metal.

25. The melting point of tungsten is .... which is the highest of all the metals.

26. Nichrome is widely used as ....

27. Stranded conductors are .... and can be .... very easily.

28. Stranding is done in .... direction for successive layers.

29. A conductor which has .... resistivity is called super-conductor.

30. A.C.S.R. conductor is .... than copper conductor.

31. For long distance high voltage overhead power transmission lines .... conductors are used.

32. The main .... of V.I.R. is that it attacks copper.

33. Ebonite is vulcanised rubber containing about .... of sulphur.

34. When a metallic conductor is strained, then there is change in its .... due to change in the length and cross-sectional area of the conductor.

ANSWER KEY
(Ohm's Law — Current, Voltage and Resistance)

1. Electrical	2. Occupies; weight	3. Molecules.
4. Atom.	5. Protons; neutrons	6. Proton
7. Negatively	8. Electric current	9. Coulomb
10. 6.28×10^{16}	11. Zero potential	12. Resistivity
13. Resistivity	14. Mho per metre	15. Contact
16. Welding	17. Less	18. 1.7
19. Wood pulp; plant fibre	20. Very high	21. Highly resistant
22. Negative	23. Increase	24. Silver white
25. 3300°C	26. Heating element	27. Flexible, coiled
28. Opposite	29. Zero	30. Cheaper
31. A.C.S.R.	32. Drawback	33. 20 percent
34. Resistance.		