Electricity

Question 1:

Select the proper choice from the given multiple choices :

Question 1.1:

The SI unit of electric charge is .

Solution :

D. coulomb

Question 1.2:

What number of electrons will be there in 1.6 C charge ?

Solution :

C. 10^{19}

Charge (Q) = No. of electrons (n) x charge of one electron (e)

$$\Rightarrow n = \frac{Q}{e}$$

$$\Rightarrow n = \frac{1.6}{1.6 \times 10^{-19}} = 10^{19}$$

Question 1.3:

1μA = ———— mA

Solution :

B. 10^{-3}

$1\mu A = 10^{-6}\,A = (10^{-3})(10^{-3})A = 10^{-3}\,mA$

Question 1.4:

Which of the following materials has more number of free electrons ?

Solution :

A. Copper

Metallic materials like copper, silver and aluminium have plenty of free electrons.

Question 1.5:

According to Ohm's law,

Solution :

D. The resistance and current both increase with the increase in voltage.

From Ohm's law:

V = IR

From this relation it is clear that, physical conditions remaining constant, resistance and current are directly proportional to the voltage. Hence, resistance and current both increase with the increase in voltage.

Question 1.6:

The formula for an electric current is———- .

Solution :

B. I = Q/t

The net quantity of an electric charge flowing through any cross-section of conductor is defined as electric current.

Thus, electric current = $\frac{\text{Quantity of electric charge}}{\text{time}}$

Question 1.7:

The amount of 2 A electric current is passed for 1 minute through one conducting wire. How much total electric charge will pass through this wire ?

Solution :

D. 120 C

$$\text{Current (I)} = \frac{\text{Quantity of electric charge (Q)}}{\text{time(t)}}$$

$$\Rightarrow 2 = \frac{Q}{60}$$

$$\Rightarrow Q = 120 \text{ C}$$

Question 1.8:

In an electrical appliance, the electric current of 4.8 A is passed, then the number of electrons passing through it in one second will be————-

Solution :

C. 3×10^{19}

$$\text{Current (I)} = \frac{\text{Quantity of electric charge (Q)}}{\text{time(t)}} = \frac{ne}{t}$$

$$\Rightarrow 4.8 = \frac{n\left(1.6 \times 10^{-19}\right)}{1}$$

$$\Rightarrow n = \frac{4.8}{1.6 \times 10^{-19}} = 3 \times 10^{19}$$

Question 1.9:

Which of the following formula represents the voltage ?

Solution :

A. $\frac{\text{Work}}{\text{Current x time}}$

$$\text{Voltage} = \frac{\text{Work done}}{\text{Electric charge}} = \frac{\text{work done}}{\text{Current x time}}$$

Question 1.10:

The unit of electric potential difference is———-

Solution :

B. J/C
SI unit of potential difference is volt.
If the work done to bring 1 C charge from one point to other is 1J, then the potential difference between these two points is called 1 volt.
1 volt = 1 joule / 1 coulomb

Question 1.11:

If the work is to be done to take 3 C electric charge from one point to another point is 15 J, what will be the potential difference between these two points ?

Solution :

C. 5V

$$\text{Potential difference} = \frac{\text{Work done}}{\text{Electric charge}}$$

$$\Rightarrow \text{P.d.} = \frac{15}{3} = 5\ \text{V}$$

Question 1.12:

The resistance of one conducting wire is 10 Ω. How much electric current will flow by connecting it with a battery of 1.5 V ?

Solution :

B. 1 Ω

Equivalent resistance of 5 conductors having same resistance of 5Ω and connected in parallel

$$= \left(\frac{\text{Resistance of each resistor}}{\text{No. of resistors}}\right) = \frac{5}{5} = 1\ \Omega$$

Question 1.13

On which factors does the resistivity of conducting wire depend ?

Solution :

D. Material of wire

Question 1.14:

If the five equal pieces of a resistance wire having 5 Ω resistance each is connected in parallel, then their equivalent resistance will be————

Solution :

D. 150 mA

From Ohm's law,

$V = IR$

$\Rightarrow I = \frac{V}{R} = \frac{1.5}{10} = 0.15\ A = 150\ mA$

Question 1.15:

The unit of resistivity of the material is———— .

Solution :

B. Ωm

$$\text{Unit of Resistivity} = \frac{\text{Unit of resistance} \times \text{unit of area}}{\text{Unit of length}}$$

$$= \frac{\Omega \times m^2}{m} = \Omega m$$

Question 1.16:

What will be the equivalent resistance between points A and B of the following electric circuit ?

Solution :

D. 10 Ω

Between points A and B, five 2 Ω resistors are connected in series.

$\therefore\ R_s = (2 + 2 + 2 + 2 + 2)\ \Omega$

or, $R_s = 10\ \Omega$

Question 1.17:

What will be the equivalent resistance between points A and B of the following electric circuit ?

Solution :

A. 4 Ω

Between points A and B, a series combination of two 4 Ω resistors is connected in parallel with one 8 Ω resistor.

$\therefore$ Equivalent resistance $R_{AB} = \left[\frac{1}{(4+4)} + \frac{1}{8}\right]^{-1} \Omega$

or, $R_{AB} = \left(\frac{2}{8}\right)^{-1} \Omega = 4\,\Omega$

Question 1.18:

The equivalent resistance between points A and B in the following electric circuit is ———-.

Solution :

C. 12.5 Ω

Between points A and B, a parallel combination of two 5 Ω resistors is connected in series with two 5Ω resistor.

$\therefore$ Equivalent resistance $R_{AB} = \left[\frac{1}{5} + \frac{1}{5}\right]^{-1} + 5 + 5$

or, $R_{AB} = 12.5\,\Omega$

Question 1.19:

Which physical quantity has a unit of kWh ?

Solution :

B. Electric power

The unit of electric power or electrical energy consumed in our houses is kWh.

Question 1.20:

lk Wh =————— joule

Solution :

A. 3.6×10^6 joule

1 kWh = 1000 watt × 3600 s

Or, 1 kWh = 3.6×10^6 joule

Question 1.21:

An electric heater consumes 1.1 kW power when 220 Y voltage applied to it. How much current will be flowing through it ?

Solution :

D. 5 A

We know that,

$P = VI$

$\Rightarrow I = \frac{P}{V} = \frac{1.1 \times 1000 \text{ watt}}{220 \text{ volt}}$

$\Rightarrow I = 5 A$

Question 1.22:

What makes the electric current flow through electric solution ?

Solution :

D. Positive and negative ions
Electric current flows through electric solution by means of positive and negative ions.

Question 1.23:

The distilled water acts as——— for the electricity.

Solution :

B. Insulator
Distilled water does not conduct electricity and hence it is an insulator.

Question 2:

Answer the following questions in brief.

Question 2.1:

What is an electric charge ? Give its types and write its unit.

Solution :

An electric charge is an intrinsic property of electron and proton like mass.

Types of electric charges:
i. Positive electric charge
ii. negative electric charge
Its SI unit is coulomb (C).

Question 2.2:

What is a free electron ? Explain conducting and non-conducting materials in terms of it.

Solution :

During the formation of metallic materials, the electrons that are loosely bound to the nucleus are separated from their parent atoms and move in random manner. These are known as free electrons.
Materials which have plenty of free electrons are capable of conducting electricity and are

called conducting materials. **Example:** Metals like copper, silver etc.
Materials which do not have free electrons are not capable of conducting electricity are called non-conducting materials. **Example:** Rubber, glass, plastic etc.

Question 2.3:

Give the definition of an electric current and define its unit.

Solution :

The net quantity of an electric charge flowing through any cross-section of conductor is defined as electric current.
Its SI unit is ‘ampere’.
One ampere of current is said to flow through a conductor when one coulomb of electric charge passes through the conductor in one second.

Question 2.4:

Give advantages and disadvantages of series and parellel connection of resistors.

Solution :

Advantages and disadvantages of series connection of resistors:

1. To control the current in a circuit, series connection is useful. On connecting the resistors in series the total circuit resistance increases and thus the current decreases.
2. Damage of electrical appliance and short circuit can be prevented by connecting the fuse in series with the mains as well as the electrical appliance.
3. Series circuits have a single path that connects the electric source to the output devices. These circuits have limited uses because if a fault occurs in one appliance or the circuit breaks, the current does not flow in the circuit and all the other components in the circuit stop working.
4. If the electrical appliances are connected in series, the applied voltage is divided and the appliance cannot give the light efficiently because of less voltage.

Advantages and disadvantages of parallel connection of resistors:

1. Parallel circuits provide the same voltage to every source and appliance in the circuit, thus all appliances work efficiently.
2. In a parallel circuit if one appliance is fused, the current continues to flow through the others. Hence other appliances continue to work.
3. The equivalent resistance in the parallel connection of resistors decreases thus, more current than one source can produce is obtained. Unless all appliances in parallel have the same voltage, current would flow from one source into the other. This will result in loss of power.
4. Even if we have several power sources, the voltage across a parallel circuit will remain the same. This is because the potential difference, which is the source of voltage, is split across the circuit as a whole; so increasing the power will not alter the voltage.

Question 2.5:

Write Faraday’s laws of electrolysis.

Solution :

Faraday's law of electrolysis:

First law: The mass (m) of the substance (metal) deposited at cathode on passing the electric current through electrolytic solution is proportional to charge passing through it (Q).

$m \propto Q$

Second law: For a given amount of current passed, the mass of different elements deposited on cathode is proportional to their chemical equivalent (e). Chemical equivalent of any atom is the ratio of atomic mass and its valency. $\left(\frac{m_1}{m_2} = \frac{e_1}{e_2}\right)$

Question 3:

Write the answers of following questions :

Question 3.1:

What is an electric potential ? Give the definition and unit of electric potential.

Solution :

Electric potential is the work done on a charge to keep it in equilibrium. It is defined as:

The work required to bring the unit positive charge from infinity to any point against the electric force is known as electric potential at that point.

$$\text{Electric potential (V)} = \frac{\text{Work done (W)}}{\text{Electric charge (Q)}}$$

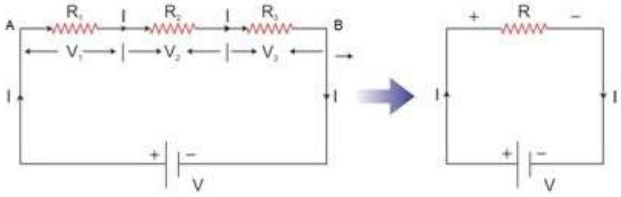
Its SI unit is joule/coulomb or volt (V).

Question 3.2:

Explain the series connection of resistors and derive the formula of equivalent resistance.

Solution :

The resistors are connected across two points in the circuit in such a way that the current flowing through each resistor is the same and only one path is available for it to flow, then the resistors are said be connected in series.



In the figure above, three resistors R_1, R_2 and R_3 are connected in series across the points A and B. Hence, the current (I) flowing through each of the resistors is same but the total voltage of the battery is divided.

If the voltage drops across V_1, V_2 and V_3 are R_1, R_2 and R_3 respectively then,

$V = V_1 + V_2 + V_3$ ……(i)

Now, if the resistor R instead of these three resistances R_1, R_2 and R_3 is connected in such a way that the current flowing through the circuit remains the same, then R is called equivalent resistance of the circuit.

For an equivalent resistor, V = IR……..(ii)

According to Ohm's law,

R_1 voltage drops across, $V_1 = I R_1$ ……..(iii)

R_2 voltage drops across, $V_2 = I R_2$ ……..(iv)

R_3 voltage drops across, $V_3 = I R_3$ ……..(v)

Adding (iii), (iv) and (v):

$V_1 + V_2 + V_3 = I R_1 + I R_2 + I R_3$ ……(vi)

Or, $V = IR = I (R_1 + R_2 + R_3)$

Or, $R = R_1 + R_2 + R_3$

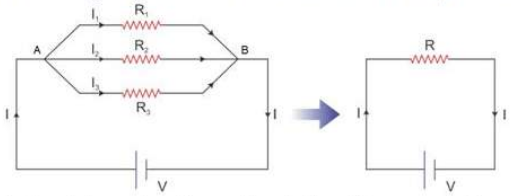
Thus, in series connection the equivalent resistor R is equal to the sum of all the resistors connected in series.

Question 3.3:

Explain the parallel connection of resistance and derive the formula of equivalent resistance.

Solution :

When more than one resistances are connected across two points in the circuit such that more than one path are available for the current to flow and the voltage drops across two ends of each resistor are same, then the resistors are said to be connected in parallel between these two points.



As shown in figure above, three resistors R_1, R_2 and R_3 are connected in parallel across the points A and B such that one end of each resistor is connected at point A and the other end at point B.

The current (I) is divided into three parts at point A. Let I_1, I_2 and I_3 be the current flowing through R_1, R_2 and R_3 respectively, then total electric current in the circuit is,

$I = I_1 + I_2 + I_3$.....(i)

In parallel connection of resistors, the voltage drop across every resistor is equal to battery voltage V.

$\therefore$ according to Ohm's law, we have

$$I_1 = \frac{V}{R_1},\ I_2 = \frac{V}{R_2},\ I_3 = \frac{V}{R_3}$$

From (i)

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

Now, if one such resistor R instead of three resistors is connected across the batter, the current flowing through the circuit will be same as I.

$$I = \frac{V}{R}$$

$$\therefore \frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$\therefore \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Here, R is the equivalent resistance of parallel connection of three resistors.

Question 3.4:

Explain electrical energy and derive its formula.

Solution :

The energy consumed by an electric circuit to flow current through it is referred as electrical energy. This energy is provided by the battery to every electric charge. The work required to keep the charge Q in motion by the battery of voltage V is

$W = VQ$

From the definition of electric current,

$Q = It$

Therefore, $W = VIt$

According to Ohm's law, $V = I R$

Therefore, $W = (IR) I t$

Or, $W = I^2Rt$

Thus, the current flowing through the resistor R for time t is I, the electrical energy consumed to is W which is converted into heat energy.

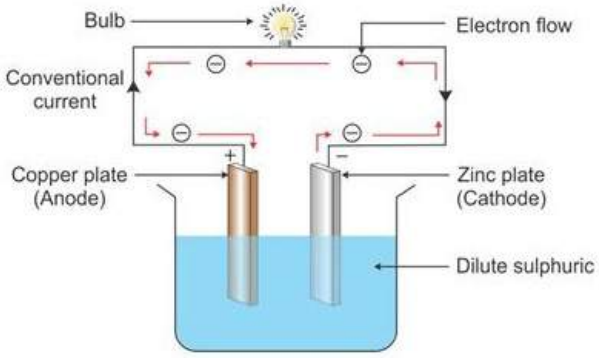
Question 4:

Answer the following questions in detail :

Question 4.1:

Draw the figure of voltaic cell and explain its construction. Explain flow of current in conductor through this cell.

Solution :



Construction: Take a solution of dilute sulphuric acid in a beaker. Dip one copper plate and another zinc plate in the solution in such a way that they do not touch each other. These plates get electrically charged due to a reaction between these two plates and the solution. The copper plate gets positively charged and is called anode. The zinc plate gets negatively charged and is called cathode. This is how voltaic cell is constructed.

Conduction:

When a small bulb is connected between the poles of this battery, it lights up because the electrons leaving the negative terminal of the battery move towards the positive terminal by forming an electric current through the bulb. So, in the bulb the electrons flow from the negative to the positive pole, but the direction of conventional current is opposite to the flow of the electrons. Hence, in a cell, the current flows from the positive towards the negative. A cell continues to provide current until its electrolyte (solution) is exhausted.

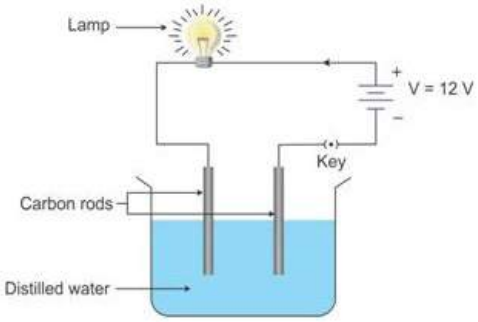
Question 4.2:

What is electrolyte ? Describe the experiment showing flow of current in electrolyte.

Solution :

The solutions that conduct electricity are called ‘electrolytes’. In electrolytes, the current flows due to positive and negative ions.

Experiment to show the flow of current in electrolyte:



Take two carbon rods and dip them in a beaker filled with tap water as shown in the figure above. Connect them with a bulb through an external circuit. We see that, once the circuit is complete the bulb glows. This indicates that tap water conducts electricity or is an electrolyte. If we replace tap water with distilled water, the bulb does not glow which indicates that distilled water is not an electrolyte. Thus, current passes through electrolytes.

Question 5:

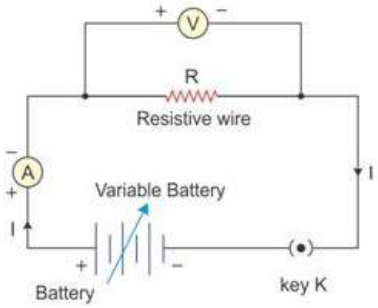
Answer the following questions pointwise :

Question 5.1:

Write Ohm's law. Describe the experiment showing Ohm's law and write its conclusions.

Solution :

Ohm's law: In the definite physical situation the electric current flowing through the conductor is directly proportional to the potential difference applied across it.
Experiment to prove Ohm's law:



For Ohm's law, we make a circuit as shown above. The nichrome wire (conductor) is connected in series with a battery and an ammeter through a key. A voltmeter is connected in parallel between its two ends.
When the key is ON, current flows through the wire, which is measured by the ammeter. In addition, the potential difference developed across the ends of the nichrome wire is measured by the voltmeter. The readings are noted in the table given below.
Next, connect two batteries instead of one and again the magnitudes of current and voltage are noted.
Similarly the experiment is performed with three batteries and so on.
Observation table:

Number	No. of batteries	Voltage across two ends of wire (V)	Current flowing through the wire (I)	V/I
1	1			

2	2			
3	3			
4	4			

From the observation, a graph of I vs V is drawn which is a straight line passing through the origin.
Conclusions:

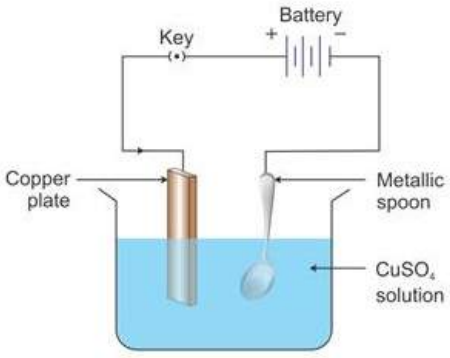
1. The electric current in the conductor increases proportionally with the increase in voltage.
2. I-V graph is a straight line.
3. The ratio of V and I remains constant every time.

Question 5.2:

What is electroplating ? Explain it with example.

Solution :

Electroplating is the process of depositing a layer of a metal on a metallic or non-metallic electrode by electrolysis in an electrolytic cell.



Let us take an iron spoon which is to be electro-plated with copper.
For this, we take copper plate and iron spoon as electrodes and copper sulphate ($CuSO_4$) is taken as an electrolyte. The electrodes are connected through an external circuit as shown in the figure.
On passing current through the electrolyte, it is decomposed into Cu^{+2} and $(SO4)^{-2}$ ions. As Cu^{+2} ion is positively charged, it moves towards the negative terminal, i.e. iron spoon, and is deposited on it. Thus, iron spoon is plated with copper. There is no scarcity of Cu atoms because the copper atoms go into the solution from the positive terminal, i.e. copper plate. This process called electroplating continues until the iron spoon is coated with copper.

Question 6:

Solve the following examples :

Question 6.1:

If 400 mA current flows through the bulb for 1 minute, how many electrons will pass through it ?

Solution :

Let 'n' be the number of electrons flowing when a current I = 400 mA = 0.4 A is passed for 1min (=60s).

We know that,

$Q = ne = It$

$\Rightarrow n = \frac{It}{e}$

$\Rightarrow n = \frac{0.4 \times 60}{1.6 \times 10^{-19}}$

$\Rightarrow n = 15 \times 10^{19}$ electrons

Question 6.2:

The 1800 C electric charge is passing through an electic bulb in one hour. How much current will pass through an electric bulb ?

Solution :

Let 'I' be the current flowing through the bulb.

Given, charge (Q) = 1800 C

Time (t) = 1hr = 3600 s

We know that,

$Q = It$

$\Rightarrow I = \frac{Q}{t}$

$\Rightarrow I = \frac{1800}{3600}$

$\Rightarrow n = 0.5A$

Question 6.3:

The three resistors of resistance 5 Ω, 10 Ω and 30 Ω are connected with a 12 V battery in parallel. Determine (a) total current in the circuit (b) equivalent circuit resistance.

Solution :

Total resistance in parallel $R' = \left(\frac{1}{5} + \frac{1}{10} + \frac{1}{30}\right)^{-1}$

or, $R' = 3\,\Omega$.....(i)

(a) Total current $(I) = \frac{\text{Voltage}}{\text{Total Resistance}} = \frac{12}{3}$

$\Rightarrow I = 4\,A$

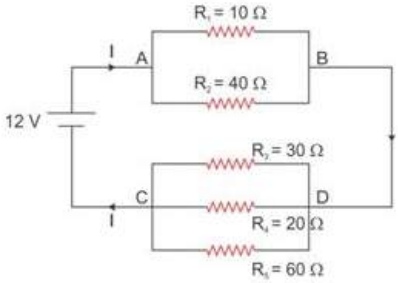
(b) From (i),

equivalent circuit resistance = 3Ω

Question 6.4:

As shown in the figure the resitance are connected with a 12 V battery. Determine (a) Equivalent curcuit resistance (b) Current flowing through the circuit.

Solution :



(a) Equivalent resistance between points A and B, $R_{AB} = \left(\frac{1}{10} + \frac{1}{40}\right)^{-1}$

or, $R_{AB} = 8\ \Omega$.....(i)

Equivalent resistance between points C and D, $R_{CD} = \left(\frac{1}{20} + \frac{1}{30} + \frac{1}{60}\right)^{-1}$

or, $R_{CD} = 10\ \Omega$

Now, resistances R_{AB} and R_{CD} are connected in series.

∴ Equivalent circuit resistance = 8 + 10 = 18 Ω

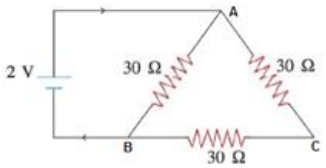
(b) Total current (I) = $\frac{\text{Voltage}}{\text{Total Resistance}} = \frac{12}{18}$

⇒ I = 0.66 A

Question 6.5:

Find the electric current in the following circuit:

Solution :



(a) Equivalent resistance between points A and B, through C is

$R_{ACB} = 30 + 30 = 60\ \Omega$

Equivalent resistance between points A and B is $R_{AB} = \left(\frac{1}{30} + \frac{1}{60}\right)^{-1}$

or, $R_{AB} = 20\ \Omega$

∴ Equivalent circuit resistance = 20 Ω

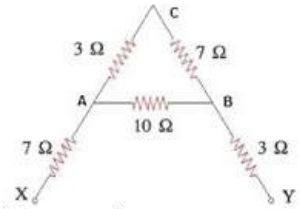
(b) Total current (I) = $\frac{\text{Voltage}}{\text{Total Resistance}} = \frac{2}{20}$

⇒ I = 0.1 A

Question 6.6:

Determine the equivalent resistance between points X and Y in the following circuit.

Solution :



(a) Equivalent resistance between points A and B, through C,

$R_{ACB} = 7 + 3 = 10\Omega$

Equivalent resistance between points A and B, $R_{AB} = \left(\frac{1}{10} + \frac{1}{10}\right)^{-1}$

or, $R_{AB} = 5\,\Omega$

Equivalent circuit resistance between X and Y = $(7 + 5 + 3)\,\Omega = 15\Omega$

Question 6.7:

Two Lamps of 100 W and 60 W are joined in parallel with 220 V line. How much current will flow through the circuit ?

Solution :

Total power (P) of two lamps in parallel = (100 + 60) W = 160 W

Given voltage (V) = 220 V

$\therefore$ Current $(I) = \frac{P}{V}$

$\Rightarrow I = \frac{160}{220} = 0.73A$

Question 6.8:

An electric heater consumes 4.4 kW power when connected with a 220 V line voltage then,

- Calculate the current passing through the heater.
- Calculate resistance of a heater.
- Calculate the energy consumed in 2 hours.

Solution :

Given, voltage (V) = 220 V

Power (P) = 4.4 kW = 4.4 x 1000 W

(i) $\therefore$ Current $(I) = \frac{P}{V}$

$\Rightarrow I = \frac{4.4 \times 1000}{220} = 20\ A$

(ii) Resistance $(R) = \frac{V}{I}$

$\Rightarrow R = \frac{220}{20} = 11\ \Omega$

(iii) Energy consumed in 2 hr = I^2Rt

$\Rightarrow E = (20)^2(11)(2 \times 3600) = 3.168 \times 10^7\ J$