

# Electric Energy, Power & Household Circuits

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## Exercise – 1

### Question 1.

(a) What do you understand by the term electric work ?

**Answer:**

**Electric work :** “Electric work is said to be done when an electric charge flows through a conductor, at some potential difference.”

$$\therefore v = \frac{W}{Q}$$

$$\therefore W = vQ$$

(b) State and define SI unit of electric work.

**Answer:**

S.I. unit of electric work  $\rightarrow$  Joule (J)

1J = 1 volt  $\times$  1 coulomb

**1 Joule :** “Is the amount of work done when a charge of one coulomb flows through a conductor at a pot. diff. of 1 volt.”

(c) Name two bigger units of electric work. How are they related to SI unit ?

**Answer:**

**Two bigger units of electric work :**

1. Kilo – Joule (kJ) =  $10^3$  J
2. Mega-joule (Mj) =  $10^6$  J

### Question 2.

**Derive an expression for electric work connecting :**

- (a) Current, resistance and time
- (b) Current, potential difference and time.
- (c) Potential difference, resistance and time.

**Answer:**

**Derivation of electric work**

We know that  $v = \frac{w}{Q}$

$\therefore w = vQ$  but  $Q = It$

$W = VI t$  ...**(i)**

**(a)** Ohm's Law  $V = IR$  part in **(i)**

$\therefore W = IRI t$

$W = I^2 R t$  ...**(ii)** current, resistance and time.

**(b)** but  $I = \frac{V}{R}$

$\therefore R = \frac{V}{I}$  put in **(ii)**

$W = \frac{V}{I} I^2 t = VI t$

**(c)**  $I = \frac{V}{R}$  Ohm's Law

put in **(i)**

$W = V \cdot \frac{V}{R} t = \frac{V^2 t}{R}$

**Question 3.**

State three factors which determine the quantity of heat produced in a conductor.

**Answer:**

Three factors which determine heat produced in a conductor :

Heat produced = Energy Work done

$W=H=I^2Rt$

$\therefore$  Three factors are I – current

R – Resistance of conductor

t – time for which current flows.

**Question 4.**

- (a) What do you understand by the term electric power ?  
(b) State SI unit of electric power and define it  
(c) Name two bigger units of electric power and their relation with SI unit.

**Answer:**

(a) Electric power : “The rate at which electrical energy is supplied by a source.”

Or

“The rate at which electrical energy is consumed by an appliance.”

$$P = \frac{w}{t}$$

but  $w = VI t$

$$P = \frac{VI t}{t} = VI$$

- (b) S.I. unit of power  $\longrightarrow$  Watt =  $J s^{-1}$

One watt : “is the electric power consumed when a current of 1 ampere flows through a circuit having a potential difference of 1 volt.”

- (c) Two bigger units of power and relation with S.I. unit.

1 kilowatt (1 kw) = 1000 w

1 Mega watt (1 mw) =  $10^6$  w

**Question 5.**

Derive an expression for electric power connecting :

- (a) Current and resistance.  
(b) Current and potential difference.  
(c) Potential difference and resistance.

**Answer:**

Derivation of electric power

$$\text{Power } P = \frac{\text{work done } (w)}{\text{time taken } (t)}$$

(a)  $w = I^2 R t$

$$\therefore P = \frac{I^2 R t}{t} = I^2 R \quad \dots(\text{i})$$

(b) but  $w = V.I.t$

$$P = \frac{w}{t} = \frac{VIt}{t} = V \times I \quad \dots(\text{ii})$$

(c)  $\therefore P = VI$  but  $I = \frac{V}{R}$

$$\therefore P = V \frac{V}{R} = \frac{V^2}{R}$$

Pot. diff and resistance.

**Question 6.**

- (a) What do you understand by term electric energy ?
- (b) Name and define the smallest commercial unit of electric energy.
- (c) Name and define the standard commercial unit of electric energy.

**Answer:**

(a) **Electric energy** :  $E = P \times t = VIt$

"Electric energy is the product of power and time." i.e. electric energy consumed by an electrical appliance is produced of 'power rating' and 'time' for which it is used.

(b) Unit of electric energy  $\rightarrow$  Joule (J)

S.I. unit of electric work  $\rightarrow$  Joule (J)

$$1\text{J} = 1 \text{ volt} \times 1 \text{ coulomb}$$

**1 Joule** : "Is the amount of work done when a charge of one coulomb flows through a conductor at a pot. diff. of 1 volt."

(c) **Standard Commercial unit of Electric Energy** : Kilo-watt-Hour 1 kWh : "Is the amount of electrical energy consumed when an electrical appliance having a power rating of 1 kilowatt is used for 1 hour."

### Question 7.

With respect to electricity, define :

1. watt hour
2. watt
3. kilowatt
4. kilowatt hour. Amongst the above units, which are the units of : (i) electric energy  
(ii) electric power.

### Answer:

(i) **Watt Hour** : “Is the amount of electrical energy consumed when an electrical appliance of 1 watt power is used for 1 hour.”

(ii) **Watt** : “Power of 1 watt is a rate of working of 1 joule per second.”

$$1 \text{ watt} = \frac{1 \text{ Joule}}{1 \text{ Second}}$$

(iii) **Kilowatt** : “Power of 1 k-w is the rate of working 1000 J per second.”  $1 \text{ k-w} = 1000 \text{ J s}^{-1}$

(iv) **Kilowatt hour** : Standard Commercial unit of Electric Energy : Kilo-watt-Hour 1 kWh : “Is the amount of electrical energy consumed when an electrical appliance having a power rating of 1 kilowatt is used for 1 hour.”

- (a) watt hour and kWh are units of electric energy.
- (b) Watt and Kwatt are units of power.

### Question 8.

How many joules of energy is equal to one kilowatt hour?

### Answer:

1 kilowatt hour

1000 watt hour

$$1000 \frac{\text{J}}{\text{S}} \times (60 \times 60 \text{ s}) = 3600000 \text{ J}$$

$$1 \text{ kWh} = 3.6 \times 10^6 \text{ J}$$

**Question 9.**

Distinguish between kilo-watt and kilowatt hour.

**Answer:**

Kilo-watt is a unit of power.

$$\text{Kilowatt} = 1000 \text{ w} = 1000 \text{ Js}^{-1}$$

Kilo-Watt-Hour — is a unit of energy consumed in 1 hour.

$$1 \text{ Kwh} = 1000 \text{ w} \times 1 \text{ hour}$$

$$1 \text{ Kwh} = 3.6 \times 10^6 \text{ J}$$

**Question 10.**

How many kilowatt is equal to one hour power ?

**Answer:**

$$\text{One hour power} = 746 \Rightarrow 750 \text{ w}$$

$$= \frac{746}{1000} = 0.746 \text{ kwatt}$$

$$\Rightarrow 0.750 \text{ kwatt.}$$

**Multiple Choice Questions**

Tick (✓) the most appropriate option.

1. A bulb has a resistance of  $20 \Omega$  and the p.d across its terminals is  $V$ . If the bulb is used for  $t$  seconds then energy consumed by the bulb is :

(a)  $\frac{V}{20} \times t$

(b)  $\frac{V^2}{20} \times t$

(c)  $V \times t = 20$

(d)  $\frac{V \times t^2}{20}$

**Answer:**

(b)  $\frac{V^2}{20} \times t$

2. A current  $I$  flows through a resistance  $R$  for the time ' $t$ ', the electric energy consumed by the resistance is :

(a)  $I \times R \times t$

(b)  $I \times R^2 \times t$

(c)  $I^2 \times R \times t$

(d)  $\frac{I^2 \times R}{t}$

**Answer:**

(c)  $I^2 \times R \times t$

3. The unit for electric work in SI system :

- (a) Joule
- (b) watt
- (c) watt second
- (d) watt hour

**Answer:**

- (a) Joule

4. An electric appliance has a rating of 1000 W – 200 V. The resistance of the element of electric appliance is :

- (a) 200  $\Omega$
- (b) 400  $\Omega$
- (c) 40  $\Omega$
- (d) 4000  $\Omega$

**Answer:**

- (c) 40  $\Omega$

5. Kilowatt hour is commercial unit of :

- (a) power
- (b) electric energy
- (c) heat energy
- (d) mechanical energy

**Answer:**

- (b) electric energy

6. Kilowatt hour and kilowatt are :

- (a) SI units of power and electric energy
- (b) commercial units of power and electric energy
- (c) SI units of electric energy and power
- (d) commercial units of electric energy and power

**Answer:**

- (d) commercial units of electric energy and power

## Numerical Problems on Electric Energy

### Practice Problems 1

#### Question 1.

Calculate the energy released by a heater, which draws a current of 5A at 220 V for 1 min.

**Answer:**

$$w = \text{Energy released} = VI t$$

$$w = 220 \times 5 \times 60 = 66000 \text{ J}$$

#### Question 2.

An electric device consumes 8640 J of energy in 30 min. while operating at 24 V. Calculate the current drawn by the device.

**Answer:**

$$VI t = w$$

$$24 \times I \times (30 \times 60) = 8640$$

$$I = \frac{8640}{24 \times 30 \times 60} = 0.2 \text{ A}$$

### Practice Problems 2

#### Question 1.

An electric kettle draws a current of 4A for 2.5 min. if the resistance of its element is 100  $\Omega$ , calculate the electric energy drawn by kettle in kilojoules.

**Answer:**

$$\text{Current } I = 4 \text{ A,}$$

$$t = (2.5 \times 60) \text{ sec.,}$$

$$R = 100 \Omega$$

$$\text{Electric energy drawn } W = I^2 R t$$

$$W = 4 \times 4 \times 100 \times \left( \frac{25}{10} \times 60 \right) = 240000 \text{ J}$$

$$W = \frac{240000}{1000} = 240 \text{ kJ}$$

**Question 2.**

A soldering iron draws an energy of 43200 J in 4 min, when the current flowing through its element is 6 A, calculate the resistance of its heating element.

**Answer:**

$$\text{Energy drawn } E = 43200 \text{ J,}$$

$$t = 4 \text{ min.} = (4 \times 60) \text{ s.}$$

$$I = 6\text{A}$$

$$R = \frac{E}{I^2 t} = \frac{43200}{6 \times 6 \times (4 \times 60)} = 5\Omega$$

**Practice Problems 3****Question 1.**

Calculate the heat energy given out by the filament of an electric bulb in 20 s, when its resistance is 4  $\Omega$  and p.d. across its ends is 12 V.

**Answer:**

$$t = 20 \text{ s, } R = 4\Omega, \text{ p.d. } V = 12 \text{ V}$$

$$\text{Heat energy given out by filament } E = \frac{V^2 t}{R}$$

$$E = \frac{12 \times 12 \times 20}{4} = 720 \text{ J}$$

**Question 2.**

An electric device gives out 5760 J of heat energy in 1 min, when current flows through it at a p.d. of 24 V. Find the resistance of the device.

**Answer:**

$$\text{Heat Energy given out } E = 5760 \text{ J}$$

$$t = 1 \text{ min.} = 60 \text{ s. p.d } V = 24\text{V}$$

$$\text{Resistance } R = \frac{V^2 t}{E} = \frac{24 \times 24 \times 60}{5760} = 6 \Omega$$

$$R = 6\Omega$$

**Practice Problems 4**

**Question 1.**

An electric heater draws a current of 3.5 A at a p.d. of 250 V. Calculate the power of 4 such heaters.

**Answer:**

$$\text{Power } P = VI \quad I = 3.5 \text{ A}$$

$$V = 250 \text{ V}$$

$$\therefore \text{Power of 4 heaters } P = 4 VI$$

$$P = 4 \times 250 \times \frac{35}{10} = 3500 \text{ W}$$

**Question 2.**

An electric bulb is rated 500 W – 200 V. Calculate the magnitude of current.

**Answer:**

$$P = 500 \text{ W}, V = 200 \text{ V}$$

$$\text{Current } I = \frac{P}{V} = \frac{500}{200} = 2.5$$

$$\therefore I = 2.5 \text{ A}$$

**Question 3.**

An electric heater of power 1000 W, draws a current of 5.0 A. Calculate the line voltage.

**Answer:**

$$\text{Power of heater } P = 1000 \text{ W}, I = 5.0 \text{ A}$$

$$\text{Voltage } V = \frac{P}{I} = \frac{1000}{5} = 200$$

$$\therefore V = 200 \text{ V}$$

**Practice Problems 5****Question 1.**

An electric heater has a resistance of 40  $\Omega$  and draws a current of 4 A. Calculate :

1. its power
2. p.d. at its ends

**Answer:**

$$(i) \text{ Power } P = I^2 R \quad R = 40\Omega$$

$$I = 4A$$

$$P = 4 \times 4 \times 40 = 640 \text{ W}$$

$$(ii) \text{ P.d. at its ends } V = \frac{P}{I} = \frac{640}{4} = 160 \text{ V}$$

### Question 2.

An electric heater of power 900 W, has a resistance of 36  $\Omega$  Calculate the magnitude of current and the p.d. at its ends.

**Answer:**

$$(i) \text{ Current } I = ? \quad P = 900 \text{ W}$$

$$R = 36 \Omega$$

$$P = I^2 R \quad \therefore I^2 = \frac{P}{R} = \frac{900}{36} = 25 = 5^2$$

$$\therefore I = 5A$$

$$(ii) \text{ P.d. across ends } V = \frac{P}{I} = \frac{900}{5} = 180 \text{ V}$$

### Practice Problems 6

#### Question 1.

An electric motor of power 1000 W, operates at 250 V. Calculate the inductive resistance of motor and current flowing through it.

**Answer:**

$$\text{Power } P = 1000 \text{ W}, \quad V = 250 \text{ V}$$

$$R = ?$$

$$(i) P = \frac{V^2}{R} \quad \therefore R = \frac{V^2}{P} = \frac{250 \times 250}{1000} = 62.5\Omega$$

$$(ii) \text{ Current } I = \frac{V}{R} = \frac{250}{62.5} = 4A$$

#### Question 2.

An electric device operates at 24 V and has a resistance of 8  $\Omega$  Calculate the power of

the device and current flowing through it

**Answer:**

$$V = 24 \text{ V}, \quad R = 8\Omega$$

$$(i) P = \frac{V^2}{R} = \frac{24 \times 24}{8} = 72 \text{ W}$$

(ii) Current flowing  $P = VI$

$$72 = 24 I$$

$$I = \frac{72}{24} = 3A$$

### Practice Problems 7

#### Question 1.

An electric bulb is rated 200 W – 200 V. It is immersed in 200 g of oil (SHC  $0.8 \text{ Jg}^{-10} \text{ C}^{-1}$ ) at  $10^\circ\text{C}$ . The bulb is switched on for 2 minutes. If all the electric energy is absorbed in the form of heat energy by the oil, calculate :

- (a) Resistance of the filament of the bulb.
- (b) Current flowing through the bulb.
- (c) Final temperature of the oil.

**Answer:**

$$P = 200 \text{ w} \quad \text{p.d. } v = 200 \text{ v}$$

$$VI = P$$

$$200 \times I = 200$$

$$I = \frac{200}{200} = 1A$$

$$(a) \quad P = \frac{V^2}{R} \quad R = \frac{V^2}{P} = \frac{200 \times 200}{200} = 200\Omega$$

$$(b) \quad I = 1A$$

(c) Final temp. of oil

$Q = \text{heat supplied} = mc (T - t)$  in 2 min.

$$P \times t = 200 \times 0.8 \times (T - 10)$$

$$200 \times (2 \times 60) = 20 \times 8 (T - 10)$$

$$(T - 10) = \frac{200 \times 120}{160} = 150$$

$$T = 150 + 10 = 160^\circ\text{C}$$

### Question 2.

An electric kettle is rated 1000 W – 250 V. It is used to bring water at 20°C to its boiling point. If the kettle is used for 11 minutes and 12 seconds, **calculate** :

- (a) Resistance of the element of the kettle.
- (b) Current flowing through the element.
- (c) Mass of water in the kettle [SHC of water =  $4.2 \text{ Jg}^{-1} \text{ C}^{-1}$ ]

### Answer:

Kettle rated 1000 w – 250 v

$$P = 1000 \text{ w} \quad \text{p.d. } v = 250 \text{ v}$$

$$t = 20^\circ \text{ T} = 100^\circ \text{C}$$

- (a) Resistance of element  $R = ?$

$$P = \frac{V^2}{R} \quad \therefore R = \frac{V^2}{P} = \frac{250 \times 250}{1000}$$

$$R = 62.5 \Omega$$

- (b) Current flowing through the element

$$I = \frac{P}{V} = \frac{1000}{250} = 4 \text{ A}$$

- (c) Mass of water in kettle =  $m$

Heat energy consumed in 11 min 12s.

$$Q = P \times t = 1000 \times (11 \times 60 + 12) \\ = (1000 \times 672) \text{ J}$$

$$Q = mc (T - t)$$

$$(1000 \times 672) = m \times 4.2 (100 - 20)$$

$$m = \frac{672 \times 1000}{4.2 \times 80} = 2000 \text{ g} = \frac{2000}{1000} = 2 \text{ kg}$$

### Practice Problems 8

#### Question 1.

Calculate the resistance of nichrome wire, which will bring 200 g of water at 20° C to its boiling points in 7 minutes, when current flowing through wire is 4A.

#### Answer:

$$I = 4\text{A}, R = ? \quad t = 7 \text{ min} = 420 \text{ s}$$

$$\text{Energy required to heat water } E = Q = mc (T - t)$$

$$\text{or } E = mc (T - t) = I^2 R t$$

$$200 \times 4.2 \times (100 - 20) = 4 \times 4 \times R \times 420$$

$$\therefore R = 200 \times \frac{42}{10} \times 80 \times \frac{1}{420 \times 16} = 10\Omega$$

### Question 2.

Calculate p.d. at the ends of a power source which, supplies current to a 4 ohm resistance wire for 20 minutes and raises temperature of 400 g of water through  $20^\circ\text{C}$ .

**Answer:**

$$\text{P.d. } V = ? \quad R = 4\Omega, \quad \text{time} = (20 \times 60) \text{ s}$$

Heat required to raise the temperature of water through  $20^\circ\text{C}$

$$Q = E = mc T$$

$$m = 400 \text{ g}, c = 4.2 \text{ J/g } ^\circ\text{C}^{-1}, T = 20^\circ$$

$$\text{Also } t = 20 \text{ min}$$

$$t = 2 \times 60 \text{ sec.}$$

$$\therefore \frac{V^2 t}{R} = mc T$$

$$\frac{V^2 \times (20 \times 60)}{4} = 400 \times \frac{42}{10} \times 20$$

$$V^2 = \frac{400 \times 42 \times 20 \times 4}{10 \times 20 \times 60} = 112$$

$$\therefore V = \sqrt{112} \quad V = \sqrt{16 \times 7} \quad V = 4\sqrt{7} \text{ V}$$

$$V = 10.5 \text{ V}$$

### Question 3.

Calculate the current flowing through an electric drill, connected to 200 V supply, if it

drills a hole in a metal plate of mass 500 g, such that its temperature rises from  $10^{\circ}\text{C}$  to  $60^{\circ}\text{C}$  in 5 minutes, assuming all the work done is converted into heat energy. [S.H.C. of metal  $0.6 \text{ Jg}^{-1} \text{ }^{\circ}\text{C}^{-1}$ ]

**Answer:**

$$I = ?, \quad V = 200 \text{ V}, \quad t = (5 \times 60) \text{ s}$$

$$\text{Heat energy } Q = W = mc T$$

$$m = 500 \text{ g}, \quad C = 0.6 \text{ Jg}^{-1} \text{ }^{\circ}\text{C}^{-1}$$

$$\therefore VIt = mc T$$

$$\text{Rise in temp.} = T = (60 - 10) = 50^{\circ}\text{C}$$

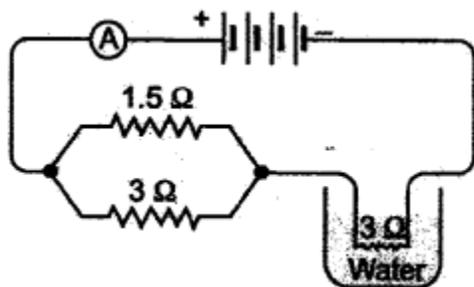
$$200 \times I \times 300 = 500 \times \frac{6}{10} \times 50$$

$$I = \frac{500 \times 30}{300 \times 200} = \frac{1}{4} = 0.25 \text{ A}$$

### Practice Problems 9

#### Question 1.

Circuit diagram shows four dry cells of e.m.f. 1.5 V and internal resistance  $0.25 \Omega$  connected to an external circuit. A  $3 \Omega$  wire is immersed in 20 g of water at  $20^{\circ}\text{C}$ . The current switched on for 6 minutes and 36 seconds. Calculate :



- Reading shown by the ammeter
- Current in  $1.5 \Omega$  wire
- Final temperature of water

**Answer:**

Potential difference of 4 cells  $E = 4 \times 1.5 = 6\text{v}$

$$R_p = \frac{1}{1.5} + \frac{1}{3} = 1\Omega$$

External resistance  $R = R_p + 3\Omega$

$$1 + 3 = 4\Omega$$

(a) Reading in ammeter  $= I = \frac{E}{R}$

$$I = \frac{6}{4} = 1.5\text{ A}$$

(b)  $v$  across parallel resistances  $v = IR_p$   
 $V = 1.5 \times 1 = 1.5\text{ v}$

$\therefore$  Current through  $1.5\Omega$  wire  $I_1 = \frac{v}{1.5} = \frac{1.5}{1.5} = 1\text{A}$

(c) Final temperature of water.

$$Q = I^2 R t = mc_w (T - 20)$$

{ $\because$  By the principle of calorimetry}

$$\Rightarrow 1.5 \times 1.5 \times 3 \times (6 \times 60 + 36) = 20 \times 4.2 (T - 20)$$

$$\Rightarrow \frac{27}{4} \times 396 = 84 (T - 20^\circ\text{C})$$

$$\Rightarrow \frac{27 \times 99}{84} = T - 20^\circ\text{C}$$

$$\Rightarrow T = 31.8 + 20^\circ\text{C} = 51.8^\circ\text{C}$$

**Question 2.**

A battery of 12 V and negligible internal resistance is connected to an external circuit consisting of three resistors of  $6\Omega$ ,  $3\Omega$  and  $2\Omega$  in parallel, which further connected to a resistance of  $3\Omega$  in series to the battery. The  $3\Omega$  resistance is immersed in 50 g oil of sp. heat capacity  $0.8\text{ Jg}^{-1}\text{ }^\circ\text{C}^{-1}$ , when the temperature of the oil rises by  $54^\circ\text{C}$ .

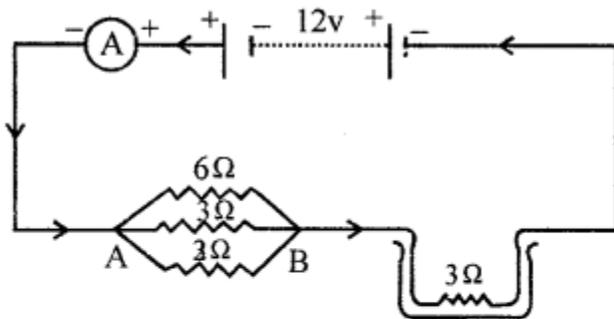
(a) Draw the labelled circuit diagram.

(b) Calculate the value of current in the train circuit.

- (c) Calculate the current following in  $2\ \Omega$  resistance in parallel.  
 (d) Calculate the time for which current is switched on.

**Answer:**

(a)



(b)  $R_p$  across AB

$$\frac{1}{R_p} = \frac{1}{6} + \frac{1}{3} + \frac{1}{3} = \frac{1}{1} \quad \therefore R_p = 1\ \Omega$$

$$R = R_p + 3\ \Omega = 1 + 3 = 4\ \Omega$$

$$\text{Current in circuit } I = \frac{V}{R}$$

$$I = \frac{12}{4} = 3\text{A}$$

$$(c) \text{ V across AB} = IR_p = 3 \times 1 = 3\text{v}$$

Current through  $2\ \Omega$

$$I_1 = \frac{V}{2} = \frac{3}{2} = 1.5\ \text{A}$$

(d)  $E = Q = m \times \text{Coil} \times \text{Rise in temperature}$   
 Energy flowing through wire in oil

$$I^2 R t = m \times \text{Coil} \times \text{Rise in temperature}$$

$$3 \times 3 \times 3 \times t = 50 \times 0.8 \times 54$$

$$t = 50 \times \frac{8}{10} \times \frac{54}{27} = 80\text{s}$$

$$t = 1\ \text{min } 20\ \text{sec.}$$

## Practice Problems 10

### Question 1.

An electric kettle rated 250 V can bring a certain amount of water to its boiling point in 8 min. If it is connected to 200 V mains, calculate the time in which water comes to its boiling point.

**Answer:**

Energy consumed by water in 8 min at 250 V

$$E = \frac{V^2 t}{R} = \frac{250 \times 250 \times 8 \text{ min}}{R} \quad \dots(\text{i})$$

Energy consumed by water at 200 V

$$E = \frac{V^2 t}{R} = \frac{200 \times 200 \times t}{R} \quad \dots(\text{ii})$$

By law of conservation of energy (i) = (ii)

$$\frac{200 \times 200 \times t}{R} = \frac{250 \times 250 \times 8}{R}$$

$$t = \frac{250 \times 250 \times 8}{200 \times 200} = 12.5 \text{ min.}$$

### Question 2.

An immersion heating rod is rated 220 V and can bring certain amount of water to its boiling point in 15 min. When this immersion rod is actually connected to an electric circuit, it brings the water to boil in 18.15 min. Calculate the line voltage.

**Answer:**

Energy consumed by water in 15 min at 220 V

$$E = \frac{V^2 t}{R} = \frac{220 \times 220 \times 15 \text{ min}}{R} \quad \dots(\text{i})$$

Energy consumed by water at 18.15 min at Volt

$$E = \frac{V^2 t}{R} = \frac{V^2 \times 18.15 \text{ min}}{R} \quad \dots(\text{ii})$$

By law of conservation of energy (i) = (ii)

$$\frac{V^2 \times 18.15 \text{ min}}{R} = \frac{220 \times 220 \times 15}{R}$$

$$V^2 = (220)^2 \times \frac{1500}{1815} = 40000$$

$$V^2 = (200)^2$$

$$V = 200 \text{ Volt.}$$

## Practice Problems 11

### Question 1.

An electric oven is marked 1000 W – 200 V. Calculate :

- Resistance of its element
- Energy consumed by the oven in 1/2 hour in joules.
- Time, in which it will consume 15 kWh of energy.

### Answer:

An electric oven marked 1000 W – 200 V means

Power of oven  $P = 1000 \text{ W}$

Voltage  $V = 200 \text{ V}$

$$(a) \text{ Resistance of its element } R = \frac{V^2}{P} = \frac{200 \times 200}{1000}$$

$$R = 40 \text{ OHM}$$

$$(b) \text{ Energy consumed by oven in } \frac{1}{2} \text{ hr i.e. in } 1800 \text{ s}$$

$$E = P \times t = 1000 \times 1800 = 18 \times 10^5 \text{ J}$$

$18 \times 10^5 \text{ J}$  of energy is consumed in  $\frac{1}{2}$  hour

As  $1 \text{ kWh} = 36 \times 10^5 \text{ J}$

$$\therefore 15 \text{ kWh} = 15 \times (36 \times 10^5 \text{ J})$$

$$\therefore 15 \text{ kWh} = 15 \times (36 \times 10^5 \text{ J}) \text{ is consumed in } = \frac{1}{2} \times \frac{15 \times 36 \times 10^5}{18 \times 10^5}$$

$$= 15 \text{ hr}$$

### Question 2.

An electric motor is rated 2 HP – 250 V. Calculate :

- (a) Current flowing through it
- (b) Energy consumed by it in one second
- (c) Time in which it will consume 90 kWh of energy. [1 HP = 750 W]

**Answer:**

Electric motor is rated 2HP – 250 V means

$$\text{Power of motor } P = 2\text{HP} = 2 \times 750 = 1500 \text{ W}$$

$$\text{Voltage of motor} = V = 250 \text{ V}$$

$$(a) \quad \text{Current flowing } I = \frac{P}{V} = \frac{1500}{250} = 6A$$

$$(b) \quad \text{Energy consumed in 1 sec.} = E = VI t$$

$$E = 250 \times 6 \times 1 = 1500 \text{ J}$$

$$(c) \quad \text{time } t = ?$$

1500 J is consumed in 1 sec

$$1 \text{ J is consumed in} = \frac{1}{1500}$$

90 kWh =  $90 \times (36 \times 10^5 \text{ J})$  is consumed in

$$= \frac{1}{1500} \times 90 \times 36 \times 10^5 \text{ sec}$$

$$= 6000 \times 36 \text{ sec.}$$

$$= \frac{6000 \times 36}{60 \times 60} = 60 \text{ hours}$$

## Practice Problems 12

### Question 1.

A geyser is rated 2000 W and operates 2 hours a day on 200 V mains. Calculate the monthly bill for running the geyser when energy costs ₹ 1.90 per kWh.

**Answer:**

$$\text{Power of geyser } P = 2000 \text{ W} = \frac{2000}{1000} = 2 \text{ kW}$$

$$t = 2 \text{ hrs per day}$$

$$\text{Energy consumed per day } E = P \times t = 2 \times 2 = 4 \text{ kWh}$$

$$\text{Energy consumed in 30 days} = 4 \times 30 = 120 \text{ kWh}$$

$$\text{Cost of 120 kWh} = 120 \times 1.90 = ₹228$$

$$\therefore \text{Monthly bill} = ₹228$$

### Question 2.

An electric oven of resistance  $20 \Omega$  draws a current of  $10 \text{ A}$ . It works  $3$  hours daily. Calculate the weekly bill when energy costs ₹  $1.50$  per kWh.

**Answer:**

$$R = 20\Omega, I = 10 \text{ A}, t = 3\text{hrs daily}$$

$$P = VI$$

$$\text{Also } V = IR$$

$$\therefore P = (IR) I$$

$$P = I^2 R$$

$$P = 10 \times 10 \times 20 = \frac{2000 \text{ W}}{1000} = 2\text{kW}$$

$$\therefore \text{Total consumption of electric over per day} = 2 \times 3 = 6 \text{ kWh}$$

Electric oven works  $3$  hours daily

$$\therefore \text{Energy consumed per day} = 6 \text{ kWh}$$

$$\text{Cost per kWh} = \text{Rs. } 1.50$$

$$\therefore \text{Energy consumed in one week} = 6 \times 7 = 42 \text{ kWh}$$

$$\therefore \text{Weekly bill} = 42 \times 1.5 = ₹63$$

### Question 3.

An electric bulb draws a current of  $0.8 \text{ A}$  and works on  $250 \text{ V}$  on an average  $8$  hrs a day. If energy costs ₹  $1.50$  per board of trade unit, calculate the monthly bill

**Answer:**

$$I = 0.8 \text{ A} \quad V = 250 \text{ V}$$

$$\text{Power} = VI = 250 \times \frac{8}{10} = 200 \text{ W}$$

$$\text{Energy consumed per day} = 200 \times 8 = 1600 \text{ Wh}$$

$$= \frac{1600}{1000} = 1.6 \text{ kWh}$$

$$\text{Energy consumed in 30 days} = 1.6 \times 30 = 48 \text{ kWh}$$

$$\text{Cost per kWh} = ₹1.5$$

$$\therefore \text{Monthly bill} = 48 \times 1.5 = ₹72$$

### Practice Problems 13

#### Question 1.

4 tube lights of 40 W each and 2 fans of 100 W each are connected to 200 V mains and operate on an average 8 hours a day. If energy costs ₹ 1.50 kWh, calculate

(a) monthly bill

(b) minimum fuse rating.

**Answer:**

$$\text{Power of 4 tube lights} = 40 \times 4 = 160 \text{ W}$$

$$\text{Power of 2 fans} = 2 \times 100 = 200 \text{ W}$$

$$\begin{aligned} \text{Energy consumed per day} &= [200 + 160] \times 8 = (360 \times 8) \text{ Wh} \\ &= \frac{(360 \times 8)}{1000} \text{ kWh} \end{aligned}$$

$$(a) \text{ Energy consumed in 1 month} = \frac{360 \times 8 \times 30}{1000} \text{ kWh}$$

$$\text{Bill per month} = \frac{36 \times 24}{10} \times 1.5 = ₹129.60$$

$$(b) \text{ Minimum fuse rating} = \text{current drawn} = \frac{P}{V}$$

$$= \frac{360}{200} = 1.8 \text{ A}$$

### Question 2.

An electric motor of 2 H.P. and two coolers of 500 W each operate on 250 V mains for 4 hours a day. If the energy costs ₹ 1.80 per kWh, calculate

- (a) weekly bill
- (b) minimum fuse rating. [Take 1 HP = 750 W]

### Answer:

$$\text{Power of motor} = 2\text{H.P} = 2 \times 750 = 1500 \text{ W}$$

$$\text{Power of 2 coolers} = 2 \times 500 = 1000 \text{ W}$$

$$\text{Energy consumed per day} = P \times \text{hr}$$

$$= [1500 + 1000] \times 4 = 10000 \text{ Wh}$$

$$= \frac{10000}{1000} = 10 \text{ kWh}$$

$$\text{Energy consumed per week} = 10 \times 7 = 70 \text{ kWh}$$

(a) Cost per kWh = ₹1.8

∴ Weekly bill =  $10 \times 7 \times 1.8 = ₹126$

(b) Minimum fuse rating = current drawn =  $\frac{P}{V} = \frac{2500}{250} = 10 \text{ A}$

### Practice Problems 14

#### Question 1.

A boys hostel has following appliances when energy is supplied at 200 V and costs ₹ 5.25 per kWh.

- (a) 40 bulbs of 100 W each, working 8 hours a day.
- (b) 20 fans each drawing a current 9.8 A and working 15 hours a day.
- (c) Two T.V. sets, each offering a resistance of 200 Ω and working 4 hours a day.
- (d) Two electric motors of 1.5 H.P. each and working 4 hours a day

1. Calculate the monthly bill
2. Amongst the fuse of 48 A and 50 A which one you will use and why ?

**Answer:**

Energy consumed by bulbs

(a)  $40 \times 100 \times 8 = 32000 \text{ WH}$

(b) Energy consumed by 20 fans =  $20 \times (V \times I) \times 15 \text{ hours}$

$$= 20 \times 200 \times \frac{8}{10} \times 15 = 48000 \text{ wH}$$

(c) Energy consumed by 2 T.V.S.

$$= 2 \times \left( \frac{V^2}{R} \right) \times 4 \text{ hrs}$$

$$= 2 \times \frac{200 \times 200 \times 4}{200} = 1600 \text{ WH}$$

(d) Energy consumed by electric motor

$$2 \times (1.5 \times 750) \times 4 = 9000 \text{ WH}$$

(i) Total energy consume in 30 days

$$= \frac{30(32000+48000+1600+9000)}{1000}$$

$$= 30 \times \frac{90600}{1000} \text{ kWh}$$

$$= 2718 \text{ kWh}$$

$$\text{Total Monthly bill} = 2718 \times 5.25 = ₹14269.50$$

(ii) Total P =  $4000\text{W} + 3200\text{W} + 400\text{W} + 2250 \text{ W} = 9850 \text{ W}$

$$\therefore \text{Minimum fuse rating} = \frac{P}{V} = \frac{9850 \text{ W}}{200 \text{ V}} = 49.75 \text{ A}$$

⇒ 50A

**Question 2.**

An establishment receives electric energy at a rate of ₹ 4.50 per kWh at a p.d. of 240 V. It uses following appliances.

(a) 20 tube lights of 40 W each working 10 h a day.

(b) Two stereo systems, each drawing a current of 2A and working 4h a day.

(c) Four ovens, each of resistance 24 Q working 6 h a day.

(d) Two cooling machines of 4 H.P. each working 15 hours a day.

1. calculate monthly bill
2. minimum fuse rating of circuit

**Answer:**

Energy consumed per day by

- (a) 20 tube lights =  $(20 \times 40) \times 10 = 8000 \text{ WH}$
- (b) 2 series =  $2 (240 \times 2) \times 4 = 3840 \text{ WH}$
- (c) 4 ovens =  $4 \times \left( \frac{240 \times 240}{24} \right) \times 6 = 57600 \text{ WH}$
- (d) Two cooling machines =  $2[4 \times 750] \times 15 = 90000 \text{ WH}$

$$\text{Total energy consumed per day} = \frac{15940}{1000} \text{ kWh}$$

$$= 159.44 \text{ kWh}$$

- (i) Energy consumed in 1 month =  $159.44 \times 30 \text{ kWh}$   
 $= 4783.20 \text{ kWh}$

$$\text{Cost} = 4783.20 \times 4.50$$

$$= ₹21524.40$$

- (ii) Total power =  $800 \text{ W} + 960 \text{ W} + 9600 \text{ W} + 6000 \text{ W}$

$$\therefore \text{Minimum fuse rating} = \frac{16360 \text{ W}}{240 \text{ V}} = 68.1$$

$$\Rightarrow 69\text{A}$$

## Exercise – 2

### Question 1.

- (a) What do you understand by the term electric fuse ?

**Answer:**

**Electric fuse :** "Is a safety device which is used to limit the current in an electric circuit. The use of a fuse safe guards the circuit and the appliances connected in that circuit from being damaged."

- (b) Name a material from which an electric fuse is made.

**Answer:**

Material used for fuse is 'Alloy of lead and Tin' having low melting point and high resistance."

(c) State two properties of a material which makes it suitable for an electric fuse.

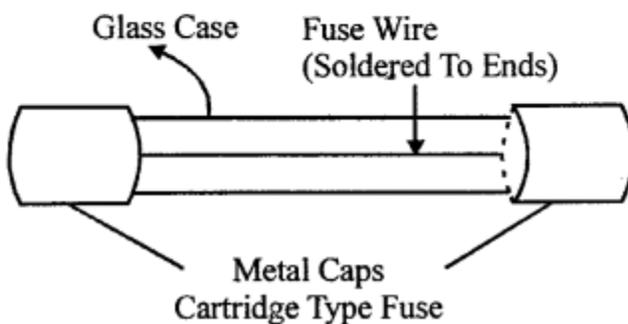
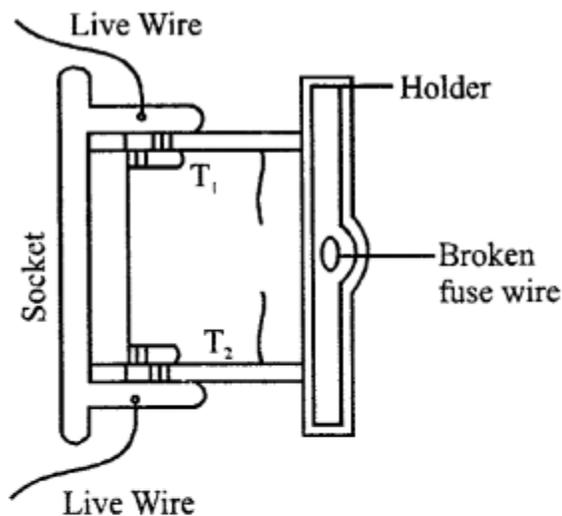
**Answer:**

**Two properties of material are :**

1. Low melting point
2. High resistance.

(d) Draw a diagram of a fuse wire, connected in a fuse socket.

**Answer:**



### Question 2.

(a) Why is a fuse wire always placed in a live wire ?

**Answer:**

So that 'The fuse may melt first, before current reaches the appliance'.

(b) How does fuse wire protect an electric circuit ?

**Answer:**

When current in the circuit exceeds the specified value (due to any reason such as high voltage, short circuiting etc.) the fuse wire gets heated up to the extent that it melts. As a result a gap is produced and the circuit breaks. The current does not flow through the live wire and appliance is saved.

(c) Two fuse wires of the same length are rated 15A and 5A. Which of the two is thicker and why ?

**Answer:**

5A wire is thicker as resistance is  $\propto 1/a$  Thicker the wire less is resistance and electrons can run freely with less collisions.

(d) Why is it dangerous to replace a fuse wire with a copper wire?

**Answer:**

"Copper has low resistivity and high melting point and does not serve the purpose of fuse."

### Question 3.

(a) What do you understand by the term earthing ?

**Answer:**

**Earthing : or Grounding :** "Bringing the appliance to zero potential".

"Earthing means to connect the metal case of electrical appliance to the earth (at zero potential) by means of a metal wire is called "Earth wire".

(b) How does earthing protect a user from receiving an electric shock?

**Answer:**

When we connect the earth wire to the metal case of the electrical appliance by using three pinplug.

The metal casing of the appliance will now always remain at zero potential of the earth, this will avoid the risk of shock if we touch the metal body as the current passes directly to earth through the earth wire.

(c) How is a household circuit earthed ?

**Answer:**

The neutral and earth wires on supply end (power station) are connected potential together, so that both of them are at zero potential and inside the house live and neutral wires are connected to the input terminals of kWh meter, where as earth wire is connected to the body of kWh meter. The live wire coming out from the output terminals of the kWh meter has another fuse in it, which is commonly called main fuse. The neutral wire and earthwire is common to all circuits.

(d) Explain how the fuse melts when a short circuit appliance gets earthed.

**Answer:**

When an earthed appliance gets short circuited, then current from its metal body flows into the earth. Since earth does not offer any resistance, therefore magnitude of the current in the circuit of a short-circuited appliance suddenly rises to a very high value. This rise in magnitude of current in turn overloads the circuit, and hence. The fuse in that circuit melts.

#### Question 4.

(a) What is the function of a switch in an electric circuit?

**Answer:**

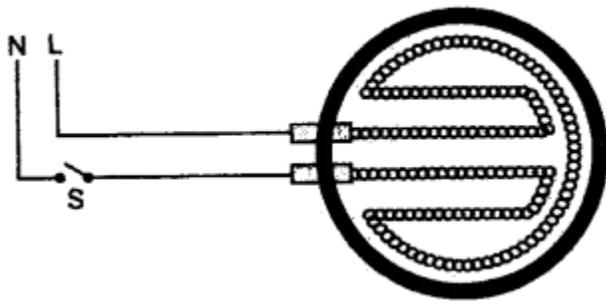
**Function of a switch :**

Function of a switch is to connect or disconnect an electric appliance in the electric circuit.

(b) Why is switched placed in a live wire ?

**Answer:**

Let the appliance (heater) when connected in a neutral wire, when the switch is in the off position and even if no current is flowing through the heater and it is not operating, how ever the heater is in contact with live wire and heating element is at the same potential as the live wire. Thus if we touch the heating coil of the heater, current will flow through our body giving us a severe shock and may prove fatal, this proves that switch should always be placed in the live wire.



(c) what consequences will follow, if a switch is placed in the neutral wire ?

**Answer:**

Even if switch is in off position the appliance will be at the potential of live wire and current will flow through the appliance.

#### Question 5.

(a) Why is household wiring done in parallel ? Give at least two reasons ?

**Answer:**

**Two advantages of parallel wiring :**

1. Electrical appliances get same voltage (220 V) as that of the power supply line.
2. If one electrical appliance stops working due to some defect, then all other appliances keep working normally.

(b) What are the disadvantages of wiring in series in a house?

**Answer:**

**Disadvantages in series circuit :**

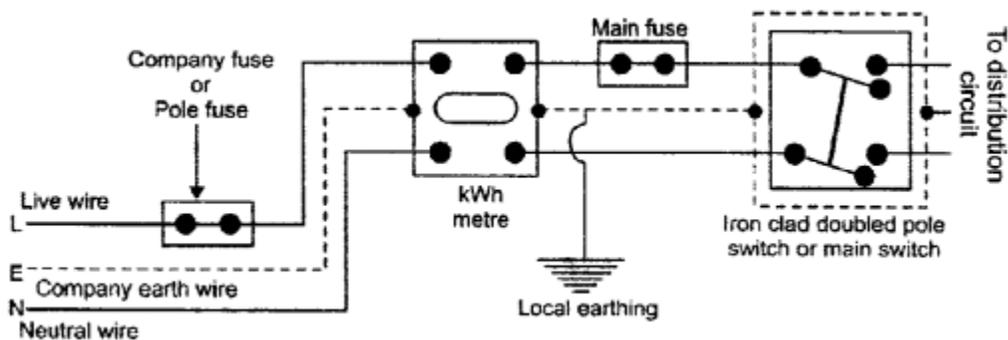
1. Over all resistance increases and current from the power supply is low.
2. If one electrical appliance stops working, due to some defect, then all other appliances also stop working.

**Question 6.**

Draw a circuit diagram for distribution of power from pole to the main switch and label it

**Answer:**

**Circuit Diagram For Distribution Of Power From Pole To Main Switch :**



**Question 7.**

Name two systems of distribution of power in a house. Give the advantages and disadvantages of each system.

**Answer:**

Two systems of power distribution.

**(i) Tree system Advantages**

1. All appliances are connected parallel and can be independently switched on and switched off.
2. The neutral wire and earth wire is common to all circuits.
3. From the main distribution board, circuits are taken out for different rooms.

**Disadvantages :**

1. It is expensive and takes a long time to install.

2. It requires plugs and sockets of different current value for different appliances depending upon their power rating.
3. When a fuse in one particular line melts. It disconnects all appliances in that circuit.

**(ii) Ring system :**

**Advantages :**

1. Every appliance has its own fuse and can be handled without disturbing other appliances.
2. Length of wire used is very small.
3. It is easier to install and maintain.

**Question 8.**

**(a)** State the colour of (i) live wire, (ii) neutral wire, (iii) earth wire according to international convention

**(b)** State the position of (i) earth pin, (ii) live pin and (iii) neutral pin in an electric plug.

**(c)** Why is the earth terminal of a plug made (i) thicker, (ii) longer

**Answer:**

**(a) The colour of**

1. Live wire -- Brown
2. Neutral wire -- Light Blue .
3. Earth wire -- green or Yellow

**(b) Position of**

1. Earth pin -- is Long and Thicker so that it should not enter live or neutral cylinder of socket.
2. Live pin -- L is on the right when earth pin goes into E, live pin goes into L.
3. Neutral-pin -- N is on the left. When earth pin goes into E, live wire in L automatically neutral goes into N.

**(c)** Earth-pin is made thicker, so that it should not enter other cylinder of socket and helps in putting right pin in right place.

Longer -- So that earth connection is done first. This ensure the user will not get a shock.

**Multiple Choice Questions**

**Tick (✓) the most appropriate option.**

**1. A fuse wire is connected in before the switch.**

- (a) neutral wire
- (b) earth wire
- (c) live wire
- (d) either (a) or (c)

**Answer:**

- (c) live wire

**2. A switch in a circuit is always connected in the :**

- (a) live wire
- (b) earth wire
- (c) neutral wire
- (d) either (a) or (b)

**Answer:**

- (a) live wire

**3. According to old convention, the colour of neutral wire is :**

- (a) red
- (b) green
- (c) black
- (d) none of these

**Answer:**

- (c) black

**4. According to new convention, the colour of live wire is :**

- (a) light blue
- (b) yellow
- (c) green
- (d) brown

**Answer:**

- (d) brown

**5. Which is not the characteristic of a fuse wire ?**

- (a) It has high resistance
- (b) It has low melting point
- (c) It has low resistance
- (d) It is an alloy of lead and tin

**Answer:**

- (c) It has low resistance

**6. In a three pin plug the live pin in :**

- (a) thinner and is toward left
- (b) thicker and is towards left

- (c) thinner and is towards right
- (d) thicker and is towards right

**Answer:**

- (c) thinner and is towards right

**7. In a household electric circuit all appliances are connected in :**

- (a) parallel circuit
- (b) series circuit
- (c) mixed circuit
- (d) any of these

**Answer:**

- (a) parallel circuit

**8. An average lighting circuit of a cpoor family has a fuse rating of**

- (a) 10 A
- (b) 15 A
- (c) 5 A
- (d) 2 A

**Answer:**

- (c) 5 A

### Questions From ICSE Examination Papers

2001

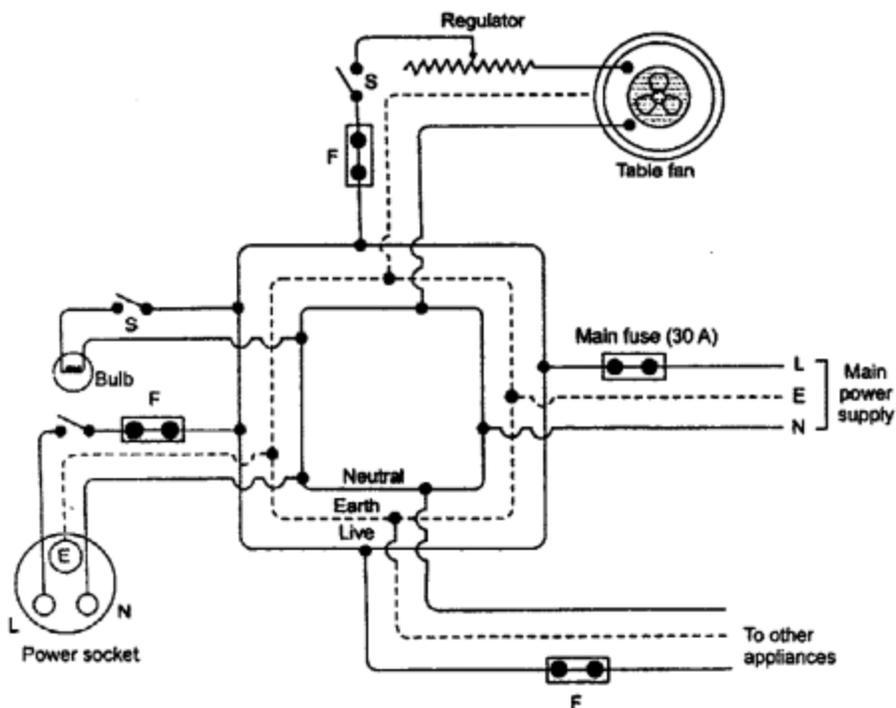
**Question 1.**

- (a) Draw a diagram of ring main circuit for domestic distribution of electric power.
- (b) Name the physical quantity which is measured in

- 1. Kilowatt hour
- 2. Kilowatt

**Answer:**

- (a)



- (b) (1) kilowatt hour -- energy consumed.  
 (2) kilowatt -- power.

**Question 2.**

A bulb is marked 100 W – 220 V and an electric heater is marked 1000 W – 220 V  
 Answer the following questions :

- (a) What is the ratio of resistance of the filament of the bulb to the element of the heater ?  
 (b) How does power-voltage rating of an electric appliance help us to decide the type of connecting wires (leads) to be used for it ?  
 (c) In the above mentioned devices in 2(a) which of the two devices needs a thicker wire.

**Answer:**

Bulb marked 100 W – 220 V

Heater marked 1000 W – 220 V

$$\frac{\text{bulb}}{\text{heater}} = \frac{100w = \frac{V^2}{R_1}}{1000 w = \frac{V^2}{R_2}}$$

$$(a) \quad \therefore \quad \frac{R_1 = \frac{V^2}{100}}{R_2 = \frac{V^2}{1000}} \quad \frac{R_1}{R_2} = \frac{V^2}{100} \times \frac{1000}{V^2}$$

$$R_1 : R_2 = 10 : 1$$

(b) The rate of heat produced in a conductor is given by the expression  $I^2 R$ . Copper wires have low resistance and the heat produced in them is so small that it gets radiated out without damaging the insulation. If current increases the heat produced burns the insulation and bare-copper wires come in contact with each other and will cause electric fire. Hence power-voltage rating helps to decide the type of connecting wires (leads) to be used for it so that it can tolerate the current flowing through it.

(c) In case of heater the lead should be thicker to offer less resistance.

### Question 3.

(a) Calculate the daily household electric bill for a family which uses the following appliances for 8 hours a day, when electrical energy costs Rs. 2 per unit

1. one 100 W bulb
2. one 100 W fan
3. one 1000 W heater.

### Answer:

Energy used in kWh daily for 8 hours in Electric bulb

$$= \frac{100 \times 8}{1000} = 0.8 \text{ kWh}$$

$$\text{Fan} = \frac{100 \times 8}{1000} = 0.8 \text{ kWh}$$

$$\text{Heater} = \frac{1000 \times 8}{1000} = 8 \text{ kWh}$$

Total energy consumed in 1 day =  $0.8 + 0.8 + 8$

$$= 9.60 \text{ kWh} = 9.6 \text{ units}$$

cost @ Rs. 2 per unit

$$= 9.6 \times 2 = \text{Rs. } 19.20$$

(b) How does earthing protect a user from electric shocks ?

### Answer:

When we connect the earth wire to the metal case of the electrical appliance by using three pinplug. The metal casing of the appliance will now always remain at zero

potential of the earth, this will avoid the risk of shock if we happen to touch the metal body directly to earth through the earth wire.

2002

**Question 4.**

A geyser has a label 2 kW, 240 V. What is the cost of using it for 30 minutes, if the cost of electricity is Rs. 3.00 per commercial unit ?

**Answer:**

(i) Geyser marked 2 kW – 240 V means

$$\text{Power} = 2\text{kW}$$

$$\text{Voltage} = 240\text{ V}$$

$$\therefore \text{Energy consumed in 30 min} \left(\frac{1}{2}h\right) 2 \times \frac{1}{2} = 1 \text{ kWh}$$

$$\text{Cost per unit} = \text{Rs. } 3$$

$$\text{Energy consumed} = V I t$$

$$\begin{aligned} \text{Energy consumed} &= \text{Power} \times \text{time} = 2 \times \frac{1}{2} \\ &= 1 \text{ kW h} = 1 \text{ unit} \end{aligned}$$

$$\text{Total cost} = 3 \times 1 = \boxed{\text{Rs. } 3} \text{ Ans.}$$

**Question 5.**

Explain briefly the function of the following in the household wiring :

- (a) a three-pin plug
- (b) main switch.

**Answer:**

(a) **Three-pin plug** is a fixture provided with three cylindrical pins made of brass. The live pin is on the right, neutral pin on the left and earth pin is on the top. When inserted in the socket, its function is to provide a tight fitting between electrical circuit and the movable electric appliance.

(b) **Main switch** : It is the on-off device for current in a circuit or in a appliance. The switch should always be connected to live wire.

**Question 6.**

Make a table with the names of 3 electrical appliances used in home in one column, their power, voltage rating and approximate time for which each one is used in one day in the other columns.

**Answer:**

Appliance	Power	Voltage Rating	Time
Geyser	2000 W	220 V	1 hr
Fan	60 W	220 V	10 hr
Tubelight	40 W	220 V	8 hr

2003

**Question 7.**

An electric kettle is rated 2.5 kW, 250 V. Find the cost of running the kettle for two hours at 60 paise per unit.

**Answer:**

Electric kettle is rated (2.5 kW – 250 V) means

$$P = 2.5 \text{ kW}$$

$$T = 2 \text{ hours}$$

$$\text{Energy drawn in 2 hours} = E = 2.5 \times 2 = 5 \text{ kWh}$$

$$\text{Cost of running the kettle} = \frac{5 \times 60}{100} = \boxed{\text{Rs. 3}}.$$

**Question 8.**

Two fuse wires of the same length are rated 5 A and 20 A. Which of the fuse wires is thicker and why?

**Answer:**

$$R \propto \frac{1}{\pi r^2} \quad R \propto \frac{1}{I}$$

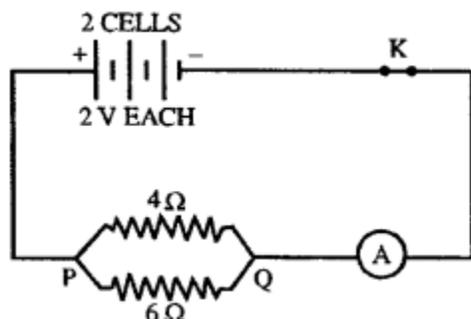
$\therefore I \propto \pi r^2$  i.e. more radius, more current.

So 20 A wire will be thicker, as it carries large current.

**Question 9.**

With reference to the given diagram, calculate

- (a) Equivalent resistance between P and Q.  
 (b) The reading of the ammeter.  
 (c) The electrical power between P and Q.



**Answer:**

(a) Equivalent resistance between P and Q

$$\frac{1}{R_p} = \frac{1}{4} + \frac{1}{6} = \frac{3+2}{12} = \frac{5}{12}$$

$$\therefore \frac{1}{R_p} = \frac{5}{12}$$

$$\therefore R_p = \frac{12}{5} = 2.4 \Omega$$

Equivalent resistance between P and Q =  $\boxed{2.4 \Omega}$  **Ans.**

(b) Ammeter reading

Key open = zero

P.D. of 2 cells =  $2 \times 2 = 4V$

$$\text{Key closed} = I = \frac{V}{R} = \frac{4}{2.4} = \frac{40}{24} = \frac{5}{3} A = 1.67 A \text{ **Ans.**}$$

(c) Power between P and Q

$$P = VI$$

$$= I^2 R$$

$$= \left(\frac{5}{3}\right)^2 \times \left(\frac{12}{5}\right) = \frac{25}{9} \times \frac{12}{5} = \frac{20}{3} = 6.67 W$$

**Question 10.**

Electrical power P is given by the expression :  $P = (Q \times V)$ , time.

(a) What do the symbols Q and V represent ?

(b) Express 'Power' in terms of current and resistance explaining the symbols used there in.

**Answer:**

(a) Q – Charge

V – Potential difference

$$(b) P = \frac{QV}{t} \quad \text{But } Q = It \therefore P = \frac{VI t}{t} = VI$$

But  $V = IR$

$$\therefore P = IRI = \boxed{I^2R}$$

P = Power (electrical)

I – Current flowing

R – Resistance

t – Time

2004

**Question 11.**

State the purpose of a fuse in an electric circuit. Name the material required for making a fuse wire.

**Answer:**

**Purpose of Fuse :**

1. The fuse limits the current in electric circuit and acts as a safety device.
2. It saves us and protects us and our expensive appliances when circuit gets over loaded or higher current flows as the fuse blows off and current supply stops.  
Material used for making fuse wire is Lead and Tin alloy.

**Question 12.**

An electric bulb is rated 240V – 60 W and is working at 100% efficiency.

(a) Calculate the resistance of the bulb.

(b) If an identical bulb is connected in series with this bulb then:

1. Draw the circuit diagram.

2. What is the rate of conversion of energy in each bulb ?
3. Total power used by the bulbs.

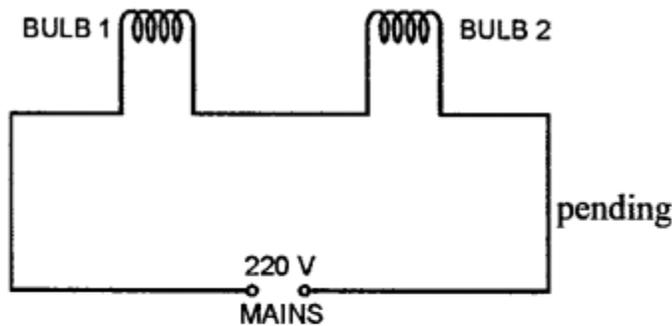
**Answer:**

(a)  $P = 60 \text{ w}$                        $V = 240 \text{ v}$

$$P = \frac{V^2}{R} \qquad \therefore R = \frac{V^2}{P} = \frac{240 \times 240}{60}$$

$$R = 960 \Omega$$

(b) (i)



(ii) Rate of conversion of energy in each bulb

$$E = W = \frac{P}{t} = \frac{60 \text{ w}}{1 \text{ sec}} = 60 \text{ Js}^{-1}$$

(iii) Power used by bulbs

$$\text{Total resistance of two bulbs in series} = R_1 + R_2 = 960 + 960 = 1920 \Omega$$

$$\text{Total power used} = P = \frac{V^2}{R} = \frac{240 \times 240}{1920} = 30 \text{ W}$$

2005

**Question 13.**

(a) In a three-pin plug, why is the earth pin made longer and thicker than the other two pins ?

**Answer:**

The earth pin is made longer and thicker, (i) So that earth connection is made first. This ensures the safety of the user because, (ii) It is made thick so that its resistance is low and any leakage of current flows easily into the earth

(b) An electrical appliance is rated 1500 W – 250 V. This appliance is connected to 250 V mains.

**Calculate :**

1. the current drawn,
2. the electrical energy consumed in 60 hours,
3. the cost of electrical energy consumed at Rs. 2.50 per KWH.

**Answer:**

(i) Power = 1500 W

Voltage = 250 V

(i)  $I = ?$

$$P = VI$$

$$I = \frac{P}{V} = \frac{1500}{250} = \boxed{6 \text{ A}} \text{ Ans.}$$

(ii) Electrical energy consumed in a hours  $E = p \times t = 1500 \times 60$

$$= 90,000 \text{ wh} = \boxed{90 \text{ kwh.}} \text{ Ans.}$$

(iii) Cost of electrical energy consumed per kWh = Rs. 2.50

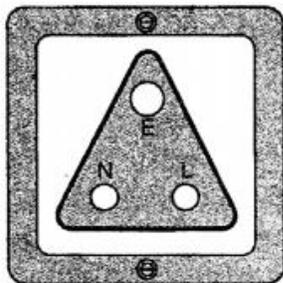
$$\text{Cost} = 90 \times 2.50 = 90 \times \frac{25}{10} = \boxed{\text{Rs. 225}} \text{ Ans.}$$

2006

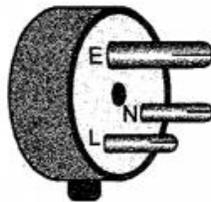
**Question 14.**

Draw a labelled diagram of a three-pin socket.

**Answer:**



Power socket



**Question 15.**

Find the cost of operating an electric toaster for 2 hours, if it draws a current of 8A on a 110 V circuit. The cost of electrical energy is Rs. 2.50 per kWh.

**Answer:**

$$P = VI \quad V = 110 \text{ volt}$$
$$= 110 \times 8 = 880 \text{ W} \quad I = 8\text{A}, \quad T = 2 \text{ hour}$$

$$= \frac{880}{1000} \text{ kW}$$

$$\therefore \text{Energy consumed in 2 hrs.} = \frac{880 \times 2}{100} = 1.76 \text{ kWh}$$

$$\text{Cost} = 1.76 \times 2.50 = 4.40$$

2007

**Question 16.**

Of the three connecting wires in a household circuit :

- (a) Which two of the three wires are at the same potential ?
- (b) In which of the three wires should the switch be connected ?

**Answer:**

- (a) Of the three wires, the Earth wire and the Neutral wire are at the same potential of zero.
- (b) The switch should be connected in the Live wire.

**Question 17.**

What is meant by earthing of an electrical appliance ? Why is it essential ?

**Answer:**

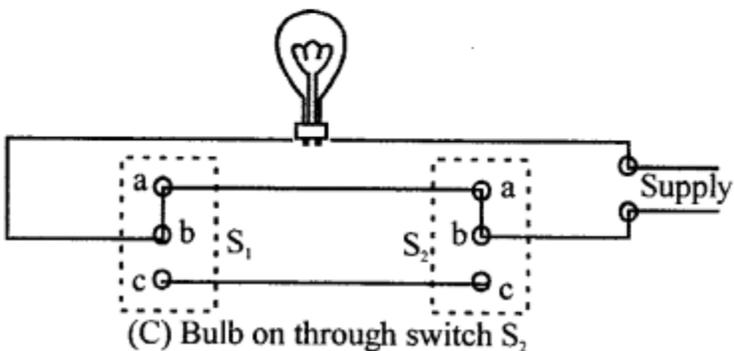
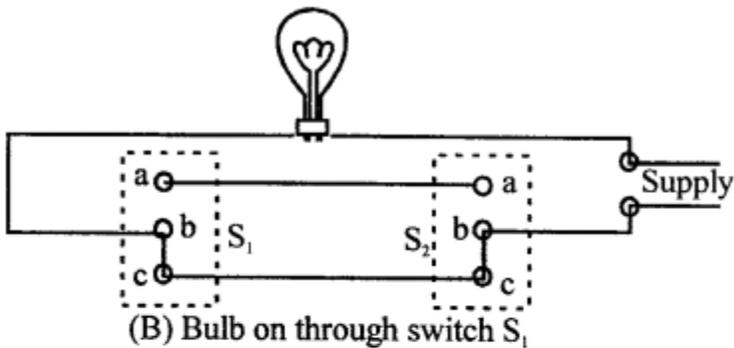
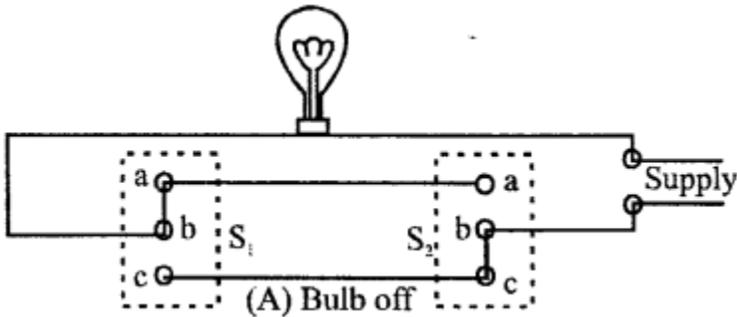
By earthing we mean that the metallic body of an electrical appliance is connected to thick wire of copper which is buried deep in the earth and at its end is a copper plate surrounded by a mixture of charcoal and common salt. It is essential to avoid any shock when the metal casing of the appliance happens to touch the live wire. The current due to short circuiting flows to the earth instead of through the human body.

2008

**Question 18.**

(a) Draw a labelled diagram of the staircase wiring for a dual control switch showing a bulb in the circuit.

**Answer:**



(b) The electrical gadgets used in a house such as bulbs, fans, heater, etc., are always connected in parallel, NOT in series. Give two reasons for connecting them in parallel.

**Answer:**

All electrical gadgets are connected in parallel because

1. All appliances will get same potential difference in parallel so flow of any one appliance is not affected on switching on or off, of other appliance.

2. In parallel arrangement if one appliance is switched off or fuses, other can effectively work.

(c) An electrical heater is rated 4 kW, 220 V. Find the cost of using this heater for 12 hours if one kWh of electrical energy costs Rs. 3.25.

**Answer:**

Power = 4 kW

Time = 12 hrs.

Cost per unit = Rs. 3.25

Total cost = Power (kW) × time (hrs.) × cost per unit  
 $= 4 \times 12 \times 3.25 = 48 \times 3.25 = \text{Rs. } 156$

**Question 19.**

How does the heat produced in a wire or a conductor depend upon the :

- (a) current passing through the conductor.  
(b) resistance of the conductor ?

**Answer:**

Heat produced in a conductor is directly proportional to  
(a) the square of current and (b) the resistance of conductor.

$$H = I^2 R t$$

$H \propto I^2$  i.e. square of current following

$H \propto R$  i.e. directly proportional to the resistance of conductor

**2009**

**Question 20.**

(a) An electric heater is rated 1000 W – 200 V. Calculate :

1. the resistance of the heating element.
2. the current flowing through it.

**Answer:**

$$\text{Power of heater} = 1000 \text{ W}$$

$$\text{P.D.} = 200 \text{ V}$$

$$R = ?$$

$$I = ?$$

$$P = \frac{V^2}{R} \text{ or } R = \frac{V^2}{P} = \frac{200 \times 200}{1000}$$

$$= 40 \Omega$$

$$V = IR$$

$$200 = I \times 40$$

$$I = 5 \text{ A}$$

(b) (i) Give two characteristic properties of copper wire which make it unsuitable for use as fuse wire.

(ii) Name the material which is used as a fuse wire ?

**Answer:**

(i) **Copper cannot be used as fuse wire because :**

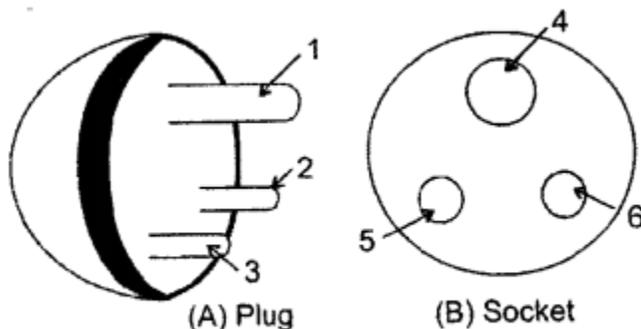
(a) it has high melting point

(b) low resistivity

(ii) **Alloy of lead and tin.**

**Question 21.**

(a) The diagrams (i) and (ii) given alongside are of a plug and a socket with arrows marked as 1, 2, 3 and 4, 5, 6 respectively on them. Identify and write Live (L), Neutral (N) and Earth (E) against the correct number.



(b) Calculate the electrical energy consumed when a bulb of 40 W is used for 12.5 hours

everyday for 30 days.

**Answer:**

$$(a) P = 1000 \text{ W}$$

$$V = 200 \text{ V}$$

$$(i) P = \frac{V^2}{R} \therefore R = \frac{V^2}{P} = \frac{200 \times 200}{1000}$$

$$R = 40 \Omega$$

$$(ii) I = \frac{V}{R} = \frac{200}{40} = 5 \text{ A}$$

(b) (i) (1) Copper has high melting point.

(2) Copper has low resistance.

(ii) Material used for fuse wire is lead-tin alloy.

(b) (i) E (4) E

(2) N (5) N

(3) L (6) L

(ii) Power = 40W

Time = 12.5 hrs  $\times$  30 days

Electrical Energy =  $P \times t$

$$= \frac{40}{1000} \times \frac{125}{10} \times 30 = 15 \text{ kWh}$$

**2010**

**Question 22.**

(a) Which part of an electrical appliance is earthed ?

(b) State a relation between electrical power, resistance and potential difference in an electrical circuit.

**Answer:**

(a) The metallic part of an electrical appliance is earthed.

(b) The required relation is  $P = \frac{V^2}{R}$  where P is power, V the potential difference and R is the resistance.

**Question 23.**

- (a) In what unit does the domestic electric meter measure the electrical energy consumed? State the value of this unit in S.I. Unit.
- (b) Why should switches always be connected to the live wire?
- (c) Give one precaution that should be taken while handling switches.

**Answer:**

1. The domestic electric meter measure, the electric energy in kWh.  
 $1 \text{ kWh} = 3.6 \times 10^6 \text{ J}$
2. The switch should always be connected to the live wire, so that current is cut off to that appliance to which it is connected.
3. The switches should not be touched with wet hand otherwise we may receive a shock.

**Question 24.**

Calculate the quantity of heat that will be produced in a coil of resistance  $75 \Omega$  if a current of  $2 \text{ A}$  is passed through it for 2 minutes.

**Answer:**

Here,  $R = 75 \Omega$ ,  $i = 2\text{A}$ ,  $t = 2 \text{ minutes} = 2 \times 60 = 120 \text{ s}$

Now, Heat produced

$$H = i^2 R t$$

$$= 2 \times 2 \times 75 \times 120 \text{ J} = 36000 \text{ J}$$

**2011**

**Question 25.**

- (a) Two bulbs are marked  $100 \text{ W}, 220 \text{ V}$  and  $60 \text{ W}, 110 \text{ V}$ . Calculate the ratio of their resistances.
- (b) (i) What is the colour code for insulation of earth wire?  
(ii) Write an expression for calculating electric power in terms of current and resistance.
- (c) (i) Name two safety devices which are connected to the live wire of a household electrical circuit.  
(ii) Give one important function of each of these devices.
- (d) (i) An electric bulb is marked  $100 \text{ W}, 250 \text{ V}$ . What information does this convey ?  
(ii) How much current will the bulb draw if connected to  $250 \text{ V}$  supply ?

**Answer:**

(a) We know that  $R = \frac{V^2}{P}$

The resistance  $R_1$  of the first bulb,  $R_1 = \frac{220 \times 220}{100} = 484\Omega$

and  $R_2 = \frac{110 \times 110}{60} = \frac{1210}{6} = 201.67\Omega$

$\therefore \frac{R_1}{R_2} = \frac{484}{1210} \times 6 = \frac{2.4}{1} = 2.4 : 1$

(b) (i) Yellow (ii)  $P = I^2R$

(c) (i) Connected devices are fuses (ii) Earthing (Earth wire)

(ii) **Fuse** : It is a safety device which is used to limit current in an electric circuit.

**Earth wire** : To save a person touching the defective appliance so that he does not get a shock and also to save the appliance from being damaged.

(d) (i)  $P = 100 \text{ W}$

$V = 250 \text{ V}$

It tells us that it will consume 100 watt at 250 V.

(ii)  $R = \frac{V^2}{P}$

$= \frac{250 \times 250}{100} = 625\Omega$

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

$= \frac{250}{625} = 0.4 \text{ A}$

### Question 26.

(a) An electrical appliance is rated at 1000 kVA, 220V. If the appliance is operated for 2 hours, calculate the energy consumed by the appliance in :

(i) kWh (ii) joule

(b) (i) What is the purpose of using a fuse in an electrical circuit?

(ii) What are the characteristic properties of a fuse wire ?

(c) (i) Write an expression for the electrical energy spent in the flow of current through an electrical appliance in terms of I, R and t.

(ii) At what voltage is the alternating current supplied to our houses ?

(iii) How should the electric lamps in a building be connected?

#### Answer:

(a) (i) Energy consumed in kWh = 1000 kVA × 2h = 2000 kWh.

(ii) Energy consumed in Joules = 1000 × 1000 VA × 2 × 3600 s  
= 7,200,000,000 J =  $7.2 \times 10^9$  J

(b) (i) The fuse wire melts and stops the flow of electric current in a given circuit, in case the circuit is overloaded or short circuited.

(ii) 1. Fuse wire should have low melting point around 200°C.

2. Fuse wire should have high electrical resistance.

(c) (i) Electrical energy (E) =  $I^2.R.t$ .

(ii) Alternating current is supplied at 220V for domestic consumption.

(iii) All lamps should be connected in parallel.

2013

### Question 27.

(a) (i) Name the device used to protect the electric circuits from overloading and short circuits.

(ii) On what effect of electricity does the above device work?

#### Answer:

1. Electric fuse.

2. It works on the heating effect of electric current.

(b)(i) An electrical gadget can give an electric shock to its user under certain circumstances. Mention any two of these circumstances.

(ii) What preventive measure provided in a gadget can protect a person from an electric shock ?

#### Answer:

(a) (i) The electrical gadget may be short circuited i.e., its live or neutral wire is touching its metallic body directly.

(ii) The hands of the user may be wet, such that water dripping from his hands makes contact with the live wire.

(b) The body of the electric gadget is connected to the earth terminal by means of earth

wire. In case of short circuit a huge surge of current flows through the earth terminal. This in turn melts fuse in the live wire and hence the flow or current stops in the gadget.

**2014**

**Question 28.**

(i) Two sets A and B, of the three bulbs each, are glowing in two separate rooms. When one of the bulbs in set A is fused, the other two bulbs, cease to glow. But in set B, when one bulb fuses, the other two bulbs continue to glow. Explain why this phenomenon occurs.

(ii) Why do we prefer arrangement of Set B for house hold circuiting?

**Answer:**

1. The bulbs of set A are connected in series. Therefore when one bulb fuse the current stop flowing. Whereas the bulbs of set B are connected in parallel. When one bulb fuse then current flows through the other bulb.
2. Set B prefer parallel combination because in it potential difference remains same.

**2015**

**Question 29.**

(a) **Fill in the blanks space.**

For a fuse, higher the current rating \_\_\_\_\_ is the fuse wire.

**Answer:**

For a fuse, higher the current rating, **thicker** is the fuse wire.

(b) (i) Name the device used to increase the voltage at a generating station.

(ii) At what frequency is AC supplied to residential houses?

(iii) Name the wire in a household electrical circuit to which the switch is connected.

**Answer:**

1. The device used to increase voltage at the generating station is the step-up transformer.
2. The residential houses are supplied with AC of frequency 50 Hz.
3. The switch is connected to the live (or phase) wire in a house-hold electric circuit.

**2016**

**Question 30.**

(a) Calculate the quantity of heat produced in a  $20\ \Omega$  resistor carrying 2.5 A current in 5 minutes.

**Answer:**

Given :  $R = 20 \Omega$ ,  $I = 2.5 \text{ A}$

$t = 5 \text{ minutes} = 5 \times 60 = 300 \text{ s}$

Quantity of heat produced is given as

$$H = I^2 \times R \times t$$

$$= (2.5)^2 \times 20 \times 300$$

$$\therefore H = 37500 \text{ J}$$

(b) State the characteristics required in a material to be used as an effective fuse wire.

**Answer:**

The material should have high resistivity and low melting point.

(c) (i) Which particles are responsible for current in conductors?

(ii) To which wire of a cable in power circuit should the metal case of a geyser be connected ?

(iii) To which wire should the fuse be connected ?

**Answer:**

1. Moving Electrons are responsible for current in conductors.
2. The metal case of a geyser should be connected to the Earth wire.
3. The fuse should always be connected to the live wire.