

### EXERCISE 8(C)

**Solution:**

The expression for the electrical energy spent in flow of current through an electrical appliance in terms of current, resistance and time is

$$\text{Electrical energy, } W = I^2Rt \text{ joule}$$

**Solution:**

(a) Expression for electrical power spent in flow of current through a conductor in terms of resistance and potential difference is

$$\text{Electrical Power, } P = V^2 / R$$

(b) Expression for electrical power spent in flow of current through a conductor in terms of current and resistance is

$$\text{Electrical Power, } P = I^2R$$

**Solution:**

(a) The symbol Q represents Charge and the symbol V represents Voltage

(b) Electrical Power,  $P = I^2R$

-where I represents current and R represents resistance

**Solution:**

Joule is the S.I. unit of electrical energy. It is related to Wh as

$$1 \text{ Wh} = 3600 \text{ J}$$

**Solution:**

The power of an appliance is 100 W. This means that 100 J of electrical energy is consumed by the appliance in 1 second.

**Question: 6**

**State the S.I. unit of electrical power.**

**Solution:**

Watt is the S.I. unit of electrical power.

**Question: 7**

**(i) State and define the household unit of electricity.**

**(ii) What is the voltage of the electricity that is generally supplied to a house?**

**(iii) What is consumed while using different electrical appliances, for which electricity bills are paid?**

**Solution:**

(i) Kilowatt hour (kWh) is the household unit of electricity. The electrical energy consumed by an electrical appliance of power 1 kW when it is used for one hour is One kilowatt hour (kWh)

(ii) The voltage of the electricity that is generally supplied to a house is 220 volt.

(iii) The electrical energy is consumed while using different electrical appliances, for which electricity bills are paid

**Question: 8**

**Name the physical quantity which is measured in (i) kW, (ii) kWh. (iii) Wh**

**Solution:**

(i) The quantity which is measured in kW is electrical power

(ii) The quantity which is measured in kWh is electrical energy

**Question: 9**

**Define the term kilowatt - hour and state its value in S.I. unit.**

**Solution:**

The electrical energy consumed by an electrical appliance of power 1 kW when it is used for one hour is one kilowatt hour (kWh). Its value in S.I. unit is  $1\text{kWh} = 3.6 \times 10^6 \text{ J}$

**Question: 10**

**How do kilowatt and kilowatt-hour differ?**

**Solution:**

Kilowatt- hour is the unit of electrical energy whereas the kilowatt is the unit of electrical power.

**Question: 11**

**Complete the following:**

(a)  $1 \text{ kWh} = (1 \text{ volt} \times 1 \text{ ampere} \times \dots\dots\dots) / 1000$

(b)

$1 \text{ kWh} = \underline{\hspace{2cm}} \text{ J}$

**Solution:**

(a)  $1 \text{ kWh} = (1 \text{ volt} \times 1 \text{ ampere} \times 1 \text{ hour}) / 1000$

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

**Question: 12**

**What do you mean by power rating of an electrical appliance? How do you use it to calculate (a) the resistance of the appliance and (b) the safe limit of the current in it, while in use?**

**Solution:**

The power rating of an electrical appliance such as electric bulb, geyser etc. is rated with power (P) and voltage (V). If an electric bulb is rated as 50 W – 220 V, it means that when the bulb is lighted on a 220 V supply, 50 W electrical power is consumed by it.

(a) To calculate the resistance of the appliance, the expression is:

$$\text{Resistance, } R = V^2 / P$$

(b) The safe limit of current in it, while in use is

$$I = P / V$$

**Question: 13**

**An electric bulb is rated ‘100 W, 250 V’. What information does this convey?**

**Solution:**

An electric bulb is rated ‘100 W, 250 V’ means that if the bulb is lighted on a 250 V supply, it consumes 100 W electric power (which means 100 J of electrical energy is converted into the light and heat energy in 1 second in the filament).

**Question: 14**

**List the names of three electrical gadgets used in your house. Write their power, voltage rating and approximate time for which each one is used in a day. Hence find the electrical energy consumed by each in a month of 30 days.**

**Solution:**

Appliance	Power (in watt)	Voltage (in volts)	Time (hours)	Electrical energy ( $E = P \times t$ )
Television set	120	220	4	0.48 kWh
Refrigerator	150	220	24	3.6 kWh
Fluorescent tube	40	220	12	0.48 kWh

**Question: 15**

Two lamps, one rated 220 V, 50 W and the other rated 220 V, 100 W, are connected in series with mains of voltage 220 V. Explain why does the 50 W lamp consume more power.

**Solution:**

Resistance of 220 V, 50 W lamp is

$$R_1 = V^2 / P_1$$

$$R_1 = (220)^2 / 100$$

$$R_1 = 968 \text{ ohm}$$

Resistance of 220 V, 100 W lamp is

$$R_2 = V^2 / P_2$$

$$R_2 = (220)^2 / 100$$

$$R_2 = 484 \text{ ohm}$$

Same current  $I$  passes through each lamp because the two lamps are connected in series.

Power consumed in 220 V, 50 W lamp is

$$P_1 = I^2 R_1$$

Power consumed in 220 V, 100 W lamp is

$$P_2 = I^2 R_2$$

Here,  $R_1 > R_2$

So,  $P_1 > P_2$

Thus 50 W lamp consumes more power

**Question: 16**

Name the factors on which the heat produced in a wire depends when current is passed in it, and state how does it depend on the factors stated by you.

**Solution:**

The amount of heat produced in a wire on passing current through it, depends on the following three factors.

- (i) The amount of current passing through the wire
- (ii) The resistance of wire and

(iii) The time for which current is passed in the wire

(i) Dependence of heat produced on the current in wire: The amount of heat  $H$  produced in the wire is directly proportional to the square of current  $I$  passing through the wire, i.e.,  $H \propto I^2$

(ii) Dependence of heat produced on the resistance of wire: The amount of heat  $H$  produced in the wire is directly proportional to the resistance  $R$  of the wire, i.e.,  $H \propto R$

(iii) Dependence of heat produced on the time: The amount of heat  $H$  produced in a wire is directly proportional to the time  $t$  for which current is passed in the wire i.e.,  $H \propto t$

### MULTIPLE CHOICE TYPE

#### Question: 1

When a current  $I$  flows through a resistance  $R$  for time  $t$ , the electrical energy spent is:

- (a)  $IRt$
- (b)  $I^2Rt$
- (c)  $IR^2t$
- (d)  $I^2R/t$

#### Solution:

The electrical energy spent when a current  $I$  flows through a resistance  $R$  for time  $t$  is  $I^2Rt$

#### Question: 2

An electrical appliance has a rating 100 W, 120 V. The resistance of element of appliance when in use is:

- (a) 1.2 ohm
- (b) 144 ohm
- (c) 120 ohm
- (d) 100 ohm

#### Solution:

The resistance of element of appliance when in use is 144 ohm

### NUMERICALS

#### Question: 1

An electric bulb of resistance 500 ohm draws current 0.4 A from the source.

Calculate: (a) the power of bulb and (b) the potential difference at its end.

#### Solution:

Given

Resistance of electric bulb ( $R$ ) = 500 ohm

Current drawn from the source ( $I$ ) = 0.4 A

(a) Power of the bulb ( $P$ ) =  $VI$

$$V = I \times R$$

$$V = 0.4 \times 500$$

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

(b) The potential difference at its end is 200 V

Therefore,

$$\text{Power (P)} = VI$$

$$P = 200 \times 0.4$$

$$P = 80 \text{ W}$$

Hence, the power of the bulb is 80 Watt

**Question: 2**

A current of 2 A is passed through a coil of resistance 75  $\Omega$  for 2 minutes. (a) How much heat energy is produced? (b) How much charge is passed through the resistance?

**Solution:**

Given,

$$\text{Current (I)} = 2 \text{ A}$$

$$\text{Resistance, R} = 75 \Omega$$

$$\text{Time, t} = 2 \text{ min or } 120 \text{ s}$$

$$\text{(a) Heat produced, H} = I^2Rt \text{ or}$$

$$H = (2)^2 (75) (120) \text{ J} = 36000 \text{ J}$$

$$\text{(b) Charge passed through the resistance, Q} = It \text{ or}$$

$$Q = (2) (120) \text{ C}$$

$$Q = 240 \text{ C}$$

**Question: 3**

Calculate the current through a 60 W lamp rated for 250 V. If the line voltage falls to 200 V, how is power consumed by the lamp affected?

**Solution:**

Given,

$$\text{Power, P} = 60 \text{ W}$$

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

We know that,

$$\text{Power, P} = VI$$

$$I = P / V$$

$$I = 60 / 250$$

$$I = 0.24 \text{ A}$$

$$\text{Resistance of lamp R} = V^2 / P$$

$$R = (250)^2 / 60$$

$$R = 1041.6 \text{ ohm}$$

If voltage falls to 200 V, then the power consumed will be

$$P = V^2 / R$$

$$P = (200)^2 / 1041.6$$

$$P = 38.4 \text{ W}$$

Hence, consumed reduces to 38.4 W

**Question: 4**

**An electric bulb is rated '100 W, 250 V'. How much current will the bulb draw if connected to a 250 V supply?**

**Solution:**

Given,

$$\text{Power, } P = 100 \text{ W}$$

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

We know that,

$$\text{Power, } P = VI$$

$$I = P / V$$

$$I = 100 / 250$$

$$I = 0.4 \text{ A}$$

**Question: 5**

**An electric bulb is rated at 220 V, 100 W. (a) What is its resistance? (b) What safe current can be passed through it?**

**Solution:**

(a) Given,

$$\text{Power, } P = 100 \text{ W}$$

$$\text{Voltage, } V = 220 \text{ V}$$

We know that,

$$\text{Power, } P = V^2 / R$$

$$R = (220)^2 / 100$$

$$R = 484 \text{ ohm}$$

(b) The safe limit of current that can be passed through it is

$$I = P / V$$

$$I = 100 / 220$$

$$I = 0.45 \text{ A}$$

**Question: 6**

**A bulb of power 40 W is used for 12.5 h each day for 30 days. Calculate the electrical energy consumed.**

**Solution:**

Energy consumed for each day,  $E = P \times t$

$$E = 40 \times 12.5$$

$$E = 500 \text{ Wh}$$

Energy consumed for 30 days

$$E = 500 \times 30$$

$$E = 15000 \text{ Wh}$$

$$E = 15 \text{ kWh}$$

**Question: 7**

**An electric press is rated '750 W, 230 V'. Calculate the electrical energy consumed by the press in 16 hours**

**Solution:**

Energy,  $E = \text{Power} \times \text{time}$

$$E = 750 \times 16$$

$$E = 12000 \text{ Wh}$$

$$E = 12 \text{ kWh}$$

**Question: 8**

**An electrical appliance having a resistance of 200 ohm is operated at 200 V. Calculate the energy consumed by the appliance in 5 minutes (i) in joule, (ii) in kWh**

**Solution:**

Given,

Resistance,  $R = 200 \text{ ohm}$

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

Time,  $t = 5 \text{ minutes}$

$$t = 5 \times 60 \text{ sec}$$

$$t = 300 \text{ sec}$$

As we know,

Energy,  $E = V^2t / R$

(i) In joules

$$E = [(200)^2 \times 300] / 200$$

$$E = 60000 \text{ J}$$

(ii) In kWh

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

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

$$60000 \text{ J} = 60000 / 3.6 \times 10^6$$

$$60000 \text{ J} = 0.0167 \text{ kWh}$$

**Question: 9**

A bulb rated 12 V, 24 W operates on a 12 volt battery for 20 minutes. Calculate:

- (i) the current flowing through it, and
- (ii) the energy consumed.

**Solution:**

Given,

Power,  $P = 24 \text{ W}$

Voltage,  $V = 12 \text{ V}$

Current,  $I = ?$

We know that,

Power,  $P = VI$

(i) The current flowing through it is

$$I = 24 / 12$$

$$I = 2 \text{ A}$$

(ii) Energy,  $E = P \times t$

$$E = 24 \times 20 \times 60$$

$$E = 28,800 \text{ J}$$

**Question: 10**

A current of 0.2 A flows through a wire whose ends are at a potential difference of 15 V. Calculate:

- (i) The resistance of the wire, and
- (ii) The heat energy produced in 1 minute.

**Solution:**

**Given,**

Current,  $I = 0.2 \text{ A}$

Potential difference,  $V = 15 \text{ V}$

Time,  $t = 60 \text{ sec}$

As  $V = IR$

(a) To calculate the resistance of the wire

$$R = V / I$$

$$R = 15 / 0.2$$

$$R = 75 \text{ ohm}$$

(b) To calculate the heat energy produced in 1 minute

Heat energy,  $H = I^2Rt$

$$H = (0.2)^2 \times 75 \times 60$$

$$H = 180 \text{ J}$$

**Question: 11**

**What is the resistance, under normal working conditions, of an electric lamp rated at '240 v', 60 W? If two such lamps are connected in series across a 240 V mains supply, explain why each one appears less bright.**

**Solution:**

Given,

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

$$\text{Power, } P = 60 \text{ W}$$

We know that,

$$P = V^2 / R$$

$$R = V^2 / P$$

$$R = (240)^2 / 60$$

$$R = 960 \text{ ohm}$$

$$I = P / V$$

$$I = 60 / 240$$

$$I = 0.25 \text{ A}$$

Thus when one lamp is connected across the mains, it draws 0.25 A current. If two such lamps are connected in series across the mains, current through each bulb becomes  $[240 / (960 + 960) \text{ ohm}] = 0.125 \text{ A}$  (i.e., current is halved.) Hence, heating ( $= I^2Rt$ ) in each bulb becomes one fourth, so each bulb appears less bright.

**Question: 12**

**Two bulbs are rated 60 W, 220 V and 60 W, 110 V respectively. Calculate the ratio of their resistances.**

**Solution:**

Given,

$$\text{Voltage, } V_1 = 220 \text{ V}$$

$$V_2 = 110 \text{ V}$$

$$\text{Power, } P_1 = P_2 = P = 60 \text{ W}$$

We know that,  $R = V^2 / P$

$$R_1 = V_1^2 / P$$

$$R_1 = (220)^2 / 60$$

$$R_2 = V_2^2 / P$$

$$R_2 = (110)^2 / 60$$

Now, dividing  $R_1$  and  $R_2$  we get,

$$R_1 / R_2 = [(220)^2 / 60] / [(110)^2 / 60]$$

$$R_1 / R_2 = 4 / 1$$

$$R_1 : R_2 = 4 : 1$$

**Question: 13**

An electric bulb is rated 250 W, 230 V.

(i) the energy consumed in one hour, and

(ii) the time in which the bulb will consume 1.0 kWh energy when connected to 230 V mains?

**Solution:**

Given,

Power,  $P = 250 \text{ W}$

Voltage,  $V = 230 \text{ V}$

(i) Energy,  $E = P \times t$

Time,  $t = 1 \times 60 \times 60$

$t = 3600 \text{ sec}$

We know that,

$E = 250 \times 3600$

$E = 9 \times 10^5 \text{ J}$

(ii)  $1000 \text{ Wh} = 250 \times t$

time,  $t = 1000 / 250$

$t = 4 \text{ hours}$

**Question: 14**

Three heaters each rated 250 W, 100 V are connected in parallel to a 100 V supply.

Calculate:

(i) The total current taken from the supply,

(ii) The resistance of each heater, and

(iii) The energy supplied in kWh to the three heaters in 5 hours.

**Solution:**

Given,

Power,  $P = 250 \text{ W}$

Voltage,  $V = 100 \text{ V}$

(i) Current through each heater,  $I = ?$

As  $P = VI$

$I = P / V$

$I = 250 / 100$

$I = 2.5 \text{ A}$

$\therefore$  Current taken for the three heaters

$= 3 \times 2.5$

$= 7.5 \text{ A}$

(ii) Resistance for each heater,  $R = V / I$

$R = 100 / 2.5$

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

(iii) Time for which energy is supplied,  $t = 5 \text{ h}$

$$\text{Energy, } E = P \times t$$

$$E = 250 \times 5$$

$$E = 1250 \text{ Wh}$$

$$E = 1.25 \text{ kWh}$$

$$\text{Energy for three heaters} = 3 \times 1.25$$

$$= 3.75 \text{ kWh}$$

**Question: 15**

**A bulb is connected to a battery of p.d. 4 V and internal resistance 2.5 ohm. A steady current of 0.5 A flows through the circuit. Calculate:**

**(i) The total energy supplied by the battery in 10 minutes,**

**(ii) The resistance of the bulb, and**

**(iii) The energy dissipated in the bulb in 10 minutes.**

**Solution:**

Given,

$$\text{Voltage, } V = 4 \text{ V}$$

$$\text{Resistance of the battery, } R_B = 2.5 \text{ ohm}$$

$$\text{Current, } I = 0.5 \text{ A}$$

(i) Energy supplied by the battery,  $E = V^2t / R$

$$t = 10 \times 60$$

$$t = 600 \text{ sec}$$

$$R = V / I$$

$$R = 4 / 0.5$$

$$R = 8 \text{ ohm}$$

$$E = [(4)^2 \times 600] / 8$$

$$E = 1200 \text{ J}$$

(ii) Total resistance,  $R = 8 \text{ ohm}$

$$\text{Resistance of the battery, } R_B = 2.5 \text{ ohm}$$

$$\text{Resistance of the bulb, } R_b = 8 - 2.5 \text{ ohm}$$

$$R_b = 5.5 \text{ ohm}$$

(iii) Energy dissipated in the bulb in 10 min,  $E = I^2Rt$

$$E = (0.5)^2 \times 5.5 \times 600$$

$$E = 825 \text{ J}$$

**Question: 16**

**Two resistors A and B of 4 ohm and 6 ohm respectively are connected in parallel.**

**The combination is connected across a 6 volt battery of negligible resistance.**

**Calculate: (i) the power supplied by the battery, (ii) the power dissipated in each resistor.**

**Solution:**

Given,

Resistance,  $R_A = 4 \text{ ohm}$

Resistance,  $R_B = 6 \text{ ohm}$

Voltage,  $V = 6 \text{ V}$

(i) Since the resistances are connected in parallel

Equivalent Resistance,  $1 / R = 1 / R_A + 1 / R_B$

$$1 / R = 1 / 4 + 1 / 6$$

$$1 / R = 10 / 24$$

$$R = 2.4 \text{ ohm}$$

We know that,

Power,  $P = V^2 / R$

$$P = (6)^2 / 2.4$$

$$P = 15 \text{ W}$$

(ii) Power dissipation across each resistor,  $P = VI$

Current across resistor  $R_A$ ,  $I_A = V / R_A$

$$I_A = 6 / 4 = 1.5 \text{ A}$$

Power dissipation across resistor  $R_A$ ,

$$P = VI_A$$

$$P = 6 \times 1.5$$

$$P = 9 \text{ W}$$

(iii) Current across resistor  $R_B$ ,  $I_B = V / R_B$

$$I_B = 6 / 6$$

$$I_B = 1 \text{ A}$$

Power dissipation across resistor  $R_B$ ,

$$P = VI_B$$

$$P = 6 \times 1$$

$$P = 6 \text{ W}$$

**Question: 17**

**A battery of e.m.f. 15 V and internal resistance 2 ohm is connected to two resistors of resistances 4 ohm and 6 ohm joined in series. Find the electrical energy spent per minute in 6 ohm resistor.**

**Solution:**

Given,

e.m.f. of battery,  $V = 15 \text{ V}$

Internal resistance of battery,  $R_B = 2 \text{ ohm}$

Resistances given in circuit,

$$R_1 = 4 \text{ ohm and } R_2 = 6 \text{ ohm}$$

(i) When resistors are connected in series,

$$\text{Equivalent resistance, } R = R_B + R_1 + R_2$$

$$R = 12 \text{ ohm}$$

$$\text{Current in the circuit, } I = 15 / 12$$

$$I = 1.25 \text{ A}$$

Now,

$$\text{Voltage across resistor } R_2, V_2 = IR = 1.25 \times 6$$

$$V_2 = 7.50 \text{ V}$$

$$\text{Time, } t = 1 \text{ min} = 60 \text{ sec}$$

$$\text{Energy across } R_2, E = V^2 t / R$$

$$E = [(7.5)^2 \times 60] / 6$$

$$E = 562.5 \text{ J}$$

**Question: 18**

**Water in an electric kettle connected to a 220 V supply took 5 minutes to reach its boiling point. How long will it take if the supply had been of 200 V?**

**Solution:**

$$P = V^2 / R$$

$$\text{Heat gained} = (V^2 / R) \times t$$

$$(V_1^2 / R) \times t_1 = (V_2^2 / R) \times t_2$$

$$t_2 = (V_1 / V_2)^2 \times t_1$$

$$t_2 = (220 / 200)^2 \times 300$$

$$t_2 = 363 \text{ s}$$

$$t_2 = 6.05 \text{ min}$$

**Question: 19**

**An electric toaster draws current 8 A in a circuit with source of voltage 220 V. It is used for 2 h. Find the cost of operating the toaster if the cost of electrical energy is ₹ 4.50 per kWh**

**Solution:**

Given,

$$\text{Voltage, } V = 220 \text{ V}$$

$$\text{Current, } I = 8 \text{ A}$$

$$\text{Time, } t = 2 \text{ h}$$

$$\text{Energy, } E = VIt$$

$$E = 220 \times 8 \times 2$$

$$E = 3520 \text{ Wh}$$

$$E = 3.52 \text{ kWh}$$

Cost of energy = ₹ 4.50 per kWh

$$\begin{aligned} \therefore \text{Cost of 3.52 kWh of energy} &= ₹ 4.50 \times 3.52 \text{ kWh} \\ &= ₹ 15.84 \end{aligned}$$

**Question: 20**

An electric kettle is rated 2.5 kW, 250 V. Find the cost of running the kettle for two hours at ₹ 5.40 per unit.

**Solution:**

Given,

Power of kettle,  $P = 2.5 \text{ kW}$

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

Time,  $t = 2 \text{ h}$

As, Energy,  $E = P \times t$

$$E = 2.5 \times 2$$

$$E = 5 \text{ kWh}$$

Cost per unit of energy = ₹ 5.40

$$\text{Cost for 5 kWh of energy} = 5.40 \times 5 = ₹ 27$$

**Question: 21**

A geyser is rated 1500 W, 250 V. This geyser is connected to 250 V mains. Calculate:

(i) The current drawn,

(ii) The energy consumed in 50 hours, and

(iii) The cost of energy consumed at ₹ 4.20 per kWh.

**Solution:**

Given,

Power of geyser,  $P = 1500 \text{ W}$

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

(i) Current,  $I = P / V$

$$I = 1500 / 250$$

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

(ii) Time,  $t = 50 \text{ h}$

Energy,  $E = P \times t$

$$E = 1500 \times 50$$

$$E = 75000 \text{ Wh}$$

$$E = 75 \text{ kWh}$$

(iii) Cost per unit of energy = ₹ 4.20

$$\text{Cost for 75 kWh of energy} = 4.20 \times 75 = ₹ 315$$