Chapter
20

Heating and Chemical Effect of Current

Joules Heating

When some potential difference V is applied across a resistance R then the work done by the electric field on charge q to flow through the circuit in time t will be $W = qV = Vit = i^2Rt = \frac{V^2t}{R} Joule$. This work appears as thermal energy in the resistor.

Heat produced by the resistance R is $H = \frac{W}{J} = \frac{Vit}{4\cdot 2} = \frac{i^2Rt}{4\cdot 2} = \frac{V^2t}{4\cdot 2R} Cal.$ This relation is called joules heating.

Electric Power

The rate at which electrical energy is dissipated into other forms of energy is called electrical power *i.e.* $\boldsymbol{P = \frac{W}{t} = Vi = i^2R = \frac{V^2}{R}}$

(1) **Units :** It's S.I. unit is *Joule/sec* or *Watt*

Bigger S.I. units are *KW*, *MW* and *HP*, remember 1 *HP* = 746 *Watt*

(2) **Rated values :** On electrical appliances (Bulbs, Heater, Geyser …. *etc*.). Wattage, voltage, ……. *etc*. are printed called rated values *e.g.* If suppose we have a bulb of 40 *W*, 220 *V* then rated power (P_R) = 40 *W* while rated voltage (V_R) = 220 *V*.

(3) **Resistance of electrical appliance :** If variation of resistance with temperature is neglected then resistance of any electrical appliance can be calculated by rated power and rated voltage *i.e.* by using $\boldsymbol{R = \frac{V_R^2}{P_R}}$.

(4) **Power consumed (illumination) :** An electrical appliance (Bulb, heater, …. *etc*.) consume rated power (P_R) only if applied voltage (V_A) is equal to rated voltage (V_R) *i.e.* If $V_A = V_R$ so $P_{consumed} = P_R$. If $V_A < V_R$ then $P_{consumed} = \frac{V_A^2}{R}$ also we have $R = \frac{V_R^2}{P_R}$ so $\boldsymbol{P_{Consumed}\ (Brightness) = \left(\frac{V_A^2}{V_R^2}\right). P_R}$

(5) **Long distance power transmission :** When power is transmitted through a power line of resistance R, power-loss will be i^2R

Now if the power P is transmitted at voltage V then $P = Vi$ *i.e.* $i = (P/V)$ So, $\text{Power loss} = \frac{P^2}{V^2} \times R$

Now as for a given power and line, P and R are constant so $\text{Power loss} \propto (1/V^2)$

So if power is transmitted at high voltage, power loss will be small and vice-versa. This is why long distance power transmission is carried out at high voltage.

Electricity Consumption

(1) The price of electricity consumed is calculated on the basis of electrical energy and not on the basis of electrical power.

(2) The unit *Joule* for energy is very small hence a big practical unit is considered known as *kilowatt hour* (*KWH*) or board of trade unit (B.T.U.) or simple unit.

(3) 1 *KWH* or 1 unit is the quantity of electrical energy which dissipates in one hour in an electrical circuit when the electrical power in the circuit is 1 *KW* thus 1 *KWH* = 1000 *W* × 3600 *sec* = 3.6 × 10^6 *J*.

(4) Important formulae to calculate the no. of consumed units is $n = \frac{\text{Total } Watt \times \text{Total } Hours}{1000}$

Combination of Bulbs

(1) **Series combination**

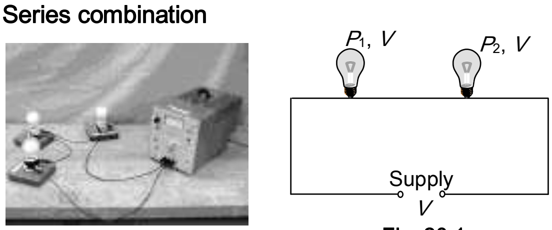


Fig. 20.1

(i) Total power consumed $\frac{1}{P_{total}} = \frac{1}{P_1} + \frac{1}{P_2} + ...$

(ii) If '*n*' bulbs are identical, $P_{total} = \frac{P}{N}$

(iii) $P_{consumed}$ (Brightness) $\propto V \propto R \propto \frac{1}{P_{rated}}$ *i.e.* in series combination bulb of lesser wattage will give more bright light and p.d. appeared across it will be more.

(2) **Parallel combination**

(i) Total power consumed $P_{total} = P_1 + P_2 + P_3 ...... + P_n$

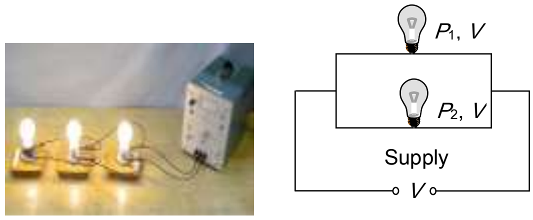


Fig. 20.2

(ii) If '*n*' identical bulbs are in parallel. $P_{total} = nP$

(iii) $P_{consumed}$ (Brightness) $\propto P_R \propto i \propto \frac{1}{R}$ *i.e.* in parallel combination, bulb of greater wattage will give more bright light and more current will pass through it.

Chemical Effect of Current

Current can produce or speed up chemical change, this ability of current is called chemical effect (shown by *dc* not by *ac*).

(1) **Electrolytes :** The liquids which allows the current to pass through them and also dissociates into ions on passing current through them are called electrolytes *e.g.* solutions of salts, acids and bases in water, *etc*.

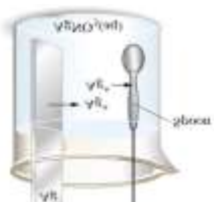
Those liquids which do not allow current to pass through them are called insulators (*e.g.* vegetable oils, distilled water *etc.*)

Solutions of cane sugar, glycerin, alcohol *etc*. are examples of non-electrolytes.

(2) **Electrolysis :** The process of decomposition of electrolyte solution into ions on passing the current through it is called electrolysis.

Practical applications of electrolysis are Electrotyping, extraction of metals from the ores, Purification of metals, Manufacture of chemicals, Production of O_2 and H_2, Medical applications and electroplating.

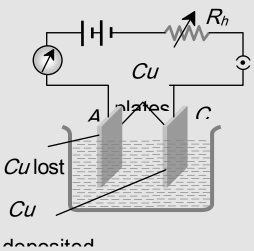
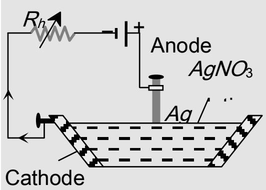
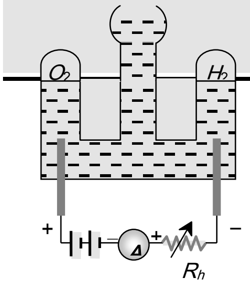
(3) **Electroplating :** It is a process of depositing a thin layer of one metal over another metal by the method of electrolysis. The articles of cheap metals are coated with precious metals like silver and gold to make their look more attractive. The



article to be electroplated is made the cathode and the metal to be deposited is made the anode. A soluble salt of the precious metal is taken as the electrolyte. (If gold is to be coated then auric chloride is used as electrolyte).

(4) **Voltameter :** The vessel in which the electrolysis is carried out is called a voltameter. It contains two electrodes and electrolyte. It is also known as electrolytic cell.

Table 20.1 : Types of voltameters

Volatameter	Anode/ cathode	Electrolyte	Deposition
Cu voltameter 	Cathode may be of any material but anode must be of *Cu*	$CuSO_4$ or $CuCl_2$	At cathode *Cu* deposited
Ag voltameter 	Cathode may be of any material but anode must be of *Ag*	$AgNO_3$	At cathode *Ag* deposited
Water voltameter 	Both electrode are made of platinum (*Pt*)	Acidulated water	H_2 and O_2 gases are collects over the cathode and anode respectively in the ratio of 2 : 1

Faraday's Law of Electrolysis

(1) **First law :** It states that the mass (m) of substance deposited at the cathode during electrolysis is directly proportional to the quantity of electricity (total charge q) passed through the electrolyte *i.e.* $m \propto q$ or $\boldsymbol{m = zq = zit}$, where the constant of proportionality z is called *electrochemical equivalent* (*E.C.E.*) *of the substance.*

Therefore we have $m = zit$. If q = 1 *coulomb*, then we have $m = z \times 1$ or $z = m$

Hence, the electrochemical equivalent of substance may be defined as the mass of its substance deposited at the cathode, when one *coulomb* of charge passes through the electrolyte.

S.I. unit of electrochemical equivalent of a substance is *kilogram coulomb*$^{-1}$ ($kg\text{-}C^{-1}$).

Table 20.2 : E.C.E. for certain substances

Element	Atomic weight	Atomic number	Valency	E.C.E. (Z) in kg/C
Hydrogen	1.0008	1	1	10.4×10^{-9}
Oxygen	15.999	8	2	82.9×10^{-9}
Aluminium	26.982	13	3	93.6×10^{-9}
Chromium	51.996	24	3	179.6×10^{-9}
Nickel	58.710	28	2	304.0×10^{-9}
Copper	63.546	29	2	329.4×10^{-9}
Zinc	65.380	30	2	338.7×10^{-9}
Silver	107.868	47	1	1118×10^{-9}
Gold	196.966	79	3	681.2×10^{-9}

(2) **Second law :** If same quantity of electricity is passed through different electrolytes, masses of the substance

deposited at the respective cathodes are directly proportional to their chemical equivalents *i.e.* $m \propto E \Rightarrow \frac{m_1}{m_2} = \frac{E_1}{E_2}$

Let m be the mass of the ions of a substance liberated, whose chemical equivalent is E. Then, according to Faraday's second law of electrolysis, $m \propto E$ or m = constant × E or $\frac{m}{E} = \text{constant}$

Chemical equivalent E also known as equivalent weight in *gm i.e.* $E = \frac{\text{Atomic mass }(A)}{\text{Valancy }(V)}$

(3) **Relation between chemical equivalent and electrochemical equivalent :** Suppose that on passing same amount of electricity q through two different electrolytes, masses of the two substances liberated are m_1 and m_2. If E_1 and E_2 are their chemical equivalents, then from Faraday's second law, we have $\frac{m_1}{m_2} = \frac{E_1}{E_2}$. Also from Faraday's first law $\frac{m_1}{m_2} = \frac{z_1}{z_2}$

So $\frac{z_1}{z_2} = \frac{E_1}{E_2} \Rightarrow z \propto E$

(4) **Faraday constant :** As we discussed above $E \propto z$

$\Rightarrow E = Fz \Rightarrow z = \frac{E}{F} = \frac{A}{VF}$. '$F$' is proportionality constant called Faraday's constant.

As $z = \frac{E}{F}$ and $z = \frac{m}{Q}$ so $\frac{E}{F} = \frac{m}{Q}$ hence if Q = 1 *Faraday* then $E = m$ *i.e.* If electricity supplied to a voltameter is 1 Faraday then amount of substance liberated or deposited is (in *gm*) equal to the chemical equivalent.

Electro Chemical Cell

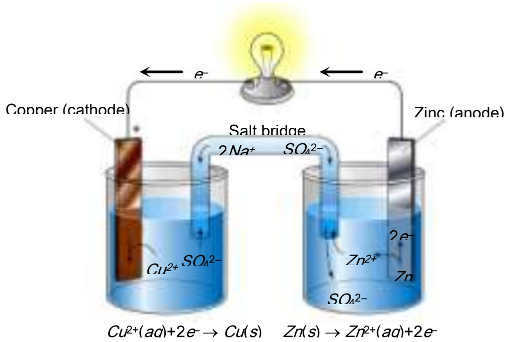


Fig. 20.4

It is an arrangement in which the chemical energy is converted into electrical energy due to chemical action taking place in it.

(1) **Primary cell :** Is that cell in which electrical energy is produced due to chemical energy. In the primary cell, chemical reaction is irreversible. This cell can not be recharged. Examples of primary cells are Voltaic cell, Daniel cell, Leclanche cell and Dry cell *etc.*

(2) **Secondary cell :** A secondary cell is that cell in which the electrical energy is first stored up as a chemical energy and when the current is taken from the cell, the chemical energy is reconverted into electrical energy. In the secondary cell chemical reactions are reversible. The secondary cells are also called storage cell or accumulator. The commonly used secondary cells is lead accumulator.

(3) **Defects In a primary cell :** In voltaic cell there are two main defects arises.

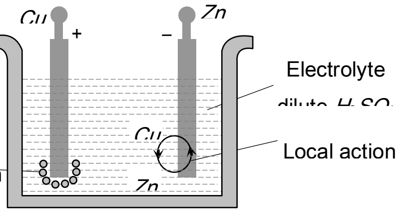


Fig. 20.5

Local action : It arises due to the presence of impurities of iron, carbon etc. on the surface of commercial Zn rod used as an electrode. The particles of these impurities and Zn in contact with sulphuric acid form minute voltaic cell in which small local electric currents are set up resulting in the wastage of Zn even when the cell is not sending the external current.

Removal : By amalgamating Zn rod with mercury (*i.e.* the surface of Zn is coated with Hg).

Polarisation : It arises, when the positive H_2 ions, which are formed by the action of Zn on sulphuric acid, travel towards the Cu rod and after transferring, the positive charge converted into H_2 gas atoms and get deposited in the form of neutral layer of a gas on the surface of Cu rod. This weakens the action of cell.

Removal : Either by brushing the anode the remove the layer or by using a depolariser (*i.e.* some oxidising agent MnO_2, $CuSO_4$ *etc* which may oxidise H_2 into water).

Thermo electric effect of current

If two wires of different metals are joined at their ends so as to form two junctions, then the resulting arrangement is called a "**Thermo couple**".

Seeback Effect

(1) **Definition :** When the two junctions of a thermo couple are maintained at different temperatures, then a current starts flowing through the loop known as thermo electric current. The potential difference between the junctions is called thermo electric emf which is of the order of a few micro-volts per degree temperature difference ($\mu V/^{o}C$).

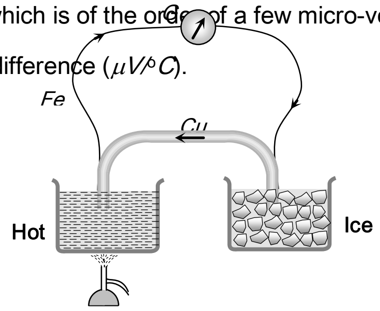


Fig. 20.6

(2) **Seebeck series :** The magnitude and direction of thermo emf in a thermocouple depends not only on the temperature difference between the hot and cold junctions but also on the nature of metals constituting the thermo couple.

(i) Seebeck arranged different metals in the decreasing order of their electron density. Few metals forming the series are as below.

Sb, *Fe*, *Cd*, *Zn*, *Ag*, *Au*, *Cr*, *Sn*, *Pb*, *Hg*, *Mn*, *Cu*, *Pt*, *Co*, *Ni*, *Bi*

(ii) Thermo electric emf is directly proportional to the distance between the two metals in series. Farther the metals in the series forming the thermo couple greater is the thermo emf. Thus maximum thermo emf is obtained for ***Sb-Bi*** thermo couple.

(iii) The current flow at the hot junction of the thermocouple is from the metal occurring later in the series towards that occurring earlier, Thus, in the ***copper-iron*** thermocouple the current flows from copper (*Cu*) to iron (*Fe*) at the hot junction. This may be remembered easily by the **hot coffee**.

(3) **Variation of thermo emf with temperature :** In a thermocouple as the temperature of the hot junction increases keeping the cold junction at constant temperature (say $0^{o}C$). The thermo emf increases till it becomes maximum at a certain temperature.

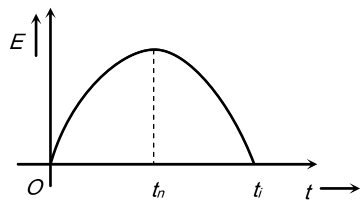


Fig. 20.7

(i) Thermo electric emf is given by the equation $E = \alpha t + \frac{1}{2}\beta t^2$ where α and β are thermo electric constant having units are $volt/^{o}C$ and $volt/^{o}C^2$ respectively (t = temperature of hot junction). For E to be maximum (at $t = t_n$)

$$\frac{dE}{dt} = 0 \;\; i.e. \;\; \alpha + \beta t_n = 0 \Rightarrow t_\eta = -\frac{\alpha}{\beta}$$

(ii) The temperature of hot junction at which thermo emf becomes maximum is called neutral temperature (t_n). Neutral temperature is constant for a thermo couple (*e.g.* for *Cu-Fe*, $t_n = 270^{o}C$)

(iii) Neutral temperature is independent of the temperature of cold junction.

(iv) If temperature of hot junction increases beyond neutral temperature, thermo emf start decreasing and at a particular temperature it becomes zero, on heating slightly further, the direction of emf is reversed. This temperature of hot junction is called temperature of inversion (t_i).

(v) Relation between t_n, t_i and t_c is $t_n = \frac{t_i + t_c}{2}$

(4) **Thermo electric power :** The rate of change of thermo emf with the change in the temperature of the hot junction is called thermoelectric power.

It is also given by the slope of parabolic curve representing the variation of thermo emf with temperature of the hot junction, as discussed in previous section.

The thermo electric power $\left(\frac{dE}{dt}\right)$ is also called **Seebeck coefficient**. Differentiating both sides of the equation of thermo emf with respect to t, we have thermoelectric power $P = \frac{dE}{dt} = \frac{d}{dt}(\alpha t + \frac{1}{2}\beta t^2)$

$\Rightarrow P = \alpha + \beta t$

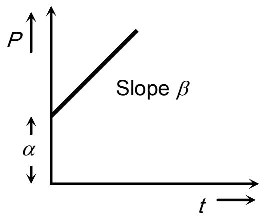


Fig. 20.8

The equation of the thermo electric power is of the type $y = mx + c$, so the graph of thermo electric power is as shown.

(5) **Laws of thermoelectricity**

(i) **Law of successive temperature :** If initially temperature limits of the cold and the hot junction are t_1 and t_2, say the thermo emf is $E_{t_1}^{t_2}$. When the temperature limits are t_2 and t_3, then say the thermo emf is $E_{t_2}^{t_3}$ then $E_{t_1}^{t_2} + E_{t_2}^{t_3} = E_{t_1}^{t_3}$ where $E_{t_1}^{t_3}$ is the thermo emf when the temperature limits are $E_{t_1}^{t_3}$

(ii) **Law of intermediate metals :** Let *A*, *B* and *C* be the three metals of Seebeck series, where *B* lies between *A* and *C*. According to this law, $E_A^B + E_B^C = E_A^C$

When tin is used as a soldering metal in *Fe-Cu* thermocouple then at the junction, two different thermo couples are being formed. One is between iron and tin and the other is between tin and copper, as shown in figure

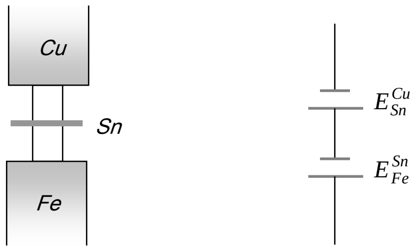


Fig. 20.9

If the soldering metal does not lie between two metals (in Seebeck series) of thermocouple then the resultant emf will be subtractive.

Peltier Effect

When current is passed through a junction of two different metals, the heat is either evolved or absorbed at the junction. This effect is known as Peltier effect. It is the reverse of Seebeck effect. (When a positive charge flows from high potential to low potential, it releases energy and when positive charge flows from low potential to high potential it absorbs energy.)

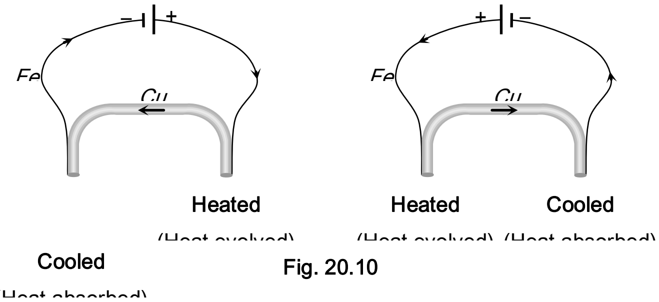


Fig. 20.10

Peltier co-efficient (π) : Heat absorbed or liberated at the junction is directly proportional to the charge passing through the junction *i.e.* $H \propto Q \Rightarrow H = \pi Q$; where π is called Peltier co-efficient. It's unit is *J/C* or *volt*.

Peltier co-efficient of a junction is the amount of heat absorbed or liberated per sec. When 1 *amp* of current is passed to the thermo couple.

It is found that $\pi = T\frac{dE}{dT} = T \times S$; where T is in Kelvin and $\frac{dE}{dT} = P =$ Seebeck coefficient S

Thomson's Effect

In Thomson's effect we deal with only metallic rod and not with thermocouple as in Peltiers effect and Seebeck's effect. (That's why sometimes it is known as homogeneous thermo electric effect. When a current flows thorough an unequally heated metal, there is an absorption or evolution of heat in the body of the metal. This is Thomson's effect.

(i) **Positive Thomson's effect :** In positive Thomson's effect it is found that hot end is at high potential and cold end is at low potential. Heat is evolved when current is passed from hotter end to the colder end and heat is absorbed when current is passed from colder end to hotter end. The metals which shows positive Thomson's effect are *Cu*, *Sn*, *Ag*, *Cd*, *Zn*... *etc*.

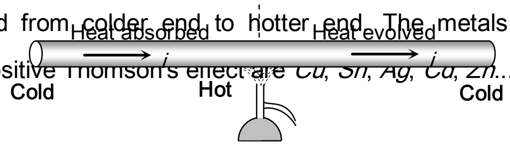


Fig. 28.11

(ii) **Negative Thomson's effect :** In the elements which show negative Thomson's effect, it is found that the hot end is at low potential and the cold end is at higher potential. Heat is evolved when current is passed from colder end to the hotter end and heat is absorbed when current flows from hotter end to colder end. The metals which shows negative. Thomson's effect are *Fe*, *Co*, *Bi*, *Pt*, *Hg* ... *etc*.

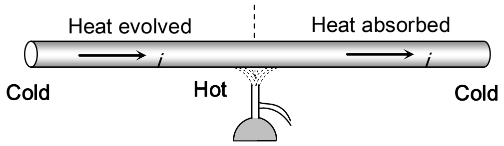


Fig. 20.12

Thomson's co-efficient : In Thomson's effect it is found that heat released or absorbed is proportional to $Q\Delta\theta$ *i.e.* $H \propto Q\Delta\theta$ $\Rightarrow H = \sigma Q\Delta\theta$ where σ = Thomson's coefficient. It's unit is *Joule/coulomb°C* or *volt/°C* and $\Delta\theta$ = temperature difference.

If Q = 1 and $\Delta\theta$ = 1 then $\sigma = H$ so the amount of heat energy absorbed or evolved per second between two points of a conductor having a unit temperature difference, when a unit current is passed is known as Thomson's co-efficient for the material of a conductor.

It can be proved that Thomson co-efficient of the material of conductor $\sigma = -T\frac{d^2E}{dT^2} = -T\left(\frac{dS}{dT}\right) = T \times \beta$; where β = Thermo electric constant $= \frac{dS}{dt}$

Application of Thermo Electric Effect

(1) **To measure temperature :** A thermocouple is used to measure very high (2000°*C*) as well as very low (– 200°*C*) temperature in industries and laboratories. The thermocouple used to measure very high temperature is called pyrometer.

(2) **To detect heat radiation :** A thermopile is a sensitive instrument used for detection of heat radiation and measurement of their intensity. It is based upon Seebeck effect.

A thermoppile consists of a number of thermocouples of *Sb-Bi*, all connected in series.

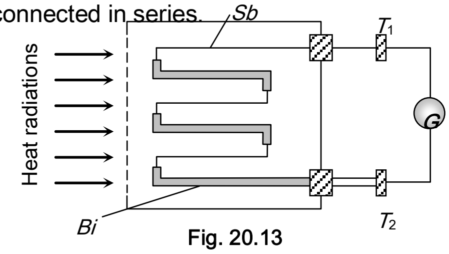


Fig. 20.13

Table 20.3: Heating effect and Thermo-electric effects

S.No.	Joule's effect	Peltier's effect	Seebeck effect	Thomson's effect
1.	Heat produced is directly proportional to the square of the current passing through a	Heat produced or absorbed at a junction is proportional to the current through the junction.	Here temperature difference of junction is used to produce thermo e.m.f. and vice versa.	Thomson's heat is proportional to the current passing through the conductor.

	conductor.			
2.	This effect is produced due to collision of free electrons with positive ions of the current carrying conductor.	This effect is produced when current is passed through junction of suitable materials.	This effect produced when junctions of a themocouple are kept at different temperatures.	This effect is produced when parts of same conductor are kept at different temperature.
3.	It is not a reversible effect.	It is a reversible effect	It is a reversible effect	It is a reversible effect
4.	Heat produced depends upon resistance (and thus temperature also) of the conductor.	Heat exchange depends upon nature of conductors and temperature of the junctions.	This effect depends upon nature of materials used to form junctions and temperature of junctions.	This effect depends upon nature of conductor and temperature difference of different parts of the conductor.
5.	It is basically a heating effect	It can be heating as well as cooling effect.	Different junctions are at different temperature.	It is heating as well as cooling effect.

This instrument is so sensitive that it can detect heat radiations from a match stick lighted at a distance of 50 *metres* from the thermopile.

(3) **Thermoelectric refrigerator :** The working of thermo-electric refrigerator is based on Peltier effect.

(4) **Thermoelectric generator :** Thermocouple can be used to generate electric power using Seebeck effect in remote areas.

(5) **Thero-couple meter :** The current to be measured passes through a resistance where heat is generated in the amount of i^2R *joule/sec*. The hot junction of the thermocouple is in contact with this resistance, and resulting thermoelectic current gives deflection in the galvanometer *G*.

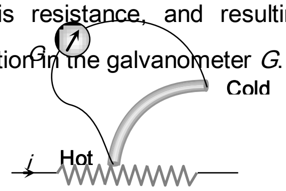
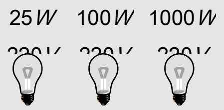


Fig. 20.14

Tips & Tricks

If $V_{Applied} < V_{Rated}$ then % drop in output power of electrical device $= \dfrac{(P_R - P_{consumed})}{P_R} \times 100$

✍ Different bulbs



⇒ Resistance $R_{25} > R_{100} > R_{1000}$

⇒ Thickness of filament $t_{1000} > t_{100} > t_{40}$

⇒ Brightness $B_{1000} > B_{100} > B_{25}$

✍ Time taken by heater to raise the temperature by $\Delta\theta$ of *m kg* (or *m litre*) water is given by $t = \dfrac{4180(\text{or } 4200) m\,\Delta\theta}{p}$

✍ Necessary series resistance to glow a bulb, if $V_{Applied} > V_{Rated}$

$$R = \left(\frac{V_{Applied} - V_{Rated}}{P_R}\right) \times V_R$$ (P_R = Rated power of bulb)

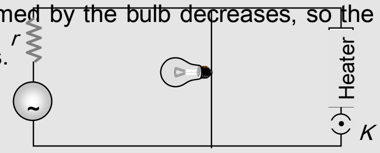
✍ When some potential difference applied across the conductor then collision of free electrons with ions of the lattice result's in conversion of electrical energy into heat energy

✍ If a heating coil of resistance R, (length l) consumed power *P*, when voltage *V* is applied to it then by keeping *V* constant if it is cut in n equal parts then resistance of each part will be R/n and from $P_{consumed} \propto \dfrac{1}{R}$, power consumed by each part $P' = nP$.

✍ In series a device of higher power rating consumes less power.

✍ Consider that *n* bulbs are connected in series across *V* volt supply. If one bulb gets fused and (*n* – 1) bulbs are again connected in series across same supply, the illumination will be more with (*n* – 1) bulbs then *n* bulbs but risk of fusing of bulbs will increases.

✍ When a heavy current appliance such us motor, heater or geyser is switched on, it will draw a heavy current from the source so that terminal voltage of source decreases. Hence power consumed by the bulb decreases, so the light of bulb becomes less.



✍ *If ρ is the density of the material deposited and A is the area of deposition then the thickness (d) of the layer of the material deposited in electroplating process is* $d = \frac{m}{\rho A} = \frac{Zit}{\rho A}$ *; where m = deposited mass, Z = electro chemical equivalent, i = electric current.*

✍ Charging current for a secondary cell

$$= \frac{\text{e.m.f. of charger} - \text{e.m.f. of cell}}{\text{Total resistance of the circuit}}$$

✍ Efficiency of a cell is given by $\eta = \frac{R}{r+R}$ where *R* is external resistance and *r* is internal resistance.

✍ The efficiency of cell is 50% when the power dissipated in the external circuit is maximum.

✍ Thermo couple can be compared to a heat engine. It absorbs heat at the junction (source) converts heat into electric energy (which appears as the circulating electric current) and rejects the remaining heat to cold junction (Sink).

Ordinary Thinking

Objective Questions

Heating Effect of Current

1. One *kilowatt* hour is equal to **[NCERT 1974; MP PMT 2002]**

(a) 36×10^5 *joules* (b) 36×10^3 *joules*

(c) 10^3 *joules* (d) 10^5 *joules*

2. If R_1 and R_2 are respectively the filament resistances of a 200 *watt* bulb and 100 *watt* bulb designed to operate on the same voltage, then **[NCERT 1980; CPMT 1991, 97]**

(a) R_1 is two times R_2 (b) R_2 is two times R_1

(c) R_2 is four times R_1 (d) R_1 is four times R_2

3. Two electric bulbs, one of 200 *volt* 40 *watt* and the other 200 *volt* 100 *watt* are connected in a house wiring circuit **[NCERT 1971; CBSE PMT 2000]**

(a) They have equal currents through them

(b) The resistance of the filaments in both the bulbs is same

(c) The resistance of the filament in 40 *watt* bulb is more than the resistance in 100 *watt* bulb

(d) The resistance of the filament in 100 *watt* bulb is more than the resistance in 40 *watt* bulb

4. The two bulbs as in the above question are connected in series to a 200 *volt* line. Then

(a) The potential drop across the two bulbs is the same

(b) The potential drop across the 40 *watt* bulb is greater than the potential drop across the 100 *watt* bulb

(c) The potential drop across the 100 *W* bulb is greater than the potential drop across the 40 *W* bulb

(d) The potential drop across both the bulb is 200 *volt*

5. Forty electric bulbs are connected in series across a 220 *V* supply. After one bulb is fused, the remaining 39 are connected again in series across the same supply. The illumination will be

[NCERT 1972; Haryana CEE 1996; DPMT 2001]

(a) More with 40 bulbs than with 39

(b) More with 39 bulbs than with 40

(c) Equal in both the cases

(d) In the ratio of $49^2 : 39^2$

6. The material of fuse wire should have

[BHU 1999; MH CET 2001; CBSE PMT 2003]

(a) A high specific resistance and high melting point

(b) A low specific resistance and low melting point

(c) A high specific resistance and low melting point

(d) A low specific resistance and a high melting point

7. Two electric bulbs whose resistances are in the ratio of 1 : 2 are connected in parallel to a constant voltage source. The powers dissipated in them have the ratio

[NCERT 1977; MP PMT 1994, 2000]

(a) 1 : 2 (b) 1 : 1

(c) 2 : 1 (d) 1 : 4

8. A heater coil is cut into two parts of equal length and one of them is used in the heater. The ratio of the heat produced by this half coil to that by the original coil is

[NCERT 1972; AIEEE 2005; CBSE PMT 2005]

(a) 2 : 1 (b) 1 : 2

(c) 1 : 4 (d) 4 : 1

9. Resistance of one carbon filament and one tungsten lamp are measured individually when the lamp are lit and compared with their respective resistances when cold. Which one of the following statements will be true [NCERT 972]

(a) Resistance of the carbon filament lamp will increase but that of the tungsten will diminish when hot

(b) Resistance of the tungsten filament lamp will increase but that of carbon will diminish when hot

(c) Resistances of both the lamps will increase when hot

(d) Resistances of both the lamps will decrease when hot

10. The mechanism of the heat produced in a conductor when an electric current flows through it, can be explained on the basis of

(a) Viscosity (b) Friction

(c) Free electron theory (d) Gauss's theorem

11. Two electric bulbs whose resistances are in the ratio of 1 : 2 are connected in series. The powers dissipated in them have the ratio [NCERT 1977]

(a) 1 : 2 (b) 2 : 1

(c) 1 : 1 (d) 1 : 4

12. You are given a resistance wire of length 50 cm and a battery of negligible resistance. In which of the following cases is largest amount of heat generated

(a) When the wire is connected to the battery directly

(b) When the wire is divided into two parts and both the parts connected to the battery in parallel

(c) When the wire is divided into four parts and all the four connected to the battery in parallel

(d) When only half the wire is connected to the battery

13. What is immaterial for an electric fuse wire [MNR 1984; MP PMT 2002; CPMT 1996, 2003]
(a) Its specific resistance
(b) Its radius
(c) Its length
(d) Current flowing through it

14. The electric bulbs have tungsten filaments of same length. If one of them gives 60 *watt* and other 100 *watt*, then [NCERT 1979]
(a) 100 *watt* bulb has thicker filament
(b) 60 *watt* bulb has thicker filament
(c) Both filaments are of same thickness
(d) It is possible to get different wattage unless the lengths are different

15. Three equal resistors connected in series across a source of e.m.f. together dissipate 10 watt. If the same resistors are connected in parallel across the same e.m.f., then the power dissipated will be [CBSE PMT 1998; KCET (Engg.) 1999; MP PMT 2003]
(a) 10 *watt* (b) 30 *watt*
(c) 10/3 *watt* (d) 90 *watt*

16. How much energy in kilowatt hour is consumed in operating ten 50 watt bulbs for 10 hours per day in a month (30 days). [NCERT 1978, 80; CPMT 1991]
(a) 1500 (b) 5,000
(c) 15 (d) 150

17. (1) The product of a volt and a coulomb is a joule.
(2) The product of a volt and an ampere is a joule/second.
(3) The product of volt and watt is horse power.
(4) Watt-hour can be measured in terms of electron volt.
State if [NCERT 1978; MP PMT 2003]
(a) All four are correct
(b) (1), (2) and (4) are correct
(c) (1) and (3) are correct
(d) (3) and (4) are correct

18. A 25 W, 220 V bulb and a 100 W, 220 V bulb are connected in parallel across a 440 V line [CBSE PMT 2001]
(a) Only 100 *watt* bulb will fuse
(b) Only 25 *watt* bulb will fuse
(c) Both bulbs will fuse
(d) None of the bulbs will fuse

19. Two electric lamps of 40 watt each are connected in parallel. The power consumed by the combination will be [CPMT 1984]
(a) 20 *watt* (b) 60 *watt*
(c) 80 *watt* (d) 100 *watt*

20. Two heating coils, one of fine wire and the other of thick wire of the same material and of the same length are connected in series and in parallel. Which of the following statement is correct
(a) In series fine wire liberates more energy while in parallel thick wire will liberate more energy
(b) In series fine wire liberates less energy while in parallel thick wire will liberate more energy
(c) Both will liberate equally
(d) In series the thick wire will liberate more while in parallel it will liberate less energy

21. An electric bulb is rated 220 *volt* and 100 *watt*. Power consumed by it when operated on 110 *volt* is [CPMT 1986; MP PMT 1986, 94; AFMC 2000]
(a) 50 *watt* (b) 75 *watt*
(c) 90 *watt* (d) 25 *watt*

22. A 25 *watt*, 220 *volt* bulb and a 100 *watt*, 220 *volt* bulb are connected in series across a 220 *volt* lines. Which electric bulb will glow more brightly [MP PET 1999; MP PMT 1999]
(a) 25 *watt* bulb
(b) 100 *watt* bulb
(c) First 25 watt and then 100 *watt*
(d) Both with same brightness

23. A resistor R_1 dissipates the power P when connected to a certain generator. If the resistor R_2 is put in series with R_1, the power dissipated by R_1 [CPMT 1985; MNR 1998]
(a) Decreases
(b) Increases
(c) Remains the same
(d) Any of the above depending upon the relative values of R_1 and R_2

24. An electric fan and a heater are marked as 100 *watt*, 220 *volt* and 1000 *watt*, 220 volt respectively. The resistance of the heater is
(a) Zero
(b) Greater than that of the fan
(c) Less than that of the fan
(d) Equal to that of the fan

25. According to Joule's law, if the potential difference across a conductor having a material of specific resistance remains constant, then the heat produced in the conductor is directly proportional to
(a) ρ (b) ρ^2
(c) $\frac{1}{\sqrt{\rho}}$ (d) $\frac{1}{\rho}$

26. Two heater wires of equal length are first connected in series and then in parallel. The ratio of heat produced in the two cases is [MNR 1987; UPSEAT 1999; MP PMT 1996, 2000, 01; AIIMS 2000; MP PET 1999, 2002; BHU 2004; Pb PET 2004]
(a) 2 : 1 (b) 1 : 2
(c) 4 : 1 (d) 1 : 4

27. Two bulbs of equal wattage, one having carbon filament and the other having a tungsten filament are connected in series to the mains, then
(a) Both bulbs glow equally
(b) Carbon filament bulb glows more
(c) Tungsten filament bulbs glows more
(d) Carbon filament bulb glows less

28. Two identical heaters rated 220 *volt*, 1000 watt are placed in series with each other across 220 *volt* lines. If resistance do not change with temperature, then the combined power is
(a) 1000 *watt* (b) 2000 *watt*
(c) 500 *watt* (d) 4000 *watt*

29. A 25 *watt*, 220 *volt* bulb and a 100 *watt*, 220 *volt* bulb are connected in parallel across a 220 *volt* line. Which bulb will glow more brightly
(a) 25 *watt* bulb
(b) 100 *watt* bulb
(c) Both will have same brightness

(d) First 25 *watt* then 100 *watt*

30. If two bulbs of wattage 25 and 100 respectively each rated at 220 *volt* are connected in series with the supply of 440 *volt*, then which bulbs will fuse [MNR 1988]

(a) 100 *watt* bulb (b) 25 *watt* bulb
(c) None of them (d) Both of them

31. If current in an electric bulb changes by 1%, then the power will change by [AFMC 1996]

(a) 1% (b) 2%
(c) 4% (d) $\frac{1}{2}$%

32. Two identical batteries, each of e.m.f. 2 *volt* and internal resistance 1.0 ohm are available to produce heat in an external resistance $R = 0.5$ *ohm* by passing a current through it. The maximum Joulean power that can be developed across *R* using these batteries is [CBSE PMT 1990; BHU 1997]

(a) 1.28 *watt* (b) 2.0 *watt*
(c) $\frac{8}{9}$ *watt* (d) 3.2 *watt*

33. A constant voltage is applied between the two ends of a metallic wire. If both the length and the radius of the wire are doubled, the rate of heat developed in the wire [MP PMT 1996]

(a) Will be doubled (b) Will be halved
(c) Will remain the same (d) Will be quadrupled

34. The heating coils rating at 220 *volt* and producing 50 *cal/sec* heat are available with the resistances $55\,\Omega, 110\,\Omega, 220\,\Omega$ and $440\,\Omega$. The heater of maximum power will be of [MP PMT 1985]

(a) $440\,\Omega$ (b) $220\,\Omega$
(c) $110\,\Omega$ (d) $55\,\Omega$

35. Which of the following statement is false

(a) Heat produced in a conductor is proportional to its resistance
(b) Heat produced in a conductor is proportional to the square of the current
(c) Heat produced in a conductor is proportional to charge
(d) Heat produced in a conductor is proportional to the time for which current is passed

36. On an electric heater 220 *volt* and 1100 *watt* are marked. On using it for 4 hours, the energy consumed in *kWh* will be

(a) 2 (b) 4.4
(c) 6 (d) 8

37. An electric heater kept in vacuum is heated continuously by passing electric current. Its temperature [MP PET 1993]

(a) Will go on rising with time
(b) Will stop after sometime as it will loose heat to the surroundings by conduction
(c) Will rise for sometime and there after will start falling
(d) Will become constant after sometime because of loss of heat due to radiation

38. Heat produced in a wire of resistance R due to current flowing at constant potential difference is proportional to [MP PET 1993]

(a) $\frac{1}{R^2}$ (b) $\frac{1}{R}$
(c) R (d) R^2

39. The power rating of an electric motor which draws a current of 3.75 *amperes* when operated at 200 *V* is about

(a) 1 H.P. (b) 500 *W*
(c) 54 *W* (d) 750 H.P.

40. An electric bulb of 100 *watt* is connected to a supply of electricity of 220 *V*. Resistance of the filament is [EAMCET 1981, 82; MP PMT 1993, 97]

(a) $484\,\Omega$ (b) $100\,\Omega$
(c) $22000\,\Omega$ (d) $242\,\Omega$

41. A cable of resistance $10\,\Omega$ carries electric power from a generator producing 250 *kW* at 10000 *volt*. The current in the cable is

(a) 25 *A* (b) 250 *A*
(c) 100 *A* (d) 1000 *A*

42. In the above question, the power lost in the cable during transmission is

(a) 12.5 *kW* (b) 6.25 *kW*
(c) 25 *kW* (d) 3.15 *kW*

43. The heat generated through 2 *ohm* and 8 *ohm* resistances separately, when a condenser of 200 μF capacity charged to 200 *V* is discharged one by one, will be [MP PET 1993]

(a) 4 *J* and 16 *J* respectively
(b) 16 *J* and 4 *J* respectively
(c) 4 *J* and 8 *J* respectively
(d) 4 *J* and 4 *J* respectively

44. Two bulbs are in parallel and they together consume 48 *W* from a battery of 6 *V*. The resistance of each bulb is

(a) $0.67\,\Omega$ (b) $3.0\,\Omega$
(c) $4.0\,\Omega$ (d) $1.5\,\Omega$

45. The heat developed in an electric wire of resistance *R* by a current *I* for a time *t* is [MP PMT 1993; MP PET 2005]

(a) $\frac{I^2 Rt}{4.2}\,cal$ (b)
(c) $\frac{I^2 R}{4.2\,t}\,cal$ (d) $\frac{Rt}{4.2\,I^2}\,cal$

46. Two bulbs, one of 50 *watt* and another of 25 *watt* are connected in series to the mains. The ratio of the currents through them is

(a) 2 : 1
(b) 1 : 2
(c) 1 : 1
(d) Without voltage, cannot be calculated

47. The brightness of a bulb will be reduced, if a resistance is connected in

(a) Series with it
(b) Parallel with it
(c) Series or parallel with it
(d) Brightness of the bulb cannot be reduced

48. A 100 *watt* bulb working on 200 *volt* and a 200 *watt* bulb working on 100 *volt* have

(a) Resistances in the ratio of 4 : 1
(b) Maximum current ratings in the ratio of $1:4$
(c) Resistances in the ratio of 2 : 1
(d) Maximum current ratings in the ratio of 1 : 2

49. There are two electric bulbs of 40 *W* and 100 *W*. Which one will be brighter when first connected in series and then in parallel,
(a) 40 *W* in series and 100 *W* in parallel
(b) 100 *W* in series and 40 *W* in parallel
(c) 40 *W* both in series and parallel will be uniform
(d) 100 *W* both in series and parallel will be uniform

50. Two resistances R_1 and R_2 when connected in series and parallel with 120 *V* line, power consumed will be 25 *W* and 100 *W* respectively. Then the ratio of power consumed by R_1 to that consumed by R_2 will be [EAMCET 1983]
(a) 1 : 1 (b) 1 : 2
(c) 2 : 1 (d) 1 : 4

51. A 220 *volt* and 800 *watt* electric kettle and three 220 *volt* and 100 *watt* bulbs are connected in parallel. On connecting this combination with 220 *volt* electric supply, the total current will be
(a) 0.15 *ampere* (b) 5.0 *ampere*
(c) 5.5 *ampere* (d) 6.9 *ampere*

52. You are given three bulbs of 25, 40 and 60 *watt*. Which of them has lowest resistance [NCERT 1982]
(a) 25 *watt* bulb (b) 40 *watt* bulb
(c) 60 *watt* bulb (d) Information is insufficient

53. The value of internal resistance of an ideal cell is [EAMCET 1989]
(a) Zero (b) $0.5\,\Omega$
(c) $1\,\Omega$ (d) Infinity

54. Electric power is transmitted over long distances through conducting wires at high voltage because [MP PET 1994]
(a) High voltage travels faster
(b) Power loss is large
(c) Power loss is less
(d) Generator produced electrical energy at a very high voltage

55. A coil develops heat of 800 *cal/sec*. When 20 *volts* is applied across its ends. The resistance of the coil is (1 *cal* = 4.2 *joule*)
(a) $1.2\,\Omega$ (b) $1.4\,\Omega$
(c) $0.12\,\Omega$ (d) $0.14\,\Omega$

56. Resistances R_1 and R_2 are joined in parallel and a current is passed so that the amount of heat liberated is H_1 and H_2 respectively. The ratio $\frac{H_1}{H_2}$ has the value [MP PMT 1994]
(a) $\frac{R_2}{R_1}$ (b) $\frac{R_1}{R_2}$
(c) $\frac{R_1^2}{R_2^2}$ (d) $\frac{R_2^2}{R_1^2}$

57. The internal resistance of a primary cell is 4 *ohm*. It generates a current of 0.2 *amp* in an external resistance of 21 *ohm*. The rate at which chemical energy is consumed in providing the current is
(a) $0.42\,J/s$ (b) $0.84\,J/s$
(c) $5\,J/s$ (d) $1\,J/s$

58. A heating coil is labelled 100 *W*, 220 *V*. The coil is cut in half and the two pieces are joined in parallel to the same source. The energy now liberated per second is [CBSE PMT 1995]
(a) 200 *J* (b) 400 *J*
(c) 25 *J* [MP PET 1993] (d) 50 *J*

59. Which of the following is not a correct statement [MP PET 1995]
(a) Resistivity of electrolytes decreases on increasing temperature
(b) Resistance of mercury falls on decreasing its temperature
(c) When joined in series a 40 *W* bulb glows more than a 60 *W* bulb
(d) Resistance of 40 *W* bulb is less than the resistance of 60 *W* bulb

60. Three light bulbs of 40 *W*, 60 *W* and 100 *W* are connected in series with 220 *V* source. Which one of the bulbs will glow brightest [MP PMT 1995; UI
(a) 40 *W*
(b) 60 *W*
(c) 100 *W*
(d) All with the same brightness [MP PMT 1975]

61. The energy consumed in 1 *kilowatt* electric heater in 30 *seconds* will be
(a) $6\times10^2\ J$ (b) $4.99\times10^7\ J$
(c) $9.8\times10^6\ J$ (d) $3\times10^4\ J$

62. Two bulbs of 500 *watt* and 200 *watt* are manufactured to operate on 220 *volt* line. The ratio of heat produced in 500 *W* and 200 *W*, in two cases, when firstly they are joined in parallel and secondly in series, will be [MP PET 1996; DPMT 1999]
(a) $\frac{5}{2},\frac{2}{5}$ (b) $\frac{5}{2},\frac{5}{2}$
(c) $\frac{2}{5},\frac{5}{2}$ (d) $\frac{2}{5},\frac{2}{5}$

63. A 60 *watt* bulb carries a current of 0.5 *amp*. The total charge passing through it in 1 *hour* is [MP PMT 1996]
(a) 3600 *coulomb* (b) 3000 *coulomb*
(c) 2400 *coulomb* (d) 1800 *coulomb*

64. An electric heater of resistance 6 *ohm* is run for 10 *minutes* on a 120 *volt* line. The energy liberated in this period of time is [MP PET 1994]
(a) $7.2\times10^3\ J$ (b) $14.4\times10^5\ J$
(c) $43.2\times10^4\ J$ (d) $28.8\times10^4\ J$

65. Two bulbs are working in parallel order. Bulb *A* is brighter than bulb *B*. If R_A and R_B are their resistance respectively then
(a) $R_A > R_B$ (b) $R_A < R_B$
(c) $R_A = R_B$ (d) None of these

66. Two conductors made of the same material are connected across a common potential difference. Conductor *A* has twice the diameter and twice the length of conductor *B*. The power delivered to the two conductors P_A and P_B respectively is such that P_A/P_B equals to
(a) 0.5 (b) 1.0
(c) 1.5 (d) 2.0

67. A heating coil can heat the water of a vessel from $20°C$ to $60°C$ in 30 *minutes*. [MP PMT 1994] Two such heating coils are put in series and then used to heat the same amount of water through the same temperature range. The time taken now will be (neglecting thermal capacity of the coils) [MP PMT 1997]
(a) 60 *minutes* (b) 30 *minutes*
(c) 15 *minutes* (d) 7.5 *minutes*

68. If 2.2 *kilowatt* power is transmitted through a 10 *ohm* line at 22000 *volt*, the power loss in the form of heat will be [MP PMT/PET 1998]

(a) 0.1 *watt* (b) 1 *watt*
(c) 10 *watt* (d) 100 *watt*

69. Two resistors having equal resistances are joined in series and a current is passed through the combination. Neglect any variation in resistance as the temperature changes. In a given time interval

(a) Equal amounts of thermal energy must be produced in the resistors
(b) Unequal amounts of thermal energy may be produced
(c) The temperature must rise equally in the resistors
(d) The temperature must rise unequally in the resistors

70. A $5°C$ rise in temperature is observed in a conductor by passing a current. When the current is doubled the rise in temperature will be approximately [CBSE PMT 1998]

(a) $16°C$ (b) $10°C$
(c) $20°C$ (d) $12°C$

71. *Watt-hour* meter measures [KCET 1994]

(a) Electric energy (b) Current
(c) Voltage (d) Power

72. An electric lamp is marked 60 *W*, 230 *V*. The cost of 1 *kilowatt* hour of power is *Rs*. 1.25. The cost of using this lamp for 8 hours is

(a) *Rs*. 1.20 (b) *Rs*. 4.00
(c) *Rs*. 0.25 (d) *Rs*. 0.60

73. 4 bulbs marked 40 *W*, 250 *V* are connected in series with 250 *V* mains. The total power is [EAMCET (Engg.) 1995]

(a) 10 *W* (b) 40 *W*
(c) 320 *W* (d) 160 *W*

74. Pick out the wrong statement [AMU 1995]

(a) In a simple battery circuit, the point of lowest potential is the negative terminal of the battery
(b) The resistance of an incandescent lamp is greater when the lamp is switched off
(c) An ordinary 100 *W* lamp has less resistance than a 60 *W* lamp
(d) At constant voltage, the heat developed in a uniform wire varies inversely as the length of the wire used

75. Two resistors of $6\,\Omega$ and 9Ω are connected in series to a 120 *volt* source. The power consumed by the $6\,\Omega$ resistor is [SCRA 1994]

(a) 384 *W* (b) 576 *W*
(c) 1500 *W* (d) 1200 *W*

76. Electric room radiator which operates at 225 *volts* has resistance of 50 *ohms*. Power of the radiator is approximately

(a) 100 *W* (b) 450 *W*
(c) 750 *W* (d) 1000 *W*

77. If a power of 100 *W* is being supplied across a potential difference of 200 *V*, current flowing is [AFMC 1993]

(a) 2 *A* (b) 0.5 *A*
(c) 1 *A* (d) 20 *A*

78. A current of 2 *A* passing through conductor produces 80 *J* of heat in 10 *seconds*. The resistance of the conductor is [CBSE PMT 1993]

(a) $0.5\,\Omega$ (b) $2\,\Omega$
(c) $4\,\Omega$ (d) $20\,\Omega$

79. A $4\,\mu F$ conductor is charged to 400 *volts* and then its plates are joined through a resistance of $1\,k\Omega$. The heat produced in the resistance is [CBSE PMT 1994]

(a) 0.16 *J* (b) 1.28 *J*
(c) 0.64 *J* (d) 0.32 *J*

80. A 10 *ohm* electric heater operates on a 110 *V* line. Calculate the rate at which it develops heat in watts [MP PMT 1999] [AFMC 1997]

(a) 1310 *W* (b) 670 *W*
(c) 810 *W* (d) 1210 *W*

81. A (100 *W*, 200 *V*) bulb is connected to a 160 *V* power supply. The power consumption would be [CBSE PMT 1997; JIPMER 2000]

(a) 64 *W* (b) 80 *W*
(c) 100 *W* (d) 125 *W*

82. A battery of e.m.f. 10 *V* and internal resistance 0.5 *ohm* is connected across a variable resistance *R*. The value of *R* for which the power delivered in it is maximum is given by [BHU 1998; JIPMER 2001, 02; CBSE PMT 2001]

(a) 2.0 *ohm* (b) 0.25 *ohm*
(c) 1.0 *ohm* (d) 0.5 *ohm*

83. A piece of fuse wire melts when a current of 15 *ampere* flows through it. With this current, if it dissipates 22.5 *W*, the resistance of fuse wire will be [KCET 1994] [MNR 1998]

(a) Zero (b) $10\,\Omega$
(c) $1\,\Omega$ (d) $0.10\,\Omega$

84. Two wires '*A*' and '*B*' of the same material have their lengths in the ratio 1 : 2 and radii in the ratio 2 : 1. The two wires are connected in parallel across a battery. The ratio of the heat produced in '*A*' to the heat produced in '*B*' for the same time is

(a) $1:2$ (b) $2:1$
(c) $1:8$ (d) $8:1$

85. A heater draws a current of 2*A* when connected to a 250 *V* source. The rate of energy dissipation is [JIPMER 1999]

(a) 500 *W* (b) 1000 *W*
(c) 250 *W* (d) 125 *W*

86. A bulb rated at (100 *W* – 200 *V*) is used on a 100 *V* line. The current in the bulb is [JIPMER 1999]

(a) $\frac{1}{4}$ *amp* (b) 4 *amp*
(c) $\frac{1}{2}$ *amp* [SCRA 1994] (d) 2 *amp*

87. A steel wire has a resistance twice that of an aluminium wire. Both of them are connected with a constant voltage supply. More heat will be dissipated in [Roorkee 1999]

(a) Steel wire when both are connected in series
(b) Steel wire when both are connected in parallel
(c) Aluminium wire when both are connected in series
(d) Aluminium wire when both are connected in parallel

88. A current *i* passes through a wire of length *l*, radius of cross-section *r* and resistivity ρ. The rate of heat generation is [AMU (Med.) 1999]

(a) $\frac{i^2 l\rho}{\pi r^2}$ (b) $i^2\left(\frac{l\rho}{\pi r^2}\right)^2$

(c) $i^2 l\rho / r$ (d) $il\rho / r$

89. Which of the following is not equal to *watt* [DPMT 1999]

(a) $(Amp)^2 \times ohm$ (b) *Amp / Volt*

(c) *Amp* × *Volt* (d) *Joule / sec*

90. Two wires with resistances R and $2R$ are connected in parallel, the ratio of heat generated in $2R$ and R is [DCE 1999, 2000]

(a) 1 : 2 (b) 2 : 1

(c) 1 : 4 (d) 4 : 1

91. If a high power heater is connected to electric mains, then the bulbs in the house become dim, because there is a [BHU 1999; Pb. PMT 2000]

(a) Current drop (b) Potential drop

(c) No current drop (d) No potential drop

92. If three bulbs 60 W, 100 W and 200 W are connected in parallel, then

(a) 200 W bulb will glow more

(b) 60 W bulb will glow more

(c) 100 W bulb will glow more

(d) All the bulbs will glow equally

93. An expression for rate of heat generated, if a current of I ampere flows through a resistance of $R\,\Omega$, is [Pb. PMT 2000]

(a) I^2Rt (b) I^2R

(c) V^2R (d) IR

94. On giving 220 V to a resistor the power dissipated is 40 W then value of resistance is [RPMT 2000]

(a) 1210 Ω (b) 2000 Ω

(c) 1000 Ω (d) None of these

95. A 60 *watt* bulb operates on 220 V supply. The current flowing through the bulb is [MP PMT 2000]

(a) 11/3 *amp* (b) 3/11 *amp*

(c) 3 *amp* (d) 6 *amp*

96. If two bulbs of wattage 25 and 30, each rated at 220 *volts*, are connected in series with a 440 *volt* supply, which bulb will fuse [MP PET 2000]

(a) 25 W bulb (b) 30 W bulb

(c) Neither of them (d) Both of them

97. Two electric bulbs (60 W and 100 W respectively) are connected in series. The current passing through them is [AMU (Med.) 2000]

(a) More in 100 W bulb (b) More in 60 W bulb

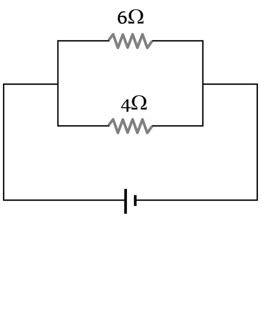
(c) Same in both (d) None of these

98. In the circuit shown below, the power developed in the 6Ω resistor is 6 watt. The power in watts developed in the 4Ω resistor is

(a) 16

(b) 9

(c) 6



(d) 4

99. Two wires A and B of same material and mass have their lengths in the ratio 1 : 2. On connecting them to the same source, the rate of heat dissipation in B is found to be 5 W. The rate of heat dissipation in A is [AMU (Engg.) 2000]

(a) 10 W (b) 5 W

(c) 20 W (d) None of these

100. If two electric bulbs have 40 W and 60 W rating at $220V$, then the ratio of their resistances will be [BHU 1999; KCET 2001]

(a) 3 : 2 (b) 2 : 3

(c) 3 : 4 (d) 4 : 3

101. An electric bulb is designed to draw power P_0 at voltage V_0. If the voltage is V it draws a power P. Then [KCET 2001]

(a) $P = \left(\frac{V_0}{V}\right)^2 P_0$ (b) $P = \left(\frac{V}{V_0}\right)^2 P_0$

[BHU 2000]

(c) $P = \left(\frac{V}{V_0}\right) P_0$ (d) $P = \left(\frac{V_0}{V}\right) P_0$

102. Three bulbs of 40 W, 60 W and 100 W are arranged in series with 220 V. Which bulb has minimum resistance [AFMC 2001]

(a) 40 W (b) 60 W

(c) 100 W (d) Equal in all bulbs

103. An electric kettle has two heating coils. When one coil is used, water in the kettle boils in 5 minutes, while when second coil is used, same water boils in 10 minutes. If the two coils, connected in parallel are used simultaneously, the same water will boil in time

(a) 3 *min* 20 *sec* (b) 5 *min*

(c) 7 *min* 30 *sec* (d) 2 *min* 30 *sec*

104. An external resistance R is connected to a battery of e.m.f. V and internal resistance r. The joule heat produced in resistor R is maximum when R is equal to [MP PET 2001]

(a) r (b) $\frac{r}{2}$

(c) $2r$ (d) Infinitely large

105. The amount of heat produced in a resistor when a current is passed through it can be found using [Kerala PET 2001]

(a) Faraday's Law (b) Kirchhoff's Law

(c) Laplace's Law (d) Joule's Law

106. Two wires have resistance of 2Ω and 4Ω connected to same voltage, ratio of heat dissipated at resistance is [UPSEAT 2001]

(a) 1 : 2 (b) 4 : 3

(c) 2 : 1 (d) 5 : 2

[AMU (Med.) 2000]

107. Two electric bulbs rated P_1 watt V volts and P_2 watt V volts are connected in parallel and V volts are applied to it. The total power will be [MP PMT 2001; MP PET 2002]

(a) $P_1 + P_2 watt$ (b) $\sqrt{P_1P_2}$ watt

(c) $\frac{P_1P_2}{P_1+P_2} watt$ (d) $\frac{P_1+P_2}{P_1P_2} watt$

108. n identical bulbs, each designed to draw a power p from a certain voltage supply, are joined in series across that supply. The total power which they will draw is [KCET 2002]

(a) p/n^2 (b) p/n

(c) p (d) np

109. A wire when connected to 220 V mains supply has power dissipation P_1. Now the wire is cut into two equal pieces which are connected in parallel to the same supply. Power dissipation in this case is P_2. Then $P_2 : P_1$ is [AIEEE 2002]

(a) 1 (b) 4

(c) 2 (d) 3

110. An electric bulb marked 40 W and 200 V, is used in a circuit of supply voltage 100 V. Now its power is [AIIMS 2002]

(a) 100 W (b) 40 W

(c) 20 W (d) 10 W

111. Electric bulb 50 W-100 V glowing at full power are to be used in parallel with battery 120 V, 10 Ω. Maximum number of bulbs that can be connected so that they glow in full power is

(a) 2 (b) 8

(c) 4 (d) 6

112. A bulb has specification of one kilowatt and 250 *volts*, the resistance of bulb is [MP PMT 2002]

(a) 125 Ω (b) 62.5 Ω

(c) 0.25 Ω (d) 625 Ω

113. If a 30 V, 90 W bulb is to be worked on a 120 V line, a resistance of how many ohms should be connected in series with the bulb [MP PMT 2002; KCET 2003]

(a) 10 *ohm* (b) 20 *ohm*

(c) 30 *ohm* (d) 40 *ohm*

114. A fuse wire with radius 1 *mm* blows at 1.5 *amp*. The radius of the fuse wire of the same material to blow at 3A will be [KCET 2003]

(a) $4^{1/3} mm$ (b) $3^{1/4} mm$

(c) $2^{1/2} mm$ (d) $3^{1/2} mm$

115. Three electric bulbs of rating 60 W each are joined in series and then connected to electric mains. The power consumed by these three bulbs will be [MP PET 2003; CBSE PMT 2004]

(a) 180 W (b) 60 W

(c) 20 W (d) $\frac{20}{3} W$

116. An electric bulb is rated 60 W, 220 V. The resistance of its filament is [MP PET 2003]

(a) 708 Ω (b) 870 Ω

(c) 807 Ω (d) 780 Ω

117. A 220 *volt*, 1000 W bulb is connected across a 110 volt mains supply. The power consumed will be [AIEEE 2003]

(a) 1000 W (b) 750 W

(c) 500 W (d) 250 W

118. Two bulbs of 100 W and 200 W working at 220 *volt* are joined in series with 220 *volt* supply. Total power consumed will be approximately. [Pb. PET 2003; BHU 2005]

(a) 65 *watt* (b) 33 *watt*

(c) 300 *watt* (d) 100 *watt*

119. How many calories of heat will be produced approximately in a 210 *watt* electric bulb in 5 minutes [Pb. PET 2004]

(a) 80000 *cal* (b) 63000 *cal*

(c) 1050 *cal* (d) 15000 *cal*

120. $A\ 5^oC$ rise in the temperature is observed in a conductor by passing some current. When the current is doubled, then rise in temperature will be equal to [BHU 2004]

(a) 5^oC (b) 10^oC

(c) 20^oC (d) 40^oC

121. If a 2 kW boiler is used everyday for 1 hour, then electrical energy consumed by boiler in thirty days is [BHU 2004]

(a) 15 unit (b) 60 unit

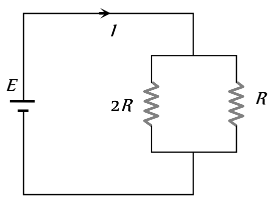
(c) 120 unit (d) 240 unit

122. What will happen when a 40 *watt*, 220 *volt* lamp and 100 *watt*, 220 *volt* lamp are connected in series across 40 *volt* supply [CPMT 2002]

(a) 100 *watt* lamp will fuse (b) 40 *watt* lamp will fuse

(c) Both lamps will fuse (d) Neither lamp will fuse

123. What is the ratio of heat generated in R and $2R$ [DCE 2003]



(a) 2 : 1

(b) 1 : 2

(c) 4 : 1

(d) 1 : 4

124. In an electric heater 4 *amp* current passes for 1 *minute* at potential difference of 250 *volt*, the power of heater and energy consumed will be respectively [DPMT 2003]

(a) 1 kW, 60 kJ (b) 0.5 kW, 30 kJ

(c) 10 kW, 600 kJ (d) None of these

125. Some electric bulbs are connected in series across a 220 V supply in a room. If one bulb is fused then remaining bulbs are connected again in series across the same supply. The illumination in the room will [J & K CET 2004]

(a) Increase (b) Decrease

(c) Remains the same (d) Not continuous

126. The resistor of resistance 'R' is connected to 25 V supply and heat produced in it is 25 J/sec. The value of R is [Orissa PMT 2004]

(a) 225Ω (b) 1Ω

(c) 25Ω (d) 50Ω

127. Three bulbs of 40 W, 60 W, 100 W are arranged in series with 220 *volt* supply which bulb has minimum resistance [Pb. PET 2000]

(a) 100 W (b) 40 W

(c) 60 W (d) Equal in all bulbs

128. If two electric bulbs have 40 W and 60 W rating at 220 V, then the ratio of their resistances will be [Pb. PET 2001]

(a) 9 : 4 (b) 4 : 3

(c) 3 : 8 (d) 3 : 2

129. A 10 V storage battery of negligible internal resistance is connected across a $50\,\Omega$ resistor. How much heat energy is produced in the resistor in 1 hour [Pb. PET 2001]

(a) 7200 J (b) 6200 J

(c) 5200 J (d) 4200 J

130. A hot electric iron has a resistance of $80\,\Omega$ and is used on a 200 V source. The electrical energy spent, if it is used for two hours, will be [Pb. PET 2002]

(a) 8000 Wh (b) 2000 Wh

(c) 1000 Wh (d) 800 Wh

131. The heat produced by a 100 *watt* heater in 2 minute will be equal to [BCECE 2004]

(a) $12\times10^{3}\ J$ (b) $10\times10^{3}\ J$

(c) $6\times10^{3}\ J$ (d) $3\times10^{3}\ J$

132. If two wires having resistance R and $2R$. Both joined in series and in parallel then ratio of heat generated in this situation, applying the same voltage, [BCECE 2004]

(a) 2 : 1 (b) 1 : 2

(c) 2 : 9 (d) 9 : 2

133. Two electric bulbs A and B are rated as 60 W and 100 W. They are connected in parallel to the same source. Then, [KCET 2004]

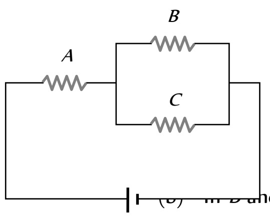
(a) Both draw the same current

(b) A draws more current than B

(c) B draws more current than A

(d) Current drawn are in the ratio of their resistances

134. Three identical resistances A, B and C are connected as shown in the given figure. The heat produced will be maximum



(a) In B (b) In B and C

(c) In A (d) Same for A, B and C

135. If $2.2\,kW$ power is transmitted through a 100Ω line at $22{,}000V$, the power loss in the form of heat will be [MP PET 2004]

(a) 0.1 W (b) 1 W

(c) 10 W (d) 100 W

136. A heater coil connected to a supply of a 220 V is dissipating some power P_1. The coil is cut into half and the two halves are connected in parallel. The heater now dissipates a power P_2. The ratio of power $P_1 : P_2$ is [AFMC 2004]

(a) 2 : 1 (b) 1 : 2

(c) 1 : 4 (d) 4 : 1

137. An electric lamp is marked 60 W, 230 V. The cost of a 1 kWh of energy is *Rs.* 1.25. The cost of using this lamp 8 *hrs* a day for 30 day is [Kerala (Med.) 2002]

(a) *Rs.* 10 (b) *Rs.* 16

(c) *Rs.* 18 (d) *Rs.* 20

138. An electric iron draws 5 *amp*, a TV set draws 3 *amp* and refrigerator draws 2 *amp* from a 220 *volt* main line. The three appliances are connected in parallel. If all the three are operating at the same time, the fuse used may be of [ISM Dhanbad 1994]

(a) 20 *amp* (b) 5 *amp*

(c) 15 *amp* (d) 10 *amp*

139. Match the List I with the List II from the combination shown. In the left side (List I) there are four different conditions and in the right side (List II), there are ratios of heat produced in each resistance for each condition : [ISM Dhanbad 1994]

	List I	List II
(I)	Two wires of same resistance are connected in series and same current is passed through them	(A) 1 : 2
(II)	Two wires of resistance R and $2R$ *ohm* are connected in series and same P.D. is applied across them	(B) 4 : 1
(III)	Two wires of same resistance are connected in parallel and same current is flowing through them	(C) 1 : 1
(IV)	Two wires of resistances in the ratio 1 : 2 are connected in parallel and same P.D. is applied across them	(D) 2 : 1

(a) $I-B;\ II-A;\ III-C;\ IV-D$

(b) $I-C;\ II-D;\ III-C;\ IV-D$

(c) $I-B;\ II-D;\ III-A;\ IV-C$

(d) $I-A;\ II-B;\ III-D;\ IV-C$ [MP PMT 2004]

140. The electric current passing through a metallic wire produces heat because of [BHU 1994]

(a) Collisions of conduction electrons with each other

(b) Collisions of the atoms of the metal with each other

(c) The energy released in the ionization of the atoms of the metal

(d) Collisions of the conduction electrons with the atoms of the metallic wires

141. The maximum current that flows through a fuse wire before it blows out varies with its radius as [SCRA 1998]

(a) $r^{3/2}$ (b) r

(c) $r^{2/3}$ (d) $r^{1/2}$

142. What is immaterial for an electric fuse wire [UPSEAT 1999]

(a) Specific resistance of the wire

(b) Radius of the wire

(c) Length of the wire

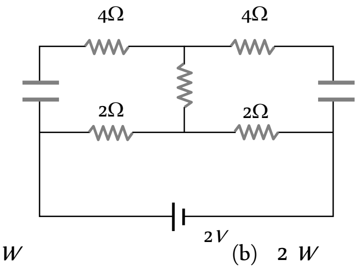
(d) Current flowing through the wire

143. The current flowing through a lamp marked as 50 W and 250 V is

(a) 5 *amp* (b) 2.5 *amp*

(c) 2 *amp* (d) 0.2 *amp*

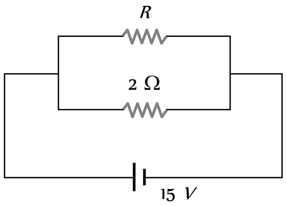
144. Find the power of the circuit [AIEEE 2002]



(a) 1.5 *W* (b) 2 *W*

(c) 1 *W* (d) None of these

145. If in the circuit, power dissipation is 150 *W*, then *R* is [AIEEE 2002]



(a) 2 Ω (b) 6 Ω

(c) 5 Ω (d) 4 Ω

146. Two resistors whose value are in ratio 2 : 1 are connected in parallel with one cell. Then ratio of power dissipated is [RPMT 2000]

(a) 2 : 1 (b) 4 : 1

(c) 1 : 2 (d) 1 : 1

147. A heater coil is cut into two equal parts and only one part is now used in the heater. The heat generated will now be [AIEEE 2005]

(a) One fourth (b) Halved

(c) Doubled (d) Four times

148. The resistance of hot tungsten filament is about 10 times the cold resistance. What will be the resistance of 100 *W* and 200 *V* lamp when not in use [AIEEE 2005]

(a) 400 Ω (b) 200 Ω

(c) 40 Ω (d) 20 Ω

149. A 5.0 *amp* current is setup in an external circuit by a 6.0 *volt* storage battery for 6.0 minutes. The chemical energy of the battery is reduced by [KCET 2005]

(a) 1.08×10^4 *J* (b) 1.08×10^4 *volt*

(c) 1.8×10^4 *J* (d) 1.8×10^4 *volt*

150. A railway compartment is lit up by thirteen lamps each taking 2.1 amp at 15 volts. The heat generated per second in each lamp will be

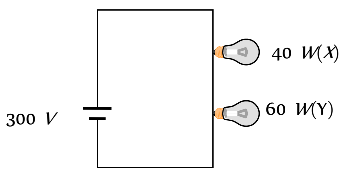
(a) 4.35 *cal* (b) 5.73 *cal*

(c) 7.5 *cal* (d) 2.5 *cal*

151. Two bulbs *X* and *Y* having same voltage rating and of power 40 watt and 60 watt respectively are connected in series across a potential difference of 300 volt, then [Orissa JEE 2005]

(a) *X* will glow brighter

(b) Resistance of *Y* is greater than *X*



(c) Heat produced in *Y* will be greater than *X*

(d) Voltage drop in *X* will be greater than *Y*

152. 3 identical bulbs are connected in series and these together dissipate a power *P*. If now the bulbs are connected in parallel, then the power dissipated will be [DPMT 2005]

(a) $\frac{P}{3}$ (b) $3P$

(c) $9P$ (d) $\frac{P}{9}$

153. A coil takes 15 *min* to boil a certain amount of water, another coil takes 20 *min* for the same process. Time taken to boil the same amount of water when both coil are connected in series

(a) 5 *min* (b) 8.6 *min*

(c) 35 *min* (d) 30 *min*

Chemical Effect of Current

1. Water can not be made conducting by adding small amount of any of the following except

(a) Sodium chloride (b) Copper sulphate

(c) Ammonium chloride (d) Sugar

2. The electrochemical equivalent Z of any element can be obtained by multiplying the electrochemical equivalent of hydrogen with

(a) Atomic weight (b) Molecular weight

(c) Chemical equivalent (d) A constant

3. A silver and zinc voltameter are connected in series and a current *i* is passed through them for a time *t* liberating *W gm* of zinc. The weight of silver deposited is nearly [NCERT 1973, 76]

(a) *W* (b) 1.7 *W*

(c) 2.4 *W* (d) 3.5 *W*

4. To deposit one gm equivalent of an element at an electrode, the quantity of electricity needed is [IIT 1984; DPMT 1982; MP PET 1998; MP PMT 1998; 2003]

(a) One *ampere* (b) 96000 *amperes*

(c) 96500 *farads* (d) 96500 *coulombs*

5. In an electrolysis experiment, a current *i* passes through two different cells in series, one containing a solution of $CuSO_4$ and the other a solution of $AgNO_3$. The rate of increase of the weight of the cathodes in the two cells will be [NCERT 1972]

[J & K CET 2005]

(a) In the ratio of the densities of *Cu* and *Ag*

(b) In the ratio of the at. weights of *Cu* and *Ag*

(c) In the ratio of half the atomic weight of *Cu* to the atomic weight of *Ag*

(d) In the ratio of half the atomic weight of *Cu* to half the atomic weight of *Ag*

6. To deposit one litre of hydrogen at 22.4 atmosphere from acidulaled water, the quantity of electricity that must pass through is

(a) 1 *coulomb* (b) 22.4 *coulomb*

(c) 96500 *coulomb* (d) 193000 *coulomb*

7. The amount of substance liberated on electrodes during electrolysis when 1 coulomb of electricity is passed, is

(a) Chemical equivalent
(b) Electrochemical equivalent
(c) Equivalent weight
(d) One mol

8. For goldplating on a copper chain, the substance required in the form of solution is

(a) Copper sulphate
(b) Copper chloride
(c) Potassium cyanide
(d) Potassium aurocyanide

9. On passing the current in water voltameter, the hydrogen

(a) Liberated at anode (b) Liberated at cathode
(c) Does not liberate (d) Remains in the solution

10. In water voltameter, the electrolysis of ...... takes place [DPMT 1999]

(a) H_2O (b) H_2SO_4
(c) H_2O and H_2SO_4 both (d) H_2 and O_2

11. For depositing 1 *gm* of *Cu* in copper voltameter on passing 2 *amperes* of current, the time required will be (For copper Z = 0.00033 *gm/C*)

(a) Approx. 20 *minutes* (b) Approx. 25 *minutes*
(c) Approx. 30 *minutes* (d) Approx. 35 *minutes*

12. A battery of e.m.f. 3 volt and internal resistance 1.0 *ohm* is connected in series with copper voltameter. The current flowing in the circuit is 1.5 amperes. The resistance of voltameter will be

(a) Zero (b) 1.0 *ohm*
(c) 1.5 *ohm* (d) 2.0 *ohm*

13. According to Faraday's laws of electrolysis, the amount of decomposition is proportional to [MP PMT 1993]

(a) $\frac{1}{\text{Time for which curent passes}}$
(b) Electrochemical equivalent of the substance
(c) $\frac{1}{\text{Current}}$
(d) $\frac{1}{\text{Electrochemical equivalent}}$

14. If in a voltaic cell 5 gm of zinc is consumed, then we get how many ampere hours ? (Given that E.C.E. of *Zn* is 3.387×10^{-7} *kg/coulomb*)

(a) 2.05 (b) 8.2
(c) 4.1 (d) $5\times3.387\times10^{-7}$

15. The current flowing in a copper voltameter is 1.6 *A*. The number of Cu^{++} ions deposited at the cathode per minute are

(a) 1.5×10^{20} (b) 3×10^{20}
(c) 6×10^{20} (d) 1×10^{19}

16. In a copper voltameter experiment, current is decreased to one-fourth of the initial value but it is passed for four times the earlier duration. Amount of copper deposited will be [MP PMT 1993]

(a) Same
(b) One-fourth the previous value
(c) Four times the previous value
(d) $\frac{1}{16}th$ of the previous value

17. A certain charge liberates 0.8 *gm* of O_2. The same charge will liberate how many gm of silver [MP PET 1999]

(a) 108 *gm* (b) 10.8 *gm*
(c) 0.8 *gm* (d) $\frac{108}{0.8}gm$

18. In charging a battery of motor-car, the following effect of electric current is used [MP PET 1993; AFMC 2003]

(a) Magnetic (b) Heating
(c) Chemical (d) Induction

19. The Avogadro's number is 6×10^{23} per gm mole and electronic charge is $1.6\times10^{-19}\,C$. The Faraday's number is [DPMT 2001]

(a) $6\times10^{23}\times1.6\times10^{-19}$ (b) $\frac{6\times10^{23}}{1.6\times10^{-19}}$
(c) $\frac{2}{6\times10^{23}\times1.6\times10^{-19}}$ (d) $\frac{1.6\times10^{-19}}{6\times10^{23}}$

20. In $CuSO_4$ solution when electric current equal to 2.5 *faraday* is passed, the gm equivalent deposited on the cathode is

(a) 1 (b) 1.5
(c) 2 (d) 2.5

21. The atomic weight of silver and copper are 108 and 64. A silver voltameter and a copper voltameter are connected in series and when current is passed 10.8 *gm* of silver is deposited. The mass of copper deposited will be

(a) 6.4 *gm* (b) 12.8 *gm*
(c) 3.2 *gm* (d) 10.8 *gm*

22. Faraday's laws of electrolysis are related to [IIT 1983]

(a) The atomic number of positive ion
(b) The equivalent weight of electrolyte
(c) The atomic number of negative ion
(d) The velocity of positive ion

23. In the process of electrolysis, the current is carried out inside the electrolyte by [AMU (Engg.) 1999]

(a) Electrons
(b) Atoms
(c) Positive and negative ions
(d) All the above

24. The mass of ions deposited during a given interval of time in the process of electrolysis depends on [DPMT 2002]

(a) The current (b) The resistance
(c) The temperature (d) The electric power

25. The amount of charge required to liberate 9 *gm* of aluminium (atomic weight = 27 and valency = 3) in the process of electrolysis is (Faraday's number = 96500 *coulombs/gm* equivalent) [MP PMT 1994; MP PET 2000]

(a) 321660 *coulombs* (b) 69500 *coulombs*
(c) 289500 *coulombs* (d) 96500 *coulombs*

26. In an electroplating experiment, *m gm* of silver is deposited when 4 *ampere* of current flows for 2 *minute*. The amount (in *gm*) of silver deposited by 6 *ampere* of current for 40 *second* will be [MNR 1991; UPSEAT 200

Pb. PET 2004; Orissa JEE 2005]

(a) 4 *m* (b) $m/2$

(c) $m/4$ (d) 2 *m*

27. In electrolysis, if the duration of the passage of current is doubled, the mass liberated is [EAMCET 1979]

(a) Doubled (b) Halved

(c) Increased four times (d) Remains the same

28. A current of 16 *ampere* flows through molten *NaCl* for 10 *minute*. The amount of metallic sodium that appears at the negative electrode would be [EAMCET 1984]

(a) 0.23 *gm* (b) 1.15 *gm*

(c) 2.3 *gm* (d) 11.5 *gm*

29. The mass of a substance liberated when a charge '*q*' flows through an electrolyte is proportional to [EAMCET 1984]

(a) q (b) $1/q$

(c) q^2 (d) $1/q^2$

30. A steady current of 5 *amps* is maintained for 45 *mins*. During this time it deposits 4.572 *gms* of zinc at the cathode of a voltameter. E.C.E. of zinc is [MP PET 1994]

(a) $3.387\times10^{-4}\,gm/C$ (b) $3.387\times10^{-4}\,C/gm$

(c) $3.384\times10^{-3}\,gm/C$ (d) $3.394\times10^{-3}\,C/gm$

31. The relation between faraday constant *F*, electron charge *e* and avogadro number *N* is [MP PET 1995]

(a) $F=N/e$ (b) $F=Ne$

(c) $N=F^2$ (d) $F=N^2e$

32. The electrochemical equivalent of magnesium is $0.126\,mg/C$. A current of 5 *A* is passed in a suitable solution for 1 *hour*. The mass of magnesium deposited will be

(a) 0.0378 *gm* (b) 0.227 *gm*

(c) 0.378 *gm* (d) 2.27 *gm*

33. Two electrolytic cells containing $CuSO_4$ and $AgNO_3$ respectively are connected in series and a current is passed through them until 1 *mg* of copper is deposited in the first cell. The amount of silver deposited in the second cell during this time is approximately

[Atomic weights of copper and silver are respectively 63.57 and 107.88] [MP PMT 1996]

(a) 1.7 *mg* (b) 3.4 *mg*

(c) 5.1 *mg* (d) 6.8 *mg*

34. A current *I* is passed for a time *t* through a number of voltameters. If *m* is the mass of a substance deposited on an electrode and *z* is its electrochemical equivalent, then

[MP PMT 1997]

(a) $\frac{zIt}{m}=\text{constant}$ (b) $\frac{z}{mIt}=\text{constant}$

(c) $\frac{I}{zmt}=\text{constant}$ (d) $\frac{It}{zm}=\text{constant}$

35. For electroplating a spoon, it is placed in the voltameter at

[MP PMT/PET 1998]

(a) The position of anode

(b) The position of cathode

(c) Exactly in the middle of anode and the cathode

(d) Anywhere in the electrolyte

36. If nearly 10^5 *coulomb* liberate 1 *gm* equivalent of aluminium, then the amount of aluminium (equivalent weight 9) deposited through electrolysis in 20 minutes by a current of 50 *amp* will be

(a) 0.6 *gm* (b) 0.09 *gm*

(c) 5.4 *gm* (d) 10.8 *gm*

37. Electroplating does not help in [AIIMS 1998]

(a) Fine finish to the surface

(b) Shining appearance

(c) Metals to become hard

(d) Protect metal against corrosion

38. When a current is passed through water, acidified with a dilute sulphuric acid, the gases formed at the platinum electrodes are

(a) 1 vol. hydrogen (cathode) and 2 vol. oxygen (anode)

(b) 2 vol. hydrogen (cathode) and 1 vol. oxygen (anode)

(c) 1 vol. hydrogen (cathode) and 1 vol. oxygen (anode)

(d) 1 vol. oxygen (cathode) and 2 vol. hydrogen (anode)

39. The negative *Zn* pole of a Daniel cell, sending a constant current through a circuit, decreases in mass by 0.13*g* in 30 *minutes*. If the electrochemical equivalent of *Zn* and *Cu* are 32.5 and 31.5 respectively, the increase in the mass of the positive *Cu* pole in this time is [AIEEE 2003]

(a) 0.242 *g* (b) 0.190 *g*

(c) 0.141 *g* (d) 0.126 *g*

40. When a copper voltameter is connected with a battery of e.m.f. 12 *volts*. 2 *gms* of copper is deposited in 30 *minutes*. If the same voltameter is connected across a 6 volt battery, then the mass of copper deposited in 45 minutes would be

[SCRA 1994]

(a) 1 *gm* (b) 1.5 *gm*

[MP PMT 1995]

(c) 2 *gm* (d 2.5 *gm*

41. The value of current required to deposit 0.972 *gm* of chromium in 3 *hours* if the E.C.E. of chromium is 0.00018 *gm* per coulomb, is

(a) 1 *amp* (b) 1.5 *amp*

(c) 0.5 *amp* (d) 2 *amp*

42. The current inside a copper voltameter [Roorkee 1992]

(a) Is half the outside value

(b) Is the same as the outside value

(c) Is twice the outside value

(d) Depends on the concentration of $CuSO_4$

43. The resistance of a cell does not depend on [RPET 1996]

(a) Current drawn from the cell

(b) Temperature of electrolyte

(c) Concentration of electrolyte

(d) The e.m.f. of the cell

44. The electrochemical equivalent of a metal is $3.3\times10^{-7}\,kg/coulomb$. The mass of the metal liberated at the cathode when a 3 *A* current is passed for 2 seconds will be

(a) $19.8\times10^{-7}\,kg$ (b) $9.39\times10^{-7}\,kg$

(c) $6.6\times10^{-7}\,kg$ (d) $1.1\times10^{-7}\,kg$

45. Faraday's 2nd law states that mass deposited on the electrode is directly proportional to [DCE 1999]

(a) Atomic mass (b) Atomic mass × Velocity

(c) Atomic mass/Valency (d) Valency

46. The relation between Faraday constant (F), chemical equivalent (E) and electrochemical equivalent (Z) is [SCRA 1994; AFMC 2000]

(a) $F = EZ$ (b) $F = \frac{Z}{E}$

(c) $F = \frac{E}{Z}$ (d) $F = \frac{E}{Z^2}$

47. The electrochemical equivalent of a material in an electrolyte depends on [MP PET 2001]

(a) The nature of the material

(b) The current through the electrolyte

(c) The amount of charge passed through electrolyte

(d) The amount of material present in electrolyte

48. On passing 96500 *coulomb* of charge through a solution $CuSO_4$ the amount of copper liberated is [MP PMT 2001]

(a) 64 *gm* (b) 32 *gm*

(c) 32 *kg* (d) 64 *kg*

49. If 96500 *coulombs* of electricity liberates one gram equivalent of any substance, the time taken for a current of 0.15 *amperes* to deposite 20*mg* of copper from a solution of copper sulphate is (Chemical equivalent of copper = 32) [Kerala (Engg.) 2002]

(a) 5 *min* 20 *sec* (b) 6 *min* 42 *sec*

(c) 4 *min* 40 *sec* (d) 5 *min* 50 *sec*

50. How much current should be passed through acidified water for 100 *s* to liberate 0.224 *litre* of H_2 [DCE 2002]

(a) 22.4 *A* (b) 19.3 *A*

(c) 9.65 *A* (d) 1 *A*

51. Who among the following scientists made the statement –"Chemical change can produce electricity" [DCE 2004]

(a) Galvani (b) Faraday

(c) Coulomb (d) Thomson

52. If a steady current of 4 *amp* maintained for 40 *minutes,* deposits 4.5 *gm* of zinc at the cathode and then the electro chemical equivalent will be [MH CET 2003]

(a) $51 \times 10^{-17}\ gm/C$ (b) $28 \times 10^{-6}\ gm/C$

(c) $32 \times 10^{-5}\ gm/C$ (d) $47 \times 10^{-5}\ gm/C$

53. The current flowing in a copper voltameter is 3.2 *A*. The number of copper ions (Cu^{2+}) deposited at the cathode per minute is

(a) 0.5×10^{20} (b) 1.5×10^{20}

(c) 3×10^{20} (d) 6×10^{20}

54. A copper voltameter is connected in series with a heater coil of resistance 0.1Ω. A steady current flows in the circuit for twenty minutes and mass of 0.99 *g* of copper is deposited at the cathode. If electrochemical equivalent of copper is 0.00033 *gm/C*, then heat generated in the coil is [Pb. PET 2002]

(a) 750 *J* (b) 650 *J*

(c) 350 *J* (d) 250 *J*

55. E.C.E. of *Cu* and *Ag* are 7×10^{-6} and 1.2×10^{-6}. A certain current deposits 14 *gm* of *Cu*. Amount of *Ag* deposited is [Orissa PMT 2004]

(a) 1.2 *gm* (b) 1.6 *gm*

(c) 2.4 *gm* (d) 1.8 *gm*

56. The chemical equivalent of silver is 108. If the current in a silver voltameter is 2 *Amp.*, the time required to deposit 27 *grams* of silver will be [MP PMT 2004]

(a) 8.57 *hrs* (b) 6.70 *hrs*

(c) 3.35 *hrs* (d) 12.50 *hrs*

57. Two voltameters, one of copper and another of silver, are joined in parallel. When a total charge *q* flows through the voltameters, equal amount of metals are deposited. If the electrochemical equivalents of copper and silver are z_1 and z_2 respectively the charge which flows through the silver voltameter is

(a) $q\frac{z_1}{z_2}$ (b) $q\frac{z_2}{z_1}$

(c) $\frac{q}{1+\frac{z_1}{z_2}}$ (d) $\frac{q}{1+\frac{z_2}{z_1}}$

58. The chemical equivalent of copper and zinc are 32 and 108 respectively. When copper and silver voltameter are connected in series and electric current is passed through for sometimes, 1.6 *g* of copper is deposited. Then, the mass of silver deposited will be

(a) 3.5 *g* (b) 2.8 *g*

(c) 5.4 *g* (d) None of these

59. Ampere hour is the unit of [Orissa JEE 2005]

(a) Quantity of charge (b) Potential

(c) Energy (d) Current

Thermo-Electricity

1. The production of e.m.f. by maintaining a difference of temperature between the two junctions of two different metals is known as

(a) Joule effect (b) Seebeck effect

(c) Peltier effect (d) Thomson effect

2. When a current passes through the junction of two different metals, evolution or absorption of heat at the junction is known as [Pb. PET 2001]

(a) Joule effect (b) Seebeck effect

(c) Peltier effect (d) Thomson effect

3. When a current passes through a wire whose different parts are maintained at different temperatures, evolution or absorption of heat all along the length of wire is known as

(a) Joule effect (b) Seebeck effect

(c) Peltier effect (d) Thomson effect

4. The thermocouple is based on the principle of [MP PET 1984; AFMC 1998; BCECE 2003]

(a) Seebeck effect (b) Thomson effect

(c) Peltier effect (d) Joule effect

5. For a thermocouple, the neutral temperature is $270°C$ and the temperature of its cold junction is $20°C$. If there is no deflection in the galvanometer, the temperature of the hot junction should be

(a) $210°C$ (b) $540°C$

(c) $520°C$ (d) $209°C$

6. Thermocouple is a device for the measurement of

(a) Absolute temperature of a metal

(b) The temperature difference between two substances

(c) The couple acting on a wire

(d) Thermal conductivity of a substance

7. The true statement for thermo e.m.f. of a thermocouple

(a) Depends on the nature of metals

(b) Depends only on temperature of cold junction

(c) Depends only on temperature of hot junction

(d) Depends on the length of the wires used for thermocouple

8. The direction of current in an iron-copper thermocouple is [MP PET 1995]

(a) From copper to iron at the hot junction

(b) From iron to copper at the hot junction

(c) From copper to iron at cold junction

(d) No current will flow

9. Peltier coefficient for the junction of a pair of metals is proportional to [MP PMT 1993; MP PET 1997]

(a) *T* absolute temperature of the junction

(b) Square of absolute temperature of the junction

(c) $\frac{1}{\text{Absolute temperature of the junction}}$

(d) $\frac{1}{\text{Square of absolute temperature of the junction}}$

10. If for a thermocouple T_n is the neutral temperature, T_c is the temperature of the cold junction and T_i is the temperature of inversion, then [MP PET 2001; AIEEE 2002]

(a) $T_i = 2T_n - T_c$ (b) $T_n = T_i - 2T_c$

(c) $T_i = T_n - T_c$ (d) None of these

11. For a thermocouple, the temperature of inversion is that temperature at which thermo e.m.f. is

(a) Zero (b) Maximum

(c) Minimum (d) None of the above

12. For a given thermocouple, the thermo e.m.f. can be

(a) Zero (b) Positive

(c) Negative (d) All of the above

13. When current is passed in antimony-bismuth couple, then

(a) The junction becomes hot when the current is from bismuth to antimony

(b) The junction becomes hot when current flows from antimony to bismuth

(c) Both junctions become hot

(d) Both junctions become cold

14. A thermocouple is made of *Cu* and *Fe*. If a battery is connected in it, then

(a) Both junctions will be at the same temperature

(b) Both junctions will become hot

(c) One junction will be hotter than the other

(d) None of these

15. Thermopile is used for [AMU Engg. 2000]

(a) Collecting the heat energy

(b) The measurement of radiant heat energy

(c) The measurement of current

(d) The change of atomic energy into heat energy

16. When a current of 1 ampere is passed through a conductor whose ends are maintained at temperature difference of $1°C$, the amount of heat evolved or absorbed is called

(a) Peltier coefficient (b) Thomson coefficient

(c) Thermoelectric power (d) Thermo e.m.f.

17. In a thermocouple, the temperature that does not depend on the temperature of the cold junction is called

(a) Neutral temperature (b) Temperature of inversion

(c) Both the above (d) None of the above

18. At neutral temperature, the thermoelectric power $\left(\frac{dE}{dT}\right)$ has the value [MP PET 2003; MP PMT 2004]

(a) Zero (b) Maximum but negative

(c) Maximum but positive (d) Minimum but positive

19. In *Cu-Fe* couple, the flow of current at the temperature of inversion is

(a) From *Fe* to *Cu* through the hot junction

(b) From *Cu* to *Fe* through the hot junction

(c) Maximum

(d) None of the above

20. In Seebeck series *Sb* appears before *Bi*. In a $Sb - Bi$ thermocouple current flows from [MP PET 1994]

(a) *Sb* to *Bi* at the hot junction

(b) *Sb* to *Bi* at the cold junction

(c) *Bi* to *Sb* at the cold junction

(d) None of the above

21. Which of the following statement is correct [MP PET 1994]

(a) Both Peltier and Joule effects are reversible

(b) Both Peltier and Joule effects are irreversible

(c) Joule effect is reversible, whereas Peltier effect is irreversible

(d) Joule effect is irreversible, whereas Peltier effect is reversible

22. For a given temperature difference, which of the following pairs will generate maximum thermo e.m.f. [MP PMT 1994]

(a) Antimony-bismuth (b) Silver-gold

(c) Iron-copper (d) Lead-nickel

23. The cold junction of a thermocouple is maintained at $10°C$. No thermo e.m.f. is developed when the hot junction is maintained at $530°C$. The neutral temperature is [MP PMT 1994]

(a) $260°C$ (b) $270°C$

(c) $265°C$ (d) $520°C$

24. Which of the following is not reversible [Manipal MEE 1995; DPMT 2001]

(a) Joule effect (b) Peltier effect

(c) Seebeck effect (d) Thomson effect

25. Neutral temperature of a thermocouple is defined as the temperature at which [MP PMT 1996]
(a) The thermo e.m.f. changes sign
(b) The thermo e.m.f. is maximum
(c) The thermo e.m.f. is minimum
(d) The thermo e.m.f. is zero

26. As the temperature of hot junction of a thermo-couple is increased (while cold junction is at constant temperature), the thermo e.m.f.
(a) Increases uniformly at constant rate
(b) Increases slowly in the beginning and more rapidly at higher temperatures
(c) Increases more rapidly in the beginning but less rapidly at higher temperatures
(d) In minimum at neutral temperature

27. As the temperature of hot junction increases, the thermo e.m.f.
(a) Always increases
(b) Always decreases
(c) May increase or decrease
(d) Always remains constant

28. The e.m.f. in a thermoelectric circuit with one junction at $0°C$ and the other at $t°C$ is given by $E = At - Bt^2$. The neutral temperature is then [AMU 1995; BCECE 2004]
(a) $\frac{A}{B}$ (b) $-\frac{A}{2B}$
(c) $-\frac{B}{2A}$ (d) $\frac{A}{2B}$

29. The temperature of cold junction and neutral temperature of a thermocouple are $15^o C$ and $280^o C$ respectively. The temperature of inversion is [AMU (Engg.) 1999]
(a) $295^o C$ (b) $265^o C$
(c) $545^o C$ (d) $575^o C$

30. Above neutral temperature, thermo e.m.f. in a thermocouple [AMU (Engg.) 1999]
(a) Decreases with rise in temperature
(b) Increases with rise in temperature
(c) Remains constant
(d) Changes sign

31. Consider the following two statements A and B, and identify the correct choice out of given answers
A. Thermo e.m.f. is minimum at neutral temperature of a thermocouple
B. When two junctions made of two different metallic wires are maintained at different temperatures, an electric current is generated in the circuit. [EAMCET (Med.) 2000]
(a) A is false and B is true (b) A is true and B is false
(c) Both A and B are false (d) Both A and B are true

32. The temperature at which thermal electric power of a thermo couple becomes zero is called [MP PMT 2001]
(a) Inversion temperature (b) Neutral temperature
(c) Junction temperature (d) Null temperature

33. Thomson coefficient of a conductor is $10\mu V/K$. The two ends of it are kept at $50^o C$ and $60^o C$ respectively. Amount of heat absorbed by the conductor when a charge of 10 C flows through it is
(a) 1000 J (b) 100 J
(c) 100 mJ (d) 1 mJ

34. For a thermocouple the neutral temperature is $270^o C$ when its cold junction is at $20^o C$. What will be the neutral temperature and the temperature of inversion when the temperature of cold junction is increased to $40^o C$ [Kerala PET 2001]
(a) $290^o C, 580^o C$ (b) $270^o C, 580^o C$
(c) $270^o C, 500^o C$ (d) $290^o C, 540^o C$

35. Two ends of a conductor are at different temperatures the electromotive force generated between two ends is [MP PMT 2001; MP PET 2002]
(a) Seebeck electro motive force (e.m.f.)
(b) Peltier electro motive force (e.m.f.)
(c) Thomson electro motive force (e.m.f.)
(d) None of these [MP PET 1999]

36. The neutral temperature of a thermocouple is $350^o C$ when the cold junction is at $0^o C$. When the cold junction is immersed in a bath of $30^o C$, the inversion temperature is [Kerala (Med.) 2002]
(a) $700^o C$ (b) $600^o C$
(c) $350^o C$ (d) $670^o C$

37. A thermoelectric refrigerator works on [JIPMER 2002]
(a) Joule effect (b) Seeback effect
(c) Peltier effect (d) Thermonic emission

38. If the temperature of cold junction of thermocouple is lowered, then the neutral temperature [JIPMER 2002]
(a) Increases
(b) Approaches inversion temperature
(c) Decreases
(d) Remains the same

39. Consider the following two statements A and B and identify the correct choice given in the answers
(A) Duddells thermo-galvanometer is suitable to measure direct current only
(B) Thermopile can measure temperature differences of the order of $10^{-3}\ ^oC$ [EAMCET 2003]
(a) Both A and B are true (b) Both A and B are false
(c) A is true but B is false (d) A is false but B is true

40. If $E = at + bt^2$, what is the temperature of inversion [DCE 2003]
(a) $-\frac{a}{2b}$ (b) $+\frac{a}{2b}$
(c) $-\frac{a}{b}$ (d) $+\frac{a}{b}$

41. Antimony and bismuth are usually used in a thermocouple, because
(a) Negative thermal e.m.f. produced
(b) Constant thermal e.m.f. produced
(c) Lower thermal e.m.f. produced
(d) Higher thermal e.m.f. produced [EAMCET 2001]

42. The smallest temperature difference that can be measured with a combination of a thermocouple of thermo e.m.f. 30μV per degree and a

galvanometer of 50 *ohm* resistance, capable of measuring a minimum current of $3 \times 10^{\cdot}$ *amp* is [MP PET 2000]

(a) 0.5 degree (b) 1.0 degree
(c) 1.5 degree (d) 2.0 degree

43. $e = \alpha t - \frac{1}{2}\beta t^2$, If temperature of cold junction is $0^o C$ then temperature of inversion is

$(\text{if}\,\alpha = 500.0 \mu V/{}^o C, \beta = 5.0 \mu V/\text{Square}\,{}^o C)$ [DCE 2001]

(a) 100 (b) 200
(c) 300 (d) 400

44. If the emf of a thermocouple, one junction of which is kept $0^\circ C$ is given by $e = at + 1/2\ bt^2$ then the neutral temperature will be [J & K CET 2005]

(a) *a/b* (b) – *a/b*
(c) *a/2b* (d) –1/ *ab*

Critical Thinking

Objective Questions

1. The resistance of the filament of an electric bulb changes with temperature. If an electric bulb rated 220 volt and 100 watt is connected $(220 \times .8)$ *volt* sources, then the actual power would be

(a) $100 \times 0.8\, watt$

(b) $100 \times (0.8)^2 watt$

(c) Between 100×0.8 *watt* and 100 *watt*

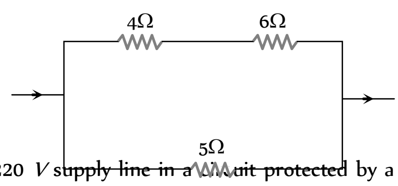
(d) Between $100 \times (0.8)^2 watt$ and 100×0.8 *watt*

2. An immersion heater is rated 836 *watt*. It should heat 1 *litre* of water from $10°C$ to $40°C$ in about [AIEEE 2004]

(a) 200 *sec* (b) 150 *sec*
(c) 836 *sec* (d) 418 *sec*

3. In the circuit shown in figure, the heat produced in 5 *ohm* resistance is 10 *calories* per *second*. The heat produced in 4 resistance is [IIT 1981; UPSEAT 2002]

(a) 1 *cal / sec*
(b) 2 *cal/sec*
(c) 3 *cal / sec*
(d) 4 *cal/sec*



4. A house is served by 220 *V* supply line in a circuit protected by a 9 *ampere* fuse. The maximum number of 60 W lamps in parallel that can be turned on, is

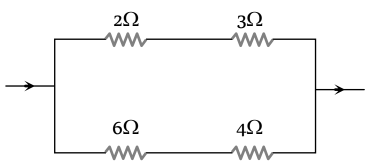
(a) 44 (b) 20
(c) 22 (d) 33

5. Water boils in an electric kettle in 15 *minutes* after switching on. If the length of the heating wire is decreased to $2/3$ of its initial value, then the same amount of water will boil with the same supply voltage in [MP PMT 1994]

(a) 15 *minutes* (b) 12 *minutes*
(c) 10 *minutes* (d) 8 *minutes*

6. In the circuit as shown in the figure, the heat produced by 6 *ohm* resistance due to current flowing in it is 60 *calorie* per *second*. The heat generated across 3 *ohm* resistance per second will be

(a) 30 *calorie*



(b) 60 *calorie*
(c) 100 *calorie*
(d) 120 *calorie*

7. The resistance of a heater coil is 110 *ohm*. A resistance *R* is connected in parallel with it and the combination is joined in series with a resistance of 11 *ohm* to a 220 *volt* main line. The heater operates with a power of 110 *watt*. The value of *R* in *ohm* is

(a) 12.22
(b) 24.42
(c) Negative
(d) That the given values are not correct

8. A 500 *W* heating unit is designed to operate from a 115 *volt* line. If the line voltage drops to 110 volt, the percentage drop in heat output will be [ISM Dhanbad 1994]

(a) 10.20% (b) 8.1%
(c) 8.6% (d) 7.6%

9. A heater of 220 *V* heats a volume of water in 5 minute time. A heater of 110 *V* heats the same volume of water in [AFMC 1993]

(a) 5 *minutes* (b) 8 *minutes*
(c) 10 *minutes* (d) 20 *minutes*

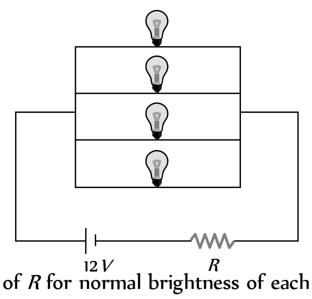
10. An electric kettle takes 4 *A* current at 220 *V*. How much time will it take to boil 1 *kg* of water from room temperature $20°C$? The temperature of boiling water is $100°C$ [CPMT 1989] [RPET 1996]

(a) 6.4 *minutes* (b) 6.3 *minutes*
(c) 12.6 *minutes* (d) 12.8 *minutes*

11. If a wire of resistance $20\,\Omega$ is covered with ice and a voltage of 210 *V* is applied across the wire, then the rate of melting of ice is

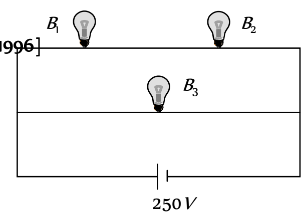
(a) $0.85\, g/s$ (b) $1.92\, g/s$
(c) $6.56\, g/s$ (d) All of these

12. Four identical electrical lamps are labelled 1.5 *V*, 0.5*A* which describes the condition necessary for them to operate at normal brightness. A 12 *V* battery of negligible internal resistance is connected to lamps as shown, then [UPSEAT 2001]



(a) The value of *R* for normal brightness of each lamp is (3/4) Ω
(b) The value of *R* for normal brightness of each lamp is (21/4) Ω
(c) Total power dissipated in circuit when all lamps are normally bright is 24 *W*
(d) Power dissipated in *R* is 21 *W* when all lamps are normally bright

13. A 100 *W* bulb B_1 and two 60-*W* bulbs B_2 and B_3, are connected to a 250 *V* source, as shown in the figure. Now W_1, W_2 and W_3 are the output powers of the bulbs B_1, B_2 and B_3 respectively. Then [MP PET 1996]

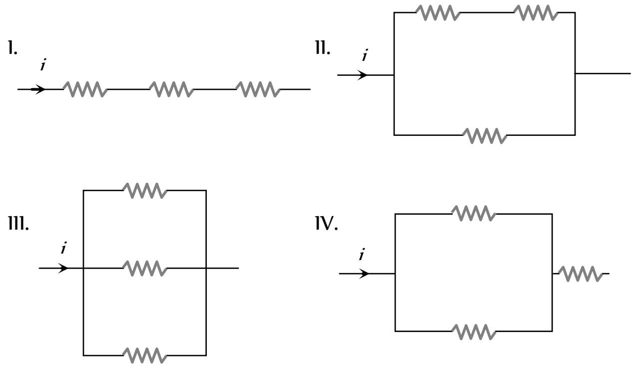


(a) $W_1 > W_2 = W_3$ (b) $W_1 > W_2 > W_3$

(c) $W_1 < W_2 = W_3$ (d) $W_1 < W_2 < W_3$

14. The three resistance of equal value are arranged in the different combinations shown below. Arrange them in increasing order of power dissipation

[IIT-JEE (Screening) 2003]



(a) III < II < IV < I (b) II < III < IV < I

(c) I < IV < III < II (d) I < III < II < IV

15. Silver and copper voltameter are connected in parallel with a battery of e.m.f. 12 *V*. In 30 *minutes*, 1 *gm* of silver and 1.8 *gm* of copper are liberated. The power supplied by the battery is

(a) 24.13 *J/sec* (b) 2.413 *J/sec*

(c) 0.2413 *J/sec* (d) 2413 *J/sec*

$(Z_{Cu} = 6.6 \times 10^{-4}\ gm/C$ and $Z_{Ag} = 11.2 \times 10^{-4}\ gm/C)$

16. A silver voltameter of resistance 2 *ohm* and a 3 *ohm* resistor are connected in series across a cell. If a resistance of 2 *ohm* is connected in parallel with the voltameter, then the rate of deposition of silver [EAMCET 1983]

(a) Decreases by 25%

(b) Increases by 25%

(c) Increases by 37.5%

(d) Decreases by 37.5%

17. The expression for thermo e.m.f. in a thermocouple is given by the relation $E = 40\,\theta - \frac{\theta^2}{20}$, where θ is the temperature difference of two junctions. For this, the neutral temperature will be

(a) $100°C$ (b) $200°C$

(c) $300°C$ (d) $400°C$

18. For copper-iron (*Cu-Fe*) couple, the thermo e.m.f. (temperature of cold junction $= 0°C$) is given by $E = (14\theta - 0.02\theta^2)\mu V$. The neutral temperature will be

(a) $350°C$ (b) 350 *K*

(c) $560°C$ (d) 560 *K*

19. One junction of a certain thermoelectric couple is at a fixed temperature T_r and the other junction is at temperature *T*. The thermo electromotive force for this is expressed by $E = K(T - T_r)\left[T_0 - \frac{1}{2}(T + T_r)\right]$. At temperature $T = \frac{1}{2}T_0$, the thermoelectric power is [MP PMT 1994]

(a) $\frac{1}{2}KT_0$ (b) KT_0

(c) $\frac{1}{2}KT_0^2$ (d) $\frac{1}{2}K(T_0 - T_r)^2$

20. The temperature of the cold junction of thermo-couple is $0°C$ and the temperature of hot junction is $T°C$. The e.m.f. is $E = 16T - 0.04T^2\,\mu$ volts. The temperature of inversion is

(a) $200°C$ (b) $400°C$

(c) $100°C$ (d) $300°C$

21. The temperature of the cold junction of a thermocouple is 0^oC and temperature of the hot junction is T^oC. The thermo e.m.f. is given by the relation $E = AT - \frac{1}{2}BT^2$ (where *A* = 16 and *B* = 0.08). The temperature of inversion is

(a) 100^oC (b) 300^oC

(c) 400^oC (d) 500^oC

22. The thermo e.m.f. of a thermo-couple is $25\mu V/^oC$ at room temperature. A galvanometer of 40 ohm resistance, capable of detecting current as low as $10^{-5}A$, is connected with the thermocouple. The smallest temperature difference that can be detected by this system is [IIT 1975] [AIEEE 2003]

(a) 20^oC (b) 16^oC

(c) 12^oC (d) 8^oC

23. An electric bulb rated for 500 watts at 100 volts is used in a circuit having a 200-volt supply. The resistance *R* that must be put in series with the bulb, so that the bulb draws 500 *W* is

(a) $10\,\Omega$ (b) $20\,\Omega$

(c) $50\,\Omega$ (d) $100\,\Omega$

24. A thermo couple develops $200\,\mu V$ between 0^oC and 100^oC. If it develops $64\,\mu V$ and $76\,\mu V$ respectively between $(0^oC - 32^oC)$ and $(32^oC - 70^oC)$ then what will be the thermo *emf* it develops between 70^oC and 100^oC

(a) $65\,\mu V$ (b) $60\,\mu V$

(c) $55\,\mu V$ [AMU (Engg.) 2000] (d) $50\,\mu V$

25. A thermo couple is formed by two metals *X* and *Y* metal *X* comes earlier to *Y* in Seebeck series. If temperature of hot junction increases beyond the temperature of inversion. Then direction of current in thermocouple will so

(a) *X* to *Y* through cold junction

(b) *X* to *Y* through hot junction

(c) *Y* to *X* through cold junction

(d) Both (b) and (c)

26. Peltier co-efficient of a thermo couple is 2 *nano volts*. How much heat is developed at a junction if 2.5 *amp* current flows for 2 *minute*

(a) 6 *ergs* (b) 6×10^{-7} *ergs*

(c) 16 *ergs* (d) 6×10^{-3} *erg*

27. Resistance of a voltameter is $2\,\Omega$, it is connected in series to a battery of 10 *V* through a resistance of $3\,\Omega$. In a certain time mass deposited on cathode is 1 *gm*. Now the voltameter and the $3\,\Omega$ resistance are connected in parallel with the battery. Increase in the deposited mass on cathode in the same time will be

(a) 0 (b) 1.5 *gm*

(c) 2.5 *gm* (d) 2 *gm*

28. A current of 1.5 *A* flows through a *copper* voltameter. The thickness of *copper* deposited on the electrode surface of area $50\,cm^2$ in 20 *minutes* will be (Density of *copper* = 9000 kg/m^3 and E.C.E. of *copper* = 0.00033 *g/C*)

(a) $2.6\times10^{-5}\,m$ (b) $2.6\times10^{-4}\,m$

(c) $1.3\times10^{-5}\,m$ (d) $1.3\times10^{-4}\,m$

29. An ammeter, suspected to give inaccurate reading, is connected in series with a *silver* voltameter. The ammeter indicates 0.54 *A*. A steady current passed for one hour deposits 2.0124 *gm* of *silver*. If the E.C.E. of *silver is* $1.118\times10^{-3}\,gmC^{-1}$, then the error in ammeter reading is

(a) + 0.04 *A* (b) + 0.02 *A*

(c) – 0.03 *A* (d) – 0.01 *A*

30. If 1 *A* of current is passed through $CuSO_4$ solution for 10 seconds, then the number of copper ions deposited at the cathode will be about

(a) 1.6×10^{19} (b) 3.1×10^{19}

(c) 4.8×10^{19} (d) 6.2×10^{19}

31. A silver and a copper voltmeters are connected in parallel across a 6 *volt* battery of negligible resistance. In half an hour, 1 *gm* of copper and 2 *gm* of silver are deposited. The rate at which energy is supplied by the battery will approximately be (Given E.C.E. of copper $=3.294\times10^{-4}\,g/C$ and *E.C.E.* of silver $=1.118\times10^{-3}\,g/C$)

(a) 64 *W* (b) 32 *W*

(c) 96 *W* (d) 16 *W*

32. A thermocouple of resistance $1.6\,\Omega$ is connected in series with a galvanometer of $8\,\Omega$ resistance. The thermocouple develops and e.m.f. of $10\mu V$ per degree temperature difference between two junctions. When one junction is kept at 0^oC and the other in a molten metal, the galvanometer reads 8 *millivolt*. The temperature of molten metal, when e.m.f. varies linearly with temperature difference, will be

(a) 960^oC (b) 1050^oC

(c) 1275^oC (d) 1545^oC

33. The *emf* of a thermocouple, one junction of which is kept at 0^oC, is given by $e=at+bt^2$ the Peltier co-efficient will be

(a) $(t+273)(a+2bt)$ (b) $(t+273)(a-2bt)$

(c) $(t-273)(a-2bt)$ (d) $(t-273)(a-2bt)$

34. A coil of wire of resistance $50\,\Omega$ is embedded in a block of ice. If a potential difference of 210 *V* is applied across the coil, the amount of ice melted per second will be

(a) 4.12 *gm* (b) 4.12 *kg*

(c) 3.68 *kg* (d) 2.625 *gm*

35. The same mass of copper is drawn into two wires 1 *mm* and 2 *mm* thick. Two wires are connected in series and current is passed through them. Heat produced in the wire is in the ratio

(a) 2 : 1 (b) 1 : 16

(c) 4 : 1 (d) 16 : 1

36. The temperature of hot junction of a thermo-couple changes from 80^oC to 100^oC. The percentage change in thermoelectric power is

(a) 8% (b) 10%

(c) 20% (d) 25%

37. A thermo couple uses Bismuth and Tellurium as the dissimilar metals. The sensitivity of bismuth is $-72\mu V/^oC$ and that of the tellurium is $500\mu\ V/^oC$. If the difference between hot and cold junction is 100^oC, then the maximum output will be

(a) $50\ mV$ (b) $7.2\ mV$

(c) $42.8\ mV$ (d) $57.2\ mV$

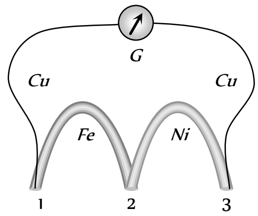
38. Three wires of copper, iron and nickel are joined to form three junctions as shown in Fig. When the temperature of junction 1 is kept 50^oC with the other two junctions at 0^oC, the sensitive galvanometer gives a deflection of 14 divisions. When the temperature of junction 3 is kept 50^oC, with the other two junctions at 0^oC, the galvanometer gives a deflection of 11 divisions. Then the deflection given by the galvanometer, when temperature of the junction 2 is kept at 50^oC, with the other two junctions at 0^oC, will be

(a) 3 *div*

(b) 11 *div*

(c) 14 *div*

(d) 25 *div*



39. The wiring of a house has resistance $6\,\Omega$. A 100 *W* bulb is glowing. If a geyser of 1000 *W* is switched on, the change in potential drop across the bulb is nearly **[MNR 1998]**

(a) Nil (b) 23 *V*

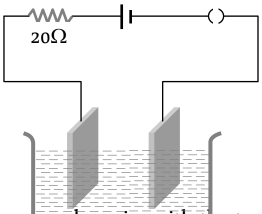
(c) 32 *V* (d) 12 *V*

40. A 12 *V* lead accumulator is being charged using 24 *V* supply with an external resistance 2Ω. The internal resistance of the accumulator is 1Ω. Find the time in which it will store 360 *W*-hour energy.

(a) 1 *hr* (b) 7.5 *hr*

(c) 10 *hr* (d) None of these

41. In a *Ag* voltameter 2.68 *gm* of silver is deposited in 10 *min*. The heat developed in $20\,\Omega$ resistor during the same period will be



(a) 192 *kJ*

(b) 192 *J*

(c) 200 *J*

(d) 132 *kJ*

42. The thermo e.m.f. of a thermocouple varies with the temperature θ of the hot junction as $E = a\theta + b\theta^2$ in *volts* where the ratio *a*/*b* is 700^oC. If the cold junction is kept at 0^oC, then the neutral temperature is [AIEEE 2004]

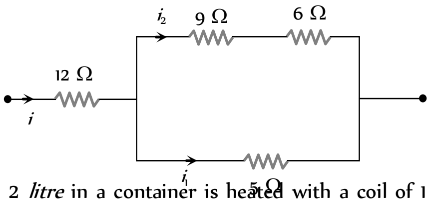
(a) 700^oC

(b) 350^oC

(c) 1400^oC

(d) No neutral temperature is possible for this thermocouple

43. In the following circuit, 5 Ω resistor develops 45 *J/s* due to current flowing through it. The power developed per second across 12 Ω resistor is [AMU (Engg.) 1999]



(a) 16 *W*

(b) 192 *W*

(c) 36 *W*

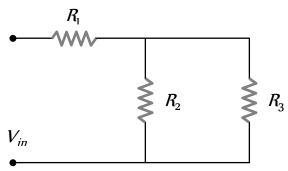
(d) 64 *W*

44. Water of volume 2 *litre* in a container is heated with a coil of 1 *kW* at 27°*C*. The lid of the container is open and energy dissipates at rate of 160 *J/s*. In how much time temperature will rise from 27°C to 77°*C* [Given specific heat of water is 4.2 *kJ/kg*]

(a) 8 *min* 20 *s* (b) 6 *min* 2 *s*

(c) 7 *min* (d) 14 *min*

45. For ensuring dissipation of same energy in all three resistors (R_1, R_2, R_3) connected as shown in figure, their values must be related as] [AIIMS 2005]



(a) $R_1 = R_2 = R_3$

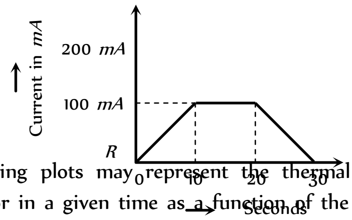
(b) $R_2 = R_3$ and $R_1 = 4R_2$

(c) $R_2 = R_3$ and $R_1 = \dfrac{1}{4}R_2$

(d) $R_1 = R_2 + R_3$

Graphical Questions

1. In a copper voltameter, mass deposited in 30 *second* is *m gm*. If the time-current graph is as shown in figure, *ECE* of copper is



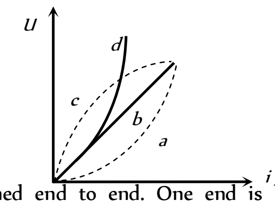
(a) *m*

(b) $m/2$

(c) 0.1 *m*

(d) 0.6 *m*

2. Which of the following plots may represent the thermal energy produced in a resistor in a given time as a function of the electric current [MP PMT 1999]



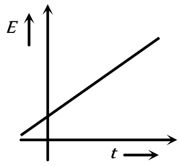
(a) *a*

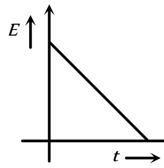
(b) *b*

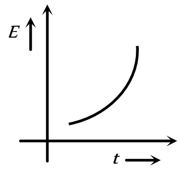
(c) *c*

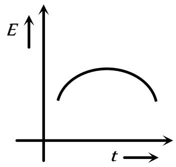
(d) *d*

3. Two different metals are joined end to end. One end is kept at constant temperature and the other end is heated to a very high temperature. The graph depicting the thermo e.m.f. is

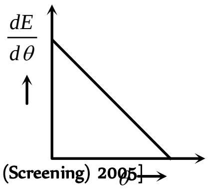
(a) 

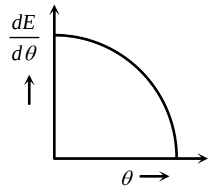
(b) 

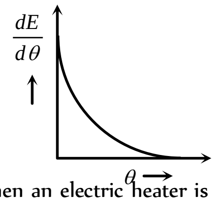
(c) 

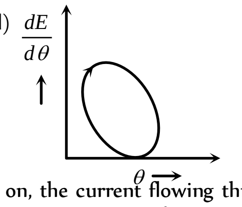
(d) 

4. Which of the following graphs shows the variation of thermoelectric power with temperature difference between hot and cold junction in thermocouples [IIT-JEE (Screening) 2005]

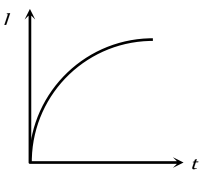
(a) 

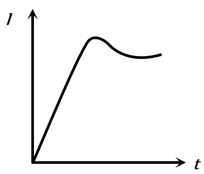
(b) 

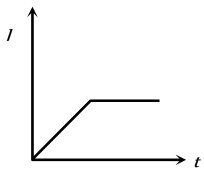
(c) 

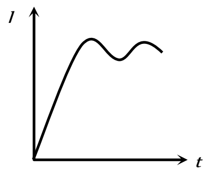
(d) 

5. When an electric heater is switched on, the current flowing through it (*i*) is plotted against time (*t*). Taking into account the variation of resistance with temperature, which of the following best represents the resulting curve

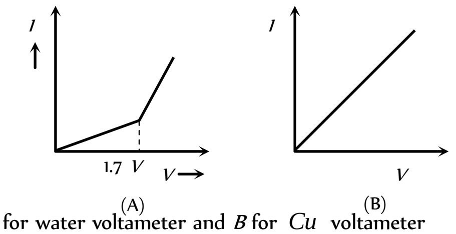
(a) 

(b) 

(c) 

(d) 

6. The V-i graphs A and B drawn for two voltameters. Identify each graph



(a) A for water voltameter and B for Cu voltameter

(b) A for Cu voltameter and B for water voltameter

(c) Both A and B represents Cu voltameter

(d) None of these

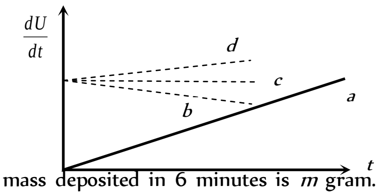
7. A constant current i is passed through a resistor. Taking the temperature coefficient of resistance into account, indicate which of the plots shown in figure best represents the rate of production of thermal energy in the resistor

(a) a

(b) b

(c) c

(d) d



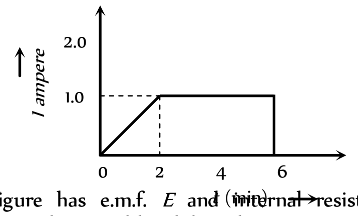
8. In a copper voltameter, mass deposited in 6 minutes is m gram. If the current-time graph for the voltameter is as shown here, then the E.C.E of the copper is

(a) $m / 5$

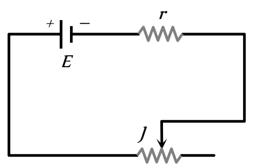
(b) $m / 300$

(c) $5\,m$

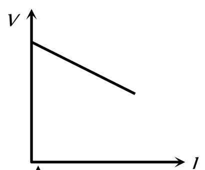
(d) $m / 18000$



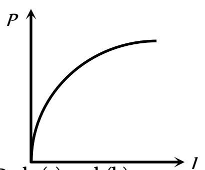
9. Battery shown in figure has e.m.f. E and internal resistance r. Current in the circuit can be varied by sliding the contact J. If at any instant current flowing through the circuit is I, potential difference between terminals of the cell is V, thermal power generated in the cell is equal to η fraction of total electrical power generated in it.; then which of the following graph is correct



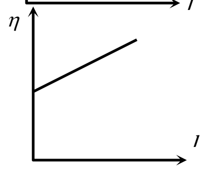
(a)



(b)



(c)



(d) Both (a) and (b) are correct

Assertion & Reason

For AIIMS Aspirants

Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c) If assertion is true but reason is false.

(d) If the assertion and reason both are false.

(e) If assertion is false but reason is true.

1. Assertion : The possibility of an electric bulb fusing is higher at the time of switching ON and OFF

Reason : Inductive effects produce a surge at the time of switch ON and OFF [AIIMS 2003]

2. Assertion : The 200 W bulbs glows with more brightness then 100 W bulbs.

Reason : A 100 W bulb has more resistance than a 200 W bulb.

3. Assertion : Fuse wire must have high resistance and low melting point.

Reason : Fuse is used for small current flow only.

4. Assertion : Two electric bulbs of 50 and 100 W are given. When connected in series 50 W bulb glows more but when connected parallel 100 W bulb glows more.

Reason : In series combination, power is directly proportional to the resistance of circuit. But in parallel combination, power is inversely proportional to the resistance of the circuit.

5. Assertion : Two bulbs of same wattage, one having a carbon filament and the other having a metallic filament are connected in series. Metallic bulbs will glow more brightly than carbon filament bulb.

Reason : Carbon is a semiconductor.

6. Assertion : An electric bulb is first connected to a dc source and then to a ac source having the same brightness in both the cases.

Reason : The peak value of voltage for an A.C. source is $\sqrt{2}$ times the root mean square voltage.

7. Assertion : Current is passed through a metallic wire, heating it red. When cold water is poured on half of its portion, then rest of the half portion become more hot.

Reason : Resistances decreases due to decrease in temperature and so current through wire increases.

8. Assertion : Through the same current flows through the line wires and the filament of the bulb but heat produced in the filament is much higher then that in line wires.

Reason : The filament of bulbs is made of a material of high resistance and high melting point.

9. Assertion : Neutral temperature of a thermocouple does not depend upon temperature of cold junction.

Reason : Its value is constant for the given metals of the couple.

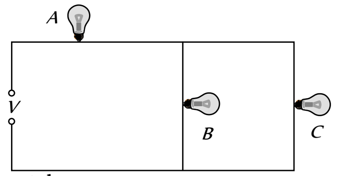
10. Assertion : In practical application, power rating of resistance is not important.

Reason : Property of resistance remain same even at high temperature.

11. Assertion : Leclanche cell is used, when constant supply of electric current is not required.

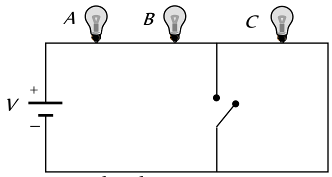
Reason : The e.m.f. of a Leclanche cell falls, if it is used continuously.

12. Assertion : In the given circuit if lamp B or C fuses then light emitted by lamp A decreases.



Reason : Voltage on A decreases.

13. Assertion : If three identical bulbs are connected in series as shown in figure then on closing the switches. Bulb C short circuited and hence illumination of bulbs A and B decreases.



Reason : Voltage on A and B decreases

14. Assertion : Heat is generated continuously is an electric heater but its temperature becomes constant after some time.

Reason : At the stage when heat produced in heater is equal to the heat dissipated to its surrounding the temperature of heater becomes constant.

15. Assertion : Electric appliances with metallic body; *e.g.* heaters, presses etc, have three pin connections, whereas an electric bulb has a two pin connection. [AIIMS 1996]

Reason : Three pin connections reduce heating of connecting cables.

16. Assertion : A laser beam 0.2 W power can drill holes through a metal sheet, whereas 1000 W torch-light cannot.

Reason : The frequency of laser light is much higher then that of torch light. [AIIMS 1996]

17. Assertion : A domestic electrical appliance, working on a three pin will continue working even if the top pin is removed. [AIIMS 1995]

Reason : The third pin is used only as a safety device.

18. Assertion : In all conductors, for studying the thermoelectric behaviour or metals, lead is taken as a reference metal.

Reason : In lead, the Thomson effect is negative.

19. Assertion : The presence of water molecules makes separation of ions easier in electrolyte.

Reason : The presence of water molecules in electrolyte decreases the resistance of electrolyte.

20. Assertion : Thermocouple acts as a heat engine.

Reason : When two junctions of thermocouple are at different temperature, thermo e.m.f. is produced.

21. Assertion : When temperature of cold junction of a thermocouple is lowered, the value of neutral temperature of this thermocouple is raised.

Reason : When the difference of temperature of two junction is raised, more thermo e.m.f. is produced.

Answers

Heating Effect of Current

1	a	2	b	3	c	4	b	5	b
6	c	7	c	8	a	9	b	10	c
11	a	12	c	13	c	14	a	15	d
16	d	17	b	18	c	19	c	20	a
21	d	22	a	23	a	24	c	25	d
26	d	27	c	28	c	29	b	30	b
31	b	32	b	33	a	34	d	35	c
36	b	37	d	38	b	39	a	40	a
41	a	42	b	43	d	44	d	45	a
46	c	47	a	48	b	49	a	50	a
51	b	52	c	53	a	54	c	55	c
56	a	57	d	58	b	59	d	60	a
61	d	62	a	63	d	64	b	65	b
66	d	67	a	68	a	69	a	70	c
71	a	72	d	73	a	74	b	75	a
76	d	77	b	78	b	79	d	80	d
81	a	82	d	83	d	84	d	85	a
86	a	87	a,d	88	a	89	b	90	a
91	b	92	a	93	b	94	a	95	b
96	a	97	c	98	b	99	c	100	a
101	b	102	c	103	a	104	a	105	d
106	c	107	a	108	b	109	b	110	d
111	c	112	b	113	c	114	a	115	c
116	c	117	d	118	a	119	d	120	c
121	b	122	d	123	a	124	a	125	a
126	c	127	a	128	d	129	a	130	c
131	a	132	c	133	c	134	c	135	b
136	c	137	c	138	c	139	b	140	d
141	a	142	c	143	d	144	c	145	b
146	c	147	c	148	c	149	a	150	c
151	a	152	c	153	c				

Chemical Effect of Current

1	d	2	c	3	d	4	d	5	c
6	d	7	b	8	d	9	b	10	a
11	b	12	b	13	b	14	c	15	b
16	a	17	b	18	c	19	a	20	d
21	c	22	b	23	c	24	a	25	d
26	b	27	a	28	c	29	a	30	a
31	b	32	d	33	b	34	a	35	b
36	c	37	c	38	b	39	d	40	b
41	c	42	b	43	d	44	a	45	c
46	c	47	a	48	b	49	b	50	b
51	a	52	d	53	d	54	a	55	c

56	c	57	d	58	c	59	a		

Thermo-Electricity

1	b	2	c	3	d	4	a	5	c
6	b	7	a	8	a	9	a	10	a
11	a	12	d	13	b	14	c	15	b
16	b	17	a	18	a	19	a	20	b
21	d	22	a	23	b	24	a	25	b
26	c	27	c	28	d	29	c	30	a
31	a	32	b	33	d	34	c	35	c
36	d	37	c	38	d	39	d	40	a
41	d	42	a	43	b	44	b		

Critical Thinking Questions

1	d	2	b	3	b	4	d	5	c
6	d	7	a	8	c	9	d	10	b
11	c	12	b	13	d	14	a	15	a
16	d	17	d	18	a	19	a	20	b
21	c	22	b	23	b	24	b	25	d
26	a	27	b	28	c	29	a	30	b
31	d	32	a	33	a	34	d	35	d
36	d	37	d	38	d	39	b	40	b
41	a	42	d	43	b	44	a	45	c

Graphical Questions

1	b	2	d	3	d	4	a	5	b
6	a	7	d	8	b	9	d		

Assertion and Reason

1	a	2	a	3	c	4	a	5	d
6	e	7	a	8	a	9	b	10	d
11	a	12	a	13	d	14	a	15	c
16	c	17	a	18	c	19	b	20	b
21	d								

Answers and Solutions

Heating Effect of Current

1. (a) 1 kWh = 1000 $W \times 3600$ sec = 36×10^5 W-sec (or J)

2. (b) $P \propto \frac{1}{R} \Rightarrow \frac{P_1}{P_2} = \frac{R_2}{R_1} \Rightarrow \frac{200}{100} = \frac{R_2}{R_1} \Rightarrow R_2 = 2R_1$

3. (c) $P = \frac{V^2}{R} \Rightarrow R_1 = \frac{V_1^2}{P_1} = \frac{(200)^2}{40} = 1000\Omega$

   and $R_2 = \frac{V_2^2}{P_2} = \frac{(200)^2}{100} = 400\Omega$

4. (b) When two bulbs are connected in series, the current will be same in both the bulbs. As a result potential drop will be more in the bulb of higher resistance *i.e.,* bulb of lower wattage.

5. (b) When 1 bulb fuses, the total resistance of the circuit decreases hence the current increases. Since $P = i^2R$, therefore illumination increases.

6. (c)

7. (c) We know that $\frac{P_1}{P_2} = \frac{R_2}{R_1} = \frac{2}{1}$

8. (a) $P = \frac{V^2}{R} \Rightarrow P \propto \frac{1}{R}$ and $R \propto l$ $\therefore P \propto \frac{1}{l} \Rightarrow \frac{P_1}{P_2} = \frac{l_1}{l_2} = \frac{2}{1}$

9. (b) $R_{conductor} \propto$ Temperature and $R_{semiconductor} \propto \frac{1}{\text{Temperature}}$

10. (c)

11. (a) In series, current is same in both the bulbs, hence $P \propto R\,(P = i^2R)$ $\therefore \frac{P_1}{P_2} = \frac{R_1}{R_2} = \frac{1}{2}$

12. (c) In this case, $P = \frac{V^2}{R}$ or $P \propto \frac{1}{R}$ and R will be minimum, when divided four parts are joints in parallel to the battery.

13. (c) Length is immaterial for an electric fuse wire.

14. (a) $P_{Rated} \propto \frac{1}{R}$ and $R \propto \frac{1}{(\text{Thickness of filament})^2}$

    So $P_{Rated} \propto (\text{Thickness of filament})^2$

15. (d) In series $P_S = \frac{P}{n} \Rightarrow 10 = \frac{P}{3} \Rightarrow P = 30\,W$

    In parallel $P_P = nP$ = 3 × 30 = 90 W

16. (d) Energy consumed in $kWh = \frac{Watt \times hour}{1000}$

    $\Rightarrow$ For 30 days, $P = \frac{10 \times 50 \times 10}{1000} \times 30 = 150 kWh$

17. (b) $W = qV$ also $P = i \times V = \frac{W}{t}$

18. (c) Because given voltage is very high,

19. (c) $P_p = nP = 2 \times 40 = 80\,W$

20. (a) In series, $P \propto R$($\because$ i is same), *i.e.* in series Fine wire (high R) liberates more energy.

    In parallel, $P \propto \frac{1}{R}$(V is same) *i.e.* thick wire (less R) liberates more energy.

21. (d) Resistance of the bulb = $\frac{V^2}{P_{Ratate}} = \frac{220 \times 220}{100} = 484\Omega$

When connected with 110 V, the power consumed

$$P_{Consumed} = \frac{V^2}{R} = \frac{110 \times 110}{484} = 25W$$

22. (a) The resistance of 25 W bulb is greater than 100 W bulb. So for the same current, heat produced will be more in 25 W bulb. So it will glow more brightly.

23. (a) Equivalent resistance in the second case $= R_1 + R_2 = R$

Now, we know that $P \propto \frac{1}{R}$

Since in the second case the resistance $(R_1 + R_2)$ is higher than that in the first case (R).

Therefore power dissipation in the second case will be decreased.

24. (c) For constant voltage, we know that $P \propto \frac{1}{R}$

So higher the power, lower will be the resistance.

25. (d) $P = \frac{V^2}{R}$ but $R = \frac{\rho l}{A} \Rightarrow P = \frac{V^2}{\rho l / A} = \frac{AV^2}{\rho l}$. Since $\frac{AV^2}{l}$ is constant as per given conditions So $P \propto \frac{1}{\rho}$.

26. (d) Power consumed means heat produced.

For constant potential difference $P_{\text{consumed}} = \text{Heat} \propto \frac{1}{R_{eq}}$

$$\therefore \frac{H_1}{H_2} = \frac{R_2}{R_1} = \frac{R/2}{2R} = \frac{1}{4}$$

(Since $R_2 = \frac{R.R}{R+R} = \frac{R}{2}$ and $R_1 = R + R = 2R$)

27. (c) Resistance of carbon filament decreases with temperature while that of tungsten increases with temperature

In series $P_{Consumed} \propto R$ *i.e.* tungsten bulb will glow more brightly

28. (c) Power of the combination $P_s = \frac{P}{n} = \frac{1000}{2} = 500\,W$

29. (b) For parallel combination $P_{Consumed} \propto \text{Brightness} \propto P_{Rated}$

30. (b) Resistance of 25 *W* bulb $= \frac{220\times220}{25} = 1936\,\Omega$

Its safe current $= \frac{220}{1936} = 0.11\ amp.$

Resistance of 100 *W* bulb $= \frac{220\times220}{100} = 484\,\Omega$

Its safe current $= \frac{220}{484} = 0.48\ amp.$

When connected in series to 440 *V* supply, then the current $I = \frac{440}{(1936+484)} = 0.18\,amp.$

Thus current is greater for 25 *W* bulb, so it will fuse.

31. (b) $P = i^2R \Rightarrow \frac{\Delta P}{P} = \frac{2\Delta i}{t}$ ($R \to$ Constant)

$\Rightarrow$ % change in power $= 2\times$ % change in current

$= 2\times1 = 2\%$

32. (b) $P_{\max} = n\left(\frac{E^2}{4\,r}\right) = 2\left(\frac{2\times2}{4\times1}\right) = 2\,W$

33. (a) $H \propto \frac{1}{R}$ (If *V* = constant) $\Rightarrow \frac{H_1}{H_2} = \frac{R_2}{R_1} = \frac{l_2A_1}{l_1A_2} = \frac{l_2r_1^2}{l_1r_2^2}$

$\Rightarrow H_2 = 2H_1$

34. (d) $\frac{H}{t} = \frac{V^2}{R} \Rightarrow \frac{H}{t} \propto \frac{1}{R}$

35. (c) $H = i^2Rt$ and $i = \frac{q}{t}$. Hence $H = \frac{q^2R}{t}$; $\therefore H \propto q^2$

36. (b) $E = \frac{1100\times4}{1000} = 4.4\ kWh$

37. (d) After some time, thermal equilibrium will reach.

38. (b) At constant p.d., heat produced $= \frac{V^2}{R}$ *i.e.* $H \propto \frac{1}{R}$

39. (a) Power $= 3.75\times200\,W = 750\,W \approx 1\,H.P.$

40. (a) $\frac{V^2}{R} = P \Rightarrow R = \frac{V^2}{P} = \frac{220\times220}{100} = 484\Omega$

41. (a) Since $P = VI \Rightarrow I = \frac{P}{V} = \frac{250000}{10000} = 25\ A$

42. (b) Power lost in cable $= 10\times(25)^2 = 6250\,W = 6.25\ kW$

43. (d) Heat generated in both the cases will be same because the capacitor has the same energy initially

$= \frac{1}{2}CV^2 = \frac{1}{2}\times200\times10^{-6}\times(200)^2 = 4\,J$

44. (d) The bulbs are connected in parallel, hence each bulb consumes $\frac{48}{2} = 24\,W$. Therefore $\frac{V^2}{R} = 24$

$\Rightarrow R = \frac{6\times6}{24} = 1.5\,\Omega$

45. (a)

46. (c) The bulbs are in series, hence they will have the same current through them.

47. (a) When resistance is connected in series, brightness of bulb decreases because voltage across the bulb decreases.

48. (b) $R = \frac{V^2}{P} \Rightarrow R_1 = \frac{200\times200}{100} = 400\,\Omega$ and $R_2 = \frac{100\times100}{200} = 50\,\Omega$. Maximum current rating $i = \frac{P}{V}$

So $i_1 = \frac{100}{200}$ and $i_2 = \frac{200}{100} \Rightarrow \frac{i_1}{i_2} = \frac{1}{4}$.

49. (a) $\frac{R_1}{R_2} = \frac{P_2}{P_1} = \frac{100}{40} = \frac{5}{2}$. Resistance of 40 *W* bulb is $\frac{5}{2}$ times than 100 *W*. In series, $P = i^2R$ and in parallel, $P = \frac{V^2}{R}$. So 40 *W* in series and 100 *W* in parallel will glow brighter.

50. (a) $P = \frac{V^2}{R} \Rightarrow \frac{P_P}{P_S} = \frac{R_S}{R_P} = \frac{(R_1+R_2)}{R_1R_2/(R_1+R_2)} = \frac{(R_1+R_2)^2}{R_1\,R_2}$

$\Rightarrow \frac{100}{25} = \frac{(R_1+R_2)^2}{R_1R_2} \Rightarrow \frac{R_1}{R_2} = \frac{1}{1}$

51. (b) Total power $P = (800+3\times100)$

Also $P = Vi \Rightarrow 1100 = 220\times i \Rightarrow i = 5A$

52. (c) Because $R \propto \frac{1}{P}$

53. (a) An ideal cell has zero resistance.

54. (c) Power loss in transmission $P_L = \frac{P^2R}{V^2} \Rightarrow P_L \propto \frac{1}{V^2}$

55. (c) $H = \frac{V^2 t}{4.2\,R}$ or $\frac{H}{t} = \frac{V^2}{4.2\,R}$

$\Rightarrow 800 = \frac{20 \times 20}{4.2 \times R} \Rightarrow R = \frac{5}{42} = 0.119 \approx 0.12\,\Omega$

56. (a) Heat produced $H = \frac{V^2 t}{4.2R} = H \propto \frac{1}{R}$ Hence $\frac{H_1}{H_2} = \frac{R_2}{R_1}$

57. (d) $\frac{H}{t} = i^2 R$. Here total $R = (21+4) = 25\ \Omega$

$\Rightarrow$ Rate of energy consumed $= 0.2 \times 0.2 \times 25 = 1\ J/s$

58. (b) When the heating coil is cut into two equal parts and these parts are joined in parallel, the resistance of coil is reduced to one fourth, so power consumed will become 4 times *i.e.* 400 Js^{-1}.

59. (d) The resistance of 40 *W* bulb will be more and 60 *W* bulb will be less.

60. (a) In series $P_{Consumed} \propto \text{Brightness} \propto \frac{1}{P_{Rated}}$

61. (d) *E* = *P* × *t* $= 1000\,W \times 30\ sec = 3 \times 10^4\ J$

62. (a) Resistance R_1 of 500 *W* bulb $= \frac{(220)^2}{500}$

Resistance R_2 of 200 *W* bulb $= \frac{(220)^2}{200}$

When joined in parallel, the potential difference across both the bulbs will be same.

Ratio of heat produced $= \frac{V^2/R_1}{V^2/R_2} = \frac{R_2}{R_1} = \frac{5}{2}$

When joined in series, the same current will flow through both the bulbs.

Ratio of heat produced $= \frac{i^2 R_1}{i^2 R_2} = \frac{R_1}{R_2} = \frac{2}{5}$

63. (d) Charge $q = it = 0.5\,A \times 3600\,\text{sec} = 1800\ culoumb$

64. (b) $H = i^2 Rt = \frac{V^2 t}{R} = \frac{120 \times 120 \times (10 \times 60)}{6} = 14.4 \times 10^5\, joule$

65. (b) In parallel $P_{consumed} \propto \text{Brightness} \propto \frac{1}{R}$

$P_A > P_B$ (given) $\therefore\ R_A < R_B$

66. (d) $R = \rho \frac{l}{A}$ and $P \propto \frac{1}{R} \Rightarrow P \propto \frac{A}{l} \Rightarrow P \propto \frac{d^2}{l} \Rightarrow P_A = 2P_B$

67. (a) $t_S = t_1 + t_2 = 30 + 30 = 60\ minutes$

68. (a) For power transmission power loss in line $P_L = i^2 R$

If power of electricity is *P* and it is transmitted at voltage *V*, then $P = Vi \Rightarrow i = \frac{P}{V}$

$P_L = \left(\frac{P}{V}\right)^2 R = \frac{P^2 R}{V^2} = \frac{2.2 \times 10^3 \times 2.2 \times 10^3 \times 10}{22000 \times 22000} = 0.1W$

69. (a) $P = i^2 R$ (*i* and *R* are same)

So *P* will be same for given resistors.

70. (c) Since $H \propto i^2$, so on doubling the current, the heat produced and hence the rise in temperature becomes four times.

71. (a) *Watt-hour meter* measures electric energy.

72. (d) Total energy consumed $= \frac{60 \times 8}{1000} = 0.48\ kWH$

So cost $= 0.48 \times 1.25 = 0.6\ Rs.$

73. (a) $P_S = \frac{P}{n} = \frac{40}{4} = 10\ W.$

74. (b) As temperature increases resistance of filament also increases.

75. (a) Current through the combination $i = \frac{120}{(6+9)} = 8\ A$

So, power consumed by 6 Ω resistance

$P = (8)^2 \times 6 = 384\ W$

76. (d) $P = \frac{V^2}{R} = \frac{(225)^2}{50} = 1012.5 \approx 1000\ W$

77. (b) $P = Vi \Rightarrow i = \frac{P}{V} = \frac{100}{200} = 0.5\ A$

78. (b) $H = i^2 Rt \Rightarrow R = \frac{H}{i^2 t} = \frac{80}{4 \times 10} = 2\,\Omega$

79. (d) Heat produced = Energy stored in capacitor

$= \frac{1}{2} CV^2 = \frac{1}{2} \times 4 \times 10^{-6} \times (400)^2 = 0.32\ J$

80. (d) $P = \frac{V^2}{R} = \frac{(110)^2}{10} = \frac{12100}{10} = 1210\ W$

81. (a) $P_{consumed} = \left(\frac{V_A}{V_R}\right)^2 \times P_R = \frac{(160)^2}{(200)^2} \times 100 = 64\ W$

82. (d) For maximum power *r* = *R*

83. (d) $P = i^2 R \Rightarrow 22.5 = (15)^2 \times R \Rightarrow R = 0.10\ \Omega$

84. (d) $R_1 = \rho \frac{l_1}{A_1}$ and $R_2 = \rho \frac{l_2}{A_2} \Rightarrow \frac{R_1}{R_2} = \frac{l_1}{l_2} . \frac{A_2}{A_1} = \frac{l_1}{l_2}\left(\frac{r_2}{r_1}\right)^2$

Given $\frac{l_1}{l_2}=\frac{1}{2}$ and $\frac{r_1}{r_2}=\frac{2}{1}$ or $\frac{r_2}{r_1}=\frac{1}{2} \Rightarrow \frac{R_1}{R_2}=\frac{1}{8}$

$\therefore$ Ratio of heats $\frac{H_1}{H_2}=\frac{V^2/R_1}{V^2/R_2}=\frac{R_2}{R_1}=\frac{8}{1}$

85. (a) $P=Vi=250\times 2=500\,W$

86. (a) $P=\frac{V^2}{R} \Rightarrow 100=\frac{(200)^2}{R} \Rightarrow R=\frac{4\times 10^4}{10^2}=400\,\Omega$

Now, $i=\frac{V}{R}=\frac{100}{400}=\frac{1}{4}\,amp$

87. (a, d) $R_{steel}=2R_{Al}$. In series $H\propto R$ (i is Same)

So, H will be more in steel wire . In parallel $H\propto \frac{1}{R}$ (V is Same), so H will be more in aluminium wire.

88. (a) $H=i^2Rt \Rightarrow \frac{H}{t}=i^2R=\frac{i^2\rho l}{\pi r^2}$

89. (b)

90. (a) $H=\frac{V^2}{R}.t \Rightarrow \frac{H_1}{H_2}=\frac{R_2}{R_1}=\frac{R}{2R}=\frac{1}{2}$

91. (b)

92. (a) In parallel $P_{Consumed} \propto P_{Rated}$

93. (b)

94. (a) $P=\frac{V^2}{R} \Rightarrow R=\frac{V^2}{P}=\frac{(220)^2}{40}=1210\,\Omega$

95. (b) $P=Vi \Rightarrow i=\frac{P}{V}=\frac{60}{220}=\frac{3}{11}\,amp$

96. (a) In series, $P_{Consumed} \propto \frac{1}{P_{Rated}} \propto V_{Applied}$

i.e. more voltage appears on smaller wattage bulb, so 25 W bulb will fuse

97. (c) Because in series current is same.

98. (b) $P=\frac{V^2}{R} \Rightarrow \frac{P_1}{P_2}=\frac{R_2}{R_1} \Rightarrow \frac{6}{P_2}=\frac{4}{6}=\frac{2}{3} \Rightarrow P_2=9\,W$

99. (c) $\frac{H}{t}=P=\frac{V^2}{R} \Rightarrow P\propto \frac{1}{R}$ also $R\propto \frac{l}{A}\propto \frac{l^2\rho}{A.l\rho}$

$\Rightarrow R\propto \frac{l^2}{m} \Rightarrow R\propto l^2$ (for same mass)

So $\frac{P_A}{P_B}=\frac{l_B^2}{l_A^2}=\frac{4}{1} \Rightarrow P_A=20\,W$

100. (a) $P=\frac{V^2}{R} \Rightarrow \frac{R_1}{R_2}=\frac{P_2}{P_1}=\frac{60}{40}=\frac{3}{2}$

101. (b) $P\propto V^2 \Rightarrow \frac{P}{P_0}=\left(\frac{V}{V_0}\right)^2 \Rightarrow P=\left(\frac{V}{V_0}\right)^2 P_0$

102. (c) $P=\frac{V^2}{R} \Rightarrow R\propto \frac{1}{P}$

So resistance of the 100 W bulb will be minimum

103. (a) In parallel $\frac{1}{t_p}=\frac{1}{t_1}+\frac{1}{t_2} \Rightarrow t_p=\frac{t_1t_2}{t_1+t_2}$

$=\frac{5\times 10}{5+10}=\frac{50}{15}=3.33\,\text{min} = 3\,min.\,20\,sec$

104. (a) For maximum joule heat produced in resistor external resistance = Internal resistance.

105. (d)

106. (c) $H=\frac{V^2}{R}t \Rightarrow \frac{H_1}{H_2}=\frac{R_2}{R_1}=\frac{4}{2}=\frac{2}{1}$

107. (a) If resistances of bulbs are R_1 and R_2 respectively then in parallel $\frac{1}{R_P}=\frac{1}{R_1}+\frac{1}{R_2} \Rightarrow$

$\frac{1}{\left(\frac{V^2}{P_p}\right)}=\frac{1}{\left(\frac{V^2}{P_1}\right)}+\frac{1}{\left(\frac{V^2}{P_2}\right)}$

$\Rightarrow P_P=P_1+P_2$

108. (b)

109. (b) When wire is cut into two equal parts then power dissipated by each part is $2P_1$

So their parallel combination will dissipate power $P_2=2P_1+2P_1=4P_1$

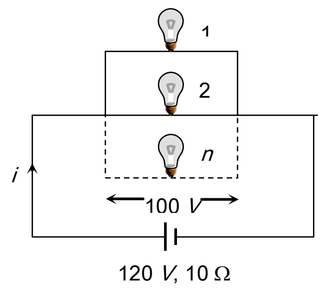
Which gives $\frac{P_2}{P_1}=4$

110. (d) $P=\frac{V^2}{R} \Rightarrow \frac{P_2}{P_1}=\frac{V_2^2}{V_1^2}$ ($\because R$ is constant)

$\Rightarrow \frac{P_2}{P_1}=\left(\frac{100}{200}\right)^2=\frac{1}{4} \Rightarrow P_2=\frac{P_1}{4}=\frac{40}{4}=10\,W$

111. (c) When each bulb is glowing at full power,

Current from each bulb $=i'=\frac{50}{100}=\frac{1}{2}A$



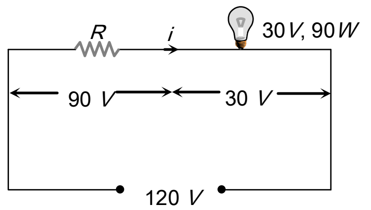
So main current $i = \frac{n}{2} A$

Also $E = V + ir \Rightarrow 120 = 100 + \left(\frac{n}{2}\right) \times 10 \Rightarrow n = 4$

112. (b) $R = \frac{V^2}{P} = \frac{(250)^2}{10^3} = 62.5\,\Omega$

113. (c) Suppose resistance *R* is corrected in series with bulb.

Current through the bulb $i = \frac{90}{30} = 3\,A$



Hence for resistance $V = iR \Rightarrow$ $90 = 3 \times R \Rightarrow R = 30\,\Omega$

114. (a) $i \propto r^{3/2} \Rightarrow \frac{r_2}{r_1} = \left(\frac{i_2}{i_1}\right)^{3/2} = \left(\frac{3}{1.5}\right)^{2/3} = (4)^{1/3}$

$\Rightarrow r_2 = (4)^{1/3} \times r_1 = 4^{1/3}$ ($\because$ r_1 = 1 *mm*)

115. (c) In series $P' = \frac{P}{n} = \frac{60}{3} = 20\,watts$

116. (c) $R = \frac{V^2}{P} = \frac{(220)^2}{60} = 807\,\Omega$

117. (d) $\frac{P_1}{P_2} = \left(\frac{V_1}{V_2}\right)^2 \Rightarrow \frac{1000}{P_2} = \left(\frac{220}{110}\right)^2 = 4 \Rightarrow P_2 = 250\,W$

118. (a) $P_S = \frac{P_1 P_2}{P_1 + P_2} = \frac{100 \times 200}{100 + 200} = \frac{200}{3} \approx 65\,watt$

119. (d) $H = \frac{V^2 t}{R \times J} Calories = \frac{P\,t}{J} = \frac{210 \times 5 \times 60}{4.2} = 15000\,cal$

120. (c) Using conservation of energy

Supplied electric energy = absorbed heat energy

$\Rightarrow i^2 Rt = mST$

$\Rightarrow T \propto i^2$ (*T* - change in temperature)

i.e. when *i* is doubled *T* will be four times *i.e.* $5 \times 4 = 20^o C$

121. (b) Energy $= P \times t$ = 2 × 1 × 30 = 60 *kWH* = 60 unit

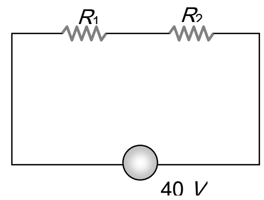
122. (d) Bulb (I) : Rated current $I_1 = \frac{P}{V} = \frac{40}{220} = \frac{2}{11} amp.$

Resistance $R_1 = \frac{V^2}{P} = \frac{(220)^2}{40} = 1210\,\Omega$

Bulb (II) : Rated current $I_2 = \frac{100}{220} = \frac{5}{11} amp$

Resistance $R_2 = \frac{(220)^2}{100} = 484\,\Omega$

When both are connected in series across 40 *V* supply



Total current through supply

$I = \frac{40}{P_1 + P_2} = \frac{40}{1210 + 484} = \frac{40}{1254} = 0.03A$

This current is less than the rated current of each bulb. So neither bulb will fuse.

Short Trick : Since $V_{Applied} < V_{Rated}$, neither bulb will fuse.

123. (a) Both *R* and 2*R* in parallel (*V* – constant)

So using $P = \frac{V^2}{R} \Rightarrow \frac{P_1}{P_2} = \frac{R_2}{R_1} \Rightarrow \frac{H_1}{H_2} = \frac{R_2}{R_1} = \frac{2}{1}$

124. (a) Power $P = Vit = 250 \times 4 = 1000\,W = 1kW$

Energy = *P* × *t* = 1 *kW* × 60 *sec* = 60 *kJ*

125. (a) $P = \frac{V^2}{R} \Rightarrow P \propto \frac{1}{R}$ (*V* - constant)

$\therefore$ When one bulb will fuse out resistance of the series combination will be reduced.

Hence from $P_{Consumed} \propto \frac{1}{R}$ illumination will increase.

126. (c) $P = \frac{V^2}{R} \Rightarrow R = \frac{V^2}{P} = \frac{25 \times 25}{25} = 25\,\Omega$

127. (a) $P_{Rated} = \frac{V_{Rated}^2}{R} \Rightarrow R \propto \frac{1}{P_{Rated}}$ (V - constant)

So bulb of high power will have less resistance.

128. (d) $P_{Rated} \propto \frac{1}{R} \Rightarrow \frac{R_1}{R_2} = \frac{P_2}{P_1} = \frac{60}{40} = \frac{3}{2}$

129. (a) Energy $= \frac{V^2}{R} \times t = \frac{10 \times 10}{50} \times 3600 = 7200\,J$

130. (c) Energy $\frac{V^2}{R} t = \frac{200 \times 200 \times 2}{80} = 1000\,Wh$

131. (a) Energy $= P \times t = 100 \times 2 \times 60 = 12000\,J = 12 \times 10^3\,J$

132. (c) Heat $H = \frac{V^2 t}{R} \Rightarrow H \propto \frac{1}{R}$ (If *V*, *t* constant)

$\Rightarrow \frac{H_S}{H_P} = \frac{R_P}{R_S} = \frac{\left(\frac{R \times 2R}{3R}\right)}{(R + 2R)} = \frac{2}{9}$

133. (c) $i \propto \frac{1}{R}$ and $P \propto \frac{1}{R} \Rightarrow i \propto P$ *i.e.* in parallel bulb of higher power will draw more current.

134. (c) Resistance of *A* is greater than the resistance of combination of *B* and *C*, hence voltage drop across *A* will be greater than that across *B* or *C*. Also $H = \frac{V^2 t}{R}$

$\Rightarrow H \propto V^2$ so $H_A > (H_B = H_C)$ (*R* = constant)

135. (b) $P = Vi \Rightarrow i = \frac{2.2 \times 10^3}{22000} = \frac{1}{10} A$

Now loss of power $= i^2 R = \left(\frac{1}{10}\right)^2 \times 100$ = 1 *W*

136. (c) $P = \frac{V^2}{R}$. If resistance of heater coil is *R*, then resistance of parallel combination of two halves will be $\frac{R}{4}$

So $\frac{P_1}{P_2} = \frac{R_2}{R_1} = \frac{R/4}{R} = \frac{1}{4}$

137. (c) Total *kWh* consumed $= \frac{60 \times 8 \times 30}{1000} = 14.4$

Hence cost $= 14.4 \times 1.25 = 18\,Rs$

138. (c) Current capacity of a fuse wire should be slightly greater then the total rated load current.

139. (b)

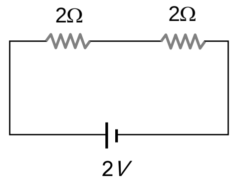
140. (d) Colliding electrons lose their kinetic energy as heat.

141. (a) It is called safe current and is proportional to $r^{3/2}$.

142. (c)

143. (d) $i = \frac{P}{V} = \frac{50}{250} = 0.2\,amp.$

144. (c) In steady state the branch containing capacitors, can be neglected. So reduced circuit is as follows



Power $P = \frac{V^2}{R} = \frac{(2)^2}{4} = 1\,W$.

145. (b) $P = \frac{V^2}{R_{eq}} \Rightarrow 150 = \frac{(15)^2}{[2R/(R+2)]} = \frac{225 \times (R+2)}{2R}$

$\Rightarrow R = \frac{450}{75} = 6\Omega$.

146. (c) $P = \frac{V^2}{R} \Rightarrow \frac{P_1}{P_2} = \frac{R_2}{R_1} = \frac{1}{2}$.

147. (c) $H = \frac{V^2 t}{R} \Rightarrow \frac{H_{Half}}{H_{Full}} = \left(\frac{R_{Full}}{R_{Half}}\right) = \frac{R}{R/2} = 2$

$\Rightarrow H_{Half} = 2 \times H_{Full}$.

148. (c) It is given $R_{Hot} = 10\,R_{Cold}$ also resistance at rated temperature $R = \frac{V^2}{P} = \frac{200 \times 200}{100} = 400\,\Omega$.

So resistance when lamp not in use.

$R_{Cold} = \frac{R_{Hot}}{10} = \frac{400}{10} = 40\,\Omega$

149. (a) The chemical energy reduced in battery

$= VIt = 6 \times 5 \times 6 \times 60\,J = 10800\,J = 1.08 \times 10^4\,J$

150. (c) The heat generated = *IVt* $= 2.1 \times 15 \times 1 = 31.5 J$

$= 31.5/4.2\ cal = 7.5 cal.$ $[\because 1\,cal = 4.2 J]$

151. (a) Resistance $\propto \frac{1}{\text{power}}$. Thus, 40 *W* bulb has a high resistance. Because of which there will be more potential drop across 40 *W* bulb. Thus 40 *W* bulb will glow brighter.

152. (c) When bulbs are connected in series, $P = \frac{V^2}{R'} = \frac{V^2}{3R}$

When bulbs are connected in parallel,

$P' = \frac{V^2}{R''} = \frac{V^2 \times 3}{R} = 3 \times 3P = 9P.$

153. (c) Time $t_S = t_1 + t_2 = 35$ min.

Chemical Effect of Current

1. (d) As sugar cannot be decomposed into ions and ions are responsible for conduction.

2. (c) $\because \frac{Z_1}{Z_2} = \frac{E_1}{E_2} \Rightarrow Z_2 = \left(\frac{E_2}{E_1}\right). Z_1$

3. (d) $\frac{m_{Zn}}{m_{Ag}} = \frac{E_{Zn}}{E_{Ag}} \Rightarrow m_{Ag} = W\left(\frac{E_{Ag}}{E_{Zn}}\right)$ = 3.3 W = 3.5 W

4. (d) 96500 *coulombs* of charge is needed to deposit one gram equivalent of an element at an electrode.

5. (c) As $\frac{m_{Cu}}{m_{Ag}} = \frac{E_{Cu}}{E_{Ag}} = \frac{\frac{1}{2}(\text{Atomic weight})_{Cu}}{(\text{Atomic weight})_{Ag}}$

6. (d) $V_2 = \frac{22.4 \times 1}{1} = 22.4\, litre$ at NTP

$\because$ 11.2 *litre* of H_2 is liberated by 96,500 C

$\therefore$ 22.4 *litre* of H_2 is liberated by 96500 × 2 = 1,93,000 C

7. (b) From $m = ZQ$, if $Q = 1C \Rightarrow m = Z$

8. (d)

9. (b) Because H has positive charge.

10. (a) Because H_2O is used as electrolyte.

11. (b) $m = Zit \Rightarrow 1 = 0.00033 \times 2 \times t$

$\therefore\ t = \frac{1}{0.00066 \times 60} min = \frac{100000}{3960} \approx 25\, min$

12. (b) $3 = 1.5(1 + r) \Rightarrow r = 1\Omega$

13. (b)

14. (c) $m = Zit = Zq$; $q = \frac{5 \times 10^{-3}}{3.387 \times 10^{-7}} amp\text{-}sec$

or $q = \frac{5 \times 10^{-3}}{3.387 \times 10^{-7} \times 3600} amp\text{-}hr = 4.1$

15. (b) Charge $Q = It$ = 1.6 × 60 = 96 C

Let n be the number of Cu^{+2} ions, then

$ne = Q \Rightarrow n = \frac{Q}{e} = \frac{96}{2 \times 1.6 \times 10^{-19}} = 3 \times 10^{20}$

16. (a) In the first case, $Zit = m$

In the second case, $Z \times \frac{i}{4} \times 4t = m$

17. (b) $\frac{\text{Mass of } O_2 \text{ ions}}{\text{Mass of } Ag \text{ ions}} = \frac{\text{Chemical equivalent of } O_2}{\text{Chemical equivalent of } Ag}$

$\Rightarrow \frac{0.8}{m} = \frac{8}{108} \Rightarrow m = 10.8\, gm$

18. (c)

19. (a) $F = Ne = 6 \times 10^{23} \times 1.6 \times 10^{-19}$

20. (d) Since 1 *faraday* deposits 1 *gm* equivalent.

21. (c) Equivalent weight of copper $= \frac{64}{2} = 32$

$\frac{\text{Equivalent weight of } Cu}{\text{Equivalent weight of } Ag} = \frac{\text{Weight of } Cu \text{ deposited}}{\text{Weight of } Ag \text{ deposited}}$

Weight of copper deposited $= \frac{10.8 \times 32}{108} = 3.2gm$

22. (b)

23. (c)

24. (a) $m \propto q \Rightarrow m \propto it$

25. (d) Equivalent weight of aluminium $= \frac{27}{3} = 9$

So 1 *faraday* = 96500 C are required to liberate 9 *gm* of *Al*.

26. (b) By Faraday's law, $m \propto it$.

$\therefore\ \frac{m_1}{m_2} = \frac{i_1 t_1}{i_2 t_2} \Rightarrow \frac{m}{m_2} = \frac{4 \times 120}{6 \times 40} \Rightarrow m_2 = \frac{m}{2}$

27. (a) $m \propto it$

28. (c) Amount of metallic sodium appears

$m = Zit = \left(\frac{A}{VF}\right) it$

$= \left(\frac{23}{1 \times 96500}\right) \times 16 \times 10 \times 60$ =2.3 *gm*

29. (a)

30. (a) $m = Zit \Rightarrow Z = \frac{m}{it} = \frac{4.572}{5 \times 45 \times 60} = 3.387 \times 10^{-4}\, gm/C$

31. (b) Faraday constant = 1 mole electron charge = Ne

$= 6.02 \times 10^{23} \times 1.6 \times 10^{-19} = 96500$

32. (d) $m = Zit = 0.126 \times 10^{-3} \times 5 \times 3600 = 2.27\, gm$

33. (b) $\frac{m_1}{m_2} = \frac{E_1}{E_2}$ (By faraday law for same current and time)

Where E_1 and E_2 are the chemical equivalents and m_1 and m_2 are the masses of copper and silver respectively.

$E = \frac{\text{Atomic weight}}{\text{Valency}}$. $E_1 = \frac{63.57}{2} = 31.79$ and

$E_2 = \frac{107.88}{1} = 107.88$

$\therefore\ \frac{1\, mg}{m_2} = \frac{31.79}{107.88} \Rightarrow m_2 = \frac{107.88}{31.79} mg = 3.4\, mg$

34. (a) $m = Zit \Rightarrow \frac{m}{Zit} = 1 (\text{constant})$

35. (b) Positive ions get deposited on cathode.

36. (c) $m = Zit$ or $m \propto it$

$\therefore \frac{m_1}{m_2} = \frac{i_1 t_1}{i_2 t_2} \Rightarrow \frac{9}{m_2} = \frac{10^5}{50 \times 20 \times 60} \Rightarrow m_2 = 5.4\ gm$

37. (c) Electroplating only provides a thin deposition of a metal on the surface which in no way can give hardness to the metal.

38. (b)

39. (d) $m = Zit \Rightarrow \frac{m_{Cu}}{m_{Zn}} = \frac{Z_{Cu}}{Z_{Zn}}$

$m_{Cu} = m_{Zn} \frac{Z_{Cu}}{Z_{Zn}} = 0.13 \times \frac{31.5}{32.5} = 0.126\ g$

40. (b) $m = Zit \Rightarrow m = \frac{ZVt}{R} \Rightarrow m \propto Vt \Rightarrow \frac{m_1}{m_2} = \frac{V_1 t_1}{V_2 t_2}$

$\Rightarrow \frac{2}{m_2} = \frac{12 \times 30}{6 \times 45} \Rightarrow m_2 = 1.5\ gm$

41. (c) $i = \frac{m}{Zt} = \frac{0.972}{0.00018 \times 3 \times 3600} = 0.5\ A$

42. (b) The current through the voltameter is same as drawn from the battery outside it.

43. (d) The resistance of the cell is independent of e.m.f.

44. (a) $m = Zit = 3.3 \times 10^{-7} \times 3 \times 2 = 19.8 \times 10^{-7} kg$

45. (c) $m = zq$, z = atomic mass / valence

46. (c)

47. (a)

48. (b) 1 faraday (96500*C*) is the electricity which liberated that amount of substance which is equal to equivalent wt. So liberated amount of *Cu* is $\frac{63.5}{2}$ $= 31.25\ gm \approx 32\ gm$

49. (b) $m = Zit \Rightarrow 20 \times 10^{-3} = \left(\frac{32}{96500}\right) \times 0.15 \times t$

$= 6.7\ min = 6\ min. 42\ sec$

50. (b) 22.4 *litre* H_2 = 1 mole H_2 = *N* molecules of H_2 = 2*N* atom of *H*

So charge required to liberate 22.4 *litre* of H_2 = 2*Ne* = 2*F*

Hence charge required to liberate 0.224 *litre* of H_2 $= \frac{2F}{22.4} \times 0.224 = \frac{2F}{100} = 2 \times 965\ C$

So current $i = \frac{Q}{t} = \frac{2 \times 965}{100} = 19.3\ amp$

51. (a)

52. (d) $m = Zit \Rightarrow Z = \frac{m}{it} = \frac{4.5}{4 \times 40 \times 60} = 47 \times 10^{-5}\ g/C$

53. (d) Charge supplied per minute = 3.2 × 60 = 192 *C*

Charge 2*e* liberates one Cu^{+2} ion

$\therefore$ No of Cu^{+2} ion liberate by 192 *C*

$= \frac{192}{2e} = \frac{192}{2 \times 1.6 \times 10^{-19}} = 6 \times 10^{20}$

54. (a) $m = Zit \Rightarrow i = \frac{m}{Zt} = \frac{0.99}{0.00033 \times 1200} = 2.5A$

Hence heat generated in the coil is

$H = i^2 Rt = (2.5)^2 \times 0.1 \times 1200 = 750\ J$

55. (c) $\frac{m_1}{m_2} = \frac{Z_1}{Z_2} \Rightarrow m_2 = \frac{m_1 Z_2}{Z_1} = \frac{14 \times 1.2 \times 10^{-6}}{7 \times 10^{-6}} = 2.4\ g$

56. (c) $m = Zit \Rightarrow t = \frac{m}{Zi} = \frac{m \times F}{E \times i}$ $\left(\because Z = \frac{E}{F}\right)$

$t = \frac{27 \times 96500}{108 \times 2} = 12062.5 \sec = \frac{12062.5}{3600} hr = 3.35\ hr$

57. (d) $m = zq \Rightarrow z \propto \frac{1}{q} \Rightarrow \frac{z_1}{z_2} = \frac{q_2}{q_1}$ ......(i)

also $q = q_1 + q_2 \Rightarrow \frac{q}{q_2} = \frac{q_1}{q_2} + 1$

$\Rightarrow q_2 = \frac{q}{1 + \frac{q_1}{q_2}}$ ......(ii)

From equation (i) and (ii) $q_2 = \frac{q}{1 + \frac{z_2}{z_1}}$

58. (c) From Faraday's law, *m/E* = constant

where *m* = mass of substance deposited, *E* = chemical equivalent.

$\therefore \frac{m_2}{m_1} = \frac{E_2}{E_1} \Rightarrow m_2 = \frac{108}{32} \times 1.6 = 5.4g$

59. (a) $q = it = \text{current} \times \text{time}$

Thermo-Electricity

1. (b) Production of e.m.f. by temperature difference is known Seeback effect.

2. (c) Production of heat at junctions due to current is known as Peltier effect.

3. (d)

4. (a)

5. (c) When there is no deflection, then this temperature is called inversion temperature. It is given by the relation

$$\theta_n = \frac{\theta_i + \theta_c}{2}$$

Where θ_c is temperature of cold junction $= 20^o C$ and neutral temperature $\theta_n = 270^o C$

$\therefore\ \theta_i = 2\theta_n - \theta_c = 540 - 20 = 520^o C$

6. (b)

7. (a) Thermo e.m.f. of a thermo couple depends on the nature of metals.

8. (a)

9. (a) According to the definition.

10. (a) $T_n = \frac{T_i + T_C}{2} \Rightarrow T_i = 2T_n - T_C$

11. (a)

12. (d)

13. (b) Based on Peltier effect.

14. (c) Peltier effect

15. (b) Thermopile is used for detection of heat radiation and measurement.

16. (b) $H = \sigma i t \Delta\theta \Rightarrow$ If i = 1 A, $\Delta\theta$ = 1°C, t = 1 *sec* then $H = \sigma$.

17. (a) According to Seebeck effect

18. (a) At neutral temperature, $\frac{dE}{dT} = 0$

19. (a) According to Seebeck effect.

20. (b)

21. (d)

22. (a) As a rule, more the metals are separated from each other in the thermoelectric series, the greater will be the thermo *emf*.

23. (b) $T_n = \frac{T_i + T_c}{2} = \frac{10 + 530}{2} = 270^o C$

24. (a) Joule effect is not reversible.

25. (b)

26. (c)

27. (c) The graph between thermo *emf* and temperature of hot junction is parabolic in shape.

28. (d) At neutral temperature E is maximum so

$$\frac{dE}{dt} = 0 \Rightarrow \frac{d}{dt}(At - Bt^2) = 0 \Rightarrow A - 2Bt = 0 \Rightarrow t = \frac{A}{2B}$$

29. (c) $t_n = \frac{t_1 + t_c}{2} \Rightarrow 280 = \frac{t_i + 15}{2} \Rightarrow t_i = 545^o C$

30. (a)

31. (a) A is false because at neutral temperature thermo emf is maximum. B is true.

32. (b) Thermo-electric power $P = \frac{dE}{d\theta}$; at t_n, $E \to$ maximum. So $P \to$ zero.

33. (d) By using $H = \sigma Q \theta$

$\Rightarrow\ H = (10 \times 10^{-6}) \times 10 \times (60 - 50) = 10^{-3} J = 1\ mJ$

34. (c) No change in neutral temperature but temperature of inversion is $t_i = 2t_n - t_c \Rightarrow t_i = 2 \times 270 - 40 = 500^o C$

35. (c)

36. (d) $t_i = 2t_n - t_c \Rightarrow t_i = 2 \times 350 - 30 = 670^o C$

37. (c)

38. (d) Neutral temperature is independent of temperature of cold junction.

39. (d)

40. (a) $E = at + bt^2$ at inversion temperature E will be minimum

Thus $\frac{dE}{dt} = 0 \Rightarrow \frac{d}{dt}[at + bt^2] = 0$

$\Rightarrow a + 2bt = 0 \Rightarrow t = -\frac{a}{2b}$

41. (d)

42. (a) $i = \frac{e}{R} \Rightarrow 3 \times 10^{-7} = \frac{(30 \times 10^{-6}) \times \theta}{50} \Rightarrow \theta = 0.5°$

43. (b) $t_n = \frac{\alpha}{\beta} = \left(\frac{500}{5}\right) = 100\,°C$

Also $t_n = \frac{t_i + t_c}{2} \Rightarrow 100 = \frac{t_i + 0}{2} \Rightarrow t_i = 200\,°C$

44. (b) At neutral temperature, thermal emf will be maximum.

$\therefore \frac{de}{dt} = a + bt$

For maximum or minima, $a + bt_n = 0$

$\therefore\ t_n = -a/b$

Critical Thinking Questions

1. (d) $P_1 = \frac{(220)^2}{R_1}$ and $P_2 = \frac{(220 \times 0.8)^2}{R_2}$

$\frac{P_2}{P_1} = \frac{(220 \times 0.8)^2}{(220)^2} \times \frac{R_1}{R_2} \Rightarrow \frac{P_2}{P_1} = (0.8)^2 \times \frac{R_1}{R_2}$ Here $R_2 < R_1$

(because voltage decreases from 220 $V \rightarrow$ 220 × 0.8 V

It means heat produced → decreases)

So $\frac{R_1}{R_2} > 1 \Rightarrow P_2 > (0.8)^2 P_1 \Rightarrow P_2 > (0.8)^2 \times 100\,W$

Also $\frac{P_2}{P_1} = \frac{(220 \times 0.8) i_2}{220\, i_1}$, Since $i_2 < i_1$ (we expect)

So $\frac{P_2}{P_1} < 0.8 \Rightarrow P_2 < (100 \times 0.8)$

Hence the actual power would be between $100 \times (0.8)^2 W$ and (100 × 0.8) W

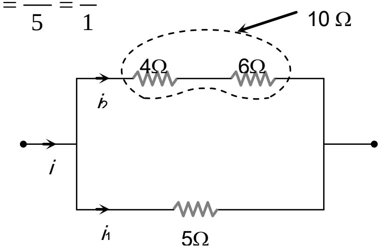
2. (b) $W = JH \Rightarrow P \times t = J \times m\, s\, \Delta\theta$

$\Rightarrow t = \frac{J \times m \times s \Delta\theta}{P}$ (For water 1 *litre* = 1*kg*)

$\Rightarrow t = \frac{4.2 \times 1 \times 1000 \times (40 - 10)}{836} = 150\, sec$

Short Trick : use formula $t = \frac{4200 \times m \times \Delta\theta}{P}$

3. (b) $\frac{i_1}{i_2} = \frac{R_2}{R_1} = \frac{10}{5} = \frac{2}{1}$



Also heat produced per sec *i.e.* $\frac{H}{t} = P = i^2 R$

$\Rightarrow \frac{P_5}{P_4} = \left(\frac{i_1}{i_2}\right)^2 \times \frac{5}{4} = \left(\frac{2}{1}\right)^2 \times \frac{5}{4} = \frac{5}{1} \Rightarrow P_4 = \frac{10}{5} = 2\, cal/s$

4. (d) $220 \times 9 = n(60) \Rightarrow n = 33$

5. (c) $H = \frac{V^2}{R} t$

Since supply voltage is same and equal amount of heat will produce, therefore

$\frac{R_1}{t_1} = \frac{R_2}{t_2}$ or $\frac{R_1}{R_2} = \frac{t_1}{t_2}$ .....(i)

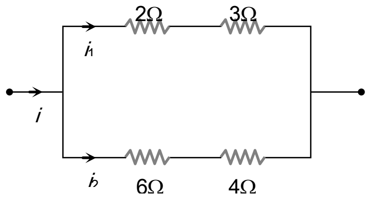
But $R \propto l \Rightarrow \frac{R_1}{R_2} = \frac{l_1}{l_2}$ .....(ii)

By (i) and (ii), $\frac{l_1}{l_2} = \frac{t_1}{t_2}$ .....(iii)

Now $l_2 = \frac{2}{3} l_1 \Rightarrow \frac{l_1}{l_2} = \frac{3}{2}$

∴ By equation (iii), $\frac{3}{2} = \frac{15}{t_2} \Rightarrow t_2 = 10$ *minutes*

6. (d)



Resistance of upper branch $R_1 = 2 + 3 = 5\,\Omega$

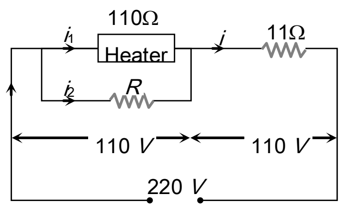
Resistance of lower branch $R_2 = 4 + 6 = 10\,\Omega$

Hence $\frac{i_1}{i_2} = \frac{R_2}{R_1} = \frac{10}{5} = 2$

$\frac{\text{Heat generated across } 3\,\Omega\,(H_1)}{\text{Heat generated across } 6\,\Omega\,(H_2)} = \frac{i_1^2 \times 3}{i_2^2 \times 6} = \frac{4}{2} = 2$

∴ Heat generated across 3 Ω = 120 *cal/sec*

7. (a) Power consumed by heater is 110 W so by using $P = \frac{V^2}{R}$



$110 = \frac{V^2}{110} \Rightarrow V = 110\, V$. Also from figure

$i_1 = \frac{110}{110} = 1A$ and $i = \frac{110}{11} = 10\, A$. So $i_2 = 10 - 1 = 9\, A$

Applying *Ohms* law for resistance R, $V = iR$

$\Rightarrow 110 = 9 \times R \Rightarrow R = 12.22\,\Omega$

8. (c) $P_{consumed} = \left(\frac{V_A}{V_R}\right)^2 \times P_R = \left(\frac{110}{115}\right)^2 \times 500 = 457.46\; W$

So, percentage drop in power output

$= \frac{(500 - 457.46)}{500} \times 100 = 8.6\%$

9. (d) Heat produced $= \frac{V^2}{R} t$

i.e. when voltage is halved, heat produced becomes one-fourth. Hence time taken to heat the water becomes four times.

10. (b) Electric power consumed by kettle $P = 220 \times 4\, W$

Heat required

$H = 1000 \times 1(100-20) = 1000 \times 80\ cal = 4200 \times 80\ J$

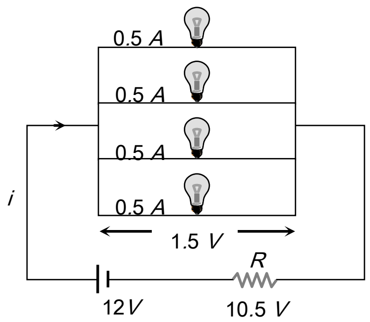
$P = \frac{H}{t} \Rightarrow H = P \times t$

$\therefore\ 220 \times 4 \times t = 4200 \times 80 \Rightarrow\ t = 6.3$ *minutes*

11. (c) $H = \frac{V^2}{R} \times t = \frac{(210)^2}{20} \times 1 = mL$

$\therefore\ \frac{(210)^2}{20} = m \times 80 \times 4.2 \Rightarrow\ m = 6.56\ g/s$

12. (b) For normal brightness of each bulb see following circuit. Current through each bulb = 0.5 *A*



So main current $i = 2A$

Also, voltage across the combination $= 1.5\, V$

So voltage across the resistance $= 10.5\, V$

Hence for resistance $V = iR \Rightarrow 10.5 = 2 \times R$

$\Rightarrow R = \frac{21}{4}\Omega$

13. (d) $P = \frac{V^2}{R}$ so $R = \frac{V^2}{P} \Rightarrow R_1 = \frac{V^2}{100}$ and $R_2 = R_3 = \frac{V^2}{60}$

Now $W_1 = \frac{(250)^2}{(R_1+R_2)^2}.R_1$, $W_2 = \frac{(250)^2}{(R_1+R_2)^2}.R_2$

and $W_3 = \frac{(250)^2}{R_3}$

$W_1 : W_2 : W_3 = 15 : 25 : 64$ or $W_1 < W_2 < W_3$

14. (a) Power dissipated $\propto$ $R_{equivalent}$

15. (a) The current taken by the silver voltameter

$I_1 = \frac{m}{Zt} = \frac{1}{11.2 \times 10^{-4} \times 30 \times 60} = 0.496\ A$

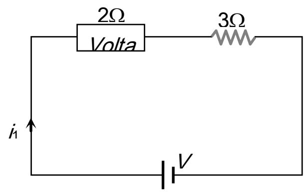
and by copper voltameter

$I_2 = \frac{1.8}{6.6 \times 10^{-4} \times 30 \times 60} = 1.515\ A$

Total current $I = (I_1 + I_2) = 2.011\ A$

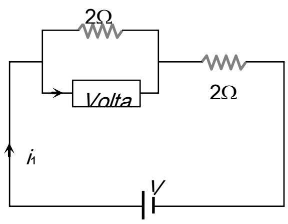
Power $P = IV = 2.011 \times 12 = 24.132\ J/\sec$

16. (d) Initially current through the voltameter $i_1 = \frac{V}{(3+2)} = \frac{V}{5}$



Finally main current $i = \frac{V}{3+1} = \frac{V}{4}$

Hence current through voltameter $i_2 = \frac{V}{8}$



$\because$ Rate of deposition $(R) = \frac{m}{t} = Zi \Rightarrow\ R \propto i$

$\therefore$ % drop in rate $= \frac{R_2 - R_1}{R_1} \times 100 = \frac{i_2 - i_1}{i_1} \times 100$

$= \frac{\left(\frac{V}{8} - \frac{V}{5}\right)}{\frac{V}{5}} \times 100 = -37.5\%$

17. (d) Comparing the given equation with standard equation

$E = \alpha t + \frac{1}{2}\beta t^2$

$\alpha = 40$ and $\frac{1}{2}\beta = -\frac{1}{20}\ \Rightarrow\ \beta = -\frac{1}{10}$

Hence neutral temperature $t_n = -\frac{\alpha}{\beta} = \frac{-40}{-1/10}$

$\Rightarrow t_n = 400^o C$

18. (a) Comparing the given equation with standard equation $E = \alpha t + \frac{1}{2}\beta t^2$, we get $\alpha = 14$ and $\frac{1}{2}\beta = -0.02$

$\Rightarrow \beta = -0.04$

Hence neutral temperature $t_n = -\frac{\alpha}{\beta} = -\frac{14}{-0.04} = 350°C$

19. (a) We know that thermoelectric power $S = \frac{dE}{dT}$

Given $E = k(T - T_r)\left[T_0 - \frac{1}{2}(T + T_r)\right]$

By differentiating the above equation *w.r.t.* *T* and

Putting $T = \frac{1}{2}T_o$, we get $S = \frac{1}{2}kT_o$

20. (b) Comparing the given equation with $E = \alpha t + \frac{1}{2}\beta t^2$

We get $\alpha = 16$ and $\frac{1}{2}\beta = -0.04 \Rightarrow \beta = -0.08$

$\Rightarrow t_n = -\frac{\alpha}{\beta} = -\frac{16}{-0.08} = 200°C$

Also $t_i = 2t_n - t_c \Rightarrow t_i = 2 \times (200) - 0 = 400°C$

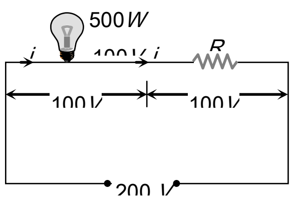
21. (c) $m = Zit \Rightarrow 20 \times 10^{-3} = \left(\frac{32}{96500}\right) \times 0.15 \times t$

$= 6.7 min = 6 min. 42 sec.$

22. (b) $e = iR \Rightarrow 25 \times 10^{-6} \times \Delta\theta = 10^{-5} \times 40$

$\Delta\theta = \frac{40 \times 10^{-5}}{25 \times 10^{-6}} = \frac{400}{25} = 16°C$

23. (b)



Rated current through the circuit $i = \frac{500}{100} = 5A$

Potential difference across *R*, $100 = 5 \times R \Rightarrow R = 20\,\Omega$

24. (b) By using $e_0^{100} = e_0^{32} + e_{32}^{70} + e_{70}^{100}$

$\Rightarrow 200 = 64 + 76 + e_{70}^{100} \Rightarrow e_{70}^{100} = 60\,\mu V$

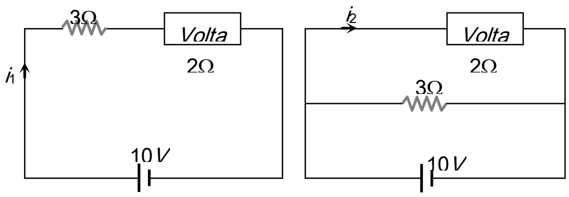
25. (d) In the normal condition current flows from *X* to *Y* through cold. While after increasing the temperature of hot junction beyond temperature of inversion. The current is reversed *i.e.* *X* to *Y* through hot junction or *Y* to *X* through cold junction.

26. (a) $H = \pi it = (2 \times 10^{-9}) \times 2.5 \times (2 \times 60) = 6 \times 10^{-7}\ J = 6\,erg$

27. (b) Remember mass of the metal deposited on cathode depends on the current through the voltameter and not on the current supplied by the battery. Hence by using $m = Zit$, we can say $\frac{m_{Parallel}}{m_{Series}} = \frac{i_{Parallel}}{i_{Series}}$

$\Rightarrow m_{Parallel} = \frac{5}{2} \times 1 = 2.5\ gm.$

Hence increase in mass = 2.5 – 1 = 1.5 *gm*



28. (c) Mass deposited $m = \text{Density} \times \text{Volume of the metal}$

$\Rightarrow m = \rho \times Ax$. Also $m = Zit$, so $Zit = \rho Ax$

$\Rightarrow x = \frac{Zit}{A\rho} = \frac{0.00033 \times 10^{-3} \times 1.5 \times 20 \times 60}{(50 \times 10^{-4}) \times 9000} = 1.3 \times 10^{-5}\ m$

29. (a) $i = \frac{m}{Zt} = \frac{2.0124}{1.118 \times 10^{-3} \times 3600} = 0.5\ A$

$\Rightarrow$ Error $= 0.54 - 0.5 = 0.04\ A$

30. (b) Total charge supplied $= 1 \times 10 = 10\ C$

$\because$ 2 electronic charge $(3.2 \times 10^{-19}\ C)$ liberates one Cu^{++} ion

$\therefore$ Number of Cu^{++} ions liberated by 10 *C* charge

$= \frac{1}{3.2 \times 10^{-19}} \times 10 = 3.1 \times 10^{19}$

31. (d) $\because\ m = Zit$ or $i = \frac{m}{Zt}$

For silver voltmeter

$$i_1 = \frac{m_1}{Z_1 t} = \frac{2}{1.118 \times 10^{-3} \times 1800} = 0.994 \ amp$$

For copper voltameter

$$i_2 = \frac{m_2}{Z_2 t} = \frac{1}{3.294 \times 10^{-4} \times 1800} = 1.687 \ amp$$

$\therefore$ Power of circuit $= V(i_1 + i_2) = 6 \times (0.994 + 1.687)$

$= 6 \times 2.681 \approx 16 \ W$

32. (a) Let the temperature of molten metal is $t^o C$.

The thermo-emf $e = 10 \times 10^{-6} t \ volt$

Current in the circuit

$$i = \frac{e}{R + R_G} = \frac{10^{-5} t}{8 + 1.6} = \frac{10^{-5} t}{9.6} amp.$$

But $i = \frac{V}{R_G} = \frac{8 \times 10^{-3}}{8}$

$\therefore \ \frac{10^{-5} t}{9.6} = \frac{8 \times 10^{-3}}{8}$ or $t = \frac{9.6 \times 10^{-3}}{10^{-5}} = 960^o C$

33. (a) $\because$ Peltier coefficient $\pi = T \frac{de}{dT}$ and $t^o C = T - 273$

$\therefore \ e = a(T - 273) + b(T - 273)^2$

Differentiating *w.r.t. T* $\frac{de}{dT} = a + 2b(T - 273)$

$$\pi = T \frac{de}{dT} = T[a + 2b(T - 273)] \Rightarrow \pi = (t + 273)(a + 2bt)$$

34. (d) $\frac{Q}{t} = \frac{V^2}{4.2 \ R} = \frac{m}{t}.L$

$\therefore \ \frac{m}{t} = \frac{V^2}{4.2 \ RL} = \frac{(210)^2}{4.2 \times 50 \times 80} \approx 2.625 \ gm$

35. (d) $H = i^2 RT = i^2 \left(\frac{\rho l}{A}\right) t = \frac{i^2 \rho V t}{A^2}$ (V = volume, = *Al*)

$\Rightarrow H \propto \frac{1}{r^4} \Rightarrow \frac{H_1}{H_2} = \left(\frac{r_2}{r_1}\right)^4 = \left(\frac{2}{1}\right)^4 = \frac{16}{1}$.

36. (d) Thermoelectric power $P \propto \theta$

$\Rightarrow \frac{P_{100} - P_{80}}{P_{80}} \times 100 = \frac{100 - 80}{80} \times 100$ = 25%

37. (d) The sensitivity of the thermocouple will be

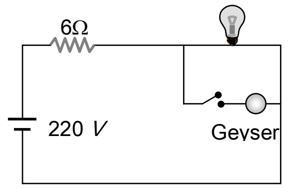
$= 500 \mu V / ^o C - (-72 \mu V / ^o C) = 572 \mu V / ^o C$

Therefore for a $100^o C$ temperature difference, the thermo e.m.f. will be

$E = 572 \times 10^{-6} \times 100 (volt) = 57.2 \times 10^{-3} = 57.2 \ mV$.

38. (d) At cold junction, current flows from copper to nickel and from iron to copper, and at hot junction from nickel to iron, thus the contributions add.

39. (b) $R_{Bulb} = \frac{220^2}{100} = 484 \ \Omega$, $R_{Geyser} = \frac{220^2}{1000} = 48.4 \ \Omega$



(i) When only bulb is ON, $V_{Bulb} = \frac{220 \times 484}{490} = 217.4 \ V$

(ii) When geyser is also switched ON, equivalent resistance of bulb and geyser is $R = \frac{484 \times 48.4}{484 + 48.4} = 44 \ \Omega$

Voltage across the bulb $V_{Bulb} = \frac{220 \times 44}{50} = 193.6 \ V$

Hence the potential drop is $217.4 - 193.6 = 23.8 \ V$

40. (b) $i = \frac{24 - 12}{3} = 4 \ A$, Time of charging $t = \frac{360`}{V.i}$

$\Rightarrow t = \frac{360}{12 \times 4} = 7.5 \ hours.$

41. (a) $I = \frac{m}{Zt} = \frac{2.68}{\frac{108}{96500} \times 10 \times 60} = \frac{2.68}{108} \times \frac{965}{6} \approx 4 \ A$

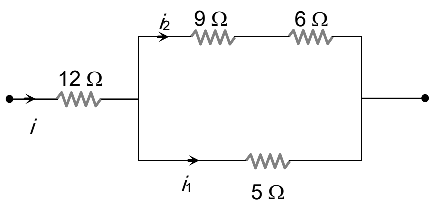
Energy $= I^2 Rt = 4^2 \times 20 \times 600 = 192 \ kJ$.

42. (d) Comparing with standard equation $E = \alpha t + \frac{1}{2} \beta t^2$

α = *a* and β = 2*b* $\Rightarrow \ t_n = -\frac{a}{2b} = -\frac{1}{2} \times 700 = -350^o C$

This is not possible.

43. (b) $\frac{i_1}{i_2} = \frac{15}{5} = \frac{3}{1}$ … (i)



Also $\frac{H}{t} = i^2 R \Rightarrow 45 = (i_1)^2 \times 5$

$\Rightarrow i_1 = 3\,A$ and from equation (i) $i_2 = 1\,A$

So $i = i_1 + i_2 = 4\,A$

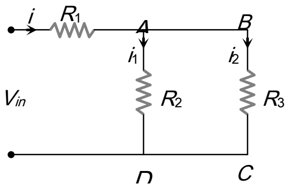
Hence power developed in $12\,\Omega$ resistance

$P = i^2 R = (4)^2 \times 12 = 192\,W$

44. (a) Heat gained by water = Heat supplied by container - heat lost $\Rightarrow$ $mS\Delta\theta$ = 1000*t* – 160*t*

$\Rightarrow t = \frac{2 \times 4.2 \times 1000 \times 50}{840}$ = 8 *min* 20 *sec*

45. (c) As the voltage in R_2 and R_3 is same therefore, according to,



$H = \frac{V^2}{R}.t,\ R_2 = R_3$

Also the energy in all resistance is same.

$\therefore \quad i^2 R_1 t = i_1^2 R_2 t$

Using $i_1 = \frac{R_3}{R_2 + R_3} i = \frac{R_3}{R_3 + R_3} i = \frac{1}{2} i$

Thus $i^2 R_1 t = \frac{i^2}{4} R_2 t$ or, $R_1 = \frac{R_2}{4}$

Graphical Questions

1. (b) Area = *it* = 2 *Coulomb* and $m = zit \Rightarrow z = \frac{m}{it} = \frac{m}{2}$

2. (d) $U \propto i^2$, hence the graph between *U* and *i* is parabolic in nature and should be above graph (*b*).

3. (d) $E = \alpha t + \frac{1}{2} \beta t^2$, graph between *E* and *t* will be a parabola, such that first emf increases and then decreases.

4. (a) Thermo electric power $P = \frac{dE}{d\theta} = \alpha + \beta\theta$

Comparing it with $y = mx + c$, option (a) is correct.

5. (b) The filament of the heater reaches its steady resistance when the heater reaches its steady temperature, which is much higher than the room temperature. The resistance at room temperature is thus much lower than the resistance at its steady state. When the heater is switched on, it draws a larger current than its steady state current. As the filament heats up, its resistance increases and current falls to steady state value.

6. (a) *Cu* voltameter with soluble electrodes obeys ohms law. In water voltameter, in the beginning when *V* is small $(< 1.7\,volt)$, very little current flows, the voltameter does not obey ohms law. As soon as *V* exceeds 1.7 *volt* (back e.m.f.) the current increases steadily according to ohms law.

7. (d) Thermal energy in resistor is $U = i^2 Rt$

where $R = R_0(1 + \alpha t) \Rightarrow U = i^2 R_0 (1 + \alpha t) t = i^2 R_0 t + i^2 R_0 t^2$

So $\frac{dU}{dt} = i^2 R_0 (1 + \alpha t)$

With the time temperature increases, hence dU/dt increases. This is best shown by curve (*d*).

8. (b) $m = Zit$ and it = Area of given curve

= Area of triangle + Area of rectangle

$\Rightarrow it = \frac{1}{2} \times (2 \times 60) \times 1 + (6 - 2) \times 60 \times 1 = 300$

$\therefore Z = \frac{m}{it} = \frac{m}{300}$

9. (d) Terminal voltage $V = E - Ir$. Hence the graph between *V* and *i* will be a straight line having negative slope and positive intercept.

Thermal power generated in the external circuit

$P = EI - I^2 r$. Hence graph between *P* and *I* will be a parabola passing through origin.

Also at an instant, thermal power generated in the cell = $i^2 r$ and total electrical power generated in the cell = *Ei*. Hence the fraction $\eta = \frac{I^2 r}{EI} = \left(\frac{r}{E}\right) I$; so

$\eta \propto I$. It means graph between η and *I* will be a straight line passing through origin.

Assertion and Reason

1. (a) The possibility of an electric bulb fusing is higher at the time of switching ON and switching OFF because inductive effect produces a surge at the time of switching ON and OFF.

2. (a) The resistance, $R = \frac{V^2}{P} \Rightarrow R \propto 1/P$

   i.e., higher is the wattage of a bulb, lesser is the resistance and so it will glow bright.

3. (c) Assertion is true but reason is false. Fuse wire must have high resistance because in series current remains same, therefore according to Joule's law $H = \frac{i^2Rt}{4.2}$, heat produced is high if *R* is high. The melting point must be low so that wire may melt with increase in temperature. As the current equal to maximum safe value, flows through the fuse wire, it heats up, melts and break the circuit.

4. (a) Resistance of 50 *W* bulb is two times the resistance of 100 *W* bulb. When bulbs are connected in series, 50 *W* bulb will glow more as $P = i^2 R$ (current remains same in series). In parallel the 100 *W* bulb will glow more as $P = V^2/R$ (potential difference remain same in parallel).

5. (d) When two bulbs are connected in series, the resistance of the circuit increases and so the voltage in each decreases, hence the brightness and the temperature also decreases. Due to decrease in temperature, the resistance of the carbon filament will slightly increase while that of metal filament will decrease. Hence, carbon filament bulb will glow more brightly $(P = i^2R)$. Also carbon is not a semiconductor.

6. (e) Voltage of dc source is constant but in ac, peak value of voltage is $\sqrt{2}$ times the *rms.* voltage. Hence bulb will glow with more brightness when connected to an ac source of the same voltage.

7. (a) When cold water is poured on half portion of the wire, its resistance decreases due to decrease in temperature. As a result of this total resistance of circuit decreases *i.e.* current through each portion of wire increases *i.e.* rest of the half portion becomes still more hot.

8. (a) As filament of bulb and line wire are in series, hence current through both is same. Now, because $H = \frac{i^2Rt}{4.2}$ and resistance of the filament of the bulb is much higher than that of line wires, hence heat produced in the filament is much higher than that in line wires.

9. (b) Neutral temperature is the temperature of hot junction, at which the thermo e.m.f. produced in the thermocouple becomes maximum. It is independent of cold junction and depends on the nature of materials of two metals used to form thermocouple.

10. (d) Because of heat production every resistance has a maximum power rating, the maximum power that can be dissipated without overheating the device. When this rating is exceeded, heat is produced, due to which resistance may change unpredictably.

11. (a) The e.m.f. of a Leclanche cell falls, because of the partial polarisation due to accumulation of hydrogen gas. In case, Leclanche cell is used in experiment, where current is drawn after short breaks, then during each break, hydrogen gas escapes and

Mn_2O_3 converts into MnO_2 by taking oxygen from the atmosphere. As a result, the cell regains its original e.m.f.

12. (a) When lamp *B* or *C* gets fused equivalent resistance of *B* and *C* increases. In series voltage distributes in the ratio of resistance, so voltage appears across *B* increases or in other words voltage across *A* decreases.

13. (d) When switch *S* is closed, bul*b C* is short circuited, so voltage *V* distributes only in two parts *i.e.* voltage on Bulb *A* and *B* increases as compared previously. Hence illumination of Bulb *A* and *B* increases.

14. (a)

15. (c) The electrical appliances with metallic body like heater, press *etc*. have three pin connections. Two pins are for supply line and third pin is for earth connection for safety purposes.

16. (c) A laser beam is a beam of light which is light amplification by stimulated emission of radiation.

    The energy per unit area of the laser beam is very high as compared to the torch light.

17. (a) Follow hint of question 15 of this section.

18. (c) Thomson e.m.f. in lead is practically zero.

19. (b) The presence of water molecules reduces force between ions by $1/81$ times because the value of dielectric constant of water is 81. That is why the separation between ions becomes easier.

20. (b) Here reason is not the correct explanation of the assertion, which is correct.

21. (d) Here assertion and reason are not correct.

Heating and Chemical Effect of Current

SET Self Evaluation Test - 20

1. An electric kettle has two coils. When one of these is switched on, the water in the kettle boils in 6 minutes. When the other coil is switched on, the water boils in 3 minutes. If the two coils are connected in series, the time taken to boil the water in the kettle is

(a) 3 *minutes* (b) 6 *minutes*
(c) 2 *minutes* (d) 9 *minutes*

2. A $3°$ rise in temperature is observed in a conductor by passing a certain current. When the current is doubled, the rise in temperature will be

(a) $15°C$ (b) $12°C$
(c) $9°C$ (d) $3°C$

3. Two indentical electric lamps marked 500 *W*, 220 *V* are connected in series and then joined to a 110 *V* line. The power consumed by each lamp is

(a) $\frac{125}{4}W$ (b) $\frac{25}{4}W$
(c) $\frac{225}{4}W$ (d) 125 *W*

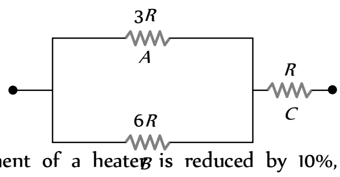
4. When 1 *gm* hydrogen $(e.c.e. = 1.044 \times 10^{-8} kg / C$ forms water, 34 *kcal* heat is liberated. The minimum voltage required to decompose water is

(a) 0.75 *V* (b) 3 *V*
(c) 1.5 *V* (d) 4.5 *V*

5. In how much time, one *litre* of H_2 will be collected by 5 *A* current ? (If $Z = 1 \times 10^{-8}\ kg / C$ and density of $H_2 = 0.09\ kg / m^3$)

(a) 30 *minutes* (b) 15 *minutes*
(c) 45 *minutes* (d) 60 *minutes*

6. The three resistances *A*, *B* and *C* have values 3*R*, 6*R* and *R* respectively. When some potential difference is applied across the network, the thermal powers dissipated by *A*, *B* and *C* are in the ratio



(a) 2 : 3 : 4
(b) 2 : 4 : 3
(c) 4 : 2 : 3
(d) 3 : 2 : 4

7. If the length of the filament of a heater is reduced by 10%, the power of the heater will

(a) Increase by about 9% (b) Increase by about 11%
(c) Increase by about 19% (d) Decrease by about 10%

8. A thermo couple develops 40 $\mu V / kelvin$. If hot and cold junctions be at $40°\ C$ *and* $20°\ C$ respectively then the emf develops by a thermopile using such 150 thermo couples in series shall be

(a) $150mV$ (b) $80mV$
(c) $144mV$ (d) $120mV$

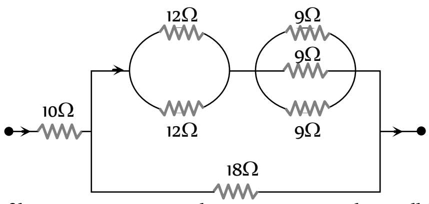
9. Amount of electricity required to pass through the H_2O voltmeter so as to liberate 11.2 *litre* of hydrogen will be

(a) 1 *Faraday* (b) $\frac{1}{2}Faraday$
(c) 2 *Faraday* (d) 3 *Faraday*

10. The resistance of the filament of a lamp increases with the increase in temperature. A lamp rated 100 *W*, 220 *V* is connected across 220 *V* power supply. If the voltage drops by 10% then the power of lamp will be

(a) 90 *W* (b) 81 *W*
(c) Between 90 *W* and 100 *W* (d) Between 81 *W* and 90 *W*

11. In the following circuit, 18Ω resistor develops $2\ J/sec$ due to current flowing through it. The power developed across 10Ω resistance is



(a) 125 *W*
(b) 10 *W*
(c) $\frac{4}{5}W$
(d) 25 *W*

12. If resistance of the filament increases with temperature, what will be power dissipated in a 220 *V*- 100 *W* lamp when connected to 110 *V* power supply

(a) 25 *W* (b) < 25 *W*
(c) > 25 *W* (d) None of these

13. Total surface area of a cathode is $0.05m^2$ and 1 *A* current passes through it for 1 *hour*. Thickness of nickle deposited on the cathode is (Given that density of nickle = $9gm / cc$ and it's E.C.E. = $3.04 \times 10^{-4} gm / C$)

(a) 2.4 *m* (b) $2.4\mu m$
(c) 2.4 μm (d) None of these

14. Two bulbs consume same power when operated at 200 *V* and 300 *V* respectively. When these bulbs are connected in series across a D.C. source of 500 *V*, then

(a) Ratio of potential difference across them is 3/2
(b) Ratio of potential difference across them is 9/4
(c) Ratio of power consumed across them is 4/9
(d) Ratio of power consumed across them is 2/3

AS Answers and Solutions

1. (d) In series $\frac{1}{P_S}=\frac{1}{P_1}+\frac{1}{P_2}\Rightarrow\frac{1}{(H_s/t_s)}=\frac{1}{(H_1/t_1)}+\frac{1}{(H_2/t_2)}$

$\because H_s=H_1=H_2$ So $t_s=t_1+t_2=6+3=9min$

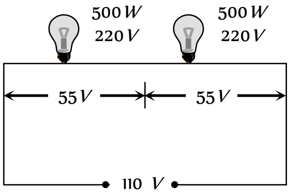
2. (b) $i^2Rt=C\theta=3C;$ C = Thermal capacity

when $i_1=2i\Rightarrow C\theta_1=4i^2Rt=4\times3C\Rightarrow\theta_1=12^oC$

3. (a) Voltage across each bulb $V'=\frac{110}{2}=55W$ so, power consumed by each bulb will be

$P'=\left(\frac{55}{220}\right)^2\times500$

$=\frac{125}{4}W$



4. (c) $m=Zit\Rightarrow it=\frac{m}{Z}=\frac{1\times10^{-3}}{1.044\times10^{-8}}C=\frac{10^5}{1.044}C$

Given $H=34\,kcal$ = 4.2 × 34 × 10 J

$\Rightarrow$ Heat generated $H=Vit=V.\frac{10^5}{1.044}$

$\Rightarrow V=\frac{4.2\times34\times1.044}{10^2}$ = 4.2 × 0.34 × 1.044 = 1.5 V

5. (a) $m=zit\Rightarrow10^{-3}\times0.09=1\times10^{-8}\times5\times t\Rightarrow t=30\,min$

6. (c) Thermal power in $A=P_A=\left(\frac{2i}{3}\right)^2 3R=\frac{4}{3}i^2R$

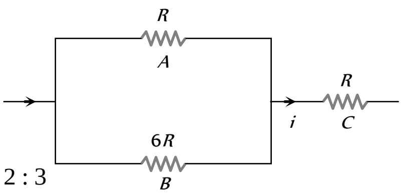
Thermal power in $B=P_B=\left(\frac{i}{3}\right)^2 6R=\frac{2}{3}i^2R$

Thermal power in

$C=P_C=i^2R$

$\Rightarrow P_A:P_B:P_C$

$=\frac{4}{3}:\frac{2}{3}:1=4:2:3$



7. (b) $P\propto\frac{1}{R}$ and $R\propto l\Rightarrow P\propto\frac{1}{l}$

$\Rightarrow\frac{P_1}{P_2}=\frac{l_2}{l_1}\Rightarrow\frac{P_1}{P_2}=\frac{(100-10)}{100}=\frac{90}{100}\Rightarrow P_2=1.11P_1$

% change in power = $\frac{P_2-P_1}{P_1}\times100=11\%$

8. (d) The temperature difference is 20°C = 20 K. So that thermo emf developed $E=\alpha\theta=40\frac{\mu V}{K}\times20K=800\mu V$

Hence total emf = $150\times800=12\times10^4\mu V=120mV$

9. (a) 22.4 *litre* H_2 =1 mole of H_2 = N molecules of H_2

= 2N atoms of H.

So charge required to liberate 22.4 *litre* of H_2 = 2Ne = 2F.

Hence charge required to liberate 11.2 *litre* of H_2 = F.

10. (d) Let the resistance of the lamp filament be R. Then $100=\frac{(220)^2}{R}$. When then voltage drops, expected power is $P=\frac{(220\times0.9)^2}{R'}$. Here R' will be less than R, because now the rise in temperature will be less. Therefore P is more than $\frac{(220\times0.9)^2}{R}=81W$

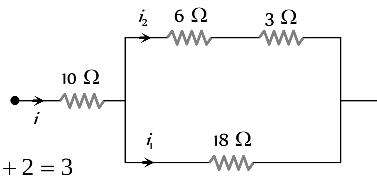
But it will not be 90% of earlier value, because fall in temperature is small. Hence (d) is correct.

11. (b) The given circuit can be redrawn as follows

$\frac{i_1}{i_2}=\frac{9}{18}=\frac{1}{2}$

and $i=i_1+i_2$

$\Rightarrow\frac{i}{i_1}=1+\frac{i_2}{i_1}=1+2=3$



From $P=i^2R\Rightarrow\frac{P_{10\Omega}}{P_{18\Omega}}=\left(\frac{i}{i_1}\right)^2\times\frac{10}{18}\Rightarrow P_{10\Omega}=10W$

12. (c) If resistance does not vary with temperature P consumed = $\left(\frac{V_A}{V_R}\right)^2\times P_R=\left(\frac{110}{220}\right)^2\times100=25W$. But in second cases resistance decreases so consumed power will be more than 25 W

13. (c) Mass deposited = density × volume of the metal

$m=p\times A\times X$ .....(i)

Hence from Faraday's first law $m=Zit$ .....(ii)

So from equation (i) and (ii)

$Zit=\rho\times Ax\Rightarrow x=\frac{Zit}{\rho A}$

$=\frac{3.04\times10^{-4}\times10^{-3}\times1\times3600}{9000\times0.05}=2.4\times10^{-6}m=2.4\mu m$

14. (c) $P=\frac{V^2}{R}$ $\therefore R=\frac{V^2}{P}$ or $R\propto V^2$ *i.e.* $\frac{R_1}{R_2}=\left(\frac{200}{300}\right)^2=\frac{4}{9}$

When connected in series potential drop and power consumed are in the ratio of their resistances. So, $\frac{P_1}{P_2}=\frac{V_1}{V_2}=\frac{R_1}{R_2}=\frac{4}{9}$

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