JEE Main Physics Previous Year Questions With Solutions on "Current Electricity"

Q1: Drift speed of electrons, when 1.5 A of current flows in a copper wire of cross section 5 mm^2 is v. If the electron density of copper is $9 \times 10^{28}/m^3$ the value of v in mm/s is close to (Take charge of electron to be = 1.6×10^{-19} C)

(a) 3

(b) 0.2

(c) 2

(d) 0.02

Solution

As I = neAvd = neAv

v = I/neA = $1.5/(9 \times 10^{28} \times 1.6 \times 10^{-19} \times 5 \times 10^{-6})$

v = 0.02×10^{-3} m/s = 0.02 mm/s

Answer: (d) 0.02

Q2: Two equal resistances when connected in series to a battery, consume electric power of 60 W. If these resistances are now connected in parallel combination to the same battery, the electric power consumed will be

(a) 240 W

(b)120 W

(c) 60 W

(d) 30 W

Solution

The power consumed when two resistance are in series combination is

$V^2/2R = 60$ W ⇒ $V^2/R=120$ W

When the two resistance are connected in parallel combination, power consumed is

$2V^2/R = 120(2)= 240$ W

Answer: (a) 240 W

Q3: A current of 2 mA was passed through an unknown resistor which dissipated a power of 4.4 W. Dissipated power when an ideal power supply of 11 V is connected across it is

(a) 11×10^{-4} W

(b) 11×10^{-5} W

(c) 11×10^{5} W

(d) 11×10^{-3} W

Solution

Case (1)

As $I^2R = P$

$R = P/I^2$

$R = (4.4)/(2 \times 10^{-3})^2 = 1.1 \times 10^6\ \Omega$

Case (2)

$P = V^2/R = (1.1)2/(1.1 \times 10^6) = 11 \times 10^{-5}$ W

Answer: (b) 11 × 10^{-5} W

Q4: An ideal battery of 4 V and resistance R are connected in series in the primary circuit of a potentiometer of length 1 m and resistance 5. The value of R, to give a potential difference of 5 mV across 10 cm of potentiometer wire is

(a) 490

(b) 495

(c) 395

(d) 480

Solution

Let I be the current in the circuit. 4 = (5 + R) I——(1)

According to given condition,

$5 \times 10^{-3} = (10/100)(5)(I)$

$I = 10^{-2}$ A …(2)

Using (1) and (2), 5 + R = 400 R = 395

Answer: (c) 395

Q5: A cell of internal resistance r drives current through an external resistance R. The power delivered by the cell to the external resistance will be maximum when

(a) R = 0.001 r

(b) R = r

(c) R = 2r

(d) R = 1000 r

Solution

The power delivered to resistance is I^2R

i.e., $P = [\varepsilon^2/(R + r)^2]R$

For the maximum power, $dP/dR = 0$

⇒ -2R + (R +r) = 0 or R = r

Answer: (b) R = r

Q6: A metal wire of resistance 3 is elongated to make a uniform wire of double its previous length. This new wire is now bent and the ends joined to make a circle. If two points on this circle make an angle 60° at the centre, the equivalent resistance between these two points will be

(a) (7/2) Ω

(b) (5/2) Ω

(c) (12/5) Ω

(d) (5/3) Ω

Solution

$R = 3\ \Omega = \rho(l/A) = \rho(l^2/V)$

$R' = \rho(l'^2/V) \Rightarrow R' = (2l)^2/l^2 \times 3 \Rightarrow R' = 12\ \Omega$

Equivalent resistance, $R_{eq} = (10 \times 2)/(10+2) = (5/3)\ \Omega$

Answer: (d) (5/3) Ω

Q7: On interchanging the resistances, the balance point of a meter bridge shifts to the left by 10 cm. The resistance of the combination is 1 kΩ. How much was the resistance on the left slot before the interchange?

(a) 990

(b) 505

(c) 550

(d) 910

Solution

Let R_1 (left slot) and R_2 (right slot) be two resistances in two slots of a meter bridge. Initially l be the balancing length

Then, $R_1/R_2 = l/(100 - l)$————-(1)

$R_1 + R_2 = 1000\ \Omega$————-(2)

On interchanging the resistances, balancing length becomes (l – 10), so

$(R_2/R_1) = (l - 10)/(110 - l)$

Using (1)

$(100 - l)/l = (l - 10)/(110 - l)$

$11000 + l^2 - 210\, l = l^2 - 10l$

$200\, l = 11000,\ l = 55$ cm

From equa (1) $R_1/R_2 = 55/45$

Using (2)

$R_1 = (55/45)(1000 - R_1)$

$R_1 + (55/45)R_1 = (1000)x(55/45)$

$100\ R_1 = 1000 \times 55$

$R_1 = 550\ \Omega$

Answer: (c)550

Q8: A constant voltage is applied between two ends of a metallic wire. If the length is halved and the radius of the wire is doubled, the rate of heat developed in the wire will be

(a) Increased 8 times

(b) Unchanged

(c) Doubled

(d) Halved

Solution

Rate of heat developed, $P = V^2/R$

For given V, $P \propto 1/R = A/\rho l = \pi r^2/\rho l$

Now, $P_1/P_2 = (r_1^2/r_2^2)(l_2/l_1)$

As per question, $l_2 = l_1/2$ and $r_2 = 2r_1$

$P_1/P_2 = (1/4) \times (1/2) = 1/8$

$P_2 = 8P_1$

Answer: (a) Increased 8 times

Q9: A heating element has a resistance of 100 Ω at room temperature. When it is connected to a supply of 220 V, a steady current of 2 A passes in it and the temperature is 500°C more than room temperature. What is the temperature coefficient of resistance of the heating element?

(a) $1\times10^{-4}\ °C^{-1}$

(b) $2 \times 10^{-4}\ °C^{-1}$

(c) $0.5 \times 10^{-4}\ °C^{-1}$

(d) $5 \times 10^{-4}\ °C^{-1}$

Solution

Resistance after temperature increases by 500°C,

R_T = Voltage applied/Current = 220/2 = 110

Also, $R_T = R_0 (1 + \alpha\Delta T)$

$110 = 100 (1 + (\alpha \times 500))$

$\alpha = 10/(100 \times 500) = 2 \times 10^{-4}\,{}^0C^{-1}$

Answer: (b) $2 \times 10^{-4}\,°C^{-1}$

Q10: A uniform wire of length l and radius r has a resistance of 100 Ω. It is recast into a wire of radius r/2.The resistance of new wire will be

(a) 400 Ω

(b)100 Ω

(c) 200 Ω

(d)1600 Ω

Solution

Resistance of a wire of length l and radius r is given by

$R = \rho l/A = (\rho l/A) x(A/A)$

$R = (\rho l/A^2) = (\rho V/\pi^2 r^4)$ ($\because$ V = Al)

i.e., R ∝ 1/r4

$R_1/R_2 = (r_2/r_1)^4$

Here, $R_1 = 100\ \Omega$, $r_1 = r$, $r_2 = r/2$

$R_2 = R_1(r_1/r_2)^4 = 16R_1 = 16000\ \Omega$

Answer: (d) 1600 Ω

Q11: A 2 W carbon resistor is colour coded with green, black, red and brown, respectively. The maximum current which can be passed through this resistor is

(a) 20 mA

(b) 0.4 mA

(c) 100 mA

(d) 63 mA

Solution

The resistance of the resistor is $50 \times 10^2\ \Omega$. So, the maximum current that can be passed through it is

$$\sqrt{\frac{P}{R}} = \sqrt{\frac{2}{50\times10^2}}A = 20\text{mA}$$

Answer: (a) 20 mA

Q12: In a large building, there are 15 bulbs of 40 W, 5 bulbs of 100 W, 5 fans of 80 W and 1 heater of 1 kW. The voltage of the electric mains is 220 V. The minimum capacity of the main fuse of the building will be

(a) 14 A

(b) 8 A

(c) 10 A

(d) 12 A

Solution

Power of 15 bulbs of 40 W = 15 × 40 = 600 W

Power of 5 bulbs of 100 W = 5 × 100 = 500 W

Power of 5 fan of 80 W = 5 × 80 = 400 W

Power of 1 heater of 1 kW = 1000

Total power, P = 600 + 500 + 400 + 1000 = 2500 W

When these combination of bulbs, fans and heater are connected to 220 V mains, current in the main fuse of building is given by

I= P/V = 2500/220 = 11.36 A ≈ 12 A

Answer: (d) 12 A

Q13: If a wire is stretched to make it 0.1% longer, its resistance will

(a) increase by 0.05%

(b) increase by 0.2%

(c) decrease by 0.2%

(d) decrease by 0.05%

Solution

Resistance of wire R = ρl/A……..(1)

On stretching, volume (V) remains constant.

So V = Al or A=V/l

Therefore, R = $\rho l^2/V$ (Using (1))

Taking logarithm on both sides and differentiating we get,

ΔR/R = 2Δl/l (Since V and ρ are constants)

(ΔR/R)% = (2Δl/l)%

Hence, when wire is stretched by 0.1% its resistance will increase by 0.2%

Answer: (b) increase by 0.2%

Q14: A thermocouple is made from two metals, antimony and bismuth. If one junction of the couple is kept hot and the other is kept cold then, an electric current will

(a) flow from antimony to bismuth at the cold junction

(b) flow from antimony to bismuth at the hot junction

(c) flow from bismuth to antimony at the cold junction

(d) not flow through the thermocouple.

Solution: Antimony-bismuth couple is ABC couple. It means that current flows from A to B at a cold junction

Answer: (a) flow from antimony to bismuth at the cold junction

Q15: The resistance of a wire is 5 ohm at 50°C and 6 ohm at 100°C. The resistance of the wire at 0°C will be

(a) 3 ohm

(b) 2 ohm

(c) 1 ohm

(d) 4 ohm

Solution

$R_t = R_0(1 + \alpha t)$

R_t is the resistance of wire at t^0 C

R_0 is the resistance of wire a 0^0 C

α is the temperature coefficient of resistance

$R_{50} = R_0 [1 + \alpha(50)]$

And $R_{100} = R_0 [1+ \alpha(100)]$

Or $R_{50} – R_0 = R_0 \alpha(50)$ ——-(1)

$R_{100} – R_0 = R_0 \alpha(100)$ ——-(2)

Dividing (1) by (2)

$(5 – R_0)/((6 – R_0) = ½$

$R_0 = 4$ ohm

Answer: (d) 4 ohm