Code: Phy/ EM-2/CE/002

Electromagnetism: Effect of Current Electricity– Typical Questions (Set 2)

No of Questions: 77 **Time Allotted: 8 Hours (in 3 parts)**

<u>All questions are compulsory</u>

[<u>Note: a</u>. Figures are conceptual only and not to the scale**]**

[<u>b</u>. Solutions may be taken up in Three parts as, Part I: 1 to 30 of Three Hours;**]**

[Part II: 31 to 60 of Three Hours; and Part III: 61 to 77] of Two Hours**]**

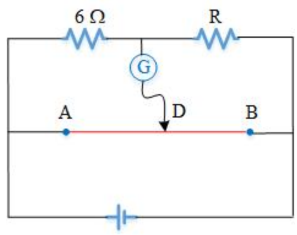
[<u>c</u>. It is advised to attempt question under examination conditions**]**

Important Note: 1. Capacitors are implementation aspect of concepts of electrostatics. The capacitors are integral part of any electrical system or circuit and any kind of application of electricity.

2. A student at a stage to refer to these questions and illustrations is expected to have attained a reasonable understanding of concepts and visualization. Moreover, forward journey involves integration of concepts on a wider canvas. Therefore, illustrations have been made a bit crisp. This would help students to harness their understanding at a faster rate.

3. Avoid fatigue due to long and continuous sitting in solving such problems. Take a reasonable break to refresh before taking next part. Gradually, capability to withstand fatigue will grow to enable you to strive more intensly.

<table>
<tr><td>Q-1</td><td>The potentiometer wire AB shown in the figure is 50 cm long. When AD= 30 cm, no deflection occurs in the galvanometer. Find R



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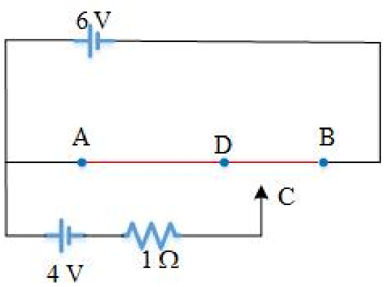
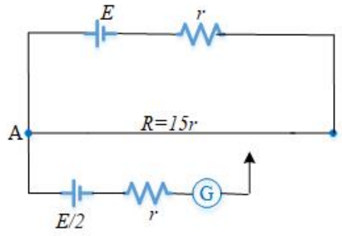
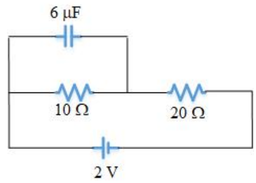
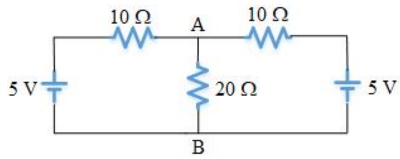
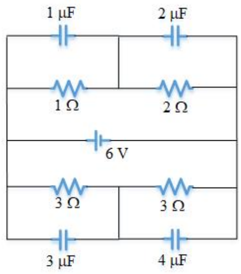
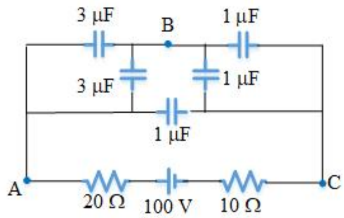
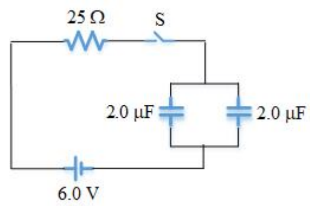
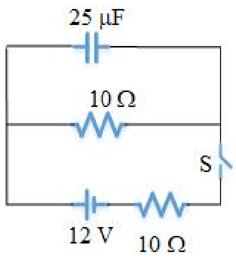
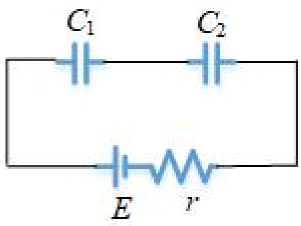
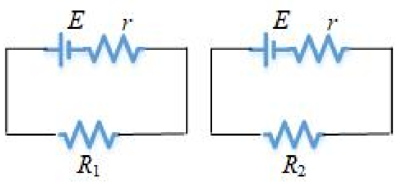
<tr><td>Q-2</td><td>A 6 volt battery of negligible internal resistance is connected across a uniform wire AB of length 100 cm. The positive terminal of the battery of emf 4 V and internal resistance 1 Ω is joined to end A as shown in the figure. Take the potential at B to be zero.

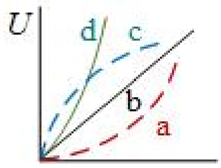
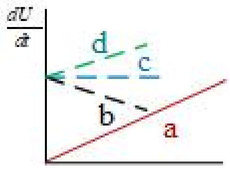


(a) What are the potentials at the points A and C?
(b) At which point D of the wire AB, the potential is equal to potential at C?
(c) If the points C and D are connected by a wire, what will be the current through it?
(d) If 4 V battery is replaced by 7.5 battery what would be the answer of parts (a) and (b)
</td></tr>
</table>

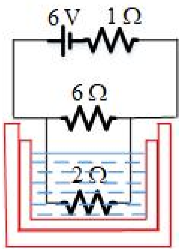
Q-3	Consider the potentiometer circuit arranged in figure. The potentiometer wire is 600 cm long. (a) At what distance from the point A should jockey touch the wire to get zero deflection in galvanometer? (b) If the jockey touches the wire at a distance of 560 cm from A, what will be the current in the galvanometer? 
Q-4	Find the charge on the capacitor shown in the figure. 
Q-5	In the figure - (a) Find the current in the 20 Ω resistor. (b) If the capacitor of capacitance 4 μF is joined between points A and B what would be the electrostatic energy stored in it in steady state? 
Q-6	Find charges on the four capacitors of capacitances 1 μF, 2 μF, 3 μF and 4 μF shown in the figure. 
Q-7	Find the potential difference between the points A and B between points B and C of figure in steady state. 
Q-8	A capacitance C, a resistor R and an emf E are connected in series at $t = 0$. What is the maximum value of- (a) Potential difference across the resistor? (b) The current in the circuit? (c) The potential difference across the capacitor? (d) The energy stored in the capacitor? (e) The power delivered by the battery? (f) The power converted into heat?
Q-9	A parallel-plate capacitor with plate area 20 cm^2 and plate separation 1.0 mm is connected to a battery. The resistance of the circuit is 10 kΩ. Find the time constant of the circuit.
Q-10	A capacitor of capacitance 10 μF is connected to a battery of emf 2 V. It is found that it takes 50 ms for the charge on the capacitor to become 12.6 μC. Find the resistance of the circuit.
Q-11	A 20 μF capacitor is joined to a battery of emf 6.0 V through a resistance of 100 Ω. Find the charge on the capacitor 2.0 ms after the connections are made.

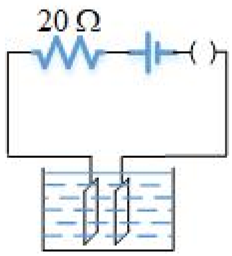
Q-12	The plates of a capacitor of capacitance 10 μF, charged to 60 μC, are joined together by a wire of resistance 10 Ω at $t = 0$. Find the charge on the capacitor in the circuit at – (a) $t = 0$ (b) $t = 30$ μs (c) $t = 120$ μs (d) $t = 1$ ms
Q-13	A capacitor of capacitance 8.0 μF is connected to a battery of emf 6.0 V through a resistance of 24 Ω. Find the current in the circuit – (a) Just after the connections are made, (b) One time constant after the connections are made.
Q-14	A parallel-plate capacitor of plate area 40 cm^2 and separation 0.10 mm is connected to a battery of 2.0 V through a 16 Ω resistor. Find electric field in the capacitor 10 ns after the connections are made.
Q-15	A parallel-plate capacitor of plate area 20 cm^2 and separation 1.0 mm and a dielectric slab of dielectric constant 5.0 filling up the space between the plates. This capacitor is connected to a battery of emf 6.0 V through a 100 kΩ resistor. Find the energy of the capacitor 8.9 μs after the connections are made.
Q-16	A 100 μF capacitor is joined to a 24 V battery through a 1.0 MΩ resistor. Plot qualitative graphs – (a) Between current and time for the first 10 minutes (b) Between charge and time for the same period.
Q-17	How many time constants will elapse before the current in a charging RC circuit drops to half of the initial value? Answer the same question for a discharging RC circuit.
Q-18	How many time constants will elapse before the charge on a capacitor falls to 0.1% of its maximum value in a discharging RC circuit?
Q-19	How many time constants will elapse before energy stored in the capacitor reaches half of its equilibrium value in a charging RC circuit?
Q-20	How many time constants will elapse before the power delivered by the battery drops to half of its maximum value in an RC circuit?
Q-21	A capacitor of capacitance C is connected to a battery of emf E at $t = 0$ through a resistance R. Find the maximum rate at which energy is stored in the capacitor. When does the rate has this maximum value?
Q-22	A capacitor of capacitance 12.0 μF is connected to a battery of emf 6.00 V and an internal resistance 1.00 Ω through resistanceless leads. 12.0 μs after the connections are made, what will be – (a) The current in the circuit, (b) The power delivered by the battery, (c) The power dissipated in heat, (d) The rate at which the energy stored in the capacitance is increasing.
Q-23	A capacitance C charged to a potential difference V is discharged by connecting its plates through a resistance R. Find the heat dissipated in one time constant after the connections are made. Do this by calculating $\int i^2 R dt$ and also by finding the decrease in the energy stored in the capacitor.
Q-24	By evaluating $\int i^2 R dt$, show that when a capacitor is charged connecting it to a battery through a resistor, the energy dissipated as heat equals the energy stored in the capacitor.
Q-25	A parallel-plate capacitor is filled with a dielectric material having resistivity ρ and dielectric constant K. The capacitor is charged and disconnected from the charging source. The capacitor is slowly discharged through the dielectric. Show that the time constant of the discharge is independent of all geometrical parameters like the plate area or separation between the plates. Find the time constant.

Q-26	In the given figure find the charge on each of the capacitors 0.20 ms after the switch S is closed. 
Q-27	The switch S shown in the figure is kept closed for a long time and is then opened at $t = 0$. Find the current in the middle 10 Ω resistor at $t = 1.0$ ms. 
Q-28	A capacitor of capacitance 100 μF is connected across a battery of emf 6.0 V through a resistor of 20 kΩ for 4.0 s. The battery is then replaced by a thick wire. What will be the charge on the capacitor 4.0 s after the battery is disconnected?
Q-29	Consider the situation shown in the figure. The switch is closed at $t = 0$ when the capacitors are uncharged. Find the charge on the capacitor C_1 as a function of time t. 
Q-30	A capacitor of capacitance C is given a charge Q. At $t = 0$, it is connected to an uncharged capacitor of equal capacitance through a resistance R. Find the charge on the second capacitor as a function of time.
Q-31	A capacitor of capacitance C is given a charge Q. At $t = 0$, it is connected to an ideal battery of emf E through a resistor R. Find the charge on the second capacitor as a function of time t.
Q-32	If a constant potential difference is applied across an incandescent bulb, the current slightly decreases as time passes and then becomes constant explain.
Q-33	Two unequal resistances R_1 and R_2 are connected across two identical batteries of emf E and internal resistance r as shown in the figure. Can the thermal energies developed in R_1 and R_2 be equal in a given time. If yes, what will be the condition? 
Q-34	When a current pass through a resistor, its temperature increases. Is it an adiabatic process?
Q-35	Apply the first law of thermodynamics to a resistor carrying a current i. Identify which of the quantities ΔQ, ΔU and ΔW are zero, which are positive and which are negative.
Q-36	Do all the thermocouples have a neutral temperature?
Q-37	In inversion temperature always double of the neutral temperature? Does the unit of temperature have an effect in deciding this question?
Q-38	Is neutral temperature always the arithmetic mean of the inversion temperature and the temperature of the cold junction? Does the unit of temperature have an effect in deciding this question?
Q-39	Do the electrodes in an electrolytic cell have fixed polarity like a battery?

Q-40	As the temperature increases, the viscosity of liquids decreases considerably. Will this decrease the resistance of an electrolyte as the temperature increases?
Q-41	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? 
Q-42	A constant current i is passed through a resistor. Taking the temperature coefficient of resistance into account, indicate which of the plots shown in the figure best represents the rate of production of thermal energy in the resistor. 
Q-43	Consider the following statements regarding a thermocouple – (A) The neutral temperature does not depend on the temperature of the cold junction. (B) The inversion temperature does not depend on the temperature of the cold junction. (a) Both A and B are correct. (b) A is correct but B is wrong. (c) B is correct but A is wrong. (d) Both A and B are wrong
Q-44	The heat developed in a system is proportional to current through it – (a) It cannot be Thomson heat. (b) It cannot be Peltier heat (c) It cannot be Joule heat (d) It can be any of the three mentioned above
Q-45	Consider the following two statements – (A) Free-electron density is different for different metals. (B) Free-electron density in a metal depends on temperature Peltier effect is caused (a) due to both A and B (b) due to A but not due to B (c) due to B but not due to A (d) neither due to A nor due to B.
Q-46	Consider the following two statements – (A) Free-electron density is different for different metals. (B) Free-electron density in a metal depends on temperature Seebeck effect is caused (a) due to both A and B (b) due to A but not due to B (c) due to B but not due to A (d) neither due to A nor due to B.
Q-47	Consider the following two statements – (A) Free-electron density is different for different metals. (B) Free-electron density in a metal depends on temperature Thomson effect is caused (a) due to both A and B (b) due to A but not due to B

	(c) due to B but not due to A (d) neither due to A nor due to B.
Q-48	Faraday constant – (a) depends on the amount of electrolyte (b) depends on the current in the electrolyte (c) is a universal constant (d) depends on the amount of charge passed through the electrolyte
Q-49	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 interval – (a) Equal amount of thermal energy must be produced in the resistors. (b) Unequal amount of thermal energy may be produced. (c) The temperature must rise equally in the resistors (d) The temperature may rise equally in the resistors.
Q-50	A copper strip AB and an iron strip AC are joined at A. The junction A is maintained at 0^0C and the free ends B and C are maintained at 100^0C. There is a potential difference between – (a) The two ends of the copper strip (b) The cooper end and the iron end at the junction (c) The two ends of the iron strip (d) The free ends B and C
Q-51	The constant a and b for the pair of silver-lead are 2.50 μV^0C^{-1} and 0.012 μV^0C^{-2} respectively. For a silver-lead thermocouple with colder junction at 0^0C – (a) There will be no neutral temperature (b) There will be no inversion temperature (c) There will not be any thermos-emf even if the junctions are kept at different temperature (d) There will be no current in the thermocouple even if the junctions are kept at different temperature.
Q-52	An electrolysis experiment is stopped and the battery terminals are reversed. (a) The electrolysis will stop (b) The rate of liberation of material at the electrodes will increase (c) The rate of liberation of material at the electrodes will remain the same (d) Heat will be produced at a greater rate.
Q-53	The electrochemical equivalent of a material depends on – (a) The nature of the material (b) The current through the electrolyte containing the material (c) The amount of charge passed through the electrolyte (d) The amount of this material present in the electrolyte
Q-54	An electric current of 2.0 A passes through a wire of resistance 25 Ω. How much heat will be developed in 1 minute?
Q-55	A coil of resistance 100 Ω is connected across a battery of emf 6.0 V. Assume that the heat developed in the coil is used to raise its temperature. If the heat capacity of the coil is 4.0 JK^{-1}, how long will it take to raise temperature of the coil by 15^0C?
Q-56	The specifications on a heater coil is 250 V, 500 W. Calculate resistance of the coil. What will be the resistance of a coil of 1000 W to operate at the same voltage.
Q-57	A heater coil is to constructed with a nichrome wire ($\rho = 1.0 \times 10^{-6}$ Ωm) which can operate at 500 W when connected to a 250 V supply. (a) What would be the resistance of the coil? (b) If the cross-sectional area of the wire is 0.5 mm^2, what length of wire would be needed?

	(c) If radius of each turn in 4.0 mm, how many turns will be there in the coil?
Q-58	A bulb with rating 250 V, 100 W is connected to a power supply of 220 V situated 10 m away using copper wire of area of cross-section 5 mm^2. How much power will be consumed by the connecting wires? Resistivity of copper is 1.7×10^{-8} Ωm.
Q-59	An electric bulb, when connected across a power supply of 220 V, consumes a power of 60 W. If the supply drops to 180 V, what will be the power consumed? If supply is suddenly increased to 240 V, what will be the power consumed?
Q-60	A servo voltage stabilizer restricts the voltage output to 220 V $\pm$ 1%. If an electric bulb rated at 220 V, 100 W is connected to it, what will be the minimum and maximum power consumed by it.
Q-61	An electric bulb marked 220 V, 100 W will get fused if it is made to consume 150 W or more. What voltage fluctuation will the bulb withstand?
Q-62	An immersion heater rated 1000 W, 220 V is used to heat 0.01 m^3 of water. Assuming that the power is supplied at 220 V and 60% of the power supplied is used to heat the water, how long will it take to increase the temperature of the water from 15^0C to 40^0C ?
Q-63	An electric kettle used to prepare tea, takes 2 minutes to boil 4 cups of water (1 cup contains 200 cc of water) if room temperature is 25^0C. (a) If the cost of power consumption is Rs 7.00 per unit (1 unit = 1000 Watt-hour), calculate the cost of boiling 4 cups of water. (b) What will be the corresponding cost, if the room temperature drops to 5^0C?
Q-64	The coil of an electric bulb takes 40 watts to start glowing. If more than 40 W is supplied, 60% of the extra power is converted into light and remaining into heat. The bulb consumes 100 W at 220 V. Find the percentage drop in the light intensity at a point if supply voltage changes from 220 V to 200 V.
Q-65	The 2.0 Ω resistor shown in the figure is dipped into a calorimeter containing water. The heat capacity of the calorimeter together with water is 2000 JK^{-1}. (a) If the circuit is active for 15 minutes, what would be the rise in the temperature of the water? (b) Suppose the 6.0 W resistor gets burnt, what would be the rise in the temperature of water in the next 15 minutes? 
Q-66	The temperature of the junction of a bismuth-silver thermocouple are maintained at 0^0C and 0.001^0C. Find the thermo-emf (Seebeck emf) developed. For bismuth-silver, $a = -46 \times 10^{-6}$ V^0C^{-1} and $b = -0.48 \times 10^{-6}$ V^0C^{-2}.
Q-67	Find the thermo-emf developed in a copper-silver thermocouple, when the junctions are kept at 0^0C and 40^0C. For silver $a_{Ag-Pb} = 2.5 \times 10^{-6}$ V^0C^{-1} and $b_{Ag-Pb} = 0.012 \times 10^{-6}$ V^0C^{-2} and for copper $a_{Cu-Pb} = 2.76 \times 10^{-6}$ V^0C^{-1} and $b_{Cu-Pb} = 0.012 \times 10^{-6}$ V^0C^{-2}.
Q-68	Find the neutral temperature and inversion temperature of copper-iron thermocouple if the reference junction is kept at 0^0C. For iron $a = 16.6 \times 10^{-6}$ V^0C^{-1} and $b = -0.030 \times 10^{-6}$ V^0C^{-2} and for copper $a = 2.76 \times 10^{-6}$ V^0C^{-1} and $b = 0.012 \times 10^{-6}$ V^0C^{-2}.
Q-69	Find the charge required to flow through an electrolyte to liberate one atom of – (a) a monovalent material (b) a divalent material
Q-70	Find the amount of silver liberated at cathode if 0.500 A of current is passed through $AgNO_3$ electrolyte for 1 hour. Atomic weight of silver is 107.9 $g.mol^{-1}$.
Q-71	An electroplating unit plates 3.0 g of silver on a brass plate in 3.0 minute. Find the current used by the unit. The electrochemical equivalent of silver is 1.12×10^{-6} $kg.C^{-1}$.

Q-72	Find the time required to liberate 1.0 litre of hydrogen at STP in an electrolyte cell be a current of 5.0 A.
Q-73	Two voltameters, one having a solution of silver-salt and the other of a trivalent metal are connected in series and a current of 2 A is maintained for 1.50 hours. It is found that 1.00 g of trivalent metal is deposited. (a) What is the atomic weight of the trivalent metal? (b) How much silver is deposited during the period? (c) Atomic weight of silver is 107.9 $g.mol^{-1}$.
Q-74	A brass plate having surface area 200 cm^2 on one side is electroplated with 0.10 mm thick silver layer on both sides using a 15 A current. Find the time taken to do the job. The specific gravity of silver is 10.5 and its atomic mass is 107.9 $g.mol^{-1}$.
Q-75	Figure shows an electrolyte of AgCl through which a current is passed. It is observed that 2.68 g of silver is deposited in 10 minutes on the cathode. Find the heat developed in the 20 Ω resistor during this period. Atomic mass of silver is 107.9 $g.mol^{-1}$. 
Q-76	The potential difference across the terminals of a battery of emf 12 V and internal resistance 2 Ω drops to 10 V when it is connected to a silver voltameter. Find the silver deposited at the cathode in half-an-hour. Atomic mass of silver is 107.9 $g.mol^{-1}$.
Q-77	A plate of area 10 cm^2 is to be electroplated with copper (density 9000 $kg.m^{-3}$) to a thickness 10 micrometer on both sides, using a cell of 12 V. Calculate the energy spent by the cell in the process of deposition. If this energy is used to heat 100 g of water, calculate the rise in temperature of the water. ECE of copper is 3×10^{-7} $kg.C^{-1}$ and specific heat capacity of water is 4200 $J.kg^{-1}.K^{-1}$.

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