Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.

2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given more importance (Not applicable for subject English and Communication Skills).

4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.

5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.

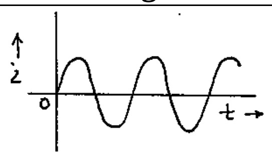
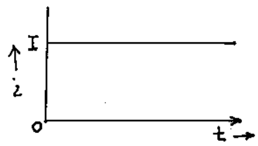
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.

7) For programming language papers, credit may be given to any other program based on equivalent concept.

1 Attempt any TEN of the following: 20

1 a) Differentiate between Direct current and Alternating current. (any two points)

Ans:

Particulars	Alternating Current	Direct Current
1. Waveform		
2. Definition	It is the current whose magnitude and direction continuously changes with respect to time.	It is the current whose magnitude and direction do not change with respect to time.
3. Use of transformer	Possible	Not possible
4. Distribution efficiency	High	Low
5. Design of machines	Simple	Complicated
6. Generation	Mostly by electromechanical energy conversion	Mostly by electrochemical energy conversion and also by conversion of AC to DC using converters
7. Applications	AC machines, Domestic and industrial supply	DC machines, electroplating, HVDC system, Battery charging

1 mark for each of any two points

1 b) Define emf and resistance.

Ans:

EMF:

The electric force that moves electric charges in conductor and produces electric current is called as 'Electro-motive force' (EMF).

1 mark for each definition

Resistance:

The opposition offered by any material to the flow of electric charges is called its resistance.

1 c) State the different types of resistors.

Ans:

Types of Resistors:

Linear Resistor		Non-linear Resistor
Fixed Resistor	Variable Resistor	i) Thermistor ii) Light Dependent Resistor (LDR) iii) Varistor
i) Carbon Composition ii) Wire wound iii) Metal film	i) Potentiometer ii) Trimmers iii) Rheostat	

½ mark for each of any four types

OR

1) Carbon Composition
2) Deposited Carbon
3) High-voltage Ink film
4) Metal film
5) Metal glaze

6) Wire-wound
7) Cermet

1 d) State Ohm's law.
Ans:
Ohm's law:
As long as physical conditions (such as dimensions, pressure and temperature) are constant, the potential difference or voltage applied across the conductor is directly proportional to current flowing through it. 1 mark for statement
i.e $V \alpha I$ or $V = R I$ 1 mark for equation
where R = constant of proportionality, called as the resistance of the conductor.

1 e) State the concept of internal voltage drop.
Ans:
Concept of internal voltage drop:
Every practical source offers some opposition to the current due to its internal parts or components. e.g. a 12V battery has electrodes made up of conducting material having finite low resistance. Such a resistance of internal parts of source is called 'Internal resistance' of source. When source delivers current to load, the current flowing through the internal resistance causes voltage drop across it. This voltage drop is called 'Internal Voltage Drop'. Due to this internal voltage drop, the terminal voltage of practical voltage source is always less than its emf. 1 mark for internal resistance 1 mark for internal voltage drop

1 f) Define Capacitor.
Ans:
Capacitor:
It is an electric device which is capable of storing energy in the form of electric charge storage. 2 marks for any equivalent definition

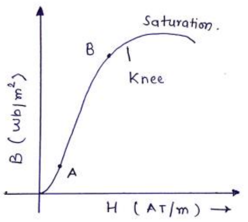
1 g) State the term Di-electric strength.
Ans:
Di-electric Strength:
The voltage which a dielectric material can withstand without breaking down (without losing its dielectric property) is called its dielectric strength. It is represented by kV/mm or kV/cm.e.g dielectric strength of air is @ 30kV/cm or 3kV/mm. 2 marks for statement

1 h) State the applications of electrolytic capacitors. (any two)
Ans:
Applications of electrolytic capacitors: 1 mark for each of any two
i) Decoupling or noise filtering in power supplies.
ii) DC link circuits in variable frequency drives.
iii) Coupling capacitor in amplifiers
iv) Energy storage in flash-lamps

1 i) Draw B-H curve for magnetic ~~curve~~ **material**.

Ans:

B-H curve for magnetic curve material:



The B-H curve is concave up for low flux desities upto point A, for medium flux densities, it becomes straight (AB), for heigher flux densities curve concaves down (after point B) Then almsot becomes flat i.e. saturation occures.

2 marks (explanation is optional)

1 j) State the applications of electromagnet.

Ans:

Applications of Electromagnet: ½ mark for each of any four

1) As Field and armature in DC Machine.
2) In cores of solenoid valves.
3) In cores of electromechanical relays.
4) In electromagnetic circuits of all AC Machines
5) Electrical measuring instruments.
6) Cores of transformers.

1 k) State Lenz's law.

Ans:

Lenz's law: 2 marks

It states that the direction of an induced emf is such that it always opposes the cause that produces it. In fact, the induced emf produces current, which produces magnetic flux and this magnetic flux opposes the changing magnetic field that is responsible for emf induction.

1 l) State different types of inductors.

Ans:

Types of inductors: 1 mark for each of any two

i) Iron cored inductor
ii) Air cored inductor
iii) Ferrite cored inductor

1 m) Write the equation of ac voltage.

Ans:

Equation of ac voltage: 1 mark for equation

$$v = V_m \sin(\omega t \pm \emptyset)$$

Where, v =instantaneous value of voltage in volt

V_m = Maximum value of voltage in volt

$\emptyset$ = Phase angle

1 mark for description of terms

1 n) State the properties of good insulating materials.

Ans:

Properties of good insulating materials: ½ mark for each of any four

1) Resistivity should be very high.
2) It should be water resistant.
3) It should not contain impurities.
4) It should not be affected by chemical process or corroded easily.

5) It should be heat resistant and fire-proof.
6) It should be mechanically strong.
7) It should not be porous.

2 Attempt any FOUR of the following: 16

2 a) State the following effects of currents: (i) Heating effect, (ii) Magnetic effect.

Ans:

(i) Heating effect :

When an electric current flows through a conductor, the flow of electron is opposed by the resistance of conductor and heat is produced. 2 marks

Joules law of heating: The heat produced is directly proportional to the square of the current, resistance and time for which current flows.

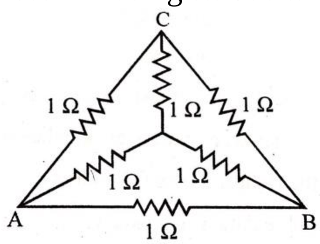
$$H \, \alpha \, I^2Rt$$

It is utilized in electric irons, water heaters, Hot plates, electric lamps etc.

(ii) Magnetic Effect:

Whenever a conductor carries electric current, the magnetic field is produced. If the conductor is a straight conductor, the magnetic field is produced round the conductor itslef. If the conductor is in the form of coil or winding (solenoid) wound over the core, the magnetic field is produced in the core. 2 marks

2 b) Calculate the total resistance across AB using star/delta transformation.

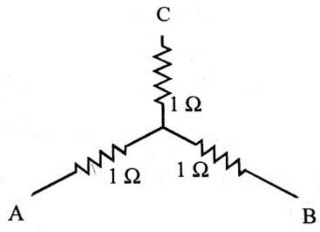


Ans:

Method I:

Step 1: Converting Inner Star into equivalent Delta

1 mark for each step



$$R_{AB} = R_A + R_B + \frac{R_A R_B}{R_C}$$

$$R_{AB} = 1 + 1 + \frac{1 \times 1}{1} = 3\ \Omega$$

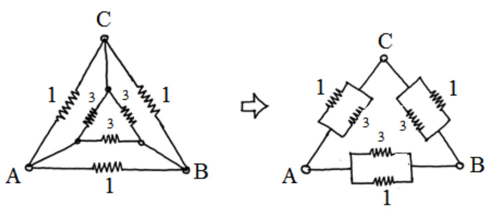
Similarly,

$R_{BC} = 3\ \Omega$

$R_{CA} = 3\Omega$

Step 2: Modified Network

Inner equivalent delta appears in parallel with outer delta.

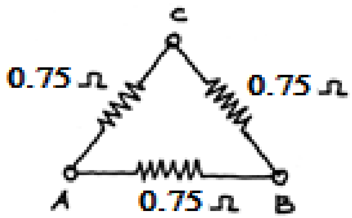


Step 3: Solving Parallel Combinations

Resistance between AB $= \frac{1\times3}{1+3} = \frac{3}{4} = 0.75\ \Omega$

Resistance between BC $= 0.75\ \Omega$

Resistance between CA $= 0.75\ \Omega$



Step 4: Resistance between A and B

Resistance between AB, $R_{AB} = \frac{0.75\times(0.75+0.75)}{0.75+(0.75+0.75)}$

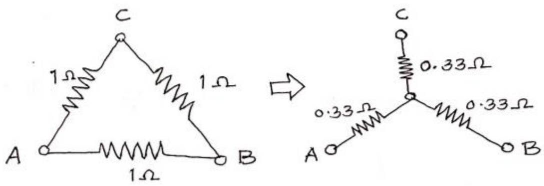
$$= \frac{1.125}{2.25} = \frac{1}{2} = 0.5\ \Omega$$

Method II:

Step I: Converting Outer Delta into equivalent Star:

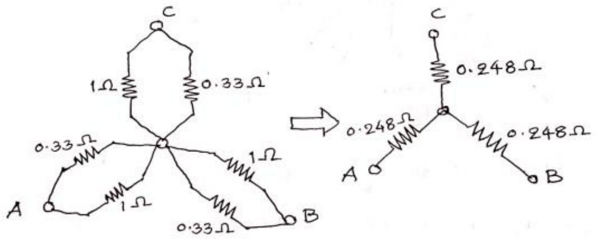
$R_A = \frac{R_{AB}R_{CA}}{R_{AB}+R_{BC}+R_{CA}} = \frac{(1)(1)}{1+1+1} = \frac{1}{3} = 0.33\ \Omega$

Similarly, $R_B = R_C = R_A = 0.33\Omega$



Step II: Modified Network:

Outer equivalent star appears in parallel with inner star.



Step III: Equivalent resistances of each leg of the star:

$$= \frac{(1)(0.33)}{1+0.33} = \frac{0.33}{1.33} = 0.248\ \Omega$$

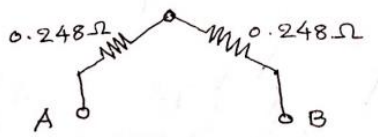
Similarly,

$$R_{Beq.} = R_{Ceq.} = 0.248\ \Omega$$

Step IV: Resistance between terminals A and B:

$R_{AB} = R_{Aeq.} + R_{Beq.} = (0.248 + 0.248)\Omega = 0.496\Omega$

$\cong 0.5\Omega$

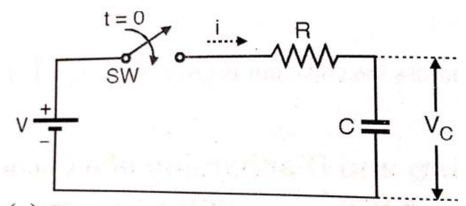


2 c) Explain charging of a capacitor with neat circuit diagram.

Ans:

Charging of a capacitor:

Fig(a) shows the circuit arrangement for charging of capacitor through a resistor. Here R and C are in series, V is the DC voltage source and SW is the switch. When switch SW is closed, say at time instant t=0, the DC voltage is supplied to RC combination. At t=0, the capacitor acts as short circuit. So the voltage across capacitor is zero. The full supply voltage appears across resistance R. Therefore, the current is given by,



(a) **Charging circuit of a capacitor**

1 mark for circuit diagram

$$i_c(0) = I_0 = \frac{V}{R}$$

2 marks for explanation

The voltage across capacitor slowly builds up exponentially and finally reaches to Supply voltage V at instant $t \to \infty$. The initial charging current falls exponentially to zero as $t \to \infty$.

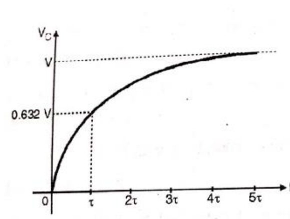
1 mark for curves

The voltage across the capacitor at any instant t is given by,

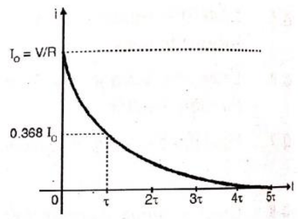
$v_c = V(1 - e^{-\frac{t}{\tau}})$

Where, V is the maximum voltage to which capacitor can charge (supply voltage)

τ = RC = charging time-constant of the circuit.



(b) Variation in capacitor voltage while charging



(c) Variation in capacitor current while charging

The instantaneous charging current is given by,

$$i_c = I_0 e^{-\frac{t}{\tau}}$$

where, I_0 is the maximum current at instant t = 0

The charging curves for voltage and current are shown in the fig (b) and (c) respectively.

2 d) Define the terms: (i) MMF (ii) Reluctance (iii) Flux density (iv) Permeance

Ans:

(i) **MMF:** It is the force that drives magnetic flux through magnetic circuit. It is equal to the work done in joules in carrying unit magnetic pole once through the entire magnetic circuit. It is measured in amp-turns. — 1 mark for each definition

(ii) **Reluctance:** The property of opposition offered by magnetic circuit to establish magnetic flux in it is called as "Reluctance". It's unit is AT/weber.

(iii) **Flux density:** It is defined as the magnetic flux passing per unit area perpendicular to the flux. It is measured in Wb/m^2.

(iv) **Permeance:** It is the reciprocal of reluctance and implies the readiness with which magnetic flux is developed. It is measured in Wb/AT.

2 e) A coil consisting of 120 turns is placed in magnetic field of 0.8 ~~mub~~ **mWb**. Calculate the average emf induced in the coil when it is moved in 0.08 sec from the given field ~~of~~ **to** 0.3 ~~mub~~ **mWb**. If the resistance of the coil is 200Ω, find the induced current in the coil.

Ans:

Given: No. of turns N = 120 — 2 marks for emf

Initial magnetic field ϕ_I = 0.8 mWb

Final magnetic field ϕ_F = 0.3 mWb

Time of movement dt = 0.08 sec

Resistance of coil R= 200Ω — 2 marks for current

Average induced emf is given by,

$$E = -N\frac{d\emptyset}{dt} = -N\frac{\emptyset_F - \emptyset_I}{dt} = -120 \times \frac{(0.3 - 0.8)10^{-3}}{0.08} = 0.75V$$

Current induced in the coil $I = \frac{E}{R} = \frac{0.75}{200} = 3.75\ mA$

2 f) Compare dry cell and liquid cell on the basis of principle of operation, cost, life and maintenance.

Ans:

Comparison between Dry cell and Liquid Cell:

Particulars	Dry Cell	Liquid Cell
Principle of operation	Irreversible chemical action	Reversible chemical action
Cost	Lower	Higher
Life	Lower	Higher
Maintenance	Very low maintenance	Maintenance required at regular intervals

1 mark for each point

3 Attempt any four: 16

3 a) Describe duality between series and parallel electrical circuit.

Ans:

Duality between Series and Parallel Circuit:

Series circuit.	**Parallel circuit**
1) $I_T = I_1 = I_2 = I_3 = \ldots\ldots$ Current is same through all the branches of the circuit	$V_T = V_1 = V_2 = V_3 = \ldots\ldots$ Voltage is same across all the parallel branches of the circuit
2) $V_T = V_1 + V_2 + V_3 + \ldots$ Total voltage is addition of all voltage drops	$I_T = I_1 + I_2 + I_3 + \ldots\ldots$ Total current is addition of all branch currents
3) $R_T = R_1 + R_2 + R_3 + \ldots$ Total resistance is addition of all individual resistances	$G_T = G_1 + G_2 + G_3 + \ldots$ Total conductance is addition of all individual conductances
4) $I_T = V_1 / R_1 = V_2 / R_2 = V_3 / R_3 ..$ Total current can be obtained by applying ohm's law at any individual resistance.	$V_T = I_1/G_1 = I_2 /G_2 = I_3/G_3$ Total voltage can be obtained by applying ohm's law at individual branch.

1 mark for each point

3 b) Three capacitors having capacitance of 4μF, 6μF and 8μF respectively. Find the equivalent capacitance when they are connected in (i) Series (ii) Parallel.

Ans:

Given: $C_1 = 4\mu F$, $C_2 = 6\ \mu F$, $C_3 = 8\mu F$

i) For Series combination:

$1/C_s = (1/C_1)+(1/C_2)+(1/C_3)$ 1 mark

$1/C_s = (1/4)+(1/6)+(1/8)$

$1/C_s = 0.25+0.167+0.125$ 1 mark

$1/C_s = 0.542$

$C_s = 1.845\ \mu F$

ii) For parallel combination:

$C_p = C_1 + C_2 + C_3$ 1 mark

$C_p = 4 + 6 + 8$

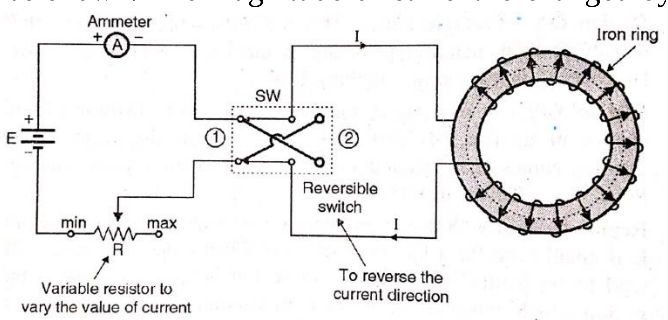
$C_p = 18\ \mu F$ 1 mark

3 c) Explain Hysteresis loop of magnetic material with neat diagram.

Ans:

Hysteresis loop of magnetic material:

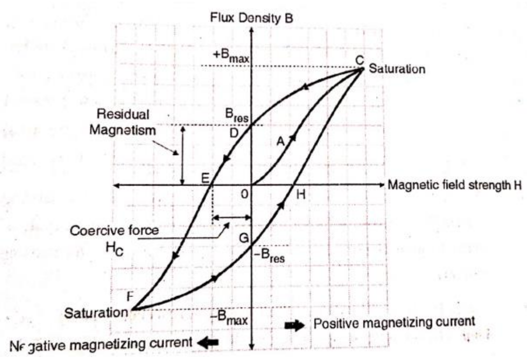
The circuit arrangement for plotting the hysteresis loop is shown in figure. The electromagnetic part consists of a coil wound on the iron ring. The current direction can be reversed using reversible switch as shown. The magnitude of current is changed by varying the resistance. Magnetic ring is subjected to a cycle of magnetization and demagnetization for both the directions of the current. Then it is found that flux density B in the ring lags behind the applied magnetizing force H. The graph of flux density B versus magnetizing force H plotted for one magnetic reversal is called hysteresis loop. Meaning of hysteresis is to lag behind.



Circuit diagram is optional

1 mark for Diagram of hysteresis loop

1 mark for explanation



Hysteresis loop represents the loss of power while magnetizing the circuit. The energy loss is given by the area under the hysteresis loop.

During demagnetization of core (ring) in forward or reverse direction of magnetic field, it is seen that even if the magnetizing force has reduced to zero, the flux density does not become zero. Some flux remains in the core. This flux is called "**Remanent or residual flux**" and the corresponding flux density is called "**Residual magnetism**". This property of magnetic material is referred as "**Retentivity**".

2 marks for definition of 4 terms (½ mark each)

To wipe out the residual flux in the core, the magnetizing force in the opposite direction is required. This force is called "**Coercive force** H_c".

At large magnetizing force values, it is seen that there is no appreciable change in flux densities. The flux density remains constant in spite of change in magnetizing force. This is called "**Magnetic saturation**".

3 d) State Faraday's first law and second law of electromagnetic induction.

Ans:

Faraday's laws of electromagnetic induction:

1st law: When a conductor cuts or is cut by the magnetic flux, an emf is induced in the conductor. OR

Whenever a changing magnetic field links with a conductor, an emf is induced in it.

2 marks for each law

2nd law: The magnitude of emf induced in the coil is directly proportional to the rate of change of flux linking with coil. i.e $e = -N\frac{d\emptyset}{dt}$

3 e) Define the terms: Cycle, Frequency, Time and Amplitude.

Ans:

1 mark for each term

1. **Cycle:** A complete set of variation of an alternating quantity which is repeated at regular interval of time is called a "cycle". OR
   In an ac waveform, each repetition consisting of one positive and one identical negative part is called as one cycle.
2. **Frequency (f):** It is defined as the number of cycles completed by an alternating quantity in one second.
3. **Time (Time period)(T):** It is defined as the time taken in seconds by an alternating quantity to complete one cycle.
4. **Amplitude:** The maximum value or peak value of an ac quantity is called as its amplitude. It is denoted by I_m, V_m etc.

3 f) Classify insulating materials on the basis of temperature withstanding ability with their limiting temperature and one example.

Ans:

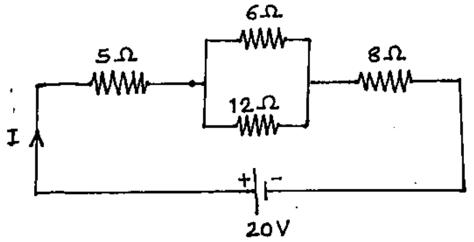
Sr. No.	Class	Limiting temp. in ^{O}C	Materials
1	Y	90	Cotton, silk paper, press board, wood.
2	A	105	Impregnated paper , silk, cotton, polymide resins
3	E	120	Cotton fabric, synthetic resin enamels, paper laminates, powder plastics.
4	B	130	Inorganic materials like mica, glass, asbestos impregnated with varnish
5	F	155	Mica, polyester, epoxide varnishes
6	H	180	Composite materials on mica, fibre, glass and asbestos bases, impregnated with silicon rubber
7	C	Above 180	Mica, Ceramics, Glass, Teflon, Quartz etc.

2 marks for classification

2 marks for examples

4 Attempt any FOUR: 16

4 a)



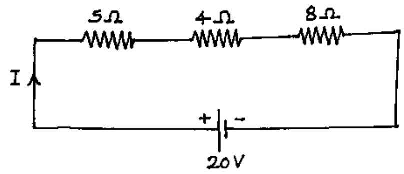
Calculate: (i) Total equivalent resistance of circuit
(ii) Total current.

Ans:

In the above circuit, the resistors 6Ω and 12Ω are in parallel. The equivalent resistance is given by, $R_p = \frac{6\times12}{6+12} = \frac{72}{18} = 4\Omega$ — 1 mark for R_p

This resistance appears in series with other two resistors as shown below.

The equivalent resistance of the circuit is given by,
$R_{eq} = 5 + 4 + 8 = 17\Omega$ — 1 mark for R_{eq}



The total current is given by Ohm's law,

$$I = \frac{V}{R_{eq}} = \frac{20}{17}$$ — 1 mark for Ohm's law eq.

$$= 1.176A$$ — 1 mark for final sol^n.

4 b) Define the terms: (i) Node, (ii) Passive network, (iii) Loop, (iv) Linear circuit.

Ans:-

(i) **Node:-** A point or junction in an electric circuit at which two or more branches meet. — 1 mark for each definition

(ii) **Passive network:-** Network without any energy source is called as passive network

(iii) **Loop:-** Any closed path in an electric circuit where each element or branch is traversed only once

Or

Closed path in any network is called as loop.

(iv) **Linear circuit:-** A circuit whose parameters (such as resistances, capacitances, inductances etc.) are always constant irrespective of changes in time, voltage or current is known as linear circuit.

4 c) Derive the expression for energy stored in the capacitor with the help of neat diagram.

Ans:-

Energy stored in Capacitor:

Let C be the capacitance of a capacitor in farad.

v be the potential difference across capacitor in volt at a particular instant.

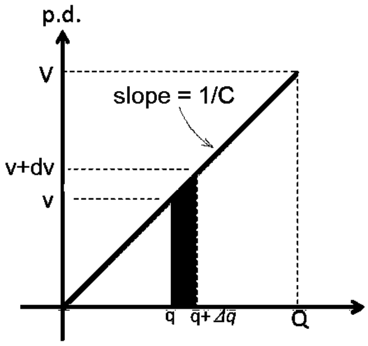
q be the charge on the capacitor at that instant.

Therefore, potential difference $v = \frac{q}{c}$ or charge $q = Cv$ — 1 mark for diagram

When the potential difference across capacitor is *v* and if small amount of charge dq is shifted from one plate to other, the voltage is changed by dv. Therefore, $dq = C.dv$ — 1 mark

The work done in shifting a small charge dq against P. D. of *v* volt is given by,

$$dW = v.dq = \left(\frac{q}{c}\right)dq \qquad \text{OR} \qquad dW = v.dq = v.C.dv$$ — 1 mark



The work done is stored as potential energy in the electrostatic field by the capacitor.

Therefore, total energy stored by the capacitor is given by, — 1 mark

E = work done $W = \int dW = \int \left(\frac{q}{c}\right)dq = \frac{1}{2c}q^2$

$$= \frac{1}{2}C\left(\frac{q}{c}\right)^2 = \frac{1}{2}Cv^2 \quad \text{joules}$$

OR

$$W = \int dW = \int Cv\,dv = \frac{1}{2}Cv^2 \quad \text{joules}$$

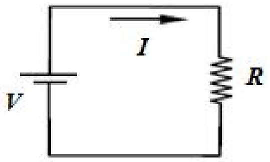
4 d) Give any two similarities and dissimilarities between electric and magnetic circuits.

Ans:

Similarities between Electric and Magnetic Circuits:

Sr. No.	Electric circuit	Magnetic circuit
1	Current: flow of electrons through conductor is current, it is measured in amp.	Flux: lines of force through medium from N pole to S pole form flux. It is measured in weber.
2	EMF: It is driving force for current, measured in volts.	MMF: It is driving force for flux, measured in amp-turn.
3	Resistance: It is opposition of conductor to current, measured in ohms	Reluctance: It is opposition offered by magnetic path to flux measured in AT/wb.
4	Resistance is directly proportional to length of conductor.	Reluctance is directly proportional to length of magnetic path.
5	For electric circuit we define the conductivity.	For magnetic circuit we define permeability.
6	Electric circuit is closed path for current.	Magnetic circuit is closed path for magnetic flux.
7	For electric circuit I = EMF/resistance	For magnetic circuit Φ= MMF/reluctance

1 mark for each of any two similarities

8	Voltage = IR	M M F = Φ S
9	Resistivity	Reluctivity
10		

Dissimilarities between Electric and Magnetic Circuits:

Sr. No.	Electric circuit	Magnetic circuit
1	Electric current flows	Flux does not actually flow (it only gets established or set up)
2	Energy is needed continuously for the flow of current	Energy is only needed for establishment of field (flux)
3	Current cannot pass through the insulators.	Flux can pass through almost all things including air
4	Electrical Insulator is available	Magnetic Insulator does not exist.

1 mark for each of any two dis-similarities

4 e) Define: (i) Self inductance, (ii) Coefficient of Self-induction.
Ans:-

(i) Self inductance:
It is the property of a coil by virtue of which it opposes any change in current flowing through it. In fact, when the current flowing through the coil attempts to change, an emf in induced and according to Lenz's rule, it acts in such a way that the change in current is opposed. 2 marks

(ii) **Coefficient of self- induction:** Coefficient of self- induction of a coil is defined as the ratio of the electromotive force produced in a coil by self-induction to the rate of change of current producing it. 2 marks

$$L = \frac{N\frac{d\emptyset}{dt}}{\frac{di}{dt}} = N\frac{d\emptyset}{di} = N\frac{\emptyset}{I}$$

It is expressed in henry.

4 f) Distinguish between paramagnetic and ferromagnetic material with any four points.
Ans:

Particulars	Paramagnetic Materials	Ferromagnetic materials
Relative permeability (μ_r)	Very low positive value, slightly greater than one	Very large values ranging from 400 to 1200 etc.
Reluctance	High	Very low
Magnetization	Requires large MMF or can not be magnetized.	Requires low MMF, can be easily magnetized.
Atomic dipole orientation	Very random even with high field strength.	Easy parallel alignment with very low magnetizing current.

1 mark for each of any four points

Examples	Copper, Aluminium, Titanium, Platinum, Oxygen	Iron, Nickel, Cobalt
Applications	Applications that demand the material which should not be affected by the external magnetic fields.	For making permanent magnets, electromagnets

5 Attempt any FOUR. **16**

5 a) Give the classification of insulating materials on the basis of state of materials and give one application of each.

Ans:

Classification of insulating material on the basis of state of materials: 1 mark for classification

1) Solid insulating materials
2) Liquid insulating materials
3) Gaseous insulating materials

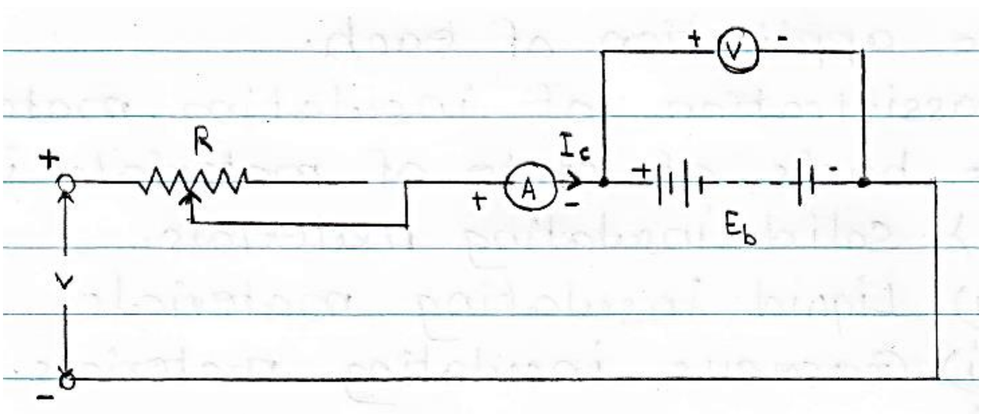
Sr. No.	Type of Material	Application
1	Solid insulating materials	Terminal boards, Switch board, Casing-capping, Spacers, Slot wages, Insulation paper for transformers, capacitors and cables, Sleeves in heating devices, Flexible cables & wires, Panel boards, Switchgears, Electrical heating & cooling equipment, Lamp holders, Switches, Plug-sockets
2	Liquid insulating materials	Switchgears, Circuit breakers, DC Capacitors, Cables, Transformers
3	Gaseous insulating materials	Switchgears, Gas Pressure Cables, Circuit breakers, Generator cooling systems, X-ray apparatus

1 mark for applications of each type

5 b) Explain constant voltage charging method. (any one)

Ans:

Constant voltage charging:



2 marks for diagram

In this method of charging, the charging voltage is kept constant throughout the charging. If the back emf of cell is low, then it results in very large charging current in the beginning and it becomes a small when there is increase in back emf owing to charging. This method has advantage that the time required for charging is almost reduced to half as compared to constant current method. — 2 marks for explanation

The charging current can be found by the equation,

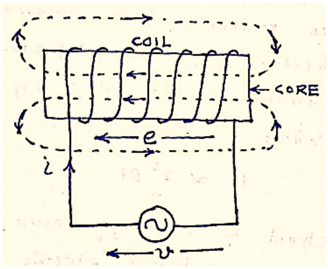
$$I = \frac{V - E_b}{R + r}$$

where, E_b is back emf,
V is supply (charging) voltage,
R is the external series resistance in circuit,
r is the internal resistance of battery.

5 c) Explain the term self-induced emf with a neat diagram.

Ans:

Self-induced emf:



2 marks for diagram

Self-induced emf is one of the types of statically induced emfs. When the emf induced in the coil is due to the change in its own flux, then it is called as "self-induced emf". Consider a coil wound on the core and supplied from an alternating voltage source as shown in the figure. The alternating current (i) flowing through the coil produces alternating flux in the core. This changing magnetic flux links with the coil itself and according to Faraday's law of electromagnetic induction, an emf 'e' is induced in the coil. The magnitude of emf is given by, — 2 marks for description

$$e = -N\frac{d\emptyset}{dt}$$

The direction of induced emf is given by Lenz's rule. The induced emf always opposes the cause of its production, which is ultimately the supply voltage. Hence the induced emf 'e' is opposite to supply voltage 'v', which is indicated by negative sign in above equation.

5 d) An iron ring with mean circumference of 80cm and cross sectional area 10 cm^2 is uniformly wound with 500 turns of wire. Determine the current required to set up a flux density of 1.2 T in the ring. Assume $\mu_r = 1000$ for iron.

Ans: — 1 mark for data identification

Given: $l = 80\ cm = 80\times10^{-2}\ m$
$a = 10\ cm^2 = 10\times10^{-4}\ m^2$
$N = 500$
$B = 1.2\ T$
$\mu_r = 1000$ $\mu_0 = 4\pi\times10^{-7}$

The relationship between flux density and magnetizing force (field strength) is given by, — 1 mark for eq^n of B

$B = \mu_0\mu_r H$

$\therefore H = \frac{B}{\mu_0\mu_r} = \frac{1.2}{4\pi\times10^{-7}\times1000} = 3000\ AT/m$ — 1 mark for H

But $H = \frac{NI}{l}$ — 1 mark for I

$\therefore I = \frac{Hl}{N} = \frac{3000\times 80\times 10^{-2}}{500} = 4.8\ amp.$

5 e) Compare Unilateral and Bilateral Circuit.

Ans:

Comparison between Unilateral and Bilateral Circuit:

Unilateral Circuit	Bilateral Circuit
If the characteristic response or behavior of circuit dependents on the direction of current through its elements, then the circuit is called as a unilateral circuit.	It is that circuit whose characteritic response or behavior is independent of the direction of current flowing through its elements.
Impedance offered to current changes with the direction of current.	Impedance offered to current is same for both the directions of current.
Power flow is affected by the direction of current.	Power flow is not affected by the direction of current.
Circuits containing elements likes diodes, transistors, thyristors etc.	Transmission line, circuits containing only resistor etc.

1 mark for each point

5 f) The field coil of a generator has 14.1 Ω at 25°C and 18.2Ω at 32°C. Find the temperature coefficient of resistance at 0°C and resistance at 0°C.

Ans:

Given: R_{25} = Resistance of the coil at 25°C = 14.1Ω

R_{32} = Resistance of the coil at 32°C = 18.2Ω

The resistance at t°C is given by,

$$R_t = R_0(1+\alpha_0 t)$$

$$R_{25} = 14.1 = R_0(1+\alpha_0\times 25) \dots\dots\dots\dots\dots\dots\dots\dots (1)$$

and $$R_{32} = 18.2 = R_0(1+\alpha_0\times 32) \dots\dots\dots\dots\dots\dots\dots\dots (2)$$

1 mark for eq^n 1 and 2

Dividing equation (1) by (2), we get

$$\frac{14.1}{18.2} = \frac{R_0(1+\alpha_0\times 25)}{R_0(1+\alpha_0\times 32)}$$

$$14.1(1+\alpha_0\times 32) = 18.2(1+\alpha_0\times 25)$$

$$14.1 + 451.2\alpha_0 = 18.2 + 455\alpha_0$$

$$455\alpha_0 - 451.2\alpha_0 + 18.2 - 14.1 = 0$$

$$3.8\alpha_0 = -4.1$$

$$\alpha_0 = -1.0789\ per\ ℃$$

1 mark for this formulation

1 mark

Putting the value of α_0 in equation (1),

$$14.1 = R_0(1+(-1.0789)\times 25) = R_0(1-26.973) = -25.97R_0$$

$$\therefore R_0 = -\frac{14.1}{25.97} = -0.542\Omega$$

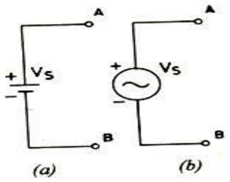
1 mark

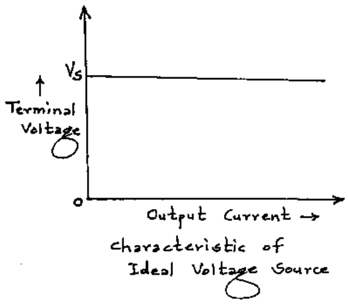
6 **Attempt any FOUR.** **16**

6 a) Define Ideal voltage source and Practical voltage source. Draw it's symbol and characteristics.

Ans:

i**) Ideal voltage source:** A voltage source whose terminal voltage always remains constant for all values of output current, is known as an ideal voltage source. It has zero internal resistance. 1 mark for each definition

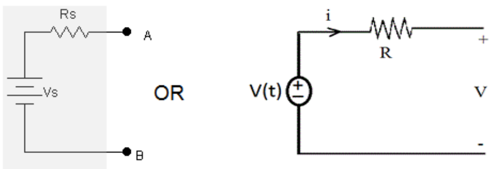




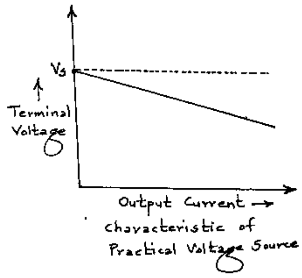
½ mark for each symbol

½ mark for each characteristic

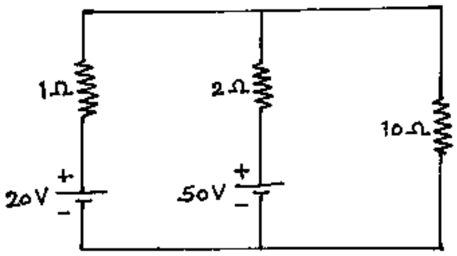
ii) Practical voltage source: A voltage source whose terminal voltage falls with the increase in the output current due to the voltage drop in the internal resistance.



Practical voltage source



6 b) Using Kirchhoff's laws calculate current through 10Ω.

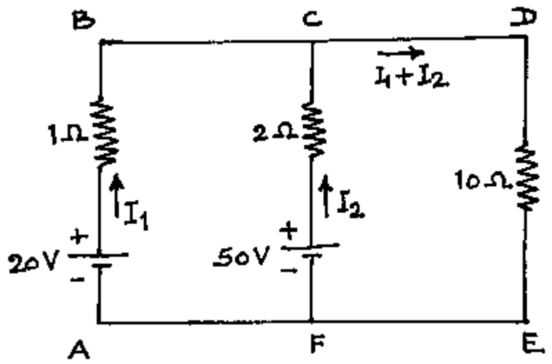


Ans:

(***NOTE: There are no. of ways and options for selection of loops for writing the voltage equations based on KVL. So Examiner is requested to allot the marks as per the steps followed)***

Step I: Mark the currents on the diagram and points for easy identification.

1 mark for each step



Step II: Write KCL and KVL based equations
By KCL at node C, the current flowing through the resistance of 10Ω is given by,
$I_3 = I_1 + I_2$
For loop ABCDEFA, by KVL we write
$(1)I_1 + 10(I_1 + I_2) = 20$
$\therefore 11I_1 + 10I_2 = 20 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$
For loop FCDEF, by KVL we write
$(2)I_2 + 10(I_1 + I_2) = 50$
$\therefore 10I_1 + 12I_2 = 50 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$
Step III: Solving simultaneous equations
Multiplying eq^n (1) by 10 and eq^n (2) by 11, we get
$110I_1 + 100I_2 = 200 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$
$110I_1 + 132I_2 = 550 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$
Subtracting eq^n (3) from eq^n (4), we get
$32I_2 = 350$
$\therefore \boldsymbol{I_2 = 10.94\ A} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$
Substituting eq^n (5) from eq^n (1), we get
$11I_1 + 10(10.94) = 11I_1 + 109.4 = 20$
$11I_1 = 20 - 109.4 = -89.4$
$\therefore \boldsymbol{I_1 = -8.13A} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$
Step IV: Final answer
The current through 10Ω resistance is,
$I_3 = I_1 + I_2 = (-8.13) + 10.94$
$\therefore \boldsymbol{I_3 = 2.81A}$ **flowing from D to E**

6 c) State Kirchhoff's Current Law and Voltage Law.
Ans:

i) **Kirchhoff's current law**: - It states that in any electrical circuit, at any node or junction, the algebraic sum of currents is equal to zero. 1 mark

OR

At any node or junction in an electric circuit, the total incoming current is equal to the total outgoing current

i..e $\sum I = 0$ 1 mark

ii) **Kirchhoff's voltage law**: - It states that in any closed circuit or mesh, the algebraic sum of all the emfs and the voltage drops (IR) is equal to zero.

OR 1 mark

In any closed loop or mesh, the total voltage rise ie equal to the total voltage drop. 1 mark

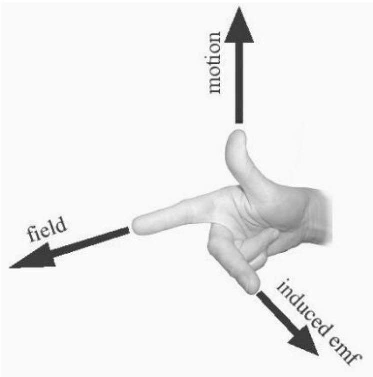
i.e. $\sum$ emf + $\sum$ IR = 0

6 d) i) State Fleming's right hand rule.

Ans:

Flemings Right hand rule:

Fleming's right hand rule states that stretch out the first three fingers of your right hand such that they are mutually perpendicular to each other, if the forefinger (first finger) indicates the direction of magnetic field, thumb indicates the direction of motion of conductor, then second (middle) finger gives the direction of induced emf and hence current in the conductor.



2 marks for statement (diagram is optional)

6 d) ii) Define mutual inductance and state its unit.

Ans:

Mutual inductance: 1 mark for definition

Mutual inductance is defined as the property of coupled coils due to which an emf is induced in one coil when current in other coil changes.

Its unit is henry. 1 mark for unit

6 e) i) Define AH efficiency and Watt-Hr efficiency of a battery.

Ans:

AH efficiency:

Ampere-hour efficiency of a battery is defined as the ratio of the output of battery in amp-hr during discharging to the input amp-hr of battery during charging. 1 mark

$$\eta_{Ah} = \frac{amp - hours\ during\ discharge}{amp - hours\ during\ charge}$$

$$= \frac{I_d T_d}{I_c T_c}$$

where, I_d be the discharge current,
T_d be the time of discharge,
I_c be the charging current,
T_c be the time of charging

Watt – Hr efficiency : The ratio of the output of a battery, measured in Watt-hours, to the input required to restore the initial state of charge, under specified conditions, is called Watt-hr efficiency. 1 mark

$$\eta_{Wh} = \frac{watt\ hours\ during\ discharge}{watt\ hours\ during\ charge}$$

$$= \frac{I_d T_d V_d}{I_c T_c V_c} = \eta_{Ah} \frac{V_d}{V_c}$$

where, V_d be the average potential difference (voltage) of battery during discharge,
V_c be the average potential difference (voltage) of battery during charging.

6 e) ii) State applications of storage batteries.

Ans:

Applications of storage batteries:

Following are the applications of storage batteries.

1) Broadcasting stations.
2) Transmission and distribution substations.
3) Telephone and telegraphic services.
4) Emergency lighting for hospitals, shops, banks etc.
5) Automobiles.
6) Solar street lights
7) Railway signaling system
8) UPS systems
9) Marine and submarine applications

¼ mark for each of any four

6 f) State the applications of following materials:

i) CRGO silicon steel
ii) HRGO silicon steel
iii) Amorphous metals
iv) Bronze

Ans:

Applications of various materials:

i) CRGO silicon steel:

a) Manufacturing distribution and power transformer cores.
b) Manufacturing cores of audio transformers, ballast transformers, speciality transformers.
c) Manufacturing cores of large transformers, generators and motors.
d) Manufacturing stator and rotor of waterwheel generators.
e) Manufacturing stator and rotor of turbo generators

1 mark for any two applications of each

ii) HRGO silicon steel:

a) Manufacturing cores of small rating transformers
b) Manufacturing cores of small rating induction motors
c) Manufacturing water-wheel generators
d) Manufacturing turbo generators

iii) Amorphous Metals:

a) Making nanocomposites for field electron emission devices.
b) Manufacturing cores of high efficiency distribution transformers
c) Manufacturing cores of special transformers
d) Manufacturing magnetic sensors
e) Magnetomotive sensors

iv) Bronze:

a) Making brush holders
b) Making knife switch blades
c) Making current carrying springs, bushings.
d) For extremely longer spans of overhead transmission lines, phosphor bronze conductors are used.
e) Cadmium bronze is used for making commutator segments and contact wires.