Important suggestions 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 principle components indicated in a 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 some questions credit may be given by judgment on part of examiner of relevant answer based on candidate understands.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q.1 a) Attempt any THREE of the following: 12 Marks

1) State the factors on which severity of shock depends.

Ans :

Important factors on which severity of shock depends

(Any Four factor expected-1 Mark each)

1. Magnitude voltage of the system.
2. The period or duration for which the area of contact with lives part.
3. It is also depends on supply system i.e. A.C or D.C.
4. Body resistance (If body is wet then body resistance reduces)
5. Shock may occur even when voltage 50V rms AC low or 75V DC sometimes OR Low voltage does not mean low hazard.
6. Path of current through body.

OR

- The magnitude of current passing through the body :-

S.No	The current strength	Effect on human system
1	A.C current of low frequency between 1m amp to 8 mA	Are just bearable does not cause any pains
2	8mA-15mA	Give painful shock without loss of muscular control.
3	20mA-50mA	If passes through chest, it may stop breathing
4	50mA-100mA	May result in ventricular cavity in body fibrillation.
5	100mA-200mA	May cause vibration of heart
6	Above -200mA	Causes death, severe burns

ii)	**Explain preventive maintenance of induction motor.**
Ans :	**Explanation of preventive maintenance of induction motor:** (Any four activity from following is expected and not all: **1 Mark each**) 1. **General: -** The machine should be stopped and isolated from all supplies before any maintenance work is done. The frequency of maintenance required depends to a large extent upon the site conditions. 2. Clean the winding of motors against affected due to surrounding atmosphere condition. 3. Air passage for ventilation blown out regularly to avoid interference with cooling system. 4. Renew switch-gear & fuse worn-out contacts i.e. starter. 5. **Brushes:** ➢ Replace worn out brushes of similar grade. ➢ Adjust the brush pressure properly. ➢ Free movement of brushes in the respective box must be ensuring. ➢ Check that the brushes are sitting properly on the slip ring & tension is uniform. ➢ Care should be taken that brushes should be vibrating in holders when motor is running. ➢ Replace if brushes are worn out within 3 mm of their supports arm. ➢ Brushes should be checked after every 100 hours running. 6. **Slip-ring:** ➢ Replace slip-rings if it is uneven wear. ➢ Clean the slip-ring dust. ➢ Tight the connections from winding to Slip lings. 7. **Bearing:** ➢ Replace worn-out bearings by equipment bearings of similar type. ➢ Clean & recharge the bearings after every 3000 hours of running. ➢ Use sand paper to clean the contacts between brushes & Slip-ring by manually rotating armature and finally clean with dry cloth in the direction of rotation only. ➢ Do not use different grade of grease. ➢ Add lubricating oil, if necessary in case of lubricating motors. ➢ In case of indirect drive, check the belt tension & if found excess ,it should be reduced. ➢ Make alignment proper. 8. **The air gap:** should be periodically checked with a feeler gauge to ensure against a worn

bearing that might permit the rotor to rub against the stator core. Even slight rubbing of the rotor against the stator will generate enough heat to destroy the coil insulation. This check is needed particularly for sleeve-bearing motors.

9. Do properly maintenance of cooling system.
10. Check the insulation resistance & polarization Index (P.I) if it is not satisfactory than machine should cleaned & drying test is conducted to improve the insulation resistance
11. Check continuity of earth conductor if found open correct it.
12. Tight all the connections in terminal box & starting unit.
13. Check the condition of foundation and found any defect rectify it.
14. Checking of base plate fixing on foundation.

OR

(Any four activity from following is expected and not all: **1 Mark each**)

Activities of preventive Maintenance:

- Inspect plant under working condition and also when it as rest.
- It includes visual inspection, cleaning, minor repairs such as replacement of small parts and adjustment of equipment.
- Routine maintenance includes all work required in cleaning of electrical equipment from dust & dirt.
- Periodic visual inspection of various equipments to locate initial condition leading to breakdown.
- Up keep of equipment and plant & repair defects at their initial stage.
- Cleaning of the fitting, tank cover, bushing of power transformers.
- Cleaning the fixed & moving contacts of starters and replacement of burnt contacts.
- Routine maintenances of electric motors involve washing and lubrication of bearing, checking of control equipment and replacement of carbon brushes.
- Checking of stationary parts.
- Checking of movable parts.
- Checking of safety measures.
- Checking of protective device
- Checking of working condition of equipment or machinery.
- Checking of surrounding in which the machinery or equipment has to work i.e. atmospheric condition.

OR

(Any four activity from following is expected and not all: **1 Mark each**)

i) Daily maintenance:-

- Dust & dirt is the principle cause of electrical breakdown. So as possible machine should be kept clean & dry both internally & externally.
- Ensure that supply voltage & frequency is within tolerance band specified in the catalog of machine.
- The insulation temperature and body temperature must be recorded frequently. It should be within permissible limits so that machine can run smoothly.
- Ensure that all terminals are clean & tight.
- Check the security of all fixing bolts, coupling grounds etc.
- Check the accessories like starter, relays & control equipments.
- Checking of cooling arrangements
- Air passage for ventilation blown out regularly to avoid interference with cooling system.
- To check the motor earthing connection.
- In case of indirect drive, check the belt tension & condition.
- To check the vibrators, checking whether motor is operating smoothly.

ii) Weekly Maintenance:-

After completing activities during daily schedule following activity are necessary during weekly schedule.

- Examine contacts of starting equipment.
- Air gap between stator and rotor be checked in case of sleeve bearing motor.
- Alignment should be thoroughly checked.

iii) Monthly Maintenance:-

After completing activities during daily & weekly maintenance schedule following activities are necessary during monthly schedule.

- Overhaul controllers.
- Renew lubricating oil
- Clean winding by vacuum pump
- Check the winding for their proper insulation.
- Check the bearing condition.

iv) Half Yearly Maintenance:-

After completing activities during all activities mention above following activities are necessary during half yearly schedule.

- Cleaning of windings of motors against affected due to surrounding atmosphere condition.
- Varnishing and Baking is carried out if found necessary.
- Check grease in ball and roller bearings.
- Check Slip-rings against unusual wearing.
- Drain all oil, wash bearings with kerosene.
- Flush with fresh oil and refill with fresh and clean lubricating oil.

v) Yearly (Annual) Maintenance:-

After completing all activities mention above following activities are necessary in yearly maintenance schedule.

- Over-haual the motors.
- Check bearing against worn-out.
- Check the bearing & brushes against worn-out.
- Check the condition of foundation.
- Check the insulation resistance.
- Check the earth resistance.

OR

Any well planed Preventive maintenance programme /function/maintenance schedule should posses following basic aspects

1. Inspection: What to inspect and how to inspect?
2. Frequencies: How often to inspect?
3. Schedules: When to inspect?
4. Records: What to record and how to record?

Planning of Maintenance:-

- The maintenance engineer should be inspect the plant periodically under working conditions and also when it is at rest with good planning and preparation.
- Mainly tests can be made during lunch time recess.
- The maintenance schedule is usually in the form of log sheets on which days, weeks, months of the year are tabulated.
- The planning of maintenance should be categorized in following ways:
  1. Routine maintenance
  2. Periodically Maintenance (weekly, fortnightly, monthly, quarterly or half yearly)
  3. Maintenance of fault as and when the fault occurs.

iii) State the method of measurement of insulation resistance and explain any one method.

Ans :

Method of measurement of insulation resistance: (Method :2 Mark & Explanation: 2 Mark)

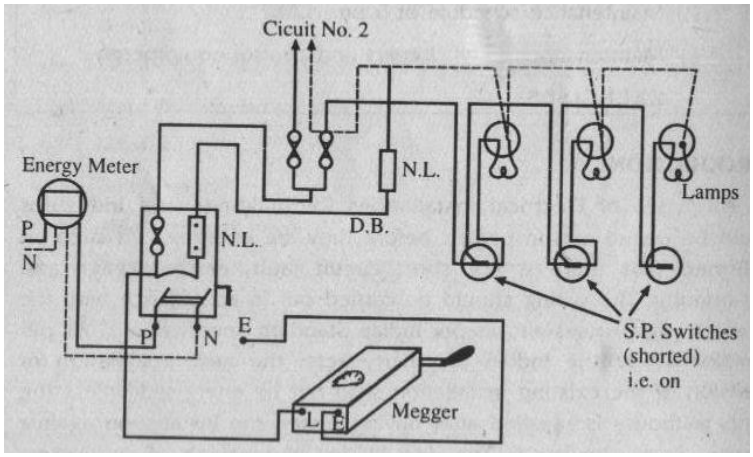
1) Megger 2) Step Voltage Method

Explain any one method Expected:

1) Megger:-

A 5000Vor 2500V or 1000V or 500V motor driven meager is used to measure the insulation resistance.

a) Insulation resistance test between installation and earth.



Insulation resistance test procedure is as follows,-

1) First make off the main switch.
2) Short the both outgoing terminals of main switch phase and neutral by external link.
3) Insert all loads and lamps in their sockets and holders.
4) Make 'ON' all the switches in the installation.
5) Make the connection of Megger as follows,-

   L – Line terminal is connected to outgoing shorted link of main switch.

   E – Earth terminal of Megger is connected of metal body of main switch which is connected to earth.
6) Rotate the handle of Megger at near about 100 to 120 rpm measure the insulation resistance.

Conclusion: - If the measured insulation resistance is more than 1 M Ω or insulation resistance is equal to or more than 50 M Ω ⁄ no. of outlets then wiring quality is good. If it

is less than that value then wiring quality is poor.

OR

Procedure :-(In case of Transformer)

- First disconnect all the line & neutral terminals of the equipment
- To check the IR, megger should be crancked (rotate) at a speed indicated in its certificate (usually 120 rpm).
- First, Megger leads to connected to HV bushing studs & LV bushing studs. This measure insulation resistance value in between the HV windings & LV bushing
- Megger leads to connected to HV bushing studs & transformer tank earth point. This measure insulation resistance value in between the HV windings & earth.
- Megger leads to connected to LV bushing studs & transformer tank earth point. This measure insulation resistance value in between the LV windings & earth.

2) Step Voltage Method:-

- In this test DC voltage in steps of 1KV, or 2 KV is applied between winding & earth.
- The voltage can be raised up to a test value & a current flowing through circuit is recorded.

Precaution:-

- The step voltage is maintained for a small time interval.

Calculation:-

- Calculate value of insulation resistance from V & I reading.

Graph:-

Then graph is plotted between calculated value of resistance & applied test voltage.

iv) Explain the use of filler guage.

Ans : **Filler gauge:** **(4 Mark)**

- It is used to check the air gap.
- The air should always be checked after dismantling and reassembly, it is also a part of routine maintenance, particular in case of sleeve bearing machines.
- In making this measurement a special long filler gauge is inserted through the apertures which are often provided in the bracket for the purpose.
- These apertures are usually plugged to exclude dirt, and the screwed plugs must be removed to permit insertion of the filler.
- Gapping apertures are usually provided at four points separated by an angle 90^0

Q.1 b)	**Attempt any ONE of the following:** **06 Marks**
i)	**List the tests to be carried out on transformer as per IS-2026. Also state the objective of heat run test on transformer.**
Ans	**1) Routine Tests** :- (Any four test from following is expected and not all: **1 Mark each & Any one objective of heat run test : 2 Mark ,Mark-Total 6 Mark)** 1. Polarity test 2. Phasing out test 3. Winding resistance test 4. Voltage ratio test 5. Magnetizing current & core loss test (O.C test)(No-load losses and current) 6. Measurement of impedance voltage, S/C impedance & copper loss.(S.C test) 7. Transformer vector group test 8. Dielectric tests (H.V. Test) a)Separate source AC voltage b)Induced overvoltage c) Lightning impulse tests 9. Oil pressure test on transformer to check against leakages past joints & gasket 10. Test on ON-load tap-changer, where appropriate 11. Measurement of Insulation resistance test **2) Type Test:-** Type tests are tests made on a transformer which is representative of other transformers to demonstrate that they comply with specified requirements not covered by routine tests In Type test all Routine tests of transformer are again conducted in addition with following tests. 1. Temperature Rise Test 2. Impulse Voltage Test 3. Noise Level test 4. Vacuum test on Tank & radiator 5. Winding resistance test 6. Voltage ratio test 7. Magnetizing current & core loss (O.C test)(No-load losses and current) 8. Measurement of impedance voltage, S/C impedance & copper loss

9. Vector group test
10. Dielectric tests (H.V. Test)a) Separate source AC volt b)Induce over voltage c)Lightning impulse test
11. Test on ON-Load tap-changer
12. Measurement of Insulation test

3) Supplementary Tests:-

1. Efficiency test
2. Back to Back test

4) Special Tests: Special tests are tests, other than routine or type tests, agreed between manufacturer and purchaser, for example

1. Noise Level
2. Harmonics on the no-load current
3. Vibration test
4. Short –circuit with stand test
5. Measurement of zero phase sequence impedance of the 3-ph transformer
6. Dielectric test(H.V. test)(Test with lightning impulse chopped on the tail)
7. Measurement of the power taken by the fans & oil pump motor

Objective of heat run test on transformer:- (Any one objective from following is expected and not all **: 2 Marks)**

- This test is used to find maximum temperature rise of transformer.
- See whether the rise in temperature is as per designed value or not.
- If not check whether it is within permissible limits or not.
- And if the temperature rise is much more in comparison to designed value, the reasons for this temperature rise should be determined, necessary modification in design made to obtain results within permissible limits.

OR

- To check the with stand capacity of insulation of winding against temperature.

OR

- If the equipment remains idle for long time the heat run test is carried out before commissioning of equipment
- It is also carried out when the equipment is re-commissioning after maintenance.
- And for machines kept in damp/flooded condition.
- Heat run test is necessary particularly for high voltage machines (above 1000V rating)

ii) **A 3-phase induction motor has the following data: Stator resistance, $R_1 = 1\Omega$, Reactance X_1, $= 3\ \Omega$, Rotor standstill, $R_2 = 1\ \Omega$, Reactance $X_2 = 2\ \Omega$**
No load exciting circuit impedance is $(10 + j\ 50)\ \Omega$, voltage per phase $V_1 = 250$ volts, stator to rotor turns ratio = 1, i.e. K = 1, Slip = 0.05
Show these values in equivalent circuit and work out:
1) Stator current (I_I) 2) Equivalent rotor current (I'_2) 3) Output (Mechanical)
4) Motor efficiency.

Ans :

Given Data:

$R_1 = 1\ \Omega \quad X_1 = 3\ \Omega \qquad R_2 = 1\ \Omega \quad X_2 = 2\ \Omega \quad K = 1 \quad$ Slip S= 0.05

$$\therefore R_{01} = R_1 + R_2^{\,1} = R_1 + (R_2 / K^2) = 1 + 1 = 2\ \Omega$$

$$\therefore X_{01} = X_1 + X_2^{\,1} = X_1 + (X_2 / X^2) = 3 + 2 = 5\ \Omega$$

$$\therefore\ R_L^{\,1} = R_2^{\,1}\left(\frac{1}{S} - 1\right)$$

$$\therefore\ R_L^{\,1} = 1\left(\frac{1}{0.05} - 1\right)$$

$$\therefore\ R_L^{\,1} = 19\ \Omega$$ ---------- **(1 Mark)**

From the above equivalent Circuit : Overall impedance per phase in primary (Stator) Circuit:

$$\therefore\ Z_{T/Ph} = (R_{01} + j\ X_{01}) + R_L^{\,1} = (2 + j\ 5) + 19$$

$$\therefore\ Z_{T/Ph} = (21 + j\ 5)\ \Omega$$ ---------- **(1 Mark)**

1. Equivalent Rotor Current = ---------- **(1 Mark)**

$$\therefore\ I_2^{\,1} = \frac{V_{1Ph}}{Z_{TPh}} = \frac{250}{21 + j\ 5} = \frac{250}{21.59\ \angle 13.39}$$

$$\therefore\ I_2^{\,1} = 11.58\ \angle -13.39 \ \ or\ 11.27 - j\ 2.681$$

I_0 = No Load primary (Stator) Current:

$$\therefore I_0 = \frac{V_1}{10 + j50} = \frac{250}{50.99 \angle 78.69}$$

$$\therefore I_0 = 4.902 \angle -78.69 \ (Polar \ \ form)$$

$$\therefore I_0 = 0.961 - j4.8068 \ \ (\text{Rectangular} \ \ form)$$

2. Stator Current: ---------- **(1 Mark)**

I_1 = Total Stator Current:

= Vector Sum of I_0 and I_2^1

= 0.96 –J 4.81 +11.27 - 2.68

= 12.23 – j 7.49

$\therefore$ *The magnitude of* $I_1 = 14.34A$ & $P.F. = Cos\ (31.48)$

$\therefore$ *The magnitude of* $I_1 = 0.8528\ lag$

$\therefore$ *Rotor Copper Losses* $= 3 I_2^{\ 2} R_2$ $\therefore I2 = I_2^{\ 1}\ (K = 1)$

$\therefore$ *Rotor Copper Losses* $= 3\ (11.584\ )^{\ 2} \times (1)$

$\therefore$ *Rotor Copper Losses* $= 402.2892$

$$\therefore \ Rotor \ Input \ = \frac{Rotor \ \ Copper \ losses}{S} = \frac{402.2892}{0.05}$$

$\therefore$ *Rotor Input* $= 8045.784$

3. Output (Mechanical) : ---------- **(1 Mark)**

$\therefore$ *Gross Rotor Output* $= (1 - S\ )$ *Rotor Input*

$\therefore$ *Gross Rotor Output* $= (1 - 0.05\ )\ 8045.784$

$\therefore$ *Gross Rotor Output* = 7643.49 *Watts*

OR

3. Mechanical Power Developed : $3(I_2)^2 R_L^1$

$= 3(11.584)^2 \times 19$

$= 7649$ *Watts*

$\therefore$ *Input Power* $= 3V_P \times I_P \times Cos\phi$

$\therefore$ *Input Power* $= 3(250)(14.34)(0.853)$

$\therefore$ *Input Power* = 9174 *Watss*

4. Motor Efficiency: ---------- **(1 Mark)**

$\therefore$ % *Efficiency* $\eta = \frac{7649}{9174} \times 100 = 83.37$

$\therefore$ % *Efficiency* η = 83.37 %

Q.2	**Attempt any TWO of the following:** **16 Marks**
a)	**Which types of precautions to be taken while working on electrical installation? (any eight)**
Ans :	**Following precautions to be taken while working on electrical installation:** (Any **Eight Precaution** from following is expected and not all **-1 Mark each**)

1. Only qualified men do the work, untrained person should not allow handling electrical equipment.
2. Do not allotted work to untrained person (worker) to handle electrical equipment.
3. Do not allow visitors & unauthorized persons to touch or handle electrical equipment.
4. Wear appropriate clothing (loose clothing is avoided)
5. Use shoes with rubber soles to avoid shock.
6. Use approved discharge earth rod for before working.
7. Do not wear suspended Necklace, arm bands, finger ring, key chain, watch with metal parts while working.
8. Do not work on live circuits without express order of the person in charge.
9. For major work take permit to shutdown the supply from authority.
10. Always obey the safety instructions given by the person in charge.

	11. Do not work without authority & operating switches without knowledge. 12. Do not work under unfavorable condition such as rainfall, Fog, high wind. 13. Do not work if there is improper illumination such as insufficient light, or producing glare or shadows. 14. Do not Do the work if you are not sure or knowledge of the condition of equipment/ machine. 15. Do not use aluminum ladders but use wooden ladders. (Use insulated ladder) 16. Use proper insulated tools & safety devices. 17. Do not guess, whether electric current is flowing through a circuit by touching. 18. Never touch a wire till you are sure that no currents are flowing. 19. Avoid working on live parts. 20. Switch off the supply before starting the work. 21. Do not make safety devices inoperative. 22. Insulate yourself on the insulating material like wood, plastic etc. before starting the work on live main. 23. Never speak to any person working upon live mains. 24. Do not sacrificing safety for speed. 25. Use proper instrument to test the circuit. 26. Always use proper insulated tools, rubber gloves, safety devices while working. 27. Well insulated & proper size of wires with ISI mark should be used. 28. Make habit to look out for danger notice, caution board, flags, and tags. 29. Do not touch or operate switches when your hands are wet. 30. Your hand & feet must be dry (not wet) while working on live main. 31. Place yourself at safe distance from working equipment. 32. Warn others when they seen to be in danger near live conductors or apparatus. 33. Remove the cords by pulling the plug, not the cords. 34. Correct rating of fuse/MCB etc should be used in the circuit. 35. Inspect all electrical equipment & devices to ensure there is no damage or exposed wires that may causes a fire or shock. 36. Avoid using electrical equipment near wet, damp areas. 37. The joints in the electrical system should mechanically & electrically sound. 38. The earth connection should be perfectly sound & proper. 39. Over loading of equipments / circuit should be avoided. 40. Do not go carelessly near running belts on machines. 41. Do not expose your eyes to an electric arc. 42. Maintenance schedule should be strictly followed. 43. Rubber mats must be placed in front of electrical switch board/ panel. 44. Ground all machine tools, body, and structure of equipments. 45. Earthing should be checked frequently. 46. When working on live equipment obey proper instruction.

47. Do not work on defective equipment.
48. Do not use defective material.
49. Inspect all electrical equipment & devices to ensure there is no damage or exposed wires that may causes a fire or shock.
50. Use superior quality of material (ISI mark)
51. By the use of proper rating protective devices with the electrical circuits.
52. There should not be any loose connection in the electrical installation & these should be checked periodically.
53. Electrical installation & equipments used in hazards area should be satisfied the specification/type of protection.
54. Know the work content and work sequence, especially all safety measures.
55. Know the proper tools and instruments required for the work, that they have the full capability of safely performing the work, and that they are in good repair and/or are calibrated.
56. Check to determine that all de-energized circuits and equipment are locked out and that ground are placed on all sides of the work area prior to beginning work.
57. Segregate all work areas with barriers or tapes, confine all your activities to these areas, and prevent unauthorized access to the area.
58. Insure that all energized circuits and equipment adjacent to the work area are isolated, protected, or marked by at least two methods (e.g., rubber mats, tapes, signs, etc.) for personnel protection.
59. Do not perform work on energized circuits and equipment without the direct authorization of your unit manager. When work on energized circuits and equipment has been authorized, use appropriate
    Safety-tested equipment (i.e., rubber gloves, sleeves, mats, insulated tools, etc.).
60. Your foreman and qualified employee must inform you of all changes in work conditions. You then must repeat this information to your foreman and qualified employee to insure your recognition and understanding of the condition.
61. Do not work alone; work with another worker or employee at all times. Do not enter an energized area without direct permission from your foreman and qualified employee.
62. Discuss each step of your work with your foreman and qualified employee before it is begun.
63. Do not directly touch an unconscious fellow worker since he or she may be in contact with an energized circuit and equipment. Use an insulated device to remove him or her from the suspect area.
64. Do not perform, or continue to perform, any work when you are in doubt about the safety procedure to be followed, the condition of the equipment, or any potential hazards. Perform this work only after you have obtained directions from your foreman and qualified employee.
65. Do not work on or adjacent to, any energized circuits and equipment unless you feel alert and are in good health.

b)	**List the eight factors affecting preventive maintenance schedule.**
Ans	**Following factors affect preventive maintenance schedule:** (Any **Eight Factor** from following is expected and not all **expected-1 Mark each)** 1. Type of machine & its working condition. 2. Working environment of industry. OR Atmospheric temperature, presence of dust, dirt, chemical fumes, moisture in the air. 3. Load cycle 4. Operating cycle of equipment or machine, or whether the machine is continuously working or otherwise. 5. If the machine is continuously overload it needs early maintenance it will also need suitable time for preventive maintenance. 6. If the machine fails, how mush loss of money it will cause due to its down period. 7. Large capacity machine or equipments are used in industry it require a sound policy for maintenance. 8. Aging of machine OR If the breakdown takes place, the cost of the repair will be more than the cost of the machine, and whether it can be replaced by a new one. 9. The machine used in the production work comes under essential equipments and they need suitable time for preventive maintenance. 10. Some industry find heavy load during particular period of year and during other period they are lightly loaded, during which maintenance can be carried out. It means that the operating cycle of plant affects the schedule. 11. Sometimes through maintenance may be necessary if the production requirement needs that the machine may be kept running to complete the production quota. It means that at a particular time production is most urgent and profitable than the cost breakdown and down period of machine during repair. 12. Cost of the maintenance. 13. Availability of trained & skilled technician. 14. Availability of spares & raw material.
c)	**List the mechanical, magnetic and electrical faults in the electrical equipments.**
Ans:	**1. Mechanical fault:- (**Any **Three points** from following is expected and not all **expected : 1 Mark each total : 3 Mark)** A fault which occurs due to mechanical failure in the electrical machines are called as

mechanical fault.

Following are the reasons of mechanical faults:-

- Warn out bearings
- Misalignment
- Rotor unbalance
- Bent shaft
- Excessive belt pull.
- Failure of lubricating system
- Loose foundation
- Overloaded bearings
- Out of roundness in a Commutator

2. Magnetic faults: (Any Three points from following is expected and not all expected : 1 Mark each total : 3 Mark)

It is internal fault caused by unbalance in magnetic condition.

Following are the reasons of magnetic faults:-

- Non-uniformity of air gap
- Short circuit between armature laminations
- Failure of insulation between core clamping bolts and core
- Misalignment of poles
- Non-uniform distribution of magnetic flux
- Bad contacts of contactor

3. Electrical faults:- (Any Two points from following is expected and not all expected : 1 Mark each total : 2 Mark)

- Internal Short circuit fault (turn to turn fault)
- Open circuit fault
- Ground fault
- Poor contact in armature winding.
- Wrong setting of brushes.
- Overheating of Commutator due to sparking
- Overvoltage
- Over frequency
- Under frequency
- Single phasing

Q. 3 **Attempt any FOUR of the following:** **16 Marks**

a) **Explain the trouble shooting chart of 3 transformers.**

Ans: **Trouble shooting chart of 3 transformer:** **(Any Four Trouble Expected: 1 Mark each)**

S.no	Troubles	Causes	Remedial Measures
1.	Transformer becomes overheating	1.It may be due to overloading. 2.Failure of cooling System. 3.High ambient temperature.	1. Reduce the load on transformer. 2. Check cooling system and rectify it. If failure.
2.	Transformer does not show output voltage	1.Primary side fuses blown out or circuit breaker may trip. 2.Failure of primary winding. 3.Tap changer, loose connection. 4.Wire connection may be open in bushing.	1. Rectified the fault and replace the fuse. 2. Rewinding the primary. 3. Tight connections at busing.
3.	Phase voltage unequal (Non-Symmetrical voltage on secondary side)	1. Unequal Loading. 2. Single phasing.	1. Make load equal. 2. Repair fault.
4.	Transformer body gives shock	1.Insulation resistance reduced. 2.Any live wire touches the transformer tank (Earth fault).	1. Reconditioning of transformer oil is necessary (either transformer oil is filter or repair by new one). 2. Check whether any live wire touches the transformer tank and rectify it.
5.	Low insulation resistance	1.Moisture in the oil.	1. Reconditioning of transformer oil is necessary.
6.	Unexpected voltage to earth measurement	1.Earth failure on one phase.	1. Remove failure.
7.	External Short circuit	1.It may be due to insufficient clearance on overhead line. 2.Accumulation of dust on insulator (Transformer bushing).	1. Provide sufficient clearance on overhead line. 2. Clean the insulator (Bushing).
8.	Internal Short circuit	1.Continuous overloaded transformer, due to this temperature increases so,	1. Rectify the cause.

			possibility of insulation failure. 2.Fault in tap changer. 3.Loose connections, causing local overheating. 4.Vibration of Rectify the causes. 5.Insulation resulting internal short circuit.	
	9.	Short circuit between adjacent turns (Turn to turn fault)	1.Reason of external short circuit. 2.Fluctuating load. 3.Transient overvoltage. 4.Moisture in oil.	1. Rectify the cause.
	10.	Rapid deformation of oil	1.Poor quality of oil. 2.Presence of moisture in oil. 3.It may be due to excessive overheating.	1. Rectify the causes.
	11.	Moisture is oil	1.Moisture in the oil while filling. 2.Breather gets saturated. (Colour of silica gel becomes pink). 3.It may be due to defective seals (gasket).	1. Transformer should be dried out. 2. Silica-gel should be replaced. 3. Gasket should be replaced. 4. Oil should be filter
	12.	Carbon & other conducting particles in oil	1.Sparking. 2.Excessive temperature of oil.	1. Transformer needs over handling (since conducting particles spread over insulation surface causes reduction in insulation resistance.
	13.	Incorrect oil level (Coil level to low)	1.Due to leakages through gasket or tank or drain valve.	1. Replace gasket by new one. 2. Weld the tank of transformer at the leakages. 3. Tight the drain valve.
	14.	Excessive core heating	1.Due to high magnetizing current or high inrush current.	1. Rectify the causes.
	15.	Temperature noise/vibration	1.Magnetostriction. 2.Loose clamping of core. 3.Mechanical vibrations of tank valves. 4.Damping	1. Use of a lower flux density. 2. Tightness of clamping lamination uniformly. Tight nut bolt & core uniformly 3. By suitable design of tank and stiffness.

16.	Troubles with core (Failure in magnetic circuit)	1.Failure of insulation of bolts used for damping core. 2.Due to vibration in core, core insulation becomes weak. 3.Dented core laminations 4.Break down of insulation between laminations. 5.Core legs are loose or not fully tightened. 6.Mis-aligned and damaged core clamping part. 7.Saturation of magnetic core. 8.Excessive core heating.	1. Rectify the causes

OR

Transformers Trouble shooting: (Any Four Point Expected)

1. **Incorrect secondary voltage:**
   This condition can be due to improper turns ratio, abnormal primary voltage, and/or shorted turns in the transformer.

2. **Bushing failure:**
   Bushing failure can be caused by flash over due to dirt accumulation and/or lightning strikes.

3. **Internal arcing:**
   Internal arcing can be caused by low liquid level exposing live parts of the transformer, loose connections, or failure of the transformer dielectric.Usually, internal arcing can become audible and cause radio interference.

4. **Core failure:**
   This condition is due to the failure of core laminations, core, bolts, clamps, and so on.

5. **Over temperature:**
   Over temperature can be caused by an over current, over voltage, I insufficient cooling, low liquid level, sludge in the transformer liquid, high ambient, or short-circuited core. In dry-type transformers, this condition can be due to clogged ducts.

6. **Winding insulation failure:**
   This is an electrical fault in the transformer winding insulation where it can involve phase-to-ground, phase-to-phase, three-phase and/or ground, or turn-to-turn-type short circuit. The causes for this type of failure may be due to a short-circuit fault, lightning, overload or over current condition, or transformer liquid containing moisture and contaminants.

7. **Pressure-relief diaphragm broken:**
This is due to an internal fault causing excessive internal pressures or the transformer liquid level being too high or excessive internal pressure due to loading of transformer.

8. **High exciting current:**
Usually, high exciting currents are due to short circuited core and/or open core joints.

9. **Low dielectric strength:**
This condition can be caused by condensation and penetration of moisture due to improper ventilation, broken relief diaphragm, leaks around transformer accessories, or cooling coil leakage.

10. **Oxidation of oil:**
Oxidation usually results in the formation of acids and sludge in the transformer liquid. It is mainly due to exposure to air and high operating temperatures.

11. **Discoloration of transformer liquid:**
Discoloration is mainly caused by carbonization of the liquid due to switching, core failure, or contaminations.

12. **Leakage of transformer liquid:**
Leakage can occur through screw joints, around gaskets, welds, casting, pressure-relief device, and so on. The main causes are improper assembly of mechanical parts, improper filters, poor joints, improper finishing of surfaces, defects in the material used, or insufficient tightness of mechanical parts.

13. **Moisture condensation:**
The main causes for moisture condensation are improper ventilation in open-type transformers and a cracked diaphragm or leaking gaskets in sealed-type transformer.

14. **Gas-sealed transformer troubles:**
In gas-sealed transformers, additional problems can be the loss of gas, oxygen content above 5%, or gas regulator malfunctions. These problems are caused by gas leaks above the oil, leaky valve seats, insufficient gas space, and/or insufficient flushing of gas space with nitrogen.

15. **Transformer switching equipment troubles:**
Many transformers are equipped with tap chargers and other switching equipment. The problems associated with these transformers may be excessive wearing of contacts, mechanism Over travel, moisture condensation in mechanism liquid, and others. Excessive contact wear is due to loss of contact pressure from weakened springs or contact-making voltmeter set at too narrow a bandwidth or

16. **Insufficient time delay.**
Mechanism over travel usually is due to defective or improper adjustment of controller contacts. Moisture condensation is due to improper ventilation, and carbonization is due to excessive operation and lack of filtering. Other problems such as control fuse blowing and mechanism motor stalling are due to short circuits in the control circuit, mechanical binding, or low-voltage conditions in the control circuitry.

b) Explain routine test for measurement of D.C. resistance of winding.

Ans: **Explanation of routine test for measurement of D.C. resistance of winding:**

PART A: **(Any Four Point Expected: 1 Mark each)**

1) Calibrated precision type measuring instruments are used.
2) Same measuring instruments are used for measurement of H.V. & L.V. winding resistance.
3) When resistance is measured by voltmeter & ammeter method at that time current shall not exceed 10% for H.V. &5% for L.V. of the rated current of the winding .Because large values of current may cause inaccuracy by heating the winding & there by changing its temperature & resistance .
4) The measurement shall be carried out after voltage and current are stable
5) The test shall be conducted at all taps of the transformer windings
6) In case of voltmeter & ammeter method, calculated value of winding resistance must be converted to A.C. resistance (because of skin effect)

   Resistance per winding = 1.6 x measure value (1.6 is due to skin effect)

7) The resistance is measured at ambient temperature & then converted to resistance at 75^0C for all practical purpose of comparison.

$$R_{t2} = R_{t1}\frac{234.5 + t_2\,^0C}{234.5 + t_1\,^0C}$$

Winding resistance at temperature of 75^{0C}. $R_{75} = R_t \frac{234.5 + 75}{234.5 + t_1}$

Where, R_{t1} = Winding resistance at temperature t_1.

t_1 = Winding temperature at the time measurement (Ambient temperature)

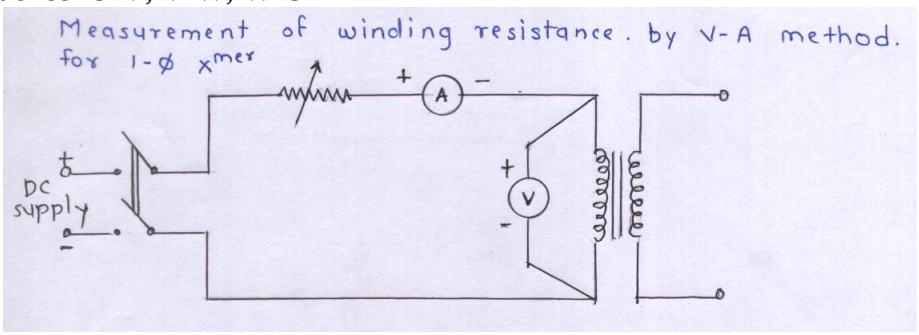
PART B

8) When resistance is to be measured of working Transformer :
   it is disconnected from supply side as well as load side
9) After de-energizing transformer it should be kept to cool for a period till it cool down (minimum 3 to 8 hrs)
10) Check the temperature of transformer oil to see that transformer is cool down or not.
11) Practically, if the temperature difference of the transformer oil between top and bottom

portion of oil is less than 5 ^{0}C, then start the procedure to measure winding resistance.

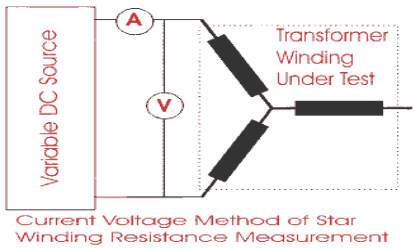
Measurement of winding resistance for single phase transformer:-

In this method of measurement of winding resistance, the test current is injected to winding & corresponding voltage drop across the winding is measured. By applying ohm's law $R_X = \frac{V}{I}\Omega$ .The measurements shall be carried out in direct current between terminals according to the sequence U-V; V-W; W-U



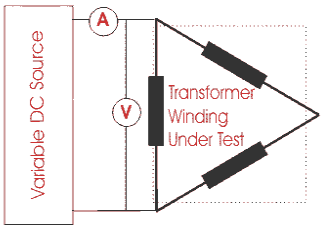
Measurement of winding resistance for Three phase transformer:-

i) For Star connected



Current Voltage Method of Star Winding Resistance Measurement

For Delta Connected



Current Voltage Method of Delta Winding Resistance Measurement

- For Star connected 3-phase winding, the resistance per phase would be half of measured resistance between two line terminals of the transformer.
- For Delta connected 3-phase winding, the resistance per phase would be 0.67 times of measured resistance between two line terminals of the transformer.

c) State and explain the properties of transformer oil.

Ans: **Following properties of transformer oil: (Any Eight Properties Expected: 1/2 Mark each)**

1. It should be have a high dielectric strength i.e. not less than 30KV (rms) for the gap 4mm of the electrodes.
2. It should be free from moisture contents & water vapour limiting value should not be more.
3. Acidity contents should be very in the oil limiting value 0.4mg of KOH/g.

4. It should have high flash point i.e. 160^0C & lower point as per specification led down (145^0C).
5. The temperature at which the oil will ignite & continue burning should be about 200^0C.
6. The oil should be chemically stable.
7. It should be not contain impurities such as sulpher & its compounds to avoid rusting & sludge formation.
8. It should posses' low viscosity.
9. Sludge value of the oil after treating should be 1.2% (limiting value is less than 0.1%)
10. Density of oil at 20^0C should be 0.89 gm/cm^3.
11. Relative permittivity should be 2.2
12. The oil should be frequently clear & plane in colour, transparent & free from suspended matter sediments.
13. Mineral oil grade B should be used.
14. The properties of good transformer & switchgear oil are recommended by IS 335-1963.
15. And for maintain the properties IS code of practice No. 1866-1961 to be refer.

d) Explain any four method of cleaning of insulation of electrical machines.

Ans: **Following methods of cleaning of insulations:-**

(Any Four method Expected: 1 Mark each)

1. Removal of loose dust by blower, the pressure of forced/suction air pressure should be moderate.
2. Removal of loose dust by vacuum cleaner,
3. Dry dust can be removed by soft brush.
4. Clean open dust/dirt on open cables by cotton waste.
5. Sticky dirt can be removed by fibrous scraper smoothly.
6. Oily viscous films can be removed with approved petroleum solvent & then cleaned by cotton cloth.
7. Oil, grease, and dirt as possible should be removed by wiping the windings with clean, dry cloths and then with clean clothes that have been moistened with a solvent recommended by the coil manufacturer.
8. Particularly 'H' Class insulation can be cleaned with fresh water & detergent.
9. The cleaning should be done as quickly as possible & excess moisture can be cleaned by dry cloth.

e) What data/parameters do we get from no load test and blocked rotor test on 3-ph induction motor.

Ans: **Data/parameters from no load test:- (Any Two Data Expected)**

(Data for No-Load Test: 2 Mark & Blocked Test: 2 Mark)

No	Parameters	Single Phase Calculation	Three Phase Calculation
1	No-load power factor	$Cos\phi_0 = \frac{P}{V_0 I_0}$	$Cos\phi_0 = \frac{P}{\sqrt{3}V_0 I_0}$
2	Energy component of no load current	$I_W = I_O \cos\phi_0$	$I_W = I_O \cos\phi_0$
3	Magnetizing component of no-load current	$I_\mu = \sqrt{I_0^2 - I_W^2}$	$I_\mu = \sqrt{I_0^2 - I_W^2}$
4	No load Impedance	$Z_0 = \frac{V_0}{I_0}$	$Z_0 = \frac{V_0/\sqrt{3}}{I_0}$
5	No load Resistance	$R_0 = \frac{V_0}{I_0}$	$R_0 = \frac{V_0/\sqrt{3}}{I_0}$
6	No load Reactance	$X_0 = \sqrt{Z_0^2 - R_0^2}$ **OR** $= \frac{V_0}{I_\mu}$	$X_0 = \sqrt{Z_0^2 - R_0^2}$ **OR** $= \frac{V_0/\sqrt{3}}{I_\mu}$

Data/parameters from blocked rotor test: (Any Two Data Expected)

No	Parameters	Single Phase Calculation	Three Phase Calculation
1	The short circuit current with normal voltage	$I_{SC} = I_S \frac{V}{V_S} Amp$	$I_{SC} = I_S \frac{V}{V_S} Amp$
2	No-load power factor	$Cos\phi_{SC} = \frac{P_S}{V_S I_S}$	$Cos\phi_{SC} = \frac{P_S}{\sqrt{3}V_S I_S}$
3	Full Load Copper Losses	$P_S = I_S^2 R_{01} Watt$	$P_S = 3I_S^2 R_{01} Watt$
4	Resistance per phase refer to stator	$R_{01} = \frac{P_S}{I_{S0}^2} Ohm$	$R_{01} = \frac{P_S}{3 I_{S0}^2} Ohm$

5	Impedance per phase refer to stator	$Z_{01} = Z_{SC} = \frac{V_S}{I_S}\ Ohm$	$Z_{01} = Z_{SC} = \frac{V_S/\sqrt{3}}{I_S} Ohm$
7	Reactance per phase refer to s	$X_{01} = \sqrt{Z_{01}^2 - R_{01}^2}\ Ohm$	$X_{01} = \sqrt{Z_{01}^2 - R_{01}^2}\ Ohm$

f) Explain factors affecting earth resistance.

Ans: **Following factors affect soil resistance (resistivity)**

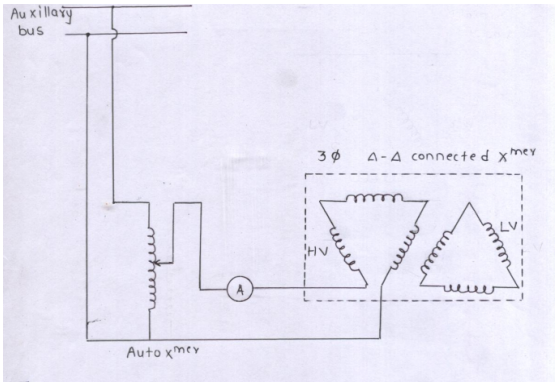
(Any Eight Factors expected: 1/2 each factor)

1. Depth of electrode embedded in the earth.
2. Temperature of soil
3. Soil Condition
4. Dissolved salts in soil
5. Climate Condition
6. Moisture content in soil
7. Physical Composition of soil
8. Effect of grain size and its distribution
9. Area Available
10. Location of Earth Pit
11. Obstructions in under ground
12. Size and spacing of earth plate and size of conductor.
13. Metal of earth plate and earth wire.
14. Quality of Coal / Charcoal used in the earth electrode pit.
15. Leakage Current Magnitude:

Q.4 a) Attempt any THREE of the following: 12 Marks

i) Explain the open delta (delta-delta) test on transformer.

Ans: **Open delta (delta-delta) test on transformer:** **(Figure: 2 Mark & Explanation: 2 Mark)**



	➢ This method is applicable in case of a delta to delta connected transformer. **Explanation or Procedure:** ➢ Make the connections as shown in circuit diagram. ➢ To circulate the current in HV side, increase the dimmer stat gradually till full load current circulates through HV winding. ➢ It will cause Full load current to circulate through LV winding also. ➢ Hence a condition similar to full load working condition is developed. ➢ To measure the temperature rise, the transformer is kept under rated load condition for several hours till maximum steady temperature is attained. ➢ When steady state temperature is reached, take the temperature of oil with the help of thermometer. ➢ Measure the resistance of winding when immediately after steady state temperature is reached to calculate temperature of winding.
ii)	**Which electrical tests are carried out before commissioning of transformer?**
Ans:	**Tests before Commissioning Transformer:-** **(Any eight Point Expected: 1/2 each point)** Following tests are required before commissioning of a transformer. 1. Overall inspection of control & relay panels 2. Tests on relays & alarm contacts 3. Voltage ratio test on all phases. 4. Measurement of earth resistance 5. Test on Buchholz relay 6. Testing of cooling system fans, cooling water pump etc 7. Operation of tap-changing arrangement 8. If required Phasing out test 9. Insulation resistance measurement 10. Oil level in conservator 11. Closing of neutral earthing switch 12. Working of meters on both sides, when transformer is loaded. 13. Operation of No-load tap changing arrangement is checked.
iii)	**State factors involved in designing the machine foundation.**
Ans :	**Following factors to be considered in designing the machine foundation:-** **(Any eight Factor Expected: 1/2 each Factor)** 1. Consider Static weight of the machine and accessories. 2. Also consider magnitude and characteristics of dynamic loads imposed by the machine

during operation.

3. The foundation should be able to carry the superimposed loads without failure.
4. The groundwater table should be confirm.
5. The foundation of a machine should be sufficiently rigid to take care of vibration and to maintain proper alignment between the motor and the load.
6. The foundation should absorb the vibrations created by the machine while operating at its full capacity.
7. The frictional resistance between foundation block and the soil should be sufficient to withstand the possible horizontal thrust caused by machine while in operation.
8. The dimension of foundation should be proportional to safe bearing capacity of soil.
9. The dimension of foundation block should be sufficient that the resultant of all the forces should pass within the foundation block.
10. The combined centre of gravity of machine and foundation should, as far as possible, be in the same vertical line as the centre of gravity of the base plane.
11. No resonance should occur; hence the natural frequency of the foundation–soil system should be either too large or too small compared to the operating frequency of the machine. For low-speed machines, the natural frequency should be high.
12. Machine foundations should be taken to a level lower than the level of the foundations of adjoining buildings.
13. For concrete masonry foundations a mixture of cement, sharp sand and broken stones in the volume ratio of 1:2:4 respectively should be used.
14. The foundation should be allowed to stand for at least 7-10 days, before the machine is put onto it.
15. The foundation must be protected from machine oil by means of acid-resisting coating or suitable chemical treatment.
16. The following size of depth of foundation:

Sr. No.	Rating of Motor	Size of depth of foundation
1	Upto 10 H.P	7.5 to 10 cms deep
2	10 to 25 H.P	15 to 20 cms deep
3	25 to 50 H.P	20 to 25 cms deep
4	50 to 75 H.P	25 to 37.5 cms deep
5	75 to 100 H.P	37.5 to 60 cms deep

OR

Following information is required and must be obtained for design of a machine foundation

- You need to review transformer/ rotating electrical machine drawings from foundation design point of view and check whether you have all the following information:
- Soil / Geotechnical information:

	Following Geotechnical information is required to start the foundation ➢ Soil allowable Bearing pressure or pile capacity ➢ Soil density ➢ Active soil pressure co-efficient of soil ➢ Earthquake soil pressure co-efficient ➢ Ground water table location ➢ Frost depth (for winter snow) ➢ Check whether you have all the following information: ➢ Transformer/ rotating electrical machine Erection weight ➢ Transformer/ rotating electrical machine Operating weight ➢ Plan dimension of Transformer /rotating electrical machine base ➢ Height of transformer/ rotating electrical machine ➢ Transformer/ rotating electrical machine Center of Gravity location in empty condition and operating condition
iv)	**State which precautions to be taken to avoid fire due to electrical reasons.**
Ans :	**Fire due to electric current can be prevented by taking the following precautions:** **(Any eight Precaution Expected: 1/2 each precautions)** 1. Use superior quality of material (ISI mark) 2. Well insulated & proper size of wires, cables should be used. 3. By the use of proper rating protective devices with the electrical circuits. 4. Overloading of electrical installation & equipment should be avoided. 5. The joints in the electrical system should mechanically & electrically sound. 6. There should not be any loose connection in the electrical installation & these should be checked periodically. 7. Electrical installation & equipments used in hazards area should be satisfied the specification/type of protection. 8. Clearances should be maintain as per Voltage level. 9. Avoid use of too many device plugged into a circuit, causing heated wire & possible a fire.

Q. 4 b) **Attempt any ONE of the following:** **06 Mark**

i) **State the classification of insulating material as per IS.**

Ans : **Insulating material can classified as following:**

(Any Six classification are expected: 1 Mark each)

Sr.No.	Type of insulating material	Property	Max. operating temperature	examples
1	Class-Y insulation	Without impregnating substance nor immersed in oil	Up to 90^{o}C	Cotton, silk, paper, press board, wood ,cellulose- ,PVC,VIR etc.
2	Class-A insulation	With impregnated varnish or insulation oil.	Up to 105^{o}C ;reinforced	Cotton, silk or paper impregnated with natural resin ,cellulose easter
3	Class-E insulation	-	Up to 120^{o}C	Synthetic resin enamels , cotton fabric and paper laminations with formaldehyde bonding
4	Class-B insulation	This has a form that inorganic material is hardened with adhesives. This is the first insulator using this structure.	Up to 130^{o}C	Glass fiber, asbestos, mica, asbestos laminates.
5	Class-F insulation	-	Up to 155^{o}C	Made of Class-B materials that are upgraded with adhesives, asbestos laminates , Glass fiber, asbestos, Mica, , built up mica.
6	Class-H insulation	-	Up to 180^{o}C	Made of inorganic material glued with silicon resin or adhesive of equivalent performance such as mica, glass fiber .
7	Class-c insulation	-	Above 180^{o}C	Made of 100% inorganic material E.g. mica, porcelain, ceramics, glass quartz, asbestos, treated glass fiber or treated asbestos etc.

OR

Maximum allowable temperatures of various types of insulation

S.No.	Insulation Classes	Maximum permissible temperature (^{0}C)
1	Class-Y or O	90^0
2	Class- A	105^0
3	Class- E	120^0
4	Class- B	130^0
5	Class- F	155^0
6	Class- H	180^0
7	Class- C	Over 180^0

OR

The insulation systems used for machine windings are classified are listed below:

1.Class O:

This insulation is rated for a total temperature of 100°C. It is made of materials or combinations of materials such as cotton, silk, and paper without impregnation.

2. Class A:

This insulation is rated for a total temperature of 105°C. It is made of materials or combinations of materials such as cotton, silk, and paper when suitably impregnated or coated or when immersed in a dielectric liquid such as oil.

3.Class B:

This insulation is rated for a total temperature of 130°C.it is made of materials or combinations of materials such as mica, glass fiber, asbestos, etc. with suitable bonding substances capable of operation at 130°C.

4.Class F:

This insulation is rated for a total temperature of 155°C. It is made of materials or combinations of materials such as mica, glass fiber, asbestos, etc., with suitable bonding substances capable of operation at 155°C.

5. Class H:

This insulation is rated for a total temperature of 180°C. It is made of materials or combinations of materials such as silicone elastomer, mica, glass fiber, asbestos, etc., with suitable bonding substances such as appropriate silicone resins and other materials capable of operation at 180°C.

6. Class C:

This insulation is rated for a total temperature of 220°C. It is made of materials or combinations of materials such as Teflon and other natural or synthetic materials capable of operation at 220°C.

ii) **A 1-4 transformer of 100 KVA, 11000/2200 volts, 50 Hz, gave the following results:**
1) O.C. test : Vo = 2200 V, Io = 1.59 A, Wo = 980 W - L.V. side
2) S.C. test: Vsc = 580 V, I_{SC} = 9.1. A, W_{SC} = 1100 W H.V. side (with L.V. shorted)
Calculate the efficiency and regulation of transformer at full load 0.8 p. f. (lagging).

Ans :

Given Data:

O.C. Test - (Input to L.V. side) Voltage V_0 - 2200 V, Current I_0 - 1.59 A, Input W_0- 980 W

S.C. test (With L.V. shorted) Voltage V_{SC} - 580V, Current I_{SC}- 9.1A, Input W_{SC}- 1100W.

Calculate the efficiency:-

$$\%\,\eta = \frac{\text{o/p}}{\text{o/p} + \text{losses}} \times 100$$ ---------- **(1/2 Marks)**

$$= \frac{\text{KVA}\cos\phi}{\text{KVA}\cos\phi + W_0 + W_{SC}} \times 100$$

$$= \frac{100 \times 10^3 \times 0.8}{100 \times 10^3 \times 0.8 + 980 + 1100} \times 100$$

$$\%\,\eta = 97.47\,\%$$ ---------- **(1 Marks)**

Calculate the regulation:

$$Z_{01} = \frac{V_{SC}}{I_{SC}} = \frac{580}{9.1} = 63.74\,\Omega$$ ---------- **(1/2 Marks)**

$$R_{01} = \frac{W_{SC}}{I^2_{SC}} = \frac{1100}{9.1^2} = 13.28\,\Omega$$ ---------- **(1/2 Marks)**

$$X_{01} = \sqrt{(Z_{01}) - (R_{01})^2}$$

$$= \sqrt{(63.74\ ) - (13.28\ )^2}$$

$$= 62.34\,\Omega$$ ---------- **(1/2 Marks)**

$$I_1 = \frac{\text{KVA} \times 10^3}{V_1}$$

$$= \frac{100 \times 10^3}{11000} = 9.1\,\text{Amp}$$ ---------- **(1 Marks)**

$\therefore$

% Reg. for 0.8 lag P.F. at full load. $\cos\phi$ = **0.8 lag,** $\sin\phi$ = **0.6**

$$\%\,\text{Reg.} = \frac{I_1\left(Z_{01}\times\cos\phi + X_{01}\times\sin\phi\right)}{V_1}\times 100$$ ---------- **(1 Marks)**

$$\%\,\text{Reg} = \frac{9.1\left(13.28\times 0.8 + 62.34\times 0.6\right)}{11000}\times 100$$

$$\%\,\text{Regulation} = 3.973\,\%$$ ---------- **(1 Marks)**

Q.5	**Attempt any TWO of the following: 16 Marks**
a)	**State and explain the factors affecting the life of insulating material.**

Ans: **Life of insulations depends on following factor:-**

(Any Eight Factors are expected: 1 Mark each)

1. **Water:** If insulation is near water for the long period than its life reduces.
2. **Moisture:** If insulation contains moisture for the long period than its life reduces.
3. **High Temperature:** Due to over loading insulation gets heated than its life reduces
4. **Mechanical Stress:** Any mechanical stress on insulation for the long period that its life reduces
5. **High voltage stress:** If insulation is used other than designed for voltage than there will be high voltage stresses it may reduces life of insulation.
6. **Dirt & Dust Particles:** If dirt & dust particles accumulated on insulation than it will absorb moisture in the air which will reduces the insulation resistance s its may cause the failure of insulation.
7. **Improper Handling:** If it is handle roughly than it may damage.
8. **Ageing:** After a long period it‘s dielectric strength reduces.
9. **Effect of oxygen & humidity:-**
   Some organic or inorganic material decomposes presence in moisture & oxygen rubber oxidized and cracks when exposed to light reduce life of insulation.
10. **Chemical action:-**
    In the soil due to chemical action, it causes corrosion of insulation. It will detoriates insulation material reduces life of insulation.

OR

Life of insulations depends on following factor:-

1. Water
2. Moisture
3. High Temperature
4. Mechanical Stress
5. High voltage stress
6. Dirt & Dust Particles
7. Improper Handling
8. Ageing
9. Effect of oxygen & humidity
10. Chemical action

b) State the method of neutral grounding. Explain the solid grounding and state advantages of grounding.

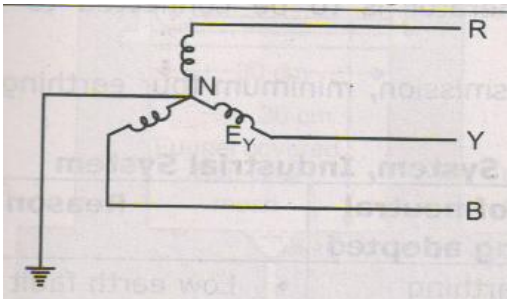
Ans:

Three types neutral grounding:

(Types: 3 Mark, Figure: 2 Mark & Explanation:1 Mark & Advantages: 2Marks)

1. Solid earthing
2. Resistance earthing
3. Reactance earthing

Explanation of Solid Earthing:



- Being solidly connected to earth.
- It cannot limit earth fault current.
- It is used when the earth fault current is not heavy.
- It not reduces interference with communication circuit.
- Used for circuits up to 22 KV

Advantages of grounding.

- Grounding is done for the protections of power system equipment
- To provide an effective return path.

- It is provided for eliminating arcing ground and over voltage surge.
- This earthing provides suitable means for earth fault protecting system.
- It increases stability of the system.

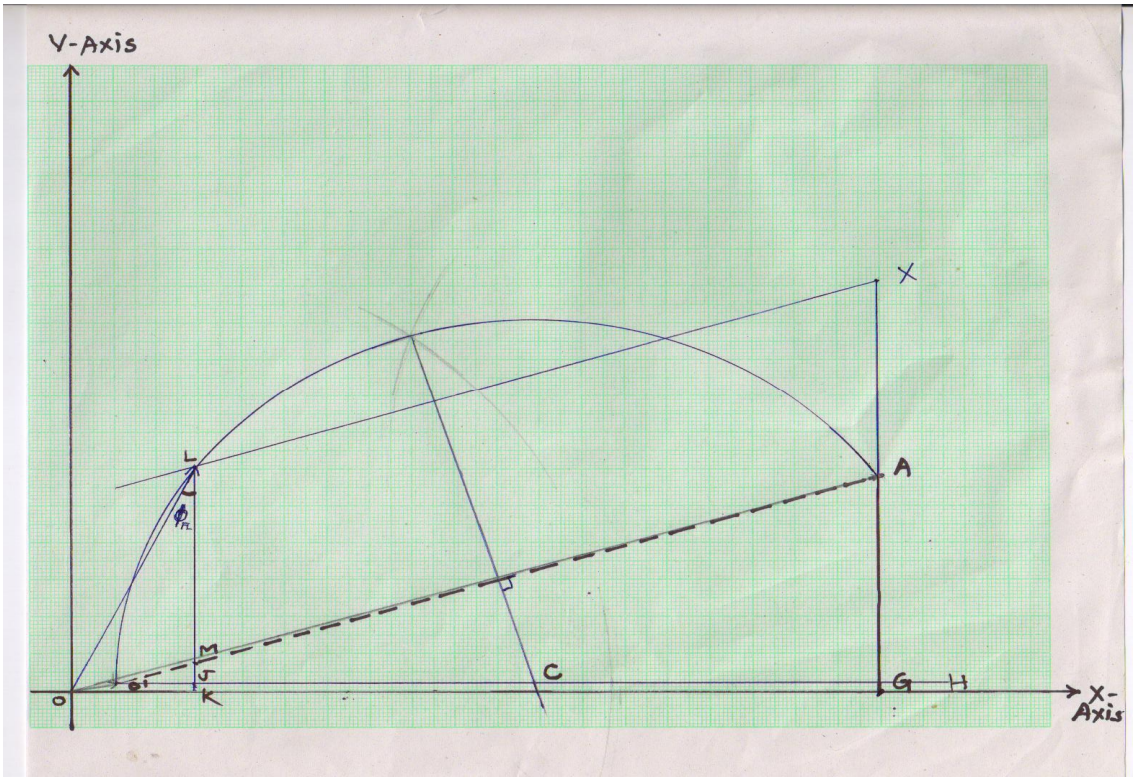
c) **A 3-phase, 500 V squirrel cage. Induction motor gave the following test results:**
No load test: 500 V, 4 A, 750 Watts.
Blocked rotor test: 100 V, 16 A, 800 Watts. Draw the circle diagram and determine:
(i) efficiency (ii) p.f when motor is supplying 25 H.P.

Ans: **No load test: 500, 4A, 750W,**

Blocked-rotor test: 100V, 16A, 800W Draw a circle diagram and determine:

i) Line current and power factor at rated output ii) Maximum O torque

Solution:-



--2Mark)

Given data: 3-ph, 500V, 25 HP, 50Hz Squirrel Cage Induction motor

1) No load Test: V_0 = 500V, I_0 = 4A, W_0 = 750 watt

Vector 00' *represents* $I_0 \angle \phi_0$

$$\phi_0 = Cos^{-1}\left(\frac{W_0}{\sqrt{3}V_0\ I_0}\right)$$

$$\phi_0 = Cos^{-1}\left(\frac{750}{\sqrt{3}\times 500\times 4}\right)$$

$\phi_0 = 77.52^0$ *Elec.* ---------- **(1/2Mark)**

2) Blocked Rotor Test: - V_{SC} = 100V, I_{SC} = 16A & W_{SC} = 800 watt

Vector $0A'$ *represents* $I_{SN} \angle \phi_{SC}$

$$I_{SN} = I_{SC}\ \left(\frac{V}{V_{SC}}\right)$$

$$I_{SN} = 16\ \left(\frac{500}{100}\right)$$

$I_{SN} = 80\ A$ ---------- **(1/2Mark)**

$$\phi_{SC} = Cos^{-1}\left(\frac{W_{SC}}{\sqrt{3}V_{SC}\ I_{SC}}\right)$$

$$\phi_{SC} = Cos^{-1}\left(\frac{800}{\sqrt{3}\times 100\times 16}\right)$$

$\phi_{SC} = 73.24^0$ *Elec.* ---------- **(1/2Mark)**

3) Let, the Current scale: - 1 cm = 4A

The vector 00' represent : $I_0 \angle \phi_0$ $I_{SN} \angle \phi_{SC}$

4) Power scale:- $= \dfrac{W_{SN}}{Lenght\ at\ \ AG\ in\ cm}$

$$W_{SN} = W_{SC}\left(\frac{V}{V_{SC}}\right)^2$$

$$W_{SN} = 800\left(\frac{500}{100}\right)^2$$

$W_{SN} = 200000$ *watts* ---------- **(1/2Mark)**

Form circle diagram length of AG in cm = 5.8 cm

$$\text{Power scale:-} = \frac{W_{SN}}{Lenght\ at\ \ AG\ in\ cm}$$

$$= \frac{20000}{5.8}$$

$$= 3448.28\ \ watts/cm$$ ---------- **(1/2Mark)**

5) Length of AX in cm $= \frac{Output\ in\ watts}{power\ \ scale}$

$$= \frac{25 \times 735.5}{3448.28}$$

$$= 5.33\ \ cm$$ ---------- **(1/2Mark)**

6) Line current at rated O/p is represented by line OL:-

= 6.8 cm

Line current at rated output = 60.3 A

7) Power factor at full load $= \frac{Line\ \ LK\ \ in\ cm}{Line\ OL\ \ in\ cm}$

$$Cos\phi = \frac{6.1}{6.8}$$

Power factor at Full load = 0.897 *Lag* ---------- **(1Mark)**

8) Efficency $\eta\ \% = Full\ laod\ \%\ \eta$

$$\eta\ \% = \frac{Line\ (lM)}{Line\ (lK)} \times 100$$

$$\%\ \eta\ = \frac{5.33}{6.1} \times 100$$

$$\therefore \%\ \ \eta\ = 87.37\ \ \%$$ ---------- **(2Mark)**

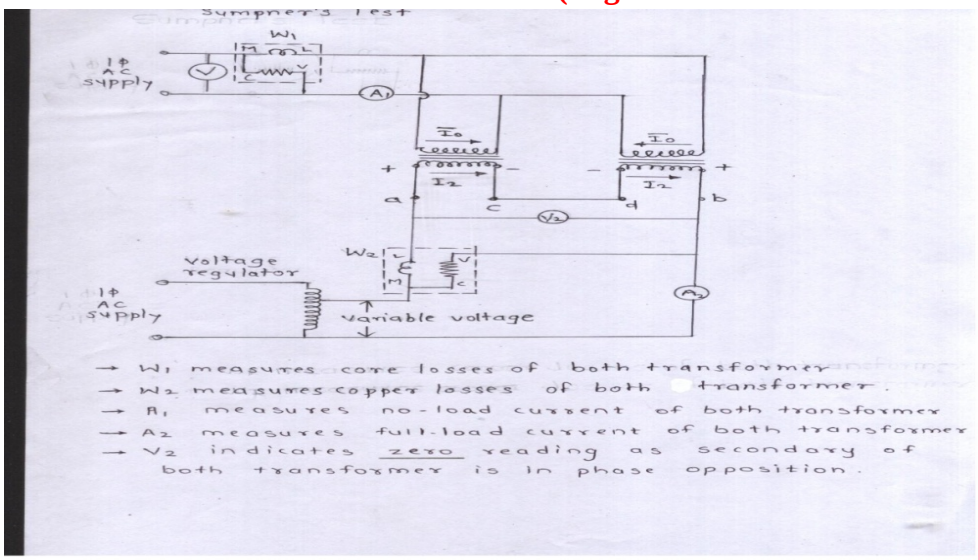
Q.6	Attempt any four of the following : 16 Marks
a)	What are the effects of misalignment on the performance of machine?
Ans :	**Effect of misalignment on the performance of machine: (direct coupled):** **(Any Four effects are expected: 1 Mark each)** 1. Increase load on bearing. 2. Increase in vibration. 3. Increase noise level 4. Increases stresses on coupling & shaft. 5. Final effect of this the bending of shaft, damages to bearing & overloading of driving machine causing it failure 6. Overall performance of machine reduces 7. It reduces the machine's life and causes a decrease in motor efficiency, 8. Misalignment phenomenon is one of main causes for economic losses in industry. **Effect of misalignment on the performance of machine: (indirect coupled)** 1. The life of belt, rope , chain & gear is shorted. 2. Produces distribute vibration. 3. Increase noise level. 4. Bent shaft. 5. Worn out bearing. 6. Final effect of this is early wear & tear of both driven & driving machine
b)	Explain importance and purpose of earthing.
Ans:	**Importance and purpose of earthing**: **(4 Mark)** ➢ Earthing means connecting the dead part (it means the part which does not carries current under normal condition) to the earth for example electrical equipment's frames, enclosures, supports etc. ➢ The purpose of earthing is to minimize risk of receiving an electric shock if touching metal parts when a leakage current is present. Earthing has been done through bonding of a metallic system to earth with the help of wire. It is normally achieved by inserting ground rods or other electrodes deep inside earth. ➢ Earthing is to ensure safety or Protection of electrical equipment and Human by discharging the electrical **leakage current** to the earth. ➢ Generally Green wire is used for this as a nomenclature. **OR** (1) Safety for Human life/ Building/Equipments:

- To save human life from danger of electrical shock or death i.e. To provide an alternative path for the leakage current to flow so that it will not danger to the user.
- To protect high rise buildings structure against lightening stroke.
- To ensure that all exposed conductive parts do not reach a dangerous potential.
- To provide safe path to dissipate lightning and short circuit currents.
- To provide stable platform for operation of sensitive electronic equipments.

c) Draw the experimental set up of the Sumpner's test on 1-Ph transformer. Also write its procedure.

Ans: **Experimental set up of the Sumpner's test on 141:1 transformer**

(Figure: 2 Mark & Procedure: 2 Mark)



Procedure :-

- For this test two identical transformer are required.
- Primary of two transformers are connected in parallel and secondaries are connected in series opposition.
- Supply is given at rated voltage and rated frequency generally to LV winding similar to OC test.
- Now supply is given to HV winding with the help of auto-transformer (Regulating-transformer) till full load current is circulated in HV winding similar to short circuit test.
- To measure the temperature rise two transformers are kept under rated load conditions for several hours till maximum steady state temperature is reached.

d)	**Explain routine preventive maintenance of transformer.**
Ans :	**Explanation of routine preventive maintenance of transformer:** (Any four activity from following is expected and not all **: 1 Mark each)** 1. **External inspection:** The transformer should be given an external inspection on a semiannual basis. The inspection should include checking the tank, radiators, auxiliary equipment, gasket leakage, and metal parts for corrosion. Also, the electrical connection should be checked for tightness and overheating. **2. Auxiliary equipment:** Auxiliary equipment required for cooling, such as fans.oil pumps, control devices, and wiring, should be checked on an annual basis. The equipment should be cleaned and damaged parts replaced. **3. Pressure-relief device:** Most sealed transformers are equipped with pressure-relief devices to relieve excessive pressure in the tank due to the internal arcing. This device is set to open at a pressure of 10–15 psi. Routine inspection of pressure-relief devices should include checking for leaks around joints, diaphragm cracking, and the like. This inspection should be done quarterly. **4. Protective alarms:** Transformers come with various types of alarms, such as over temperature, liquid temperature, and pressure-relief devices. These are usually open-type contacts that can be connected to either alarm or trip the circuit breaker. The alarm contact and associated wiring should be inspected on a monthly basis. **5.Ground connections:** The transformer tank is always solidly grounded to eliminate electric shock per the NEC. The frequency of this inspection and test should be annual. **6. Lightning arrester:** When transformers are supplied from overhead line, lightning arresters are used to protect the transformer from lightning and other surges. Lightning arresters should be inspected for looseness, broken parts, dirt, and other deposits. All dirt and deposit should be cleaned, loose connections tightened, and broken parts replaced during this check. The inspection of the lightning arrestor and its grounding system should be done annually. **7. Protective devices:** It is important that protective devices are inspected and maintained on a regular basis to ensure that these devices will operate in case of transformer malfunction or failure. **8. Liquid level:** Liquid level is important since it not only supplies the cooling medium but also insulates the windings. Any liquid lost by the transformer should be replaced promptly. **OR** (Any four activity from following is expected and not all**: 1 Mark each**) 1. **Breather:-** ➢ In case of plain breather its ends must be kept clean & ventilation holes free from dust for

proper breathing action.

- When the color of silicagel crystal changes from blue to pink than it is necessary to change the silicagel crystal by new blue colour crystal. *(Silicagel crystals are baked at 200^{0}C until it restore blue colour. It is preferable to have a spare charge of silicagel, so that the breather can be replaced immediately.)*

2. **Bushing: -** Porcelain bushing are cleaned & examined for cracks & chips. Any serious damage will require replacement of bushing by new one.
3. **Oil Level:** The oil levels vary with temperature. The oil level can be checked accurately only when the transformer has been off for some hrs. And if found low top up oil, when oil topped up shall be of the same make.
4. **Gaskets:** Gaskets may be replaced if necessary. It is preferable to have in stock a set of spare gaskets obtained from manufacture.
5. **Cooling System:** Check the cooling system fans etc, Lubricate the fan bearings and if worn out, replace it
6. **Oil Sampling:** Samples of oil taken from the bottom of the tank through the sampling value or drain value. The samples of oil should be taken when the transformer is warm & under dry weather about three liter oil is collected for sample. After taking sample the value is tightly closed. After taking of sample of oil following test of oil should be conducted
   - Crackle Test
   - Dielectric Strength
   - Flash point Test
   - Acidity Test
   - Sludge Test

   And oil should be Filter or replace if needed.
7. Oil which is unsatisfactory can be treated; Sludge, dust, dirt, moisture can be removed by filtration. Or by drying out test.
8. Oil condition of OLTC to be examined in every year. For that, oil sample to be taken from drain valve of diverter tank, and this collected oil sample to be tested for dielectric strength (BDV) and moisture content (PPM). If BDV is low and PPM for moisture is found high compared to recommend values, the oil inside the OLTC to be replaced or filtered.
9. All connections (of HV & LV side) must be tight. If any dirt dust is accumulated on connection clean it by metal polish paper
10. Insulation Resistance: The insulations resistance is measured. Compare with values at the time of commissioning and processes if required. *(It should not be less than 2000 mega ohm for each 1000V of operating voltage)*
11. Move taps changer through all positions a few times; Examine contacts of ON-load tap changers replace all worn-out & burnt contacts.
12. Set the limit switch in position.
13. Clean glasses on gas relay, thermometer and liquid level indicator,
14. Conservator to be cleaned from inside after every three years.
15. See that the conservator is filled up to the filling oil level marked

16. Check alarm and trip contacts replace all worn-out & burnt contacts.
17. Check the earth resistance. Take suitable action if it is high.
18. Check Condition of relief vent diaphragm, replace if cracked or broken
19. Check Condition of Pressure relief devices
20. All the relays, alarms and control switches along with their circuit, in R&C panel (Relay and Control Panel) and RTCC (Remote Tap Changer Control Panel) to be cleaned by appropriate cleaning agent.
21. The pockets for OTI, WTI (Oil Temperature Indicator & Winding Temperature Indicator) on the transformer top cover to be checked.
22. The calibration of OTI and WTI must be carried once in two years.
23. Tan & delta; measurement of bushings of transformer also to be done once in two years.
24. **Internal Inspection**:-
    - This inspection involves the internal investigation of the tank and core.
    - For internal inspection it includes lifting of core & winding from the tank for complete examination & inspection e.g.
    - Sludge at the bottom of the tank can be removed.
    - The megger tests are carried out on the core & coils out of tank.
    - Tapping switch should be examined.
    - All bolts used in general assemble should be checked.
    - Replace gasket by new one.
25. **Welding:** - Leaking joints can be repaired only by welding.
26. When welding is completed the core & winding are brought back to the tank & refit back as it was carefully.
27. **Paint work:** It should be paint at least one time in twice year.
28. Cleanliness in the Substation yard should be done.
29. Lock the rollers for accidental movement on rails.

OR

(Any four activity from following is expected and not all: 1 Mark each)

1. **Hourly:-**
    1. Check & measure Voltage & current.
    2. Check & measure ambient temperature.
    3. Check & measure Oil & winding temperature.
2. **Daily:-**
    1. Check Oil level in transformer.
    2. Check the air passage of breather is clear.
    3. Check Condition of relief diaphragm.
    4. Check the colour of Silica gel in breather.
    5. Checks tap changer.
    6. Check tank and radiator against oil leakage.
    7. Check the cooling system.

8. Check the ground connection (earthing).

3. **Monthly:-**

1. Check Oil level in transformer.
2. Check the temperature indicators
3. Breathing holes in silica gel breather should also be checked monthly and properly cleaned if required, for proper breathing action.

4. **Quarterly:-.**

1. Bushing is checked.
2. Oil strength (dielectric) is checked.
3. Cooling arrangement.
4. Operating mechanism.

5. **Half Yearly:-**

1. Check conservator.
2. Check the acidity of oil in transformer.
3. Test oil filled in bushing.
4. Check the gasket joints.
5. Check the terminals and connections in the boxes.
6. Examine the lighting arrestor.
7. Examine relay and alarm contacts there operations, fuses etc.
8. Check the earth resistance.
9. Check the insulation resistance.
10. Check cooling system.
11. Internal inspection.
12. Check the foundation.
13. Test for pressure.
14. Check On-load tap changer and driving gear.

6. **Yearly:-**

1. Check Oil in transformer.
2. Check Oil filled bushings.
3. Check Gasket joints.
4. Check Cable boxes.
5. Check Surge diverter & gap.
6. Check Relay alarm & their circuits.
7. Check Earth resistance.

4. **Two Yearly:-**

Check oil conservator, Buchholz relay & transformer oil.

OR

TABLE 5.7
Transformer Inspection and Maintenance Checklist

General inspection items	*Frequency*
Load current	Hourly or use recording meters
Voltage	Hourly or use recording meters
Liquid level	Hourly or use recording meters
Temperature	Hourly or use recording meters
Protective devices	Yearly
Protective alarms	Monthly
Ground connections	Every 6 months
Tap changer	Every 6 months
Lightning arresters	Every 6 months
Pressure-relief devices	Every 3 months
Breather	Monthly
Auxiliary equipment	Annually
External inspection	Every 6 months
Internal inspection	5 to 10 years
Insulating liquid	*Frequency*
Dielectric strength	Annually
Color	Annually
Neutralization number	Annually
Interfacial tension	Annually
PF test	Annually
Moisture content	Annually
Gas-analysis test	Annually
Solid insulation (winding)	*Frequency*
IR	Annually
PF	Annually
FRA	Annually
PI	Annually
Hi-pot (AC or DC)	Five years or more
Induced voltage	Five years or more
Polarization recovery voltage	Annually
DC winding resistance	Annually

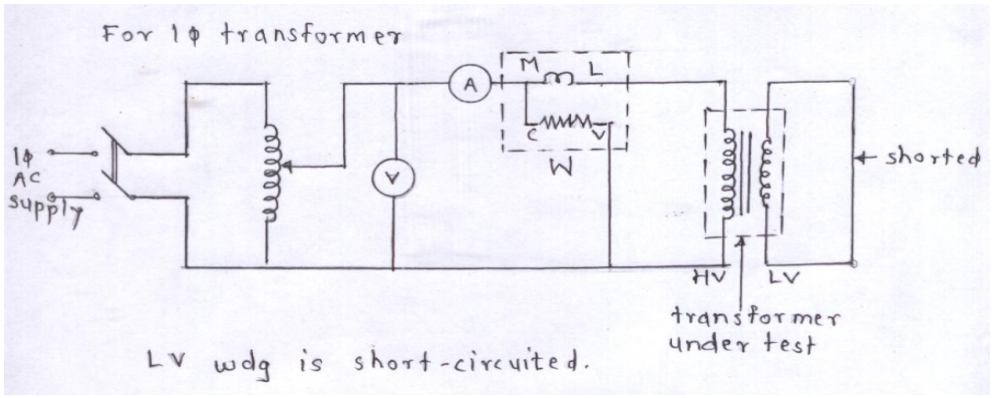
e) Explain How S.C test is performed on single phase transformer

Ans :

Measurement of Load Loss & Impedance (Efficiency & Regulation):-
(Figure :2 Mark & Procedure: 2 Mark)

Equipment used: Wattmeter's or power analyzer. Voltmeter & ammeter used should be calibrated precision type

Circuit Diagram: - Single Phase



This test is conducted to find out copper losses of the transformer at full load condition.

This test is conducted generally on HV side of the transformer and LV winding is shorted.

Assumptions:

- The voltage applied to circulate full load current is quite small compared to rated primary voltage of transformer (usually 5 to 10% of normal rated voltage.)
- So that core losses in transformer are negligible (core losses α V)
- Hence the input power here consists of copper losses in transformer only

Precautions:-

- Supply is given to HV winding & LV winding is short circuited.
- Auto transformer should be kept at minimum position at start ('0' position)
- The indicating instrument used Voltmeter & ammeter used should be calibrated precision type
- In case of 3-phase transformer two wattmeter method is used to measure the power.
- The test should be carried out quickly as possible

Procedure:-

- Increase applied voltage slowly with the help of auto transformer till full rated current is circulated.
- Take the corresponding readings of input voltage (V_{sc}), input current (I_{sc}) and input power (W_{sc})

Observation Table:-

V_{SC} in volts	I_{SC} in amp	W_{SC} (P_S) in watt

Calculation:-

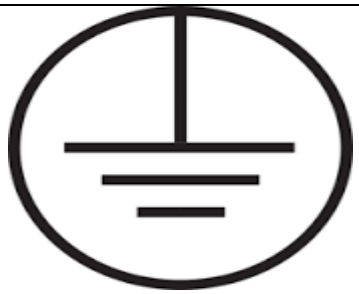
No	Parameters	Single Phase Calculation
1	The short circuit current with normal voltage	$I_{SC} = I_S \frac{V}{V_S}\ Amp$
2	power factor	$Cos\phi_{SC} = \frac{P_S}{V_S I_S}$
3	Resistance per phase refer to primary	$P_S = I_S^2\ R_{01}\ Watt$
4	Impedance per phase refer to primary	$Z_{01} = Z_{SC} = \frac{V_S}{I_S}\ Ohm$
6	Reactance per phase refer to primary	$X_{01} = \sqrt{Z_{01}^2 - R_{01}^2}\ Ohm$

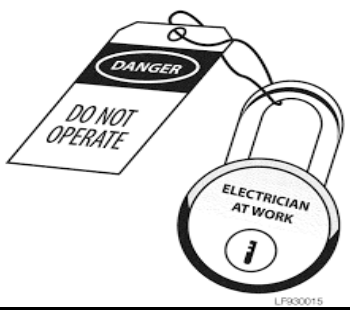
f) **State four Safety signs and symbols used in industry.**

(Any Following or similar Four Safety Signs & Symbol Expected : 1 Mark each)

Ans

Following are the Safety Signs & Symbols used in Industry :

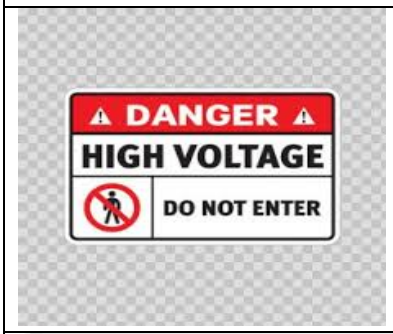




 Danger Electric shock risk	 DANGER OF DEATH ELECTRICITY KEEP OUT	 DANGER ELECTRICAL SHOCK HAZARD DO NOT TOUCH!
 Switch off when not in use	 Danger This is a hazardous area No unauthorised entry All visitors please report to site office	 DANGER COMPRESSED GAS
 Danger of death High voltage	 No Smoking Smoking and naked flames forbidden No access for pedestrians Do not extinguish with water Not drinkable No access for unauthorised persons No access for industrial vehicles Do not touch	 Danger electric shock risk
 Danger Electric shock risk	 SAFETY FIRST Read Operating and Safety Manuals before using lift	 DANGER ELECTRICAL HAZARD


REPORT
ALL ACCIDENTS
NO MATTER HOW
SLIGHT TO YOUR
SUPERVISOR


SAFETY PRACTICES
Flammable
Harmful / Irritant
Corrosive
Poison / Toxic
Explosion
Biohazard
Oxidizer
Radioactive


DANGER
HIGH VOLTAGE
DO NOT ENTER


DANGER
11000 VOLTS
११००० वोल्ट्स
ख़तरा


DANGER
ELECTRICAL
HAZARD
AUTHORIZED PERSONNEL ONLY.


DANGER
HIGH
VOLTAGE

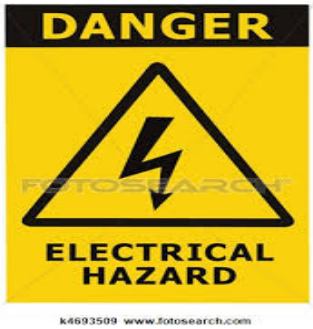

FIRST AID
KIT


FIRE
Extinguisher

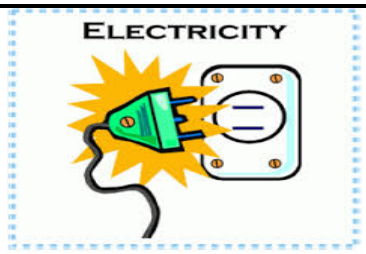

NO SMOKING

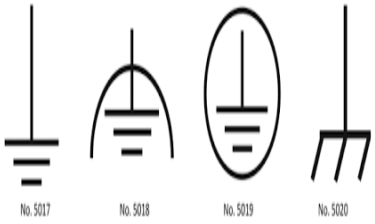

FIRST AID

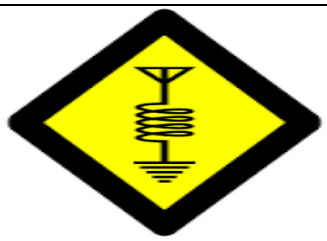

Protective
gloves must
be worn


DANGER
ELECTRICAL
HAZARD
k4693509 www.fotosearch.com


HARMFUL







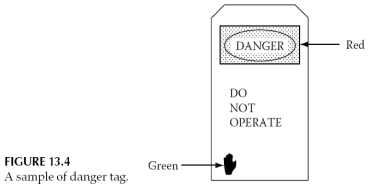


FIGURE 13.4
A sample of danger tag.

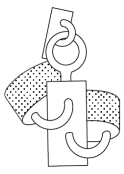


FIGURE 13.6
A sample of Gang lock clips to lock out equipment.

---------- END----------