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**
a)	**State any four objectives of the preventive maintenance of electrical machines.**
Ans:	**(Any Four Points From the following or equivalent points are Expected 1 Mark to Each Point Total 4 Marks)** **Objective of preventive maintenance of electrical machines:-** 1. To keep the plant in good working condition at the lowest possible cost. 2. To determine the need for major & minor repairs. 3. To avoid unnecessary production loss 4. To reduce loss in production time. 5. To provide greater safety & protection to the workers. 6. To increase life of machine/equipment. 7. To prevent premature failure. 8. To maintain the accuracy of the plant equipment. 9. To avoid direct loss of profit. 10. To avoid need for over-time. 11. To avoid rescheduling of production. 12. There will be energy saving if equipment or machine is well maintained 13. To use less standby equipment. 14. To run the machine / equipment/ plant without any interruption

15. To avoid major breakdown or fault.
16. To reduce breakdown to a minimum and increases the efficiency of equipments and machinery. OR To maintain the optimum productive efficiency of the plant equipment and machinery.
17. To reduce breakdown period.
18. To avoid inconvenience.
19. To reduce the danger of unanticipated breakdown.
20. To make plant equipment and machinery always available and ready for use.
21. To reduce the work content of maintenance jobs.
22. To achieve maximum production at minimum repair cost.

b) List out any eight properties of transformer oil.

Ans: **(Any Eight Properties From the following or equivalent are Expected 1/2 Mark to Each Point Total 4 Marks)**

Properties Of Transformer Oil :-

1. Specific resistance:-

   It should be have a high Specific resistance. (*at 90°C is 35 × 10^{12} ohm–cm*)

2. Dielectric strength :-

   It should be have a high dielectric strength(*more than 75KV & minimum 30KV*)

3. DDF (Dielectric dissipation factor) (tanδ):-

   It should be as low as possible.(*at 90℃ less than 0.001, 0.002 max.*)

4. Relative permittivity (Dielectric constant):- It should be 2.2

5. Flash Point :-

   Oil should have very high flash point.(greater than 160^0c)

6. Fire point -

   It should have high fire temperature not less than 200°C it should be 25^0 C greater than flash point

7. Pour Point:-It should be low (- 6^0C even - 40^0C)
8. Oil should have low viscosity.(less viscous for more fluidity)
9. Oil should have low density. (Density of oil at 20^0C should be 0.89 gm/cm^3.)
10. Oil should be free from moisture (moisture content should be less than 10 ppm &Water content in oil is allowed up to 50 ppm

	11. Oil should be chemically stable. Acidity content should be very low. (0.03mg KOH/mg Maximum) 12. Oil should be free from dissolved gas.(*less than 0.1%*) 13. The oil should be clear & plane in colour, transparent & free from suspended matter.
c)	**What is the effect of misalignment on the performance of machine ?**
Ans:	**(Any Four Points From the following or equivalent points are Expected 1 Mark to Each Point Total 4 Marks)** **Effect of misalignment on the performance of machine:-** 1. There will be excessive vibrations. 2. Increase noise level. 3. The shaft will bent. 4. Increases in friction loss. 5. Premature bearing and coupling failure 6. Premature failure of belt/Rpope/chain in case of indirect drive. 7. It increases maintenance cost. 8. It increases energy consumption. 9. It reduces motor efficiency. 10. Overall performance of machine reduces. 11. Early wear & tear of both driving & driven machine. 12. Loose or broken foundation bolts and coupling bolts 13. High bearings temperature. 14. High lubricating oil temperature.
d)	**Draw any four Safety Symbols.**
Ans:	**Safety symbols :** **(Any Four Symbols expected: 1 Mark each)** 


DANGER
11000 VOLTS
११००० वोल्ट्स
ख़तरा
FIRST AID
KIT
FIRE
Extinguisher
NO SMOKING
FIRST AID
Protective gloves must be worn
DANGER
ELECTRICAL HAZARD
ELECTRICITY
DANGER
ELECTRICAL EQUIPMENT
AUTHORIZED PERSONNEL ONLY
WARNING
ARC FLASH AND SHOCK HAZARD
Appropriate PPE Required.
Failure to comply can result in death or injury.
SAFETY FIRST
Proper maintenance and inspection is necessary for safe operation
WARNIN
ELECTRICAL SHOCK HAZA
DO NOT TOUCH TERMINALS
TERMINALS ON BOTH LINE AND
LOAD SIDES MAY BE ENERGIZE
IN THE OPEN POSITION
DC VOLTAGE IS ALWAYS PRESE
WHEN SOLAR MODULES
ARE EXPOSED TO SUNLIGHT
CAUTION
230
volts
Explosive
CAUTION
RISK OF ELECTRIC SHOCK
DO NOT OPEN
WARNING
RISK OF ELECTRICAL SHOCK
DANGER!
HIGH VOLTAGE
CAUTION
DANGER!
DANGER
HIGH VOLTAGE
UNAUTHORIZED PERSONNEL
KEEP OUT
DANGER
HIGH VOLTAGE
Danger
Electric shock risk
DANGER
HIGH VOLTAGE


No. 5017
No. 5018
No. 5019
No. 5020
DANGER
Electrical shock hazard
DANGER
CONSTRUCTION AREA
KEEP OUT
HIGH VOLTAGE
DANGER
DO NOT OPERATE
ELECTRICIAN AT WORK
DANGER
ELECTRICAL HAZARD
DANGER OF DEATH
ELECTRICITY
KEEP OUT
DANGER
ELECTRICAL SHOCK HAZARD
DO NOT TOUCH!
DANGER
ELECTRICAL HAZARD
REPORT ALL ACCIDENTS
NO MATTER HOW SLIGHT TO YOUR SUPERVISOR
Danger
of death
High voltage
Danger
electric shock risk
SAFETY FIRST
Read
Operating and Safety Manuals before using lift
DANGER
ELECTRICAL HAZARD
DANGER
HIGH VOLTAGE

Q.1 B)	**Attempt any ONE of the following :** **06 Marks**
a)	**State objective of routine, type and special test. Give example of each.**
Ans	**(Any Three objective 1 Mark each Total 3 Marks, Any one example of each 1 Mark each Total 3 Marks: Total 6 Marks)**

Following are the objectives of Routine, Type and Special test:-

(Any Three objectives are expected)

1. Objective of testing is to finding error/defects in product.
2. To confirm whether the results obtain during testing are within tolerance limits specified by BIS / ISS To provide an indication of the product reliability and quality.
3. To provide an indication of the product reliability and quality.
4. To determine the quality of material used & workmanship.
5. To avoid in convinces, accidents, minimize risk & for safety purpose.
6. To confirm whether machine/equipment/ product is manufactured as per design data or not.

Example of each:-

i) Routine Test :- **(1 Mark)**

Is Conducted on each and every Product/Part for example as below

1. Insulation resistance Test.
2. Winding resistance Test.

ii) Type Test: - **(1 Mark)**

These tests are carried out on 2 or 3 randomly machines from the lot of the manufactured machines of same design and specification. **For example as below**

1. Temperature-rise type test.

2. Dielectric type tests.

iii) Special Test :- **(1 Mark)**

These are performed for specific purpose only as per demand of customer **for example as below**

1. Measurement of acoustic noise level.
2. Vibration Test

OR Student may Written This way

1) Objective of Routine test : **(Objective : 1 Mark & Example : 1 Mark)**

1. To Keep Plant in good working condition.
2. To Check the quality and confirmation of Specification.

Example of Routine Test:

1. Insulation resistance Test.
2. Winding resistance Test.

2) Objective of Type test : **(Objective : 1 Mark & Example : 1 Mark)**

1. To prove that the product meets specification and design expectations.
2. To Check the quality and confirmation of Specification.

Example of Type Test:

1. Temperature-rise type test.
2. Dielectric type tests

3) Objective of Special test : **(Objective : 1 Mark & Example : 1 Mark)**

1. To obtain information useful to the user during maintenance

Example of Special Test:

1. Measurement of acoustic noise level.
2. Vibration Test

b) What is indirect method of testing ? What are its advantages and drawbacks ?

Ans: **Indirect loading Method :-** **(4 Marks)**

In case of indirect testing method equipment/machine are not directly loaded but instead of

loading machine runs on No- load. To determine the performance of machine.

Advantages indirect method of testing: (1 Marks)

1. Power consumption is less.
2. Time required is less.

Disadvantages indirect method of testing: (1 Marks)

1. Result obtained is approximately equal.

Q.2	**Attempt any TWO of the following :**	**16 Marks**
a)	**State any eight factors on which severity of shock depends.**	

Ans: ((**Any Eight Points From the following or equivalent points are Expected 1 Mark to Each Point Total 8 Marks)**

The effect of electrical shock on human bodies depends on following factors.

1. Magnitude voltage of the system.
2. The period or duration.
3. It is also depends on supply system i.e. A.C or D.C.
4. Body resistance
5. The presence of moisture in the environment.
6. Path of current through body.
7. The phase of the heart cycle when the shock occurs.
8. The general health of the person prior to the shock.
9. The magnitude of current passing through the body :- If magnitude is above 25mA, It gives painful shock.

OR

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 fib ration of heart
6	Above -200mA	Causes death, severe burns

b) Distinguish between routine maintenance and breakdown maintenance of electrical equipments.

Ans: **(Any Four Point Expected : 2 Mark each Total 8 Marks)**

Sr.No.	Routine maintenance	Breakdown maintenance
1.	Maintenance before complete breakdown of equipment is known as routine maintenance.	Maintenance after complete breakdown of equipment is known as breakdown maintenance.
2.	Systematic inspection, detection, correction, and prevention of incipient failures, before they become actual or major failures.	NO Systematic inspection, detection, correction, and prevention of incipient failures.
3.	Maintenance activities are related with repair, replacement and service of components.	No Maintenance activities.
4.	There is fix maintenance program / schedule	There is no fix maintenance program / schedule
5.	Routine maintenance depends on Operating cycle of equipment or machine	Breakdown maintenance does not depend on Operating cycle of equipment or machine
6.	Routine maintenance is done as per service manual issued by the equipment manufacturer.	Breakdown maintenance is carried out when Machine may not find time to put for routine maintenance due to constant working load
7.	Routine maintenance ensures that it consumes least productive time.	Breakdown maintenance is carried out when The profit of production from machine is more than cost of breakdown maintenance.
8.	Routine maintenance is carried out by maintenance department.	Breakdown maintenance is carried out in company authorized repair center.
9.	It requires more workers because regular checks are a must.	you simply need to call someone in for a onetime fix to repair equipment/machine
10.	Because the equipment is being regularly checked, they are at less risk to breaking down equipment/machine without notice.	Because the equipment is not being regularly checked, they are more risk to breaking down equipment/machine without notice.
11.	Due to routine maintenance life of equipment/machine increases.	As routine maintenance is not done life of equipment/machine reduces.
12.	In general as equipment is kept in the best	In general when equipment is not kept in the

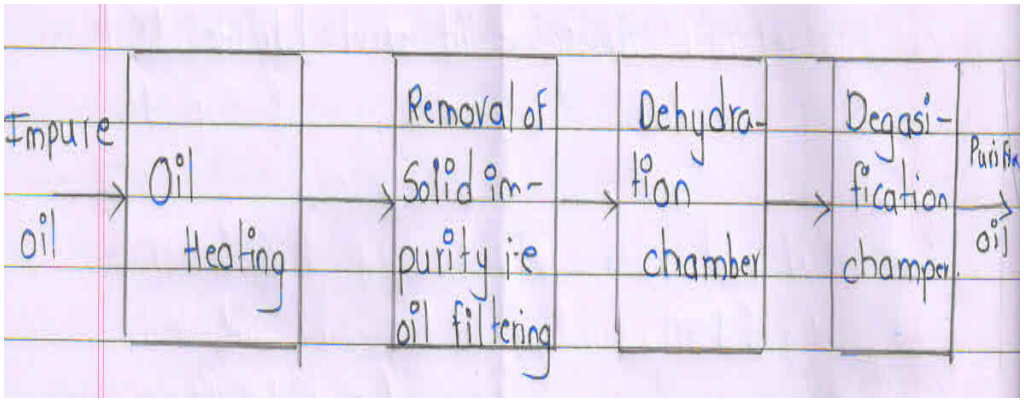
	conditions possible, it will drain less energy, reduces energy bill.	best conditions possible, it will drain more energy, increases energy bill.
13.	Due to routine maintenance, It creates a safer working environment for employees.	It will not create a safer working environment for employees.
14.	Maintenance is done In Industries premises	Break down maintenance is done authorized servicing center only
15.	E.g. : Insulation resistance & Winding resistance	E.g. generator of plant, drinking water, Pumping motor
16.	Machine spare parts even in good condition it should be replace when its life is end.	Maintenance is done only when machine fail to operate

c) State the methods of purifying and drying out the transformer oil and explain any one method in brief with neat sketch.

Ans:

(Methods of Purifying : 2 Marks & Drying : 2 Mark and Any one method explanation : Figure : 2 Mark & explanation : 2 Mark – Total 8 Marks)

1) Method of purifying transformer oil:-



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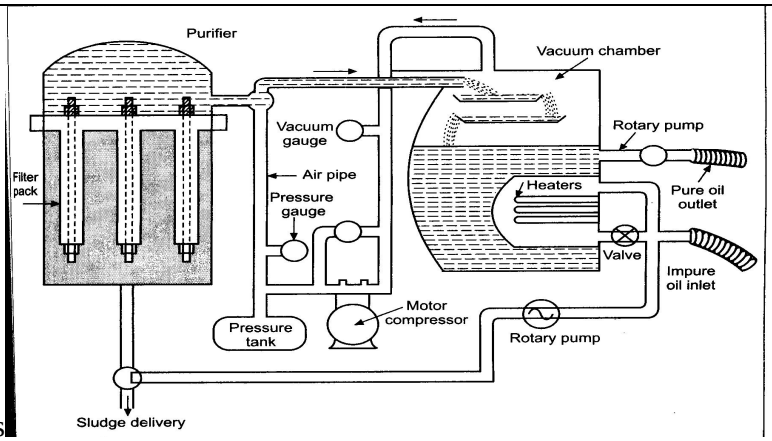


Figure of Stream Line Purifiers

OR

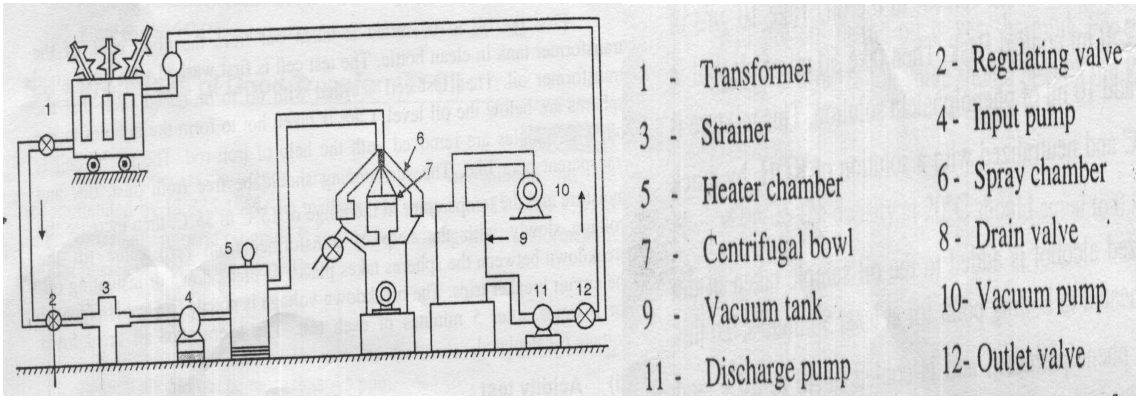


Figure of Centrifugal Purifiers

Step 1 :-

In first step oil is heated with the help of heater to a desired level, generally $65^0C - 70^0C$ Due to increase in temperature viscosity of oil becomes low, so it is easy for filtration.

Step 2 :-

In this step, solid impurities, dirt, dust & sludge is removed from oil.For this there are two methods (Only one method is expected)

1. **Stream Line Purifiers Or By Filter Cartidge Or By Filter Pack :-**

In this process oil under high pressure is passed through very thin paper disc of size ranging from 500 micron to 0.5 micron. The purified oil will go down and impurities remain in paper disc. Paper will also absorb moisture contain in oil.

OR

2. **Removal Of Sludge By Spinning / centrifuging action :-**

- Oil which is to be filter is filled in drum which is rotated at very high speed by an electric motor.
- Due to spinning of drum high centrifugal forces are created in oil.
- So heavier particles (Sludge/dirt/dust) thrown out of drum.
- It can also throw out water in oil which is in the free form, but it cannot thrown out small solid impurities.

Step 3 :-

This is last step, after de-sludging oil is passed through de-hydration (de-humidification) and de-gasification chamber.

In this step, transformer oil is heated till dissolved moisture, gases in oil gets evaporated.

OR Student May Write

2) Method of drying out the transformer oil:-

1.External method:- As Above explained

2. Internal method:- By short circuiting the LV winding & applying reduced voltage to the HV winding. This process is continued till moisture in oil gets removed/evaporated

3. Combination of external & internal:- To reduce the drying out time both above two process can be done simultaneously. The drying process should be stopped when desired values of-hot IR/PI/DAR will get.

Q. 3	**Attempt any FOUR of the following :**	**16 Marks**
a)	**State any four external causes of failure of equipments.**	
Ans:	**External causes for the Failure of electrical equipments:-**	

(Any four causes expected 1 Mark each, Total 4 Marks)

1. Overvoltage/ under voltage
2. Unbalanced voltage
3. Over frequency / under frequency
4. Single phasing from supply side
5. Lightning surge
6. Overloading for long time
7. Unbalanced loading

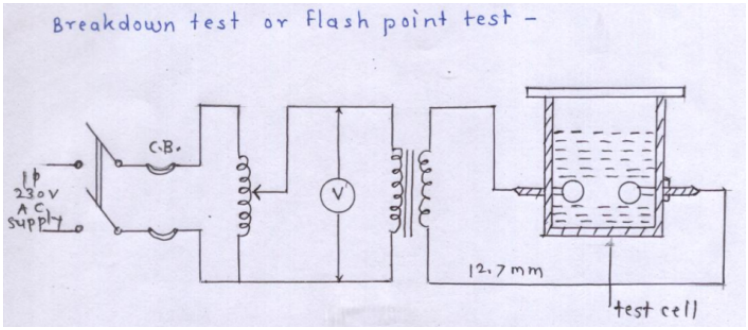
	8. High ambient temperature 9. Loose connection 10. Short circuit fault in supply system.
b)	**What is Growler ? State working and use of it.**
Ans:	**Growler:-** **(1 Marks)** A **growler** is an device used for testing insulation of a motor for shorted coils. **Working:-** **(1 Marks)** Whenever there is short circuit in winding growler produces strong vibrations & noise **Use of Growler:-** **(2 Mark)** ➢ It is used to find out shorted turn faults in armature winding or rotor and stator winding of motor.
c)	**List out and explain any one test to be carried on transformer oil.**
Ans:	Following are the various test which are carried out:- **(List of Any Four Test expected : 1/2 each Test)** 1) Dielectric Strength 2) Moisture content test (Crackle Test) 3) Flash point test 4) Fire point test 5) Pour point test 6) Acidity Test 7) Viscosity Test 8) Density Test 9) Dissolved Gas Analysis (DGA) Test 10) Power factor (dielectric losses – tan ∂) Test 11) Sludge Test 12) Colour test

13) Sulpher content Test

Explanation Following test to be carried on transformer oil:-

(Any One test explanation expected: Figure :1 Mark & Explanation: 1 Mark)

1) Breakdown voltage test:-

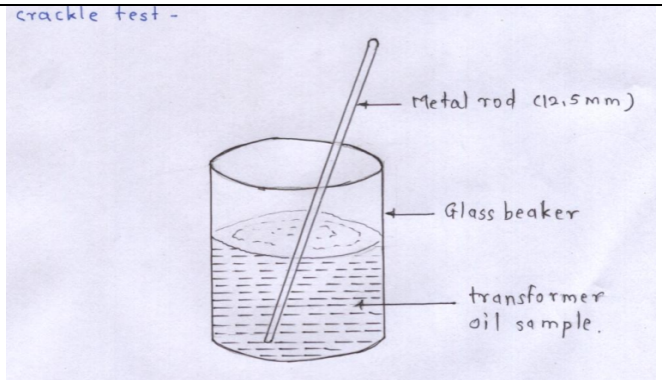


- The sample of oil is taken from the transformer tank.
- In this kit, there are two electrodes separated by small gap of 2.5 mm (in some kit it 4mm) between them. The gap of electrode is first checked with a gauge.
- The cup is filled with sample of oil to be tested up to about 1 cm above the electrodes.
- The cup top is covered with clean glass plate.
- Now slowly raise the voltage between the electrodes till sparking starts between the electrodes. And note down voltage reading.
- Generally this measurement is taken 3 to 6 times in same sample of oil
- And the average value of these reading is taken.
- Average of all results is considered as the breakdown voltage of oil sample.

Conclusion:-

- As a general thumb rule, the minimum BDV for energizing any transformer rated 33 kV or below is 30 kV. For higher voltages the minimum BDV is 40 kV.
- If this value is lower than 30 KV than it indicates presence of moisture in oil.

2) Crackel Test:-



- This test is performed to check the presence of moisture in the insulating oil.
- To perform this test, a sample oil of 250 ml is taken in a breaker (Glass).
- One iron rod of 12.5 mm thick is made heated up to red hot and dipped in this sample of oil.
- If there is any hissing sound coming through the oil in the breaker, it indicates the presence of moisture contents in the oil. Which will be considered not suitable for the use

d) State different methods for measurement of insulation resistance. Explain one in brief.

Ans: Following are the methods of measurement of Insulation Resistance : **(2 Marks)**

1. Spot Test Or Short Time Method
2. Time Resistance Test Or Dielectric absoption Test
3. Step Voltage Test

Explanation:- **(Any One Method Is Expected : 2 Marks)**

1.Spot Test Or Short Time Method:-

- The megger is connected across the insulation & test voltage is applied for a fix period of time normally 60 sec. & take the reading.
- A curve is plotted from the readings as shown in graph
- Good insulation will show a continuous increase in the resistance value.
- This test is suitable for a short wiring run.

2.Time-resistance test:-

- The megger is connected across the insulation & test voltages is applied for a period of 10 min.

(600sec.) & take the reading.

- Take readings at fixed time intervals (successive)
- A curve is plotted from the readings as shown in graph
- A good insulation shows a continuous increase in the IR resistance value
- This test is suitable for the predictive and preventive maintenance of rotating machines.
- The PI and DAR are calculated from the readings to verify healthiness of insulation..

3.Step voltage test:-

- The megger is connected across the insulation & test voltage of different magnitude is applied for a period of 60 sec. & take the reading.
- The test voltage at each step is from lower voltage to higher voltage.
- A curve is plotted from the readings.
- Good insulation will show a continuous increase in the resistance value
- Take care that voltage applied to test the IR should be below the rated voltage of winding / equipment.

OR Student May Write IR Measurement With The Help of Megger:-

Procedure of measurement of IR With the help of megger is as below:- **(4 Marks)**

Step 1 :-

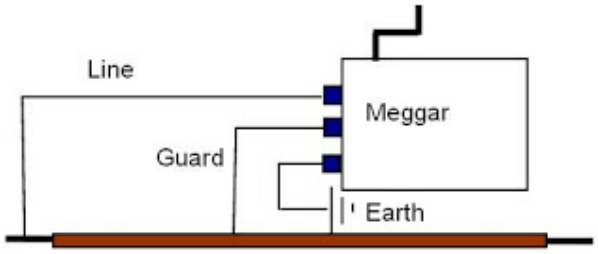
- First select the rating of megger to be used from available ratings 500V,1000V,2500V etc.Take care that voltage applied to test the IR should be below the rated voltage of winding / equipment to avoid overstressing the insulation, but the voltage should be high enough to measure IR

Step 2 :-

- Disconnect the winding / equipment from supply
- The winding to be tested should be first isolated.
- The other winding should connect to ground.

Step 3 :-

- Make the connection as below:-



- 'LINE' terminal is connected to winding (Conductor) whose insulation is to be checked.
- 'EARTH' terminal is connected to ground
- 'GUARD' terminal is connected to surface of insulation.

Step 4 :-

- To check the IR megger should be cranked (rotate) at a speed indicated in its certificate (usually speed = 120 rpm) for 1 minute or 10 min)
- Read value of IR at the end of test.
- Take more than two reading to get move accurate value of IR

Step 5 :-

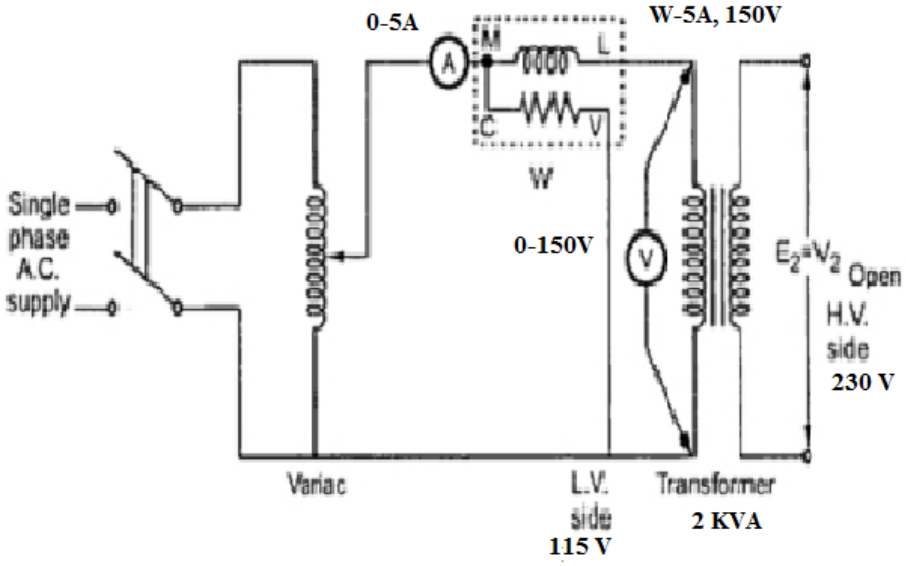
- This measured value of IR should be compared with the minimum acceptable IR value

e) Draw a neat circuit diagram to perform O.C. and S.C. test on single phase transformer with all meter rating marked for a 2 kVA, 230/115 V single phase transformer.

Ans:

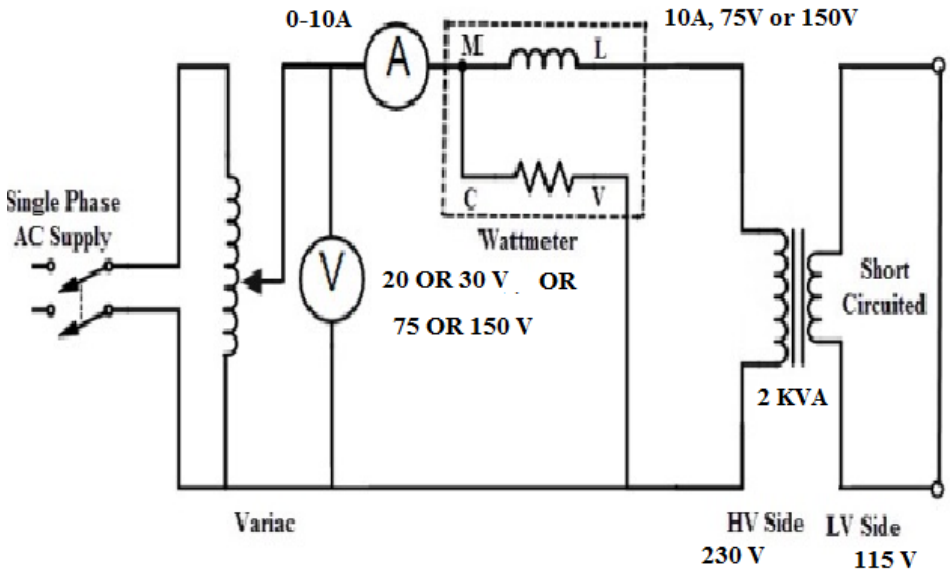
(Figure OC & SC: 3 Mark & Meter rating : 1 Mark)

1) Neat Circuit Diagram: Open circuit Test :



or equivalent circuit

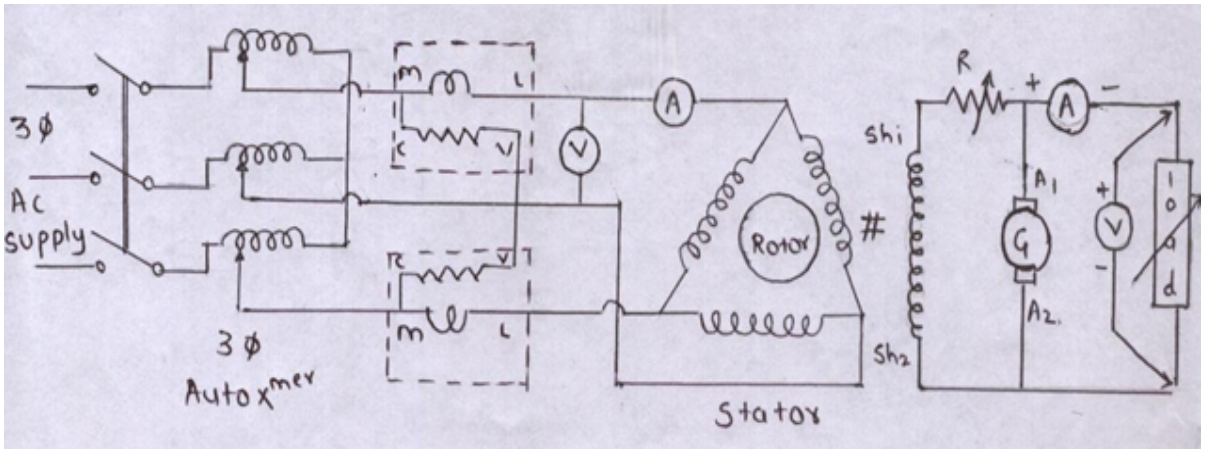
2) Neat Circuit Diagram: Short Circuit Test :



or equivalent circuit

Q.4 A)	**Attempt any THREE of the following :** **12 Marks**
a)	**How will you perform direct loading test on 3-Ph induction motor? Draw necessary circuit diagram.**
Ans:	**(Figure : 2 Marks & Explanation : 2 Marks, Total 4 Marks)**

a) Full Load Test Circuit Diagram: (If generator is coupled with induction motor):



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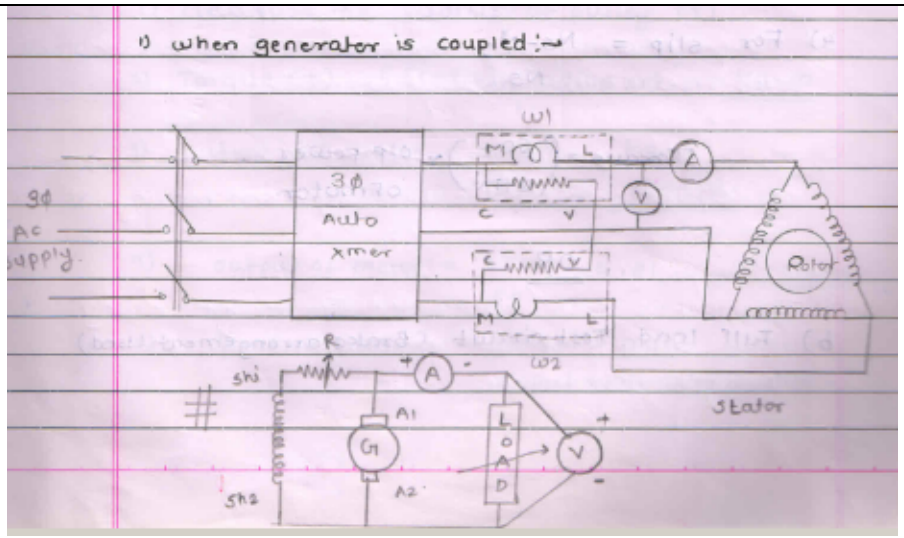


Explanation:-

- Increase the applied voltage to the stator gradually up to its rated value.
- Now increase load gradually and measured the readings of applied voltage, current, Power, and Speed for various loads on the motor up to full load.

Observation Table:-

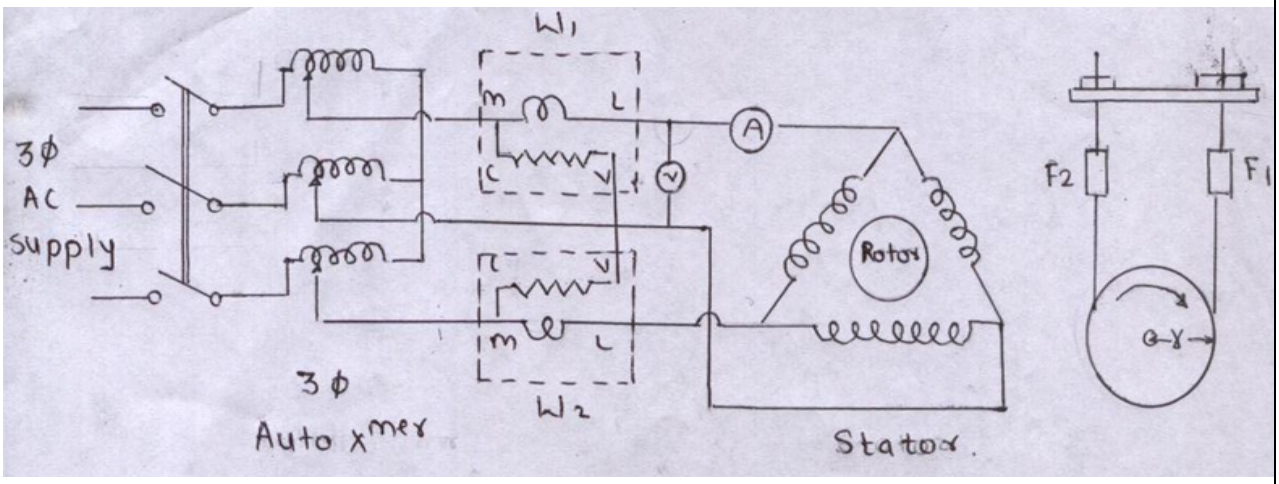
V_{dc} volts	I_{dc}amp	W(P) =W_1+W_2 watt	Speed in rpm

Calculations:-

- Efficiency of generator must be known
- $output\ of\ motor = \frac{V_{DC} \times I_{DC}}{\eta\ of\ generator}$ (efficiency of generator should be assume)
- Efficiency of I.M $= \frac{Output\ of\ motor}{Input\ \ watt\ meter\ reading}$
- Note:- Calculation of each load reading is calculated as above and average is taken to calculate efficiency of motor

OR Student may written following way

b) Full Load Test Circuit Diagram (If Brake arrangement is used):-



Explanation:

- Connect the circuit as shown in circuit diagram.
- Switch ON supply and start the motor.
- Increase the load gradually on the motor up to full load.

Observation Table:-

Vin volts	I in amp	W(P) $=W_1+W_2$ watt	Speed in rpm	F_1in Kg	F_2 in Kg	F_1-F_2 in Kg

Calculations:-

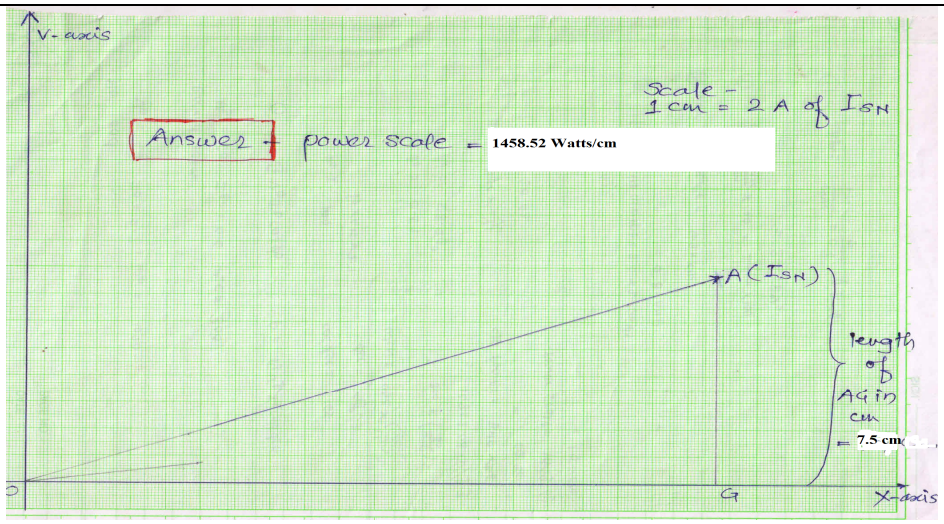
- *T is the torque in kg meter and* $T = (F_1 - F_2) \times r$ *mkg* (Where **r** is radius of pulley in meter)
- output of motor $= \frac{2\pi NT}{60}$ kg – m/Sec

  $output\ of\ motor = \frac{2\pi NT}{60} \times 9.81\ watts$
- Efficiency of I.M $= \frac{Output\ of\ motor}{Input\ \ watt\ meter\ reading}$
- Note:- Calculation of each load reading is calculated as above and average is taken to calculate efficiency of motor

b)	**State any four factors on which earth resistance depends.**
Ans:	**(Any Four factors From the following or equivalent factors are Expected 1 Mark to Each Point Total 4 Marks)** **Following factors on which earth resistance depends:-** 1. Moisture content in soil 2. Dissolved salts in soil 3. Soil Condition 4. Size of earth pit 5. Climate Condition 6. Size of earth electrodes 7. Metal of earth plate and earth wire. 8. Number of earth pits / erath electrode 9. Temperature of soil 10. Depth of electrode embedded in the earth. 11. Lengthen the earth electrode in the earth. 12. Resistance of the electrode itself and connections to it. 13. Contact resistance between the electrode and the soil adjacent to it. 14. Resistance of the surrounding earth. 15. Physical Composition of soil 16. Effect of grain size and its distribution 17. Location of Earth Pit 18. Size and spacing of earth plate and size of conductor. 19. Quality of Coal / Charcoal used in the earth electrode pit. 20. Leakage Current Magnitude

c)	**State the function of following tools : (i) Bearing puller (ii) Filler guage (iii) Dial tester (iv) Spirit level**
Ans:	**(Function of Each Tool 1 Mark , Total 4 Marks)** **i) Bearing Puller:-** ➢ Bearing puller is used for holding and removing the bearing safely ➢ It is also used to remove gears or pulleys from a shaft. **ii) Filler guage:-** A **feeler gauge** is a tool used ➢ To measure gap widths. ➢ To measure the clearance between two parts.(e.g. air gap between stator & rotor) **iii) Dial tester:-** ➢ Is used to check the run-out (Unbalance) of rotating parts (commutators, rotor, shafts) ➢ Also used to check the mis-alignment of shaft in electrical machines. **iv) Spirit level:-** ➢ It is used to check the level. OR ➢ To indicate whether a surface is horizontal (level) or vertical (plumb).
d)	**State any eight precautions to be taken to avoid fire due to electrical reasons.**
Ans:	**(Any Eight precautions From the following or equivalent precautions are Expected 1/2 Mark to Each Point, Total 4 Marks)** **Precautions to be taken to avoid fire due to electrical reasons:-** 1. Overloading on cables/wires/machine should be avoided 2. Frequently checking of electrical cables, wires appliances, and closely inspect cords and plugs 3. Correct rating of fuse/MCB/switch gear etc. should be used in the circuit. 4. Do not use of too many device plugged into a circuit. 5. Joint in wiring/cabling must be mechanically & electrically sound 6. Joints in wiring must be sound.

	7. There should not be any loose connection in the electrical installation. 8. Replace deteriorated cables, wires, etc. by new one. 9. Electrical installation & equipments used in hazards area should be satisfied the specification/type of protection. 10. Do not store highly flammable liquids near(close to) electrical oven/furnace to avoid fire. 11. Do not keep electric heaters near curtains or furniture. 12. Use ground fault protection. Like ELCB/earth fault relay. 13. Test electrical safety devices 14. Do not make safety devices inoperative. 15. Replace Wiring that becomes defective with the passage of time 16. Maintenance should be done strictly as per schedule. 17. Use of superior quality of material ISI mark. 18. Replace faulty electrical installation and outdated appliances. 19. Replace Old electrical sockets and unsafe appliances 20. Maintain clearance as per voltage level
Q. 4B)	**Attempt any ONE of the following : 06 Marks**
a)	**A three phase 415 volts, 5.5 kW induction motor gives following results :** **No load test : 415 V, 4.6A, W_1 = 1000 W, W_2 = - 560 W** **Blocked roter test : 98 V, 10 A, W_1 = 770 W, W_2 = - 160 W** **Using scale 1 cm = 2 A, find power scale.**
Ans:	**Given Data:** No load test:- 415 V; 4.6 Amp; W_1 = 1000 W; W_2 = –560 watts Blocked rotor test:- 98 V; 10 Amps; W_1 = 770 W; W_2—160 watts Draw a circle diagram and determine: i) Efficiency, current and power factor at rated output ii) Maximum output **Solution:-**



------- **(2 Mark)**

Given data: 3-ph, 415V, 5.5 kW), 50Hz

1) Blocked Rotor Test: - V_{SC} = 98V, I_{SC} = 10A & W_{SC} = (W_1-W_2) = (770-160) = 610 watt

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

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

$$I_{SN} = 10 \left(\frac{415}{98}\right)$$

$$I_{SN} = 42.35\ A$$ ---------- **(1Mark)**

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

$$\phi_{SC} = Cos^{-1}\left(\frac{610}{\sqrt{3}\times 98\times 10}\right)$$

$$\phi_{SC} = 68.94^0\ Elec.$$ ---------- **(1Mark)**

2) Given Current scale: - 1 cm = 2A

The vector 0A represents - $I_{SN} \angle \phi_{SC}$

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

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

$$W_{SN} = 610(\frac{415}{98})^2$$

$W_{SN} = 10938.91\ \ watts$ ---------- **(1Mark)**

4) Power Scale= $= \dfrac{W_{SN}\ in\ Watts}{Length\ of\ \ AG\ \ from\ graph\ \ paper\ in\ cm}$

$$= \frac{10938.91}{7.5\ cm}$$

$= 1458.52\ \ watt/cm$ ---------- **(1Mark)**

OR

Let the current scale be , 1 cm = x Amp. Then the power scale will be given by: **(6 Mark)**

$$1cm = \sqrt{3} \times V_{rated} \times X$$

$$Here,\ \ X = 2A, V_{rated} = 415V$$

$\therefore$ *Power Scale will be* :

$$\therefore\ 1cm = \sqrt{3} \times 415 \times 2$$

$$\therefore 1\ cm = 1437.56\ \ Watt$$

b) **State classification of insulating materials as per IS : 1271 — 1958. State temperature limits and one example of each.**

Ans: **(Any Six Classification is expected with one example 1 Mark each Total 6 Marks)**

Sr.No.	Insulation Classes	Maximum permissible temperature (^{0}C)	Insulating Material **Any One Example Is Expected**
1	Class-Y or O	90^0	Cotton, silk, paper, press board, wood, cellulose-, PVC, VIR.(Cotton, silk, paper, cellulose, wood etc.neither impregnated nor immersed in oil comes

			under this class.)
2	Class- A	105^0	Cotton, silk or paper impregnated paper & cellulose Easter.(Cotton, silk and paper suitably impregnated with natural resins, cellulose ester or immersed in oil come under this class.)
3	Class- E	120^0	Laminated Cotton, Synthetic resin enamels and paper laminations.
4	Class- B	130^0	Glass fiber, asbestos, mica, asbestos laminates. (Mica, glass fibers, asbestos with suitable bonding substances comes under this class.)
5	Class- F	155^0	Laminated asbestos, Glass fiber, and asbestos, Mica, built up mica.(Mica, glass fibers, asbestos Built up Mica, glass fibers, asbestos laminates etc. with suitable bonding substances of high thermal stability come under this class.)
6	Class- H	180^0	Made of inorganic material glued with silicon resin or adhesive coated on mica, glass fiber.(Materials such as Silicon elstomer and materials like Mica, glass fibers, asbestos with suitable bonding substances such as silicones come under this class. Built up Mica, glass fibers, asbestos laminates also comes under this class .)
7	Class- C	Over 180^0	Made of 100% inorganic material E.g. mica, porcelain, ceramics, glass, quartz, asbestos.(Mica, ceramics, glass, quartz without binders or with silicon binders of higher thermal stability come under this class.)

OR

This led IEC (International Electro technical Commission) to come up with the new categories:

- Class Y : 90^0 C: Paper, cotton, silk, natural rubber, polyvinyl chloride, etc. without impregnation. (formerly O)
- Class A : 105^0 C: Same as class Y but impregnated, plus nylon.
- Class E : 120^0 C: Polyethylene terephthalate (terylene fibre, melinex film), cellulose triacetate, polyvinyl acetate enamel.
- Class B : 130^0 C: Mica, fiberglass (alkali free alumino borosilicate), bituminized asbestos, bakelite, polyester enamel.
- Class F : 155^0 C: As class B but with alkyd and epoxy based resins, polyurethane.
- Class H : 180^0 C: As class B with silicone resin binder, silicone rubber, aromatic polyamide

(nomex paper and fiber), polyamide film (enamel, varnish and film) and estermide enamel.

- Class C : Above 180^0 C: As class B but with suitable non-organic binders; (Teflon, Mica, Micanite, Glass, Ceramics, Poly tetra fluoroe thylene)

Q.5 **Attempt any TWO of the following :** **16 Marks**

a) **Explain the open delta (delta-delta) test on transformer.**

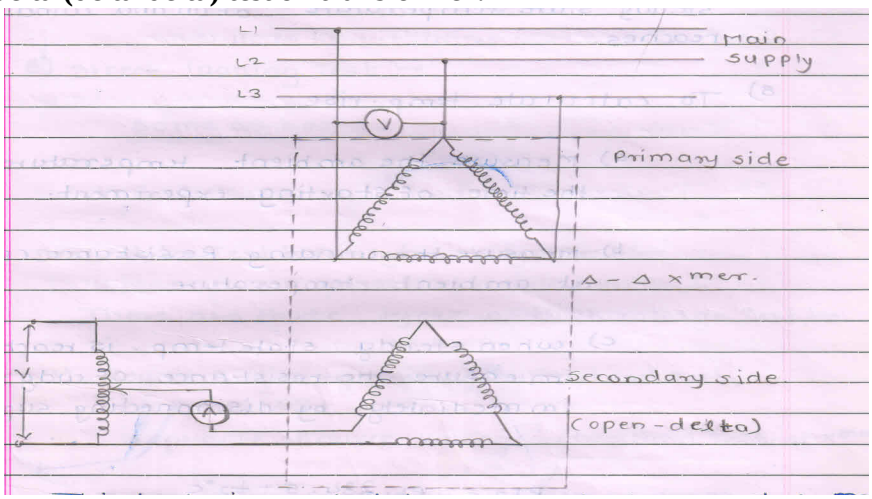
Ans:

(Objective:- 2 Marks, Circuit Diagram:- 4 Marks , Procedure:- 2 Marks)

This test is conducted on Delta/Delta Transformer to determine temperature rise for following purpose:- **(Any two objectives are expected)** **(2 Marks)**

1. To see whether rise in temperature of transformer oil and winding is as per designed value or not at full load.
2. TO see whether temperature rise of transformer oil & winding is within permissible limit or not.
3. This test is used to find maximum temperature rise of transformer oil & & winding at full load.
4. To see that transformer cooling arrangement is effectively designed or not.
5. To verify that whether the class of insulation used is able to withstand with rise in temperature at full load.
6. To find out gunanted temperature of oil & winding of transformer.
7. To understand possible overhead locations (Hotspot' inside and outside of the winding of transformer at full load.

Open delta (delta-delta) test on transformer: **(4 Marks)**



or equivalent fig

Procedure /Explanation : **(2 Marks)**

1. The primary side is excited at rated voltage & frequency.

2. The secondary side is connected in open delta
3. With the help of auto transformer increase the voltage in the secondary open delta winding till full load current circulate.
4. To measure the temperature rise the transformer is kept under rated load condition till maximum steady state temperature of oil and winding reaches
5. To calculate temperature rise:
   a) Measure the ambient temperature at the time of starting experiment
   b) Measure the winding resistance (Rt_1) at ambient temperature.
   c) When steady state temperature is reached measure the resistance of winding (Rt_2) immediately by disconnecting supply

$$Rt_2 = \frac{Rt_1\ 234.5 + t_2{}^0C}{234.5 + t_1{}^0C}$$

$$t_2 = ...^0C$$

$$Temperature\ \ rise = t_2 - t_1 = ...^0C$$

6. For measurement of oil temperature use thermometer
   a. Measure top oil temperature
   b. Measure bottom oil temperature

b) State factors involved in designing the machine foundation.

Ans: **Machine Foundation:-**

(Any Eight Factor or similar points Expected : 1 Mark each, Total 8 Mark)

Following information is required to start the foundation:-

1. Drawings of machine from foundation design point of view
2. Dimension of the machine:-
   - Its length
   - & width
   - Height of machine
3. Information about condition of soil:-
   - Bearing capacity of soil
   - Soil density
   - Ground water table location

4. Weight of machine:-
   - Erection weight
   - Operating weight
   - Imposed weight
   - Accessories weight
5. CG location in static and operating condition.
6. Level of plinth should be above the maximum flood level of the site.
7. Ground water level.
8. Whether machine is static, Rotating or Reciprocating.
9. Surrounding atmospheric condition.
10. Earth quake resistance should be considered while designing foundation.
11. The foundation should be able to absorb the vibration while operating at its full capacity.
12. The dimension of foundation should be proportional to safe bearing capacity of soil.

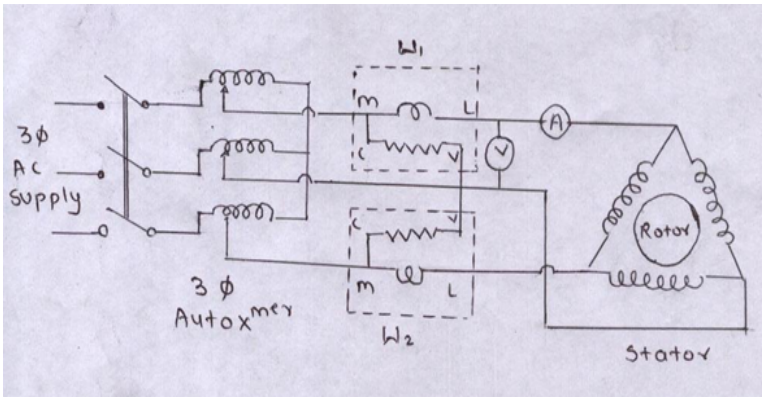
c) State the objective and procedure of performing reduced voltage running up test on 3-ph induction motor.

Ans: **(objective:- 3 Marks, Circuit Diagram:- 4 Marks , Procedure:- 1 Marks)**

Objectives:- :- (Any two objectives are expected) (3 Marks)

1. To determine the ability of motor to run equal and nearly equal to rated speed of the motor even at reduced voltage.
2. To see whether there is any tendency of crawling presents in the motor at reduced voltage.
3. To check whether , noise level, speed is within the tolerance limit or not

Circuit Diagram: (4 Marks)



or equivalent figure

Procedure:- **(1 Marks)**

1. Run the motor with rated voltage & measure the speed.
2. Now apply the reduced voltage $1/\sqrt{3}$ of rated value and measure the speed

   a) The motor below 37 KW, conduct the test in both direction.

   b) For motors above 37 KW, conduct the test only in specified direction of rotation.

Q.6 **Attempt any FOUR of the following :** **16 Marks**

a) **Prepare chart for maintenance schedule of distribution transformer as per ISS : 10028-1981.**

Ans: **(Any Four Point Expected : 1 Mark each point, Total 4 Marks)**

No	Frequency of inspection/Schedule	Inspection details (Any Two points are expected for each schedule activity)
1	Hourly	1. Measure & Check temperature it should be compared with rated figures 2. Check against rated figures
2	Daily	1. Cleanliness in the substation yard 2. Check Oil level in transformer. 3. Check the colour of Silica gel in breather. 4. Check physical condition of transformer. 5. Check the ground connection (earthing). 6. Check the condition of relief diaphragm
3	Monthly	1. Breathing holes in silica gel breather should be checked 2. Checking the Bushing for Dirt, dust deposits and cracks 3. Checking the radiator for Dirt and dust deposit 4. Measuring and checking the IR. 5. Checking the temperature alarms
4	Quarterly	1. Check cooling fan bearing motors 2. Examine contacts of alarms circuits 3. Check SC, EF relays 4. Check Winding and Oil temperature indicator and Buocholz Relay 5. Check Oil strength (dielectric). 6. Check operating mechanism of OLTC.
5	Half Yearly	1. Check the terminals and connections in the Cable boxes. 2. Examine the fuses etc. 3. Check the condition of foundation. 4. Check the earth resistance. 5. Check the oil level in OLTC. 6. Check conservator level of oil. 7. Check the lighting arrestor.

6	Yearly	1. Check Gasket for any leakage. 2. Test Oil 3. Check acidity and sludge
7	2 Yearly	1. Check Conservator tank. 2. Check the angle of bucholz relay 3. Check the operating condition of buchholz relay. 4. Check the condition of gasket. 5. Check the Transformer tank 6. Check WTI & OTI
8	5 Yearly	1. Overall inspection

OR Student may written this way

(Any Two points are expected for each schedule activity)

No	Frequency of inspection	Inspection
1	Hourly	1. Ambient temperature 2. Winding temperature 3. Oil temperature 4. Voltage (HV, LV side) 5. Current (HV, LV side)
2	Daily	1. Cleanliness in the substation 2. Oil level in transformer. 3. Colour of Silica gel in breather. 4. Physical condition of transformer. 5. Ground connection (earthing). 6. Relief diaphragm
3	Monthly	1. Breathing holes in silica gel breather 2. Bushing 3. Radiator 4. Insulation Resistance 5. Temperature alarms
4	Quarterly	1. Cooling fan bearing motors and operating mechanism 2. Alarms circuits contacts 3. SC, EF relays 4. Winding and Oil temperature indicator and Buocholz Relay 5. Oil strength (dielectric). 6. Operating mechanism of OLTC.
5	Half Yearly	1. Terminals and connections in Cable box 2. Fuses. 3. Foundation. 4. Earth resistance

		5. Oil level in OLTC. 6. Conservator oil Level 7. Lighting arrestor.
6	Yearly	1. Gasket joints 2. Oil filled bushing and OLTC 3. Oil in transformer
7	2 Yearly	1. Conservator tank 2. Angle of bucholz relay 3. Operating condition of buchholz relay. 4. Gasket 5. Transformer tank. 6. WTI & OTI
8	5 Yearly	Transformer overhaul

OR Student may written this way

(Any Two points are expected for each schedule activity)

1. Hourly Maintenance

1. Check & measure Voltage & current: It should be compared with rated figures given on name plate.
2. Check & measure ambient temperature.
3. Check & measure Oil & winding temperature: Ensure that temperature rise within permissible limit.

2. Daily Maintenance

After completing the activities during Hourly schedule following activities are necessary in Daily schedule

7. Check Oil level in transformer.
8. Check the air passage of breather is clear see that there is no dirt , dust accumulated at air passage.
9. Check the colour of Silica gel in breather.
10. Check tank and radiator against oil leakage.
11. Check the cooling system.
12. Check physical condition of transformer.
13. Check tap changer and oil position

14. Cleanliness in the substation yard should be done
15. Check the ground connection (earthing).

3. Monthly Maintenance

After completing the activities during daily schedule following activities are necessary in monthly schedule

6. Check the temperature indicators
7. Breathing holes in silica gel breather should also be checked monthly and properly cleaned if required, for proper breathing action.
8. Cleaning of Bushing for Dirt and dust deposit
9. Cleaning of the radiator for Dirt and dust deposit
10. The IR is compared with values from the safety point of view & process if required.
11. Checking the temperature alarms

4. Quarterly Maintenance

After completing the activities during Monthly schedule following activities are necessary in Quarterly schedule

1. Check Oil strength (dielectric).
2. Check operating mechanism of OLTC.
3. Check position of relief diaphragm fitted at the end of explosion vent against detoriated or damaged.

5. Half Yearly Maintenance

After completing the activities during Quarterly schedule following activities are necessary in Half yearly schedule

1. Check the acidity of oil in transformer.
2. Check oil filled in bushing.
3. Check the gasket joints.
4. Check the terminals and connections in the boxes.
5. Examine relay and alarm contacts there operations, fuses etc.
6. Check the foundation.
7. Check the earth resistance& insulation resistance.
8. Check the oil against moisture content in OLTC.

9. Check conservator see that level of oil is at marking.
10. Check the cable box
11. Examine the lighting arrestor.
12. All connections of HV & LV side should be tight and replace lugs if required.

6. Yearly Maintenance

After completing the activities during Half yearly schedule following activities are necessary in Yearly schedule

1. Check Oil in transformer against acidity, resistivity, sludge formation and tanδ.
2. Check Oil filled bushings.
3. Check lubricating oil in gear box of driving mechanism.
4. Check Surge diverter & gap.
5. All valves should be checked for any leakage and for open/close operation.
6. All activities mention above after 6 months are to be done

7. Two Yearly Maintenance

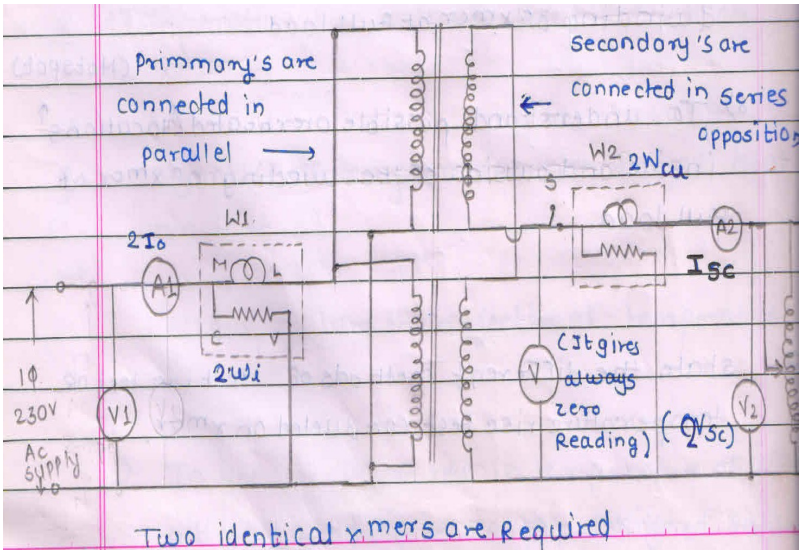
After completing the activities during Yearly schedule following activities are necessary in Two Yearly schedule

7. Conservator tank should be cleaned inside
8. Check the angle of bucholz relay
9. Check the transformer oil filtration process is to be done to restore the quality of oil.
10. Filter oil of OLTC
11. Examine the Contacts of OLTC
12. Check the radiator against any bend or dents
13. Check the operating condition of buchholz relay.
14. Leakage joints in transformer tank should be repaired by welding
15. Gasket may be replaced if necessary.
16. The level of oil in thermometer packets should be checked
17. All nuts, bolts, fasteners, should be checked
18. Paint the transformer to avoid rusting.

8. Five Yearly Maintenance

After completing the activities during Two Yearly schedule following activities are necessary in Five Yearly schedule

1. Overall inspection of core & winding by removing from transformer tank

b)	**State and explain effects of misalignment in rotating machines.**
Ans:	**(Any Four Points From the following or equivalent points are Expected 1 Mark to Each Point Total 4 Marks)** **Effects of misalignment:-** 1. There will be excessive vibrations. 2. Increase noise level. 3. The shaft will bent. 4. Increases in friction loss. 5. Premature bearing and coupling failure 6. Premature failure of belt/Rope /chain in case of indirect drive. 7. It increases maintenance cost. 8. It increases energy consumption. 9. It reduces motor efficiency. 10. Overall performance of machine reduces. 11. Early wear & tear of both driving & driven machine. 12. Loose or broken foundation bolts and coupling bolts 13. High bearings temperature. 14. High lubricating oil temperature.
c)	**Draw circuit diagram for back to back test on transformer.**
Ans:	**Circuit diagram for back to back test on transformer :** **(4 Marks)**  **or equivalent figure**

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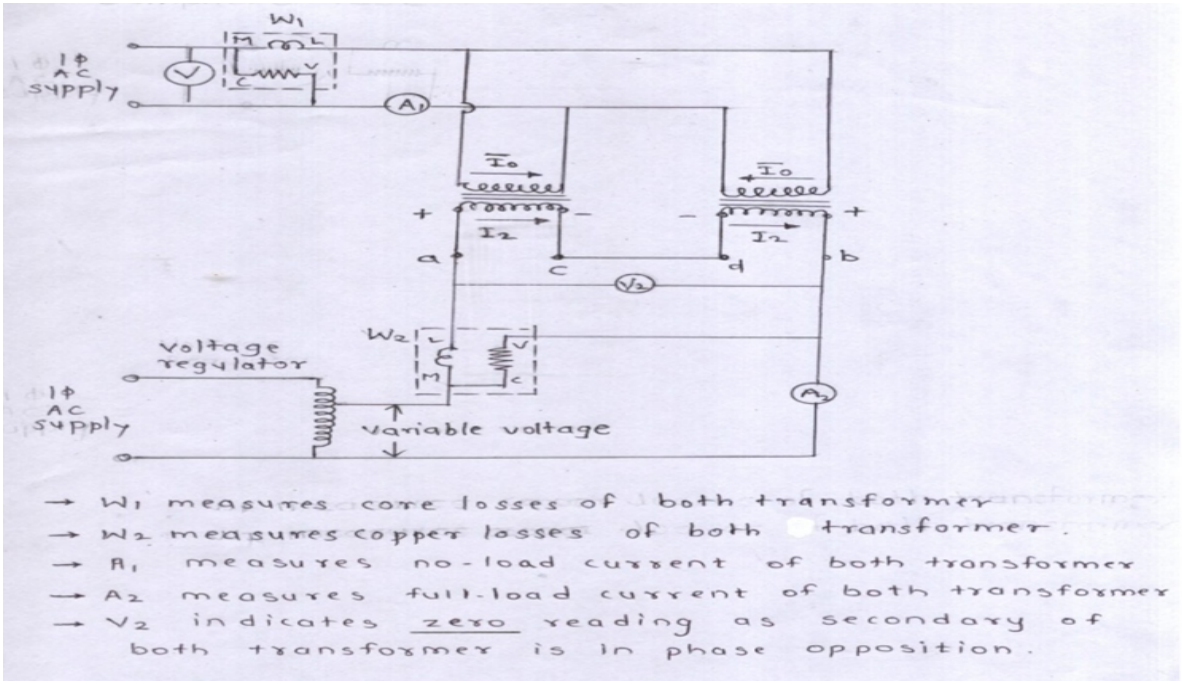

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d) Prepare a troubleshooting chart for 3phase squirrel cage induction motor. (any 4)

Ans:

(Any four Troubles from following or equivalent troubleshooting chart should be considered 1 Mark for each trouble/fault Total 4 Marks)

Sr.No.	Type of Troubles/ fault	Causes Any Two Causes are Expected	Remedies
1.	Motor fails to start	➢ Terminal voltage too low ➢ Blowing of fuse/single phasing. ➢ Defective starting mechanism ➢ Open circuit in supply cable. ➢ Loose contact. ➢ Overloaded	Rectify The Cause
2.	Motor stalls	➢ Wrong application ➢ Over load ➢ Low voltage	Rectify the Cause
3.	Motor does not pick up rated speed	➢ Starting load is high ➢ Low Voltage ➢ Low frequency ➢ Broken rotor bars or loose rotor	Rectify the Cause

	4.	Run Slow (Motor starts Sluggishly)	➢ Low voltage. ➢ Low frequency. ➢ Single phasing. ➢ Overload	Rectify the Cause
	5.	Motor Runs Hot	➢ Over/Under voltage. ➢ Over/Under frequency ➢ High ambient temperature ➢ Failure of cooling system ➢ Inadequate ventilation	Rectify the Cause
	6.	Vibration	➢ Loose foundation ➢ Worn out bearings ➢ Mis-alignment ➢ Run out to shaft/rotor	Rectify the Cause
	7.	Noise	➢ Loose foundation ➢ Worn out bearings ➢ Mis-alignment ➢ No uniform air gap or rotor rubbing on stator ➢ Foreign matter in air gap.	Rectify the Cause
	8.	Bearing overheating	➢ The bearing is not correctly assembled ➢ Too much grease/ No grease/ Foreign matter in grease. ➢ Oil level too high/ low. ➢ No oil ➢ Poor grade of oil or dirty oil.	

e) **A 110 kVA, 1-Ph transformer has a ratio of 1100/440 V the wattmeter reading on O.C. test is 1100 W. if the secondary winding S.C a voltage of 500 V at normal frequency applied to primary produces full load current the wattmeter is 1000 W. Calculate : (i) Secondary voltage, (ii) efficiency when current of 250 A at lagging PF is taken by a load connected to low voltage terminal. The primary voltage being 1100 V.**

Ans:

i) To calculate Full Load current:

$$I_{FL} = \frac{KVA \times 10^3}{V_1}$$

$$I_{FL} = \frac{110 \times 10^3}{1100}$$

$I_{FL} = 100 \ \ Amp$ - ---------- **(1/2 Marks)**

ii) To Calculate Secondary terminal Voltage:

V_2= 440V $\cos\phi = 0.8$ (lag) , $\sin\phi = 0.6$ (Assumed not mentioned in numerical)

Sec. terminal Voltage = $\sqrt{(V_2 Cos\phi + R_{02} I_2)^2 + (V_2 Sin\phi + I_2 X_{02})^2}$

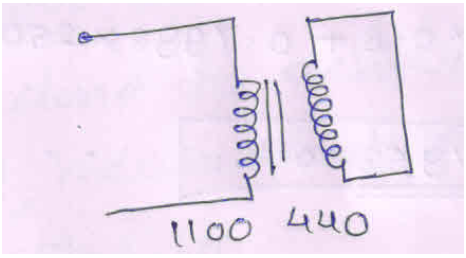
$V_2 = 440\,V$

$$I_2 = \frac{KVA \times 10^3}{V_2}$$

$$I_{FL} = \frac{110 \times 10^3}{440}$$

$I_2 = 250\ \ Amp$ ---------- **(1/2 Marks)**

iii) To Calculate resistance and reactance :



Full load copper losses : $I_{FL2}R_{O1}$

$$R_{01} = \frac{1000}{(100)^2}$$

$$R_{01} = 0.1\,\Omega$$

$$Z_{01} = \frac{V_{SC}}{I_{SC}}$$

$$Z_{01} = \frac{500}{100}$$

$$Z_{01} = 5\,\Omega$$

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

$$= \sqrt{(5)^2 - (0.1)^2}$$

$$X_{01} = 4.9989\,\Omega$$

We need R_{02} & X_{02} for Calculation:

$$K = \frac{V2}{V1} = \frac{440}{1100} = 0.4$$ ---------- **(1/2 Marks)**

$$R_{02} = K^2 \; R_{01}$$
$$R_{02} = (0.4)^2 \times 0.1$$
$$R_{02} = 0.016\,\Omega$$

$$X_{02} = K^2 \; X_{01}$$
$$X_{02} = (0.4)^2 \times 4.9989$$
$$X_{02} = 0.7998\,\Omega$$

Sec. terminal Voltage = $\sqrt{(V_2 Cos\phi + R_{02} I_2)^2 + (V_2 Sin\phi + I_2 X_{02})^2}$ ---------- **(1/2 Marks)**

Sec. terminal Voltage = $\sqrt{(440 \times 0.8 + 0.016 \times 250)^2 + (440 \times 0.6 + 0.7998 \times 250)^2}$

Sec. terminal Voltage = 584.7953 *Volts* ---------- **(1/2 Marks)**

To Calculate efficiency at 0.8 P.F lagging and full load:

Output in Power = KVA x P.F
= 110 x 0.8
= 88 KW

Total Losses in KW $= \omega_i + \omega_{cu}$
$= 1100 + 1000$
$= 2100\,Watt$ ---------- **(1/2 Marks)**

Losses in KW = $\frac{2100}{1000}$

Losses in KW = 2.1 *KW*

$$\%\ Efficiency\ (\eta) = \frac{output\ \ power}{out\ \ power + Total\ losses} \times 100$$ ---------- **(1/2 Marks)**

$$\%\ Efficiency\ (\eta) = \frac{88}{88 + 2.1} \times 100$$

$\%\ Efficiency\ (\eta) = 97.66\ \%$ ---------- **(1/2 Marks)**

---------- **END**----------