Important Instruction 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**

i) Define the terminologies used in: (Note : OR means any one statement expected)

(Each Definition 1 Mark)

1) Safety:

The meaning of the term safety is being safe, not being dangerous or in danger **OR**

The any method or technique or process which can minimize unwanted events or accidents is called as safety. **OR**

The preventive measures which are taken to avoid small or big accidents is known as safety. $Safety \propto \frac{1}{Risk}$

2) Hazard:

Hazard is a probable or possible cause of an accident. **OR**

Hazard is a potential condition a waiting to be converted in to an unwanted event or accident. **OR**

The things that arises without planning or random

3) Authority :

The person who has power to give orders & make others to obey the some is called as authority.

4) Responsibility:

The meaning of responsibility is being responsible or accountable for everything which are undergoes activities under the plant in charge.

ii) Explain why testing is carried out on machines or equipments.

Due to following reason testing is carried out on machines or equipments: (Any Four Expected – 1 Mark each)

1) Testing of electrical machine/ equipment is done to confirm whether the performance is as per design data or not.
2) It is done at manufacture's end & also by consumer before commissioning.
3) Variation in the actual values & designed values must be within tolerance limits as specified by ISS (Indian Standards Specification)
4) If the variations in results are not within tolerance limit it is necessary to modify design & material used.
5) Objectives of testing are to determine the quality of material used & workmanship.
6) Testing in all respect is also required when a new design or modified design is used, to check whether the new product works as per the revised designed or not.
7) Testing of equipment/machinery is also done after major maintenance of equipment.
8) Testing is necessary to avoid in convinces, avoid accidents & for safety purpose also.

OR

1) Due to testing it confirms whether machine/equipment is manufactures as per design data or not.
2) It verifies the actual values during testing and values specified by ISS
3) Testing verifies the difference between actual values & design values are whether within permissible limits or not.

4) Due to testing we can confirm quality of material & workmanship.

5) Due to testing it avoids in convinces avoid accidents.

iii) Give the maintenance schedule of Distribution transformer as per ISS 10028:1981

(1 Mark each point)

(Note: - Any Four Points from Below Are Expected & Not All)

Maintenance Schedule of distribution transformer up to 1000 KVA as per ISS 10028:1981:-

No	Frequency of inspection	Inspection	Inspection details	Action required when conditions are unsatisfactory
1	Hourly	Current, Voltage, temperature,	Check against rated figure	Starts fans if necessary
2	Daily	Dehydrating breather	Check that air passages are clear & check colour of acting agent	It silica gel is pink change it or reactivate it for use again
3	Monthly	Oil level in transformer	Check transformer oil level	If low add dry oil, examine the transformer for leads
4	Quarterly	Bushing	Examine for cracks and dirt deposits	Clean or replace
5	Half yearly	Conservator	Check for moisture cover	Improve ventilation check oil
6	Yearly	a) oil in transformer	Check for dielectric strength and water content, check for acidity and sluge	Take suitable action to restore quality of oil
7	Yearly	b) Earth resistance		Take suitable action if resistance is high
8	Yearly	c) Relay, alarms and their circuits etc	Examine relay alarms contacts, their operation fuses etc; check relay accuracy etc	Clean the components and replace contacts and fuses if necessary, change setting if necessary
9	Two Yearly	Non-conservator transformer	Internal inspection above core	Filter oil regardless of condition
10	Five yearly or after internal fault		Overall inspection lifting of core and coils	Wash by housing down with clean dry oil.

OR

Maintenance Schedule of Distribution transformer above 1000 KVA as per ISS 10028:1981

No	Frequency of inspection	Inspection	Inspection details	Action required when conditions are unsatisfactory
1	Hourly	a) Ambient temperature	Check that temperature is reasonable than normal	If abnormal heating shut down the transformer and investigate if heating is persistent higher.
		b) winding temperature		
		c) Oil temperature		
		d) Load voltage	Check against rated figures	
2	Daily	a) Oil level in transformer level	Check against transformer oil transformer for leaks	If low add dry oil examine
		b) Oil level in bushing	-	-
		c) Leakage of water into cooler	-	-
		d) Relief diaphragm	-	Replace if cracked or broken
		e) Silica jel Breather	Check that air passages are free, Check colour of active agent	If silica jel is pink change it by active spare charge and the old charge may be reactivated for further use
3	Quarterly	a) Bushings	Examine for cracks and direct deposits	Clean or replace
		b) oil in transformer	Check for dielectric strength and water contents	Take suitable action to restore quantity of oil
		c) Cooler fan bearing motors and operating mechanism	Lubricate bearings, check gear box, examine contacts, check manual controls and interlocks	Replace burnt or worn contacts of other parts.
4	Half Yearly	Oil cooler	Test for pressure	-
5	Yearly or earlier if transformer can conveniently be taken out for checking	a) Oil in transformer	Check acidity	Filter or replace and sluge
		b) Oil filled bushing	Test Oil	Filter or replace and sluge
		c) Gasket joints	-	Tighten the bolts to avoid uneven pressure
		d) Cable boxes	Check for ceiling arrangement for fitting holes, examine compound for leaks	Replace gaskets if leaking
		e) Surge diverter and gaps	Examine for crack and dirt deposit	Clean or replace
		f) Relays, alarm and their circuits etc	Examine relay and alarm contacts, their operation, fuses etc; check relay accuracy etc.	Clean the components and replace contacts and fuses if necessary, change setting if necessary
		g) Earth resistance	-	Take suitable action if it is high
6	5 Yearly	1000 to 3000 KVA	Overall inspection	Wash by hosing down

			including lifting of core coils	with clean dry coils

iv) Explain the care (protection) to be taken electrical equipments during the period of inactivity. (Note: Any similar point should be consider) **(4 Marks)**

Following care (protection) to be taken electrical equipments during the period of inactivity

1) All electrical connection should be disconnected.
2) Surrounding area of equipment should be made clean.
3) Equipment should be covered by suitable means so that no dirt, dust and moisture enter directly in equipment.
4) Caution board should be placed near machine **"THAT MACHINE IS UNDER IN ACTIVE"**

Q.1 b) Attempt any ONE of the following **6 Marks**

i) Given Data:

V= 217V, I = 4.6A, N= 960 rpm, radius = 0.045 m, F_1= 13kg and F_2= 3.3kg

Solution:

$Input\ \ power = V \times I$ ---------- **(1 Mark)**

$Input\ \ power = 217 \times 4.6$

$Input\ \ power = 998.2\ \ Watt$ ---------- **(1 Mark)**

$Torque\ \ T = (F1 - F2) \times r \times 9.81$ ---------- **(1 Mark)**

$T = (13 - 3.3) \times 0.045 \times 9.81$

$T = 4.282\ \ N - m$ ---------- **(1 Mark)**

$$Output\ \ power\ in\ watt\ = T \times \frac{2\pi N}{60}$$

$$Output\ \ power\ = 4.282 \times \frac{2 \times \pi \times 960}{60}$$

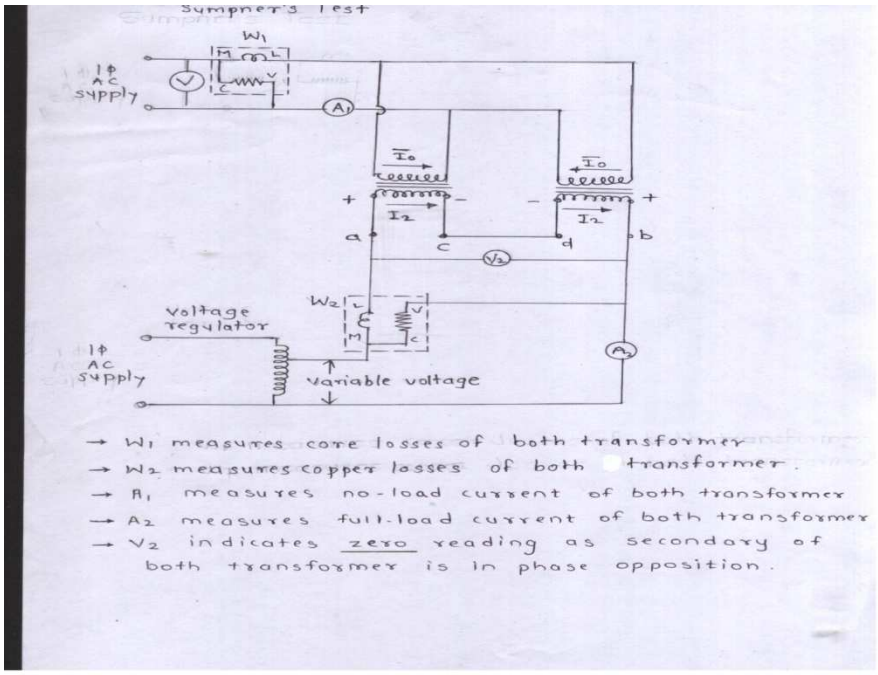
$$Output\ \ power\ in\ W\ = 430.473\ \ Watt$$ ---------- **(1 Mark)**

$$Efficency\ of\ Motor\ = \frac{output\ of\ motor\ \ in\ watt}{input\ of\ \ motor\ \ in\ watt} \times 100$$

$$Efficency\ of\ Motor\ = \frac{430.473}{998.2} \times 100$$

$$Efficency\ \ of\ \ Motor\ = 43.124\ \%$$ ---------- **(1 Mark)**

ii) Explain the procedure for back to back test on transformer with neat circuit diagram. State advantages and disadvantages of this method. (Procedure-2 Mark, Digaram-2 Marks and advantages – 1 Mark , Disadvanatges-1 Mark)



Or equivalent figure

Procedure:-

i) Make the connection as per circuit diagram shown in above experimental setup.
ii) The primary is connected in parallel while secondaries are connected in series opposition.
iii) One voltage regulator is required to inject voltage to secondary of transformer.
iv) Now supply is given at rated voltage & rated frequency (usually LV winding)
v) Take a reading of voltmeter V_1, ammeter A_1 and wattmeter W_1 in the circuit of primary side.
vi) Close switch 'S' and increase the auxiliary supply voltage in steps to circulate ,full load current in secondary &
vii) Take the reads of voltmeter V_2, ammeter A_2 and wattmeter W_2in the circuit of secondary side.

Advantages:- (Any one advantages expected)

1. Power consumption is low (only to met the losses)
2. No external load is required.
3. In addition to temperature rise we can determine efficiency & regulation of a transformer by this test.
4. Transformer with full flux drawing full load currents & hence is closest to the actual loading conditions with a physical load.

Disadvantages:-

1. The primary current of transformer 1 is less (being phasor difference of I_1 & I_0) than that of transformer (being phasor sum of I_1 & I0) where $2I_0$ is the load current.

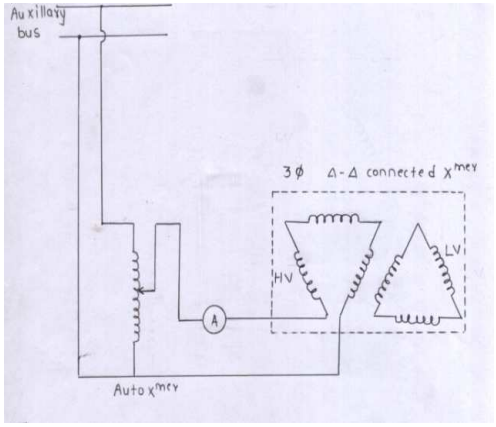
   Thus the two transformer do not operate under identical conditions one may have slightly less temperature than the other (or more heating effect of one as compared to other)

Q.2 Attempt any Four of the following **16 Marks**

a) Describe the open delta (delta-delta) test on transformers. (Figure-2 Mark & Explanation-2 Mark)

Open Delta (Delta-Delta) Test on Transformer:-

Circuit Diagram:-



Or equivalent figure

Explanation-

This method is applicable in case of a delta to delta connected transformer.

1. To circulate the current in the secondary as well as primary the connection are made as shown in figure.
2. Secondary voltage of auxiliary transformer is so adjusted that full load current circulates through 3-ph transformer secondary (as recorded by Ammeter A)
3. It will cause Full load current to circulate through transformer primary also.
4. Hence a condition similar to full load working conditions is developed.
5. To measure the temperature rise, the transformer is kept under rated load condition for several hours till maximum steady temperature is attained.

b) What are the factors to be considered in designing the machine foundation?

Following factors to be considered in designing the machine foundation: - (Each point 1 Marks) Note: Any Similar points may be consider

1. The foundation should absorb the vibrations created by the machine while operating at its full capacity.

2. The foundation should spread over as much area that will not exceed the intensity of load over the soil more than its safe bearing capacity.
3. The frictional resistance between foundation block and the soil should be sufficient to withstand the possible horizontal thrust caused by machine while in operation.
4. The foundation block should be so spread that the resultant of all the forces should pass within the foundation block.

c) Give the four reasons for developing electrical and magnetic faults. (Electrical fault reason-2 Mark & Magnetic fault reason- 2 Marks)

1) Following are some reasons due to Electrical faults:- (Any Two reasons are expected)

1. Low insulation resistance.
2. Punctured insulation between adjacent turns.
3. Punctured insulating separators between HV and LV winding.
4. Punctured insulation between ends of winding and yoke.

OR

1. Punctured insulator
2. Turn to turn short circuit.
3. Bad contacts of loss of contact.
4. Burning and darkening of Commutator.
5. Poor contacts in armature winding connection with Commutator.
6. Wrong setting of brushes on Commutator.
7. Wrong pole polarity. In case of transformer, puncturing of insulating separator, former between HV and LV end face insulation between ends of winding and yoke, failure of oil layer insulation between current carrying parts and tank wall.

2) Following are some reasons due to Magnetic Faults:- (Any Two reasons are expected)

Transformer may fail due to following magnetic faults:-

1. Warped and dented core laminations
2. Break down of insulation between laminations.
3. Core legs or yoke are loose or not fully tightened.

4. Faulty insulation of clamping studs.
5. Mis-aligned and damaged core clamping parts.

OR

1. Abnormal heating of core due to breakdown of insulation between core laminations or non- uniform distribution of magnetic flux between parallel branches.
2. Failure of insulation between core clamping bolts and core, short circuit between armature laminations, framing of laminations at teeth, loose pole fasting, mis-alignment of poles
3. Non –uniformity of air gap. In case of transformer wrapped and dented core laminations, burned iron due to sharp rise of losses in the core.
4. Turn to turn short circuit.
5. Bad contacts of loss of contact.

d) List the four agents which contaminates the insulating oil. (Any Four Point- 1 Mark each)

The insulating oil agents contaminated when the following impurities are present in oil:

1. Presence of water.
2. Presence of dissolved moisture.
3. Presence of carbon deposits.
4. Presence of dirt & dust.
5. Presence of sulpher.
6. Presence of gases.
7. Presence of acids.
8. Presence of alcohol.
9. Presence of acetones & aldehydes.
10. Presence of sludge.

e) List the four factors affecting preventive maintenance schedule

following Factors affecting preventive maintenance schedule:

(Any four points expected- 1 Marks each point)

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 times 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.

f) List the common troubles in electrical installation. **(4 Marks)**

Note: In this question questions credit may be given by judgment on part of examiner of relevant answer based on candidate understands

List the common troubles in Electrical Installation for example:-

1. Open circuit fault trouble
2. Short circuit fault trouble
3. Earth fault trouble

OR Student may write any one of the following

(Note: - Any Four Points from Below Are Expected & Not All)

a) Troubles in D.C Machines:-

4. Shorted coils
5. Grounded coils
6. Open coils
7. Reverse filed poles
8. Reverse commutating pole winding
9. Shorted armature coil
10. Open armature coil
11. Flash over between positive & Negative brush
12. Grounded armature coil

b) Troubles in A.C Machines:-

1. Shorted stator coils
2. Grounded stator coils
3. Open Stator coils
4. Broken rotor bar or open rotor bar

c) **Troubles in Transformer:-**

1. Open circuit (either in H.V or L.V)
2. Short circuit (between in H.V and L.V)
3. Ground fault (between H.V and core)
4. Ground fault (between H.V and supporting structure)
5. Shorted turns (either in H.V or L.V)
6. Presence of moisture in transformer oil.
7. Failure of magnetic circuit

d) Troubles in circuit breakers:

1. Damage of arcing contacts
2. Loosening of nuts and bolts of operating mechanisms.
3. Damage of arc control device
4. Failure of operating mechanism
5. Relay failure

Q.3 Attempt any Four of the following **16 Marks**

a) Explain the four factors on which severity of electrical shock depends.

The following Factors on which severity of Electrical shock depends: (Any four point Expected- 1 Mark each)

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

i) Magnitude voltage of the system.

ii) The period or duration for which the areas of contact with live part.

iii) It is also depends on supply system i.e. A.C or D.C.

iv) Body resistance (If wet resistance of body reduces)

v) Shock may occur even when voltage 50V rms AC low or 75V DC sometimes OR Low voltage does not mean low hazard.

vi) 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 fibration of heart
6	Above -200mA	Causes death, severe burns

b) Explain the importance of batteries in a sub-station and describe how you will take care of batteries. **(Importance -2 Marks & Care- 2 Marks)**

Importance of batteries in sub-station:

1. The DC auxiliary power source is required for protection system to operate protective relays of circuit breaker.
2. The DC auxiliary power source is required for control system in sub-station.
3. As a emergency supply for lighting and fan in control room.

Care of storage batteries: (Any four points from below total points are expected and not all)

Daily:-

1. Inspect the battery and the room for general cleanliness.
2. Check the height of the electrode.
3. Keep the record of the topping if done.
4. Check the voltage of the pilot cells.
5. Record and check the specific gravity and temperature of the electrolyte of the pilot cells.
6. Record and check the ambient temperature.

Weekly:-

1. Inspect the battery very carefully a) Remove dust or dirt if accumulated b) Keep the battery clean and dry.
2. Check the cells for cracks and electrolyte leakage if so take remedial measures.
3. Record and check the specific gravity, voltage and temperature of the pilot cells.
4. Check for plate bucking, collection of sediments at the bottom of the cell etc.
5. Give quick fleshing charge after every heavy discharge.

Fortnightly:-

1. Carry out inspection schedule as laid down above.
2. Topping of all the cells be done with distilled water.

Quarterly:-

1. Check specific gravity and temperature of each cell.
2. Check the voltage of the battery and each cell.
3. Check the level of electrolyte of each cell.

4. All the bolts and nuts should be checked for tightness. Petroleum jelly or Vaseline should be applied.
5. Check float and/or trickle charges.
6. Test the battery load and small continuously load.

Yearly Inspection:-

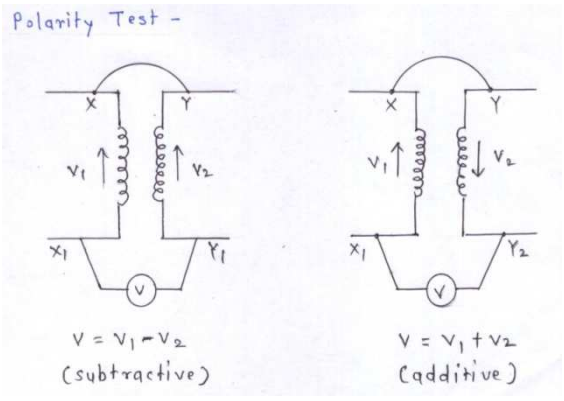
In addition to the inspection schedule given above, check for the following.

1. Condition of the individual cell.
2. Resistance i.e terminal as well as cell to cell.
3. Inspection of battery rack.
4. Level of the sediments if collected at the bottom of the cell.
5. Paint a fresh the racks, walls of the room with acid resistance paint if needed.

c) Explain the polarity test and phasing out test on transformer with diagram. (Figure -1 and explanation-1 Mark for each test)

1) Polarity test on Transformer :-

Figure:-



Or equivalent figure

The primary & secondary are supposed to have the same polarity when the turns in both winding go round the core in the same direction & the start & end leads are marked in the same ways. The direction of current in the two winding will then be the same.

Subtractive Polarity:

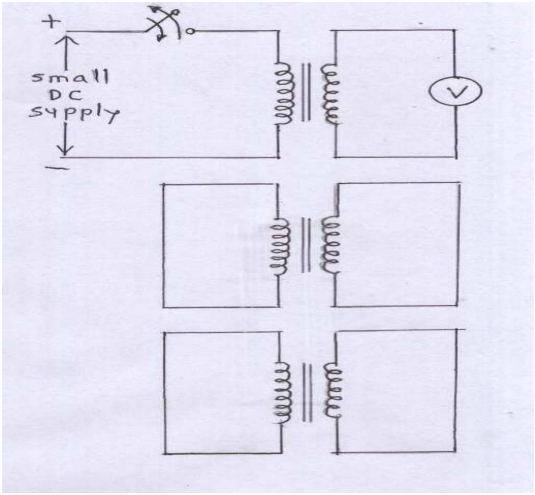
If 'X' & 'Y' connected together the voltage across X_1 & Y_1 will be found to be V= V_1-V_2 & the polarity is said to be same is called subtractive polarity.

Additive Polarity: -

If 'X' & 'Y' connected together the voltage across X_1 & Y_1 will be found to be V= V_1+V_2 & the polarity is said to be opposite is called additive polarity.

2) Phasing out test on transformer:

Figure: -



Or equivalent figure

Explanation:-

- Short primary & secondary winding of other phases expect the one under test.
- Connect voltmeter to secondary winding.
- A small DC current is circulated through the primary winding through switch.
- Now with the help of switch interrupt the DC supply instantly & repeatedly.
- If voltmeter indicator deflects than it indicates the two windings concerned belong to the same phase.
- If not deflect then two windings are not belong to same phase.
- Repeat the procedure by connecting voltmeter to secondary side to next secondary winding till voltmeter gives deflection.

In this way we can search the phasing out test.

d) Describe routine, preventive and breakdown maintenance with suitable examples. (One mark each meaning and 1 Marks to all example)

Note: In this question questions credit may be given by judgment on part of examiner of relevant answer based on candidate understands

Routine Maintenance means:- (Any one of the following point should be consider)

- It should be carried out daily if possible.
- The maintenance schedule is usually in the form of log sheets on which days, weeks, months of the year are tabulated.
- Routine maintenance is carried out without dismantling the equipment, but it must always be disconnected from supply before any repairs are undertaken.
- The routine maintenance work is carried out by the maintenance staff.
- Routine maintenance means checking/Cleaning/Repairing/Replacement of machine/equipment.

For Example (Activities)-: (Any one expected)

- 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.
- 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.
- Periodic visual inspection of various equipments to locate initial condition leading to breakdown.
- Inspect plant under working condition and also when it as rest.
- Up keep of equipment and plant & repair defects at their initial stage.
- Checking of stationary parts.
- Checking of movable parts.
- Checking of working condition of equipment or machinery.

- Checking of surrounding in which the machinery or equipment has to work i.e atmospheric condition.
- Checking of safety measures.
- Checking of protective device

1. **Preventive Maintenance:-**

Preventive maintenance is carried out to reduce the failure of equipment to minimum. **OR**

Preventive maintenance means proper maintenance and is carried out to reduce the failure of equipment to minimum. It consists of adoption of measures (reasons) to know before breakdown

For example: - (**Any one expected)**

1. Measurement of insulation resistance by megger,
2. Cleaning of machine by suitable blower to blown out dust, dirt etc
3. Checking of oil lubricated bearings.
4. Overhaul control equipment
5. It includes inspection of loose connection, ventilation, replacement of worn parts, change of oil, checking of insulation etc.
6. Overhaul

2. **Corrective or Breakdown Maintenance :**

Corrective maintenance is carried out when an equipment fails or does not work satisfactory. **OR**

When industrial plants or electrical machines are running and stop incidentally, it is known as breakdown. Breakdown maintenance is carried out when machine fail to run.

For example: - (**Any one expected)**

1. In this type of maintenance, immediate steps are taken to repair the fault.
2. Rewinding is carried out if winding is burnt out or parts are replaced immediately.
3. At the same time, following checks are carried out so that further breakdown should be not taking place.

i) Tightness of stationary parts is checked.

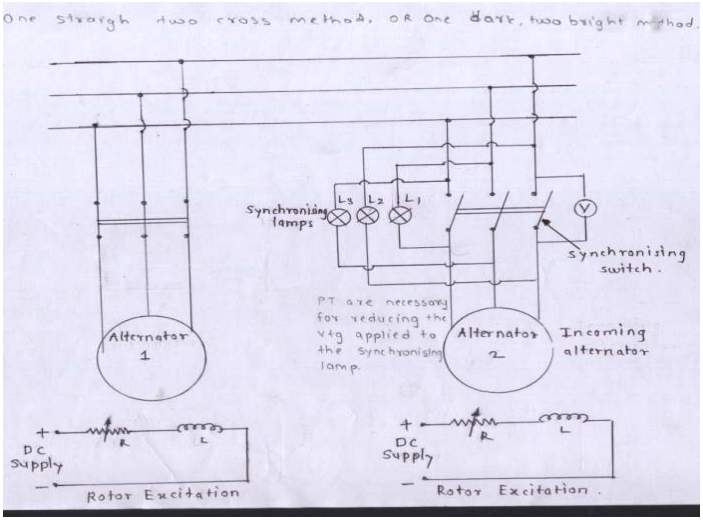
ii) It is also checked that the moving parts are free to move and there is no damage to it.

iii)Reasons for the fault to take place, which can be eliminated.

Atmospheric condition and surroundings in which the machine has to work

e) Explain one dark lamp and two equally bright lamp method of synchronization with diagram. **(Explanation-2 Marks & Figure-2 Marks)**

One dark lamp and two equally bright lamp method of synchronization:



Or equivalent figure

V_{L1} = Voltage across the lamps $L_1 = V_{R1} – V_{R2}$

V_{L2} = Voltage across the lamps $L_2 = V_{Y1} – V_{Y2}$

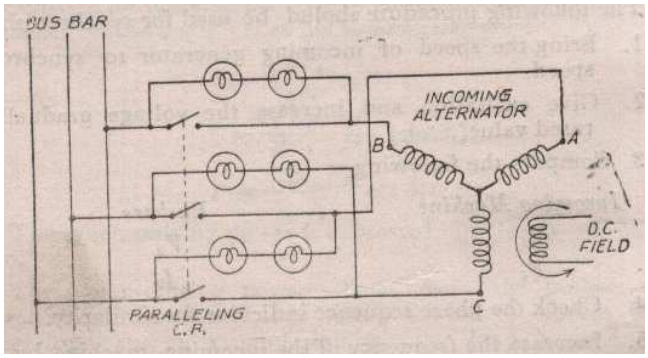
V_{L3} = Voltage across the lamps $L_3 = V_{B1} – V_{B2}$

- The 3 lamp pairs L_1 & L_2, and L_2 & L_2, and L_3 & L_3 of equal wattage and voltage rating are connected as shown in figure across the switch and to the bus bar and alternator terminals.
- The Phasor diagram of the bus bar voltages ($V_{R1}=V_{Y1}=V_{B1}$) and the Phasor diagram of voltage of incoming alternator ($V_{R2}=V_{Y2}=V_{B2}$) are shown in the figure.
- The lamps will still flickers in this case also and the rate of their flickering will depend on the amount of diff of the frequencies of the two alternators.

- The correctness of the phase sequence is indicated by the lamps blowing bright or dark, one after another and not simultaneously.
- The correct instant of closing the synchronizing switch is when the straight connected lamps are dark and the cross connected lamps are equally bright.

OR

Method of synchronizing by means lamps:



- If the synchroscope is not available, synchronizing lamp method is used.
- There are different methods of lamp connection. The method of two bright and one dark lamp indication is illustrated in above figure.
- In this connection the lamps become bright and dark as follows for correct phase sequence. “Two lamps bright and one lamp dark at a time”.
- If all the lamps become simultaneously dark or bright, the phase sequence is wrong.
- The switch is closed when the voltage, frequency and the lamps (2 bright and 1 Dark) satisfy the condition of synchronism.

Q.4. a) Attempt any Three of the following **12 Marks**

i) Explain the methods of testing : 1) Direct 2) Indirect by giving example (Explanation- 1 Mark & Example 1 Mark for each test)

1) Direct loading method of testing:-

- Direct method of testing is, in which the machine under test can be loaded directly, either with the help of brake arrangement or coupling a calibrated machine to its shaft for loading purpose.

- This test is conducted for small capacity equipment/machine/transformer.
- Power consumption is more
- During this test more heat is generated.
- Results obtain are more accurate.

For Example Methods:

a) Brake load Test b) Calibrated machine test

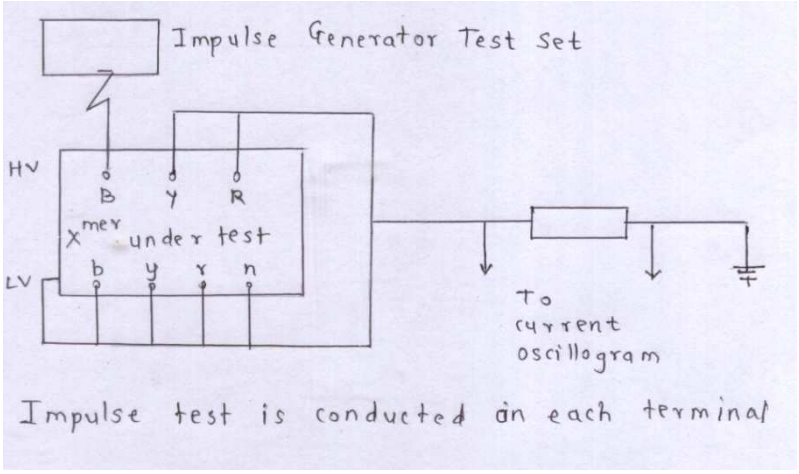
2) Indirect loading Method of testing:-

- In case of indirect testing method equipment/machine/transformer are not directly loaded but machine runs on No- load.
- Its performance characteristics are determined by using the data obtained in the no-load test performed on the machine.
- This test is conducted for large capacity equipment/machine/transformer.
- Power consumption is less.
- Efficiency at any desired load condition, even over loads can be determined by this test.

For example :- Swinburne's Test, OC/SC Test, To draw the circle diagram of 3-ph I.M

ii) Describe the impulse voltage withstand test on transformers. (Explanation-2 Mark & Figure-2 Mark)

Figure:-



Or equivalent figure

Objectives:-

- To ensure the effectiveness i.e. dielectric strength of the insulation system of transformer against lighting impulse.
- The impulse voltage withstand test is intended to check the ability of the transformer to withstand over-voltages of atmospheric origin.

Equipment used:

Impulse voltage test is conducted for this impulse generator is used to obtain specified impulse voltage wave. The standard impulse waves are of three types:

1. Lightning impulse: 12/50 micro sec.
2. Switching impulse: 250/2500 micro sec.(test is conducted for power transformer above 365KV)

   Chopped impulse wave: 1.2/50 wave chopped at about 5 micro sec.(chopped impulse test is special test performed if user needed.)

Impulse frequency test voltages for oil immersed transformer table :(Note: Any one voltage is expected not all)

No.	Normal system Voltage KV rms	Highest system voltage KV rms	Impulse withstand voltage 1/50 wave positive & negative polarity KV (crest)
1	3.3	3.6	45
2	6.6	7.2	60
3	**11**	**12**	**75**
4	**22**	**24**	**125**
5	**33**	**36**	**170**
6	66	72.5	325
7	110	123	450*
8	**132**	**145**	**550***
9	**220**	**245**	**900***
10	**400**	**420**	**1425***
	*Applicable where the system is effectively earthed		

iii) State four properties of good transformer oil.

Following Properties of Good Transformer oil:- (Any four point expected-1 Mark each pt)

1. It should be have a high dielectric strength (Not less than 30KV (rms) for the gap 4mm of the electrodes or 20KV (rms) for the gap 2.5mm 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.

iv) What are the effects of mis-alignment?

The following Effects of Mis-alignment:- (Any four point expected – 1 Mark each)

1. Misalignment causes, it reduces the machine's life and causes a decrease in motor arrangement efficiency, and misaligned machinery is more prone to failure due to increased load on bearing, seals and coupling.
2. In most of the cases, misalignment in motor exhibits the combination of both types of misalignment.

3. Offset Misalignment which is the amount by which the alignment of driver and driven shaft are out of parallel alignment and Angular Misalignment which is the amount by which the alignment of driver and driven shaft.
4. Detection of misalignment using broken rotor bar sideband and components.
5. Effect of increased vibration is premature bearing failure.
6. cause increased vibration and loads on the *machine* parts for which they have not been designed
7. Reduce the bearing life.

Q.4. b) Attempt any ONE of the following **6 Marks**

i) Explain the following tests on transformer oil 1) Acidity test 2) Sludge test and 3) Flash point test **(Each Test- 2 Marks)**

1) Acidity Test:

The limits of permissible acidity test of oil are:

i) Acidity below 0.5 mg (KOH)/g: - No action need be taken if oil is satisfactory in all other respects.

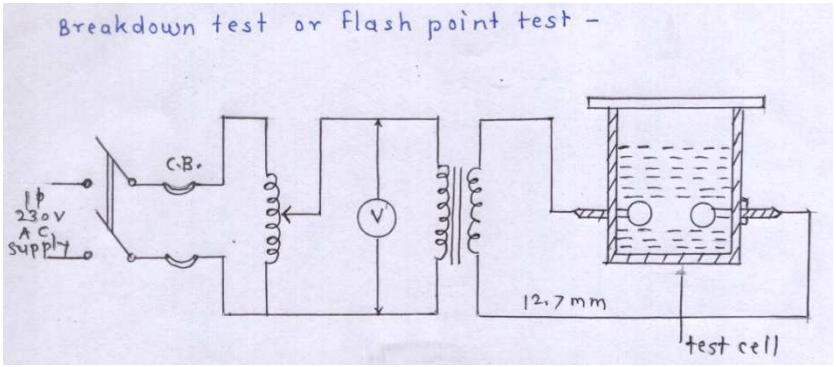
ii) Acidity between 0.5 mg & 1.0 mg (KOH)/g: - Oil is to be kept under observation.

iii) Acidity exceeds 10 mg (KOH)/g: - Oil should be discards or treated.

2) Sludge Test: -

Sludge is formed when oil gets overheated or due to suspended solid impurities in oil. Oil which has been contaminated by a fault in a transformer is unsuitable for use.

3) Flash point Test:-

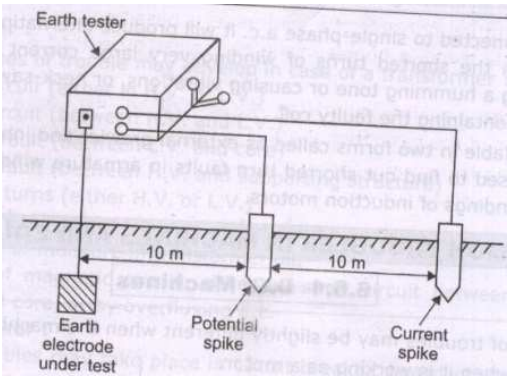


Or equivalent figure.

- The sample of oil is down from near the top & bottom of the transformer.
- 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 to be covered with clean glass plate.
- The supply is switched ON & voltage is raised gradually by the variac.
- Till final break down of oil takes place & circuit breaker gets tripped & disconnect the transformer from the main supply.
- The test is performed with 2 or 3 consecutive samples of the oil one by one.
- Average of all subsequent tests is considered as the breakdown voltage of oil sample.
- This value is noted down which must be 30 KV (rms) for 4 mm +- 0.02 mm gap.
- If this value is lower than 30 KV than it indicates presence of moisture in oil.
- Oil in good condition when its breakdown voltage is 45 KV (rms) for 4mm gap for one minute.

ii) Describe the use of following tools 1) Earth Tester 2) Megger 3) Multimeter (Each Tools -2 Marks and figure not expected)

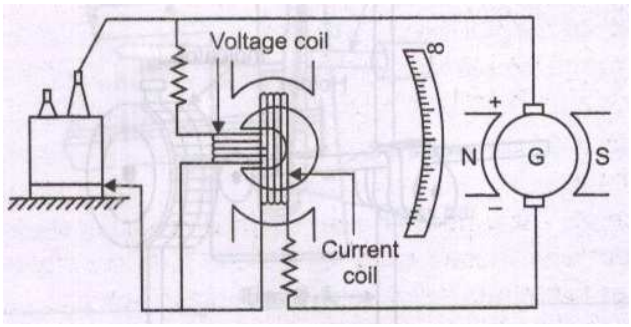
1) Earth Tester: -



- Earth tester is used for measurement of earth resistance.
- A earth tester works on the same principle as a megger.
- The difference being that slip-rings are also provided on the hand driven generator to permit AC supply to the external circuit through the soil to eliminate electrolytic effects.

- A Commutator which will rectify the current before it is applied to the moving coil elements. Figure represents the circuit diagram for measuring earth electrode resistance

2) Megger:-



- Megger is used to find out insulation resistance of electrical machine/equipment
- Meggers (mega ohm meter) are available for DC voltage of 500V to 2500V. Generally in practice 500V meggers are used.
-

3) Multimeter:- (Any Two expected)

- Measurement of voltage of various ranges.
- Measurements of current of various ranges.
- Measurement of DC resistance
- To check the Continuity

Q.5. Attempt any Two of the following **16 Marks**

a) Given Data:

Note: 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.

i) No-load Test:

V_1= 200V, I_0 =5A, W_0= 350 watt

$$\phi_0 = Cos^{-1}\left(\frac{W_0}{\sqrt{3}\,V_1\,I_0}\right) = Cos^{-1}\left(\frac{350}{\sqrt{3}\times 200\times 5}\right)$$

$\phi 0 = 78.34^0$ *Electrical lag* ---------- **(1 Marks)**

ii) Blocked Rotor Test:

V_{SC}= 100V, I_{SC} =26A**, W_{SC}= 1700 watt**

$$\phi_{SC} = Cos^{-1}\left(\frac{W_{SC}}{\sqrt{3}\,V_{SC}\,I_{SC}}\right) = Cos^{-1}\left(\frac{1700}{\sqrt{3}\times 100\times 26}\right)$$

$\phi_{SC} = 67.82^0$ *Electrical lag* ---------- **(1 Marks)**

iii)

$$I_{SN} = \left(\frac{V}{V_{SC}}\right)\times I_{SC} = \left(\frac{200}{100}\right)\times 26$$

$I_{SN} = 52\ A$ ---------- **(1 Marks)**

iv) Current Scale:

1 cm = 2.5 A,

v) (To write this procedure to draw circle diagram is not expected)

Draw Vector OO$'$ lag behind V-Axis by ϕ_0. This is I_O

Draw Vector OA lag behind V-Axis by ϕ_{SC}. This is I_{SN}

Join O$'$ A This is output line

Draw Horizontal line O$'$H.

By Drawing perpendicular bi sector of O$'$ A, It will inter sect O$'$H at C. C is the centre of required semi circle having radius CA or C O$'$

vi) Power Scale:-

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

$$W_{SN} = (\frac{200}{100})^2 \times 1700$$

$$W_{SN} = 6800\ Watts$$

Power Scale = $\frac{W_{SN}}{Length\ of\ \ AG\ in\ cm}$

Power Scale = $\frac{6800}{8.5}$

Power Scale = $800\ watts/cm$ ---------- **(1 Marks)**

vii) Length of AX in cm=

$$= \frac{Output\ \ in\ watt}{Power\ \ \ Scale}$$

$$= \frac{3730}{800} = 4.66\ cm$$ ---------- **(1 Marks)**

viii) Draw line parallel to output line O/ A from point 'X', it will intersect the semi circle near V-axis at L. The length of vector OL is 6 cm

∴ Full load current = length of OL in cm X current scale

= 6 cm X 2.5 A/cm

= 15A ---------- **(1 Marks)**

ix) **To write the following procedure is not expected**

Torque Line O/ E bi sects AH because stator copper losses = Rotor copper losses

Draw a line tangent to semi circle parallel to torque line at 'S'. Drop the perpendicular on 'X' axis, it will intersect torque line at 'P'. The Length of 'SP' in cm represent maximum torque

and the vertical length from point 'L' on torque line i.e. 'LN' represents maximum full load torque

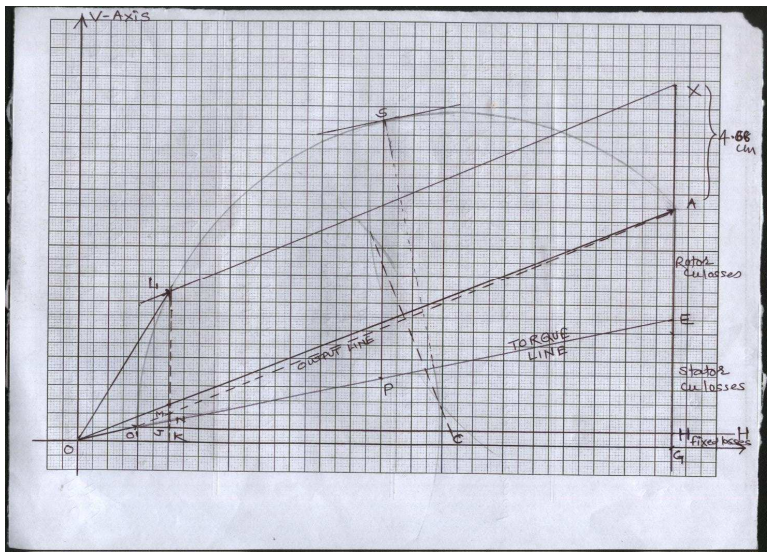
$$\frac{Maximum\ torque}{full\ \ load\ torque} = \frac{SP\ in\ cm}{LN\ in\ cm} = \frac{9.2}{4.7}$$

Maximum torque =1.96 (full load torque) ---------- **(1 Marks)**

x) Power factor = $\frac{LK\ in\ cm}{OL\ in\ cm} = \frac{5.5}{6}$

Power factor = 0.92 ---------- **(1 Marks)**

Circle Diagram:-



b) Given Data:

T_A = 100 KVA, R_A = 0.9%, X_A = 6%

T_B = 50 KVA, R_B = 1%, X_B = 5%

Solutions:-

i) Load carried (Shared) by each Transformer

$(KVA)_L = 125\angle -36.8698\ KVA$

$Z_A = R_A + X_A \qquad Z_A = 0.9 + j\ 6$

$Z_A = 6.0671 \angle 81.4692$ Ohm---------- **(1 Mark)**

Let the base impedance to base = 100 KVA

Convert the impedance to base KVA

$Z_B = \frac{100}{50}(1 + j\,5)$ ---------- **(1 Mark)**

$Z_B = 2\,(1 + j\,5)$

$Z_B = 2 + j\,10$ Ohm

$Z_B = 10.1980 \angle 78.6900$ Ohm ---------- **(1/2 Marks)**

$Z_A + Z_B = (0.9 + j\,6) + (2 + j\,10)$

$Z_A + Z_B = (0.9 + 2) + j\,(6 + 10)$

$Z_A + Z_B = 2.9 + j\,16$

$Z_A + Z_B = 16.2602 \angle 79.7266$ Ohm---------- **(1/2 Marks)**

i) Load carried (Shared) by each Transformer:

Transformer A = $(KVA)_A = (KVA)_L \times \frac{Z_B}{Z_A + Z_B}$ ---------- **(1/2 Marks)**

$(KVA)_A = 125 \angle -36.8698 \times \frac{10.1980 \angle 78.6900}{16.2606 \angle 79.7266}$

$(KVA)_A = 125 \angle -36.8698 \times 0.6271 \angle -1.0366$

$(KVA)_A = 78.3950 \angle -37.9064 \quad KVA$

$\therefore (p.f)_A = Cos\ (37.9064)$

$\therefore (p.f)_A = 0.7890 \quad lag$ ---------- **(1/2 Marks)**

$(KW)_A = (KVA)_A \times (p.f)_A$

$(KW)_A = 78.3950 \times 0.7890$

$(KW)_A = 61.8548 \quad KW$ ---------- **(1 Marks)**

Transformer B= $(KVA)_B = (KVA)_L \times \frac{Z_B}{Z_A + Z_B}$

$$(KVA)_B = 125 \angle -36.8698 \times \frac{6.0671 \angle 81.4692}{16.2606 \angle 79.7266}$$

$$(KVA)_B = 125 \angle -36.8698 \times 0.3731 \angle -1.7426$$

$$(KVA)_B = 46.6395 \angle -35.1272 \quad KVA$$ ---------- **(1 Marks)**

$$\therefore (p.f)_B = Cos \ (35.1272)$$

$$\therefore (p.f)_B = 0.8178 \quad lag$$ ---------- **(1/2 Marks)**

$$(KW)_B = (KVA)_B \times (p.f)_B$$

$$(KW)_B = 46.6395 \times 0.8178$$

$$(KW)_B = 38.1453 \quad KW$$ ---------- **(1 Marks)**

If load is increased continuously which transformer gets loaded first? Why? ----(1/2 Mark)

If load is increased continuously, **Transformer 'A'** will get overloaded first, because Load shared by transformer is directly proportional to KVA rating and inversely proportional to its impedance. The KVA rating of the transformer 'A' is greater than transformer 'B', while impedance of transformer 'A' is less than transformer 'B'

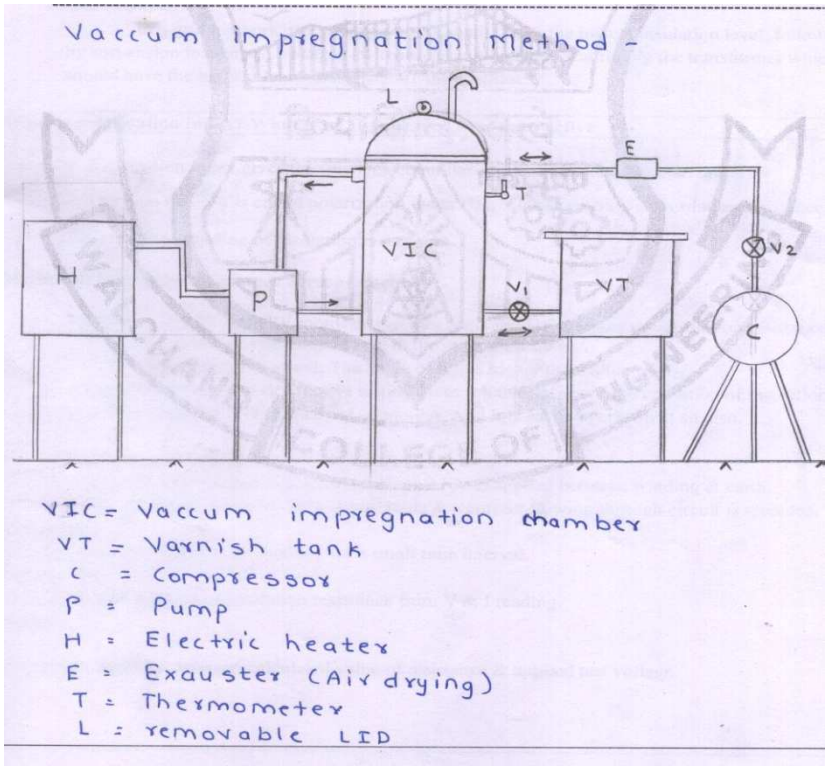
c) Explain the procedure for cleaning, washing and drying of insulation and describe the vacuum impregnation method of varnishing. (**Procedure of cleaning, washing& drying-4 Marks and Vaccum impregnation Method Explanation-2 Marks & Figure- 2 Marks)**

Following procedure of cleaning, washing and drying of insulation of electrical machines:-
(Any four point expected)

i) Removal of loose dust by blower, the pressure of forced/suction air should be moderate.
ii) Removal of loose dust by vaccum cleaner,
iii) Dry dust can be removed by soft brush.
iv) Clean open dust/dirt on open cables by cotton waste.
v) Sticky dirt can be removed by fibrous scraper smoothly.
vi) Oily viscous films can be removed with approved petroleum solvent & then cleaned by cotton cloth.
vii) Particularly 'H' Class insulation can be cleaned with fresh water & detergent.

viii) The cleaning should be done as quick as possible & excess moisture can be cleaned by dry cloth & machine should be booked dry in oven.

Vacuum impregnation method of varnishing:



Or equivalent figure

The procedure to impregnate the winding (insulation):-

- This method is similar to hot dip method. In Hot Dip method we can't be sure whether all the air spaces (pockets inside) the winding are perfectly impregnated with the varnish or not.
- In vaccum impregnation all the air is removed, so varnish occupies all such spaces. After this if proper baking is done the varnishing is perfect and through.
- The plant consists of a large air tight chamber 'A' with a removable lid'B'. The varnish is stored in Tank 'C'. The compressor can create vaccum or pressure of 1.5 kg/cm^2 to 2 kg/cm^2 in tank A as required.

OR

The procedure to impregnate the winding (insulation):-

1. The winding is placed in tank A, and then it is heated up to 100^0C for 2 to 4 hours by circulating steam or oil through the jacket. This drives all the moisture and air inside the coil.
2. During this process the tank is thoroughly evacuated with the help of compressor, for heating the water or oil, electrical boiler is used and for the circulation of steam or oil, the pump is used.
3. The value V' is now opened and as there is vacuum in the chamber 'A' the varnish from varnish tank 'C' rushes into chamber 'A'. The inflow of varnish continuous until the winding or coil to be impregnated is fully immersed into the varnish. The value 'V' is then closed.
4. Air pressure at 1.5 kg/cm^2 is applied into the space above the varnish level into the tank. The varnish is now forced into porous spaces inside the coil.
5. The valve 'V' is again opened after about half an hour. The varnish flows back to varnish tank 'C' under the pressure present in the chamber 'A'. When whole of the varnish goes back to tank 'C' valve 'V' is again closed.
6. The coil is then removed and kept in a baking oven for 4 to 8 hours at a temperature of 100^0C to110^0C. This will cause the varnish to set properly and become bone dry. The temperature should not be more than 110^0C otherwise insulation will get damaged.

Q.6. Attempt any Four of the following **16 Marks**

a) Explain the procedure for leveling and alignment of electrical machine.

The following procedure for leveling and alignment of electrical Machine: (Any two points expected) **(4 Marks)**

i) The motor shaft should be level. The motor shaft cannot be made level unless the shaft of the driven machine is previously leveled. Therefore the driven shaft is leveled 1st that is the shaft must be in line. In case of belt or gear drives, they must be parallel.

ii) The two shafts must be in line, the two shafts should be on the same centre.

iii) The lining up is checked by making measurements with steel tape, from the centre of the driven shaft to the centre of the motor shaft.

OR

Procedure of alignment of shaft of electrical machine

The shafts of driven and driving machine are aligned by various methods. The most common one is the alignment by flexible coupling method. **There are three steps in the alignment of the shafts.**

i) Axial positioning of the shafts.
ii) Paralleling of shafts axis.
iii) Centering of shaft axis

OR

Procedure of alignment of shaft of electrical machine: (Any two points expected)

i) Align the motor and the driven machine on bed-plate in their final position with shims under their feet.
ii) Mark both half-coupling by means of chalk line. Make accurate measurement between the gaps between the faces of the vertical surfaces. Turn the motor shaft through 90^0,180^0, 270^0 and 360^0 and note the reading of the gap.
iii) The excess difference is reduced below 0.05 mm by adjusting the shims.
iv) Likewise the difference in the highs of axis of drive coupling and driven coupling is gauged by suitable method. One of the method of gauging the gap between vertical surfaces of coupling and the difference in heights is by using single point turn point Run over Gauge.

b) Prepare trouble shooting chart for 3-Ph Induction motor. (Any four points expected -1 Mark each point)

(Note: - Any Four Points from Below Are Expected & Not All)

S.No	Type of fault	Causes	Remedies
1	Motor fails to start up	-Open circuit in DOL/Star-delta starter. -Brushes make no contact with slip	Rectify The Cause.

		rings. -Rotor of fan rubbing on stator -Worn contacts of star-delta starter. -Excessive load on starting. -Terminals voltage too low	
2	Motor starts up sluggishly/Excessive speed reduction when motor is loaded	- Supply voltage is too low (Voltage drop when motor is loaded) - Stator connected in Star instead of delta. - One motor terminal was by mistake connected to neutral instead of phase	Rectify The Cause.
3	Motor hums a) During Stat up b) When running	a)Unequal phase resistance - Open circuit - Or inter turn short circuit on rotor b) Short circuit between turn to turns or parts of stator winding - Multiple winding to frame short circuit (earth fault)	Rectify The Cause.
4	Thermal overload protection operate while motor is running	-System frequency too high -Excessive core loss -Single phasing i.e O.C. in stator winding or supply cable -Stator winding is incorrectly connected i.e. in star instead of delta -Motor was incorrectly selected for type of duty involved. e.g selecting short time or intermittent duty instead of continuous duty at full load -Inadequate ventilation (i.e cooling system) -Air flow obstructed -Thermal overload protection incorrectly rated or adjusted.	Rectify The Cause.
5	Regular Clicking(short sound)	Foreign matter in air gap	Remove foreign matter
6	Vibration	-Misalignment in coupling or flange -Accumulation of dirt on fan. -Vibration in driven machine	-Realign motor& driven equipment. -Clean motor -Run motor disconnected from driven load & check for vibration. Eliminate source in driven equipment. -Alter rigidity of base

		-Twisted base or flange -Excessive end play. -Shaft bent or flange face run out	structure -Check flange alignment and shims. -Adjust end play. -Straighten or replace shaft, Reface or replace housing
7	Motor over heating (Check with thermocouple or by resistance method, do not depend on touch)	-Overload -Single phasing - Dirt in motor - Unbalanced voltage - Rotor rubbing on stator - High ambient -Open Stator winding - Air Recirculation -Over voltage/under voltage - Ground - Improper electrical connections -Heat exchanger tubes blocked	- Measure load & compare with nameplate rating and reduce the load. - Check current all phases - Check flow of air, filters, if so equipped and clean motor. - Check voltage, all phases - Check air gap, repair motor as necessary. -Check air inlet temperature. - Disconnect motor from load. Check idle amps for balance in all phases, check stator resistance in all phases for balance -Check intake & exhaust for obstructions. -Check voltage and compare to rating plate. - Locate with test lamp or insulation tester and repair -Recheck electrical connections. Clean tubes, if so equipped
8	Bearing Overheating	- Oil level too high or low -Misalignment - Excessive end thrust - Too much grease (ball or roller Bearing)	- Correct oil level - Realign motor and driven equipment. - Reduce thrust. Recheck mounting & alignment. - Relieve supply to point set by manufacture.

c) Explain the procedure for developing preventive maintenance schedule.

The following procedure is carried out for developing preventive maintenance schedule :

(One Mark for each procedure point)

Well planed Preventive maintenance programmed /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?

OR

- 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.

OR

(Note: - Any Four Points from Below Are Expected & Not All)

i) Periodic visual inspection of various equipments to locate initial condition leading to breakdown.
ii) Up keep of equipment and plant & repair defects at their initial stage.
iii) Checking of stationary parts.
iv) Checking of movable parts.
v) Checking of working condition of equipment or machinery.
vi) Checking of surrounding in which the machinery or equipment has to work i.e atmospheric condition.
vii) Checking of safety measures.
viii) Checking of protective device.

ix) Checking the list of consumable and non consumable items to be used in the equipments and machinery.

x) Checking of stores and stored inventory.

xi) Checking of tools, trackless, jacks and fixtures etc.

xii) To attend major breakdown and repairs.

d) What are the precautions to be taken, to avoid fire due to electrical reasons?

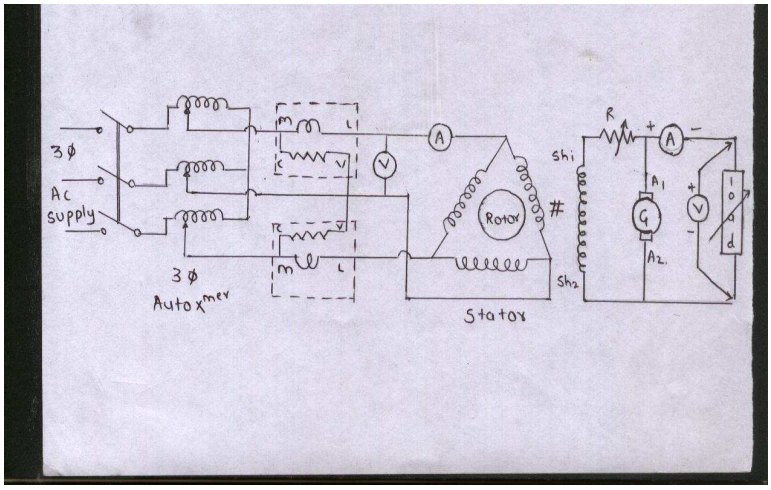
Fire due to electric current can be prevented by taking the following precautions: (Any four points expected -1 Mark each point)

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 maintained as per Voltage level.
9. Avoid use of too many device plugged into a circuit, causing heated wire & possible a fire.

Draw a neat circuit diagram for performing load test on 415V, 3-Ph, 4.8A, 3HP, Delta connected Squirrel cage induction motor. Specify the meter reading. (Circuit diagram -3 Marks & Ranges of meter -1 Mark) (Any One Figure is expected)

Full Load Test Circuit Diagram:

a) If generator is coupled with induction motor:-



Or equivalent figure

Range Of Meters: AC Side:- (Note : Nearest standard rating may be consider)

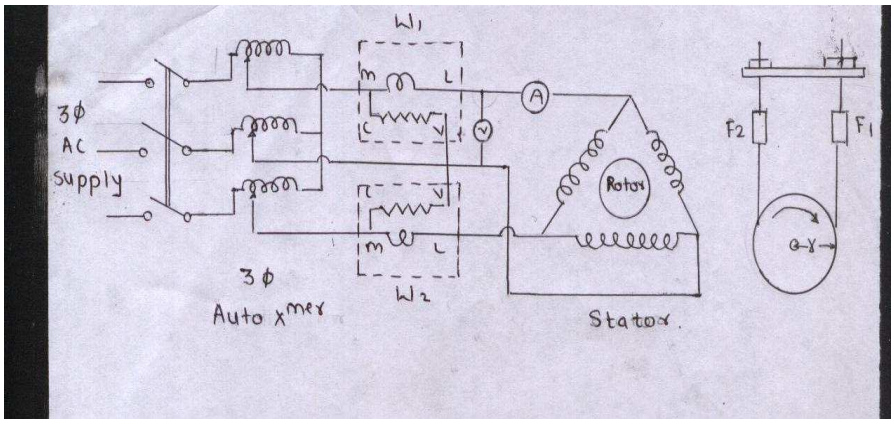
1) Voltmeter = 0 to 600V, 2) Ammeter = 0 to 5A 3) Wattmeter = 5A, 600V

Range Of Meters: D.C Side:- (Note : Nearest standard rating may be consider)

1) Voltmeter = 0 to 300V, 2) Ammeter = 0 to 5A

OR

b) If Brake arrangement is used:-



Or equivalent figure

Range Of Meters: AC Side:-

1) Voltmeter = 0 to 600V, 2) Ammeter = 0 to 5A 3) Wattmeter = 5A, 600V

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