SUMMER – 2022 EXAMINATION

Subject Name: Maintenance of Electrical Equipment **Model Answer : 22625:MEE**

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. No.	Sub Q. N.	Answer	Marking Scheme
1.		**Attempt any FIVE of the following:**	**10 Marks**
	a)	List out any four precautions to be taken to avoid fire caused by Electrical reason.	

Ans:

Precautions to be taken to avoid fire caused by Electrical reason:

1. Use correct rating fuse and MCB.
2. Follow IE Rules while working with every electrical installation.
3. Use ISI Mark material / equipment.
4. Provide sound and proper Earthing.
5. Use correct rating wires, cables, auxiliaries etc.
6. Carry out regular and proper maintenance.
7. Keep heat - producing appliances unplugged when not in use.
8. Don't ignore signs of trouble like as burn marks/discoloration around a socket, burning smell when an item is plugged in or in use, electrical sparks each time you plug in a device, one (or all) of your breakers frequently trips or your fuses regularly blow etc.
9. Keep always ready and use proper firefighting equipment.
10. Avoid poor joints and loose connections.
11. Provide proper protective gears/system.
12. Replace or repair loose or frayed cords on all electrical devices.
13. Avoid running extension cords across doorways or under carpets.
14. Follow manufacturer's instructions for operating every electrical machine / device / equipment etc.
15. Consider having additional circuits or outlets added by a qualified electrician so you do not have to use extension cords.
16. Avoid overloading outlets. Plug only one high-wattage appliance into each receptacle outlet at a time.
17. Place lamps on level surfaces, away from things that can burn and use bulbs that match the lamp's recommended wattage.

½ Mark for each of any four precautions = 2 Marks

OR Equivalent Answers/Points

b) State the concept of predictive maintenance.

Ans:

Concept of Predictive Maintenance:

Predictive maintenance is a technique that uses condition-monitoring tools & techniques to track performance of equipment during normal operation to detect possible defects and fix them before they result in failure. — 1 Mark

Ideally predictive maintenance allows the maintenance frequency to be as low as possible to prevent unplanned reactive maintenance without incurring costs associated with doing too much preventive maintenance. — 1 Mark

OR Equivalent Answer

c) Define the following terms in connection with safety.
   i) Hazard
   ii) Accident

Ans:

i) Hazard:

Hazard is a probable or possible cause of an accident. **OR,** The things that arise without planning or at random. **OR,** Hazard is a potential condition awaiting to be converted into an unwanted event or accident. **OR,** Hazard is potential source of harm. — 1 Mark

ii) Accident:

The event that happens unexpectedly and causes damage or injury is called as accident. **OR,** An event that is without apparent cause or is unexpected. **OR,** An unwanted event which cannot be anticipated in advance may be termed as an accident. **OR,** An occurrence in an industrial establishment causing bodily injury to a person which makes him unfit to resume his duties in the next 48 Hours. — 1 Mark

d) State the meaning of special test. Give one example of special test.

Ans:

Meaning of Special Test:

Special tests are conducted to know behavior of machine / equipment / product in different conditions and are conducted only when results of such tests are demanded by purchaser. — 1 Mark

Example of special test:

1. Determination of noise / sound level.
2. Measurement of the harmonics of the no-load current.
3. Determination of zero phase sequence impedance level etc.
4. Dielectric special tests.
5. Determination of capacitances windings-to earth, and between windings.
6. Determination of transient voltage transfer characteristics.
7. Short-circuit withstand test.
8. Measurement of the power taken by the fan and oil pump motors.
9. Measurement of dissipation factor (tan δ) of the insulation system capacitances etc.

1 Mark for any one example

e) List the different methods of drying of insulation.

Ans:

Methods of drying of insulation:

The drying out of electrical equipment can be carried out by applying heat by any one of the following methods:

1. Circulating hot oil through suitable purifying plant (for oil filled equipment).
2. Circulating hot air (for air or SF6 gas filled equipment).

½ Mark for each of any four methods = 2 Marks

3. Blowing in hot air.
4. Hot oil spray under vacuum.
5. Using space heaters / heat radiating high wattage lamp.
6. Heating by induction coil.
7. Heating by short circuit method.
8. Heating the equipment in hot chamber.
9. Vacuum type drying.
10. By connecting using immersion type heaters in the transformer tank.

f) List out the routine tests to be carried out on transformer as per IS-2026. (any four).

Ans:

Routine tests to be carried out on transformer as per IS-2026:

1. Measurement of insulation resistance.
2. Measurement of winding resistance.
3. Turns ratio test.
4. Voltage ratio test.
5. Polarity test.
6. Vector group test.
7. No-load losses and current test.
8. Measurement of impedance voltage, short-circuit impedance and load losses **OR** Short circuit test.
9. Continuity test
10. Magnetizing current, no load losses **OR** Open circuit test
11. Magnetic balance test
12. High voltage test.
13. Dielectric tests.
14. Separate source AC voltage test.
15. Induced overvoltage test.
16. Lightning impulse voltage tests.
17. Test on the "On-load tap changers".
18. Phasing out test.

½ Mark for each of any four tests = 2 Marks

g) State the use of following.
   i) Bearing puller
   ii) Growler

Ans:

i) Use of bearing puller:

A bearing puller is a tool used to remove bearing sets, pulleys or gears from a rotating machine shaft or from a blind bearing hole. The most common application is removing a caged set of ball or tapered bearings from a rotating shaft. — 1 Mark

iii) Growler:

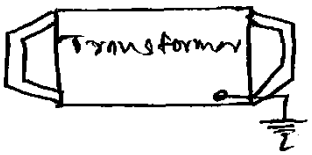
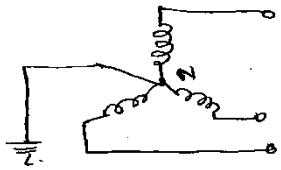
A growler is an electrical device used for testing insulation of a motor winding etc. for shorted coils. It is an equipment used for finding shorted turns of armature coil or stator / rotor winding. — 1 Mark

2. Attempt any THREE of the following: 12 Marks

a) Differentiate between Equipment Earthing and Neutral Earthing.

Ans:

Difference between Equipment Earthing and Neutral Earthing:

Sr. No	Equipment Earthing	Neutral Earthing
1		
2	When the non-current carrying metallic part of the electrical equipment are connected to earth through a very low resistance path then it is called as equipment earthing.	When neutral of three phase star connected sides of transformers, generators, motors is connected to earth then it is called as neutral earthing.
3	It provides protection to live beings (animals / humans) against electric shocks.	Provides elimination of arching grounds and over voltage surges.
4	Does affect stability of the power system in any way.	Stability of the power system is increased.
5	Equipment earthing is provided through pipe earthing, plate earthing or earth mats etc.	Neutral earthing is provided through solid earthing, resistance earthing, reactance earthing etc.
6	It does not provide any means for protection of the system against earth faults.	It provides suitable means for earth fault protection of the equipment / system.

1 Mark for each of any four differences = 4 Marks

OR Equivalent Answer

b) Explain moisture proofness test conducted on single phase Induction motor.

Ans:

Procedure of Moisture Proof-ness Test Conducted on Single Phase Induction Motor:

1. Disconnect / remove the single phase induction motor from supply completely.
2. Keep / put the single phase induction motor in a closed chamber having humidity of 90% with a temperature of 42^0C.
3. Maintain the above said condition for a full day / 24Hours.
4. Afterward take the motor out of the chamber and then conduct it for insulation resistance test and high voltage test.
5. If the results of insulation resistance test and high voltage test are satisfactory then the result of moisture proof-ness test is OK.
6. If the results of insulation resistance test and high voltage test are not satisfactory then it means that the motor windings are with moisture, further action / activity should be taken accordingly.

4 Marks

c) List any four External causes for abnormal operation of electrical equipment.

Ans:

External Causes for Abnormal Operation of Electrical Equipment:

1. Sometimes in the generating station / receiving station / substation there occurs over

voltage or under voltage which affect the normal working of the machine / equipment.
2. High voltage disturbances.
3. Sustained power frequency over voltage disturbances.
4. Lightning surges.
5. Switching surges.
6. Travelling waves.
7. Arcing grounds.
8. Resonance conditions.
9. External short circuit – the short circuit may occur in two or three phases of feeder / distributor lines.
10. Sometimes due to wind, rains, birds etc. short circuit occurs in the supply system which affects working of machine / equipment instantly.
11. If supply system generator working in generating station is subjected change in the speed of prime mover, then supply frequency changes which affects the working of machine / equipment / system connected to this supply system.
12. Under frequency effect in power transformers i.e. if frequency reduces in a system, flux in the core changes and causes abnormal operation for the machine / equipment which are supplied by such transformers.
13. Sometimes negative sequence currents are developed due to unbalance supply system which affects the normal working of the machine / equipment.
14. If external load on the machine is sustained for a length of period, the insulation may start burning due to excessive temperature rise.
15. External damage to machine / equipment supply cable, fault in MCCB, fault in MCB, damage happened by mechanical means as accidental breakage of cable etc.

1 Mark for each of any four causes = 4 Marks

d) List eight agents which contaminate the insulating oil.

Ans:

Agents Which Contaminate the Insulating Oil:

1. Water.
2. Moisture.
3. Dirt / dust.
4. Carbon deposits.
5. Sulphur.
6. Acids.
7. Gases.
8. Alcohols.
9. Grease.
10. Acetones and aldehydes.
11. Presence of sludge which is mainly an oxidation product, whose formation is accelerated by temperature and contact with air.
12. Presence of solid particles.

½ Mark for each of any eight agents = 4 Marks

3. Attempt any <u>THREE</u> of the following: **12 Marks**

a) Distinguish between routine and break down maintenance of electrical equipment.

Ans:

Distinguishing points between Routine and Breakdown Maintenance of Electrical Equipment:

Sr. No.	Item	Routine Maintenance	Breakdown Maintenance
1.	Definition	Maintenance carried daily for not to have any breakdown of equipment.	Maintenance carried after breakdown / fault intended to repair equipment.
2.	When to Execute?	Almost daily	After fault / breakdown.
3.	Objective	Includes visual inspection, cleaning, minor repairs in initial stage.	To bring back the faulty machine into service at the earliest.
4.	Nature of Schedule	It is a partial planed schedule.	It is not a planned schedule. Carried after breakdown.
5.	Scope for Delay	There is scope for delay sometimes / delay of one / two days.	This cannot be delayed at any cost.
6.	Staff Involved	This work is carried by operator of machine or by the maintenance staff.	This work is carried by experts / trained maintenance staff only.
7.	Down Time	No down time occurs as the activities are simple and can perform / check on line also.	Cannot predict about downtime as it depends on the nature of fault, but definitely downtime occurs.
8.	Example / Activities	Cleaning / checking / daily records etc.	Rewinding of burnt winding, replacement of blown fuses and the work carried out after fault.
9	Schedule	There is a fix maintenance schedule / programme as per service manual.	There is no fix maintenance schedule / programme.

1 Mark for each of any four distinguishing points = 4 Marks

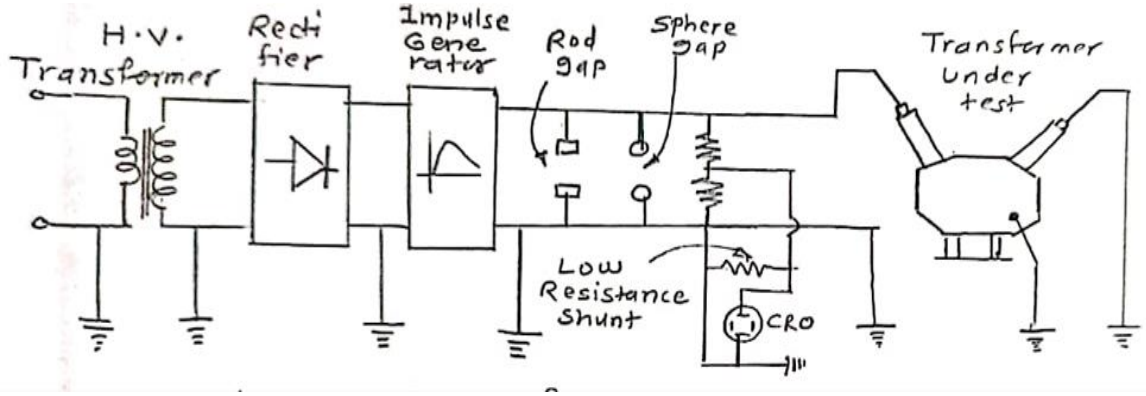
OR Equivalent Answer

b) Explain with neat diagram impulse test on a power transformer.

Ans:

Impulse Test on a Power Transformer:

The set up for impulse test is shown in the following figure as:



1 Mark

For carrying out impulse test an "Impulse Generator" is used which will develop unidirectional desired wave shapes with the help of H. V. transformer, rectifier unit. The rod gap and sphere gap arrestors are used for producing chopped wave as well as for circuit protection and the CRO is used for measurement / recording purposes. During the test one terminal of the impulse generator is connected to any one terminal of the transformer and other terminals of winding under test, frame etc. are effectively earthed. The impulse test is carried out in the following sequence by application of –

(i) One full wave
(ii) Two chopped waves
(iii) Two full waves

1. One full wave:

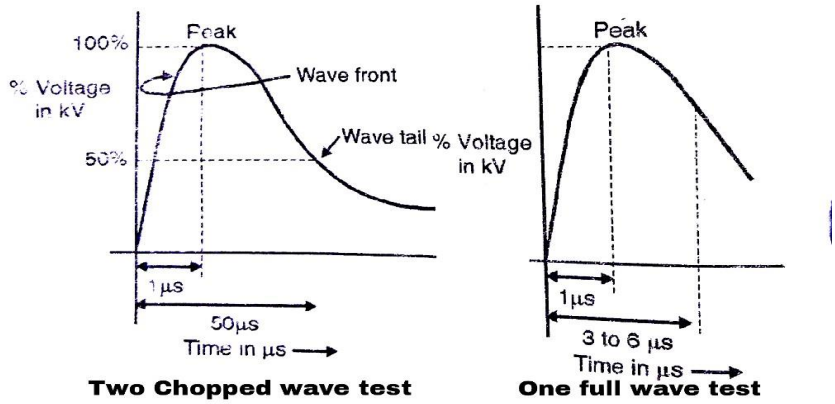
First of all, one full 1/50 wave is applied to the transformer under test, by application of this wave which has a very steep wave front, it is seen that whether the insulation of transformer will withstand for the very high rate of rise of voltage to which it will be subjected at the time of lightning surges. The maximum value of test voltage for different voltage rating windings is given in the bellow table. 1 Mark

2. Two chopped waves:

If the transformer insulation withstands 1/50 wave without any damage, then two chopped waves are applied within a very short interval (of 3 micro seconds to 6 micro seconds) of time as shown in the figure. The aim of application of a chopped wave is that at the time of puncturing of rod gap the voltage suddenly falls to zero, hence similar situation can be obtained.

3. Two chopped waves:

If the transformer insulation withstands above two tests without any damage, then it will be tested for this part. Here two full 1/50 waves are applied in sequence to the equipment. The maximum value of test voltage for different voltage rating windings is given in the bellow table.



1 Mark

Transformer voltage rating in kV	3.6	7.2	12	17.5	24	36	52	72.5	100	145	170	245
Test voltage in kV	45	60	75	96	125	170	250	325	450	650	750	1050

1 Mark

c) List out DO's and Don'ts to achieve safety for electrical supervisor while working in substation (any four points).

Ans:

DO's and Don'ts to Achieve Safety for Electrical Supervisor While Working in Substation:

DO's:

1. Work on low & medium voltage mains and apparatus should be carried only by authorized person(s) and all mains and apparatus to be worked upon shall be isolated from all sources of supply before starting the work.
2. Warning boards shall be attached to or kept adjacent to the line apparatus and the limit of the zone, in which work may be carried out, should be specifically indicated.
3. Ensure that all the safety apparatus such as rubber mats, stool, platforms or other safety devices to be used, should be in good condition.
4. When any live mains are to be earthed, the procedure prescribed should be scrupulously followed.
5. Maintenance on H.T. Breaker should be attempted only when it is fully isolated and withdrawn.
6. No work should be done on the transformers unless, it is disconnected from all external electrical circuits and all windings have been solidly earthed.
7. De - energize incoming power before removing top and side access or cover plates of any bus cover. Lock out the incoming power source. Earth the main horizontal bus before working on the bus.
8. Check voltage, if any, by multi meter / test lamp so as to be sure that circuit breaker / switches are open or that the bus is de - energized.
9. Isolate all remote-control voltage sources when working on the board.
10. Pad - lock the breakers with isolated position and test before working on a branch circuit.
11. Follow proper Electrical Isolation procedures to avoid in - advertent activation of any Electrical equipment i.e., put "Men at Work" tally on the isolated circuit. Remove the fuses etc. before working.
12. Obey warnings to stay away from electrical circuits and locked - out equipment.
13. Wear rubber gloves and any other assigned protective clothing and safety equipment while working.
14. Inspect electrical tools before each use.
15. Keep all electrical circuit contact points enclosed.
16. Do use a quality surge suppresser with enough sockets for every component.
17. Do look out for overhead power lines every time you use an insulated ladder or pole. Stay at least 10 feet away from any electrical lines.
18. When in doubt, seek help from experts and advice to the juniors.
19. Keep away any chemicals which are compatible from electrical panels etc.
20. Follow manufacturers' recommendations and requirements while working on that machine / equipment.
21. Eliminate all potential tripping hazards in the work area.
22. If any device / machine emits an unusual odor, turn it off and unplug it immediately. Do not use the device / machine until it is repaired.
23. Wear safety glasses while working.

½ Mark for each of any four points = 2 Marks for Dos

24. If you see that cables of electrical device are worn or frayed, make sure you replace it as soon as possible.
25. Ensure every rotating / static machine has been installed properly and is stable.
26. Employers should control any remaining risk by providing the worker / operator with the necessary information, instruction, training, supervision and appropriate safety equipment.
27. Ensure control switches are clearly marked to show what they do.
28. Have emergency stop controls where necessary.
29. If machines are controlled by programmable electronic systems, changes Made in any programme should be carried out by a competent person to all the concern persons.
30. Know the work content and work sequentially.
31. Place sign "Men are working" or other warning boards on the Main Switch before working.
32. Cultivate the habit of turning your face away whenever an electric arc or flash may occur.
33. Guard against arcs as well as high voltages, remember that burns from arcs may be very serious.
34. Take extreme care when breaking an inductive circuit as dangerously high voltage is likely to result.
35. Thoroughly discharge to earth all the cables before working on their cores.
36. Always treat the circuit alive until you have proved them to be dead.
37. Test insulating rubber glows periodically.
38. Place rubber mats in front of electrical switching panels.

Don'ts:

1. Do not touch a person who is in direct contact with live electrical conductors. By this, you can receive serious shock too.
2. In hazardous area, avoid direct contact between explosive mixture and means of ignition.
3. Do not inadvertently activate any electrical equipment. Follow standard electrical isolating procedure to avoid inadvertent activation on any electrical equipment.
4. Do not panic in case of power failure. Emergency lighting have been provided in all working areas in company through Diesel Generating Sets which start automatically within 10 - 15 seconds of the power failure. Stay calm until then.
5. Do not work alone in main switch or feeder panel enclosure.
6. Never leave electrical equipment without properly earthed.
7. Do not put in use any piece of electrical equipment that gives a tingling sensation when touched. This is defective. Inform about it to your supervisor immediately.
8. No live part should be within unsafe distance of a person working on live low and medium voltage mains, so that he does not come in contact with it unless he is properly protected.
9. Do not touch or temper with any electrical gear or conductor, unless you have made sure that it is dead and earthed. High voltage apparatus may give leakage shock or flash over even without touching.
10. Do not disconnect earthing connections.
11. Do not expose your eyes to an electric arc. Painful injury may result even with short

exposure.

12. Do not close or open a switch or fuse slowly or hesitatingly, do it quickly and positively.
13. Do not use metal case flash light around apparatus which is energized.
14. Do not get closer than 10 feet to a power line (if you're an unqualified employee).
15. Do not reach blindly into a space that may contain energized equipment.
16. Do not use a power tool that smokes, sparks, smells, or shocks.
17. Do not store liquids of any sort near electrical equipment.
18. Do not assume the black coating on wires is insulation – it could be just plastic weatherproofing that provides no protection from contact injuries.
19. Do not use damaged or brittle electrical cords, even if bare wires aren't visible.
20. Do not allow untrained, unqualified staff to handle key maintenance or inspection tasks.
21. Do not undertake maintenance tasks in an arbitrary order. You need a way to rank electrical components in order of how critical they are and then follow that order logically.
22. Do not take a run - to - failure attitude to electrical parts. You should replace them before they become inefficient and potentially dangerous.
23. Do not renew a blown fuse until you are satisfied as to the cause and you have rectified the irregularity.
24. Do not close any Switch / GOS / Breaker unless you are familiar with the circuit, which it controls and know the reason for its being kept open.
25. Do not work on energized circuits without taking extra precautions as use of rubber gloves and gauntlets.
26. Do not touch or tamper with any electrical equipment or conductor, unless you have made sure that it is dead and earthed.
27. Do not work on the live circuit without the specific orders of the supervisor and make certain that all safety precautions have been taken.
28. Do not disconnect earthing connection or render ineffective safety gadgets installed on mains and apparatus.
29. DO not use fire extinguisher on electrical equipment unless it is clearly marked for that purpose.
30. DO not throw water on live electrical equipment in case of fire.
31. DO not remove danger notice plates or other signs or interface with safety barriers or go beyond them.
32. DO not allow visitors and un-authorized persons to touch or handle electrical apparatus or come within the danger zone of H.V. apparatus.
33. Don't allow unauthorized and untrained persons to work on Electrical Systems.

½ Mark for each of any four points = 2 Marks for Don'ts

OR Equivalent Answer

d) Describe the factors affecting the preventive maintenance schedule.

Ans:

Factors Affecting the Preventive Maintenance Schedule:

1. Type of machine / equipment and its working conditions.
2. Working environment of industry i.e., presence of dirt, moisture, chemical fumes, atmospheric temperature etc.
3. Some industry finds heavy load during particular period of year and during other

period they are lightly loaded, during which maintenance can be carried out, ultimately the operating cycle of plant affect the schedule.

4. Whether the machine is continuously working or intermittently working?
5. If the machines / equipment is continuously overload then it needs more maintenance and also needs suitable time for the preventive maintenance so affects preventive maintenance schedule.
6. If the machine fails, how much loss of money and time, it will cause due to its down period.
7. Ageing of machine / equipment (If the breakdown takes place, the cost of the repair will be more than cost of the machine, and whether it can be replaced by a new one).
8. Production requirement i.e., the machines / equipment used in production work comes under essential equipment and they need to maintained very much carefully.
9. Non availability of spares & raw material.
10. Non availability of tools, jacks, fixture required for preventive maintenance.
11. Non availability of trained & skilled technicians.
12. Operating cycle of equipment or machine affect the maintenance schedule.
13. Cost of the maintenance.
14. Due to accident, fires, worker strike the work is held up for certain period. This is also a cause of disturbing a preventive maintenance schedule.
15. Load cycle of the machine.
16. Cost of standby machines and equipment.
17. Cost of outage due to failure of supply against cost of maintenance.
18. Improper communication / co-operation with production department.
19. Importance of the machine / equipment.
20. Sometimes even if the maintenance may be necessary but the production requirement needs that machine may be kept running to complete the production target. It means that for particular time production is most urgent and profitable than the cost of breakdown period of machine during the repairs.
21. Large capacity / highly precise machine / equipment used in industry upon which maximum operation depends are to be maintained properly otherwise affects the preventive maintenance schedule.

½ Mark for each of any eight points = 4 Marks

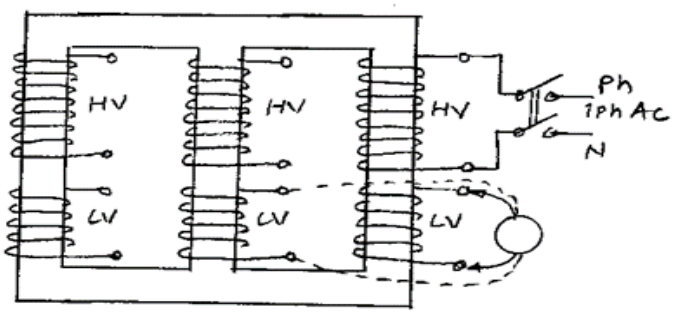
OR Equivalent Answer

4. Attempt any <u>TWO</u> of the following: **12 Marks**

a) With the help of neat diagram, explain phasing out test to be carried on transformer.

Ans:

Phasing Out Test to be Carried on Transformer:



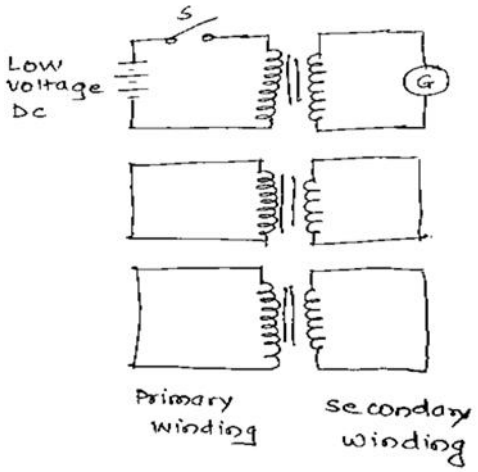
This test is carried out to find out the corresponding HV and LV phase winding

- The circuit diagram is as shown in figure. Here normal ac voltage is applied to one of the HV or LV windings. In this case to HV winding and the voltages across all three LV windings are measured.
- The winding across which is much more measured voltage obtained compared to other two windings represent the secondary of the winding to which supply is connected.

3 Marks for diagram.

The test is repeated for finding out remaining concerned secondary windings in the same manner.

OR



This test is carried out only on three phase transformers to identify primary and secondary winding belonging to the same phase.

As shown in figure all the phases of three phase transformer are short circuited except a primary and supposed secondary.

3 Marks for Explanation.

A low voltage D.C. supply is given through a battery to the primary winding. The galvanometer is connected to the terminals of secondary winding which is not shorted.

The key "K" is connected shown. Now the keys pressed and deflection of galvanometer is observed carefully.

Similarly, galvanometer is connected to the other secondaries and procedure is repeated. The winding across which maximum deflection occurs is the secondary phase winding that corresponds to primary winding to which source connected.

Repeat the same procedure for other primary winding and find the corresponding was secondary side.

NOTE: In place of galvanometer low range voltmeter or multi-meter can also be used

b) State factors involved in designing a rotating machine foundation.

Ans:

Factors Involved in Designing a Rotating Machine Foundation:

1. Drawings of the dimensions of the foundation from design point of view, drawings of fasteners, as well as auxiliary equipment, communications and hole sizes.
2. Actual foundation drawing of machine provided by the manufacturer.
3. Dimensions as length, width and height of the machine.
4. The technical characteristics of machines (name, type, number of rotations per minute, power, total weight, duty cycle etc.)
5. Data about condition of soil as bearing capacity, soil density and ground water table location.

6. Weight of the machine as erecting weight, operating weight, imposed weight and weight of accessories.
7. CG (center of gravity) location in static and dynamic conditions of machine.
8. Level of plinth (it should be above the maximum flood level of the site).
9. Ground water level.
10. Surrounding atmospheric conditions.
11. Type of machine whether it is static, rotating or reciprocating.
12. Earth quake resistance should be considered while designing the foundation.
13. Foundation should be able to absorb vibrations while operating at its full capacity.
14. The dimensions of foundation should be proportional to safe bearing capacity of soil.
15. Foundation should transmit both static and dynamic weight of the machine to ground.
16. Data on the geological conditions of the construction site and soil properties.
17. The frictional resistance between foundation block and soil should be sufficient to withstand the possible horizontal thrust caused by machine while in operation. This will avoid sliding of foundation over the soil due to the horizontal thrust.
18. The foundation block should be so spread that the resultant of all the forces should pass with in the foundation block. This will safely guard against overturning of the machine while in operation.
19. Information / data about the magnitudes, places of application and directions of action of static loads, as well as about amplitudes and frequencies, places of application and direction of dynamic loads.
20. Information / data about location of the designed foundation relative to the nearest structures.
21. The requirements for the protection of the foundation from groundwater, as well as other external factors characteristic of the design environment.
22. Data on maximum permissible deformations of the foundations and their basement.

½ Mark for each of any twelve factors = 6 Marks

OR Equivalent Answer

c) Prepare trouble shooting chart of three phase induction motor for any three faults.

Ans:

Troubleshooting Chart of Three Phase Induction Motor:

Motor Fault / Problem	Cause	Remedies
Motor stalls	One phase may be open	Check and correct supply lines for open phase.
	Wrong application	Change type or size. Consult motor manufacturer.
	Overload	Reduce load.
	Low voltage	Check that nameplate voltage is maintained. Check and correct connections.
	Open circuit	Fuses blown. Check and correct overload relay, stator and push buttons.
Unbalanced line current on poly-phase motors during normal operation	Unequal terminal volts	Check and correct the leads and connections.
	Single phase operation	Check and correct for open contacts, blown fuse etc.
	Unbalanced voltage	Check and Correct for the unbalanced

		power supply.
Motor fails to start	Blown fuses	Replace fuse with proper type and rating.
	Overload control may be tripped	Check and reset overload in starter.
	Improper power supply / fault with supply	Check and correct for rated power supply which agrees with nameplate specifications.
	Improper line connections / loose connections	Check connections with wiring diagram supplied with motor and correct / tight the connections.
	Open circuit in stator winding or control switch or in starter or in rotor winding	This is normally indicated by a humming sound when switch is closed. Check for loose wiring connections. Confirm that all control contacts are closing. Check and correct for open circuit in stator / rotor winding.
	Mechanical failure	Check to see that motor and drive turns freely. Check bearings and lubrication. Correct it
	Short circuited stator / rotor winding	Indicated by blown fuses. Stator / rotor winding must be repaired / rewound accordingly.
	Poor stator coil connections	Remove end belts, locate poor connections with test lamp & correct it.
	Rotor defective	Check for broken bars or end rings then repair / replace it accordingly.
	Motor may be overloaded	Reduce load or load the motor as per its rating.
	Wrong connections of control circuit	Check physically and correct them.
	Stator / rotor winding may be earthed or touched with body	Check or insulate the stator / rotor winding or rewind the faulty winding.
	Brushes making no contact with slip rings	In case of slip ring induction motor check spring pressure on the brushes or replace worn out brushes or check and correct the condition of slip rings.
Noisy Operation / Motor giving noise/ Humming of motor	Air gap not uniform	Check and correct bracket fits or bearing.
	Rotor unbalance / Misalignment of rotor	Check and correct the balancing / misalignment of rotor or rebalance rotor.
	One phase may be open / Single phasing	Check and correct supply lines for open phase.
	Rotor rubbing on starter / Broken rotor bars / Bent shaft	Check and correct the alignment / bent shaft of rotor, check for broken rotor bars and repair / correct it.
	Any part of the motor may be loosely fitted	Check and fit all the parts of motor correctly.
	Mechanical problems like squeezed bearing, cooling	Check and correct against all concern mechanical problems.

	fan touching with stator, improper belt pressure, improper mounting, wrong coupling, improper foundation		
	Magnetic locking between stator and rotor	Check and correct against magnetic locking / use skewed rotor.	
	In case of slip ring induction motor there is unequal rotor resistance per phase / open circuit on one phase / Inter turn or short circuit fault in stator winding	Check and correct against equal rotor resistance per phase and rectify open circuit / inter turn / short circuit fault of stator winding.	2 Marks for each fault with two causes and concern remedy of any three faults = 6 Marks
	Earth fault with stator / rotor winding	Locate and repair the earth / ground fault.	
	Incorrect supply frequency	Maintain the rated / constant frequency.	
	In case of slip ring induction motor the rotor may be open circuited or brushes are not making correct contact or slip ring surface may be rough or slip rings may be eccentric	Check and correct against open circuit in rotor winding, spring pressure of brushes. Replace the correct slip rings.	
Motor runs and then dies down	Power failure	Check for loose connections to line or break in cable or blown fuses or tripped MCB and correct it.	
	Starter / starting gear may be defective	Check for starter contacts and clean / replace them. Check for starter coil, repair / replace it. Use proper rating starter / overload relay.	
	Loose connections in stator / rotor winding / burnt supply cable / burnt MCB / burnt main switch	Check and correct for all types of loose connections in stator / rotor winding / replace or repair proper size supply cable / MCB / main switch.	
Motor takes too long to accelerate and / or draws high current (Amps)	Excessive load	Reduce load and load the motor properly	
	Low voltage during start up	Check for high resistance. Adequate wire size.	
	Defective / short squirrel cage rotor	Replace with new rotor	
	Applied voltage too low	Improve voltage at terminals of transformer by tap changing.	
Wrong rotation	Wrong sequence of phases	Reverse connections at motor or at switchboard.	
Motor does not come up to speed or Motor runs slow or	Motor is applied for the wrong application	Consult manufacturer for right application of motor.	
	Voltage too low at motor	Use higher voltage on transformer	

Motor starts sluggishly.	terminals because of line drop	terminals or reduce load. Check connections. Check and use conductors of proper size.
	Starting load too high	Check and correct the load on the motor which is supposed to carry at start.
	Broken rotor bars or loose rotor	Look for cracks near the rings. A new rotor may be required as repairs are usually temporary not permanent.
	Open / short stator winding or delta wound motor connected in star or single phasing	Locate fault with testing device and repair / rectify the concern cause.
	In case of slip ring induction motor the rotor may be open circuited / external resistance may completely cut off / brushes are not making correct contact or slip ring surface may be rough or slip rings may be eccentric	Check and correct against open circuit in rotor winding, balanced external rotor resistance, spring pressure of brushes. Replace the correct slip rings / brushes.
Motor overheats while running with load / Motor runs hot / Thermal over load	Motor overloaded	Reduce load or load the motor as per its rating.
	Frame or bracket vents may be clogged with dirt and prevent proper ventilation of motor or poor ventilation.	Open vent holes and check for a continuous stream of air from the motor / maintain proper ventilation / check and repair the cooling arrangements.
	Motor may have one phase open / loose connections / wrong connections	Check to make sure that all leads are well connected.
	Grounded coils	Locate and repair
	Unbalanced terminal voltage / supply voltage is too high	Check for faulty leads, connections and supply voltage and correct for it.
	Rotor rubbing on starter / broken rotor bars	Check and correct the alignment of rotor, for broken rotor bars and repair / correct it.
	Mechanical / drive troubles	Check against mechanical / load side troubles like very tight belt / wrong coupling / gear problems / faulty or worn bearings etc. Correct / repair / replace them.
Hot bearings general	Bent or sprung shaft	Straighten or replace shaft.
	Excessive belt pull	Decrease belt tension.
	Pulley too far away	Move pulley closer to motor bearing.
	Pulley diameter too small	Use larger pulleys.
	Misalignment	Correct by realignment of drive.

Hot bearings ball	Insufficient grease	Maintain proper quantity of grease in bearing.
	Deterioration of grease or lubricant contaminated	Remove old grease, wash bearings thoroughly in kerosene and replace with new grease.
	Excessive lubricant	Reduce quantity of grease.
	Overloaded bearing	Check and correct alignment, side and end thrust.
	Broken ball or rough races	Replace bearing, first clean housing thoroughly.
Motor works with high speed	Sudden increase / Excessive supply voltage	Check and adjust the supply voltage as per rating.
	Motor may running under load / no load	Load the motor as per its rating / avoid no load / under load running of the motor.
	Starting gear may be defective	Check and correct the starting gear circuitry.
Motor vibrates	Motor misaligned	Realign it.
	Weak support / loose foundation	Strengthen base / properly support the motor.
	Coupling out of balance	Balance the coupling.
	Driven equipment/ rotor unbalanced	Re-balance driven equipment /rotor.
	Defective bearings	Replace bearing
	Bearings not in line / bent shaft	Line up the bearings properly, check and correct for bent shaft.
	Balancing weights shifted	Re-balance the motor.
	Poly-phase motor running single phase	Check for open circuit
	Excessive end play / excessive belt pull	Adjust bearing and belt pressure.
	Fluctuating supply voltage with harmonics	Provide specified supply voltage, frequency. Use power quality improvement circuitry.

5. Attempt any TWO of the following: **12 Marks**

a) Explain with neat circuit diagram back-to-back test on single phase transformer to determine efficiency and regulation.

Ans:

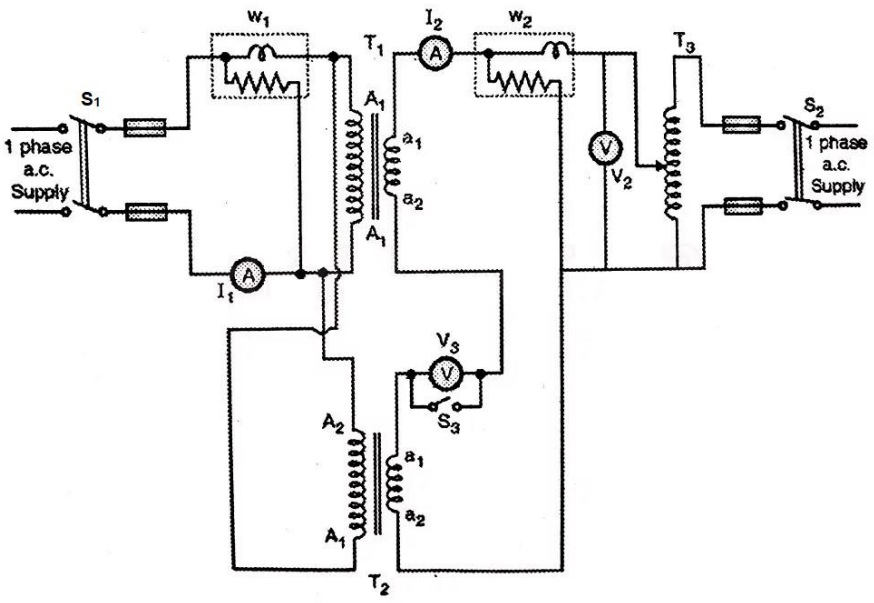
Back-to-Back Test on Single Phase Transformer:

- T_1 and T_2 are two identical transformers, T_3 is autotransformer, S_1 (At the input side of primaries), S_2 and S_3 are switches. A-ammeters, V-voltmeters and W-watt-meters.
- As shown in figure the primaries of two transformers (T_1 and T_2) are connected in parallel across the supply at rated voltage of primary. Their secondaries are connected in phase opposition or back-to-back fashion. When primaries of two transformers are energized by switching ON switch S_1, the emfs induced in secondary windings come in phase opposition. Since the two transformers are identical, there is no circulating current in the local circuit formed by secondary's even, if primaries energized.

- To ensure that the secondaries are connected in phase opposition, a voltmeter (V_3) and a switch S_3 is connected in parallel as shown. V_3 should be of double range of that of secondary voltage, because, if the polarities are not connected in phase opposition the voltmeter may receive twice the voltage of secondary. When voltmeter V_3 indicates zero it ensures that secondaries are connected in phase opposition, then switch S_3 is closed. If voltmeter V_3 does indicate zero or indicate more than zero, then secondary connections are interchanged.

2 Marks

- To circulate the necessary full load current one auto transformer (T_3) is used in the secondary circuit as shown. Voltage is injected by switching ON switch S_2 and by varying the voltage with the help of T_3, full load current is circulated in the secondaries. The current corresponding to this circulating current also flows in closed circuit formed in primaries, however it does not appear in the ammeter and wattmeter connected in primary side so the current taken from supply side is only the total no load current of two transformers.
- The wattmeter reading (W_1) connected in the primary side indicates total no load loss or iron loss of two transformers.
- The wattmeter connected in secondary side (W_2) indicates total copper loss or load loss of two transformers caused by the circulating current.
- Since both the losses are known efficiency of the transformer can be easily determined.



2 Marks

Determination of Efficiency:

The readings of all ammeters, voltmeters and watt-meters are noted in observation table as given bellow:

Sr. No.	V_1 (Volts)	I_1 (Amp)	W_1 (Watts)	V_2 (Volts)	I_2 (Amp)	W_2 (Watt)

Since two transformers are identical,

Iron loss of each transformer = $\frac{W_1}{2}$

Copper loss of each transformer = $\frac{W_2}{2}$

So %Efficiency of each transformer = $\frac{Full\ Load\ output}{Full\ load\ output + \frac{W_1}{2} + \frac{W_2}{2}} \times 100$ 1 Mark

Determination of regulation:

- Note down the no load voltage of transformer as $0V_2$
- The injected voltage (V_2) supplied to secondary side circulates the full load current in the secondaries of both transformers. The current corresponding to this circulating current also flows in the primaries (in the local circuit formed). Thus, this injected voltage (V_2) supplies the voltage drops (IZ drop) of both transformers. Hence voltage drop of one transformer will be V_2 / 2, i.e., injected voltage / 2.

$$\% \text{ Voltage Regulation} = \frac{voltage\ drop}{secondary\ no\ load\ voltage} \times 100$$

$$= \frac{V2/2}{secondary\ no\ load\ voltage} \times 100$$ 1 Mark

OR

$$W_{cu} / 2 = I_2^2 R_{02}$$

$$Z_{02} = V_{sc} / I_{sc} = ((V_2/2)/I_2)$$

$$X_{02} = \sqrt{{Z_{02}}^2 - {R_{02}}^2}$$

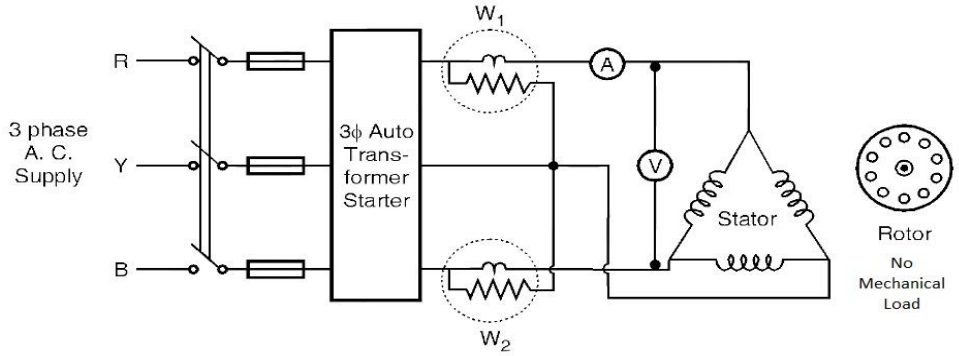
$$\% \text{ Regulation} = I_2(R_{02}\cos\emptyset \pm X_{02}\sin\emptyset)/V2$$

b) Draw and explain the circuit diagram to perform no load and Block Rotor test on three phase Induction Motor.

Ans:

No Load and Block Rotor Test on Three Phase Induction Motor:

No Load Test on Three Phase Induction Motor:



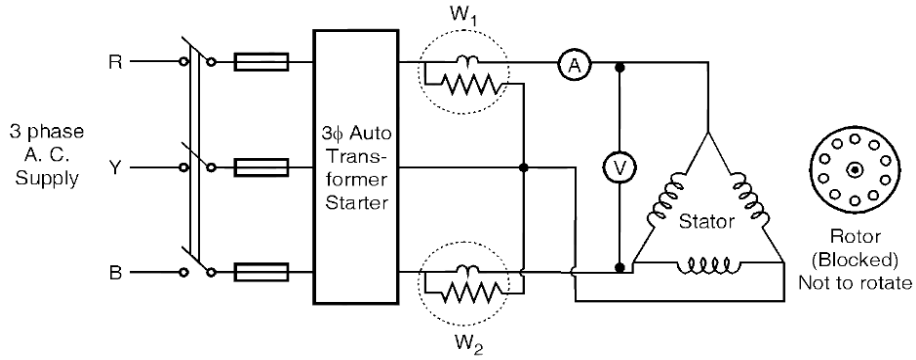
1½ Marks for circuit diagram

1. Determine the meters and their ratings based on the name plate readings of the three-phase induction motor under test.
2. Connect the circuit as shown in circuit diagram.
3. Set / check the three-phase autotransformer to be at zero output.

1½ Marks for

4. First switch on the 3-phase supply and close the TPST. explanation
5. In this test the stator winding is connected to supply through auto transformer.
6. Gradually increase the voltage applied to the machine to the rated voltage. Motor runs at a speed quite close to its synchronous speed.
7. Take the corresponding readings of voltmeter (as input voltage Vo), ammeter (as input current Io), wattmeter (as input power Wo) & speed.

Block Rotor Test on Three Phase Induction Motor:



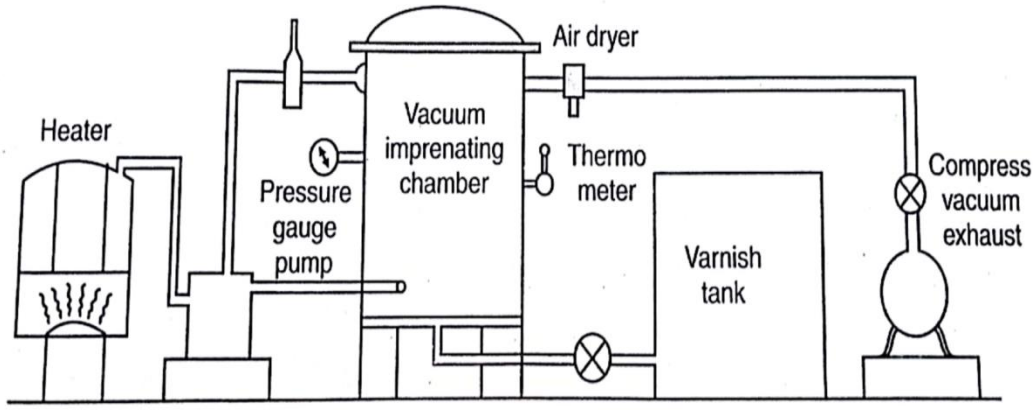
1½ Marks for circuit diagram

1. Determine the meters and their ratings based on the name plate readings of the three-phase induction motor under test.
2. Connect the circuit as shown in circuit diagram.
3. Set / check the three-phase autotransformer to be at zero output. 1½ Marks for explanation
4. Block the rotor mechanically in such a way that it does not revolve (speed of rotor must maintain zero).
5. Now switch ON the 3-phase supply and close the TPST.
6. Gradually increase the voltage applied to the motor until up to full load current will circulate in the stator winding.
7. Take the corresponding readings of voltmeter (as input voltage Vsc), ammeter (as input current Isc), wattmeter (as input power Wsc).

c) Draw and explain vacuum impregnation method of varnishing.

Ans:

Vacuum Impregnation Method of Varnishing:



2 Marks

Construction:

The vacuum impregnating plant consist of a large air tight double jacketed vacuum impregnated chamber which has a removable top cover. The interior part of tank can be

heated up by circulating steam or hot air through the jacket. The insulating varnish is kept stored in another storage tank. A motor driven compressor cum vacuum pump with suitable valves to create vacuum in the tank is used which can also create pressure as required. 1 Mark

Working of Vacuum Impregnation Plant:

- First the wound armature, stator or rotor is placed in the vacuum impregnating chamber by opening the top cover, then it is tightly closed.
- The chamber is then heated up to 100^0 C by circulating steam or hot oil through jacket of chamber for nearly four hours. During this period the air from chamber is pumped out by vacuum exhauster and the vacuum is maintained which will help in vaporising the moisture present in the coils and removing the air completely.
- Now insulating varnish from varnish tank is allowed to flow into vacuum impregnated chamber till the varnish come up to level in which windings are completely immersed, then the valve of varnish storage tank is closed.
- The pressure from compressor of about 1.4 to 2.1 kg/cm2 is applied above the varnish surface, which will make the varnish to be forced in all the porous spaces in the interior of coils and this pressure is maintained for an hour / two hours according to the size and weight of the winding. 3 Marks
- Now the valve of varnish tank is opened and varnish is made to flow back to the tank under air pressure till the excess varnish also gets drained out. The valve of tank is is then closed and the armature is baked in the chamber at 1000 to 1100C for nearly 8 hours or till the varnish is completely dried out and become bone dry.
- The air pressure and circulating steam or oil in the jacket is then stopped and the armature or stator is then removed by opening the top cover of chamber.

OR Equivalent Answer

6. **Attempt any THREE of the following:** **12 Marks**

a) Explain the sequence to be followed in operating any one type of fire extinguisher.

Ans:

Sequence to be Followed in Operating the Fire Extinguisher:

There are a number of different types of portable fire extinguishers, each can be identified by the colour coding and labelling. Check that the extinguisher you intend to use is suitable for the type of fire encountered e.g., a water extinguisher must never be used on any fire involving electrical equipment. There are four (4) basic steps for using modern portable fire extinguishers. The acronym **PASS** is used to describe these four basic steps. 4 Marks

1. **Pull (Pin**)
   Pull pin at the top of the extinguisher, breaking the seal.
2. **Aim**
   Approach the fire standing at a safe distance. Aim the nozzle or outlet towards the base of the fire.
3. **Squeeze**
   Squeeze the handles together to discharge the extinguishing agent inside. To stop discharge, release the handles.
4. **Sweep**
   Sweep the nozzle from side to side as you approach the fire, directing the extinguishing agent at the base of the flames.

b) Enlist routine test and type test performed on three phase alternator.

Ans:

Routine Tests and Type Tests Performed on Three Phase Alternator:

1. Insulation resistance test on stator windings.
2. Measurement of d. c. resistance of armature windings and field windings.
3. Di-electric tests (High voltage tests) on stator windings by a. c. voltage for 1 minute.
4. Di-electric test with d. c. voltage.
5. Measurement of d. c. resistance of field-discharge resistor.
6. Measurement of vibrations.
7. Testing of insulation of the field-discharge resistor with respect to frame.
8. Testing of insulation resistance and di-electric withstand of field insulation.
9. Noise measurement.
10. Measurement of air gap between stator and rotor.
11. Open-circuit characteristic by measuring terminal voltage for various field currents at no load and rated speed.
12. Short-circuit characteristic by charging the field current and measuring short-circuit armature current.
13. Sudden three phase short-circuit test to record the oscillograms of short-circuit currents in three phases.
14. Testing of synchronizing circuits.
15. Testing on voltage regulators, excitation systems.
16. Polarity test for field poles.
17. Phase sequence test.
18. Heat run test.

½ Mark for each of any eight tests = 4 Marks

c) Distinguish between O. C. test and S. C. test performed on transformer (any four points).

Ans:

Distinguishing Points Between O. C. Test and S. C. Test Performed on Transformer:

Sr. No.	O. C. Test on Transformer	S. C. Test on Transformer
1.	This test is conducted to determine the iron losses (or core losses) and parameters R_0 and X_0 of transformer.	This test is conducted to determine R_{01} (or R_{02}), X_{01} (or X_{02}) and full-load copper losses of the transformer.
2.	In this test the rated voltage is applied to the primary. (usually low-voltage winding) while the secondary is left open circuited.	In this test fraction of rated voltage which is sufficient to circulate the full load current is applied to the primary.
3.	Here usually low-voltage winding is supplied and high voltage winding is left open circuited.	Here usually high-voltage winding is supplied and low voltage winding is made short circuited.
4.	As normal rated voltage is applied to primary, therefore, normal iron losses will occur in the transformer core.	As normal rated full load current is circulated in both primary & secondary, therefore, full load copper losses will occur in the transformer windings.
5.	Here wattmeter will record the iron losses and very small amount of	Here wattmeter will record the copper losses and very small amount of iron

1 Mark for each of any four distinguishing points = 4 Marks

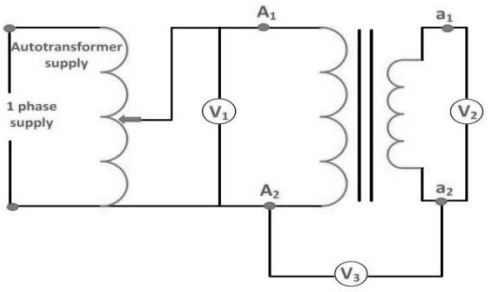
	copper loss.	loss.
6.	Since no-load current I_0 is very small (usually 2-10 % of rated current). Cu losses in primary under no-load condition are negligible as compared with iron losses.	Since the voltage applied is very small (usually 2-10 % of rated voltage). Iron losses in short circuit condition are negligible as compared with copper losses.

d) Describe the procedure for conducting polarity test of a single phase transformer with the necessary circuit diagram.

Ans:

Polarity Test of a Single-Phase Transformer:

- The rated voltage (V_1) is applied to the primary and its two terminals are marked as A_1 and A_2, respectively, as shown in figure.
- The secondary winding terminals are also marked as a_1 and a_2, as shown in figure and the voltage measured across it will be V_2.
- Now a voltmeter V_3 is connected across A_2 and a_2. if it measures the difference of V_1 and V_2, Then the ***A*₂ and *a*₂ are of the same polarity**.



2 Marks for circuit diagram

2 Marks for description

- If a voltmeter V_3 measures the addition of V_1 and V_2 then the ***A*₂ and *a*₂ are of opposite polarity**.

e) Give different factors affecting the life of insulating materials.

Ans:

Different Factors Affecting the Life of Insulating Materials:

1. Dielectric strength / Electrical stress / High voltage stress.
2. Temperature / Thermal stress / High temperature.
3. Mechanical stress.
4. Moisture absorption.
5. Water.
6. Dirt and dust particles on the surface of insulation.
7. Surface tracking and arcing.
8. Ageing.
9. Improper handling.
10. Oxidation.
11. Atmosphere.
12. Impurities.
13. Light.
14. Chemical reaction.

½ Mark for each of any eight factors = 4 Marks