Important suggestions to examiners:

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

Q.1 a)	**Attempt any THREE of the following:** **12 Marks**
i)	**State the factors on which severity of electric shock depends. Also state the effect of current on human system.**
Ans:	**The effect of electrical shock on human bodies depends on following factors**: **(Any Four Points Expected: 1/2 Mark each)** 1. Magnitude voltage of the system. 2. The period or duration for which the area of contact with lives part. 3. It is also depends on supply system i.e. A.C or D.C. 4. Body resistance (If wet resistance of body reduces) 5. Shock may occur even when voltage (50V rms AC low or 75V DC sometimes OR Low voltage does not mean low hazard.) 6. Path of current through body. 7. The magnitude of current passing through the body 8. The presence of moisture in the environment. 9. The phase of the heart cycle when the shock occurs. 10. The general health of the person prior to the shock

Effects of Electrical Current on the Body : **(Any two From following : 1 Mark each)**

S.No.	Current	Reaction
1	**1 milliamp**	Just a faint tingle.
2	**5 milliamps**	Slight shock felt. Disturbing, but not painful.
3	**6–25 milliamps**	Painful shock. Muscular control is lost. This is the range where "freezing
4	**9–30 milliamps**	Currents" start. It may not be possible to "let go."
5	**50–150 milliamps**	Extremely painful shock, breathing stops. Severe muscle contractions. Death is possible.
6	**1,000–4,300 milliamps** (1–4.3 amps)	Heart pumping action not normal occurs. Muscles contract; nerve damage occurs. Death is likely.
7	**10,000 milliamps**. (10 amps)	Cardiac arrest and severe burns occur death.

ii) Why is the maintenance of electrical equipment's necessary? State different categories' of maintenance.

Ans: **Maintenance of electrical equipment's is necessary because of following points:-**

(Any Four Points Expected: 1/2 Mark each)

1. It prevents minor faults from developing into major breakdown.
2. It prevents premature failure.
3. It reduces breakdown period.
4. It reduces breakdown to a minimum and increases the efficiency of equipment's and machinery.
5. It keeps the machine in good working condition by reducing wear and tear.
6. It provides greater safety & protection to the workers.
7. It uses less standby equipment's.
8. It increases life of machine/equipment.
9. It avoids inconvenience.
10. It increases productivity.

11. It determines the need for major & minor repairs.
12. It develop maintenance schedule at low cost.

Different categories' of maintenance:- **(Any Four Points Expected: 1 Mark each)**

1. Preventive Maintenance
2. Routine Maintenance
3. Periodic Maintenance
4. Maintenance on Fault or Corrective or Breakdown Maintenance
5. Overhaul

iii) Define the term 'Polorization Index'. How is it used for interpreting the condition of insulation?

Ans:

Meaning of Polarization index (PI): ---------- **(2 Marks)**

The ratio of $\frac{R_{60}}{R_{15}}$ is called polarization index.(R60 = 60sec.reading of insulation resistance & R15 = 15 sec. reading of insulation resistance) **OR**

The ratio of $\frac{R_{600}}{R_{60}}$ is called polarization index.(R_{600} = 600 sec. reading of insulation resistance & R_{60} = 60 sec. reading of insulation resistance)

Interpretation the condition of insulation - **(Any Four Points Expected: 1 Mark each)**

Polarization index gives the true idea about the quality of insulation polarization.

PI	Insulation Condition
< 1	Dangerous
< 2	Questionable
< 4	Good
> 4	Excellent

iv) State the limits of voltage current frequency and speed for the safe working of electrical

	machines?
Ans:	**Limits of voltage current frequency and speed for the safe working of electrical machines :** **(1 Mark Each, Total 4 Marks)** 1. **Voltage:** The terminal voltage is 10% of rated voltage. For a period of 10 sec. (T.V. differing from rated value by not more than 6 %.) 2. **Frequency:** Supply of frequency is 5% of rated frequency. For a period of 10 sec. (Frequency differing from its rated value by not more than 3 %.) 3. **Current :-** The permissible current unbalance 8% For a period of 15 sec OR Starting Current: Less than 4.5 times the rated current. 4. **Variation of speed: -** On highest side: 3% of synchronous speed. On lowest speed: + 3% of synchronous speed.
Q.1 b)	**Attempt any ONE of the following:** **06 Marks**
i)	**State the objectives of testing? Explain the roles of BIS (Bureau of Indian standards) in testing of Electrical Equipments.**
Ans	**Objectives of testing** :- **(Any Four Points Expected: 1 Mark Each, Total 4 Marks)** 1. To find an error in machine/equipment/ product. 2. To find the defects in machine/equipment/ product. 3. To confirm whether machine/equipment/ product is manufactured as per design data or not. 4. To confirm whether the performance of machine/equipment/ product is as per design data or not. 5. To determine that the machine/equipment/ product appears to be working as stated in the specifications 6. To confirm whether the results obtain during testing are within tolerance limits specified by BIS / ISS 7. If the variations in results are not within tolerance limit it is necessary to modify design & material used. 8. To determine the quality of material used & workmanship. 9. To provide an indication of the product reliability and quality. 10. To avoid in convinces, accidents, minimize risk & for safety purpose.

11. 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.

12. Testing of equipment/machinery is also done after major maintenance of machine/equipment.

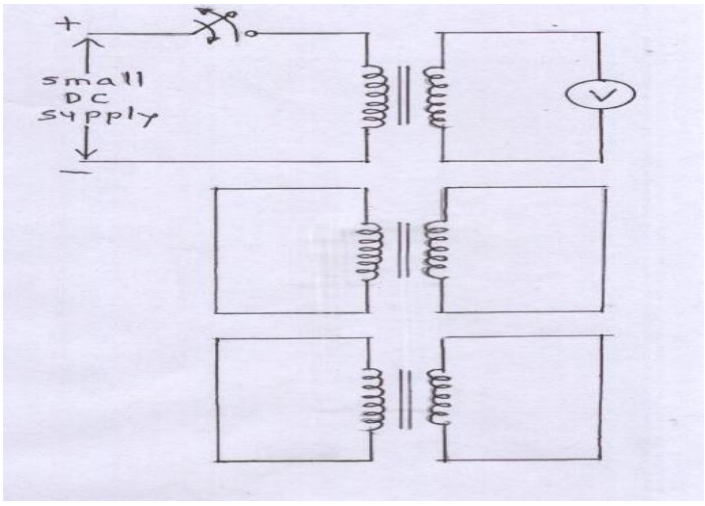
Roles of Bureau of Indian Standards (BIS) in testing of electrical equipment's:-

(Any Two Points Expected:1 Mark Each, Total 2 Marks)

1. Bureau of Indian standards is our National institute; it specifies the standards for particular in machine/equipment/ product /materials etc.
2. It gives licenses or Certification to manufacturers whose products are as per specified standards.
3. For machines it gives limit of losses & efficiency
4. To improve product (machines) quality according to their standards
5. To avoid in convinces, accidents, minimize risk & for safety purpose, BIS plays important role.
6. BIS plays important role to provide an indication about the product reliability and quality.

ii) How will you conduct the phasing out test on a 3 phase transformer as per IS 2026? Explain with necessary circuit diagram.

Ans: **Circuit diagram of phasing out test on a 3 phase transformer:** ---------- **(2 Marks)**



or equivalent fig

Procedure:- **(2 Mark)**

	➢ This test is carried out to identify primary & secondary windings belonging to same phase. ➢ 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. ➢ Repeat the procedure by connecting voltmeter to secondary side to next secondary winding till voltmeter gives deflection. ➢ 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.
Q.2	**Attempt any TWO of the following: 16 Marks**
a)	**What precautions should be taken to avoid fire due to electrical reasons? Explain the operation of fire extinguishers.**
Ans:	**Following Precautions should be taken to avoid fire due to electrical reasons:** **(Any Four Expected : 1 Mark Each , 4 Marks)** 1. Frequently checking of electrical cables, wires appliances, and closely inspect cords and plugs 2. Overloading on cables/wires/machine should be avoided 3. Do not use of too many device plugged into a circuit. 4. Correct rating of fuse/MCB/switch gear etc. should be used in the circuit. 5. Joints in wiring must be sound. 6. There should not be any loose connection in the electrical installation. 7. Replace deteriorated cables, wires, etc. by new one. 8. Use ground fault protection. like ELCB/earth fault relay. 9. Test electrical safety devices 10. Do not make safety devices inoperative. 11. Electrical installation & equipments used in hazards area should be satisfied the specification/type of protection. 12. Replace Wiring that becomes defective with the passage of time 13. Maintenance should be done strictly as per schedule.

14. Use of superior quality of material ISI mark.
15. Replace faulty electrical installation and outdated appliances.
16. Replace Old electrical sockets and unsafe appliances
17. Maintain clearance as per voltage level
18. Do not store highly flammable liquids near (close to) electrical oven/furnace to avoid fire.
19. Do not kept electric heaters near curtains or furniture.

Operation of fire extinguishers:- ---------- **(4 Marks)**

Stand 6 to 8 feet away from the fire and follow the four-step PASS procedure. If the fire does not begin to go out immediately, leave the area at once. Always be sure the fire department inspects the fire site.

- Pull the safety pin from the handle.
- Aim the extinguisher nozzle at the base of the fire.
- Squeeze the handle or lever slowly to discharge the agen**t.**
- Sweep side to side over the fire until expanded.

b) Explain the maintenance schedule of distribution transformer as per ISS 10028-1981.

Ans: **(Any Eight points are expected: 1 Mark to each point, Total 8 Marks)**

S.No	Frequency of maintenance	Inspection
1	Hourly	Current, Voltage, temperature,
2	Daily	Dehydrating breather
3	Monthly	Oil level in transformer
4	Quarterly	Bushing
5	Half yearly	Conservator
6	Yearly	a) oil in transformer b) Earth resistance c) Relay, alarms and their circuits etc
7	Two Yearly	Non-conservator transformer
8	Five Yearly	Overall inspection of core & winding by removing from transformer tank

OR

Actions to restore transformer to its original condition.

(Any Two points are expected from following schedule: 4 mark each point, total 8 Mark)

1. Hourly Maintenance

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

2. Daily Maintenance

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

- Check Oil level in transformer.
- Check the air passage of breather is clear see that there is no dirt , dust accumulated at air passage.
- Check the colour of Silica gel in breather.
- Check tank and radiator against oil leakage.
- Check the cooling system.
- Check position of relief diaphragm fitted at the end of explosion vent against detoriated or damaged.
- Check physical condition of transformer.
- Check tap changer and oil position
- Cleanliness in the substation yard should be done
- Check the ground connection (earthing).

3. Monthly Maintenance

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

- Check the temperature indicators
- Breathing holes in silica gel breather should also be checked monthly and properly cleaned if required, for proper breathing action.

4. Quarterly Maintenance

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

- Examine the Bushing for Dirt and dust deposit.
- Check Oil strength (dielectric).
- Check operating mechanism.

5. Half Yearly Maintenance

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

- Check the acidity of oil in transformer.
- Check oil filled in bushing.
- Check the gasket joints.
- Check the terminals and connections in the boxes.
- Examine relay and alarm contacts there operations, fuses etc.
- Check the foundation.
- Check the earth resistance & insulation resistance.
- Check the oil against moisture content in OLTC.
- Check conservator see that level of oil is at marking.
- Check the cable box
- Examine the lighting arrestor.
- All connections of HV & LV side should be tight and replace lugs if required.

6. Yearly Maintenance

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

- Check Oil in transformer against acidity, resistivity, sludge formation and tanδ.
- Check Oil filled bushings.
- Check lubricating oil in gear box of driving mechanism.
- Check Surge diverter & gap.

- All valves should be checked for any leakage and for open/close operation.
- All activities mention above after 6 months are to be done

7. Two Yearly Maintenance

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

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

8. Five Yearly Maintenance

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

- Overall inspection of core & winding by removing from transformer tank

OR

Transformer Inspection and Maintenance

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

c) Give probable causes and remedies for the following troubles in 3-phase induction motor?
(i) Motor runs hot (ii) Motor runs slow
(iii) Excessive sparking between brushes and slip rings in slip ring I.M.
(iv) Motor vibrates.

Ans **(Any Two causes are expected from following troubles, 1 Mark each, Total 8 Marks)**

Sr.No	Type of fault/abnormal conditions/Troubles	Causes	Remedies
1.	Motor Runs Hot	➢ Single phasing. ➢ Overload ➢ Over/Under voltage. ➢ Unbalance voltage ➢ Over/Under frequency ➢ Poor motor ventilation/ Air flow obstructed or inadequate ventilation. ➢ Ventilating Fan is not working ➢ Rotor rubbing on stator ➢ Worn bearings ➢ High ambient temperature at the motor controller. (above 40^0C) ➢ Excessive core loss. ➢ Stator winding is in correct connected (Wrong connection) ➢ It may be due to internal faults	Rectify the Cause

		inside the winding or for winding to earth. ➢ Check the correct starting time and duty cycle. ➢ Broken rotor bars ➢ Shorted stator coils ➢ Dirt in motor	
2.	Motor Run Slow	➢ Low voltage. ➢ Low frequency. ➢ Single phasing. ➢ Overload ➢ Stator connected in star instead of delta. ➢ Improper connection of motor leads to supply line ➢ Shorted stator coils ➢ Broken rotor bars	Rectify the Cause
3.	Excessive Sparking between brushes & slip ring in slipring I.M.	➢ Line current is more ➢ Brushes are bedding or sticking in holders-not properly ➢ Dirt is accumulated on brushes ➢ Improper pressure and spring tension.	Rectify the Cause
4.	Motor Vibrates	**1. Electrical Causes:-** ➢ Un-even air gap ➢ Shorted stator ➢ Shorted rotor coil or open rotor bars ➢ Loose iron core/rotor spider **2. Mechanical Causes:-** ➢ Reflected vibration from the driven load. ➢ Reflected vibration from adjoining machines ➢ Dynamic unbalance of the rotor ➢ Mis-alignment to the coupled load ➢ Incorrect balancing of job when mounted on face plate ➢ Incorrect Leveling ➢ Due to bent shaft ➢ Defective bearings ➢ Loose foundation bolts	Rectify the Cause

Q. 3	**Attempt any FOUR of the following: 16 Marks**
a)	**State the objectives of high voltage test on 3-phase I.M.? Explain the procedure of carrying out H.V. test on 3-phase I.M.**

Ans:

Objective of objectives of high voltage test on 3-phase I.M:- ---------- **(2 Marks)**

- To determine the weakness of insulation damaged insulation or insufficient clearances etc.
- To determine the level of insulation of the motor.

Procedure of carrying out H.V. test on 3-phase I.M.:- ---------- **(2 Marks)**

The test voltages should be of power frequency and as far as possible should have a sine wave shape.

- This test consists in applying the specified test voltage between the various windings and earth.

No.	Description	Test Voltage (for 60 sec.)
1	Stator Windings	1000V + **Twice rated** voltage with a minimum of 1500 Volts
2	Rotor windings of slip ring induction motors (unidirectional)	1000V + **Twice open** circuit standstill voltage as measured between slip rings with (unidirectional) rated voltage applied to stator windings
3	For motors to be reversed or braked while running , rotor winding	1000 V+ **Four times** open circuit standstill voltage

Conclusion :-

- During high voltage test if no failure of insulation occurs at full test voltage then test is successful.
- i.e. quality & level of insulation is good.

b)	**Short circuit test with secondary S_1, S_2 shorted are conducted on single phase 2.5 kVA, 250/125V transformer. The following readings are obtained at 30°C.** **Current = 8 Amp; Voltage applied = 36 volts,** **Power = 128 watts.** **Assuming full load winding temperature as 75° C, Calculated Resistance, impedance and full load loss of the transformer at working temperature of 75°C.**

Ans:

Given Data:

1-ph: 2.5 KVA Transformer 250/125 Volts V_{SC} = 36 V I_{SC} = 8 A W_{SC} = 128 W

Solution:

1. **Resistance at 30^0C** $W_{SC} = I_{SC}^2 R_{01}$

$$R_{01}\ at\ (30^0C) = \frac{W_{SC}}{I_{SC}^{\ 2}} = \frac{128}{(8)^2}$$

$$R_{01}\ at\ (30^0C) = 2\ \Omega$$ ---------- **(1/2 Mark)**

2. $Z_{01} = \frac{V_{SC}}{I_{SC}} = \frac{36}{8} = 4.5\ \Omega$ ---------- **(1/2 Mark)**

$$\therefore X_{01} = \sqrt{(Z_{01})^2 - (R_{01})^2}$$ ---------- **(1/2 Mark)**

$$\therefore X_{01} = \sqrt{(4.5)^2 - (2)^2}$$

$$\therefore X_{01} = 4.0311\Omega$$ ---------- **(1/2 Mark)**

3. Resistance at 75^0C :

$$\frac{R_2}{R_1} = \frac{t_2 + 234.5}{t_1 + 234.5}$$

$$\therefore R_{01}\ at\ (75^0C) = R\ at\ (30^0C) \times \frac{234.5 + 75}{234.5 + 30}$$

$$\therefore R\ at\ 75^0C = 2.3402\ \Omega$$ ---------- **(1/2 Mark)**

There will be no effect on inductive reactance, The value of inductive reactance will be remain the same

$$\therefore X_{01}\ at\ (75^0C) = X_{01}(30^0C) = 4.0311\ \Omega$$

4. Impedance at 75^0C :

$$\therefore Z_{01}\ at\ (75^0C) = \sqrt{R_{01}(75^0C)^2 + X_{01}(75^0C)^2}$$ ---------- **(1/2 Mark)**

$$\therefore Z_{01}\ at\ (75^0C) = \sqrt{(2.3402)^2 + (4.0311)^2}$$

$$\therefore Z_{01}\ at\ (75^0C) = 4.6611\ \Omega$$ ---------- **(1/2 Mark)**

5. full load loss at 75^0C :

$$= W_{SC} \text{ at } (\text{room temperature}) \times \frac{234.5+75}{234.5+(\text{Room temperature})}$$

$$= 128 \text{ at } (30^0 C) \times \frac{234.5+75}{234.5+30}$$

full load loss at 75^0C $= 149.776$ *Watt* ---------- **(1/2 Mark)**

c) State the different methods of purifying and filtration of insulating oil. Explain any one in brief. (Diagram not necessary)

Ans:

Methods of oil purifying and filtration of insulating oil:- ---------- **(2 Marks)**

1. Stream line purifiers (Filter pack type)
2. Centrifugal purifiers

Explanation:- (**Any one Step expected)** ---------- **(2 Marks)**

First step:-

To obtain better results raise the oil temperature to a desired level, generally up to 65 ^{0}C to 70 ^{0}C before filtering

Second step:-

In this step removal of sludge, dirt dust & solid impurities from the transformer oil gets removed.

Two methods have been used for removal of the sludge, dirt dust & solid impurities:

1. **Stream line purifiers:-**

Removal of sludge by filter candles/cartridge/filter pack (Stream Line Purifiers):

- In this process oil under high pressure is passed through very thin paper-discs (Filter packs, Filter candles (cartridges)).
- The purified oil will go down and impurities remain in paper-discs.
- It also helps to remove the moisture from oil.

2 . **Centrifugal purifiers**:-

- In this method oil filled assembly is rotated at very high speed by an electric motor.
- Due to this high centrifugal forces are created in oil assembly, So heavier particles(sludge) thrown out of bowl directly and purified oil remains in bowl.

- It can also throw out water from the oil that is in free form.
- But it cannot throw out small solid impurities.

Third step:-

After de-sludging the third steps in the oil is passed in dehydration (dehumidification) and degasification in the degassing chamber.

In this step transformer oil is heated till dissolved moisture, gases in oil are gets evaporated. The process is done in vacuum

d) Classify the insulating materials as per IS 1271-1985 as per the operating temperature with two examples of each classification.

Ans: **(Any Four classification with their operating temperature with exmaple: 1 Mark each Total 4 Marks)**

Sr.No.	Insulation Classes	Maximum permissible temperature (^{0}C)	Insulating Material
1	Class-Y or O	90^0	Cotton, silk, paper, press board, wood , cellulose-,PVC,VIR .
2	Class- A	105^0	Cotton, silk or paper impregnated paper & cellulose Easter.
3	Class- E	120^0	Laminated Cotton, Synthetic resin enamels and paper laminations.
4	Class- B	130^0	Glass fiber, asbestos, mica, asbestos laminates.
5	Class- F	155^0	Laminated asbestos, Glass fiber, and asbestos, Mica, built up mica.
6	Class- H	180^0	Made of inorganic material glued with silicon resin or adhesive coated on mica, glass fiber.
7	Class- C	Over 180^0	Made of 100% inorganic material E.g. mica, porcelain, ceramics, glass quartz, asbestos.

e) State the Internal and External causes for failure/Abnormal operation of equipments. (four causes of each)

Ans: **(2 Marks for Internal and 2 Marks for external causes, Total 4 Marks)**

Internal and external causes for the abnormal operation of electrical equipment's:

Internal Faults Causes:- **(Any Four points are expected from the following)**

1. Insulation break down between winding & earth

2. Insulation breaks down between different phases.
3. Insulation breaks down between adjacent turns i.e. inter-turn fault.
4. Open circuit (either in H.V or L.V)
5. Short circuit (between in H.V and L.V)
6. Ground fault (between H.V and core)
7. Ground fault (between H.V and supporting structure)
8. Shorted turns (either in H.V or L.V)
9. Presence of moisture in transformer oil.
10. Failure of magnetic circuit
11. Transformer core fault.

Externals Faults Causes:- **(Any Four points are expected from the following)**

1. External short circuit ,the short circuit may occurs in two or three phases of electrical power system
2. High voltage disturbance
3. Sustained Power frequency over voltage
4. Lighting Surges
5. Switching Surges (There may be always a chance of system over voltage due to sudden disconnected of large load.)
6. Arcing Grounds
7. Travelling Waves
8. Sudden Changes in system condition
9. Resonance
10. Under frequency effect in power transformer**:** If frequency reduces in a system the flux in the core increases ($\phi \alpha \frac{V}{f}$), it causes similar effect that of the over voltage.

Q.4 a)	**Attempt any THREE of the following:** **12 Marks**
i)	**Discuss about the 'Electrical Safety' as per IE Rules 1956.**

Ans:

'Electrical Safety' as per IE Rules 1956:- **(Any four points are expected, 1 Mark each)**

1) Cut-out on consumer's premises:

- The supplier shall provide a suitable cut-out in each conductor of every service-line other than an earthed or earthed neutral conductor or the earthed external conductor of a concentric cable within a consumer's premises, in an accessible position. Such cut-out shall be contained within an adequately enclosed fireproof receptacle.
- Where more than one consumer is supplied through a common service-line, each such consumer shall be provided with an independent cut-out at the point of junction to the common service
- Every electric supply line other than the earth or earthed neutral conductor of any system or

the earthed external conductor of a concentric cable shall be protected by a suitable cut-out by its owner

- No cut-out, link or switch other than a linked switch arranged to operate simultaneously on the earthed or earthed neutral conductor and live conductors shall be inserted or remain inserted in any earthed or earthed neutral conductor of a two wire-system or in any earthed or earthed neutral conductor of a multi-wire system or in any conductor connected thereto with the following exceptions:(a) A link for testing purposes, or (b) A switch for use in controlling a generator or transformer.

2) Danger Notices:

- The owner of every medium, high and extra-high voltage installation shall affix permanently in a conspicuous position a danger notice in Hindi or English and the local language of the district, with a sign of skull and Bones on
- (a) Every motor, generator, transformer and other electrical plant and equipment together with apparatus used for controlling or regulating the same;
- (b) All supports of high and extra-high voltage overhead lines which can be easily climb-upon without the aid of ladder or special appliances.

3) Safety:

- Two or more gas masks shall be provided conspicuously and installed and maintained at accessible places in every generating station with capacity of 5 MW and above and enclosed sub-station with transformation capacity of 5 MVA and above for use in the event of fire or smoke.
- Provide that where more than one generator with capacity of 5 MW and above is installed in a power station, each generator would be provided with at least two separate gas masks in accessible and conspicuous position.

4) High Voltage Equipments installations:

- High Voltage equipments shall have the IR value as stipulated in the relevant Indian Standard.
- At a pressure of 1000 V applied between each live conductor and earth for a period of one minute the insulation resistance of HV installations shall be at least 1 Mega ohm Medium and Low Voltage Installations- At a pressure of 500 V applied between each live conductor and earth for a period of one minute, the insulation resistance of medium and low voltage installations shall be at least 1 Mega ohm.

5) Every switchboard shall comply with the following provisions, namely:

- A clear space of not less than 1 meter in width shall be provided in front of the switchboard;
- If there are any attachments or bare connections at the back of the switchboard, the space (if any) behind the switchboard shall be either less than 20 centimeters or more than 75 centimeters in width, measured from the farthest outstanding part of any attachment or conductor;
- If the space behind the switchboard exceeds 75 centimeters in width, there shall be a passage-way from either end of the switchboard clear to a height of 1.8 meters.

6) Use of energy at high and extra-high voltage:

Voltage	Ground clearance	Sectional clearance
11KV	2.75 Meter	2.6 Meter
33KV	3.7 Meter	2.8 Meter
66KV	4.0 Meter	3.0 Meter
132KV	4.6 Meter	3.5 Meter
220KV	5.5 Meter	4.3 Meter
400KV	8.0 Meter	6.5 Meter

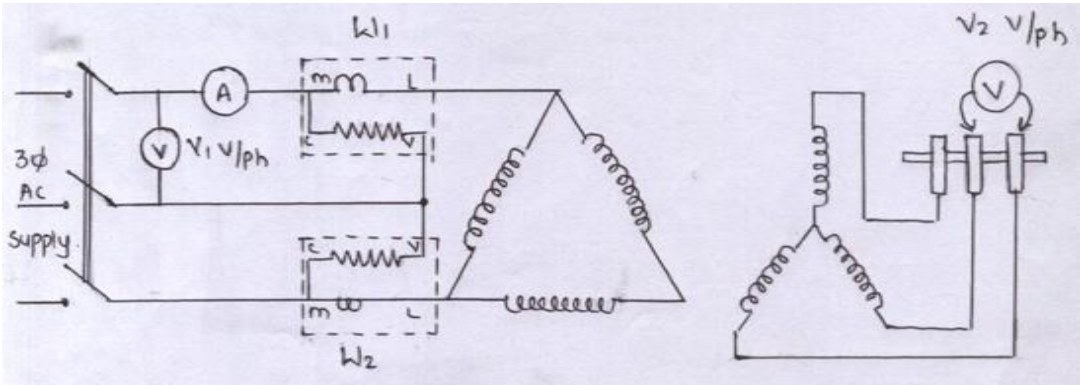
7) Connection with earth:

- In case of the delta connected system the neutral point shall be obtained by the insertion of a grounding transformer and current limiting resistance or impedance wherever considered necessary at the commencement of such a system.
- Where the earthing lead and earth connection are used only in connection with earthing guards erected under high or extra-high voltage overhead lines where they cross a telecommunication line or a railway line, and where such lines are equipped with earth leakage relays of a type and setting approved by the Inspector, the resistance shall not exceed 25 ohms.

8) Clearance above ground of the lowest conductor

- No conductor of an overhead line, including service lines, erected across a street shall at any part thereof be at a height of less than:
- For low and medium voltage lines 5.8 meters
- For high voltage lines 6.1 metres
- No conductor of an overhead line, including service lines, erected along any street shall at any part thereof be at a height less than:
- For low and medium voltage lines 5.5 metres
- For high voltage lines 5.8 metres
- No conductor of in overhead line including service lines, erected elsewhere than along or across any street shall be at a height less than:
- For low, medium and high voltages lines=4.6 meters.
- For low, medium and high voltage=4.0 meters.

	• For high voltage lines above 11,000 volts=5.2 meters. • For extra-high voltage lines the clearance above ground shall not be less than 5.2 metres plus 0.3 meter for every 33,000 volts or part thereof by which the voltage of the line exceeds 33,000 volts.
ii)	**Describe the 'moisture proofness' and 'leakage current' test on single phase induction motor?**
Ans:	**1. Moisture-proofness Test:-** ---------- **(2 Marks)** The motor shall be subjected to and shall satisfy the high voltage test and insulation resistance test immediately after having been placed for a period of 24 hours, without passing current through the motor in a closed chamber in which relative humidity is maintained not less than 90% at a temperature of $40^0 + 2^0C$ **2. Leakage current Test:-** ---------- **(2 Marks)** A voltage equal to 1.1 times the rated voltage is applied to the motor and the leakage current is measured between any one terminal and the metal parts and a tin foil covering the outer parts of the insulation. The resistance of the test circuit should be 2000 ± 50 ohms. The leakage current should not be greater than 2.5 mA.
iii)	**List the devices and tools required for loading unloading; lifting and carrying heavy electrical equipments. (any eight)**
Ans:	**(Any Eight names of devices and tools expected : 1/2 Mark each ,Total 4 Marks)** **Equipment used for loading unloading; lifting and carrying heavy electrical equipments:-** 1) Stationary Cranes 2) Overhead or Gantry Cranes 3) Mobile Cranes 4) Truck Mounted Crane 5) Steam Crane 6) Chain pulley Block 7) Chain Hoist 8) Electric Hoist 9) Screw Jacks 10) Winches 11) Hoses & tripods (For temporary supports) 12) Ceiling ropes.

iv)	**What are the requirements for installation of transformers with respect to** **1) Location 2) Facilities for maintenance.**
Ans:	**(Any four points are expected 1 Mark each, Total 4 Marks)** Following are the requirements for installation of Transformer with respect to : **1) Location and 2) Facilities for maintenance**:- 1. Near load centre : Transformer should be located near load center to reduce cost of Transmission and distribution lines and to reduce losses in it. 2.Easy access for transmission Line : There should be easy access for incoming and outgoing line. 3.Easy access towards Transformer:- There should be easy access towards for Transformer for transportation of equipment & manpower etc. 4.Space(Land) available : Transformer The land proposed for a Transformer should be normally level and open from all sides 5. Bearing capacity of land (Hard land) : To reduce erection cost and for better foundation of Transformer land should be have high bearing capacity (hard soil.) 6.Area free from earthquake : To avoid damage to Transformer area should be free earth quake. 7. Transformer should be installed only on poles strong enough to carry their weight. 8. Transformer poles should be straight.
Q. 4b)	**Attempt any ONE of the following: 06 Mark**
i)	**Explain with circuit diagram the open circuit voltage ratio test on 3-phase slip ring induction motor.**
Ans:	**(Circuit Diagam 3 Marks , Explanation 3 Marks, Total 6 Marks)** **Circuit Diagam:-** 

Explanation:-

Objectives:-

- To confirm the voltage ratio, or turns ratio between stator & rotor of slip ring induction motor is as per design values are not,

Procedure:-

- In this test the rotor is kept open circuited, and the stator winding is connected to rated voltage at rated frequency,
- Measure the input voltage and voltage between slip rings to check the balance.
- If any rotor unbalance is observed, reading may be taken at several positions of rotor.

Calculations:-

- The turn's ratio between stator turns and rotor turns is approximately equal to

$$= \frac{1}{2}\ \frac{V_1 + V_2}{V_2}$$

Where, V_1 *is voltage measured across stator ter* min *als*

V_2 *is voltage across to rotor winding*

ii) Explain in brief, how the cleaning of Insulation covered with loose dry dust; sticky dirt; oily viscous film is carried out. Also describe the methods of drying of electrical insulation by external heat method.

Ans: Following methods of cleaning of insulations:-

1. Loose dry dust:- ---------- **(1 Mark)**

- Remove loose dust by forced air, pressure should be moderate.
- Remove loose dust by suction air / industrial vacuum cleaner.
- Dry dust can be removed by soft brush.
- Clean open dirt & dust by cotton waste.

2. Sticky dirt:- ---------- **(1 Mark)**

- Sticky dirt can be removed by smooth fibrous scrubber.

3. Oily viscous film:- ---------- **(1 Mark)**

- Oily viscous film can be removed with recommended petroleum solvent & then wipe/rub with soft cotton cloth.
- Oil, grease, and dirt as possible should be removed by wiping with clean, dry cloths and then wipe/rub with wet cloth with a solvent recommended by the manufacturer.

Methods of drying of electrical insulation by external heat method: ---------- **(1 Mark)**

- **Radiating lamps**:- Lamp heat is used for drying insulation
- **Drying chambers**:- Insulation is kept in drying chamber for drying.

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

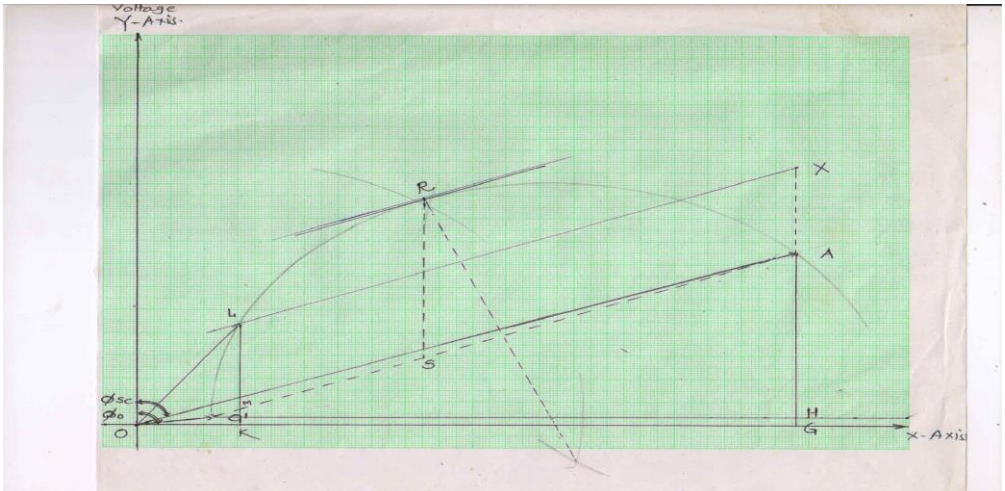
a) **A three phase, 415 volts; 5.5 kW induction motor tested for circle diagram gave the following results. Power was measured by two wattmeter method.**
No load test:- 415 V; 4.6 Amp; W_1 = 1000 W; W_2 = –560 watts.
Blocked rotor test:- 98 V; 10 Amps; W_1 = 770 W; W_2—160 watts. Using scale 1 cm = 2 Amp find power scale. Estimate efficiency and current (magnitude and p.f.) at full load and maximum output.

Ans:

Given Data:

No load test:- 415 V; 4.6 Amp; W_1 = 1000 W; W_2 = –560 watts
Blocked rotor test:- 98 V; 10 Amps; W_1 = 770 W; W_2—160 watts
Draw a circle diagram and determine:
i) Efficiency, current and power factor at rated output ii) Maximum output

Solution:-



------- **(1Mark)**

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

1) No load Test: $V_0 = 415V$, $I_0 = 4.6A$, $W_0 = (W_1-W_2) = (1000-560) = 440$ watt

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

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

$$\phi_0 = Cos^{-1}\left(\frac{440}{\sqrt{3}\times 415\times 4.6}\right)$$

$\phi_0 = 82.35^0$ *Elec.* ---------- **(1/2Mark)**

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

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

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

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

$I_{SN} = 42.35\ A$ ---------- **(1/2Mark)**

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

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

$\phi_{SC} = 68.94^0$ *Elec.* ---------- **(1/2Mark)**

3) Let, the Current scale: - 1 cm = 2A

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

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

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

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

$$W_{SN} = 10938.91 \ watts$$ ---------- **(1/2Mark)**

5) OA is output line, AX is output $= \dfrac{Output\ in\ watts}{power\ scale}$

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

$$= 1458.52 \ watt/cm$$ ---------- **(1/2Mark)**

6) Length of AX in cm $= \dfrac{Output\ in\ watts}{power\ scale}$

$$= \frac{5.5\times10^3\ watt}{1458.52}$$

$$= 3.8\ cm$$ ---------- **(1/2Mark)**

From circle diagram : Point 'L' represent the full load condition of I.M :

7) full load current = Length of 'OL' in cm x Current scale

= 5.4 cm x 2 A/cm

= 10.8 Amp ---------- **(1 Mark)**

8) Power factor at full load = $Cos\phi = Cos\ 35^0$

Power factor at Full load = 0.82 *Lag* ---------- **(1Mark)**

9) Full load % efficiency = $\dfrac{l\,(LM)}{l\,(LK)}\times100$

$$= \frac{3.8\ cm}{4.4\ cm}\times100$$

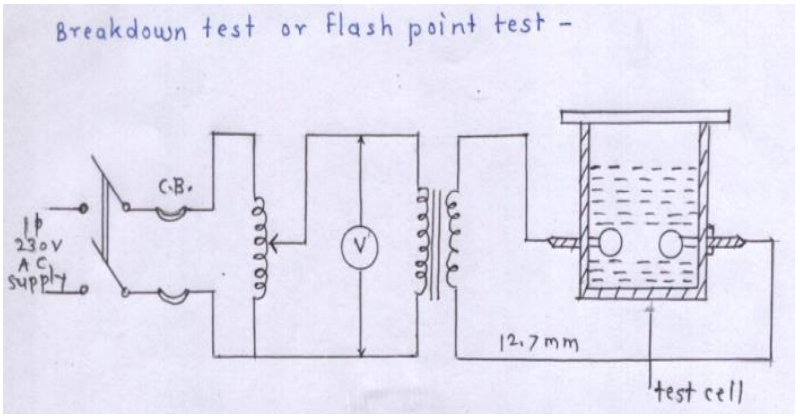
Full load % efficiency = 86.36 % ---------- **(1Mark)**

10) Maximum output = length of 'RS' in cm x power scale

= 6.9 cm x 1458.52

Maximum output = 10063.79 watts ---------- **(1Mark)**

b)	**Explain with sketch or figure: wherever possible; in brief the following tests conducted on Transformer oil:- (i) Dielectric strength test (ii) Acidity test**
Ans:	**(i) Dielectric strength test:-** ---------- **(Figure : 2 Mark & Explanation : 2 Marks)**



or equivalent figure

- The sample of oil is taken from near the top & bottom of the transformer.
- In this kit, there are two electrodes separated by small gap of 2.5 mm (in some kit it 4mm) between them. The gap of electrode is first checked with a gauge.
- The cup is filled with sample of oil to be tested up to about 1 cm above the electrodes.
- The cup top is covered with clean glass plate.
- Now slowly increase the voltage between the electrodes till sparking starts between the electrodes. And note down voltage reading.
- Generally this measurement is taken 3 to 6 times in same sample of oil and the average value of these reading is taken. Average of all results is considered as the breakdown voltage of oil sample.
- This value is noted down for good Oil condition its breakdown voltage is 45 KV (rms) for 4mm gap.
- Minimum **breakdown** voltage **of transformer oil** or **dielectric strength of transformer oil** at which this oil can safely be used in transformer, is considered as 30 KV. If this value is lower than 30 KV than it indicates presence of moisture in oil

(ii) Acidity test :- ---------- **(4 Marks)**

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.

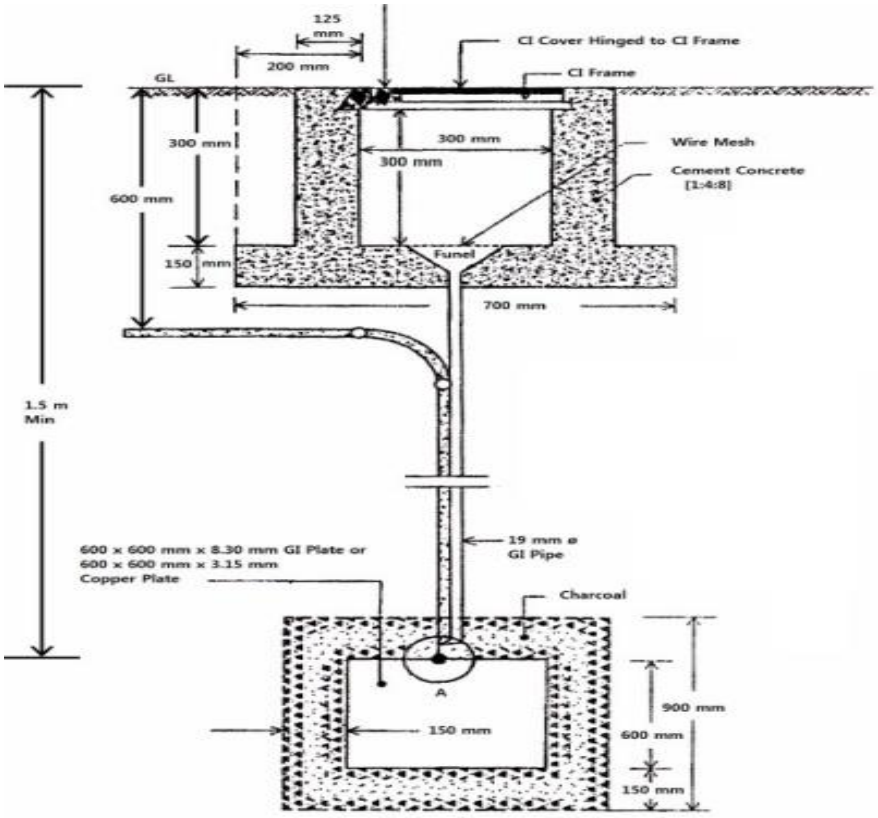
iii) Acidity exceeds 10 mg (KOH)/g: - Oil should be discards or treated.

OR

10 gm of sample oil is taken in a 250 cc conical flask. In other flask 50 cc of alcohol is taken and 1 cc of phenolphthalein is added in it. This is heated to 40-50° C and neutralized with a solution of KOH. This neutralized alcohol to boiling point and boiled for 5 minutes 1 cc of phenolphthalein is added in it and titrated quickly after cooling with KOH solution.

c) Explain with labelled neat diagram:-
(i) Plate earthing as per IS with components
(ii) Also give the difference between installation earthing and system grounding.

Ans: **(i) Plate type Earthing:** **(Figure: 2 Marks, Explanation: 2 Marks, Total 4 Marks)**



Explanation of Plate type earthing:

- Excavation on earth for a normal earth Pit size is 1.5M X 1.5M X 3.0 M.
- **Specifications:** Generally for plate type earthing normal Practice is to use GI earthing plate of

size mentioned below as per requirement.

- **GI Earthing Plate:**

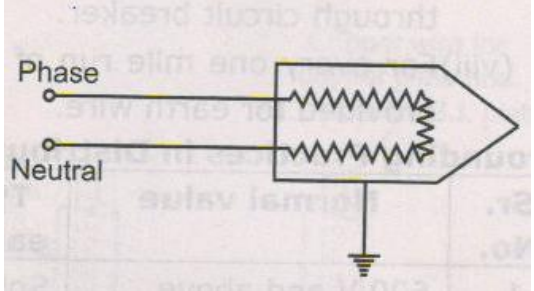
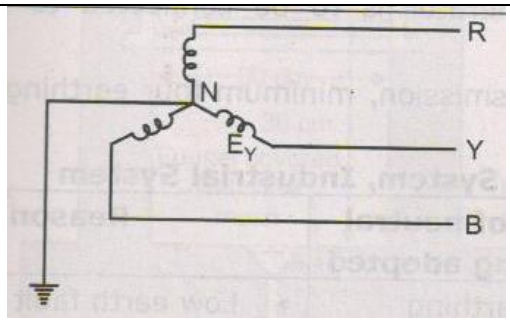
Plate Size	*Weight*
600 x 600 x 3 mm	*10 Kg App.*
600 x 600 x 4 mm	*12 Kg App.*
600 x 600 x 5 mm	*15 Kg App.*
600 x 600 x 6 mm	*18 Kg App.*
600 x 600 x 12 mm	*36 Kg App.*
1200 x 1200 x 6 mm	*70 Kg App.*
1200 x 1200 x 12 mm	*140 Kg App.*

- OR Copper plate of size 600 mm x 600 mm x 3.15 mm
  Plate burred at the depth of 3 mtr. in the vertical position

- These types of earth pit are generally filled with alternate layer of charcoal & salt up to 4 feet from the bottom of the pit.
- Make a mixture of Coal Powder, Salt & Sand all in equal part. Because of following reasons-
  1. Coal is made of carbon which is good conductor minimizing the earth resistant.
  2. The salt percolates and coal absorbs water keeping the soil wet.
  3. Use of Coal Powder also beneficial as it is anti corrosive.
- Prepare a Concrete chamber of size 450mm×700mm as shown in fig. and close the chamber by removable C.I. plate. Make arrangement with the help of G.I. pipe of size 19mm and funnel for pouring the water in earth pit when required.
- The electrical installation which to be earthed, is connected to the plate by means of copper or aluminium earth continuity strip of sufficient cross-section.
- and GI strip of size 40×6 mm or 50 mmx6 mm bolted with the plate is brought up to the ground level or Cu Strip of size 25×3 mm or 40×3 mm or 50×3 mm is used if Copper plate is used.

(ii) Difference between Installation earthing and System grounding :

(Any Four points expected 1 Mark each, Total 4 Marks)

S.No	Installation earthing	System Grounding
1	Earthing means connecting the dead part (it means the part which does not carries current under normal condition) to the earth for example electrical equipment's frames, enclosures, supports etc.	Grounding means connecting the live part (it means the part which carries current under normal condition) to the earth for example neutral of transformer.
2	It is equipment earthing.	It is source or system earthing.
3	Earthing is an alternate low resistance path for leakage current.	Grounding is a source for unwanted currents and also as a return path for main current for protection of delicate equipments.
4	The purpose of earthing is to minimize risk of receiving an electric shock if touching metal parts when a leakage current is present.	Grounding is done for the protections of power system equipment and to provide an effective return path.
5	The purpose of earthing is to minimize risk of receiving an electric shock to human.	It is provided for eliminating arcing ground and over voltage surge.
6	Generally Green wire is used for this as a nomenclature.	Generally Black wire is used for this as a nomenclature.
7	EEarthing connections are of four types: • Plate earthing • Pipe earthing • Rod earthing • Strip earthing	E Grounding connections are of three types: • Solid earthing • Resistance earthing • Reactance earthing
8	It is nothing to do with the system stability.	It increases stability of the system.
9	It does not provide any means for protection system against earth fault.	This earthing provides suitable means for earth fault protecting system.
10		

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

a) **Define the tolerances? Give the values of tolerances for power Transformer as per IS 2026-2011.**

Ans: **(Definition ---2 Marks, Tolerance in case of Power Transformer 2 Marks)**

Meaning of Tolerances:-

It is maximum permissible variation in the actual values & designed values as specified by ISS / BIS is called tolerance.

Tolerance in case of Power Transformer (Any two points are expected)

No	Test Item	Tolerance
1	Measurement of winding Resistance	HV winding within ± 8 % and LV winding within ± 12 %
2	Measurement of voltage ratio (Ratio of Transformer) OR The permissible tolerance for turns ratio.	± 0.5 % for each tap
3	Measurement of short circuit impedance	Not exceed ± 10% of guaranteed impedance
4	load losses (Copper Losses)	Not exceed +15% of guaranteed for load loss
5	Measurement of No-load losses (Iron Losses)& No-load current	Not exceed +15 % of guaranteed for No-load loss
6	Separate source AC voltage withstand test	No collapse of the test voltage.
7	Induced AC voltage test	No collapse of the test voltage.
8	Measurement of insulation resistance	> 2000 M.ohm between HV-LV > 2000 M.ohm between HV-GND > 500 M.ohm between LV-GND
10	Maximum permissible temperature rise over ambient while delivering full load continuously	Oil - 45^{o}C Winding- 55^{0}C
11	Minimum percentage impedance for transformer of 33/11 KV rating are	Up to 1 MVA -5% 3 MVA - 6% 5 MVA - 7% 7.5 MVA - 8% 8 MVA to 12 MA - 9%
12	Standards for transformer noise	from 40 dB to 60 dB for units below 500kVA, And 76 dB for units between 8MVA and 10M VA.

b)	**List the Routine tests conducted on synchronous generator as per IS 7132-1973.**
Ans:	**Routine tests conducted on synchronous generator as per IS 7132-1973:-** **(Any Four Test Expected – 1 Mark each Test)** 1. Insulation Resistance test. 2. Measurement of resistance of winding of stator. 3. No load running test. 4. Phase sequence test 5. Regulation test 6. Measurement of open circuit characteristics
c)	**Describe the factors affecting the preventive maintenance schedule.**
Ans:	**It depends on following Factors:** **(Any Four factors Expected – 1 Mark each factor)** 1. Load cycle / Operating cycle of equipment or machine, or whether the machine is continuously working or otherwise. 2. Type of machine & it's working condition. 3. Cost of the maintenance. 4. Availability of spares & raw material. 5. Availability of trained & skilled technician. 6. It depends on production requirement. **7.** Working environment of industry.(Presence of dust, dirt, chemical fumes, moisture in the air) 8. If the machine is continuously overload it needs early maintenance it will also need suitable time for preventive maintenance. 9. If the machine fails, how mush loss of money it will cause due to its down period. 10. Aging of machine 11. The machine used in the production work comes under essential equipments and they need suitable time for preventive maintenance.
d)	**Describe the procedure for levelling and aligning of direct coupled drive.**
Ans:	**Procedure levelling and aligning of direct coupled drive:-** **(Any Four Point Expected – 1 Mark each point)** ➢ Align the motor and the driven machine on bed-plate. ➢ Firstly aligned axis of both the shafts in the same line and not make an angle with each other.

(Axial positioning of the shafts.)

- Aligned both the shafts correctly in the vertical & horizontal plane. (Paralleling of shafts axis.)
- Aligned both the shafts correctly on the same center axis. (Centering of shaft axis)
- Any variation in levels is corrected by suitable steel shims (steel packing plates). It is leveled by adding or removing shims.
- To check alignment there are three methods:-
  1. By visual inspection, combined with straightedge or ruler:- This method has less accuracy.
  2. By use of Dial Indicator: - This method has high accuracy.
  3. By use of Laser- guided tools: - This method has highest accuracy.

e) Describe the requirements of foundation for rotating electrical machinery.

Ans: Following factors to be considered in designing the machine foundation:-

(Any Four point expected : 1 Mark each)

1. Consider Static weight of the machine and accessories.
2. Also consider the operating weight.
3. The foundation should be able to carry the superimposed loads.
4. The foundation should be able to absorb the vibration while operating at its full capacity.
5. The foundation should be sufficiently rigid to maintain proper alignment between the motor and the driven machine.
6. The foundation should be sufficiently rigid to withstand the possible horizontal thrust caused by machine while in operation.
7. The dimension of foundation should be proportional to safe bearing capacity of soil.
8. The dimension of foundation block should be sufficient that the resultant of all the forces should pass within the foundation block.
9. The combined centre of gravity of machine and foundation should be as far as possible, be in the same vertical line.
10. For concrete foundations use concrete ratio of 1:2:4.

11. The foundation should be well cure before machine put on it.
12. Depth of foundation should be proportional to the bearing capacity of soil.
13. Level of plinth should be above the maximum flood level of the site.
14. The surface of foundation must be protected from machine oil by means of suitable chemical coating or suitable chemical treatment.
15. The following size of depth of foundation:

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

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