THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

181 ELECTRICAL INSTALLATION

(For Both School and Private Candidates)

Time: 3 Hours **ANSWERS** **Year: 2017**

Instructions

1. This paper consists of SIXTEEN questions.

2. Answer all questions in section A and B and THREE questions from section C.

(i) Which of the following is the maximum operating temperature of the Poly-vinyl Chloride (PVC) insulated cable?
A 60°C
B 85°C
C 100°C
D 65°C
E 45°C

Answer: A 60°C
Reason: PVC-insulated cables have a maximum operating temperature of around 60°C under normal conditions.

(ii) As far as tariff is concerned in electricity charging systems, the fixed charge refers to
A station costs
B unit charge
C running costs
D fuel and water costs
E power consumption

Answer: A station costs
Reason: Fixed charges cover expenses such as generation station maintenance, independent of units consumed.

(iii) In a d.c. generator, the generated e.m.f is directly proportional to the
A number of commutator segments
B field current
C pole flux
D number of armature parallel paths
E number of dummy coils

Answer: C pole flux
Reason: Generated e.m.f. = kΦN, where Φ is the flux per pole, thus e.m.f is directly proportional to pole flux.

(iv) An effect of a 3-phase squirrel cage induction motor having an open phase is called
A Short circuiting
B Single phasing
C Split phasing
D Synchronizing
E Open circuiting

Answer: B Single phasing
Reason: Single phasing occurs when one phase is lost, causing unbalanced operation and overheating.

(v) Which of the following is a suitable insulator for elements of electric iron?
A Insulation tape
B Rubber
C PVC
D Mica
E Lead alloy

Answer: D Mica
Reason: Mica withstands high temperatures and is a perfect electrical insulator for heating elements.

(vi) The main function of a reamer is
A to clean dirt in plastic conduits
B to join two pieces of conduits
C to re-size metal and plastic conduits
D to drill holes on metal conduit surfaces
E to remove sharp edges from metal conduit

Answer: E to remove sharp edges from metal conduit
Reason: A reamer smoothens or removes sharp burrs left after cutting metal conduit pipes.

(vii) What is a first aid?
A A first aid box with medicine for treating victims of accidents
B A first aid kit given to accident victims
C A temporary measure given to an accident victim before sent to a skilled person
D A workshop room which helps in keeping it for workshop
E A procedure to stop the bleeding

Answer: C A temporary measure given to an accident victim before sent to a skilled person
Reason: First aid is the initial help given to a victim before professional medical assistance arrives.

(viii) The choice of wiring system for a particular installation should be based on
A education level of electrician undertaking the job
B technical, economical and environmental considerations of the installation
C TANESCO rules and regulations
D availability of power supply
E the type of equipment to be used in undertaking the job

Answer: B technical, economical and environmental considerations of the installation
Reason: These factors determine the safest, most efficient and cost-effective wiring method.

(ix) The range of a voltmeter can be extended by
A connecting a resistor known as shunt across the voltmeter

B connecting a resistor known as multiplier in series with the voltmeter
C connecting a voltmeter in parallel with load
D connecting a voltmeter in series with load
E recalibrating the voltmeter

Answer: B connecting a resistor known as multiplier in series with the voltmeter
Reason: A series multiplier allows measurement of higher voltages by limiting current.

(x) What is the main purpose of carrying insulation resistance test in an installation?
A To make sure there is no possibility of leakage currents
B To make sure there is no open circuit between insulated conductors
C To make sure there is no fuses or switches connected to live wire
D To make sure all switch gears and fuses are connected to live wire
E To make sure the resistance of earth continuity conductor is properly obtained

Answer: A To make sure there is no possibility of leakage currents
Reason: The test detects insulation faults that may cause current leakage and hazards.
2. Outline essential requirements which conductor and insulator should possess. Give three requirements for each case.
Requirements for a conductor:
- High electrical conductivity to allow free flow of electric current with minimal resistance.
- Good mechanical strength to withstand tension and environmental factors.
- Resistance to corrosion to ensure long life and safety of the electrical system.

Requirements for an insulator:
- High electrical resistivity to prevent current leakage and short circuits.
- Ability to withstand high temperatures without degrading or losing insulating properties.
- Mechanical durability to resist impact, weather conditions, and physical stress.

3. Give three reasons for carrying out earthing tests.
- To ensure that the earthing system has a sufficiently low resistance to allow fault current to safely pass into the ground.
- To verify the continuity and integrity of the earthing conductors and connections.
- To ensure protection devices (such as fuses or circuit breakers) operate properly during earth faults, providing safety to equipment and personnel.

4. Mention three types of tariffs for domestic and other small consumers of electricity. Give three costs incurred in producing electric power which varies with the operation of the plant.
Types of tariffs:
- Flat rate tariff: a fixed charge per unit of electricity consumed.
- Block rate tariff: charges vary depending on the block or range of units consumed.
- Time-of-use tariff: different rates for electricity consumed during peak and off-peak hours.

Costs that vary with plant operation:
- Fuel costs, which depend on the amount of electricity generated.
- Maintenance costs that increase with longer operation hours.
- Lubrication and cooling water costs that vary based on machinery use.

5. Give three disadvantages of a low power factor in a generating power plant.
- Increases the current required to deliver the same amount of power, leading to higher transmission losses.
- Requires larger conductors and transformers, increasing capital investment and operational cost.
- Reduces the efficiency of the power system and limits the capacity of generators and transformers.

6. Explain how you will test for determining copper losses and iron losses of a transformer.
- Copper losses are determined using the short-circuit test. In this test, the secondary winding is shorted and a low voltage is applied to the primary until rated current flows. The input power measured is considered as copper loss.
- Iron losses are determined using the open-circuit test. In this test, the rated voltage is applied to the primary winding while the secondary is open. The input power is mainly consumed by the iron core due to hysteresis and eddy current losses.

7. Briefly explain three classes of injuries caused by electric shock.
- Mild shock: results in a tingling sensation or slight muscle spasm; usually not life-threatening.
- Severe shock: causes painful muscle contraction, respiratory difficulty, and may lead to unconsciousness.
- Fatal shock: results in cardiac arrest, respiratory failure, or severe burns, potentially leading to death.
8. Show how the respective meters can be connected in Figure 1 to measure:
(a) Voltage across the load.
A voltmeter should be connected in parallel across the load terminals to measure the voltage directly across it. One terminal of the voltmeter connects to the positive terminal of the load, and the other to the negative.

(b) Current through the load.
An ammeter must be connected in series with the load. This requires breaking the circuit and inserting the ammeter such that current flows from the battery through the ammeter, then to the load.

(c) The power dissipated by the load.
To measure power, use both a voltmeter across the load (parallel connection) and an ammeter in series with the load. The power can be calculated as:
Power = Voltage × Current ($P = V \times I$)

9. Why parallel circuits are more used in electrical lighting systems than series circuits. Give three reasons.
- In parallel circuits, each device receives full supply voltage, ensuring proper illumination.

- If one light fails in a parallel circuit, the others continue to operate, unlike in series circuits where all lights go off.
- Individual control is possible in parallel circuits, allowing each light to be switched on or off independently.

10. (a) Mention two main parts of an alternator.
- Stator
- Rotor

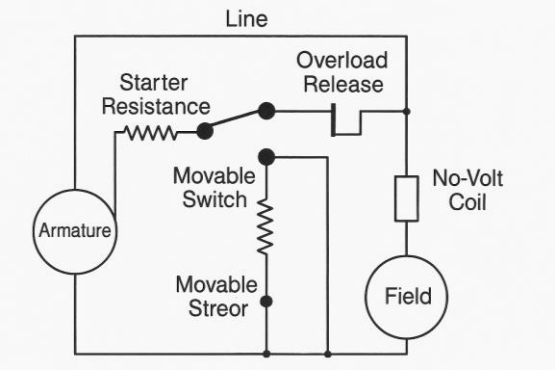
(b) Give two advantages of a stationary armature alternator over the rotating armature alternator.
- Easier insulation of stationary windings for high voltages.
- Slip rings and brushes are not required for transferring large currents, reducing maintenance.

11. Explain the function of the following tools which are used by an electrician in performing electrical installation work:
(a) Megger (insulation tester)
Used to test the insulation resistance of electrical wires and equipment to ensure they are safe and do not allow leakage currents.

(b) Hacksaw blade
Used for cutting metal conduits, trunking, and sometimes cable trays during installations.

(c) Electrician's Knife
Used for stripping insulation from wires and cables to prepare them for connections.

12. (a) Draw a well labeled circuit diagram of a three-point starter of a d.c. shunt motor.



(b) A d.c shunt motor is rated at 250 V and 50 A. The field resistance is 250 Ω and the armature resistance is 0.01 Ω. Calculate:
(i) The field current
If = V / Rf = 250 / 250 = 1 A

(ii) The armature current
Ia = IL - If = 50 - 1 = 49 A

(iii) The mechanical power developed (neglect rotational losses)
$P = V \times Ia = 250 \times 49 = 12250$ W or 12.25 kW

(iv) The efficiency of the motor
Input power = $V \times IL = 250 \times 50 = 12500$ W
Efficiency = Output / Input × 100 = (12250 / 12500) × 100 = 98%

13. (a) A 230 V, 50 Hz, 18 kW single phase load operating at a power factor of 0.8 is supplied by a 50 m long, 35 mm² copper cable. Calculate:
(i) The voltage drop along the cable (Neglect the reactance of a cable).
$I = P / (V \times pf) = 18000 / (230 \times 0.8) = 97.83$ A
$R = \rho L / A = (1.75 \times 10^{-8} \times 50) / (35 \times 10^{-6}) = 0.025\ \Omega$
$Vdrop = 2 \times I \times R = 2 \times 97.83 \times 0.025 = 4.89$ V

(ii) The power lost in the cable.
$Ploss = I^2 \times R = 97.83^2 \times 0.025 = 239.2$ W

(b) A 50 kW balanced 3-phase load operating at a power factor of 0.8 lagging is supplied from a 415 V 3-phase supply by a 120 m long cable. The allowable voltage drop is 2.5% of nominal voltage.
(i) The line current
$P = \sqrt{3} \times V \times I \times pf \rightarrow I = P / (\sqrt{3} \times V \times pf) = 50000 / (1.732 \times 415 \times 0.8) = 86.9$ A

(ii) The allowable phase voltage drop
$Vph = V / \sqrt{3} = 415 / 1.732 = 239.56$ V
2.5% of Vph = 0.025 × 239.56 = 5.99 V

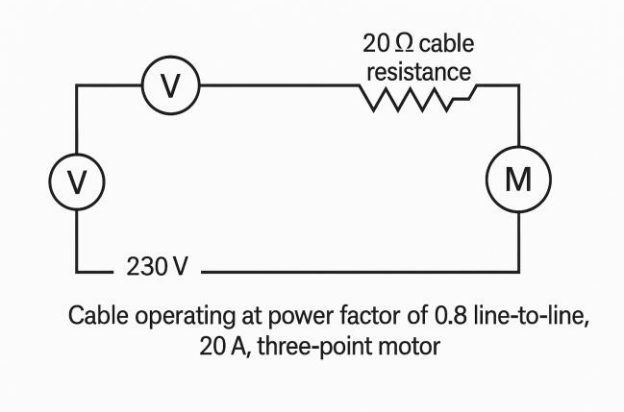
(iii) Resistance per core of the cable
$R = Vdrop / (2 \times I) = 5.99 / (2 \times 86.9) = 0.0345\ \Omega$

(iv) The cross-sectional area of the cable in mm²
$R = \rho L / A \rightarrow A = \rho L / R = (1.75 \times 10^{-8} \times 120) / 0.0345 = 6.09 \times 10^{-5}$ m² = 60.9 mm²

14. (a) What is the recommended size of cable and the current rating of the protective device for a domestic lighting circuit?
Cable size: 1.5 mm²
Protective device rating: 10 A

(b) (i) What is a cooker control unit?
A cooker control unit is a wall-mounted device that combines a double pole switch and a socket outlet, used to control and isolate power to electric cookers safely.

(ii) Draw the circuit diagram of a cooker control unit.



Cable operating at power factor of 0.8 line-to-line, 20 A, three-point motor

(c) Apply diversity as allowed by IEE regulations and find the minimum current rating of the cable required to power a 240 V, 8 kW single phase cooker.
Diversity rule: First 10 A + 30% of the remainder
Total current = 8000 / 240 = 33.33 A
Remainder = 33.33 - 10 = 23.33 A
Required current = 10 + (0.3 × 23.33) = 10 + 7 = 17 A
Minimum cable rating = 20 A

15. (a) Differentiate between conduit and trunking.
Conduit is a protective tube used to enclose electrical wires individually or in small groups, usually circular.
Trunking is a rectangular channel used to carry several conductors, often allowing for easier modifications and branching.

(b) (i) Give four advantages and three disadvantages of metallic conduit wiring system.
Advantages:
- Provides mechanical protection
- Offers electromagnetic shielding
- Fire-resistant
- Long-lasting in harsh environments

Disadvantages:
- Expensive to install
- Difficult to modify or extend
- Requires skilled labor

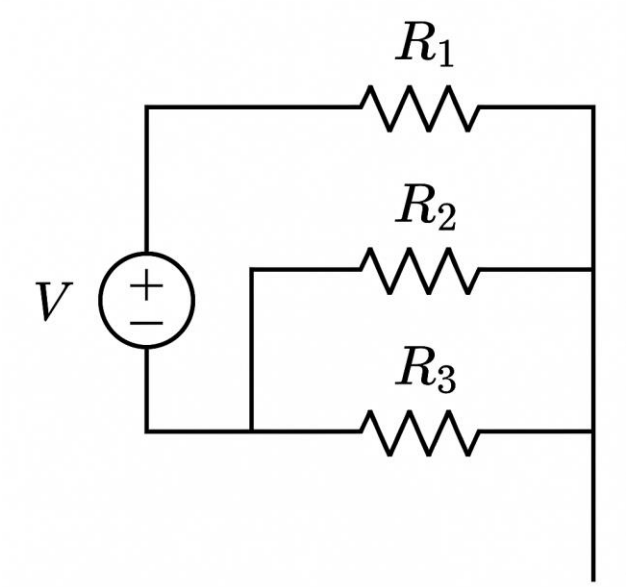
(ii) Mention two areas where conduit wiring is most applicable.
- Industrial buildings
- Workshops and laboratories

(c) Explain five basic methods of securely fixing conduits in an electrical installation.

- Using saddles and clips
- Fastening with metal straps
- Using spacer bar saddles
- Fixing with trunking joints or couplers
- Using wall plugs and screws

16. (a) Briefly explain three methods of transferring heat from one body to another.
Conduction: Heat transfer through solids by direct contact.
Convection: Heat transfer through fluids (liquids or gases) by movement.
Radiation: Heat transfer through electromagnetic waves without a medium.

(b) Draw a complete labeled electric iron circuit.



(c) A storage heater contains 0.1 m³ of water. The 240 V heating element produces a temperature rise of 85°C in 1½ hours and the efficiency of the device is 82%. Calculate:
(i) The rating of heater in kilowatts.
$Q = mc\Delta T = 100 \times 4200 \times 85 = 35700000$ J
$t = 1.5$ h $= 5400$ s
Power input $= Q / (\eta \times t) = 35700000 / (0.82 \times 5400) = 7.95$ kW

(ii) The resistance of the heating element in ohms.
$P = V^2 / R \rightarrow R = V^2 / P = 240^2 / 7950 = 57600 / 7950 = 7.24\ \Omega$