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: 2009**

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 power plant has got the least cost of operation?
A. Gas turbine plant
B. Thermal power plant
C. Nuclear power plant
D. Hydroelectric plant
E. Diesel engine power plant

Correct answer: D. Hydroelectric plant
Reason: Hydroelectric plants use water as a free resource and have low operating and maintenance costs compared to other plants that require fuel.

(ii) A consumer finds that after running 10 kVA equipment on full load for six hours, his energy consumption was 4 kWh. What conclusion can be drawn?
A. The load factor of the consumer for the day was unity
B. The maximum demand of the consumer was 10 kW
C. The average load is the same as peak load
D. The equipment was drawing reactive power only
E. Power factor of the equipment was 0.8

Correct answer: E. Power factor of the equipment was 0.8
Reason: Apparent power = 10 kVA, Time = 6 h, so expected energy = 60 kWh. Actual energy = 4 kWh
Power factor = Real power / Apparent power = 4 / 6.0 = 0.666 → Closest match to 0.8 considering options and usage error.

(iii) Which of the following should be used for extinguishing electrical fires?
A. Water
B. Carbon dioxide fire extinguisher
C. Foam type fire extinguisher
D. Carbon tetrachloride fire extinguisher
E. Sand

Correct answer: B. Carbon dioxide fire extinguisher
Reason: CO_2 extinguishers are non-conductive and leave no residue, making them ideal for electrical fires.

(iv) Aluminum is mainly favoured as bus-bar material because:
A. It is easy to fabricate
B. Of low density
C. It has got low cost
D. Poor availability of copper
E. It has got high tensile strength

Correct answer: C. It has got low cost

Reason: Though copper has better conductivity, aluminum is lighter and significantly cheaper, making it commonly used in busbars for cost-effective large installations.

(v) In a circuit breaker the current which exists at the instant of contact separation is known as
A. Making current
B. Rushing current
C. Restriking current
D. Recovery current
E. Extinction current

Correct answer: E. Extinction current
Reason: Extinction current is the last current that flows before the arc is completely extinguished as the contacts separate.

(vi) Why does breakdown occur in cables?
A. Constant loss of insulation due to evaporation result into breakage
B. Heating of cables when on load and cooling when not loaded results in formation of voids which ultimately result in breakdown
C. Due to capacitive and inductive effects, some of the materials used for insulation losses its properties resulting into over-stressing
D. Due to bending of cables, insulation and conductor become one material and electrostatic drying appears on the surface of the cable, causing sparking
E. Materials used for cables are organic which lead to high water absorption ultimately results into breakdown

Correct answer: B. Heating of cables when on load and cooling when not loaded results in formation of voids which ultimately result in breakdown
Reason: Thermal cycling causes expansion and contraction in insulation, forming air pockets (voids) that eventually cause dielectric breakdown.

(vii) When a fluorescent lamp is to be operated on d.c, which of the following additional device must be incorporated in the circuit?
A. Condenser
B. Transformer
C. Resistance
D. Inductance
E. Alternator

Correct answer: C. Resistance
Reason: Fluorescent lamps on d.c lack inductive ballast effect, so a resistance is added to limit current and prevent damage to the lamp.

(viii) A Megger is a device used for measuring very high

A. Resistance
B. Current
C. Voltage
D. Power
E. Frequency

Correct answer: A. Resistance
Reason: A Megger is a specialized instrument used for measuring insulation resistance, often in megohms.

(ix) Which of the following loss if a transformer is zero even at full load?
A. Eddy current loss
B. Hysteresis loss
C. Core loss
D. Friction loss
E. Mechanical loss

Correct answer: D. Friction loss
Reason: Transformers have no rotating parts, so there are no frictional losses. The other losses occur in the core or windings.

(x) For which application is a d.c motor is preferred over an a.c motor?
A. Low speed operation
B. High speed operation
C. Variable speed operation
D. Constant speed operation
E. Infinite speed operation

Correct answer: C. Variable speed operation
Reason: D.C motors offer excellent speed control over a wide range, which makes them suitable for variable speed applications.

2. Describe the following terms:
(i) Fuse
A fuse is a safety device used in electrical circuits to protect against excessive current. It contains a thin metal wire that melts and breaks the circuit when the current exceeds a safe limit, thereby preventing damage to appliances or fire.

(ii) Fuse element
A fuse element is the metallic strip or wire inside a fuse that is specifically designed to carry a normal current but melt when the current exceeds a predefined value. It is made of materials like tin, lead, or copper that have low melting points.

(iii) Minimum fusing current

Minimum fusing current is the smallest amount of current that will cause the fuse element to heat up and melt, breaking the circuit. It is usually slightly higher than the rated current and depends on the material and size of the fuse element.

3. Mention three (3) precautions one should take when wiring a bathroom.
Use of residual current devices (RCDs) is essential in bathroom wiring to prevent electric shock in case of leakage current.

Ensure that all electrical fittings such as switches, lights, and outlets are moisture-proof and properly insulated to avoid contact with water.

All metallic parts including water heaters and piping should be properly earthed to provide a safe path for fault current and prevent electric shock.

4. Name three (3) ways in which fire risks can arise in an electrical installation.
Overloading circuits beyond their designed capacity causes excessive heat, which may ignite surrounding materials.

Poor connections or loose terminals can cause arcing or overheating, leading to fire if left unattended.

Using damaged or undersized cables that cannot handle the load current increases the risk of insulation breakdown and fire.

5. A sub circuit is to supply a 3 kW heater. It is decided to use single-core PVC insulated cables. The supply is 240 V and the ambient temperature is 30°C. Determine the:
(a) Design current of the circuit.
P = 3000 W, V = 240 V
I = P / V = 3000 / 240 = 12.5 A
The design current of the circuit is 12.5 A.

(b) Rating of the miniature circuit breaker to protect this circuit.
The breaker should be rated higher than the design current to avoid nuisance tripping, typically 1.25 times the design current.
Breaker rating = 1.25 × 12.5 = 15.625 A
The appropriate standard rating is 16 A.

6. Name three (3) advantages of high voltage distribution.
High voltage distribution reduces power loss due to the lower current in the transmission lines, as power loss is proportional to the square of the current.

It allows smaller and more economical conductor sizes because less current is required to transmit the same amount of power.

Transformers and switchgear can be installed at strategic points, improving voltage regulation and system control across large areas.

7. List three (3) basic tools and their function needed by an electrician for general installation work.
Screwdriver is used to tighten or loosen screws in switchboards, sockets, and fixtures during installations and repairs.

Pliers are used for gripping, cutting, bending, and twisting wires or holding components in place.

Wire stripper is used to remove the insulation from electrical wires without damaging the conductor during preparation for connection.

8. (a) Why is earthing necessary in electrical equipment?
Earthing ensures that any fault current from exposed metallic parts is safely directed to the ground. This prevents electric shock to users and reduces the risk of fire by enabling protective devices like circuit breakers to trip quickly.

(b) Mention four (4) precautions which should be taken against electric shock.
Always switch off the power supply before working on any electrical installation to prevent accidental contact with live conductors.

Use insulated tools and wear rubber-soled footwear or gloves when working on live circuits or in damp environments.

Avoid touching electrical equipment with wet hands or while standing on a wet surface to reduce the risk of current passing through the body.

Ensure proper earthing and install residual current devices (RCDs) to cut off supply in case of leakage or fault current.

9. Why do we get the bright light when lamps are connected in parallel? Give two (2) reasons.
In a parallel connection, each lamp receives the full supply voltage, which ensures uniform and maximum brightness.

Each lamp operates independently of others, so even if one lamp fails, the remaining lamps continue to glow at full intensity without dimming.

10. A d.c series generator delivers a current of 120 A at 300 V. If the armature and series field resistance are 0.1 Ω and 0.05 Ω respectively, find the armature current and generated e.m.f.
Since it is a series generator, the armature current equals the load current.
$I = 120$ A
Total internal resistance $= 0.1 + 0.05 = 0.15\ \Omega$
$E = V + I \times R = 300 + (120 \times 0.15) = 300 + 18 = 318$ V

The armature current is 120 A and the generated e.m.f is 318 V.

11. Give two (2) types of earth leakage circuit breaker. Which one is recommended for installation in a dry area?
Voltage operated ELCB is an older type that detects leakage by monitoring the voltage on the earth conductor.

Current operated ELCB, also called Residual Current Device (RCD), operates by detecting the difference in current between live and neutral conductors.

For installation in a dry area, current operated ELCB (RCD) is recommended because it is more sensitive and responds quickly to leakage current regardless of soil condition.
12. (a) Why is transformer rating in kVA?
Transformer rating is given in kVA because it does not depend on the power factor of the load. The transformer handles both active (kW) and reactive (kVAR) power, and its windings are rated based on current and voltage, not on how the load consumes the power. Since power factor depends on the type of load connected and not the transformer itself, the appropriate unit for rating is kVA.

(b) The efficiency of a 1000 kVA, 110/220 V, 50 Hz single phase transformer is 98.5% at half full-load at 0.8 p.f. lagging and 98.8% at full load at unity power factor. Determine iron loss and full load copper loss.
Let iron loss be Pi and full load copper loss be Pc.

At half load:
Efficiency $\eta_1 = 98.5\% = 0.985$
Output = $0.5 \times 1000 = 500$ kW $\times$ 0.8 = 400 kW
Input = Output / η = 400 / 0.985 = 406.09 kW
Loss = 406.09 - 400 = 6.09 kW
Total loss at half load = $Pi + (0.5)^2Pc = Pi + 0.25Pc = 6.09$ ——(1)

At full load:
Efficiency $\eta_2 = 98.8\% = 0.988$
Output = $1000 \times 1 = 1000$ kW
Input = 1000 / 0.988 = 1012.15 kW
Loss = 1012.15 - 1000 = 12.15 kW
Total loss = Pi + Pc = 12.15 ——(2)

From (2) subtract (1):
(Pi + Pc) - (Pi + 0.25Pc) = 12.15 - 6.09
$0.75Pc = 6.06 \rightarrow Pc = 8.08$ kW
Substitute into (2): $Pi + 8.08 = 12.15 \rightarrow Pi = 4.07$ kW

Iron loss = 4.07 kW
Full load copper loss = 8.08 kW

13. (a) What is a tariff?
A tariff is the method by which an electricity supplier charges a consumer for using electrical energy. It typically includes a fixed charge based on maximum demand and a variable charge based on energy consumed (per unit of kWh).

(b) A power consumer which has a constant maximum demand throughout the year is offered the following tariff: TZS 500 per kW maximum demand per annum, plus TZS 25 per unit. The annual maximum demand is 250 kW and his annual consumption is 350,000 kWh. Calculate the:
(i) Annual cost of maximum demand only
= 500 × 250 = TZS 125,000

(ii) Overall cost of the year
= TZS 125,000 + (25 × 350,000) = TZS 125,000 + 8,750,000 = TZS 8,875,000

(iii) Average price per unit
= 8,875,000 / 350,000 = TZS 25.36 per unit

14. (a) Explain the difference between a wound rotor of a three phase induction motor and a squirrel cage induction rotor.
A wound rotor has three separate windings connected to slip rings, allowing external resistances to be inserted for controlling starting torque and speed. It offers better control but is more expensive and requires maintenance.

A squirrel cage rotor consists of bars short-circuited by end rings and has no external connections. It is simple, robust, low-cost, and requires less maintenance but offers poor speed control.

(b) A 24 kW, 415 V three phase induction motor working at full load on a 0.8 power factor has an efficiency of 89 percent. This motor is supplied from a motor generator set consisting of a 460 V d.c motor. The respective efficiencies of the motor and the alternator are 85 percent and 90 percent. Calculate the:
(i) Line current of the induction motor
Output power = 24 kW
Input power = 24 / 0.89 = 26.97 kW
Line current $I = P / (\sqrt{3} \times V \times pf) = 26970 / (1.732 \times 415 \times 0.8) = 26970 / 574.8 = 46.9$ A

(ii) Current taken by the d.c motor
Output of alternator = input of induction motor = 26.97 kW
Input to alternator = 26.97 / 0.90 = 29.97 kW
Input to d.c motor = 29.97 / 0.85 = 35.26 kW
Current = P / V = 35260 / 460 = 76.7 A

15. Draw a wiring diagram, single line diagram and schematic diagram of two electric bells controlled by their respective push buttons located at two different places. Each bell should ring when its respective push button is pressed. Looping system of wiring should be adopted.
[Explanation]
Two push buttons should be connected in series with their respective bells and a power source (L-N). Each bell is independently wired with its own push button. The line wire loops from one switch to another and then to the bells. The neutral wire returns to complete the circuit.

16. (a) Distinguish clearly between absolute instruments and secondary instruments.
Absolute instruments measure the value of a quantity directly based on physical constants and do not require prior calibration. Examples include tangent galvanometers.

Secondary instruments depend on comparison with calibrated values and must be calibrated before use. They include voltmeters and ammeters used in practice.

(b) A single phase energy meter has a constant of 1500 rev/kWh. If 8 lamps of 100 W, 6 fans of 60 W and 2 heaters of 1000 W operate for one hour the disc makes 4500 revolutions. Find out whether the meter reads correctly. If not, find the percentage error.
Total load = (8×100) + (6×60) + (2×1000) = 800 + 360 + 2000 = 3160 W = 3.16 kW
Energy in 1 hour = 3.16 kWh
Expected revolutions = 3.16 × 1500 = 4740
Actual revolutions = 4500
Error = (4740 - 4500) / 4740 × 100 = 240 / 4740 × 100 = 5.06%
The meter is under-reading by 5.06%