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: 2014**

Instructions

1. This paper consists of SIXTEEN questions.

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

(i) The suitable type of switches for controlling one light or a group of lights from three different positions are
A. two – 2 – way – 2 gang switches and an intermediate switch
B. 2 – way – 3 – gang switch
C. two – 2 – way – 1 gang switches and an intermediate switch
D. 1 – way – 3 – gang switch
E. 1 – way – 1 – gang switch and two – 2 – way – 1 – gang switches

Correct answer: C. two – 2 – way – 1 gang switches and an intermediate switch
Reason: To control a light from three different locations, two 2-way switches and one intermediate switch are used in the middle to allow current flow in multiple paths.

(ii) Fuse failure due to bad contact is the result of
A. excessive voltage in the circuit
B. heating effect
C. increased current in the circuit
D. wrong size of a fuse wire
E. lowered resistance due to bad contact

Correct answer: B. heating effect
Reason: Poor contact increases resistance locally, which causes heat generation and eventual fuse blow.

(iii) What type of the capacitor is used on a capacitor start motor?
A. Electrolytic capacitor
B. Large foil paper capacitor
C. Ceramic capacitor
D. Disc capacitor
E. Power factor correction capacitor

Correct answer: A. Electrolytic capacitor
Reason: Capacitor start motors use electrolytic capacitors because they provide high starting torque due to their large capacitance.

(iv) Which of the following has the greatest electrical resistance?
A. A thick copper wire 2 m long
B. A thick copper wire 5 m long
C. A thin copper wire 2 m long
D. A thin copper wire 5 m long
E. A thick copper wire 1 m long

Correct answer: D. A thin copper wire 5 m long
Reason: Resistance increases with length and decreases with thickness. A thin and long wire has the highest resistance.

(v) For a cable to cross a road, it should
A. run as overhead cable
B. be buried in trenches
C. be hardened and tempered
D. be laid in pipes or conduits
E. be surrounded by bust to absorb vibrations

Correct answer: D. be laid in pipes or conduits
Reason: Laying cables in conduits provides mechanical protection and isolates them from traffic and moisture.

(vi) A device which changes its electrical resistance when illuminated by light is called
A. photo voltaic
B. photo electric
C. photo conductive
D. photo diode
E. photo transistor

Correct answer: C. photo conductive
Reason: Photo conductive devices change resistance in response to light; commonly used in light-sensitive applications.

(vii) The tool used to remove sharp edges of a metal conduit is known as
A. reamer
B. chisel
C. pin punch
D. wire stripper
E. gas pliers

Correct answer: A. reamer
Reason: A reamer smooths and removes burrs from the inner edge of a conduit after cutting.

(viii) A good instrument suitable for testing verification of polarity is known as
A. voltmeter
B. tong tester meter
C. ohmmeter
D. ammeter
E. photometer

Correct answer: A. voltmeter
Reason: A voltmeter is used to check voltage and polarity across terminals or wires.

(ix) The source of electric power which is mostly used in Tanzania is
A. water
B. gas
C. solar
D. wind
E. coal

Correct answer: A. water
Reason: Tanzania relies heavily on hydroelectric power which is generated from water sources.

(x) The element which is mostly used to control heat in electric irons is
A. magnet
B. resistor
C. metal strips
D. fuse
E. circuit breaker

Correct answer: C. metal strips
Reason: Bimetallic metal strips expand with heat to control or cut off the circuit in electric irons for temperature regulation.

2. Define the following terms as used in electrical installation field:
(i) Consumer's earthing terminal.
A point in an electrical installation where the consumer connects their earthing conductor to ensure all exposed conductive parts are at earth potential.

(ii) Artificial respiration.
A life-saving procedure applied to a person who has stopped breathing due to electric shock or other reasons to maintain airflow into the lungs.

(iii) Switch gears.
Mechanical devices used to switch, control, and protect electrical circuits and equipment, such as circuit breakers and switches.

3. (a) Why is it necessary to test verification of polarity?
It ensures that live and neutral wires are connected to their correct terminals in sockets and appliances, preventing hazards like electric shocks or malfunctioning of equipment.

(b) What is the purpose of
(i) Earthing fault loop impedance test?
To ensure that in the event of a fault, the earth fault current will be sufficient to trip the protective device quickly, reducing risk of shock or fire.

(ii) Testing between poles?
To confirm correct wiring and proper phase sequence, as well as to detect short circuits or incorrect polarity.

4. Briefly, explain three factors in which severity of electric shock depends on.
- Magnitude of current: Higher current causes more severe injuries or death.
- Duration of contact: Longer exposure increases the damage.
- Path of current through body: Current passing through vital organs like the heart or brain is more dangerous.

5. Outline essential required properties in which conductor and insulator should possess. Give three requirements for each case.
Conductor:
- High electrical conductivity
- Mechanical strength
- Resistance to corrosion

Insulator:
- High electrical resistance
- Thermal stability
- Mechanical durability

6. (a) (i) Give the meaning of the term tariff as used in power supply
Tariff refers to the pricing system used by electricity providers to charge consumers for power consumption.

(ii) What is the main objective of tariff?
To ensure fair revenue recovery for the supply company while encouraging efficient usage among consumers.

(b) Mention two types of cost of producing electric power incurred by the supply company.
- Fixed cost (e.g., infrastructure, salaries)
- Variable cost (e.g., fuel, maintenance)

7. Write the function of the following accessories:
(i) Two way switch
Allows control of one light from two different positions, useful in staircases or long corridors.

(ii) Ceiling rose
Serves as a junction point for wiring and supports the connection of a hanging light fitting.

(iii) Switch socket
Provides a point for connecting and controlling electric appliances with an inbuilt switch and socket outlet.

8. A single phase step-down transformer having a ratio of 10:1 has primary voltage of 6.6 kV. Since losses are negligible, calculate the secondary current when it is loaded at 13200 VA.
Primary voltage = 6600 V
Transformer ratio = 10:1
Secondary voltage = 6600 / 10 = 660 V
Apparent power S = 13200 VA
I = S / V = 13200 / 660 = 20 A
Secondary current = 20 A

9. A four pole d.c generator has a wave wound armature having 50 slots with 14 conductors per slot and is driven at 1000 rpm. If the useful flux per pole is 24 mWb, calculate the value of electromotive force produced.
Given:
P = 4, Z = 50 × 14 = 700, N = 1000 rpm, Φ = 24 mWb = 0.024 Wb, A = 2 (wave winding)
E = (P × Φ × Z × N) / (60 × A)
E = (4 × 0.024 × 700 × 1000) / (60 × 2)
E = (67.2 × 1000) / 120
E = 67200 / 120 = 560 V
Electromotive force = 560 V

10. Explain three differences between magnetic and electric circuits.
- Magnetic circuits deal with magnetic flux, while electric circuits deal with electric current.
- Magnetic circuits use materials like iron cores; electric circuits use conductors like copper.
- Magnetic reluctance resists flux; electric resistance resists current.

11. (a) Where do the following wiring systems are recommended to be used?
(i) Ducting – For industrial and commercial buildings where future cable addition or removal is expected.
(ii) Trunking – In modern buildings for neat wiring layouts and easy access to cables.

(b) What type of conduit must be used for flame proof installations?
Metallic conduit (e.g., steel conduit) is used for flame-proof installations to prevent ignition of flammable gases or vapors.

12. (a)(i) Electric heating is far superior and mostly preferred compared to other methods of heating. Discuss six factors which support this statement.
- Clean and pollution-free since it doesn't produce smoke or residue.
- Precise temperature control allows accurate heating.
- Higher efficiency as electrical energy is directly converted to heat.
- Lower initial installation cost.
- Faster response and heating time.
- No need for fuel storage or handling.

(ii) What are the domestic and industrial applications of electric heating? In each case, mention four applications.
Domestic:
- Water heaters
- Electric kettles
- Irons
- Ovens

Industrial:
- Electric furnaces
- Heat treatment of metals
- Drying paints and enamels
- Plastic molding

(b) A three heat circuit system consists of plate containing two elements A and B controlled by heat switch. Element A has a resistance of 500 Ω and element B has a resistance of 600 Ω.
(i) Draw the circuit to show the arrangement of the elements and switch at high and low positions.
[Diagram is expected to show element A and B with switch configuration for high (A and B in parallel) and low (A only) positions.]

(ii) Calculate the value of the circuit resistance when the switch is at low and high positions.
Low position: $R = 500\ \Omega$ (A only)
High position: $R = (500 \times 600) / (500 + 600) = 300000 / 1100 = 272.73\ \Omega$

(iii) What is the power consumption of the element in high position if the element is connected across a 240 V supply?
$P = V^2 / R = 240^2 / 272.73 = 57600 / 272.73 = 211.23$ W

13. (a) Draw a diagram of a 3-phase, 4-wire supply system which shows the service connection at a consumer's premises. In your diagram show the phase and line voltages.
[Diagram expected with 3 phase lines L1, L2, L3 and neutral N, showing 415 V line-to-line and 240 V phase-to-neutral.]

(b) Explain five factors to be considered when selecting the type of wiring system.
- Type of building (residential/industrial)
- Environmental conditions (temperature, moisture)
- Durability and life span of material
- Safety and insulation standards
- Ease of installation and maintenance

(c) Find the total saving in electrical load and percentage increase in illumination, if instead of using twelve 150 W tungsten filament lamps we use twelve 80 W fluorescent tubes.
Given:

- Choke loss = 25% of rated fluorescent tube = 0.25 × 80 = 20 W
- Effective power per tube = 80 + 20 = 100 W
- Fluorescent luminous efficiency = 40 lm/W
- Incandescent = 15 lm/W

(i) Old load = 12 × 150 = 1800 W
New load = 12 × 100 = 1200 W
Saving = 600 W
Percentage saving = (600 / 1800) × 100 = 33.33%

(ii) Old illumination = 1800 × 15 = 27000 lm
New illumination = 1200 × 40 = 48000 lm
Increase = 48000 - 27000 = 21000 lm
Percentage increase = (21000 / 27000) × 100 = 77.78%

14. (a) Give four advantages and four disadvantages of a moving iron instrument.
Advantages:
- Simple construction
- Can measure both AC and DC
- Rugged and durable
- Low cost

Disadvantages:
- Less accurate
- Non-linear scale
- Affected by frequency variation
- Limited range

(b) With the aid of diagram, explain how the power is balanced in 3-phase balanced circuit.
[Diagram of star or delta system with explanation that in a balanced system, sum of powers in each phase is constant and equal total power = $\sqrt{3} \times VL \times IL \times \cos\varphi$]

(c)(i) The steady readings obtained from two single phase watt meters used to measure the power supply to a three phase load are 14 W and 35 kW. Calculate the
(i) Power factor
P = 14 + 35 = 49 kW
W1 = 14, W2 = 35
$\tan\theta = (\sqrt{3}(W1 - W2)) / (W1 + W2) = (\sqrt{3}(14 - 35)) / 49 = -21\sqrt{3} / 49 = -0.7347$
$\theta = \tan^{-1}(0.7347) = 36.4°$
Power factor = $\cos(36.4°) = 0.805$

(ii) Line current if the supply is 415 V, 3-phase
$P = \sqrt{3} \times VL \times IL \times \cos\varphi$

$49000 = \sqrt{3} \times 415 \times IL \times 0.805$
$49000 = 578.68 \times IL$
$IL = 49000 / 578.68 = 84.67$ A

15. (a) State the function of the following devices in fluorescent lamp
(i) Choke – Provides high voltage for starting and limits current during operation
(ii) Capacitor – Improves power factor and reduces flickering
(iii) Starter switch – Helps initiate discharge by preheating the electrodes

(b)(i) What is the meaning of stroboscopic effect of fluorescent lamp?
Apparent slow or stop motion of rotating machinery under fluorescent lighting due to light flickering at power frequency.

(ii) Why is stroboscopic effect dangerous in some instances?
It can cause misjudgment of machine motion leading to accidents or injuries.

(iii) Suggest three methods which could be employed to minimize the stroboscopic effect.
- Use of three-phase lighting
- Increasing frequency of power supply
- Use of electronic ballasts

(iv) Show by means of circuit diagram how twelve fluorescent lamps can be arranged on 3-phase supply system to minimize the effect in (iii) above.
[Diagram expected: Lamps distributed equally among the three phases with overlapping cycles to balance flicker]

(c) A workshop measures 15 m × 25 m and is lighted by 30 lamps of 200 watts each having an efficiency of 15 lumens per watt. Assuming utilization factor of 0.5 and depreciation factor of 0.8. Find the illumination on the working plane.
Total lumens = $30 \times 200 \times 15 = 90000$ lumens
Effective lumens = $90000 \times 0.5 \times 0.8 = 36000$ lumens
Area = $15 \times 25 = 375$ m²
Illumination = $36000 / 375 = 96$ lux

16. (a) (i) Write down two types of protection which should be provided in the face plate starter.
- Overload protection
- Short circuit protection

(ii) Describe how the speed of d.c shunt motor is controlled.
By varying the field current (field resistance method) or adjusting the armature voltage.

(iii) What are the factors in which the speed of a d.c motor depends on?
- Applied voltage

- Field flux
- Armature resistance

(iv) Briefly, explain three types of loss in a d.c machine.
- Copper loss: I^2R loss in windings
- Iron loss: Due to hysteresis and eddy currents in core
- Mechanical loss: Due to friction and windage

(b) A 7.5 kW, 220 V shunt motor has a full load speed of 1000 rpm. The resistance of the armature and field circuits is 0.25 Ω and 146 Ω respectively. The full load efficiency of the motor is 85.3%. Neglecting brush drop and effect of armature reaction, calculate back e.m.f generated on full load.
Input power = Output / Efficiency = 7500 / 0.853 = 8789.8 W
Input current I = P / V = 8789.8 / 220 = 39.95 A
Field current = 220 / 146 = 1.51 A
Armature current = 39.95 - 1.51 = 38.44 A
Back e.m.f E = V - Ia × Ra = 220 - (38.44 × 0.25) = 220 - 9.61 = 210.39 V