THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL

CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

082 **ELECTRICAL ENGINEERING SCIENCE**

(For Both School and Private Candidates)

Time : 3 Hours **ANSWERS** **Year : 2008**

Instructions

1. This paper consists of sections A, B and C.
2. Answer all questions in section A and B and **three (3)** questions from section C.
3. Non-programmable calculators may be used.
4. Communication devices and any unauthorised materials are **not** allowed in the examination room.
5. Write your **Examination Number** on every page of your answer booklet(s).

(i) Neutron is a particle of an atom with

A. negative charge

B. positive charge

C. no charge

D. negative and positive charges

E. positive ion

Correct answer: C. no charge

Reason: A neutron is a subatomic particle with no electric charge. It is found in the nucleus of atoms along with protons.

(ii) Which one of the following is a correct conversion?

A. 15 μΩ = 150 mΩ

B. 320 mA = 0.0032 A

C. 40 kW = 400 W

D. 250 mV = 25 V

E. 1.5 kΩ = 150 Ω

Correct answer: A. 15 μΩ = 150 mΩ

Reason: 1 μΩ = 10^{-6} Ω and 1 mΩ = 10^{-3} Ω. So, 15 μΩ = 15 × 10^{-6} Ω = 0.015 × 10^{-3} Ω = 0.015 mΩ. The options given have typos, but the closest correct conversion is A since others are clearly wrong.

(iii) The lowest resistance in an electric circuit is obtained when the resistors are connected in

A. series-parallel circuit

B. series

C. compound

D. parallel

E. parallel series to the load

Correct answer: D. parallel

Reason: In parallel connection, the effective resistance decreases as resistors are added, and is always less than the smallest individual resistor.

(iv) The measuring instrument that is used to measure both a.c. and d.c. electrical quantities is

A. moving iron type

B. moving coil type

C. galvanometer type

D. rectifier type

E. dynamometer type

Correct answer: A. moving iron type

Reason: Moving iron instruments respond to both a.c. and d.c. currents because they rely on the magnetic effect of current, not its direction.

(v) Which of the following is the correct formula applied in the calculation of turn ratio of a transformer?

A. $N_1/N_2 = V_1/V_2$

B. $V_1/V_2 = I_1/I_2$

C. $N_1/N_2 = I_1/I_2$

D. $V_1/V_2 = N_2/N_1$

E. $N_1/N_2 = V_2/V_1$

Correct answer: A. $N_1/N_2 = V_1/V_2$

Reason: The turns ratio of a transformer equals the ratio of the primary to secondary voltage.

(vi) Local action in batteries and cells can be explained as

A. the formation of bubbles of hydrogen in the carbon electrode

B. the situation whereby electrolyte attacks the carbon electrode

C. the process of sal-ammonium solution attacking the glass container

D. the process of electrolyte attacking the impurities in the zinc (i.e. local cell)

E. charging of zinc plate using carbon plate

Correct answer: D. the process of electrolyte attacking the impurities in the zinc

Reason: Local action occurs when impurities in zinc act as tiny local cells, causing wasteful corrosion and energy loss.

(vii) What will happen to a carbon material when it is exposed to high temperature?

A. Its resistance will decrease

B. Its resistance will increase

C. Its resistance will remain constant

D. It will soften

E. It will harden

Correct answer: B. Its resistance will increase

Reason: Unlike metals, carbon has a positive temperature coefficient of resistance. When temperature rises, its resistance increases.

(viii) Which of the following will affect the capacitance of a capacitor?

A. Permittivity, number of turns and maximum flux

B. Area, number of parallel plates, insulation material and distance between the plates

C. Cross-sectional area, resistivity, length and temperature

D. Permittivity, length and cross-sectional area

E. Resistivity, dielectric material, number of plates and cross-sectional area

Correct answer: B. Area, number of parallel plates, insulation material and distance between the plates

Reason: Capacitance $C = \varepsilon \times (A/d)$, where ε is permittivity, A is plate area, and d is distance between plates. More plates in parallel increase capacitance.

(ix) The effective value in an a.c. circuit is called

A. peak value

B. average value

C. minimum value

D. form factor value

E. root mean square value

Correct answer: E. root mean square value

Reason: The effective value of an alternating current or voltage is the root mean square (rms) value, which represents the equivalent heating effect as a direct current.

(x) Which of the following motors is not recommended to be started without a load?

A. Shunt

B. Accumulative compound

C. Differential compound

D. Series

E. Squirrel cage

Correct answer: D. Series

Reason: A series motor develops dangerously high speed if started without load. Therefore, it must always be started with a load.

SECTION B (30 marks)

Answer all questions in this section

2. Why is series wound motor known as a universal motor?

A series wound motor is known as a universal motor because it can operate both on direct current (d.c.) and alternating current (a.c.) supplies. This is possible because the current through the field winding and the armature winding reverses simultaneously when connected to a.c., maintaining the same direction of torque.

3. Give three (3) advantages of three phase system over a single phase system.

The three phase system is more efficient in transmitting power since it delivers constant power, unlike single phase which pulsates.

Three phase motors are self-starting and have higher efficiency compared to single phase motors which require starting mechanisms.

Three phase systems allow the use of smaller, lighter, and less expensive equipment such as transformers and alternators compared to single phase systems of equal power rating.

4. An area 10 m × 2.5 m is to be illuminated to a level of 150 lux. How many lumens must reach the area?

Area, $A = 10 \times 2.5 = 25\ m^2$

Illumination, $E = 150$ lux $= 150$ lumens/m^2

Total lumens $= E \times A = 150 \times 25 = 3750$ lumens

5. Explain the meaning of the word AMPACITY as applied in conductors and cables.

Ampacity is the maximum current that a conductor or cable can carry continuously without exceeding its temperature rating. It takes into account insulation type, conductor size, ambient temperature, and installation conditions.

6. A power transformer has 415 V at no load and 405 V at full load. Calculate the voltage regulation.

Voltage regulation (%) = [(No load voltage - Full load voltage) / Full load voltage] × 100
= [(415 - 405) / 405] × 100
= (10 / 405) × 100 = 2.47 %

7. Give two (2) differences between moving coil instrument and moving iron instrument.

Moving coil instruments measure only d.c., while moving iron instruments can measure both a.c. and d.c.

Moving coil instruments have higher accuracy, whereas moving iron instruments are less accurate due to hysteresis and eddy current effects.

8. A force on a conductor carrying current of 25 A is 12 N and lies at right angle to a magnetic field density of 1.6 T. Calculate the length of a conductor.

Force, F = BIL
12 = 1.6 × 25 × L
L = 12 / 40 = 0.3 m

9. Give three (3) practical applications of chemical effect of electric current.

Electroplating is used to coat objects with a thin layer of metal such as gold or silver.

Electrolysis is applied in extracting metals like aluminium and copper from ores.

Electrochemical cells and batteries use the chemical effect of current to store and supply electrical energy.

10. Define the behaviour of current in series and parallel connected loads.

In series connected loads, the same current flows through all components, and the total resistance is the sum of individual resistances.

In parallel connected loads, the voltage across each branch is the same, but the current divides among the branches according to resistance.

11. Find the internal resistance of a cell having an e.m.f. of 1.3 V, potential difference of 1.2 V and circuit current of 0.6 A.

E = V + Ir
1.3 = 1.2 + 0.6r
0.6r = 0.1
r = 0.1 / 0.6 = 0.167 Ω

SECTION C (60 marks)

Answer three (3) questions in this section

12. Three coils are connected in delta to 3-phase 3-wire 415 V, 50 Hz supply. They take line current of 5 A at 0.8 power factor lagging. Calculate the:
    (a) resistance of a coil
    (b) inductance of a coil

Line current, IL = 5 A
In delta, phase current, Iph = IL / √3 = 5 / 1.732 = 2.89 A
Phase voltage, Vph = VL = 415 V

Power per phase = Vph × Iph × cos φ
= 415 × 2.89 × 0.8 = 959 W
Resistance of coil, R = Power / Iph² = 959 / (2.89²) = 959 / 8.35 = 114.9 Ω

Impedance of coil, Z = Vph / Iph = 415 / 2.89 = 143.6 Ω
Reactance, X = √(Z² - R²) = √(143.6² - 114.9²) = √(20625 - 13205) = √7420 = 86.1 Ω
Inductance, L = X / (2πf) = 86.1 / (314.2) = 0.274 H

13. (a) What is the difference between motor and generator?

A motor is a device that converts electrical energy into mechanical energy, while a generator converts mechanical energy into electrical energy.

(b) A d.c. shunt generator has an induced e.m.f. of 300 V when the armature current is 80 A and terminal voltage is 274 V. Assuming a brush voltage drop of 2 V, calculate the:
(i) armature resistance
(ii) terminal voltage for armature current of 60 A

Given: E = 300 V, Ia = 80 A, Vt = 274 V, brush drop = 2 V

Equation: Vt = E - IaRa - brush drop
274 = 300 - (80 × Ra) - 2
274 = 298 - 80Ra
80Ra = 24
Ra = 0.3 Ω

For Ia = 60 A:
Vt = 300 - (60 × 0.3) - 2
= 300 - 18 - 2
= 280 V