**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 : 2017**

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**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).

1. For each of items (i) – (x), choose the correct answer from among the given alternatives and write its letter beside the item number in the answer booklet provided.

(i) Which one of the following is the other name for alternating current generators?

A. Silent pole generators

B. Shaded pole generators

C. Dynamometers

D. Alternators

E. Dynamos

Correct answer: D. Alternators

Reason: AC generators are called alternators, while dynamos are DC generators.

(ii) What is the term used to represent the difference between the synchronous speed and the actual speed of the rotor of an a.c motor?

A. Frequency

B. Slip

C. Motor speed

D. Maximum speed

E. Angular speed

Correct answer: B. Slip

Reason: Slip = (Ns – Nr)/Ns × 100%, where Ns is synchronous speed and Nr is rotor speed.

(iii) The unit used to measure flux density is

A. weber

B. $kg/m^3$

C. weber/m

D. tesla

E. $weber/m^3$

Correct answer: D. tesla

Reason: Flux density B = Φ/A, unit is $Wb/m^2$ = Tesla.

(iv) Which of the following is the effect of electrical current?

A. Electrical effect

B. Mechanical effect

C. Heating effect

D. Potential effect

E. Current effect

Correct answer: C. Heating effect

Reason: Current flowing through a conductor produces heating due to Joule effect ($I^2R$).

(v) The main particles of an atom are

A. Molecules, protons and electrons

B. Protons, neutrons and electrons

C. Neutrons, electrons and molecules

D. Electrons, molecules and charges

E. Charges, protons and neutrons

Correct answer: B. Protons, neutrons and electrons

Reason: An atom consists of protons and neutrons in the nucleus, with electrons orbiting around.

(vi) Which of the following electrical machines operates in most similar way to the principle of operation of a 3 phase induction motor?

A. Synchronous motor

B. Repulsion start induction motor

C. Transformer with a shorter secondary

D. Capacitor start induction run motor

E. Series motor

Correct answer: C. Transformer with a shorter secondary

Reason: An induction motor works on transformer principle with a rotating magnetic field, the rotor acting like the shorted secondary.

(vii) The basic devices found in every electrical measuring instruments are

A. integrating, recording and operating

B. repulsion, attracting and damping

C. operating, controlling and damping

D. operating, indicating and recording

E. damping, recording and integrating

Correct answer: C. operating, controlling and damping

Reason: Measuring instruments require an operating system to produce deflection, a controlling system (spring/ gravity), and a damping system to avoid oscillations.

(viii) Which statement is the most correct among the following?

A. The quantity of heat depends on mass only.

B. The quantity of heat depends on mass, nature of material only.

C. The quantity of heat depends on temperature, nature of material and mass.

D. The quantity of heat depends on temperature only.

E. The quantity of heat depends on its dielectric material.

Correct answer: C. The quantity of heat depends on temperature, nature of material and mass.

Reason: Heat $Q = mc\Delta T$, depends on mass m, specific heat c (nature of material), and temperature rise $\Delta T$.

(ix) Which one of the following is the correct definition of a “neutral point” in relation to magnetic effect?

A. A place where there is no resultant magnetic field.

B. A place where there is a resultant magnetic field.

C. A place where the production of magnetic field is traced.

D. A place where the magnetic field is constant.

E. A place where the magnetic field cuts the flux.

Correct answer: A. A place where there is no resultant magnetic field

Reason: A neutral point is where fields from two magnetic sources cancel each other, resulting in zero net field.

(x) The necessary condition for resonance to occur in an a.c circuit is

A. inductive reactance to be equal to capacitive reactance

B. inductive reactance to be less than one

C. capacitive reactance to be greater than inductive reactance

D. supply frequency to be equal to capacitive reactance

E. capacitance to be equal to inductance

Correct answer: A. inductive reactance to be equal to capacitive reactance

Reason: At resonance, XL = XC, so their effects cancel and circuit impedance is purely resistive.

2. (a) State Ohm's law.

Ohm's law states that the current through a conductor is directly proportional to the voltage across it, provided temperature and other physical conditions remain constant.

(b) What voltage should be applied across 2200 Ω resistor in order for a current of 10 mA to flow through it?

R = 2200 Ω, I = 10 mA = 0.01 A

V = IR = 0.01 × 2200 = 22 V

3. Briefly describe three methods of transferring heat from a body.

Conduction: heat transfer through direct contact between molecules.

Convection: heat transfer in fluids by movement of heated particles.

Radiation: heat transfer through electromagnetic waves without medium.

4. Define the following terms:

(a) Electromagnetic induction

Electromagnetic induction is the process by which an emf is induced in a conductor when the magnetic flux linking it changes.

(b) Reluctance

Reluctance is the opposition offered by a magnetic circuit to the flow of magnetic flux.

(c) Coefficient of coupling

Coefficient of coupling is the fraction of magnetic flux from one coil that links with another coil in mutual induction.

5. Briefly explain how you can extend the range of:

(a) an ammeter

By connecting a low resistance (shunt) in parallel with the meter to bypass excess current.

(b) a voltmeter

By connecting a high resistance (multiplier) in series with the meter to allow measurement of higher voltages.

6. Briefly describe two common faults in Leclanche cells.

Polarization, where hydrogen bubbles form at the electrode, increasing internal resistance.

Local action, caused by impurities in zinc leading to wastage and reduced efficiency.

7. A coil has a resistance of 18 Ω when its mean temperature is 20°C and 20 Ω when its mean temperature is 50°C. Find its temperature coefficient at 0°C.

R1 = 18 Ω at T1 = 20°C, R2 = 20 Ω at T2 = 50°C

Formula: $Rt = R0(1 + \alpha t)$

So, $(R2 – R1)/(R1 \times (T2 – T1)) = \alpha / (1 + \alpha T1)$ approximately.

Better method: $\alpha = (R2 – R1) / (R1(T2 – T1))$

$= (20 – 18) / (18 \times (30)) = 2 / 540 = 0.0037$ /°C

8. (a) State the Lambert's cosine law of illuminations.

It states that the illumination on a surface is proportional to the cosine of the angle between the normal to the surface and the direction of incident light.

(b) A lamp giving a 95.5 candela in all directions is suspended 8 m above the working plane. Calculate the illumination directly under the lamp on the working plane.

I = 95.5 cd, h = 8 m

$E = I / h^2 = 95.5 / (8^2) = 95.5 / 64 = 1.49$ lux

9. Draw the circuit for a single phase half-wave rectifier.

The circuit consists of an AC supply, a single diode in series, and a load resistor connected across the diode. During positive half cycles, current flows through the diode and resistor; during negative half cycles, the diode blocks current.

10. Define the following terms as used in a.c current:

    (a) Frequency

    Frequency is the number of cycles completed by an alternating current in one second, measured in hertz (Hz).

    (b) Amplitude

    Amplitude is the maximum value of the alternating current or voltage from its average or mean position.

    (c) Root mean square

    The root mean square (rms) value of an a.c. is the equivalent steady current value which would produce the same heating effect in a resistor as the alternating current.

11. A three phase system supplies a line current of 72.16 A and line voltage of 250 V when it is delta connected. Calculate:

    (a) phase current

    (b) phase voltage

    In delta connection, line voltage = phase voltage = 250 V

    Line current IL = $\sqrt{3}$ × phase current Iph

    72.16 = 1.732 × Iph

    Iph = 72.16 / 1.732 = 41.7 A

    (a) Phase current = 41.7 A

    (b) Phase voltage = 250 V

12. Two similar coils have a coupling coefficient of 0.25 when they are connected in series with total inductance of 80 H. Calculate:

    (a) self inductance

    (b) mutual inductance

    (c) the total inductance when the coils are connected in series opposing.

Let self inductance of each coil = L

For series aiding: Ltotal = L1 + L2 + 2M = 80 H

Here, L1 = L2 = L, M = k√(L1L2) = kL = 0.25L

So, Ltotal = 2L + 2(0.25L) = 2L + 0.5L = 2.5L = 80 H

L = 80 / 2.5 = 32 H

(a) Self inductance = 32 H

(b) Mutual inductance = 0.25 × 32 = 8 H

(c) For series opposing: Ltotal = L1 + L2 – 2M = 32 + 32 – 16 = 48 H

13. (a) An ammeter has a full scale deflection of 15 mA and a resistance of 50 Ω. The instrument is to be converted to a voltmeter with a full scale deflection of 240 V. Calculate:
    (i) the value of multiplier required
    (ii) the total resistance of the voltmeter

Ifsd = 15 mA = 0.015 A, Rm = 50 Ω, V = 240 V

Total resistance required = V / Ifsd = 240 / 0.015 = 16,000 Ω

Multiplier = Total – Rm = 16,000 – 50 = 15,950 Ω

(i) Multiplier = 15,950 Ω

(ii) Total resistance = 16,000 Ω

(b) If a moving coil instrument has a full scale current of 20 mA and coil resistance of 10 Ω. Calculate the value of shunt resistor to enable the instrument to measure up to 1 A.

Ifsd = 20 mA = 0.02 A, Rm = 10 Ω, I = 1 A

Shunt current Ish = I – Ifsd = 1 – 0.02 = 0.98 A

Rsh = (Ifsd × Rm) / Ish = (0.02 × 10) / 0.98 = 0.2 / 0.98 = 0.204 Ω

14. (a) Define the following terms as applied in electrical conductors:
    (i) Electrical potential
    It is the amount of work done to move a unit positive charge from infinity to a point in an electric field.

(ii) Potential difference

It is the work done in moving a unit positive charge between two points in an electric circuit.

(iii) One volt

One volt is defined as the potential difference between two points when one joule of work is done in moving one coulomb of charge between those points.

(iv) Electric current

It is the rate of flow of electric charge through a conductor.

(b) Twelve cells each of e.m.f 1.5 volts and internal resistance of 0.2 Ω are arranged four in series per row, three rows in parallel. When the external resistance is 4 Ω, calculate;

(i) circuit total resistance

(ii) the circuit current

(iii) the terminal potential difference

(iv) power dissipated in external resistance.

Each row of 4 cells in series:

$E = 4 \times 1.5 = 6$ V

Internal resistance $= 4 \times 0.2 = 0.8$ Ω

For 3 parallel rows:

Effective emf = 6 V

Effective internal resistance $= 0.8 / 3 = 0.267$ Ω

(i) Total resistance $= R_{ext} + r = 4 + 0.267 = 4.267$ Ω

(ii) Circuit current $= E / R = 6 / 4.267 = 1.41$ A

(iii) Terminal p.d $= I \times R_{ext} = 1.41 \times 4 = 5.64$ V

(iv) Power dissipated $= I^2R_{ext} = (1.41^2 \times 4) = 7.95$ W

15. (a) What is the effect of heat on pure metal or conductor?

When heat is applied, the resistance of pure metals increases due to increased vibrations of atoms, which obstruct the flow of electrons.

(b) (i) Mention four factors which determine the resistance of pure conductors.

Material of conductor, length of conductor, cross-sectional area, and temperature.

(ii) Briefly describe the relationship between each factor and its resistance.

Resistance increases with length.
Resistance decreases with increase in cross-sectional area.
Resistance depends on the material's resistivity.
Resistance increases with temperature for metals.

(c) The resistance of copper wire coil at 0°C is 100 Ω. Calculate:
(i) the resistance of the coil at 30 °C
(ii) the resistance of coil if temperature rises from 30 °C to 50 °C.

Temperature coefficient of copper $\alpha \approx 0.004$ /°C

(i) $R_t = R_0(1 + \alpha t) = 100(1 + 0.004 \times 30) = 100(1.12) = 112\ \Omega$
(ii) At 30°C: 112 Ω, At 50°C: $R = 100(1 + 0.004 \times 50) = 100(1.2) = 120\ \Omega$
Increase = 120 – 112 = 8 Ω

16. A two conductor distributor AB, 1400 meters long is fed at end A at 220 V. The loads are as follows; 60 A at 200 meters, 40 A at 700 meters and 80 A at 1000 meters from the feeding end point. The resistance of cable is 1.1 Ω/1000 meters. With the aid of a simple sketch diagram, calculate:
    (a) the total current fed in distributor
    (b) the current in each section of the cable
    (c) the total resistance in each section of the cable.

(a) Total current = 60 + 40 + 80 = 180 A

(b) Current in sections:
From A to 200 m: current = 180 A
From 200 m to 700 m: current = 180 – 60 = 120 A
From 700 m to 1000 m: current = 120 – 40 = 80 A
From 1000 m to 1400 m: current = 80 – 80 = 0 A

(c) Resistance per meter = 1.1 / 1000 = 0.0011 **Ω**

From A to 200 m: R = 200 × 0.0011 = 0.22 **Ω**

From 200 m to 700 m: R = 500 × 0.0011 = 0.55 **Ω**

From 700 m to 1000 m: R = 300 × 0.0011 = 0.33 **Ω**

From 1000 m to 1400 m: R = 400 × 0.0011 = 0.44 **Ω**