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 : 2005**

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 the items (i) – (x) choose the correct answer from among the given alternatives and write its letter beside the item number.

(i) Lumen/m² is the SI unit for

A. illumination

B. light source intensity

C. luminous flux

D. flux

E. space height ratio

Correct answer: A. Lumen per square metre is the unit of illumination (lux).

(ii) The solution used in batteries to generate electromotive force is known as

A. hydrogen gas

B. electrolyte

C. copper solution

D. H_2SO_4

E. sodium chloride

Correct answer: D. Sulphuric acid (H_2SO_4) is the solution used in lead-acid batteries.

(iii) The instrument which can be affected by magnetic field when used is known as

A. moving iron instrument

B. voltmeter

C. moving coil instrument

D. ammeter

E. photometer

Correct answer: C. A moving coil instrument can be affected by an external magnetic field.

(iv) Total current in a circuit can be measured by connecting an ammeter

A. in series with the load

B. in parallel with the load

C. in parallel series with the load

D. in series parallel with the load

E. across the supply

Correct answer: A. An ammeter is always connected in series with the load.

(v) The main parts of an alternator are

A. salient pole and smooth cylindrical pole

B. armature and pole

C. stator and rotor

D. poles, yoke, commutator and armature

E. commutator, armature and rotor

Correct answer: C. The two main parts of an alternator are the stator and rotor.

(vi) Power triangle is formed by three components which are

A. impedance, resistor and inductive reactance

B. resistance, inductive reactance and active power

C. reactive power, apparent power and true power

D. true power, inductive reactance and capacitive reactance

E. impedance, inductive reactance and power factor

Correct answer: C. The power triangle relates true power, reactive power and apparent power.

(vii) Electromotive force is

A. voltage obtained in a circuit when there is no load connected

B. current obtained in a circuit when there is load connected

C. voltage measured in a circuit when there is load connected

D. current measured in a circuit when there is no load connected

E. the voltage generated by a circuit

Correct answer: A. E.m.f. is the potential difference produced by a source when no current is drawn.

(viii) Impedance is the

A. total opposition to the flow of current in a.c. circuits

B. flow of power in circuits

C. total inductance in circuits

D. total opposition to the flow of voltage in a circuit

E. power factor of the circuit

Correct answer: A. Impedance is the total opposition to the flow of current in a.c. circuits (Z).

(ix) The extra low voltage of d.c. supply is

A. 220 V

B. 32 V

C. 50 V

D. 110 V

E. 230 V

Correct answer: B. Extra low voltage is considered as 32 V or less.

(x) The range of an ammeter can be extended by connecting a shunt resistor with a load

A. in parallel

B. in series

C. series parallel

D. parallel series

E. across the load

Correct answer: A. A shunt connected in parallel with an ammeter extends its range.

2. State the functions of the following:

(a) Oscilloscope – An oscilloscope is used to display and analyze the waveform of electrical signals. It can measure amplitude, frequency, phase difference, and detect distortions in waveforms.

(b) Digital ammeter – A digital ammeter measures the current flowing through a circuit and displays the reading in numeric form with high accuracy.

(c) Hydrometer – A hydrometer is used to measure the specific gravity of the electrolyte in a lead-acid battery, which helps determine the state of charge of the battery.

3. What is a calorie?

   A calorie is the amount of heat energy required to raise the temperature of 1 gram of water by 1°C. Its SI equivalent is 4.186 joules.

4. Calculate the slip of a 4-pole synchronous motor whose rotor frequency is 2 Hz. The speed of the motor is 1,500 r.p.m.

   Synchronous speed Ns = 120f/P = (120 × 50)/4 = 1500 r.p.m.
   Slip s = fr/fs = 2/50 = 0.04 or 4%.

5. State three methods used to charge lead-acid cells.

   Constant voltage charging method.
   Constant current charging method.
   Trickle charging method.

6. List down three types of a.c. alternators.

   Salient pole alternator.
   Non-salient (cylindrical rotor) alternator.
   Hydro and turbo alternators (based on applications).

7. List down six (6) sources of electricity.

   Water (hydropower).
   Fossil fuels (coal, oil, natural gas).
   Nuclear energy.
   Solar energy.
   Wind energy.
   Geothermal energy.

8. State three (3) cooling systems of a transformer.

Air natural cooling (AN).

Oil natural cooling (ON).

Forced air or forced oil cooling (AF/OF).

9. Define the term “armature reaction” of a d.c. generator.

Armature reaction is the distortion and weakening of the main magnetic flux in a d.c. machine caused by the magnetic field produced by current flowing in the armature conductors.

10. Two capacitors of 15 μF each are connected in series across 240 V supply. Calculate the charge flowing in a circuit.

For capacitors in series: $1/Ceq = 1/C1 + 1/C2 = 1/15 + 1/15 = 2/15$.

$Ceq = 15/2 = 7.5\ \mu F = 7.5 \times 10^{-6}$ F.

$Q = Ceq \times V = 7.5 \times 10^{-6} \times 240 = 1.8 \times 10^{-3}$ C = 1.8 mC.

11. Calculate the instantaneous voltage of a system which supplies a maximum voltage of 30 V at an angle of 45°.

$Vinst = Vmax \times \sin\theta = 30 \times \sin(45°)$.

$= 30 \times 0.707 = 21.2$ V.

12. A consumer heater requires an immersion heater for a tank containing 200 litres of water. The water is to be heated from 10 °C to 70 °C in 4 hours. Calculate the nearest element size in kilowatt if the efficiency of the heating system is 80 percent.

Mass of water = 200 litres = 200 kg.

Temperature rise $\Delta T = 70 - 10 = 60$ °C.

Heat required $Q = mc\Delta T = 200 \times 4200 \times 60 = 50{,}400{,}000$ J.

Time = 4 hours = $4 \times 3600 = 14{,}400$ s.

Power required = $Q/t = 50{,}400{,}000 / 14{,}400 = 3500$ W = 3.5 kW.

Considering efficiency $\eta = 0.8$, Input power = 3.5 / 0.8 = 4.375 kW.

Nearest element size = **4.4 kW**.

13. Explain how sparks can be reduced in a d.c. generator. A d.c. shunt generator supplies a current of 30 A at 415 V. The armature resistance is 0.85 Ω and the field resistance is 2.5 Ω. Assuming a brush drop of 1.5 V, calculate the:

Sparks can be reduced in a d.c. generator by using interpoles (commutating poles), compensating windings, ensuring smooth commutator segments, and maintaining good brush contact.

(a) Armature current.
Load current = 30 A.
Shunt field current If = V/Rf = 415 / 2.5 = 166 A.
Armature current Ia = Load current + Field current = 30 + 166 = 196 A.

(b) Generated voltage.
V = 415 V.
Ea = V + IaRa + brush drop = 415 + (196 × 0.85) + 1.5.
= 415 + 166.6 + 1.5 = **583.1 V**.

14. (a) What is the function of a centrifugal switch as used in a.c. motors?
It disconnects the starting winding or starting capacitor from the circuit once the motor reaches about 70–80% of synchronous speed.

(b) Explain the difference between a capacitor start induction motor and an inductor start induction motor.
A capacitor start motor uses a capacitor in series with the auxiliary winding to improve starting torque.
An inductor start motor uses an inductance in series with the auxiliary winding, giving lower starting torque than capacitor start.

(c) State two factors upon which the output of an a.c. generator depends.
The magnetic flux per pole.
The speed of rotation of the armature.

(d) Name four types of single phase motors.
Shaded pole motor.
Split phase motor.

Capacitor start motor.

Repulsion motor.

15. A 6600/550 V, 25 kVA transformer has iron losses of 350 W and its primary and secondary winding resistances are 14.5 Ω and 0.1 Ω respectively. Determine the full-load efficiency at a power factor of:

(a) Unity.

Output = 25 kVA = 25,000 W.

Copper loss = $I^2(R1+R2)$.

Primary current I1 = 25,000 / 6600 = 3.79 A.

Secondary current I2 = 25,000 / 550 = 45.45 A.

Copper loss = $(3.79^2 \times 14.5) + (45.45^2 \times 0.1) = 208.7 + 206.6 = 415.3$ W.

Total losses = 415.3 + 350 = 765.3 W.

Efficiency η = Output / (Output + Losses) = 25,000 / (25,000 + 765.3) = 0.970 = **97.0%**.

(b) 0.6 lagging.

Output = 25,000 × 0.6 = 15,000 W.

Efficiency = 15,000 / (15,000 + 765.3) = 0.951 = **95.1%**.

16. (a) State Ohm's law.

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

(b) Examine the diagram below and answer the questions:

R1 = 1 Ω in series with a parallel combination of R2 = 2 Ω and R3 = 3 Ω.

(i) Find the total current of the circuit shown above.

Equivalent resistance of R2 || R3 = (R2 × R3)/(R2+R3) = (2×3)/(2+3) = 6/5 = 1.2 Ω.

Total resistance = R1 + (R2 || R3) = 1 + 1.2 = 2.2 Ω.

Total current = V / R = 120 / 2.2 = 54.55 A.

(ii) Find the total voltage of the circuit.

Total voltage given = 120 V.

(iii) Calculate the total power of the circuit.

Power = V × I = 120 × 54.55 = **6546 W ≈ 6.55 kW**.