TVET CURRICULUM DEVELOPMENT, ASSESSMENT AND CERTIFICATION COUNCIL (TVET CDACC)

Qualification Code	**:**	**071606T4MCT**
Qualification	**:**	**Mechatronics Technician Level 6**
Unit Code	**:**	**ENG/OS/MC/CC/06/6/A**
Unit of Competency	**:**	**Apply Thermodynamics Principles**

WRITTEN ASSESSMENT

INSTRUCTIONS TO CANDIDATE

1. You have **THREE** hours to answer all the questions.
2. Marks for each question are indicated in the brackets.
3. The paper consists of **TWO** sections: **A** and **B**.
4. Do not write on the question paper.
5. A separate answer booklet will be provided.

This paper consists of FOUR (4) printed pages. Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.

SECTION A: (40 MARKS)

*(Attempt **ALL** the questions from this section)*

1.
   a) Name TWO types of systems in thermodynamics (2 marks)
   b) Identify the difference in the statement of the first law of thermodynamics between the systems named in (a) above (2 marks)
   c) Give the general equation for each of the systems named in (a) above. (2 marks)
2. Define the following cycles: (4 marks)
   a) Rankine cycle
   b) Carnot cycle
3. List THREE types of compressors (3 marks)
4. Distinguish between a substance and a property of a system (2 marks)
5. State any THREE commonly used refrigerants. (3 marks)
6. Outline FOUR advantages of reciprocating engine cycles. (4 marks)
7. Identify the THREE forms of equilibrium in thermodynamics. (3 marks)
8. Define saturation state of a substance. (2 marks)
9. Using neat and well labelled diagrams, differentiate between reversible and irreversible heat transfer of substances. (4 marks)
10. State Newton's second law of motion and write its expression. (2 marks)
11. Draw a well labelled graph to show the Rankine cycle. (4 marks)
12. State the THREE modes of heat transfer. (3 marks)

SECTION B: (60 MARKS)

*(Attempt any **THREE** questions from this section)*

13. A steam engine cylinder has a swept volume of 0.03 m^3 and a clearance volume of 0.001 m^3. Cut-off is at 0.4 of the stroke. Saturated steam is admitted at 7 bar and expands isentropically to the blow-down. The mass which expands inside the cylinder during the blow-down may be assumed to do so isentropically. Cushioning is timed so that isentropic compression brings the clearance steam to the admission state. Calculate the work done per machine cycle and the isentropic efficiency when the engine exhausts at atmospheric pressure. (20 marks)

14.

a) Describe the main events occurring in a four-stroke petrol CI engine. (8 marks)

b) Demonstrate how the events in a four-stroke CI engine described in (a) above differ from those in an SI engine (4 marks)

c) Explain how the operation of a two-stroke engine differs from a four-stroke engine. (8 marks)

15.

a) Briefly describe a steam engine (4 marks)

b) Discuss the two peculiar features of a steam engine (4 marks)

c) A four-cylinder engine has a bore of 57mm and a stroke of 90mm. Its rated speed is 2800rev/min and it is tested at this speed against a brake which has a torque arm of 0.356m. The net brake load is 155N and the fuel consumption is 6.74l/h. the specific gravity of the petrol is 0.735 and it has a lower calorific value, $Q_{net.c}$ of 44200kJ/kg. A morse test is carried out and the cylinders are cut out in order 1, 2, 3, 4 with corresponding brake loads of 111, 106.5, 104.2 and 111 N respectively. Calculate for this speed, the engine torque, the bmep, the brake thermal efficiency, the specific fuel consumption, the mechanical efficiency and the iemp. (12 marks)

16.

a) Dry saturated steam at 2.8 bar is expanded in a simple convergent nozzle to a pressure of 1.7 bar. The throat area is 3 cm^2 and the inlet velocity is negligible. Estimate the exit velocity and mass flow:

   i. If phase equilibrium is assumed throughout the expansion (7 marks)

   ii. Assuming the supersaturated expansion to conform to $pv^{1.3}$ = constant (7 marks)

b) Outline THREE conditions that need to be satisfied in order to achieve a steady flow in engineering processes (3 marks)

c) A gas turbine expands 6 kg/s of air from 8 bar and 700oC to 1 bar isentropically. Calculate the exhaust temperature and the power output. $\gamma = 1.4$ $c_p = 1005$ J/kg K (3 marks)