

071906T4AEN

AGRICULTURAL ENGINEERING LEVEL 6

ENG/OS/AGR/CC/05/6/A

Apply Thermodynamics Principles

July/August 2025



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

WRITTEN ASSESSMENT

Time: 3 HOURS

INSTRUCTIONS TO CANDIDATE

1. This paper consists of TWO sections: A and B.
2. Attempt ALL questions in section A and ANY THREE (3) questions in section B.
3. Marks for each question are indicated in the brackets.
4. Candidates are provided with a separate answer booklet
5. Do not write on the question paper.

This paper consists of FOUR (4) printed pages

**Candidates should check the question paper to ascertain that all
pages are printed as indicated and that no questions are missing.**

SECTION A (40 MARKS)

Attempt ALL the questions in this section.

1. Define the following terms as used in thermal engineering. (4 Marks)
 - a. Open System.
 - b. Adiabatic System.
 - c. Thermodynamic State.
 - d. Thermodynamic path.
2. An irreversible thermodynamic process can be defined as a process in which the system and the surroundings do not return to their original condition once the process is initiated. State FOUR examples of irreversible thermodynamic processes. (4 Marks)
3. A steady-flow process is one in which the mass and energy within a control volume remain constant over time. Outline FOUR assumptions made in the system analysis for steady flow. (4 Marks)
4. An isentropic air turbine is used to supply 0.1 kg/s of air at 0.1 MN/m² and at 285 K to a cabin. The pressure at inlet to the turbine is 0.4 MN/m². Determine the temperature at turbine inlet. (4 Marks)
5. It is necessary to store one K.mole of methane at a temperature of 300K and pressure of 60Mpa. Determine the volume of the cylinder that is required for storage using ideal gas equation. (4 Marks)
6. The effectiveness of a heat exchanger is a measure of how well it performs compared to the ideal heat transfer. List FOUR factors which affect effectiveness of the heat exchanger. (4 Marks)
7. Sketch and label the indicator diagram of a steam engine. (4 Marks).
8. Outline FOUR ways in which the efficiency of Rankine cycle may be improved. (4 Marks)
9. Heat engine is a cyclic device, used to convert heat to work. State FOUR characteristics of heat engines. (4 marks)
10. A tank has a volume of 0.5m³ and contains 10 kg of an ideal gas having a molecular mass of 24. If the temperature is 25°C. Calculate the gas pressure. (4Marks)

SECTION B (60 MARKS)***Attempt Any THREE Questions in This Section***

11. Air is drawn in a gas turbine unit at 15°C and 1.01 bar and pressure ratio is 7 : 1. The compressor is driven by the H.P. turbine and L.P. turbine drives a separate power shaft. The isentropic efficiencies of compressor, and the H.P. and L.P. turbines are 0.82, 0.85 and 0.85 respectively. If the maximum cycle temperature is 610°C. Calculate:

- (i) The pressure and temperature of the gases entering the power turbine.
- (ii) The net power developed by the unit per kg/s mass flow.
- (iii) The work ratio.
- (iv) The thermal efficiency of the unit.

Neglect the mass of fuel and assume the following:

For compression process $c_{pa} = 1.005 \text{ kJ/kg K}$ and $\gamma = 1.4$

For combustion and expansion processes: $c_{pg} = 1.15 \text{ kJ/kg K}$ and $\gamma = 1.333$ (20 Marks)

12. A rotary – screw air compressor is a type of air compressor that uses a rotary-type positive displacement mechanism to compress air.

- a. With the aid a neat line diagram, explain the working principle of rotary screw type air compressor (10 Marks)
- b. A refrigerant being used in refrigeration should have various desirable thermodynamic properties, physical properties and working properties. Explain FIVE thermodynamic properties of refrigerants (10 Marks)

13. Heat engines and other cyclic devices usually involve a fluid to and from which heat is transferred while undergoing a cycle.

- a. Outline FOUR common classes of internal combustion engines (4 Marks)
- b. With the aid of diagrams, explain the operation of an internal combustion engine. (16 Marks)

14. There are different modes of heat transfer as far as engineering thermodynamics is concerned.

- a. Explain THREE modes of heat transfer (6 Marks)
- b. State FOUR factors that determine the rate of heat transfer (4 Marks)
- c. A perfect gas for which ratio of specific heat is 1.4 occupies a volume of 0.3m³ at 100 Kpa and 270C. The gas undergoes compression to 0.06m³. Find the heat transfer during compression for the following methods of compression.
 - (i) $PV=C$ (4 Marks)

(ii) Isentropic.

(6 Marks)

Given $P_1=100\text{kPa}$, $V_1 = 0.3\text{m}^3$, $T_1 = 27^\circ\text{C}$, $V_2 = 0.06\text{m}^3$