**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. Define the following terms as used in thermodynamics (4 Marks)
    a) Thermodynamics
    b) Heat
    c) Work
    d) System
2. Distinguish between a property and a process as used in thermodynamics. Give **one** example in each case. (4 Marks)
3. State any **four** methods used to measure torque of an engine (4 Marks)
4. Identify any **two** types of steam turbines (2 Marks)
5. List **four** characteristics of a good refrigerant (4 Marks)
6. Define the term cogeneration as used in steam turbines (2 Marks)
7. Give the meaning of Rankine cycle. (2 Marks)
8. Outline the **four** processes of a Carnot cycle (4 Marks)
9. Differentiate between positive work done and negative work done in a system in thermodynamics (2 Marks)
10. Using a well labelled graph, show proof of existence of the property 'internal energy' (4 Marks)
11. Define the following terms as used in thermodynamics (3 Marks)
    a) Thermal equilibrium
    b) Mechanical equilibrium
    **c)** Chemical equilibrium
12. Name **three** types of heat exchangers (3 Marks)
13. Outline **two** types of recuperative heat exchangers (2 Marks)

## SECTION B: (60 MARKS)

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

14.

a) In the turbine of a gas turbine unit, the gases flow through the turbine at 17 kg/s and the power developed by the turbine is 14000 kW. The enthalpies of the gases at inlet and outlet are 1200 kJ/kg and 360 kJ/kg respectively. The velocities of the gases at inlet and outlet are 60 m/s and 150 m/s respectively. Calculate the rate at which heat is rejected from the turbine. Find also the area of the inlet pipe given that the specific volume of the gases at inlet is 0.5 $m^3$/kg (10 Marks)

b) A back-pressure steam cycle works as follows. The boiler produces 8 kg/s of steam at 40 bar and 500 ℃. This is expanded to 2 bars with an isentropic efficiency of 0.88. The pump is supplied with feed water at 0.5 bars and 30 ℃ and delivers it to the boiler at 31 ℃ and 40 bars. Calculate the net power output of the cycle. (10 Marks)



15. A single-acting two-stage compressor with complete intercooling delivers 6 kg/min of air at 16 bars. Assuming an intake state of 1 bar and 15℃, and that the compression and expansion processes are reversible and polytropic with n = 1.3, calculate the power required, the isothermal efficiency and the free air delivery. Also calculate the net heat transferred in each cylinder and in the intercooler. If the clearance ratios for the low- and high-pressure cylinders are 0.04 and 0.06 respectively, calculate the swept and clearance volumes for each cylinder. The speed is 420 rev/min (20 Marks)

16.

a) Calculate the refrigeration effect and coefficient of performance for the refrigeration cycle shown in the Figure 1 below, when the fluid is ammonia and the upper and lower temperatures are 30 ℃ and —15 ℃ respectively. Find also the corresponding values for a reversed Carnot cycle operating between the same temperatures. (8 Marks)

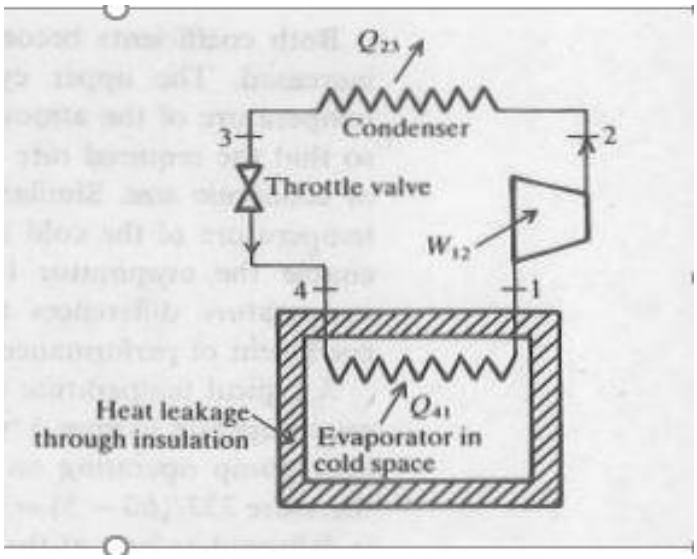


*Figure 1*

b) The cycle in (a) is modified so that the refrigerant enters the compressor as a saturated vapour, and is subcooled to 18°C before entering the throttle valve. Find the refrigeration effect and $CP_{ref}$. What would be the result if R134a were the refrigerant instead of ammonia? (7 Marks)



c) Describe the process of a simple refrigeration of air. (5 Marks)

17.

a) Determine the throat area, exit area and exit velocity for a steam nozzle to pass a mass flow of 0.2 kg /s when the inlet conditions are 10 bar and 250 °C and the final pressure is 2 bars. Assume that the expansion is isentropic and that the inlet velocity is negligible. (16 Marks)

b) Sketch a pressure-volume diagram for the heat engine (4 Marks)