UNIVERSITI
TEKNOLOGI
PETRONAS

FINAL EXAMINATION
JANUARY 2019 SEMESTER

COURSE	**:**	**CDB1053 - INTRODUCTION TO ENGINEERING THERMODYNAMICS**
DATE	**:**	**14 APRIL 2019 (SUNDAY)**
TIME	**:**	**9.00 AM - 12.00 NOON (3 HOURS)**

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Answer Booklet.
2. Begin **EACH** answer on a new page in the Answer Booklet.
3. Indicate clearly answers that are cancelled, if any.
4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions, if any.
5. **DO NOT** open this Question Booklet until instructed.

Note :

i. There are **SIX (6)** pages in this Question Booklet including the cover page .
ii. **DOUBLE-SIDED** Question Booklet.
iii. Thermodynamics Property Table will be provided

1. A piston-cylinder device initially contains air at 150 kPa, 0.4 m^3 and 27°C. At this state, the piston is resting on a pair of stops, as shown in **FIGURE Q1**. Heat is transferred to the air and the piston started to move when a pressure of 350 kPa is achieved. The air is continued to be heated until its volume has tripled.

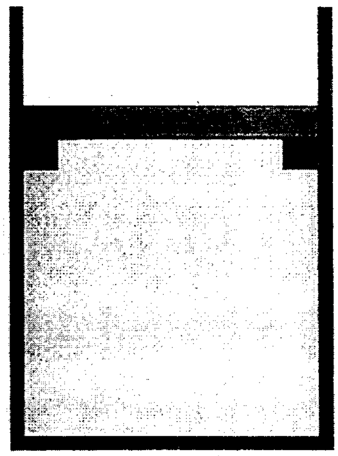

FIGURE Q1: Piston-cylinder device with set of stops

a. State **ONE (1)** assumption made in the analysis.

[2 marks]

b. Show the processes in $P-V$ (pressure – volume) diagram.

[4 marks]

c. Determine the final temperature of air.

[4 marks]

d. Derive the overall energy balance for the processes and calculate the total heat transferred to the air in kJ.

[10 marks]

2. a. State the function of a turbine.

[2 marks]

b. Steam enters an adiabatic turbine at 5 MPa, 600°C and 80 m/s and leaves at 50 kPa, 150°C and 140 m/s. The mass flow rate of the steam flowing through the turbine is 8 kg/s. Assume this is a steady-flow process and changes in kinetic and potential energies are negligible.

i. Determine the isentropic efficiency of the turbine.

[10 marks]

ii. Calculate the actual power output of the turbine in kW.

[4 marks]

iii. If the insulation on the turbine is removed, comment on the power output of the turbine.

[4 marks]

3. A heat pump system for maintaining a heated space at high temperature consists of a compressor, a condenser, a throttling valve and an evaporator. At steady state, refrigerant-134a enters the compressor at 200 kPa and 10°C and is compressed adiabatically to 800 kPa and 40°C. From the compressor, refrigerant enters the condenser and it condenses to saturated liquid phase at 800 kPa. The refrigerant then expands through the throttling valve to 200 kPa. Cold air enters the condenser at 100 kPa and 27°C with a volumetric flow rate of 0.4 m^3/s and leaves at 57°C under isobaric condition.

a. By using comparison between coefficient of performance of heat pump (COP_{HP}) and coefficient of performance of refrigerator (COP_R), prove that COP_{HP} can be greater than unity.

[4 marks]

b. Calculate the mass flow rate of refrigerant-134a in kg/s.

[10 marks]

c. Determine the COP_{HP} if the given rate of heat released to the heated space is 13.8 kJ/s.

[6 marks]

4. A simple Brayton cycle with air as the working fluid has a pressure ratio of 12. The air enters a compressor at 300 K and a turbine at 1000 K. Assume variation specific heats with temperature for air.

a. Determine the amount of heat transferred to the Brayton cycle in kJ/kg.

[7 marks]

b. Calculate the back work ratio.

[8 marks]

c. An engineer proposes to utilize a regenerator to this Brayton cycle. Evaluate the validity of the proposal.

[5 marks]

5. a. Discuss **TWO (2)** differences between Otto and Diesel cycle.

[4 marks]

b. An ideal Otto cycle has a compression ratio of 9 and uses air as the working fluid. Air is at 300 K and 100 kPa at the beginning of the compression process and at 1600 K at the end of the heat addition process. Assume variation specific heats with temperature for air. Calculate the thermal efficiency of the cycle.

[16 marks]

-END OF PAPER-