# UNIVERSITY OF RUHUNA

**Faculty of Engineering**

End-Semester 1 Examination in Engineering: December 2023

**Module Number: ME1202**

**Module Name: Fundamentals of Thermodynamics (C-23)**

**PART B**

**[90 minutes]**

[Answer **all questions**, each question carries **12** marks]

**Note:** Provide neat sketches and state any reasonable assumptions made; Symbols have their usual meaning; Steam table is provided.

Q1 a) Write down **two** examples for closed systems and open systems, and briefly explain the differences between closed and open system.

[2.0 Marks]

b) Write down **three** alternative statements of the second law of thermodynamics.

[3.0 Marks]

c) Draw the schematic and accompanying $p$-$v$ diagram of the Carnot vapour power cycle executed by simple water power plant and briefly explain its thermodynamic processes.

[3.0 Marks]

d) The minimum power required to drive a heat pump which maintains a house at the temperature of 20 °C is 3 kW. If the outside temperature of the house is 3 °C, calculate the amount of heat loss from the house.

[2.0 Marks]

e) An object of known mass and initially at rest falls from a specified elevation. It hits the ground and comes to rest at zero elevation. Is energy conserved in this process? Discuss.

[1.0 Mark]

f) Briefly explain the statement "Kinetic and gravitational potential energies are extensive properties of a closed system".

[1.0 Mark]

Q2 a) Air is contained in a vertical piston–cylinder assembly fitted with an electrical resistor. The atmosphere exerts a pressure of 1 bar. On the top of the piston, which has a mass of 45 kg and a face area of 0.092 $m^2$. Electric current passes through the resistor, and the volume of the air slowly increases by 0.045 $m^3$ while its pressure remains constant. The mass of the air is 0.27 kg, and its specific internal energy increases by 41.9 kJ/kg. The air and piston are at rest initially and finally. The piston–cylinder material is a ceramic composite and thus a good insulator. Friction between the piston and cylinder wall can be ignored, and the local acceleration of gravity is 9.75 $m/s^2$.

i) Determine the heat transfer from the resistor to the air assuming air inside the cylinder as the system.

[3.0 Marks]

ii) Calculate the heat transfer from the resistor to the air assuming air and the piston as the system.

[3.0 Marks]

b) Four-tenths (4/10) kilogram of a certain gas is contained within a piston-cylinder assembly. The gas undergoes a process for which the pressure-volume relationship is $pV^{1.5}$ constant. The initial pressure is 3 bar, the initial volume is 0.1 $m^3$, and the final volume is 0.2 $m^3$. The change in specific internal energy of the gas in the process is - 55 kJ/kg. Assume that there are no significant changes in kinetic or potential energy. Calculate the net heat transfer for the process, in kJ.

[3.0 Marks]

c) Briefly explain the following terms relevant to the *P-T* diagram of a pure substance.

i) Sublimation line
ii) Vaporization line
iii) Melting line

[3.0 Marks]

Q3 a) What is thermodynamic power cycle? Give **three** examples.

[3.0 Marks]

b) A steam power plant operates in a Carnot cycle. Steam leaves the boiler at a temperature of 352.29 °C and pressure of 170 bar. The condenser temperature is 28.96 °C and pressure is 0.04 bar.

i) Draw the relevant *T-s* diagram for the above process.

[0.5 Marks]

ii) Calculate the efficiency of the cycle.

[1.0 Marks]

iii) Determine the heat input to the boiler.

[1.5 Marks]

iv) Calculate the work done by the turbine.

[1.5 Marks]

v) What is the heat output of the condenser?

[1.5 Marks]

c) List **two** reasons why the Carnot cycle is not a feasible model for steam power plants.

[3.0 Marks]