UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2015/2016

COURSE NAME	:	THERMODYNAMICS I
COURSE CODE	:	BDA20202
PROGRAMME	:	BDD
EXAMINATION DATE	:	JUNE 2016 / JULY 2016
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE (5)** QUESTIONS **ONLY** OUT OF **SIX (6)** QUESTIONS.

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

Q1 (a) An angler was traveling in a gasoline-powered boat at 30 km/h. The boat's engine was rather old, thus, its efficiency is no longer optimum, and it produces a louder exhaust sound. It was a hot sunny day with a temperature of 35°C and 70% relative humidity. The barometer installed in his boat showed a steady reading of 770 mmHg. He took out a 325 mL soda can from his cool box filled with ice water at 4°C. He knew that within seconds the temperature of the soda can will increase by absorbing heat from the surroundings. From the scenario given, define the following terms:

(i) first law of Thermodynamics,
(ii) second law of Thermodynamics;
(iii) intensive properties;
(iv) extensive properties;
(v) specific gravity;
(vi) isochoric;
(vii) absolute pressure; and
(viii) the standard atmosphere pressure.

(10 marks)

(b) An oil pump is drawing 35 kW of electric power while pumping oil with a density, $\rho = 860 \text{ kg/m}^3$ at a rate of 0.1 m^3/s. The inlet and outlet diameters of the pipe are 8 cm and 12 cm, respectively. If the pressure rise of oil in the pump is measured to be 400 kPa and the motor efficiency is 90 percent, determine the mechanical efficiency of the pump.

(10 marks)

Q2 (a) A polytropic process is defined as $PV^n = C$, where n is polytropic index and C is a constant. Derive the equation for a boundary work of an ideal gas undergoing a polytropic process at the isothermal condition.

(5 marks)

(b) At initial state (state-1), a tank contains water vapor at 250°C with an unknown pressure. When the tank is cooled isochorically to 150°C at second state (state-2), the vapor starts condensing. Since the tank is not insulated, further heat loss occurred isobarically until all the water vapor in the tank turns to liquid at final state (state-3).

(i) Estimate the pressure, specific volume, and the enthalpy at its initial state;

(ii) determine the pressure, specific volume, and enthalpy at state-3; and

(iii) sketch the process from initial to final state on a *T-v* diagram complete with the saturation line. Plot the point and pressure curve for each state, and show their axis values on the diagram. Describe the phases of each state in the calculations.

Note: Show all steps and calculations involved.

(15 Marks)

Q3 Consider the following closed systems:

(a) A piston-cylinder device contains 0.15 kg of air initially at 2 MPa and 350°C. The air is first expanded isothermally to 500 kPa. Then compressed polytropically with a polytropic exponent of 1.2 to the initial pressure, and finally compressed at the constant pressure to the initial state. Determine the boundary work for the expansion and polytropic compression process.

(10 marks)

(b) A well-insulated rigid tank contains 5 kg of a saturated liquid-vapor mixture of water at 100 kPa. Initially, three-quarters of the mass are in the liquid phase. An electric resistor placed in the tank is connected to a 110-V source, and a current of 8-A flows through the resistor when the switch is turned on. Determine how long it will take to vaporize all the liquid in the tank. Show the process on a *T-v* diagram with respect to saturation lines.

(10 marks)

Q4 (a) Derive the equation of the energy balance for a general steady flow system in kW based on the first law of thermodynamics. The derivation should consist of the following quantities: mass flow rate, heat, work, enthalpy, velocity, and distance.

(5 marks)

(b) Refrigerant-134a at 1 MPa and 90°C is to be cooled to 1 MPa and 30°C in a condenser by air. The air enters at 100 kPa and 27°C with a volume flow rate of 600 m^3/min and leaves at 95 kPa and 60°C. Determine the mass flow rate of the refrigerant.

(15 marks)

Q5 (a) A designer claims that he has successfully developed the most efficient heat engine that produces 380 kJ of net work from 760 kJ heat source at 327°C while rejecting the waste heat to a sink at 47°C. From the knowledge of Thermodynamics, do you think this claim is reasonable? Why?

(7 marks)

(b) In a geothermal power plant, geothermal water is used as a heat source to produce power. The water enters the power plant at a rate of 440 kg/s, at the temperature of 160°C and leaves at 92°C. If the net power produced by the power plant in 22 MW and the environment at the temperature of 25°C is used as a low-temperature reservoir, determine:

(i) the actual thermal efficiency;

(ii) the maximum possible thermal efficiency of this power plant; and

(iii) the actual rate of heat rejection from the power plant.

(13 marks)

Q6 (a) What is **Mollier** diagram? Sketch this diagram for a fluid undergoing an adiabatic steady flow through a nozzle. Label the diagram accordingly and indicate its actual and isentropic process, kinetic energies, and pressure curves on the diagram.

(5 marks)

(b) Air enters an adiabatic steady flow nozzle at 400 kPa and 547°C with low velocity, and exits at 240 m/s. If the isentropic efficiency of the nozzle is 90%, determine the exits temperature and pressure of the air.

(15 marks)

– END OF QUESTION –