UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	THERMODYNAMICS
COURSE CODE	:	DAK 20703
PROGRAMME CODE	:	DAK
EXAMINATION DATE	:	FEBRUARY 2023
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER **ALL** QUESTIONS
		2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK.**
		3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

Q1 (a) In a vessel, there are 100 L of refrigerant-134a that meant to cool down a space for confectionary purposes. The total mass inside the vessel is 20kg whereas the pressure around the system is 140 kPa.

(i) Determine the temperature of the refrigerant

(5 marks)

(ii) Find the value of the quality

(3 marks)

(iii) Solve the enthalpy of the refrigerant

(3 marks)

(iv) Calculate the volume occupied by the vapor phase

(4 marks)

(b) A valve is connected from $2m^3$ of air tank at 35 °C and 350kPa to another tank containing 10kg of air at 45 °C and 150kPa. The entire system achieved the thermal equilibrium at 30 °C with the surrounding when the valve was opened.

(i) Determine the volume of the second tank

(2 marks)

(ii) Calculate the total mass at the equilibrium

(4 marks)

(iii) Find the final pressure at the equilibrium

(4 marks)

Q2 (a) Water in a boiler steamed up at 1000kPa and 125 °C experienced a heat transfer at 100kJ. During the process, the total work done on the system is 40kJ at a volume of $0.020m^3$. The velocity of water changed from 30 m/s to 10 m/s as the water level elevates to 50 meters. (Given $g = 9.81\ m/s^2$)

(i) Identify the state of water during the process

(2 marks)

(ii) Calculate the mass of water in the boiler

(3 marks)

(iii) Determine the change of internal energy inside the system

(5 marks)

(b) The reversible fluid expansion at an isothermal condition of 300kPa occur towards the volume of 0.0286 m^3 at 110kPa. The process then proceeds at constant pressure with the work done at 0.65 kJ until it reaches a constant volume at 75kPa. At the end of the process, the entire system finally compressed the fluid polytropically back to the initial condition.

(i) Determine the work done at the isothermal condition

(5 marks)

(ii) Find the final volume of fluid at constant pressure

(3 marks)

(iii) Calculate the total work done on this reversible system

(7 marks)

Q3 (a) Define the following terms in thermodynamic system.

(i) Standard enthalpy of formation
(ii) Heat capacity
(iii) Specific heat

(6 marks)

(b) Heat is defined as a process of transferring energy between two objects or systems due to temperature difference. Distinguish between sensible and latent heat.

(4 marks)

(c) Sulfur dioxide gas burns in oxygen to produce sulfur trioxide (SO_3) gas. Calculate the heat release (in kilojoules) per gram of the compound reacted with oxygen. The standard enthalpy of formation for sulfur trioxide is -395.2 kJ/mol. (Relative atomic mass S=32; O=16. $\Delta H^o{}_f$ of SO_2= -296 kJ/mol).

(5 marks)

(d) From the following data,

$C\ (graphite) + O_2(g) \rightarrow CO_2\ (g)$ ΔH^o_{rxn} = -393.5kJ

$H_2\ (g) + \frac{1}{2}\ O_2\ (g) \rightarrow H_2O(l)$ ΔH^o_{rxn} = -285.8kJ

$2C_2H_6\ (g) + 7O_2\ (g) \rightarrow 4CO_2\ (g) + 6H_2O\ (l)$ ΔH^o_{rxn} = -3119.6kJ

Calculate the heat released per mole of 100 g C_2H_6 for the reaction.

$$2C\ (graphite) + 3H_2\ (g) \rightarrow C_2H_6\ (g)$$

(10 marks)

Q4 (a) The heat engine that operates on the reversible Carnot cycle is called the Carnot Heat Engine. List **four (4)** reversible processes that make up the Carnot cycle.

(4 marks)

(b) Distinguish between heat pump and heat engines.

(6 marks)

(c) The food compartment will maintain the refrigerated space at 4 ^{o}C. A Carnot refrigerator operates at room temperature (25 ^{o}C) and consumes 5 kW of power. Calculate the rate of heat removal from the food compartment.

(5 marks)

(d) Steam enters an adiabatic turbine at 6 MPa and 400 ^{o}C with a mass flow rate of 2.5 kg/s and leaves at 25 kPa. The isentropic efficiency of the turbine is 80 percent. Calculate the actual temperature at the exit turbine. The kinetic energy of the steam is neglected.

(10 marks)

-END OF QUESTIONS-

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FORMULA

$x = \frac{m_g}{m_f + m_g} = \frac{m_g}{m_{Total}}$

$v = v_f + (v_g - v_f)$

$\left(\frac{Q_H}{Q_L}\right)_{rev} = \frac{T_H}{T_L}$

$\eta_{th\ rev} = 1 - \frac{T_H}{T_L}$

$\eta_{th} = \frac{W_{net,out}}{Q_{in}}$

$\left(\frac{T_2}{T_1}\right)_{s=const.} = \left(\frac{v_1}{v_2}\right)^{k-1}$

$\left(\frac{T_2}{T_1}\right)_{s=const.} = \left(\frac{P_2}{P_1}\right)^{(k-1)/k}$

$COP_R = \frac{Q_L}{W_{net,in}} = \frac{Q_L}{Q_H - Q_L}$

$E_{in} - E_{out} = \Delta E_{system}$

$Q - W = \Delta U$

$\dot{m} = \frac{1}{v}(\mathcal{V}A)$

$W = \dot{W}\Delta t$

$PV = mRT$

$COP_R = \frac{1}{(T_H/T_L) - 1}$

$COP_{HP} = \frac{Q_H}{W_{net,in}} = \frac{Q_H}{Q_H - Q_L}$

$W = VI\Delta t$

$Q - W = \Delta U + \Delta KE + \Delta PE$

$W = P_1V_1 \ln\frac{V_2}{V_1}$

$\Delta U = U_2 - U_1 = C_v(T_2 - T_1)$

$\Delta H = H_2 - H_1 = C_P(T_2 - T_1)$

$\dot{W} = \dot{m}(h_2 - h_1)$

$W = \frac{P_2V_2 - P_1V_1}{1-n}$

$q_{net} - w_{net} = \left(u_2 - u_1 + \frac{V_2^{\,2} - V_1^{\,2}}{2} + \frac{g(z_2 - z_1)}{1}\right)$

$\left(h_1 + \frac{V_1^{\,2}}{2}\right) = \left(h_2 + \frac{V_2^{\,2}}{2}\right)$

$P_1V_1 = P_2V_2$

$W = P(V_2 - V_1)$

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\frac{P_1}{P_2} = \left(\frac{V_2}{V_1}\right)^n = \left(\frac{T_1}{T_2}\right)^{\frac{n}{n-1}}$

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CONVERSION OF UNITS

Mass	1 kg	= 1000 g = 0.001 metric ton = 2.20462 lb_m = 35.27392 oz
	1 lb_m	= 16 oz = 5 x 10^{-4} ton = 453.593 g = 0.453593 kg
Length	1 m	= 100 cm = 1000 mm = 10^6 microns (μm) = 10^{10} angstroms ($\overset{0}{A}$)
		= 39.37 in = 3.2808 ft = 1.0936 yd = 0.0006214 mile
	1 ft	= 12 in = 1/3 yd = 0.3048 m = 30.48 cm
Volume	1 m^3	= 1000 liters = 10^6 cm^3 = 10^6 ml
		= 35.3145 ft^3 = 220.83 imperial gallons = 264.17 gal
		= 1056.68 qt
	1ft^3	= 1728 in^3 = 7.4805 gal = 0.028317 m^3 = 28.317 liters
		= 28 317 cm^3
Force	1 N	= 1 kg.m/s^2 = 10^5 dynes = 10^5 g.cm/s^2 = 0.22481 lb_f
	1 lb_f	= 32.174 lb_m.ft/s^2 = 4.4482 N = 4.4482 x 10^5 dynes
Pressure	1 atm	= 1.01325 x 10^5 N/m^2 (Pa) = 101.325 kPa = 1.01325 bars
		= 1.01325 x 10^6 dynes/cm^2
		= 760 mm Hg at 0°C (torr) = 10.333 m H_2O at 4°C
		= 14.696 lb_f/in^2 (psi) = 33.9 ft H_2O at 4°C
		= 29.921 in Hg at 0°C
Energy	1 J	= 1 N.m = 10^7 ergs = 10^7 dyne.cm
		= 2.778 x 10^{-7} kW.h = 0.23901 cal
		= 0.7376 ft-lb_f = 9.486 x 10^{-4} Btu
Power	1 W	= 1 J/s = 0.23901 cal/s = 0.7376 ft.lb_f/s = 9.486 x 10^{-4} Btu/s
		= 1.341 x 10^{-3} hp