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UNIVERSITI KUALA LUMPUR
MALAYSIAN INSTITUTE OF CHEMICAL AND BIO-ENGINEERING TECHNOLOGY

FINAL EXAMINATION
OCTOBER 2026 SEMESTER

COURSE CODE	:	CLD20302
COURSE TITLE	:	THERMODYNAMICS
PROGRAMME NAME	:	DIPLOMA IN CHEMICAL ENGINEERING TECHNOLOGY (FOOD)
DATE	:	27 JANUARY 2026
TIME	:	9:00AM - 12:00PM
DURATION	:	3 HOURS

INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper is printed on both sides of the paper.
3. This question paper consist of TWO sections.
4. Section A consist total of 60 marks. Answer ALL questions.
5. Section B consist of three questions. Answer TWO (2) questions only.
6. Please write your answer on the answer booklet provided.
7. Please answer all questions in English only.
8. Refer to the attached Formula/ Appendies. ☐ *Tick if applicable*

THERE ARE 8 PAGES OF QUESTIONS INCLUDING THIS PAGE

SECTION A (Total: 60 marks)

Answer ALL questions.

Please use the answer booklet provided.

Question 1

Answer the following questions

(a) Define superheated vapor.

(2 marks)

(b) State **TWO (2)** examples of pure substance.

(2 marks)

(c) A tank has an inlet pipe that allows fluid to enter. Briefly explain whether the tank is a closed system or open system.

(2 marks)

(d) A sealed rigid tank holds water vapor at 200°C with a quality of 45%. Determine the specific volume of the steam–water mixture.

(6 marks)

(e) A rigid vessel contains 3 kg of refrigerant-134a at 400 kPa and 80°C. Identify the phase of refrigerant-134a.

(3 marks)

Question 2

Answer the following questions:

(a) Describe heat of combustion.

(2 marks)

(b) Identify the Enthalpy of formation (25°C, 1 atm) from property table.

i. Oxygen

(2 marks)

ii. Nitrogen

(2 marks)

iii. Propane.

(2 marks)

(c) Solve the change in the enthalpy (kJ/kg) of carbon monoxide as its temperature changes from 27 to 277°C using Table A-2b.

(7 marks)

Question 3

Answer the following questions:

(a) Determine if the mass entering a control volume must equal the mass exiting during an unsteady-flow process.

(1 marks)

(b) For a device with one inlet and one outlet having equal volume flow rates, state if the flow must be steady and explain.

(3 marks)

(c) Identify the system type for boiling soup in a lidded pot and justify.

(3 marks)

(d) Air enters a nozzle steadily at 1.85 kg/m^3 and 45 m/s and leaves at 0.95 kg/m^3 and 180 m/s. The inlet area of the nozzle is 60 cm^2

i. Estimate the mass flow rate (kg/s) through the nozzle.

(4 marks)

ii. Estimate the exit area (cm^2) of the nozzle.

(4 marks)

Question 4

Answer the following questions:

(a) Describe the main purpose of heat pump.

(2 marks)

(b) List the **FOUR (4)** main components of a simple heat pump cycle.

(4 marks)

(c) Show the equation of coefficient of performance (COP_{hp}).

(2 marks)

(d) State the Clausius statement of the second law of thermodynamics.

(3 marks)

(e) A heat engine receives 1500 kJ of heat from a source of 800 K and rejects 400 kJ of it to a sink at 250 K. Recognize Q_H, Q_L, T_H, T_L.

(4 marks)

SECTION B (Total: 40 marks)

Answer TWO (2) questions only.

Please use the answer booklet provided.

Question 1

Refrigerant-134a is throttled from the saturated liquid state at 1000 kPa to 320 kPa in an adiabatic flow with no work. Neglect kinetic and potential energy changes.

(a) Calculate the temperature drop during this process.

(12 marks)

(b) Calculate the specific internal energy (kJ/kg) of the refrigerant-134a at the final state after throttling.

(8 marks)

Question 2

Answer the following questions.

(a) A thermal power plant receives heat from a furnace at a rate of 400 GJ/hr. The waste heat is transferred to the cooling water at a rate of 175 GJ/hr. Calculate the net power output and thermal efficiency of the plant.

i. Calculate the net power output (GJ/hr) of this power plant.

(4 marks)

ii. Calculate the thermal efficiency of this power plant.

(4 marks)

(b) A small food processing facility stores temperature-sensitive dairy products in a specialized room that must be maintained at 20°C for quality and safety. The facility uses a heat pump to supply heat to the room. During a particularly cold winter night, the outdoor temperature drops to −3°C, causing the room to lose heat at a rate of 120,000 kJ/h. The plant manager is concerned about increasing electricity consumption. An energy consultant explains that assuming Carnot performance, the minimum power input required to operate the heat pump can be estimated using thermodynamic principles. Calculate the Carnot power (kW) required to drive the heat pump.

(12 marks)

Question 3

A commercial refrigeration system with refrigerant-134a as the working fluid is to be cooled by cooling water in a condenser. The refrigerant enters the condenser at 900 kPa and 70°C and leaves at 32°C at the same pressure. The cooling water enters as a compressed liquid at 200 kPa and 15°C at a rate of 4.0 kg/s and leaves at 30°C at constant pressure.
Assuming the condenser is well insulated (adiabatic) and kinetic/potential energy changes are negligible.

(a) Based on the given information, illustrate and label a condenser.

(6 marks)

(b) Calculate the mass flow rate (kg/s) of the refrigerant.

(14 marks)

END OF EXAMINATION PAPER

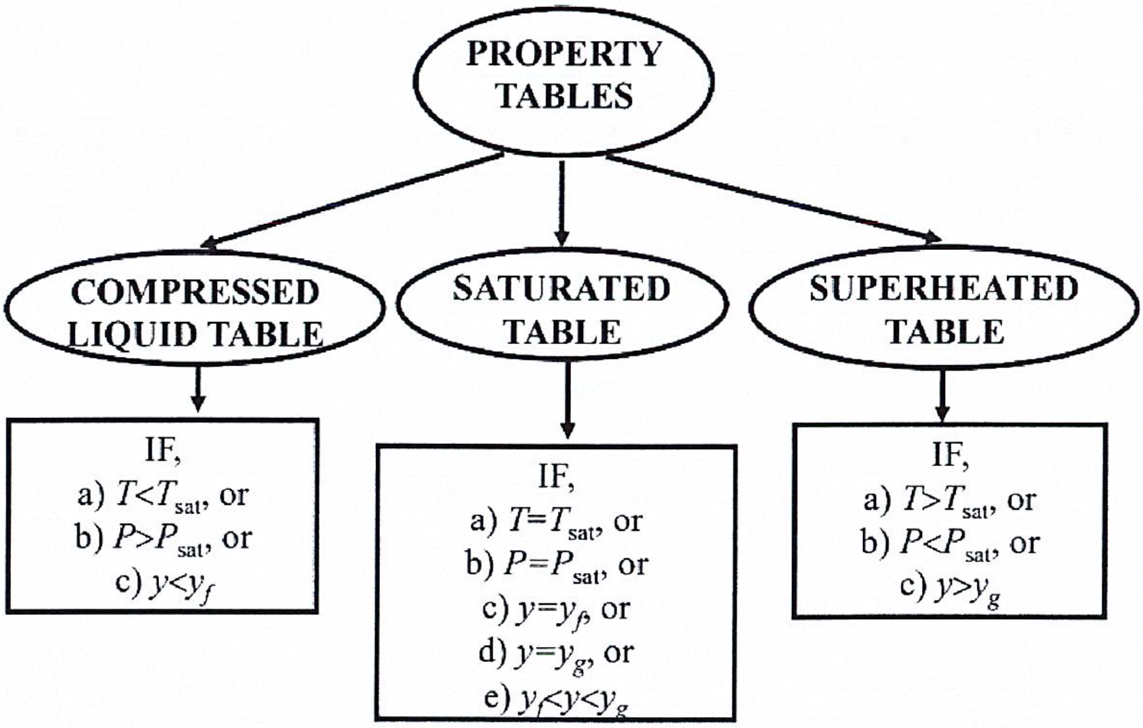
APPENDIX 3

FACTORS FOR UNIT CONVERSIONS

Quantity	Equivalent Values	
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

APPENDIX 2

PHASE CONDITIONS



Heat Exchanger:

$$\text{MB}: \sum \dot{m}_{in} = \sum \dot{m}_{out} \Rightarrow \dot{m}_1 + \dot{m}_3 = \dot{m}_2 + \dot{m}_4$$

$$\text{EB}: \dot{E}_{in} = \dot{E}_{out}$$

$$\dot{m}_1 h_1 + \dot{m}_3 h_3 = \dot{m}_2 h_2 + \dot{m}_4 h_4$$

Entropy Balance:

$$S_{in} - S_{out} + S_{gen} = \Delta S_{system}$$

Thermal Efficiency and Coefficient of Performance (COP):

$$\eta_{th} = \frac{W_{net,out}}{Q_{in}} = \frac{Q_H - Q_L}{Q_H} = 1 - \frac{Q_L}{Q_H}$$

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

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

$$COP_R = \frac{Q_L}{W_{net,in}} = \frac{Q_L}{Q_H - Q_L} = \frac{1}{Q_H/Q_L - 1}$$

$$COP_{R,rev} = \frac{T_L}{T_H - T_L} = \frac{1}{T_H/T_L - 1}$$

$$COP_{HP} = \frac{Q_H}{W_{net,in}} = \frac{Q_H}{Q_H - Q_L} = \frac{1}{1 - Q_L/Q_H}$$

$$COP_{HP,rev} = \frac{T_H}{T_H - T_L} = \frac{1}{1 - T_L/T_H}$$

APPENDIX 1

Quality and Saturated Region:

$$y = y_f + x(y_g - y_f)$$
$$= y_f + x\,y_{fg}$$

Sensible Heat Effect:

$$Q = \Delta U = \int_{T_1}^{T_2} C_V\,dT$$

$$Q = \Delta H = \int_{T_1}^{T_2} C_P\,dT$$

Energy Balance (Closed System):

$$Q_{\text{net, in}} - W_{\text{net, out}} = \Delta U + \Delta KE + \Delta PE$$

Energy Balance (Open System):

$$\underbrace{\dot{E}_{\text{in}} - \dot{E}_{\text{out}}}_{\substack{\text{Rate of net energy transfer} \\ \text{by heat, work, and mass}}} = \underbrace{dE_{\text{system}}/dt \overset{\nearrow\ 0\ (\text{steady})}{}}_{\substack{\text{Rate of change in internal, kinetic,} \\ \text{potential, etc., energies}}} = 0$$

$$\underbrace{\dot{E}_{in}}_{\substack{\text{Rate of net energy transfer in} \\ \text{by heat, work and mass}}} = \underbrace{\dot{E}_{out}}_{\substack{\text{Rate of net energy transfer out} \\ \text{by heat, work and mass}}}$$

$$\dot{Q}_{\text{in}} + \dot{W}_{\text{in}} + \sum_{\text{in}} \dot{m}\theta = \dot{Q}_{\text{out}} + \dot{W}_{\text{out}} + \sum_{\text{out}} \dot{m}\theta$$

$$\dot{Q}_{\text{in}} + \dot{W}_{\text{in}} + \sum_{\text{in}} \underbrace{\dot{m}\left(h + \frac{V^2}{2} + gz\right)}_{\text{for each inlet}} = \dot{Q}_{\text{out}} + \dot{W}_{\text{out}} + \sum_{\text{out}} \underbrace{\dot{m}\left(h + \frac{V^2}{2} + gz\right)}_{\text{for each exit}}$$

$$\dot{Q}_{\text{net, in}} - \dot{W}_{\text{net, out}} = \Delta\dot{H} + \Delta\dot{KE} + \Delta\dot{PE}$$

Turbine:

$$\dot{W}_{\text{net, out}} = \dot{m}(h_1 - h_2)$$

Throttling Valve:

$$h_i = h_e$$