



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

FINAL EXAMINATION
OCTOBER 2025 SEMESTER

COURSE CODE : CLB20403
COURSE TITLE : THERMODYNAMICS
PROGRAMME NAME : BACHELOR OF CHEMICAL ENGINEERING TECHNOLOGY
(PROCESS) WITH HONOURS
DATE : 23 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. Answer ALL questions for Section A.
5. Section B consist of four questions. Answer THREE (3) questions only.
6. Please write your answer on the answer booklet provided.
7. Please answer all questions in English only.
8. Please answer MCQ/EMQ questions using OMR sheet. ☐ *Tick if applicable*
9. Refer to the attached Formula/ Appendies. ☐ *Tick if applicable*

THERE ARE 5 PAGES OF QUESTIONS INCLUDING THIS PAGE

SECTION A (Total: 40 marks)

Answer ALL questions.

Please use the answer booklet provided.

Question 1

- (a) The specific volume of an ideal refrigerant-134a is $0.03105 \text{ m}^3/\text{kg}$ at 0.9 MPa and 70°C . However, this refrigerant-134a exists as a dense vapour. For a refrigeration process to be considered safe, the specific volume of the vapour must be multiplied with the correction factor. Thus, calculate the new specific volume (in m^3/kg) of refrigerant-134a vapor with the aid of compressibility chart.

(9 marks)

- (b) The molar volume of pure pentane and butane are $0.38 \text{ m}^3/\text{kmol}$ and $0.24 \text{ m}^3/\text{kmol}$, respectively. If 168 mol equimolar solution consists of mixture of both materials is to be prepared. Calculate the volume (in m^3) of pure pentane and butane that must be mixed to prepare the solution.

(5 marks)

- (c) Propane (C_3H_8) is combusted with oxygen at 25°C and 1 atm producing water and carbon dioxide. If the enthalpy of combustion is found to be $-2,043,990 \text{ kJ/kmol}$, predict the phase of water produced.

(6 marks)

Question 2

- (a) A 0.35 kg of nitrogen gas initially contained in a piston cylinder device at 2890 kPa and 300°C. The piston cylinder undergoes polytropic ($PV^{1.7} = \text{constant}$) expansion where the pressure drops to 1753 kPa. Then, a problem happened caused the piston to do sudden compression at constant pressure. Finally, the problem consequently caused the piston to stop moving and pressure arise to the initial state. By considering all processes happened at 300°C, calculate the boundary work (in kJ) for each process.

(13 marks)

- (b) A rigid tank contains water vapor at 250°C and an unknown pressure. When the tank is cooled to 150°C, the vapor starts condensing. Estimate the initial pressure (in MPa) and internal energy (in kJ/kg) in the tank. (Hint: No interpolation).

(7 marks)

SECTION B (Total: 60 marks)

Answer THREE (3) questions only.

Please use the answer booklet provided.

Question 1

- (a) Three isolated tanks (Tank A, Tank B and Tank C) are separated by two partitions. Tank A consists of 1.5 kg steam at 1.4 MPa and 350°C. Tank B consists of 2.3 kg of 0.73 quality of steam at 305°C. Meanwhile Tank C consists of 950 kPa saturated vapour water with mass of 1.96 kg. Now the partitions are removed, and the three sides are allowed to mix until the mechanical and thermal equilibrium are established. The final pressure recorded after the partitions are removed is 750 kPa. If the phase for final state is saturated liquid-vapour mixture with $x = 0.685$, determine the final internal energy in kJ/kg.

(15 marks)

- (b) A 600 MW steam power plant, which is cooled by a nearby river, has a thermal efficiency of 40 percent. Determine the rate of heat transfer (in MW) to the river water.

(5 marks)

Question 2

- (a) A steam enters an adiabatic turbine at 8 MPa and 500°C with a mass flowrate of 5 kg/s and leaves at 30 kPa. The isentropic efficiency of the turbine is 0.80. Determine the temperature (in °C) at the turbine exit.

(15 marks)

- (b) Explain the increase in entropy principle.

(5 marks)

Question 3

- (a) In a typical automated pressure controlling process of a piston cylinder, a system glitch has occurred. This causes the piston to encounter a sudden compression, resulting in a 40% reduction of its original size. However, the glitch did not affect the pressure. If the system consists of 100 kg of tetrafluoroethane with a volume of 11.675 m^3 at 240 kPa initially, determine the change in total internal energy of the substance in kJ/kg.

(15 marks)

- (b) Explain the differences between Otto engine and Diesel engine.

(5 marks)

Question 4

- (a) An adiabatic turbine is operated using steam as working fluid producing 12.05 MW power. An 11.4 kg/s steam flows steadily through the turbine at pressure of 9 MPa, temperature of 600°C and velocity of 77 m/s. The outlet velocity of the turbine is 46 m/s. The outlet stream of the turbine is channelled to a throttling valve. If the pressure at the exit stream of the throttling valve is 175 kPa, determine the specific volume (in m^3/kg) at the exit stream of throttling valve.

(15 marks)

- (b) A refrigerator is to remove heat from the cooled space at a rate of 300 kJ/min to maintain its temperature at -8°C . If the air surroundings the refrigerator is at 25°C , determine the minimum power input (in kW) required for this refrigerator.

(5 marks)

END OF EXAMINATION PAPER

APPENDIX A: LIST OF FORMULA.

$$F = ma$$

$$P = \frac{F}{A}$$

$$x = \frac{m_{\text{vapour}}}{m_{\text{total}}}$$

$$Pv = RT$$

$$T_R = \frac{T}{T_{cr}} \quad \text{and} \quad P_R = \frac{P}{P_{cr}}$$

$$v_R = \frac{v_{\text{actual}}}{\frac{RT_{cr}}{P_{cr}}}$$

$$W_b = P_o(V_2 - V_1)$$

$$W_b = mP_o(v_2 - v_1)$$

$$W_b = mRT_o \ln \frac{V_2}{V_1}$$

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

$$PV^n = C$$

$$\left(P + \frac{a}{v^2}\right)(v - b) = RT \quad \text{with} \quad a = \frac{27R^2T_o^2}{64P_{cr}} \quad \text{and} \quad b = \frac{RT_o}{8P_{cr}}$$

$$P = \frac{R_u T}{\bar{v}^2} \left(1 - \frac{c}{\bar{v}T^3}\right) (\bar{v} + B) - \frac{A}{\bar{v}^2} \quad \text{with} \quad A = A_o \left(1 - \frac{a}{\bar{v}}\right) \quad \text{and} \quad B = B_o \left(1 - \frac{b}{\bar{v}}\right)$$

$$P = \frac{R_u T}{\bar{v}} + \left(B_o R_u T - A_o - \frac{C_o}{T^2}\right) \frac{1}{\bar{v}^2} + \frac{bR_u T - a}{\bar{v}^3} + \frac{a\alpha}{\bar{v}^6} + \frac{c}{\bar{v}^3 T^2} \left(1 + \frac{\gamma}{\bar{v}^2}\right) e^{-\gamma/\bar{v}^2}$$

$$S_{\text{gen}} = \sum \Delta S = \Delta S_{\text{system}} + \Delta S_{\text{surroundings}}$$

$$\Delta S = S_2 - S_1 = \int_1^2 \left(\frac{\delta Q}{T}\right)_{\text{int rev}} = \frac{Q_{\text{rev}}}{T}$$

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

$$\dot{Q} + \dot{m}_1 h_1 = \dot{m}_2 h_2$$

$$\dot{m}_3 h_3 = \dot{m}_4 h_4 + \dot{Q}$$

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

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

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

$$\eta_{th} = \frac{Q_H - Q_L}{Q_H} = 1 - \frac{Q_L}{Q_H}$$

$$COP_R = \frac{Q_L}{Q_H - Q_L} = \frac{1}{Q_H/Q_L - 1}$$

$$COP_{HP} = \frac{Q_H}{Q_H - Q_L} = \frac{1}{1 - Q_L/Q_H}$$

$$x = \frac{y - y_f}{y_{fg}}$$

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

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

$$\dot{m} = \rho \dot{V} = \frac{\dot{V}}{v} = \rho \bar{V} A = \frac{A \bar{V}}{v}$$

$$\Delta u = u_2 - u_1 = \int_1^2 C_V(T) dT = C_{V,ave} (T_2 - T_1)$$

$$\Delta h = h_2 - h_1 = \int_1^2 C_P(T) dT = C_{P,ave} (T_2 - T_1)$$

$$\bar{V}_2 = \sqrt{2(h_1 - h_2) + \bar{V}_1^2}$$

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

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

$$\dot{W} = \dot{m}v[P_2 - P_1]$$

$$\Delta ke = \frac{V_2^2 - V_1^2}{2}$$

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

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

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

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

$$\eta_C \cong \frac{h_{2s} - h_1}{h_{2a} - h_1}$$

$$\eta_T \cong \frac{h_1 - h_{2a}}{h_1 - h_{2s}}$$

$$\eta_P = \frac{w_s}{w_a} = \frac{u(P_2 - P_1)}{h_{2a} - h_1}$$

$$V = n_1 \bar{V}_1 + n_2 \bar{V}_2$$

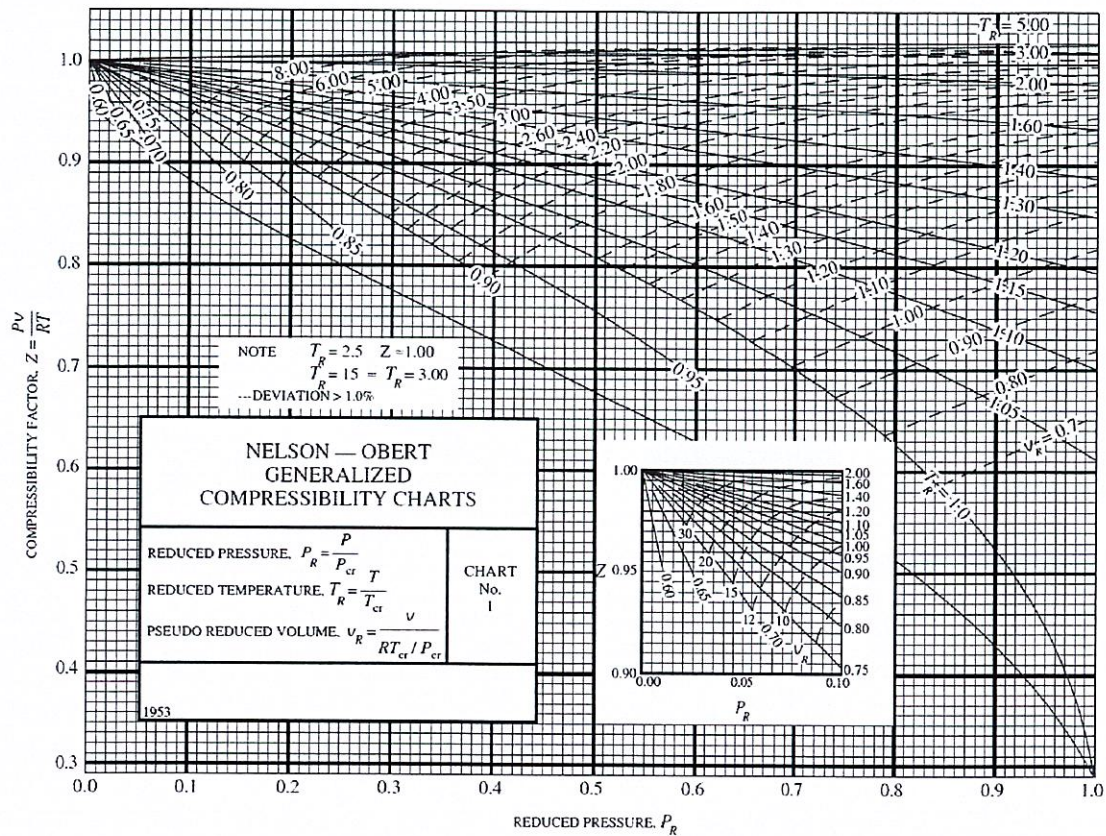
$$V = x_1 \bar{V}_1 + x_2 \bar{V}_2$$

$$n_{\text{total}} = \frac{V_t}{v}$$

$$n = X n_{\text{total}}$$

$$V^t = n V$$

APPENDIX B: GENERALIZED COMPRESSIBILITY CHART.

(a) Low pressures, $0 < P_R < 1.0$ (b) Intermediate pressures, $0 < P_R < 7$ 