

**INTRODUCTION TO ENGINEERING THERMODYNAMICS
(CHE2104)**

Time Allotted : 2½ hrs

Full Marks : 60

Figures out of the right margin indicate full marks.

*Candidates are required to answer Group A and
any 4 (four) from Group B to E, taking one from each group.*

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve:

12 × 1 = 12

Choose the correct alternative for the following

- (i) For ideal gases $\Delta H = C_p \Delta T$ is valid
(a) for constant pressure process (b) for constant volume process
(c) irrespective of the nature of the process (d) none of the above
- (ii) Which of the following is an extensive property of the system
(a) heat capacity (b) pressure
(c) molar heat capacity (d) concentration
- (iii) In an adiabatic process
(a) heat transfer is zero (b) work done is zero
(c) temperature change is zero (d) enthalpy remains constant
- (iv) Reduced pressure of a gas is the ratio of its
(a) pressure to critical pressure (b) critical pressure to pressure
(c) pressure to triple point pressure (d) triple point pressure to pressure
- (v) Real gas behave like an ideal gas at
(a) low temperature and low pressure
(b) high temperature and low pressure
(c) low temperature and high pressure
(d) high temperature and high pressure
- (vi) For water, if v_g is specific volume of vapour and v_l is the specific volume of liquid then with the change of pressure ($v_g - v_l$)
(a) increases (b) decreases
(c) remain constant (d) may increase or decrease
- (vii) The absolute entropy for all crystalline substances at absolute zero temperature is
(a) one (b) zero
(c) less than zero (d) not possible to be determined

- (viii) Refrigeration cycle
 (a) involves transfer of heat from low temperature to high temperature
 (b) violates 2nd law of thermodynamics
 (c) both (a) and (b)
 (d) involves transfer of heat from high temperature to low temperature
- (ix) A power cycle continuously converts
 (a) heat into work
 (b) work into heat
 (c) one form of work into other form of work
 (d) mass into energy
- (x) In diesel cycle heat supplied to the compressed air at
 (a) constant volume (b) constant temperature
 (c) constant pressure (d) none of the above

Fill in the blanks with the correct word

- (xi) Isochoric process means a constant _____ process
- (xii) Work done in case of free expansion is _____.
- (xiii) Entropy is a measure of _____ of a system.
- (xiv) The principle of liquefaction of gas is _____ expansion
- (xv) A system from which finite quantities of heat can be removed without affecting its temperature is called _____.

Group - B

2. (a) What is system boundary from thermodynamic point of view. Classify different types of system with example. [[CO1](Understand/LOCQ)]
- (b) A spherical balloon of diameter 0.4 m contains a gas at 1 bar and 300 K. The gas is heated and the balloon is allowed to expand. The pressure inside the balloon is found to vary linearly with the diameter. What would be the work done by the gas when the pressure inside reaches 4 bar. [[CO2](Analyse/IOCQ)]
(2 + 4) + 6 = 12
3. (a) Derive the relation between specific heat at constant volume and specific heat at constant pressure for an ideal gas. Why specific heat at constant volume is less than specific heat at constant pressure of a gas. [[CO1](Analyse/LOCQ)]
- (b) An ideal gas in a closed system is compressed adiabatically. Derive an expression in terms of temperature and pressure to determine the minimum amount of work to be done on the system. [[CO1](Analyse/IOCQ)]
(3 + 2) + 7 = 12

Group - C

4. (a) Sketch a general P-T phase diagram of a pure substance and identify all different region and line in it. What is subcooled liquid and superheated vapour. [[CO3](Remember/LOCQ)]

- (b) Calculate the molar volume of methane at 200 K and 80 bar using generalized compressibility chart. Given, $T_c = 190.7$ K and $P_c = 46.4$ bar. (Compressibility factor chart to be provided) [[CO3](Understand/LOCQ)]
(5 + 3) + 4 = 12
5. (a) Determine the van der Waals constants and molar volume of ethane at critical points, given that the critical temperature and pressure are 416.3 K and 66.8 bar respectively. [[CO3](Apply/IOCQ)]
- (b) Use Redlich-Kwong equation to calculate the pressure of 1 kg gaseous ammonia contained in a vessel of 25 L at a constant temperature of 340 K. The critical temperature and pressure are 405.5 K and 112.8 bar respectively. [[CO3](Evaluate/HOCQ)]
6 + 6 = 12

Group - D

6. (a) Show that, the efficiency of a reversible heat engine only depends on the temperature of thermal reservoir between which it is working. [[CO4](Analyse/LOCQ)]
- (b) A rigid insulated tank of volume 10m^3 is divided into two compartments by a removable partition. One compartment of volume 5m^3 contains ideal gas A at 300 K and 1 bar while the other compartment contains ideal gas B at 400 K and 2 bar. The partition is removed and the gas is allowed to mix. After mixing, calculate the total change in entropy of the process. Given, specific heat capacity ratio of both ideal gases is 1.4. [[CO4](Evaluate/HOCQ)]
6 + 6 = 12
7. (a) Atmospheric air is a mixture of 21 moles of oxygen for every 79 moles of nitrogen. It is desired to separate 100 moles of air at 300 K and 1 bar into its pure components at 300 K and 1 bar. Calculate the minimum amount of work to be done for this purpose. Treat oxygen and nitrogen as ideal gases. [[CO4](Analyse/IOCQ)]
- (b) The efficiency of a Carnot heat engine can be increased either by increasing the source temperature while the sink temperature is held constant or by decreasing the sink temperature while the source temperature is held constant. Which of the two possibilities is more effective? [[CO4](Evaluate/IOCQ)]
6 + 6 = 12

Group - E

8. (a) Derive an expression to estimate the thermal efficiency of ideal air-standard otto cycle. [[CO6](Understand/LOCQ)]
- (b) The work output of an ideal Carnot engine operating between two thermal reservoir at 1000 K and 300 K respectively, is utilized to run the compressor of a refrigerator working R-12 refrigerant. The heat rejected by the engine to the sink is 30 kW. The refrigerator operates between 240 K and 300 K. Calculate the capacity and COP of the refrigerator and the circulation rate of the refrigerant. [[CO6](Apply/IOCQ)]
6 + 6 = 12

9. In a 1-MW steam power plant, superheated steam at 2800 kPa and 598 K enters the turbine and it is expanded to the condenser pressure of 5 kPa. Assuming an isentropic turbine efficiency of 85% and an isentropic pump efficiency of 80% determine the following

- (i) The ideal Rankine cycle efficiency for the stated conditions
- (ii) The thermal efficiency of the plant
- (iii) The rate of steam consumption.

[(CO6)(Evaluate/HOCQ)]

(4 + 4 + 4) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	36	39	25