

II B.Tech II Semester Regular Examinations, Apr/May 2008**CHEMICAL ENGINEERING THERMODYNAMICS-I****(Chemical Engineering)****Time: 3 hours****Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

1. (a) Define the following:
 - i. Work
 - ii. Internal energy
 - iii. Kinetic energy
 - iv. Potential energy.(b) Water is falling from a height of 100 metre, at a rate of 5000 kg/hr is used to feed turbine in a hydro electric power station. What is potential energy?[8+8]
2. Compute the degrees of freedom if,
 - (a) System is made up by liquid solution of alcohol and liquid water in equilibrium with its vapours.
 - (b) System is made by partial decomposition of NH_4Cl .
 - (c) A mixture of N_2 , H_2 and NH_3 exists in chemical equilibrium at elevated temperature.[5+5+6]
3. (a) What is ideal gas? Name the two basic assumptions, which were made use of in deriving the ideal gas equation of state from kinetic theory arguments.
(b) Define isothermal compressibility and coefficient of volume expansion. [10+6]
4. Steam at 0.5MPa and 200⁰ C enters a nozzle with a velocity of 1m/s at the rate of 1kg/s and leaves as dry saturated steam at 0.1MPa. The energy loss as heat from the nozzle is 10kJ/s. Calculate the exit velocity of steam. [16]
5. An inventor claims to have designed a heat engine, which absorbs 1500 kJ and 150kJ energy as heat from reservoirs at 1000K and 300K respectively and rejects 600kJ energy as a heat to a reservoir at 600K. It delivers 1050 kJ work. Judge, whether the claim is acceptable or not. [16]
6. One kg of water at 273 K is brought into contact with a heat reservoir at 373 K. When the water has reached 373 K, find the entropy change of the water, of the reservoir, and of the universe. Specific heat of water is 4.187 kJ kg⁻¹K⁻¹. [16]
7. A refrigeration plant produces 0.135 kg/s of the ice at -4⁰C from water at 29⁰C. If the power required to drive the plant is 24kW, determine the capacity of the ice plant in tones and the actual COP. C_p of ice is 2.1 kJ kg⁻¹ K⁻¹. [16]

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8. (a) Define availability.
(b) Does the availability depends upon the conditions of system and surroundings.
[6+10]

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1. (a) What are various prefixes for SI units.
 (b) An astronaut weighs 700 N in Houston, Texas, where the local acceleration of gravity is 9.792 ms^{-2} . What are astronauts' mass and weight on the moon, where g is 1.67 ms^{-2} ? [6+10]
2. (a) What is the necessity of classifying point and path functions?
 (b) What is heat? Is it a path function? Explain. [8+8]
3. If one kmol of methane is stored in 0.32 m^3 tank at 302K, estimate the pressure of the gas using Redlich - Kwong equation of state. The critical constants of methane are $P_c = 4.60 \text{ MPa}$ and $T_c = 190.6 \text{ K}$. [16]
4. Ammonia gas is compressed from 21°C and 200 kPa to 1010 kPa in an adiabatic compressor with an efficiency of 0.81. Estimate the work required per mol of ammonia, enthalpy and entropy changes of the ammonia. [16]
5. (a) A reversible engine absorbs 1150 kJ as heat from a source at 575°C , delivers 575 kJ as work and rejects the rest of the energy to a sink. Determine the sink temperature.
 (b) A Carnot engine absorbs 1100 kJ as heat from a reservoir at 550 K and rejects energy to a sink at 295 K. Determine the efficiency of the engine and energy rejected to the sink. [8+8]
6. A steel casting [$C_p = 0.5 \text{ kJ kg}^{-1} \text{ K}^{-1}$] weighing 40 kg and at a temperature of 450°C is quenched in 150 kg of oil at 25°C [$C_p = 0.25 \text{ kJ kg}^{-1} \text{ K}^{-1}$] If there are no heat losses, what is the change in entropy of
 (a) casting
 (b) the oil and
 (c) both considered together. [16]
7. A refrigeration plant produces 0.135 kg/s of the ice at -4°C from water at 29°C . If the power required to drive the plant is 24kW, determine the capacity of the ice plant in tones and the actual COP. C_p of ice is $2.1 \text{ kJ kg}^{-1} \text{ K}^{-1}$. [16]
8. A system has equation of state as, $PV=ZRT$,
 show that, $\left(\frac{\partial H}{\partial p}\right)_T = \frac{-RT^2}{p} \left(\frac{\partial Z}{\partial T}\right)_p$ [16]

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1. (a) Is it possible that $W \neq 0$, even if $dV=0$? Given an example.
(b) A car of 1100 kg mass is moving with a speed of 80 km/h on a road, which is 120 m above the sea level. Calculate the kinetic energy and potential energy of the car. [6+10]
2. A system is taken from state 1 to state 2 along a path A. During this process it received 200 kJ energy as heat and does 100 kJ work. If the system is taken from state 2 to state 1 by a different path B, it is necessary to spend 150 kJ work on the system. Determine the heat interaction along the path B. Suppose the system is restored to state 1 from state 2 by an adiabatic path C, how much work has to be done on the system? [16]
3. If one kmol methane is stored in a 0.3 m^3 tank at 300K, estimate the pressure of the gas using generalized compressibility. The critical constants of methane are $P_c = 4.60 \text{ MPa}$ and $T_c = 190.6\text{K}$. [16]
4. Discuss the functioning of converging/diverging nozzle. Develop suitable equations. [16]
5. A Carnot engine (I) operates between two reservoirs at temperatures 1920K and TK while a second Carnot engine (II) operates between the reservoirs at T K and 302K. It is found that both the engines have the same efficiency. Determine the value of T. [16]
6. A fluid undergoes a reversible adiabatic compression from 0.5 MPa, 0.2m^3 to 0.05m^3 according to the law, $PV^{1.3} = \text{constant}$. Determine the change in enthalpy, internal energy and entropy during the process. [16]
7. (a) What is the importance of COP of a refrigerator? A Carnot refrigerator is operating between the reservoirs at -25°C and 35°C . Determine the COP of the refrigerator.
(b) Determine the COP of a Carnot heat pump operating between -25°C and 35°C . [10+6]
8. A lump of 1000 kg steel at 1180 K is to be cooled to 398 K. If it is desired to use the steel as a source of energy, calculate the available energy and unavailable energy. The ambient temperature is 301 K and the specific heat capacity of steel is $0.5 \text{ kJ kg}^{-1} \text{ K}^{-1}$. [16]

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1. The acceleration of gravity is given as a function of elevation above sea level by, $g = 980.6 - 3.086 \times 10^{-6} H$ where g is in cm/s^2 , and H is in cm . If an aeroplane weighs 10,000 kgf at sea level, what is the gravity force on it at 10,000 m elevation? What is the percentage difference from the sea level weight? [16]
2. (a) Define the following:
 - i. State of the system,
 - ii. Properties of the system.(b) What are intensive and extensive properties? [8+8]
3. (a) Name the two conditions, which every equation of state should satisfy.
(b) What are the units of the Van der Waals constants a and b . [10+6]
4. (a) What is multistage compression? What are its advantages.
(b) What is the objective of inter cooling in multistage compression? [10+6]
5. (a) A reversible engine absorbs 1200 kJ as heat from a source at 600°C , delivers 600 kJ as work and rejects the rest of the energy to a sink. Determine the sink temperature.
(b) A Carnot engine absorbs 1000 kJ as heat from a reservoir at 500 K and rejects energy to a sink at 300 K. Determine the efficiency of the engine and energy rejected to the sink. [8+8]
6. One gram mol of nitrogen behaving as an ideal gas undergoes an irreversible isothermal compression from 1 to 10 atm at 127°C in a piston cylinder assembly. The heat removed from the gas as a result of compression process is absorbed by heat sink maintained at a temperature of 27°C . The irreversible process is 83% efficient as compared to reversible process. Calculate ΔS of the gas, ΔS of the reservoir and ΔS_{total} . [16]
7. A refrigeration plant for a food store operates as a reversed Carnot heat engine cycle. The store is to be maintained at a temperature of -5.5°C and the heat transfer from the store to the cycle is at the rate of 5.5 kW. If the heat is transferred from the cycle to the atmosphere at a temperature of 23°C , Calculate the power required to drive the plant. [16]

8. A particular thermodynamic system has the following fundamental relation $U = \frac{CS^3}{VN}$, where C is a constant. Transform the given fundamental relation into the enthalpy representation. [16]
