Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

B.E. Semester-III (Food Processing Technology) Examination December 2009

Subject Code: 131404

Subject Name: Food Engineering Thermodynamics

Date:23 / 12 /2009 **Time: 11.00 am – 1.30 p m**

Total Marks: 70

Instructions

1. **Answer all questions.**
2. **Maximum marks for each question is indicated against the questions.**
3. **Make suitable assumptions wherever necessary.**
4. **Use the provided Psychometric Chart and Steam Tables if required.**
5. **Avoid Cutting/Overwriting.**

Q.1 **(a)** Define ideal gas and write ideal gas equation of state specifying various terms and their units in the equation. A vessel of 250 litre volume contains nitrogen gas at 2 bar pressure and 25 ^{o}C. Calculate the mass of nitrogen in kg assuming ideal gas behaviour. [Take R = 8.314 J/mol K] **04**

(b) An insulated rigid cold storage is first loaded with some fresh food stuff and then its door is firmly closed. After some time, an energy meter attached to the electric supply system of the cold storage indicates that it has consumed 10 kWh of energy. Calculate the work done, net heat transfer from the system and the ensuing change in internal energy of the system in kJ. **03**

(c) One mole of an ideal gas initially at 300 K and 1 bar pressure is first compressed reversibly and adiabatically upto 6 bar pressure and then cooled at constant pressure to its original temperature. The gas is then restored to its original state through an isothermal process. Show the cyclic process on a P–V diagram and calculate the net work done and the associated heat interaction in J/mol during the process. **07**
[Take γ for the gas = 1.4 and R = 8.314 J/mol K]

Q.2 **(a)** Prove that for a pure substance undergoing an infinitesimally reversible process, dU = TdS – PdV & dH = TdS + VdP **03**

(b) Prove that for an infinitesimally reversible process, we must have **04**
$(\partial T/\partial V)_S = -(\partial P/\partial S)_V$ & $(\partial T/\partial P)_S = (\partial V/\partial S)_P$

(c) Starting from the Gibb's equation "dg = vdP –sdT" prove that for a vapour-liquid system in equilibrium, **07**

$$\ln\left(\frac{P_2}{P_1}\right) = \frac{h_{fg}}{\overline{R}}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

Calculate the approximate pressure at which a boiler is to be operated if it is desired to boil water at 150 ^{o}C. It is known that water boils at 100 ^{o}C at 101.325 kPa (1 Atmosphere) and the enthalpy of vaporization is 2257 kJ/kg.

OR

(c) Explain Joule-Kelvin effect with the help of a T-P diagram. For a constant enthalpy process involving real gases prove that: **07**

$$\mu_{J,T} = \frac{1}{C_P}\left[T\left(\frac{\partial V}{\partial T}\right)_P - V\right].$$

Show that $\mu_{J,T} = 0$ for ideal gases.

Q.3 **(a)** Assuming the symbols have their usual meanings, prove that specific humidity of moist air is given by: **06**

$\omega = 0.622\left(\frac{p_\omega}{p - p_\omega}\right)$. The weather report of Anand district on a particular winter day states that the atmospheric air was at 25 ^oC & 50% RH at 3.00 PM. Using Psychrometric chart find out the following: Dry Bulb Temperature, Wet Bulb Temperature, Absolute humidity, Dew point temperature, Specific volume & Specific enthalpy. Mark the findings on the Psychometric chart and attach it with your answer script.

(b) Using Steam tables, find out the following during evaporation of 1 kg water at 2 MPa: saturation temperature, change in entropy in kJ/K, latent heat of vaporization in kJ/kg and change in specific volume in m^3/kg. **04**

(c) Draw a neat and well labelled P-V diagram of water showing its saturation states, various phases, critical point and triple point line. What is meant by 'quality or dryness fraction'? **04**

OR

Q.3 **(a)** Explain the terms 'dew point temperature' and 'relative humidity'. Atmospheric air at a certain location where the barometer reads 750 mm Hg is at 35 ^oC DBT & 23 ^oC WBT. Calculate % relative humidity, absolute humidity and dew point temperature of this air. **06**

(b) Ten kilogram of wet steam at 126 ^oC contains 75% dry steam and 25% liquid water. How much heat will be released by the wet steam in kJ when it is allowed to condense to liquid water at 90 ^oC. **04**

(c) Using steam tables, calculate the enthalpy of superheated steam at 160 ^oC and 1.6 bar pressure. **04**

Q.4 **(a)** With the help of schematic diagrams, explain operation of a heat engine, a refrigerator and a heat pump clearly mentioning their indices of performance. **06**

(b) A stationary mass of gas is compressed without friction from an initial state of 0.4 m^3 to a final state of 0.16 m^3, the pressure remaining constant at 0.110 MPa during the process. There is a transfer of 38.6 kJ of heat from the gas during the process. Calculate the work done and the change in internal energy during the process? **04**

(c) What do you understand by Perpetual Motion Machine of the Second Kind (PMM2)? Write Carnot theorems on efficiency of a Carnot engine which are also consequences of the 'second law of thermodynamics'. **04**

OR

Q.4 **(a)** What is a heat engine? State its salient characteristics. Briefly describe the working of a heat engine (e.g. a thermal power plant) with the help of a schematic diagram and write its index of performance. **06**

(b) A steam turbine developing 400 kW receives a flow of $20x10^3$ kg/h of steam @ 100 m/s. The exit velocity of steam is 320 m/s. The inlet pipe is 4 m above the exhaust pipe. Using Steady Flow Energy Equation (S.F.E.E), calculate the change in enthalpy in kJ/kg. **03**

(c) State Kelvin-Plank and Clausius statements of 'second law of thermodynamics'. Explain their equivalence by supplementing your answer with appropriate example and mathematical justification. **05**

Q.5 **(a)** Explain adiabatic process with the help of P-V and T-S diagrams and derive the expression PV^{γ} = Constant. **06**

(b) Ten moles of an ideal gas maintained at 200 kPa and 35 ^{0}C is compressed reversibly and adiabatically to 2 MPa. Compute the work done on the gas, the change in internal energy and the final temperature of the gas. Express your answers in SI units. Take $\gamma = 1.4$. **05**

(c) Explain different types of thermodynamic equilibria and state their conditions of stability. **03**

OR

Q.5 **(a)** What do mean by a Carnot engine? Draw the P-V and T- S diagram for a Carnot cycle and derive the expression for efficiency of a Carnot engine operating between source temperature T_1 and Sink temperature T_2. **07**

(b) State the first law of thermodynamics for a cyclic process and enumerate its practical limitations. **03**

(c) Explain Gibb's phase rule with an appropriate example. A three component mixture of water, ethanol and acetic acid is in equilibrium with its own vapours. Calculate the degrees of freedom. **04**

****