Seat No.: ________ Enrolment No.___________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– III (New) EXAMINATION – WINTER 2019

Subject Code: 3130507 **Date: 30/11/2019**

Subject Name: Chemical Engineering Thermodynamics I

Time: 02:30 PM TO 05:00 PM **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1	**(a)**	Write short note on “Gibb’s phase rule”.	**03**
	(b)	Distinguish between intensive and extensive properties with suitable example.	**04**
	(c)	Explain the P-V-T behavior of pure fluids with the help of neat diagram.	**07**
Q.2	**(a)**	Distinguish between state function and path function.	**03**
	(b)	Explain about principle of corresponding states.	**04**
	(c)	State first law of thermodynamics? Derive the expressions for 1^{st} law of thermodynamics for non-flow process.	**07**
		OR	
	(c)	Heat is transferred to10 kg of air which is initially at 100 kPa and 300 K until its temperature reaches 600 K. Determine the change in internal energy and change in enthalpy, amount of heat supplied and the work done for a Constant volume process. Assume air as an ideal gas. Given that: R=8.314 kJ / kmol K, Cp=29.099 kJ / kmol K, Cv =20.785 kJ / kmol K and molecular weight of air =29	**07**
Q.3	**(a)**	State various equations of state for real gases.	**03**
	(b)	Define the following i. Sensible heat ii. Latent heat iii. Standard heat of combustion iv. Standard heat of formation	**04**
	(c)	Explain about Van- Der-Waals equation of state.	**07**
		OR	
Q.3	**(a)**	Discuss Virial equations and their applications.	**03**
	(b)	Define the statements for the second law of thermodynamics i. Clausius Statement ii. Kelvin – Planck Statement	**04**
	(c)	Discuss effect of temperature on heat of reaction and derive necessary equation.	**07**
Q.4	**(a)**	Write a short note on Third law of thermodynamics.	**03**
	(b)	Describe absorption refrigeration cycle.	**04**
	(c)	Explain and prove Carnot’s principle with neat sketch**.**	**07**
		OR	
Q.4	**(a)**	Write a short note on Jet ejector.	**03**
	(b)	Using Maxwell’s equation prove that : $dH = CpdT + V(1 – \beta T)dP$ Where β is coefficient of volume expansion	**04**

(c) Derive the expression for change in entropy when an ideal gas changes its state from (P_1, V_1, T_1) to (P_2, V_2, T_2) for following process- **07**

1) Constant volume process.
2) Constant pressure process.
3) Isothermal process.

Q.5 **(a)** Assuming air is mixture of 21 % oxygen and 79% nitrogen by volume calculate entropy of 1 kmol air relative to pure oxygen and nitrogen, all at the same temperature and pressure. **03**

(b) Discuss briefly about single and multistage compressors. **04**

(c) What is the criterion of exactness? Using the criterion of exactness derive the Maxwell equation. **07**

OR

Q.5 **(a)** Discuss any three major desirable properties of good refrigerant. **03**

(b) Write a short note on Thermodynamic Diagrams. **04**

(c) A refrigeration machine operating at a condenser temperature at 290 K needs 1 kW of power per ton of refrigeration. **07**

Determine:

1) Coefficient Of Performance(COP)
2) Heat rejected to the condenser
3) The lowest temperature that can be maintained.

Given that: 1 Ton of refrigeration = 12660 kJ/h=3516.67 W

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GUJARAT TECHNOLOGICAL UNIVERSITY

BE- SEMESTER–III (NEW) EXAMINATION – WINTER 2020

Subject Code:3130507 **Date:04/03/2021**

Subject Name:Chemical Engineering Thermodynamics I

Time:10:30 AM TO 12:30 PM **Total Marks:56**

Instructions:

1. **Attempt any FOUR questions out of EIGHT questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1	**(a)**	What are various units of temperature? Also, mention relations between them on various temperature scales?	**03**
	(b)	Differentiate between i) State function -Vs- Path function ii) Reversible process -Vs- Irreversible process	**04**
	(c)	Apply first law of thermodynamics to steady state flow process and derive mass and energy balance equation for open system.	**07**
Q.2	**(a)**	Define and explain Ideal gas.	**03**
	(b)	What is EOS (Equation of State)? List some of them.	**04**
	(c)	Derive equation of constants of Vander Waal's equation of state in terms of critical constants of a substance.	**07**
Q.3	**(a)**	Mention Statements of second law of thermodynamics.	**03**
	(b)	Define and explain following : (i) Sensible heat (ii) Latent heat (iii) Standard heat of formation (iv) Standard heat of reaction	**04**
	(c)	Derive Carnot equations for a Carnot cycle using an ideal gas	**07**
Q.4	**(a)**	State and explain Hess's law of constant heat summation.	**03**
	(b)	Explain concept of entropy in brief	**04**
	(c)	If 10 mol of ethylene is heated from 200 to 1,000 °C in a steady-flow process at approximately atmospheric pressure, what is its entropy change ? The heat capacity equation for ethylene is: $\frac{{C_P^{ig}}_{ms}}{R} = 1.424 + 14.394\times10^{-3}T_{lm} - 4.392\times10^{-6}T_{am}T_{lm}$	**07**
Q.5	**(a)**	Explain Residual properties in brief.	**03**
	(b)	Explain Effect of temperature on heat of reaction in detail.	**04**
	(c)	Derive Maxwell equations using fundamental property relations for a homogeneous fluid of constant composition.	**07**
Q.6	**(a)**	How much heat is required when 200 gm of $CaCO_3$ is heated at atmospheric pressure from 30 ^{0}C to 700 ^{0}C? Data: $C_P/R = 12.572 + 2.637 \times 10^{-3}\, T - 3.12 \times 10^{5}\, T^{-2}$, T is in K	**07**
	(b)	Explain Various types of thermodynamic diagrams in brief.	**07**
Q.7	**(a)**	With reference to refrigeration, Define following: (i) COP (Coefficient of Performance) (ii) Ton of refrigeration (iii) Heat Pump	**03**
	(b)	Compare Vapor Compression refrigeration and Absorption refrigeration cycles.	**04**

	(c)	Show that the maximum velocity attained by a gas in steady state adiabatic flow in a horizontal pipe of a constant cross-sectional area is equal to the sonic velocity.	**07**
Q.8	**(a)**	Define Mach number and state its significance	**03**
	(b)	What is a Nozzle? Briefly describe flow through nozzles.	**04**
	(c)	List the factors affecting the choice of refrigerant and explain vapor pressure of refrigerant in detail.	**07**

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GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–III (NEW) EXAMINATION – WINTER 2021

Subject Code:3130507 Date:21-02-2022

Subject Name:Chemical Engineering Thermodynamics I

Time:10:30 AM TO 01:00 PM Total Marks:70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

			Marks
Q.1	**(a)**	State Zeroth law and Third law of thermodynamics	**03**
	(b)	Discuss in brief about choice of refrigerant for refrigeration system.	**04**
	(c)	Explain vapour compression refrigerant cycle with neat flow diagram and T-S diagram.	**07**
Q.2	**(a)**	Discuss strength and limitations of thermodynamics in chemical engineering.	**03**
	(b)	Select whether the following properties are extensive or intensive: (a) temperature, (b) volume, (c) specific volume (d) heat capacity, (e) potential energy, (f) pressure (g) Internal energy (h) Enthalpy.	**04**
	(c)	Starting from fundamentals, Derive a mathematical expression of the first law of thermodynamics for a steady state flow process.	**07**
		OR	
	(c)	Using Maxwell's equation prove that : dH = Cp dT + V(1 – β T) dP dS = Cp dT/T – β V dP. Where β = Volume expansivity.	**07**
Q.3	**(a)**	How many degrees of freedom have each of the following system? (1) Liquid water in equilibrium with its vapor. (2) Liquid water in equilibrium with a mixture of water vapor and nitrogen. (3) A liquid solution of alcohol in water in equilibrium with its vapor.	**03**
	(b)	From the First Principle $dU = dQ - dW$ prove the following $\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$	**04**
	(c)	Discuss Cluasius Inequality in detail	**07**
		OR	
Q.3	**(a)**	Give answer with Justification: Two reversible heat engines are operated between absolute temperature T_1, T_2& T_3 as shown in **figure (i).** If the work done per cycle by two engine are same then the temperature T_2 must be: a. Arithmetic mean of T_1& T_3 b. Geometric mean of T_1& T_3 c. Logarithmic mean of T_1& T_3 d. Harmonic mean of T_1& T_3	**03**
	(b)	Explain concept of entropy in brief.	**04**
	(c)	Discuss the Thermodynamic temperature scale in detail	**07**
Q.4	**(a)**	Explain physical significance of Virial coefficients.	**03**
	(b)	Give significance of Compressibility factor and volume expansivity	**04**

	(c)	Discuss the PVT- behavior of pure liquids with PV and PT diagram for a pure material.	**07**

OR

Q.4	**(a)**	Explain the principle of corresponding states and discuss the generalized compressibility chart.	**03**
	(b)	Define: i) standard heat of formation ii) standard heat of combustion iii) standard heat of reaction iv) latent heat	**04**
	(c)	Calculate the volume occupied by one mole of oxygen at 300 K and 100 bar using (a) The ideal gas law (b) The vad der waals equation. $a = 0.1378\ N\ m^4/\ mol^2$ and $b = 3.18 \times 10^{-5}\ m^3/\ mol$	**07**
Q.5	**(a)**	Define: sonic velocity, nozzle and Mach no.	**03**
	(b)	Write a Short note on Ejector	**04**
	(c)	The standard heat of reaction at 298K is -42.433 kJ for the reaction $C_2H_{4(g)} + H_2O_{(g)} \rightarrow C_2H_5OH_{(g)}$. Calculate the heat of reaction at 400 K. The constants in the heat capacity equation Cp = a + bT + cT2 are as given below: (C_P is in J/mol.K and T in K)	**07**

Component	a	b	c
C_2H_4	11.85	119.75×10^{-3}	-36.53×10^{-6}
H_2O	30.38	9.62×10^{-3}	1.19×10^{-6}
C_2H_5OH	29.27	166.39×10^{-3}	-49.93×10^{-6}

OR

Q.5	**(a)**	Explain working principle of Linde liquefaction process in brief	**03**
	(b)	Explain isenthalpic process in detail	**04**
	(c)	Using Hess's law, calculate the heat of formation for chloroform ($CHCl_3$) with the following data:	**07**

(a) $CHCl_{3(g)} + 0.5O_{2(g)} + H2O \rightarrow CO_{2(g)} + 3HCl_{(g)}$; ΔH^0 298 = -509.93 kJ
(b) $H_2(g) + 0.5O2_{(g)} \rightarrow H_2O_{(l)}$; ΔH^0 298 = -296.03 kJ
(c) $C_{(s)} + O2_{(g)} \rightarrow CO_{2(g)}$; ΔH^0 298 = -393.78 kJ
(d) $0.5H_{2(g)} + 0.5Cl_{2(g)} \rightarrow HCl_{(g)}$; ΔH^0 298 = -167.57 kJ

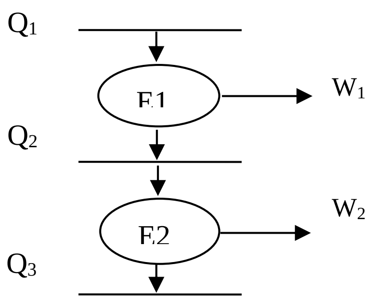

Figure (i)

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GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–III (NEW) EXAMINATION – SUMMER 2021

Subject Code:3130507 Date:11/09/2021

Subject Name:Chemical Engineering Thermodynamics I

Time:10:30 AM TO 01:00 PM Total Marks:70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

Q.1	**(a)**	Define and explain "Reversible Process".	**03**
	(b)	Differentiate between (i) Macroscopic Vs Microscopic approach (ii) Intensive Vs Extensive Properties	**04**
	(c)	State and explain first law of thermodynamics. Also, derive energy balance equation for closed system.	**07**
Q.2	**(a)**	What is Cubic EOS? List some of them.	**03**
	(b)	Explain Virial expansions, Virial coefficients and compressibility factor.	**04**
	(c)	Explain PVT behavior of a pure substance with the help of PT and PV diagram in brief.	**07**
		OR	
	(c)	One kmol of an ideal gas, initially at 30^0C and 1 bar undergoes the following mechanically reversible changes. It is compressed isothermally to a point such that when it is heated at constant volume to 120^0C its final pressure is 12 bar. Calculate Q, W ΔU and ΔH for the process. Take $C_p = (7/2)R$ and $C_v = (5/2)R$.	**07**
Q.3	**(a)**	Mention various statements of the second law of thermodynamics.	**03**
	(b)	Explain various equations proposed for predicting latent of pure substances.	**04**
	(c)	Derive Carnot equations for a Carnot cycle using an ideal gas.	**07**
		OR	
Q.3	**(a)**	State Carnot theorem and its corollary.	**03**
	(b)	Explain effect of temperature on heat of reaction.	**04**
	(c)	A steel casting [Cp = 0.5 kJ kg^{-1} K^{-1}] weighing 40 kg and at a temperature of 450°C is quenched in 150 kg of oil [Cp = 2.5 kJ kg^{-1} K^{-1}] at 25°C. If there are no heat losses, what is the change in entropy of (i) the casting (ii) the oil, and (iii) both considered together?	**07**
Q.4	**(a)**	Define heat capacity and explain its temperature dependency.	**03**
	(b)	Explain heat effects of some industrial reactions.	**04**
	(c)	Write down Maxwell's equations and derive one of them.	**07**
		OR	
Q.4	**(a)**	What are residual properties? Explain.	**03**
	(b)	Explain thermodynamic diagrams.	**04**
	(c)	Define and explain following with examples of each: (1) Sensible heat (2) latent heat (2) Standard heats of formation, reaction and combustion.	**07**
Q.5	**(a)**	What are the factors (properties) affects the choice of a refrigerant?	**03**

	(b)	Derive an equation for the Co-efficient of performance (COP) of Carnot refrigeration cycle.	**04**
	(c)	Starting from energy balance equation and the continuity relation, show that the maximum velocity attained by a gas in steady state adiabatic flow in a horizontal pipe of a constant cross-sectional area is: -	**07**

$$u_{\max}^2 = -V^2\left(\frac{\partial P}{\partial V}\right)_S$$

OR

Q.5	**(a)**	Explain "Critical Pressure Ratio" in case of a fluid flowing through nozzle.	**03**
	(b)	Write a short note on ejectors.	**04**
	(c)	Describe Vapor compression refrigeration cycles with neat diagrams.	**07**

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GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– III (NEW) EXAMINATION – SUMMER 2022

Subject Code:3130507 Date:15-07-2022

Subject Name:Chemical Engineering Thermodynamics I

Time:02:30 PM TO 05:00 PM Total Marks:70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

			Marks
Q.1	**(a)**	Define: (1) Open system, (2) Closed system, (3) Isolated system.	**03**
	(b)	Explain the concept of entropy in brief.	**04**
	(c)	Discuss the scope and limitations of chemical engineering thermodynamics.	**07**
Q.2	**(a)**	Explain Vandarwaals equation of state.	**03**
	(b)	Define: (1) Steady state, (2) Equilibrium state, (3) Intensive property, (4) Extensive property.	**04**
	(c)	Apply the first law of thermodynamics to the steady-state flow process and derive the mass and energy balance equation for an open system.	**07**
		OR	
	(c)	Calculate the change in internal energy and change in enthalpy for 1 kmol water, as it is vaporized at the constant T of 373 K and constant P of 101.3 kPa. The specific Volume of liquid and vapour at these conditions is 1.04×10^{-3} and 1.675 m^3/kmol respectively. 1030 kJ of heat was added to water for this change.	**07**
Q.3	**(a)**	An ideal gas is expanded from 5 bar to 4 bar isothermally at 600 K. Calculate the change in internal energy and heat supplied in the process.	**03**
	(b)	Define the following terms (i) Adiabatic Process, (ii) Isothermal Process, (iii) Isobaric Process, (iv) Isothermal Process.	**04**
	(c)	Determine the change in internal energy, the change in enthalpy, and the heat supplied, and the work done in the isobaric process. Heat is transferred to 10 kg of air which is initially at 100 kPa and 300 K until its temperature reaches 600 K. Assume air is an ideal gas and molecular weight of air = 29. Cp = 29.09 kJ/kmol K, Cv = 20.785 kJ/kmol K, R = 8.314 kJ/kmol K.	**07**
		OR	
Q.3	**(a)**	One kmol CO_2 occupies a volume of 0.381 m^3 at 313 K. Calculate the pressure given by the van der Waals equation. Take a = 0.365 Nm^4/mol^2 and b = 0.428×10^{-5} m^3/mol.	**03**
	(b)	Write equations of (i) Ideal gas EOS, (ii) Virial EOS, (iii) Redlich/Kwong (RK) EOS.	**04**
	(c)	Pure CO is mixed with 100% excess air and burnt. Only 80% of the CO burns. The reactants are at 373 K and the products are at 573 K. Calculate the amount of heat added or removed per kmol of CO fed to the reactor. Mean molal specific heats between 298 K and T K in kJ/ kmol K are:	**07**

Gas	T = 373 K	T = 573 K
CO	29.22	30.61

CO_2	-	43.77
O_2	29.84	30.99
N_2	29.17	29.66

Standard heats of formation at 298 K in kJ/ mol are CO = –110.524 and CO_2 = –393.514.

Q.4 **(a)** Explain the PVT behavior of pure substances. **03**

(b) State any two statements of the second law of thermodynamics. **04**

(c) Consider the compression of air (molecular weight = 29) from 10^5 Pa at 300 K to 3.6×10^6 Pa in an ideal two-stage compressor with intercooling. Assume that the temperature of the air leaving the intercooler is also 300 K and that the optimum interstage pressure is used. The compressor is water jacketed and the polytropic exponent n is 1.30 for both stages. Determine the work of compression per kg of air. **07**

OR

Q.4 **(a)** Explain the principle of corresponding states. **03**

(b) Give limitations of the first law of thermodynamics. **04**

(c) Steam at 600 kPa and 573 K (H = 3062 kJ/kg) enters a nozzle at a rate of 10 kg/s and discharges it at 100 kPa and 473 K (H = 2875 kJ/kg). Heat loss to the surroundings is estimated to be 100 kW. Assuming that the inlet velocity of steam is negligible, determine the discharge velocity. **07**

Q.5 **(a)** Define: (1) Internal Energy, (2) Enthalpy, (3) Heat Capacity. **03**

(b) Prove that “entropy of the universe is increasing” by analyzing the concept of entropy. **04**

(c) Explain the working principle of the Linde liquefaction process in brief. **07**

OR

Q.5 **(a)** State first law of thermodynamics, and third law of thermodynamics. **03**

(b) Hydrocarbon oil is to be cooled from 425 K to 340 K at a rate of 5000 kg/h in a parallel flow heat exchanger. Cooling water at a rate of 10,000 kg/ h at 295 K is available. The mean specific heats of the oil and water are respectively 2.5 kJ/kg K and 4.2 kJ/kg K. Analyze the process for a total change in entropy and is the process reversible? **04**

(c) Outline the important properties of a refrigerant. **07**

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