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# B.M.S. College of Engineering, Bengaluru-560019

**Autonomous Institute Affiliated to VTU**

## April 2024 Semester End Main Examinations

**Programme: B.E.** **Semester: III**
**Branch: Chemical Engineering** **Duration: 3 hrs.**
**Course Code: 19CH3DCTD1** **Max Marks: 100**
**Course: Process Engineering Thermodynamics-I**

**Instructions**: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.
3. Use of steam tables is permitted.

**Important Note:** Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.



### UNIT - I

1 a) Discuss internal energy, heat, various types of systems with example. **08**

b) A special manometer fluid has a specific gravity of 2.95 and is used to measure a pressure of 1.15 bar at a location where the barometric pressure is 760 mm Hg. What height will the manometer fluid indicate? **06**

c) State and explain the phase rule. **06**

### UNIT - II

2 a) Derive the equation for first law of thermodynamics for steady state flow system. **10**

b) A piston–cylinder device contains 0.1 kg of saturated water vapour is maintained at a constant pressure of 400 kPa. Heat is supplied by means of a resistance heater provided within the cylinder. A current of 0.2 A from a 230-V source is passed continuously for 10 min. Heat loss from the system is estimated to be 15.41 kJ. Making use of steam tables, determine the final temperature of the steam. From steam tables (saturated steam), the enthalpy at this condition is ($H1$) = 2738.6 kJ/kg. **10**

**OR**

3 a) Explain with example reversible and irreversible processes for thermodynamic system with surroundings. **10**

b) Iron filings are contained in a cylinder in an atmosphere of oxygen. It combines with oxygen according to the following reaction. **10**

$$2\ Fe + (3/2)\ O_2 \rightarrow Fe_2O_3$$

The pressure inside the cylinder is maintained at 101 kPa. The temperature is kept constant at 298 K by removing heat. For 2 mol iron reacted, calculate work interaction and $\Delta U$, given that 831.08 kJ of heat is liberated in the process.

### UNIT - III

4 a) van der Waals proposed the following equation to explain the *P-V-T* behaviour of real gases. $(P + a/v^2)\ (v - b) = RT$, where *a* and *b* are called van der Waals constants. Explain the applicability of the equation to vapour liquid equilibrium state. **12**

b) Elucidate virial equation of state and compressibility charts. **08**

**OR**

5 a) Derive the equation for processes involving ideal gases at constant pressure and constant temperature to enumerate different energy charges of the system. **10**

b) Heat is transferred to 10 kg of air which is initially at 100 kPa and 300 K until its temperature reaches 600 K. Determine the change in internal energy, the change in enthalpy, the heat supplied, and the work done in the following processes: **10**
(a) Constant volume process (b) Constant pressure process.
Assume that air is an ideal gas for which the P-V-T relationship is PV = nRT, where n is the number of moles of the gas and R is the ideal gas constant. R = 8.314 kJ/kmol K. Assume $C_P$ = 29.099 kJ/kmol K, $C_V$ = 20.785 kJ/kmol K and molecular weight of air = 29.

**UNIT - IV**

6 a) State and explain the following. **06**

i. Hess's law of heat summation
ii. The standard heat of reaction

b) Using Hess's law, calculate the heat of formation of chloroform ($CHCl_3$) with the following given data. **08**

(a) $CHCl_3$ (g) +1/2 $O_2$ + $H_2O$ (l) $\rightarrow CO_2$(g) + HCl (g) ; $H^0_{298}$ = -509.93 kJ

(b) $H_2$ (g) + 1/2 $O_2$ (g) $\rightarrow H_2O$ (l); $H^0_{298}$ = -296.03 kJ

(c) C (s) + $O_2$ (g) ) $\rightarrow CO_2$(g); $H^0_{298}$ = -393.78 kJ

(d)1/2 $H_2$ (g) + ½ $Cl_2$ (g ) $\rightarrow$ HCl (g) ; $H^0_{298}$ = -167.57 kJ

c) Define sensible heat and explain the temperature effect on heat capacity. **06**

**UNIT – V**

7 a) Elucidate on the concept of the Carnot principle for a cyclic operation that describe the second law of thermodynamics. **10**

b) Oil at 500 K is to be cooled at a rate of 5000 kg/h in a counter-current exchanger using cold water available at 295 K. A temperature approach of 10 K is to be maintained at both the ends of the exchanger. The specific heats of oil and water are, 3.2 and 4.2 kJ/kg K respectively. Determine the total entropy change in the process. **10**

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