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UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2017

Program: B.Tech CE+RP/B.Tech APE-Gas **Semester – III**
Subject (Course): Chemical Engineering Thermodynamics-I **Max. Marks : 100**
Course Code : CHEG-222 **Duration : 3 Hrs**
No. of page/s:2

Instruction(s):

(a) For all the problems state the assumptions you consider clearly.

(b) Assume the appropriate value of missing data if any.

Section –A

(Answer all questions, equal marks)

6 x 10 = 60 Marks

1. State the First law for a closed system undergoing a cycle and derive steady flow energy equation for Turbine work.

2. **100 kg** of Water at **100^{O}C** are mixed with **60 kg** of water at **60^{O}C**, while the temperature of the surrounding is **15^{O}C**, determine the decrease in available energy due to mixing

3. Draw the **T-*s***, **P-*v*** and **T-*v*** diagrams for pure substance

4. What is **Adiabatic Flame Temperature**? Derive equations for obtaining Adiabatic Flame Temperature for **Constant Pressure** and **Constant Volume** Processes

5. Describe the working principle of **Throttling Colorimeter** for measurement of quality of Steam with neat diagram

6. A gas undergoes a thermodynamic cycle consisting of three processes beginning at the initial state where **p_1 = 1bar**, **V_1= 1.5 m^3** and **U_1=5412 kJ**. The processes are follows
   (a) Process **1-2**, compression with **pV = Constant** to **p_2= 2 bar**, **U_2= 690 kJ**
   (b) Process **2-3**, **W_{23} = 0**, **Q_{23} = -150kJ** and
   (c) Process **3-1**, **W_{31}= 50kJ,** neglecting **KE** and **PE** changes, determine the heat interactions **Q_{12}** and **Q_{31}**?

Section-B

(Answer any 2 questions)

2 x 20 = 40 Marks

7. **(a)** Explain the characteristics and working principle of **Ideal Vapor Compression Refrigeration Cycle** with the help of a neat sketch **[10]**

(b) An ideal vapor compression refrigeration cycle that uses the refrigerant **R-134a**, as its working fluid maintains a condenser at **800 kPa** and the evaporator at **-12 ^{O}C**, determine the system's **COP** and the amount of power required to service a **150 kW** cooling load **[10]**

8. **(a)** Why is the **Carnot cycle** not a realistic model for a steam power plant? Explain **[8]**

(b) Consider a **210-MW** steam power plant that operates on a simple **ideal Rankine cycle**. Steam enters the turbine at **10 MPa** and **500^{O}C** and is cooled in the condenser at a pressure of **10 kPa**. Show the cycle of a **T – *s*** diagram ***w.r.t*** saturation lines and determine

- **(i)** the quality of steam at the turbine exit
- **(ii)** the thermal efficiency of the cycle
- **(iii)** the mass flow rate of the steam. **[12]**

9.

(a) Hydrogen is burned with a stoichiometric amount of air during an adiabatic steady-flow combustion process. Both the fuel and the air enter the combustion chamber at **25° C** and **1 atm**. Calculate the exit temperature of the product gases, assuming complete combustion.

The combustion equation for H2 with stoichiometric air is **[15]**

1. $$H_2 + \frac{1}{2}(O_2 + 3.76\,N_2) \rightarrow H_2O + \frac{1}{2}(3.76)\,N_2$$

Species	$\overline{h_f^0}$ kJ/kmol	$\overline{h}_{298}$ kJ/kmol
H_2	0	-
O_2	0	-
N_2	0	8669
$H_2O(g)$	-241820	9904

(b) Derive the **Clapeyron's** equation for latent heat of vaporization of a pure substance **[5]**