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National Institute of Technology, Hamirpur

B. Tech. (Chemical Engineering) - 3rd Semester

End Term Exam (December, 2020)

CHD-212 CHEMICAL ENINEERING TERMODYNAMICS-I

Duration: 2 hrs **Max. Marks: 50**

Note: *This question paper consists of four questions and one page.*

- *Attempt all questions.*
- *Assume appropriate data wherever necessary*

Q1. Attempt the following. [1+2+3×4=15]

(a) What do you understand by point function and path function? Give any two example of each.

(b) Write down the mathematical expression for Redlich-Kwong and Virial equation along with the notations.

(c) Why the performance of a heat pump or a refrigerator does not measured in terms of thermal efficiency, but in terms of COP?

(d) What is an air standard cycle? Why are such cycles conceived? Give example of any two such cycles.

(e) Define the work principle of Brayton cycle along with the P-V and T-S plots.

(f) Differentiate Otto and Dual cycle for the same maximum pressure and Temperature with three point of each.

Q2. An air refrigeration machine rated at 10 ton in used to maintain the temperature of a cold room at 261 K, when the cooling water is available at 293 K. The machine operates between pressures of 1.013 bar and 4.052 bar. Assume a 5-K approach in the cooler and the refrigerator. The specific heat of air may be taken as 1.008 kJ/kg K and $\gamma = 1.4$. Calculate the COP and air circulation rate. [5]

Q3. The compression ratio in air standard Otto cycle is 8. The temperature and pressure at the beginning of the compression stroke are 290 K and 100 kPa. Heat transferred per cycle is 450 kJ/kg of air. The sp. Heat of air are C_p = 1.005 KJ/kg K and C_v = 0.718 KJ/kg K. Determine the following; [10]

i) The pressure and temperature of the air at the end of each process.

ii) The thermal efficiency (iii) Work done by kg of air (iv) The mean effective pressure

Q4. Dry methane is burned with dry air. Both are at 298 K initially. The flame temperature is 1600 K. If the complete combustion is assumed, how much excess air is being used? The reaction is; [10]

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

The standard heat of reaction is -8.028×10^5 J/mol of methane reacted. Mean molal sp. Heats of gases between 298 K and 1600 K are in J/Kmol:

CO_2 = 51.66, H_2O = 40.45, O_2 = 34.01, and N_2 = 32.21

Q5. Nitrogen is compressed infinitesimally and isothermally at 300 K from 1 bar to 8 bar. Calculate the work done using the virial equation of state. [10]

$$Z = 1 + B/V$$

For nitrogen, Tc = 126.2 K, Pc = 34 bar, ω = 0.038