INDIAN INSTITUTE OF TECHNOLOGY KANPUR

ESO 201A: Thermodynamics

(2023-24 I Semester)

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Tutorial 4

Question 1: A 1-m^3 tank containing air at 10°C and 350 kPa is connected through a valve to another tank containing 3 kg of air at 35°C and 150 kPa. Now the valve is opened, and the entire system is allowed to reach thermal equilibrium with the surroundings, which are at 20°C. Determine the volume of the second tank and the final equilibrium pressure of air. **(Ans. 1.768 m^3, 222 kPa)**

Question 2: Determine the specific volume of refrigerant-134a vapor at 0.9 MPa and 70°C based on (a) the ideal-gas equation, (b) the generalized compressibility chart, and (c) data from tables.

(Ans. (a) 0.03105 m^3/kg (b)0.02776 m^3/kg (c)0.027413 m^3/kg)

Question 3: A 3.27-m^3 tank contains 100 kg of nitrogen at 175 K. Determine the pressure in the tank using (a) the ideal-gas equation, (b) the van der Waals equation, and (c) the Beattie- Bridgeman equation. Compare your results with the actual value of 1505 kPa.

(Ans. (a) 1588 kPa, (b) 1495 kPa, (c) 1504 kPa)

Question 4: Calculate the total work, in kJ, for process 1–3 shown in Fig. 1 when the system consists of 2 kg of nitrogen.

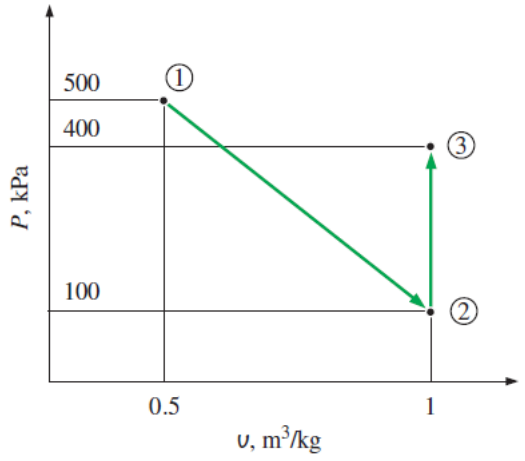

Fig. 1

(Ans. 300 kJ)

Question 5: A piston–cylinder device contains 0.15 kg of air initially at 2 MPa and 350°C. The air is first expanded isothermally to 500 kPa, then compressed polytropically with a

polytropic exponent of 1.2 to the initial pressure, and finally compressed at the constant pressure to the initial state. Determine the boundary work for each process and the net work of the cycle.

(Ans. 37.18 kJ, -34.86 kJ, -6.97 kJ, -4.65 kJ)

Question 6: A 0.5-m^3 rigid tank contains refrigerant-134a initially at 160 kPa and 40 percent quality. Heat is now transferred to the refrigerant until the pressure reaches 700 kPa. Determine (a) the mass of the refrigerant in the tank and (b) the amount of heat transferred. Also, show the process on a P-v diagram with respect to saturation lines.

(Ans. 10.03 kg, 2708 kJ