1. (25%) Carbon dioxide is assumed to follow the equation of state

$$(P + a/V^2 T^{0.5})(V - b) = RT$$

where a and b are constants for any gas. Given that the critical pressure and temperature of carbon dioxide are 72.9 atm and 304.2°K respectively, , determine the compressibility factor of the gas at 100° C and at a volume of 3.057 x 10 cm³ /mole.

Note: Gas constant R = 82.05 cm³ atm/° K mole

2. (25%) Propane (C_3H_8)is burned in 100% excess air. Combustion is complete and takes place at 100 Kpa. Determine
(a) the dew-point temperature of the product of combustion
(b) the moles of water condensed per mole of fuel burned, if the products of combustion are cooled to 25 °C.

TABLE A·1.1 (SI) Water: Liquid-Vapor Saturation, Temperature Table (SI)

Temp. °C T	Pressure kPa P	Specific Volume m³/kg		Internal Energy kJ/kg			Enthalpy kJ/kg			Entropy kJ/kg·K		
		Sat. Liquid v_f	Sat. Vapor v_g	Sat. Liquid u_f	Evap. u_{fg}	Sat. Vapor u_g	Sat. Liquid h_f	Evap. h_{fg}	Sat. Vapor h_g	Sat. Liquid s_f	Evap. s_{fg}	Sat. Vapor s_g
0.01	0.6113	0.001 000	206.14	0.00	2375.3	2375.3	0.01	2501.3	2501.4	.0000	9.1562	9.1562
5	0.8721	0.001 000	147.12	20.97	2361.3	2382.3	20.98	2489.6	2510.6	.0761	8.9496	9.0257
10	1.2276	0.001 000	106.38	42.00	2347.2	2389.2	42.01	2477.7	2519.8	.1510	8.7498	8.9008
15	1.7051	0.001 001	77.93	62.99	2333.1	2396.1	62.99	2465.9	2528.9	.2245	8.5569	8.7814
20	2.339	0.001 002	57.79	83.95	2319.0	2402.9	83.96	2454.1	2538.1	.2966	8.3706	8.6672
25	3.169	0.001 003	43.36	104.88	2304.9	2409.8	104.89	2442.3	2547.2	.3674	8.1905	8.5580
30	4.246	0.001 004	32.89	125.78	2290.8	2416.6	125.79	2430.5	2556.3	.4369	8.0164	8.4533
35	5.628	0.001 006	25.22	146.67	2276.7	2423.4	146.68	2418.6	2565.3	.5053	7.8478	8.3531
40	7.384	0.001 008	19.52	167.56	2262.6	2430.1	167.57	2406.7	2574.3	.5725	7.6845	8.2570
45	9.593	0.001 010	15.26	188.44	2248.4	2436.8	188.45	2394.8	2583.2	.6387	7.5261	8.1648
50	12.349	0.001 012	12.03	209.32	2234.2	2443.5	209.33	2382.7	2592.1	.7038	7.3725	8.0763
55	15.758	0.001 015	9.568	230.21	2219.9	2450.1	230.23	2370.7	2600.9	.7679	7.2234	7.9913
60	19.940	0.001 017	7.671	251.11	2205.5	2456.6	251.13	2358.5	2609.6	.8312	7.0784	7.9096
65	25.03	0.001 020	6.197	272.02	2191.1	2463.1	272.06	2346.2	2618.3	.8935	6.9375	7.8310
70	31.19	0.001 023	5.042	292.95	2176.6	2469.6	292.98	2333.8	2626.8	.9549	6.8004	7.7553

3. (25%)

Helium is contained in a closed system initially at 135 kPa and 30°C and undergoes a constant-pressure process until the volume is doubled. The mass of helium present is 1.2 kg, and the heat transferred to the helium during the process amounts to 1750 kJ. Determine whether this process is internally reversible, internally irreversible, or impossible.

$C_p = 5.1926 \frac{kJ}{kg \cdot k}$ $C_{v_0} = 3.1156 \frac{kJ}{kg \cdot k}$ $k = 1.667$ $R = 2.07703 \frac{kJ}{kg \cdot k}$

4.

Consider the steady flow through an adiabatic pipe with friction (see sketch below). The inlet state is specified in terms of properties P_1, T_1. Due to friction the outlet pressure drops to a known value $P_2 = P_1 - \Delta P$.

Assuming that the working fluid is an ideal gas (with gas constant R and constant specific heat c_v), determine:

a) The outlet temperature T_2 = function (P_1, T_1, P_2). (5%)

b) The rate of entropy generation inside the pipe, $\dot{m}$ (5%)
   $(s_2 - s_1)$ = function (P_1, T_1, P_2), where $\dot{m}$ is given.

Assuming that the working fluid is an incompressible fluid (with constant specific heat c and constant specific volume v) determine:

c) The specific enthalpy change through the pipe, $h_2 - h_1$. (5%)

d) The temperature change, $T_2 - T_1$. (5%)

e) The specific entropy change, $s_2 - s_1$. (5%)

state 1
P_1, T_1
$\dot{m} \rightarrow$

state 2
$P_2 = P_1 - \Delta P$
$\rightarrow \dot{m}$

adiabatic wall