1. A stationary piston-cylinder device contains 2 kg of air at 27°C and 100 kPa. The air is now compressed to a pressure of 500 kPa according to the relation $PV^{1.4}$ = constant. Determine the following:
   (a) the initial volume of air. (5%)
   (b) the final volume of air. (5%)
   (c) the work input during the process. (5%)
   (d) the change in total internal energy of the system (ΔU). (5%)
   (e) the amount of heat transfer (Q) during the process. (5%)

Gas constant of air, $R = 0.287\ \text{kJ/kgK}$; Idea gas properties of air are given:

Temperature - T - (K)	Enthalpy - h - (kJ/kg)	Relative Pressure - p_r -	Internal Energy - u - (kJ/kg)
250	250	0.733	178
300	300	1.39	214
350	350	2.38	250
400	401	3.81	286
450	452	5.76	323
500	503	8.41	359
550	555	11.9	397
600	607	16.3	435
650	660	21.9	473

2. Given the properties for T is temperature, p is pressure v is specific volume, u is specific internal energy, s is the specific entropy, R is gas constant, and a,b are constants. Please answer the following problems.
   (a) Prove that Gibbs relation as $Tds = du - pdv$ and physical means of relation ? (7%)
   (b) Find $\left(\frac{\partial s}{\partial v}\right)_T$ value and physical means for a ideal gas.(6%)
   (c) Find $\left(\frac{\partial s}{\partial v}\right)_T$ value for a gas whose equation of state is $(p - \frac{a}{v^2})(v - b) = RT$.(6%)
   (d) Find $\left(\frac{\partial s}{\partial p}\right)_T$ value and physical means for a gas whose equation of state is $p(v - b) = RT$.(6%)

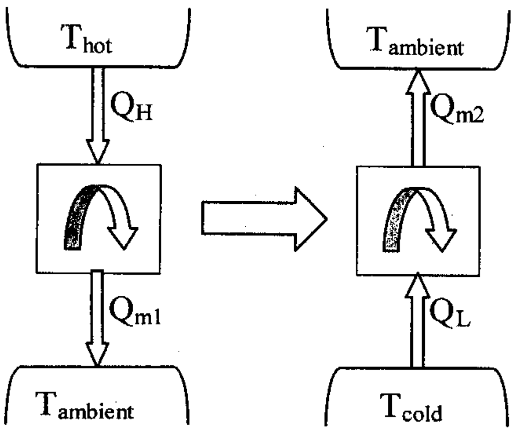
3. There is 100 m^3 of an air-water vapor mixture at 0.1 Mpa, 30℃, 55% relative humidity. Please determine the dew point, mass of air and mass of vapor (4% each). If the air-water vapor mixture is cooled to 15℃, please find the mass of the condensed water. (6%) Please see Table A.1 for the thermodynamic properties of water.

TABLE A.1SI ***Thermodynamic Properties of Water (SI Units)***
TABLE A.1.1SI ***Saturated Water: Temperature Table (SI Units)***

		Specific Volume, m^3/kg		Internal Energy, kJ/kg			Enthalpy, kJ/kg			Entropy, kJ/kg K		
Temp. °C T	Press. kPa, MPa P	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	0.001000	206.132	0.00	2375.3	2375.3	0.00	2501.3	2501.3	0.0000	9.1562	9.1562
5	0.8721	0.001000	147.118	20.97	2361.3	2382.2	20.98	2489.6	2510.5	0.0761	8.9496	9.0257
10	1.2276	0.001000	106.377	41.99	2347.2	2389.2	41.99	2477.7	2519.7	0.1510	8.7498	8.9007
15	1.7051	0.001001	77.925	62.98	2333.1	2396.0	62.98	2465.9	2528.9	0.2245	8.5569	8.7813
20	2.3385	0.001002	57.790	83.94	2319.0	2402.9	83.94	2454.1	2538.1	0.2966	8.3706	8.6671
25	3.1691	0.001003	43.359	104.86	2304.9	2409.8	104.87	2442.3	2547.2	0.3673	8.1905	8.5579
30	4.2461	0.001004	32.893	125.77	2290.8	2416.6	125.77	2430.5	2556.2	0.4369	8.0164	8.4533
35	5.6280	0.001006	25.216	146.65	2276.7	2423.4	146.66	2418.6	2565.3	0.5052	7.8478	8.3530
40	7.3837	0.001008	19.523	167.53	2262.6	2430.1	167.54	2406.7	2574.3	0.5724	7.6845	8.2569
45	9.5934	0.001010	15.258	188.41	2248.4	2436.8	188.42	2394.8	2583.2	0.6386	7.5261	8.1647
50	12.350	0.001012	12.032	209.30	2234.2	2443.5	209.31	2382.7	2592.1	0.7037	7.3725	8.0762
55	15.758	0.001015	9.568	230.19	2219.9	2450.1	230.20	2370.7	2600.9	0.7679	7.2234	7.9912
60	19.941	0.001017	7.671	251.09	2205.5	2456.6	251.11	2358.5	2609.6	0.8311	7.0784	7.9095
65	25.033	0.001020	6.197	272.00	2191.1	2463.1	272.03	2346.2	2618.2	0.8934	6.9375	7.8309
70	31.188	0.001023	5.042	292.93	2176.6	2469.5	292.96	2333.8	2626.8	0.9548	6.8004	7.7552
75	38.578	0.001026	4.131	313.87	2162.0	2475.9	313.91	2321.4	2635.3	1.0154	6.6670	7.6824
80	47.390	0.001029	3.407	334.84	2147.4	2482.2	334.88	2308.8	2643.7	1.0752	6.5369	7.6121
85	57.834	0.001032	2.828	355.82	2132.6	2488.4	355.88	2296.0	2651.9	1.1342	6.4102	7.5444
90	70.139	0.001036	2.361	376.82	2117.7	2494.5	376.90	2283.2	2660.1	1.1924	6.2866	7.4790
95	84.554	0.001040	1.982	397.86	2102.7	2500.6	397.94	2270.2	2668.1	1.2500	6.1659	7.4158
100	0.10135	0.001044	1.6729	418.91	2087.6	2506.5	419.02	2257.0	2676.0	1.3068	6.0480	7.3548

4. Please explain the meanings of "enthalpy of formation" (3%) and "adiabatic flame temperature" (4%).

5. One wish to produce refrigeration at -30℃. A reservoir, shown in figure is available at 200℃ and the ambient temperature is 30 ℃. Thus, work can be done by a cyclic heat engine operating between the 200℃ reservoir and the ambient. This work is used to drive the refrigerator. Determine the ratio of the heat transferred from the 200℃ reservoir to the heat transferred from the -30℃ reservoir, assuming all process are reversible. (10%)



6. A Carnot refrigeration cycle is analyzed for the production of 1 kmol of liquid helium at 4.2 K from saturated vapor at the same temperature. (The enthalpy of evaporation for helium at 4.2 K is 83.3 kJ/kmol)
   (a) What is the work input to the refrigerator for the cycle with an ambient at 300 K? (10%)
   (b) What is the coefficient of performance for the cycle with an ambient at 300 K? (5%)