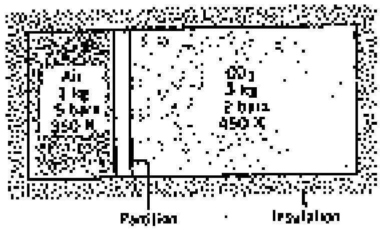
1) (25%)

One kilogram of air, initially at 5 bars, 350°K, and 3 kg of carbon dioxide CO_2, initially at 2 bars, 450°K are confined to opposite sides of a rigid, well-insolate container, as illustrated in the Figure. The partition is free to move. The air and carbon dioxide each behave as ideal gases. Please determine the final equilibrium temperature, in K and the final pressure in bars, if the partition is (a) assumed to allow conduction from one gas to the other without energy storage in the partition itself, or (b) assumed to be an perfect insulator to heat on both sides. Assume constant specific heat for air c_v =0.726 kJ/kgK, and for CO_2, c_v =0.75 kJ/kgK.



2. (25%)

(a) What is the thermodynamic temperature scale (4%)

(b) Can you draw a *p-v*, *T-s* diagram of a Carnot power cycle? Please also show its direction of process. (6%)

(c) Express the thermal efficiency of a Carnot cycle by function of temperature, if the working temperatures are in t_h =727 °C and t_c =227 °C respectively. (5%)

(d) Can a Carnot cycle also be used as a refrigerated cycle? (2%) If no, explain why? If yes, please also show its coefficient of performance (β) when the its working temperatures are the same as question (c) (3%)

(e) From the same Carnot power cycle in (c), if the ambient temperature is T_o =300*K*, please also find the second law efficiency (ε) from the availability point of view (5%).

3.(25%) By using T-S (temperature vs. entropy) and/or P-V (pressure vs. volume) diagrams, please explain the relations between thermal efficiency and the maximum pressure within an Otto cycle and a Brayton Cycle. Please also discuss the high-pressure restrictions for both cycles in practical power systems (reciprocating engine and gas turbine power plant).

4). (25%)

(a) The Helmholtz function of a gas is given as

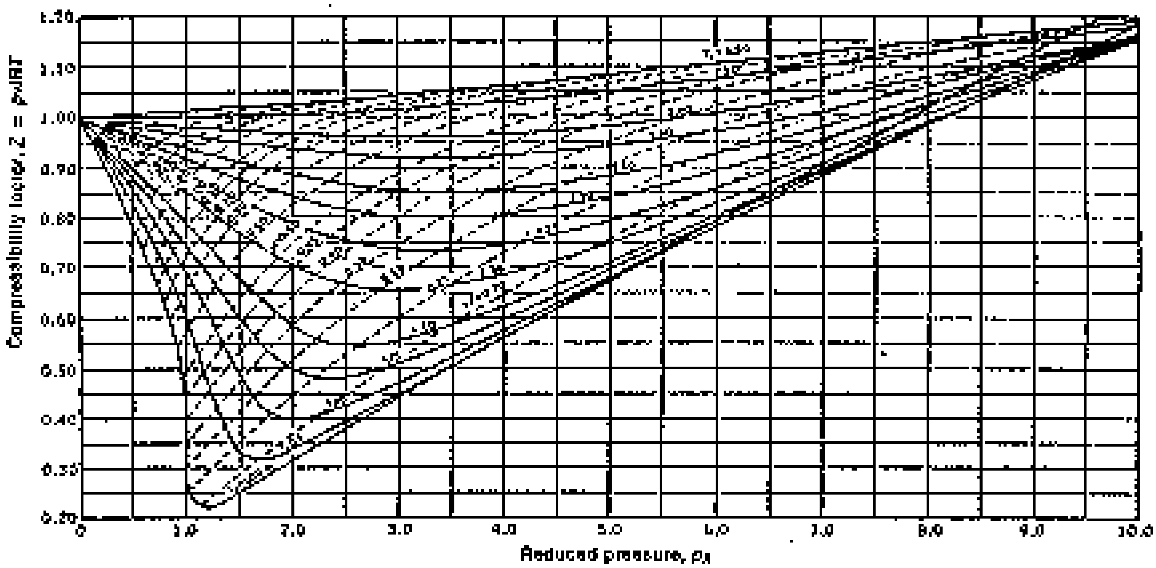
$\Phi(\rho,T)=\Phi_0(T)+RT[\ln\rho+\rho B(\rho)]$

Where Φ_0 is a known function of T and B is a known function of ρ.

Please find p and s (entropy) of this gas.

(b) CO_2 gas undergoes a process at constant p=200 atm from 310°K to 400°K.

Please find the work done for this process.



Atomic or Molecular Weights and Critical Propert
Common Elements and Compounds

Substance	Chemical formula	M	T_{cr}, K	P_{cr}, bars
Acetylene	C_2H_2	26.04	309	62.8
Air (equivalent)	—	28.97	133	37.7
Ammonia	NH_3	17.04	406	112.8
Argon	Ar	39.94	151	48.6
Carbon dioxide	CO_2	44.01	304	73.9
Carbon monoxide	CO	28.01	133	35.0
Nitrogen	N_2	28.01	126	33.9
Octane	C_8H_{18}	114.22	569	24.9
Oxygen	O_2	32.00	154	50.5

Ideal Gas Specific Heats of Some Common Gases (kJ/kg · K)

Temp. K	c_p	c_v	k	c_p	c_v	k	c_p	c_v	k
	Air			Carbon dioxide, CO_2			Oxygen, O_2		
250	1.003	0.716	1.401	0.791	0.602	1.314	0.913	0.653	1.398
300	1.005	0.718	1.400	0.846	0.657	1.288	0.918	0.658	1.395
350	1.008	0.721	1.398	0.895	0.706	1.268	0.928	0.668	1.389
400	1.013	0.726	1.395	0.939	0.750	1.252	0.941	0.681	1.382
450	1.020	0.733	1.391	0.978	0.790	1.239	0.956	0.696	1.373
500	1.029	0.742	1.387	1.014	0.825	1.229	0.972	0.712	1.365
550	1.040	0.753	1.381	1.046	0.857	1.220	0.988	0.728	1.358
600	1.051	0.764	1.376	1.075	0.886	1.213	1.003	0.743	1.350
650	1.063	0.776	1.370	1.102	0.913	1.207	1.017	0.758	1.343
700	1.075	0.788	1.364	1.126	0.937	1.202	1.031	0.771	1.337