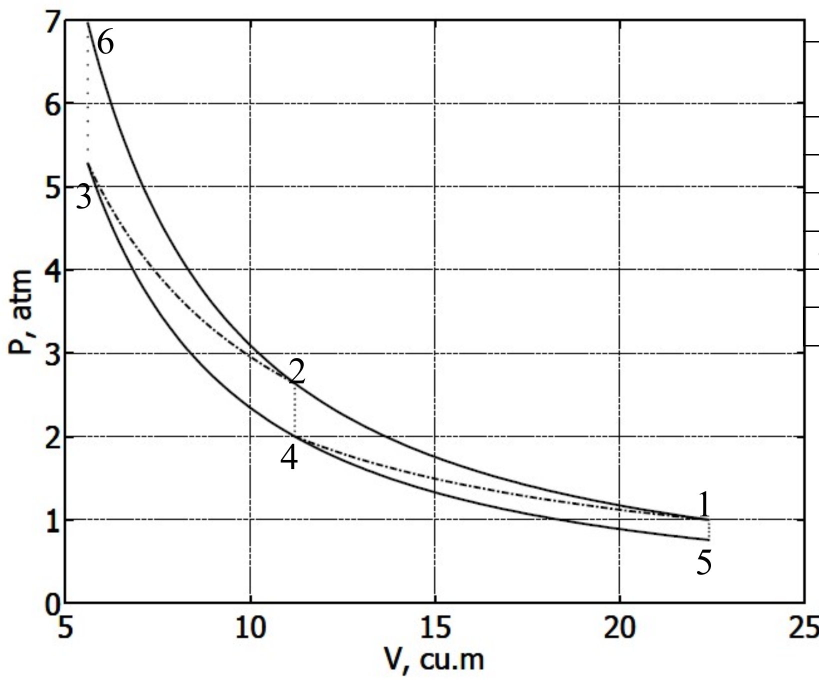
INDIAN INSTITUTE OF TECHNOLOGY, BOMBAY
Department of Metallurgical Engineering and Materials Science
MM 209: THERMODYNAMICS : 2019-20: Fall

Tutorial No. 3 **Date: Aug 23, 2019**

1. 1 kmol of a diatomic ideal gas ($C_p/C_v = 1.4$) undergoes a series of *reversible* processes going through states 3,2,1,4 and back to 3. For the four processes calculate the q, w, ΔE, ΔH and ∫(δq/T). Do similar calculations for the isochoric reversible processes from state 4 to state 2, and state 5 to state 1. The bold lines 1-2-6 and 5-4-3 are reversible adibatics; the dotted lines are reversible isotherms.

   Which answers will not be the same if the processes are not reversible? What can you conclude from this?



state	V, m^3	P, atm	T, K
1	22.42	1	273.2
2	11.21	2.64	360.4
3	5.60	5.28	360.4
4	11.21	2.00	273.2
5	22.42	0.76	207.0
6	5.60	6.98	476.3

Process	Type	q	w	ΔE	ΔH	∫(δq/T)
3→2	Isothermal.rev					
2→1	Adiabatic.rev					
1→4						
4→3						
4→5						
5→1						
4→2						

[Try this at home : If you reversibly expand the gas from 3 to 2 along a straight line path in the above diagram, calculate q, w, ΔE, ΔH and ∫(δq/T)]

2. 18.02 g of liquid water is enclosed under a frictionless weightless piston at 373.15K and 1atm pressure. The pressure above the piston is lowered slightly (infinitesimally) below 1 atm and the water is allowed to vaporize isothermally until no liquid is left. For this process, q=40671 Joule. Specific volume of water is 1.043 x $10^{-3}m^3/kg$ and that of steam is $1.677m^3/kg$ at 373.15K and 1atm. (This is the same problem as in Tut 1). Now however,

   a. Calculate ΔH and $\int(\delta q/T)$ for the process.

   b. We find that at 303.15 K, liquid water is in equilibrium with its vapour at a pressure of 4.25 kPa.
   Find ΔH and $\int(\delta q/T)$ for the reversible evaporation of water at 4.25 kPa pressure at 303.15 K into vapour at 303.15 K and 4.25kPa pressure.
   Cp, water = 4.186 J/g/K; Cp, water vapour = 1.706 J/g/K, independent of pressure. *(these are fictitious data)*

Assume that change in enthalpy in both water and the vapour due to isothermal change in pressure is negligible.

[HINT: expand both water and vapour 101.4 kPa to 4.25 kPa at 373.15 K and then cool them to 303.15 K].