

- A 1-L cylinder contains 5 moles of $H_2(g)$, what is the pressure inside the cylinder at $25^\circ C$ according to

 - the ideal gas law? (5%)
 - the van der Waals equation? ($a=0.2476 \text{ L}^2 \text{ bar mol}^{-2}$, $b=0.02661 \text{ L mol}^{-1}$) (6%)
- One mole of an ideal gas expands from 5 to 1 bar at 298 K. Calculate the work (w)

 - for a reversible expansion. (6%)
 - for an expansion against a constant pressure of 1 bar. (6%)
- Calculate the enthalpy of formation of $PCl_5(s)$, given the heats of the following reactions at $25^\circ C$: (8%)

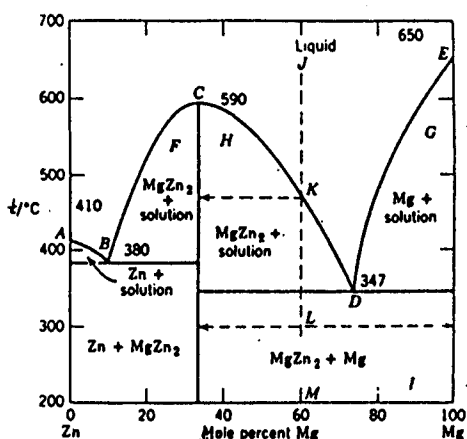
$$2 P(s) + 3 Cl_2(g) = 2 PCl_3(l) \quad \Delta_r H^\circ = -635.13 \text{ kJ mol}^{-1}$$

$$PCl_3(l) + Cl_2(g) = PCl_5(s) \quad \Delta_r H^\circ = -137.28 \text{ kJ mol}^{-1}$$
- What is the entropy of mixing of 0.5 mol of $O_2(g)$ with 0.5 mol of $N_2(g)$ at $25^\circ C$. (8%)
- One mole of an ideal gas at $27^\circ C$ expands isothermally and reversibly from 10 to 1 bar. Calculate ΔU , ΔH , ΔS , and ΔG . (12%)
- Given at 1393 K

$$Fe_2O_3(s) + 3 CO(g) = 2 Fe(s) + 3 CO_2(g) \quad K_1 = 0.0467$$

$$2 CO_2(g) = 2 CO(g) + O_2(g) \quad K_2 = 1.4 \times 10^{-12}$$

What is the equilibrium pressure of $O_2(g)$ in a vessel containing $Fe_2O_3(s)$ and $Fe(s)$ at equilibrium at 1393 K? (The standard state pressure is 1 bar.) (8%)
- Calculate the equilibrium pressure for the conversion of graphite ($d=2.25 \text{ g cm}^{-3}$) to diamond ($d=3.51 \text{ g cm}^{-3}$) at $25^\circ C$. ($\Delta G^\circ = 2900 \text{ J mol}^{-1}$, $(\partial \Delta G / \partial P)_T = \Delta V$) (8%)
- Given the temperature-composition diagram for the Zn-Mg system. Describe what happens when the solution at point J is cooled down to $200^\circ C$ as indicated by the vertical line. (12%)



- Write the atomic orbital (AO) ψ_{1s} for hydrogen atom;
 - draw the curve ψ_{1s} vs. the coordinate r (the distance of electron to nucleus);
 - write the molecular orbital for linear combination of AO (LCAO-MO) $\psi(\sigma_{g1s})$ for H_2^+ ion;
 - draw the curve $\psi(\sigma_{g1s})$ vs. the coordinate R (the internuclear distance);
 - write the probability density for ψ_{1s} . (15%)
- For the AO ψ_{2p_z} of hydrogen atom (6%)

 - what are its quantum numbers?
 - draw the picture to show its electron distribution.