1. For van der Waals equation,

a) Please write van der Waals equation (3 %)

b) Please find the critical point (T_c, p_c, v_c) (9 %)

c) Assume $T_r = {}^{T}/_{T_c}, p_r = {}^{p}/_{p_c}, v_r = {}^{v}/_{v_c}$, please show that van der Waals equation can be written as $\left(p_r + \frac{3}{v_r{}^2}\right)\left(v_r - \frac{1}{3}\right) = \frac{8}{3}T_r$ (8 %)

2. For ideal gas is under a reversible and adiabatic process, please prove pV^{γ} =constant. $(\gamma = C_p/C_v)$ (10 %)

3. At 27 ^{0}C, one mole ideal gas is under reversible expansion from 1 liter to 1.5 liter isothermally. Calculate the work generated during this process. (10 %) (ln1.5 = 0.4055)

4. One liter of a 0.1 M solution of a substance A is added to two liters of a 0.05 M solution of a substance B. Assume ideal behavior of mixing, please calculate the entropy of mixing. (10 %) (ln 3 = 1.0986; ln 1.5 = 0.4055)

5. Please derive following equations (F: Helmholtz free energy, G: Gibbs free energy)

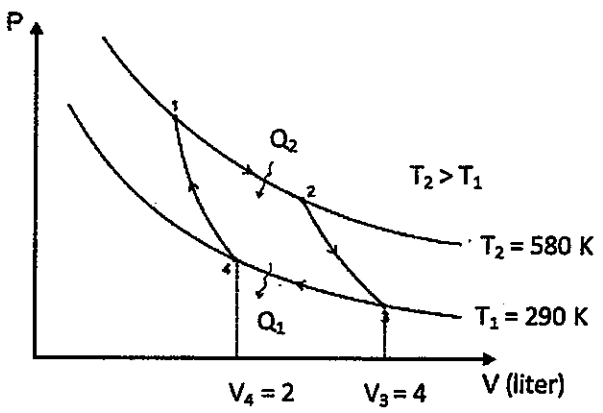
a) $d\left(\frac{F}{T}\right) = -\frac{U}{T^2}dT - \frac{P}{T}dV$ (5 %)　　b) $d\left(\frac{G}{T}\right) = -\frac{H}{T^2}dT - \frac{V}{T}dP$ (5 %)

c) $U = -T^2\left(\frac{\partial}{\partial T}\left(\frac{F}{T}\right)\right)_v$ (5 %)　　d) $H = -T^2\left(\frac{\partial}{\partial T}\left(\frac{G}{T}\right)\right)_p$ (5 %)

6. One mole ideal gas is under the process (Carnot cycle) as shown in the figure.

a) Please calculate the efficiency, η, of this cycle. (5 %)

b) Please calculate the maximum work can be produced in one cycle. (10 %) (ln 2 = 0.69315)



7. In a reaction taking place in the body at 37°C, the change in enthalpy was -125 kJ mol^{-1} and the change in entropy was -126 J K^{-1} mol^{-1}.

a) Calculate the change in Gibbs energy. (5 %)

b) Calculate the total change in entropy of the system and the surroundings. (5 %)

8. The enthalpy of the phase transition from graphite to diamond which under 100 kbar occurs at 2000 K is 1.9 kJ mol^{-1}. Calculate the entropy of transition at that temperature. (5%)

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