1.) The density of water vapor at 327.6 atm and 776.4 K = 1.332 x 10^2 g/L. The Van der Waals constants for water are: a = 5.536 atm L^2/mol^2, b = 0.03049 L/mol and the molecular weight = 18.02. Calculate the

(4) a.) the molar volume

(4) b.) Using the answer in a.) find the compressibility factor for water at the above condition.

(7) c.) Find the compressibility factor for water at the above condition from the Van der Waals equation expressed as a virial equation. Hint: Z = 1 + (b-a/RT)/V + (b/V)^2, where V is the molar volume.

2.) 65 g of Xenon (atomic mass = 131.3) is placed into a container at 2.00 atm and 298 K. The gas is allowed to expand adiabatically to 1 atm. Calculate the final temperature if the expansion was

(10) a.) reversible

(10) b.) irreversible against a constant pressure of 1 atm.
3.) By considering $S=S(T,P)$ one may derive the expression $dS = (C_p/T)dT - V^"dP$. Starting with this expression prove that $(M_S/M_V)V = \frac{6C_v}{T}$. Hint: remember that $C_p - C_v = TV^"/6$.

4a.) Find the value of $(M_S/M_V)_T$ for a Van der Waals gas, and from this find the value for the entropy change of for the isothermal expansion of 1 mole of a gas from $V_1$ to $V_2$.

b.) Will the increase in entropy be greater or less than for an ideal gas?

5.) Supercooled liquid water at -5 °C has vapor pressure of 421.7 Pa, while ice at -5 °C has a vapor pressure of 401.7 Pa. Devise a reversible path to convert liquid water at -5 °C to ice at -5 °C, and calculate the value of $G$ for the conversion of 10.0 g of water to ice at this temperature. You may take the Molecular weight of water to be 18.0.
(10) 6.) Given the following standard reduction potentials:
\[ \text{Ce}^{3+} + 3 \text{e}^- \rightarrow \text{Ce} \quad E^0 = -2.48 \text{V} \]
\[ \text{Ce}^{4+} + \text{e}^- \rightarrow \text{Ce}^{3+} \quad E^0 = 1.61 \text{V} \]
Find the reduction potential for
\[ \text{Ce}^{4+} + 4 \text{e}^- \rightarrow \text{Ce} \]

(15) 7.) Na and K melt at 98 °C and 65 °C respectively. They form a solid compound NaK that decomposes at 20 °C to a solid, and a melt containing 60 mole % K. There is a eutectic point at -5 °C. Sketch a phase diagram consistent with this data, and indicate what material is present in each region.

Describe what will happen if you cool a liquid having a composition of 45 mole % Na from a temperature of 50 °C to a temperature of -10 °C.
Liquids A and B form an ideal solution. The vapor pressure of pure A = 300 torr, and that of pure B = 100 torr. The vapor in equilibrium with a certain liquid mixture has a mole fraction of A = 0.5. Find the mole fraction of A in the liquid and the total vapor pressure.

For a reaction that is n-th order in one reactant only we derived the following integrated equation for the concentration of A as a function of time:
\[
\frac{1}{[A]_t^n} - \frac{1}{[A]_0^n} = (n-1)kt
\]
Find the half life for such a reaction.

Take the logarithm of the expression for the half life and show that
\[
\frac{\Delta \log t_{1/2}}{\Delta \log [A_0]} = -(n-1)
\]

At a given temperature, the half life for the decomposition of acetaldehyde equals 410 sec, when the initial pressure is 363 torr, but it increases to 880 second when the initial pressure is 169 torr. Find the order for this decomposition.
The formation of phosgene, COCl₂, by the reaction CO + Cl₂ → COCl₂ follows the following mechanism:

\[
\begin{align*}
  & \text{Cl}_2 \rightleftharpoons 2\text{Cl} & \quad k_1 \\
  & \text{Cl} + \text{CO} \rightleftharpoons \text{COCl} & \quad k_2 \\
  & \text{COCl} + \text{Cl}_2 \rightarrow \text{COCl}_2 + \text{Cl}. & \quad k_3
\end{align*}
\]

Apply the steady state approximation to Cl and COCl and find an expression for the rate of formation of COCl₂.