1. The normal boiling temperature of ethanol is equal to 78.5°C and the molar enthalpy change of vaporization is equal to 40.5 kJ mol⁻¹. Estimate the vapor pressure of enthanol at 100°C. (5 pts.)

2. Estimate the pressure on a system of liquid and solid water if the equilibrium melting temperature is equal to −0.1°C. The density of ice is 0.917 g/cm³, the density of liquid water is 1 g/cm³, and the molar enthalpy change of fusion is 6008 J/mol. (5 pts.)

3. Calculate the Gibbs energy change of mixing and the entropy change of mixing for a solution of 1 mol of benzene and 2 mol of toluene at 25°C. Assume the solution to be ideal. (5 pts.)

4. Find the freezing point depression of a solution of 10 g of sucrose (molecular weight = 342.3 g/mol) in 1 kg of water. The value of the freezing point depression constant for water is equal to 1.86 K kg mol⁻¹. (5 pts.)

5. Find the osmotic pressure of a solution of 5 g of glucose (molecular weight = 180 g/mol) in enough water to make 1 liter of solution. Assume the van't Hoff equation is applicable. (5 pts.)

6. At 60°C, the vapor pressure of pure benzene and toluene are 0.513 and 0.185 bar, respectively. What are the equations of the bubble point line and the dew point line? (5 pts.) For a solution with 0.6 mol fraction toluene, what is the mole fraction of toluene in the equilibrium vapor phase at 60°C. (5 pts.)

7. A sample of oxygen gas (assumed to be ideal) is collected over water at 25°C at a total pressure of 748.5 torr, with a partial pressure of water vapor equal to 23.8 torr. If the volume of the collected gas is equal to 0.454 L liter, find the mass of the oxygen. (5 pts.) If the oxygen was produced by the decomposition of KClO₃ (molecular weight = 122.55 g/mol), find the mass of KClO₃. (5 pts.)

8. A sample of a gas is compressed from a volume of 5 L to a volume 1 L at a constant external pressure of 1 atm. Calculate the work done on the system. (5 pts.)

9. Calculate the efficiency of a Carnot heat engine that represents a steam engine with its boiler at 300°C and its exhaust at 100°C. (5 pts.)

10. Find $\Delta S$ (entropy change) if 1 mol of argon (assumed to be ideal) is expanded reversibly and isothermally from a volume of 50 L to a volume of 250 L at 25°C. (5 pts.)

11. Find the entropy change of mixing of 1 mol of dry air. Assume that it is composed of 0.78 mol of nitrogen, 0.21 mol of oxygen, and 0.01 mol of argon. (5 pts.)

12. Find the volume of the solution by mixing of 1 mol of water and 1 mol of ethanol at 25°C. The molar volume of the pure substances are $V(\text{water}) = 18.02 \text{ cm}^3/\text{mol}$, $V(\text{ethanol}) = 58.4 \text{ cm}^3/\text{mol}$. The partial molar volumes of ethanol and water at this composition are 57.6 cm³/mol and 16.7 cm³/mol respectively. (5 pts.)

13. Consider the reaction $\text{N}_2\text{O}_5(g) \leftrightarrow 2\text{NO}_2(g)$. Calculate the value of $K$ (equilibrium constant) at 25°C. The value of $\Delta G^\circ$ (standard-state Gibbs energy change) may be considered as 4.729 kJ/mol at this temperature. (5 pts.)
14. Assuming that $\Delta H^\circ (=57 \text{ kJ/mol})$ is temperature independent, estimate the value of the equilibrium constant $K$ at 100°C for a gas phase reaction. The value of the equilibrium constant $K$ at 25°C is equal to 0.148 for this gas phase reaction. (5 pts.)

15. Given the following calorimetric information, calculate the standard Gibbs energy of formation ($\Delta G^\circ$) of $\text{H}_2\text{O(g)}$ at 298.15K. (5 pts.)

<table>
<thead>
<tr>
<th>Substance</th>
<th>$\Delta H^\circ / \text{kJmol}^{-1}$</th>
<th>$S^\circ / \text{JK}^{-1}\text{mol}^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{H}_2\text{O(g)}$</td>
<td>-241.82</td>
<td>188.83</td>
</tr>
<tr>
<td>$\text{H}_2(g)$</td>
<td>0</td>
<td>130.69</td>
</tr>
<tr>
<td>$\text{O}_2(g)$</td>
<td>0</td>
<td>205.14</td>
</tr>
</tbody>
</table>

16. A hypothetical zero-order reaction has a rate constant equal to 0.015 (mol L$^{-1}$s$^{-1}$) at a certain temperature. If the initial concentration of the single reactant is 1 (mol L$^{-1}$), find the concentration after a reaction time of 5 (s) and the time required for all of the reactant to react at this temperature. (10 pts.)

17. Estimate the value of the activation energy if a rate constant doubles in value between 20°C and 30°C. (5 pts.)