Part A.

1. (10%) Consider an equilibrium system which consists of two phases, for example, \( \text{H}_2\text{O(l)} \leftrightarrow \text{H}_2\text{O(g)} \). If there is only water vapor in the gas phase, then the vapor pressure of water is equal to 24 torr at 298.15 K. Now, let enough air is present in the gas phase, and the total pressure of air and water vapor is 1 atm (1 atm = 760 torr). Please neglect the solubility of air in liquid water, and calculate the vapor pressure of water if the temperature is still fixed at 298.15 K.

2. (10%) Consider the active transport of Na\(^+\) ions in most animal cells. The concentration of Na\(^+\) is 10 mM inside the cell membrane, and it is 140 mM outside the cell membrane. If the electric potential inside the cell membrane is 70 mV lower than that outside the cell membrane, please calculate the energy necessary for transporting 1 mole Na\(^+\) ions out of the cell. (T = 310 K)

3. (10%) According to the transition-state theory, please write down the relation between the rate constant and the free energy of activation.

4. (10%) For the 1s orbital of the hydrogen atom, \( \psi_{1s} = \frac{1}{\sqrt{\pi}} \frac{1}{a} e^{-r/a} \) where \( a \) is the Bohr radius. Calculate the probability of finding the electron within the Bohr radius from the nucleus.

5. (10%) Explain why the first ionization energy of Be is larger than that of B.
Part B.

1. (30%) (a) Define the physical properties—(1) viscosity, (2) osmosis, (3) heat of combustion.
   (b) Describe experimental methods for measuring these properties (including devices, instruments or any related technique).
   (c) Give an example for the application of these properties in chemistry.

<table>
<thead>
<tr>
<th>Properties</th>
<th>(a) Definition</th>
<th>(b) Methods</th>
<th>(c) Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Viscosity</td>
<td></td>
<td></td>
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<tr>
<td>(2) Osmosis</td>
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<td></td>
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<tr>
<td>(3) Heat of combustion</td>
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</table>

2. (10%) Fluorescence quenching by KI is a powerful tool for investigation accessibility of molecular probe, such as carboxyfluorescein. The relation between fluorescent intensity of the probe and the KI concentration is expressed as Stern-Volmer equation.

\[ \frac{F_0}{F} = 1 + K_{sv} [KI] \]

Where \( F_0 \) is the fluorescence of probe sample without quencher. \( F \) is the fluorescence of probe sample in the presence of quencher. \([KI]\) is the concentration of quencher KI. \( K_{sv} \) is called Stern-Volmer constant. Use the following experimental data to determine the Stern-Volmer constant \((K_{sv})\) of carboxyfluorescein in the presence of quencher KI.

<table>
<thead>
<tr>
<th>[KI] (mM)</th>
<th>0</th>
<th>40</th>
<th>80</th>
<th>120</th>
<th>160</th>
</tr>
</thead>
<tbody>
<tr>
<td>( F ) (intensity)</td>
<td>12.448</td>
<td>8.813</td>
<td>6.566</td>
<td>4.962</td>
<td>4.124</td>
</tr>
</tbody>
</table>
3. (10%) (a) How to identify zero order and first order reactions.

(b) The rate of a reaction was measured over the temperature range 300-500 K and the rate constants that were recorded below. Find the activation energy of this reaction.

\[
\begin{array}{|c|c|c|c|c|c|}
\hline
T (K) & 300 & 350 & 400 & 450 & 500 \\
\hline
k (L/mol s) & 7.9 \times 10^6 & 3.0 \times \times 10^7 & 7.8 \times 10^7 & 1.6 \times 10^8 & 3.2 \times 10^8 \\
\hline
\end{array}
\]