1. (5 pts) The molecular weight of a biological molecule is $1.2 \times 10^5$. What will be the osmotic pressure (mm Hg) of a solution of 30.0 g of this compound in 1,700 mL of benzene at 40.0°C. Assume no change in volume of the solvent upon addition of the solute.

$$
\frac{P}{T} = \frac{nRT}{V} = \frac{(30.0 \text{ g})(1.2 \times 10^5 \text{ g/mole})(0.0821 \text{ L atm/mol K})(313 \text{ K})}{1700 \text{ L}} = 3.78 \times 10^{-3} \text{ atm}
$$

$$
= 2.87 \text{ mm Hg}
$$

2. (4 pts) Write four valid expressions for the rate of the following reaction. Don’t forget the appropriate multiplier and sign for each. $4 \text{NH}_3 + 7 \text{O}_2 \rightarrow 4 \text{NO}_2 + 6 \text{H}_2\text{O}$

$$
\text{Rate} = -\frac{\Delta \text{[NH}_3]}{\Delta t} = \frac{\Delta \text{[O}_2]}{\Delta t} = \frac{\Delta \text{[NO}_2]}{\Delta t} = \frac{\Delta \text{[H}_2\text{O}]}{\Delta t}
$$

3. (6 pts) Consider the data given for the rate of disappearance of NO in the reaction $2 \text{NO(g)} + \text{O}_2 \rightarrow 2\text{NO}_2\text{(g)}$.

   a) What is the rate law for this reaction?

   $$\text{SEE 14.23}$$

   b) What is the average value of the rate constant calculated from the three data sets?

<table>
<thead>
<tr>
<th>Experiment</th>
<th>[NO] (M)</th>
<th>[O] (M)</th>
<th>Initial Rate (M/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0126</td>
<td>0.0125</td>
<td>$1.41 \times 10^{-2}$</td>
</tr>
<tr>
<td>2</td>
<td>0.0252</td>
<td>0.0250</td>
<td>$1.13 \times 10^{-1}$</td>
</tr>
<tr>
<td>3</td>
<td>0.0252</td>
<td>0.0125</td>
<td>$5.64 \times 10^{-2}$</td>
</tr>
</tbody>
</table>

4. (5 pts) Cobalt-60, $^{60}\text{Co}$, is a radioactive isotope which gives primarily high-energy gamma radiation useful for treatment of certain cancers in a process called teletherapy. This radioactive decay follows first order kinetics with a half life of 5.24 years. It is imperative the operator know exactly how much cobalt-60 is present at the time of treatment. If a hospital purchased 20.0 grams of cobalt-60 on January 1, 1997, how much would be present on January 1, 2005? Keep in mind the results of your calculation could lead to an effective treatment of the cancer, no effective treatment, or unnecessary exposure to a deadly level of radiation.

$$
\frac{1}{2} = \frac{0.693}{k} \Rightarrow k = \frac{0.693}{5.24 \text{ yr}} = 0.132 \text{ yr}^{-1}
$$

$$
\ln \frac{\text{Initial}}{\text{Final}} = -kt, \text{ assume const vol = } \ln \text{ Final} = \ln (20.0) - (0.132 \text{ yr}^{-1})(8 \text{ yr})
$$

$$
\ln x = 1.9440
$$

$$
\Rightarrow x = 6.96 \text{ g}
$$
1. (3 pts) After swimming in the ocean for several hours, swimmers noticed that their fingers appeared to be very wrinkled. How would you account for this in terms of colligative properties?

   The osmotic pressure of sea water is greater than biological systems, leading to an extraction of water from the skin.

2. (6 pts) The rapid reaction, \( \text{OCl}^- + \text{I}^- \rightarrow \text{OI}^- + \text{Cl}^- \),
gives the following initial rate data.

<table>
<thead>
<tr>
<th>Exp #</th>
<th>[OCl(^-)]</th>
<th>[I(^-)]</th>
<th>ini. rate M/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0015</td>
<td>0.0015</td>
<td>1.36 x 10(^4)</td>
</tr>
<tr>
<td>2</td>
<td>0.0030</td>
<td>0.0015</td>
<td>2.72 x 10(^4)</td>
</tr>
<tr>
<td>3</td>
<td>0.0015</td>
<td>0.0030</td>
<td>2.72 x 10(^4)</td>
</tr>
</tbody>
</table>

   a) Write the rate law for this reaction.

   b) Calculate the rate constant.

   c) Calculate the rate when \([\text{OCl}^-] = 1.0 \times 10^{-3} \text{ M}\) and \([\text{I}^-] = 5.0 \times 10^{-4} \text{ M}\).

3. (7 pts) The decomposition of \( \text{NO}_2 \) proceeds as follows: \( \text{NO}_2 \rightarrow \text{NO} + \frac{1}{2} \text{O}_2 \). The rate law is second order in \( \text{NO}_2 \), with a rate constant of 0.543 \( \text{M}^{-1} \text{s}^{-1} \) at 300 °C.

   \[ \frac{1}{[\text{NO}_2]} = \frac{1}{[\text{NO}_2]_0} + kt \]

   a) If the initial concentration of \( \text{NO}_2 \) is 0.260 M, how long will it take for the concentration to drop to 0.100 M?

   \[ \frac{1}{0.100} - \frac{1}{0.260} = (0.543 \text{ M}\text{s}^{-1}) t \Rightarrow t = \frac{6.15 \text{ M}^{-1}}{0.543 \text{ M}\text{s}^{-1}} = 11.35 \text{ s} \]

   b) What is the half life of the reaction when the initial concentration is 0.260 M?

   \[ t_{1/2} = \frac{1}{k[\text{NO}_2]_0} = \frac{1}{(0.543 \text{ M}^{-1} \text{s}^{-1})(0.260 \text{ M})} \approx 7.085 \text{ s} \]

4. (4 pts) Strontium-90, \(^{90}\text{Sr}\), is a radioactive element which decays by emitting a \( \beta \)-particle. It is a first order process with a half-life of 28.8 years. Contamination of the environment with this isotope poses serious health hazards because of its persistence and similarity in the body to calcium makes it a particularly difficult contaminant. If a sample of grass and hay initially contains a total of 100.0 g of \(^{90}\text{Sr}\), how much will still be present after a period of 100.0 years?

   \[ t_{1/2} = \frac{0.693}{k} \Rightarrow k = \frac{0.693}{28.8 \text{ yr}} = 0.0241 \text{ yr}^{-1} \]

   \[ \ln [A]_t = \ln [A]_0 - kt, \text{ assume constant} \]

   \[ \ln [x]_t = \ln (100.0) - (0.0241 \text{ yr}^{-1} \times 100.0 \text{ yr}) = 46.1 - 2.41 = 43.69 \]

   \[ x = 3.98 \text{ g} \]