Questions 1-10 compare two quantities. For the following pairs, select A if the item in column A is larger, B if the item in column B is larger, C if they are equal, or D if you cannot tell from the information provided. (2 points each.)

**Which is greater?**

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 0.08206 L·atm/(mole·K)</td>
<td>0.00831 kJ/(mole·K)</td>
</tr>
<tr>
<td>2. Amount of water added to make a 3 m solution starting with 100 g of a given substance</td>
<td>Amount of water added to make a 3 M solution with 100 g of the same substance</td>
</tr>
<tr>
<td>3. Surface tension of water</td>
<td>Surface tension of water with soap added</td>
</tr>
<tr>
<td>4. Vapor Pressure of water at 100 °C</td>
<td>Vapor Pressure of automobile antifreeze at 100 °C</td>
</tr>
<tr>
<td>5. Boiling Point of an ideal solution containing 1.5 m NaBr</td>
<td>Boiling Point of an ideal solution containing 1.0 m CaF₂</td>
</tr>
<tr>
<td>6. Boiling Point of water at sea level</td>
<td>Boiling Point of water at 10000 feet altitude</td>
</tr>
<tr>
<td>7. Rate of an uncatalyzed reaction</td>
<td>Rate of the same reaction with catalyst</td>
</tr>
<tr>
<td>8. A temperature measured in Kelvin</td>
<td>The same temperature measured in °C</td>
</tr>
<tr>
<td>9. The overall reaction order of the reaction 2A → B + C</td>
<td>1</td>
</tr>
<tr>
<td>10. Size of an egg (with the shell removed) in a 2 M sucrose solution</td>
<td>Size of the same egg in pure water</td>
</tr>
</tbody>
</table>
Questions 11 to 13 refer to the following solution:

50.0 grams of glycerol (HOCH₂CHOHCHOH₂OH, molecular weight 92.09 g/mole) are added to 0.250 kg of water. This solution has a final volume of 285 mL.

11. (2 points) Calculate the molarity of the solution.
   a. 2.17
   b. 1.91
   c. 0.962
   d. 0.167
   e. 0.0376

12. (2 points) Calculate the mole fraction of glycerol in the solution.
   a. 2.17
   b. 1.91
   c. 0.962
   d. 0.167
   e. 0.0376

13. (2 points) Calculate the molality of the solution.
   a. 2.17
   b. 1.91
   c. 0.962
   d. 0.167
   e. 0.0376

14. (4 points) What are the units of rate constant for a 2nd order reaction?
   a. M sec⁻¹
   b. sec⁻¹
   c. M¹ sec⁻¹
   d. M² sec⁻¹
   e. Cannot tell from the information provided

15. (4 points) How do you make a 0.250 m solution using 92.1 g of MgBr₂?
   a. Add 2.00 kg water
   b. Add 250 g water
   c. Add water to a final volume of 2.00 L
   d. Add water to a final volume of 250 mL
   e. None of the above
16. (4 points) From the following phase diagram, if we start at point A and change the pressure to 100 mm Hg, which of the following statements is true:

1. The sample starts as a solid and ends as a gas. ✔
2. The sample is above the critical point temperature. ✗
3. The sample undergoes two phase changes.

- a. 1 and 2 are true
- b. 2 and 3 are true
- c. 1 and 3 are true
- d. 1, 2, and 3 are true
- e. None of a-d above

17. (4 points) Rank the following compounds in the order of increasing boiling point:

CH₃-CH₂-CH₃, H₂O, O₂, NaCl

- a. O₂ < H₂O < NaCl < CH₃-CH₂-CH₃
- b. O₂ < CH₃-CH₂-CH₃ < H₂O < NaCl
- c. O₂ < H₂O < CH₃-CH₂-CH₃ < NaCl
- d. CH₃-CH₂-CH₃ < O₂ < H₂O < NaCl
- e. H₂O < O₂ < CH₃-CH₂-CH₃ < NaCl

18. (4 points) If 75 kJ of heat is added to 36.0 g of water at 100 °C, what is the final state of the water?

- a. Gas only
- b. Mixture of liquid and gas
- c. Liquid only
- d. None of the above
- e. Cannot determine the final state

We are adding less heat, so some liquid remains.
19. (6 points) 300 g of an unknown material is used to make 2.00 L of a solution. The osmotic pressure of the solution is measured as 20.0 atm at room temperature. What is the molecular weight of the unknown?

\[ \frac{P}{c} = cRT \Rightarrow c = \frac{P}{RT} = \frac{20 \text{ atm}}{(0.68206 \text{ atm mole}^{-1}) (278 \text{ K})} \]

\[ = 0.818 \text{ mol/L} \]

\[ 0.818 \text{ mol/L} \times 2.00 \text{ L} = 1.636 \text{ mol} \]

\[ \frac{300 \text{ g}}{1.636 \text{ mol}} = 183.9 \text{ g/mol} \]

20. (6 points) If an individual registers a blood alcohol level of 0.0267 M (or 0.16% by volume), what will this person’s blood alcohol level be 4 hours later if the rate constant for the oxidation of ethanol in the liver is 0.00425 M/hour?

\[ \begin{aligned} A_0 &= A + kT \\ A &= A_0 - kT \\ &= 0.0267 \text{ M} - (0.00425 \text{ M/hr})(4 \text{ hr}) \\ &= 0.0097 \text{ M} \end{aligned} \]

21. (6 points) A liquid has a vapor pressure of 125 mm Hg at 400 K and a vapor pressure of 313 mm Hg at 500 K. Calculate the molar heat of vaporization of this liquid.

\[ \frac{P_2}{P_1} = \exp \left( \frac{\Delta H}{RT} \right) \]

\[ \Delta H = R \left( \frac{\ln \left( \frac{P_2}{P_1} \right)}{\frac{1}{T_1} - \frac{1}{T_2}} \right) \]

\[ = \left( 8.31 \text{ J/mole K} \right) \left( \frac{313}{125} \right) \]

\[ = 15.255 \text{ J/mole} \]

\[ = 15.25 \text{ kJ/mol} \]
22. (6 points) If 300. g of CaCl₂ are added to 0.500 kg of water so that the final volume of the solution is 625. mL, what is the vapor pressure of the solution at 40°C if the vapor pressure of water is 55.3 mm Hg?
   a. 51.3 mm Hg
   b. 50.4 mm Hg
   c. 34.6 mm Hg
   d. 4.90 mm Hg
   e. None of the above

23. (6 points) What is the boiling point of the above CaCl₂ solution? (Assume that it is an ideal solution.)
   a. 108.30 °C
   b. 106.64 °C
   c. 102.77 °C
   d. 91.7 °C
   e. 8.30 °C

24. (6 points) The following data were measured for the reaction
   \[ 2 \text{Cl}_2 \text{O}_7 \text{(aq)} + 2 \text{OH}^- \text{(aq)} \rightarrow \text{ClO}_5^- \text{(aq)} + \text{ClO}_2^- \text{(aq)} + \text{H}_2\text{O} \text{(l)} \]

<table>
<thead>
<tr>
<th>Experiment</th>
<th>[ClO₂⁻]</th>
<th>[OH⁻]</th>
<th>Initial rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.060 M</td>
<td>0.030 M</td>
<td>2.48 x 10⁻³ M/sec</td>
</tr>
<tr>
<td>2</td>
<td>0.060 M</td>
<td>0.060 M</td>
<td>2.76 x 10⁻³ M/sec</td>
</tr>
<tr>
<td>3</td>
<td>0.020 M</td>
<td>0.090 M</td>
<td>8.28 x 10⁻³ M/sec</td>
</tr>
<tr>
<td>4</td>
<td>0.100 M</td>
<td>0.025 M</td>
<td>??</td>
</tr>
</tbody>
</table>

What is the initial rate of reaction 4?
   a. 2.30 x 10⁻² M/sec
   b. 5.74 x 10⁻² M/sec
   c. 3.43 x 10⁻² M/sec
   d. 2.87 x 10⁻² M/sec
   e. None of the above
25. (6 points) How much N\textsubscript{2} dissolves in a SCUBA diver who dives to 20 meters (66 ft)? Assume the diver has 40 L of fluids and that the N\textsubscript{2} pressure on her at this depth is 2.32 atm.

\begin{align*}
S_g &= k_y P_g \\
&= (8.42 \times 10^{-7} \text{M/mm Hg}) \times (2.32 \text{ atm}) \times \left( \frac{760 \text{ mm Hg}}{1 \text{ atm}} \right) \\
&= 0.00148 \text{ M} \\
0.00148 \text{ moles} &\times 40 \text{ L} \times \frac{28 \text{ g N}_2}{\text{ mole N}_2} = 1.16 \text{ g N}_2
\end{align*}

26. (6 points) If the half life of \textsuperscript{14}C is 5760 years, how long will it take for 98% of the 0.625 g of \textsuperscript{14}C in a geological sample to disappear?

\begin{align*}
\frac{1}{2} &= \frac{0.625 \text{ g}}{k} \\
k &= \frac{0.625 \text{ g}}{5760 \text{ g year}} = 1.08 \times 10^{-7} \text{ year}^{-1} \\
-\ln \frac{A_0}{A} &= -k \tau \\
\tau &= \frac{-\ln \left( \frac{0.02}{1} \right)}{0.643 \times 10^{-7} \text{ year}^{-1}} \\
&= 32500 \text{ years}
\end{align*}

27. (6 points) How many grams of NaCl do you need to add to 6.00 kg of water to make a solution that freezes at -10 °C? (Assume the solution is ideal.)

\begin{align*}
\Delta T &= \frac{k \cdot m \cdot i}{K \cdot i} \\
-10^\circ C &= \frac{1.86^\circ C / \text{m}}{2.09 \text{ m NaCl} \cdot \text{m H}_2\text{O}^*} \cdot 2 \text{ m H}_2\text{O} \times 6 \text{ kg H}_2\text{O} \\
&= 2.69 \text{ m moles NaCl} \times 6 \text{ kg H}_2\text{O} = 16.13 \text{ m moles NaCl} \\
16.13 \text{ m moles NaCl} \times 58.44 \text{ g NaCl/mole} &= 943 \text{ g NaCl}
\end{align*}