1) What are the values on this graph for temperature and pressure at STP? \( T = \) \( 0^\circ C \) , \( P = 1.00 \text{ atm} \)

2) The **normal freezing point** of a substance is the temperature at which a substance changes from a liquid to a solid at standard pressure. What is the normal freezing point of this substance? \( 100^\circ C \)

3) The **normal boiling point** of a substance is the temperature at which a substance changes from a liquid to a gas at standard pressure. What is the normal boiling point of this substance? \( 330^\circ C \)

4) The **normal melting point** of a substance is the temperature at which a substance changes from a solid to a liquid at standard pressure. What is the normal melting point of this substance? \( 100^\circ C \)

5) What is the phase (s, l, g) of a substance at 2.0 atm and 100 \(^\circ\) C? \( g \)

6) What is the phase (s, l, g) of a substance at 0.75 atm and 100 \(^\circ\) C? \( l \)

7) What is the phase (s, l, g) of a substance at 0.5 atm and 100 \(^\circ\) C? \( g \)

8) What is the phase (s, l, g) of a substance at 1.5 atm and 50 \(^\circ\) C? \( s \)

9) What is the phase (s, l, g) of a substance at 1.5 atm and 200 \(^\circ\) C? \( l \)

10) What is the phase (s, l, g) of a substance at 1.5 atm and 800 \(^\circ\) C? \( g \)

11) What are the conditions of the triple point of this substance? \( T = 80^\circ C \) \( P = 0.00 \text{ atm} \)

12) If a quantity of this substance was at an initial pressure of 1.25 atm and a temperature of 300 \(^\circ\) C, and was then lowered to a pressure of 0.25 atm, what phase transition(s) would occur? **Vaporization (l→g)**

13) If a quantity of this substance was at an initial pressure of 1.25 atm and a temperature of 0 \(^\circ\) C, and was then lowered to a pressure of 0.25 atm, what phase transition(s) would occur? **Sublimation (s→g)**

14) If a quantity of this substance was at a pressure of 1.0 atm and an initial temperature of 200 \(^\circ\) C, and was then lowered to a temperature of -200 \(^\circ\) C, what phase transition(s) would occur? **Freezing (l→s)**

15) If a quantity of this substance was at a pressure of 0.5 atm and an initial temperature of 200 \(^\circ\) C, and was then lowered to a temperature of -200 \(^\circ\) C, what phase transition(s) would occur? **Deposition (g→s)**

16) If this substance was at a pressure of 2.0 atm, at what temperature would it melt? \( 180^\circ C \)

17) If this substance was at a pressure of 2.0 atm, at what temperature would it boil? \( 810^\circ C \)

18) If this substance was at a pressure of 0.75 atm, at what temperature would it melt? \( 90^\circ C \)

19) If this substance was at a pressure of 0.75 atm, at what temperature would it boil? \( 150^\circ C \)

20) At what temperature do the gas and liquid phases become indistinguishable from each other? \( 810^\circ C \)

21) At what conditions would it be possible to find this substance in the gas, liquid, and solid phase?

\[ P = 0.65 \text{ atm} \quad T = 90^\circ C \]

22) If I had an amount of this substance at a pressure of 1.00 atm and a temperature of -100 \(^\circ\) C, what phase change(s) would occur if I increased the temperature to 600 \(^\circ\) C? At what temperatures would each transition occur? **Melting at 100 \(^\circ\) C, then Vaporization at 330 \(^\circ\) C**

23) If I had an amount of this substance at a pressure of 2.00 atm and a temperature of -150 \(^\circ\) C, what phase change(s) would occur if I decreased the pressure to 0.25 atm? At what pressures would each transition occur? **Sublimation at 0.25 \text{ atm}**
Part 2: Answer the following questions about the generic phase diagram to the right.

1) What letter represents the solid phase? A
2) What letter represents the liquid phase? C
3) What letter represents the gas phase? B
4) What letter represents the triple point? D

In your own words, define the term “triple point”.

All 3 phases exist at the same time.

5) What is this substance’s normal melting point (at 1 atm of pressure)? 60°C
6) What is this substance’s normal boiling point (at 1 atm of pressure)? 100°C
7) Above what substance’s normal boiling point, is it impossible to liquefy this substance, no matter what the pressure? 110°C
8) At what temperature and pressure do all three phases coexist? 0.3 atm, 45°C
9) At a constant temperature, what would you do to cause this substance to freeze (change from a liquid to a solid)? Increase the pressure
10) What does sublimation mean? Solid turns into a gas without being a liquid first

Part 3: Answer the following questions about the phase diagram for water to the right.

1) At a pressure of 1 atmosphere, what is the normal freezing point of water? 0°C
2) What is the normal boiling point of water at 1 atmosphere of pressure? 100°C
3) In the mountains of Asheville, people are roughly 2,100 feet above sea level, which means the normal atmospheric pressure is slightly less than 1 atm. In Asheville, will water freeze at a lower temperature or a higher temperature than at 1 atm? higher

Will water boil at a higher temperature or lower temperature than at 1 atm? lower

Part 4: Answer the following questions about the phase diagram for carbon dioxide to the right.

1) At 1 atmosphere and room temperature (25 °C), would you expect solid carbon dioxide to melt to the liquid phase or sublime to the gas phase? sublime

2) Some industrial processes require carbon dioxide, which is stored onsite in large tanks as a liquid. Assuming we are at room temperature, how could carbon dioxide be liquefied? Increase the pressure to 70 atm.
Part 5: Answer the following questions about Compound X using the phase diagram to the right.

1) If you were to have a bottle containing Compound X in your closet, what phase would it most likely be in? **Solid**

2) At what temperature and pressure will all three phases coexist? \( T = 440 \degree C \)  
   \( P = 3.5 \text{ atm} \)

3) If you have a bottle of Compound X at a pressure of 3 atm and a temperature of 100 \degree C, what will happen if you raise the temperature to 400 \degree C? **Sublimation**

4) Why can’t Compound X be boiled at a temperature of 200 \degree C?  
   The liquid phase only exists above 450 \degree C.

5) Is it possible to drink Compound X safely? Why or why not?  
   No because we only drink liquids, but 450 \degree C (or hotter) would burn us!

6) What is the critical temperature of Compound X? **823 \degree C**

Part 6: Label the areas of Gas, Liquid and Solid on the phase diagram below. Then, complete the data table to the right. Use the completed phase diagram and data table to answer the questions.

<table>
<thead>
<tr>
<th>Phase Diagram</th>
<th>Temperature (K)</th>
<th>Pressure (atm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triple Point</td>
<td>150 K</td>
<td>0.8 atm</td>
</tr>
<tr>
<td>Normal Melting Point</td>
<td>185 K</td>
<td>1 atm</td>
</tr>
<tr>
<td>Normal Boiling Point</td>
<td>275 K</td>
<td>1 atm</td>
</tr>
<tr>
<td>Critical Point</td>
<td>440 K</td>
<td>3.8 atm</td>
</tr>
</tbody>
</table>

1) What changes in phase will occur if this substance is slowly compressed at constant temperature from 0.01 atm to 3.5 atm at:
   a) 100 K **Deposition (g → s)**
   b) 150 K **Condensation (g → l)**
   c) 300 K **Condensation (g → l)**
   d) 500 K **Nothing (supercritical fluid)**

2) What are the necessary conditions for this material to sublime?  
   **Must be under 150 K and 0.8 atm.**
NOTE: Parts 7 & 8 are required for Honors. Standard may complete these for extra credit!

Part 7: Construct the phase diagram for a substance on the axes below based on the following data. Your diagram does NOT need to be to scale.

- Label solid, liquid, and gas areas
- Draw lines of equilibrium between solid and gas, liquid and gas, solid and liquid phases using the numbers provided
- Label your axes including units and add all the numbers from the data table

<table>
<thead>
<tr>
<th>Phase State</th>
<th>Temperature</th>
<th>Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triple Point</td>
<td>55 K</td>
<td>0.10 atm</td>
</tr>
<tr>
<td>Normal Melting Point</td>
<td>68 K</td>
<td>1 atm</td>
</tr>
<tr>
<td>Normal Boiling Point</td>
<td>183 K</td>
<td>1 atm</td>
</tr>
<tr>
<td>Critical Point</td>
<td>218 K</td>
<td>50 atm</td>
</tr>
</tbody>
</table>

Part 8: Use the following phase diagram for Tastegudum (a compound from another universe) to answer the following questions.

1) Label the regions of the diagram that correspond to the solid, liquid, and vapor phases.

2) Draw a small circle around the critical point for tastegudum.

3) Draw a small square around the triple point for tastegudum.

4) What is the critical pressure ($P_c$) of tastegudum? \[ 90\text{ atm} \]

5) What is the critical temperature ($T_c$) of tastegudum? \[ 750^\circ\text{C} \]

6) At what temperature will all three phases of tastegudum coexist at equilibrium? $T = 280^\circ\text{C}$, $P = 35\text{ atm}$

7) What is the boiling point temperature for tastegudum when the external pressure is 60 atm? \[ 500^\circ\text{C} \]

8) What is the freezing point temperature for tastegudum when the external pressure is 60 atm? \[ 300^\circ\text{C} \]
9) If you were to have a container containing tastegudum in your kitchen, in what state (phase of matter) would you expect to see it? Explain.

\[ \text{STP = 25°C, 1 atm, so tastegudum would be a gas.} \]

10) A container of tastegudum is sitting at a pressure of 45 atm and 0 °C. What will happen as the temperature is raised by 400 °C?

    It will melt \((275°C)\) and then evaporate \((400°C)\).

11) A container of tastegudum is sitting at a temperature of 300 °C under 1 atmosphere of pressure. What will happen as the pressure is increased to 90 atmospheres?

    It will condense \((90 \text{ atm})\) and then freeze \((60 \text{ atm})\).

12) Why can tastegudum NOT be brought to a boil at a temperature of 200 °C?

    At \(200°C\), tastegudum is either a gas \((<30 \text{ atm})\) or a solid \((>30 \text{ atm})\), but never a liquid.

13) Assuming it is not poisonous, could tastegudum be used as a drink on Earth? Explain.

    No because the temperature must be higher than 280°C, and that's too hot to drink AND the pressure needs to be greater than 33 atm, which would crush us.

14) When skating on ice, one is actually skating on water. In reality, the weight of an entire person is put on such a small area of ice by the narrow blade of the skate. This tremendous pressure on the ice causes it to melt into water. By comparing the phase diagram for tastegudum with that of water, do you think tastegudum would make a good skating surface, or not? Defend your answer.

    No, because the pressure needs to be MUCH greater to turn tastegudum into a liquid.