Changes in Phase of Water Activity – Accel. Chemistry Name: _____ Per: __

Introduction: Water is a substance commonly found on Earth and in the atmosphere in all three phases of matter (solid, liquid, and gas). This unique property of water is a major factor in determining weather patterns on Earth.

When analyzing the phase changes that a substance undergoes, chemists often use a line graph called a heating curve. The graph is drawn using temperature on the y-axis and time on the x-axis. For areas where the substance is in a single phase, the line has a positive slope. When the substance is changing state, the line has a slope of 0.

Objective: You will use data to create a graph which shows the changes in temperature as water undergoes phase changes from solid to liquid and liquid to gas. You will compare the relative amounts of energy needed for each step.

Pre-Lab:

1. Define the following terms:
   a. Molar enthalpy of vaporization:

   b. Molar enthalpy of fusion:

   c. melting point:

   d. vaporization:

2. Write the correct sign of ΔH_{system} for each of the following changes in physical state.
   a. $C_2H_5OH_{(S)} \rightarrow C_2H_5OH_{(l)}$ _____
   b. $H_2O_{(g)} \rightarrow H_2O_{(l)}$ _____
   c. $CH_3OH_{(l)} \rightarrow CH_3OH_{(g)}$ _____
   d. $NH_{3\,(l)} \rightarrow NH_{3\,(s)}$ _____

3. Are the following systems endothermic or exothermic?
   a. $Br_{2\,(l)} \rightarrow Br_{2\,(s)}$ _____
   b. $NH_{3\,(g)} \rightarrow NH_{3\,(l)}$ _____
   c. $C_5H_{12\,(g)} + 8\ O_{2\,(g)} \rightarrow 5\ CO_{2\,(g)} + 6\ H_2O_{(l)}$ _____

Teacher Initials: _____

Procedure: Use the data below to create a graph on a piece of graph paper and label the following

- *Title*: Heat Curve of Water
- *x axis* = time (min.)
- *y axis* = temp (°C)

Time min.	Temp °C	Time min.	Temp°C	Time min.	Temp°C
1	-9	**11**	45	**21**	100
2	-3	**12**	60	**22**	100
3	0	**13**	75	**23**	100
4	0	**14**	90	**24**	100
5	0	**15**	100	**25**	100
6	0	**16**	100	**26**	105
7	0	**17**	100	**27**	118
8	0	**18**	100	**28**	123
9	15	**19**	100	**29**	129
10	30	**20**	100	**30**	135

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Analysis: Use your graph to answer the following questions.

1. According to your graph, during what period of time was the sample in the solid (ice) phase? (Label it on your graph)
   a. At what minute did the ice begin to melt _____ (Label this on your graph)
   b. How many minutes did the ice take to melt _____
   c. At what minute is the ice entirely melted _____ (Label this on your graph)
2. According to your graph, in what period of time was the sample in the liquid (water) phase? (Label it on your graph)
   a. At what minute did the water begin to boil _____ (Label this on your graph)
   b. How many minutes did the water take to boil _____
   c. At what minute is the water entirely boiled _____ (Label this on your graph)
3. According to your graph, when was the sample in the gas (steam) phase? (Label it on your graph)

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Calculation/Discussion Questions: (*please answer in Complete Sentences*)

4. According to your graph, did the temperature increase while the ice was melting?

5. According to your graph, what happened to the temperature of the water between the time the ice melted and the water boiled?

6. Which phase change requires the most energy?

7. For the sections of the graph when the water was in a single phase, use $\Delta H = mc\Delta T$ to calculate the enthalpy change. Assume that you have 100.0 g of water. Show your work below.
   a. Solid: b. Liquid: c. Gas:

8. For the sections of the graph where the water was undergoing a phase change, calculate the enthalpy change for each one.
   a. Solid → Liquid b. Liquid → Gas

Answer the following problems and show your work. Use pg. 530 in your text for values.

1. How much heat is evolved when 275g of ammonia gas condenses to a liquid at its boiling point?

2. Calculate the heat required to melt 25.7 g of solid methanol at its melting point.

3. How much heat is required to vaporize 343 g of liquid ethanol at its boiling point?

4. How many moles of water must condense to evolve (give off) 1250 J of heat? $\Delta H_{cond} = -40.7 kJ/mol$

5. A sample of ammonia liberates 5.66 kJ of heat as it solidifies at its melting point. What is the mass of the sample? $\Delta H_{solid} = -5.66 kJ/mol$.