**Changes in Phase of Water Activity** – 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:
   1. Molar enthalpy of vaporization:
   2. Molar enthalpy of fusion:
   3. melting point:
   4. boiling point:
   5. vaporization:
2. Write the correct sign (positive or negative) of ΔHsystem for each of the following changes in physical state.
   1. C2H5OH (S) → C2H5OH (l) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   2. H2O (g) → H2O (l) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   3. CH3OH (l) → CH3OH (g)  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   4. NH3 (l) → NH3 (s) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. Are the following systems endothermic or exothermic?
   1. Br2 (l) → Br2 (s)  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   2. NH3 (g) → NH3 (l) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   3. C5H12 (g) + 8 O2 (g) → 5 CO2 (g) + 6 H2O (l) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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

**Teacher Initials: \_\_\_\_\_\_\_\_\_**

* *Title*: Heat Curve of Water
* *x axis* = time (min.), 1 min increments from 0 to 29
* *y axis* = temp (°C), 5 degree increments from -10 to 135

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **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 |  |  |

**Title:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Analysis:** Use your graph to answer the following questions.

**Teacher Initials: \_\_\_\_\_\_\_\_\_**

1. According to your graph, during what period of time was the sample in the solid (ice) phase? (Label it on your graph)
2. At what minute did the ice begin to melt \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (Label this on your graph)
3. How many minutes did the ice take to melt \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. At what minute is the ice entirely melted \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (Label this on your graph)
5. According to your graph, in what period of time was the sample in the liquid (water) phase? (Label it on your graph)
6. At what minute did the water begin to boil \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (Label this on your graph)
7. How many minutes did the water take to boil \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
8. At what minute is the water entirely boiled \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (Label this on your graph)
9. According to your graph, when was the sample in the gas (steam) phase? (Label it on your graph)

**Teacher Initials: \_\_\_\_\_\_\_\_\_\_\_**

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

1. According to your graph, did the temperature increase while the ice was melting? Why or why not?
2. According to your graph, what happened to the temperature of the water between the time the ice melted and the water boiled?
3. Which phase change requires the most energy?

***Answer the following problems and show your work.***

1. How much heat is evolved when 275g of ammonia gas (NH3) condenses to a liquid at its boiling point? (∆Hvap = 23.3 kJ/mol)
2. Calculate the heat required to melt 25.7 g of solid methanol (CH3OH) at its melting point. (∆Hfus = 3.22 kJ/mol)
3. How many moles of water must condense to evolve (give off) 1250 J of heat? (∆Hcond= -40.7kJ/mol)