Exercise 10.5a

Enthalpy of Fusion & Vaporization

Name: _____

Date: _____ Per: _____

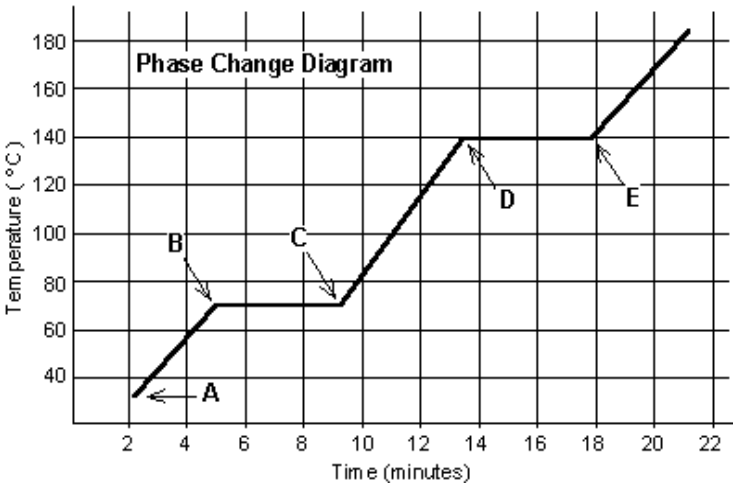
A change in enthalpy (ΔH) is a measurement of energy transfer in the form of heat. Energy may be gained from the surrounding environment by a substance (or system) in an endothermic process (+ΔH), removing heat (i.e., cooling) the surrounding environment. Energy may also be released to the surrounding environment by a substance (or system) in an exothermic process (-ΔH), causing heating of the surrounding environment.

During a phase change the temperature of the substance does not change. Energy is either being absorbed by a substance to overcome intermolecular forces and spread the particles out or is being released as the potential energy of separated particles is converted to motion and particles are drawn together into more condensed arrangements.

Enthalpy of fusion (energy necessary to break solids into liquids) and enthalpy of fusion (energy necessary to separate liquids into gases) may be expressed per gram of substance (kJ/g) or per mole of substance(kJ/mol). The values for water are:

$\Delta H_{(fus)}$ for H_2O is 6.02 kJ/mol | $\Delta H_{(vap)}$ for H_2O is 40.7 kJ/mol

Directions: *The graph was drawn from data collected as a substance was heated at a constant rate. Use the graph to answer the following questions.*



At (**A)** the substance exists in a _____ state. Material in this phase has _____ volume and _____ shape. As _____ is added to the substance, the particles of the substance _____ more rapidly causing the _____ to rise. At **(B)** the temperature of the substance is _____°C. This represents the _____ point of the substance. Between **(B)** and **(C)** temperature remains _____ as energy is added to the substance. The energy breaks _____ forces and increases the substance's _____ energy. At **(C)** the substance has completely _____ and exists in a _____ state. Material in this phase has _____ volume and _____ shape. The energy added to the substance between **(B)** and **(C)** was used to convert the substance from a _____ to a _____. This heat energy is called the ***enthalpy of fusion***. Between **(C)** and **(D),** as heat is added, the _____ increases indicating an increase in _____ energy of the substance. At point **(D)** the temperature of the substance is _____ °C and the substance has reached its _____ point. Additional heat added to the substance after **(D)** breaks _____ forces and increases the substance's _____ energy. The energy involved in the change from **(D)** to **(E)** is _____ than the energy involved in the change from **(B)** to **(C)**. The change between **(D)** and **(E)** is called _____. At (**E)**, the substance is completely in the _____ phase. Material in this phase has _____ volume and _____ shape. The energy added to the substance between **(D)** and **(E)** converted the substance from a _____ to a _____ state. This energy is called the ***enthalpy of vaporization***. Beyond **(E)**, the substance is in the _____ phase and added heat causes the particles to move _____ as indicated by the increasing temperature. In summation, the sloped regions of the graph represent changes in _____ energy causing particles to _____, and the level regions of the graph represent changes in _____ energy causing particles to _____.

Which of these three substances was likely used in this phase change experiment? ___

Substance	Melting point	Boiling point
X	20 °C	100 °C
Y	40 °C	140 °C
Z	70 °C	140 °C

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Calculating the change in enthalpy of a substance as it goes through a phase change is a simple process of multiplying the amount of substance expressed in either moles or grams by the appropriate enthalpy of phase change. Heat energy may be gained or released during a phase change, so the sign (+/−) used to express the change in enthalpy (ΔH) is critical. While the heat of fusion of water ($\Delta H_{(fus)}$) is +6.02 kJ/mol, due to it being an endothermic process, the heat of solidification ($\Delta H_{(sol)}$) is an exothermic process and energy must be indicated to be leaving the system by using the negative value (−6.02 kJ/mol).

$\Delta H_{(fus)}$ for H_2O is 6.02 kJ/mol | $\Delta H_{(vap)}$ for H_2O is 40.7 kJ/mol

Directions: *The graph was drawn from data collected as a substance was heated at a constant rate. Use the graph to answer the following questions.*

1. Calculate the enthalpy of fusion for water in J/g.

2. Calculate the enthalpy of vaporization for water in cal/gram (1 calorie (cal) = 4.184J).

3. Calculate the enthalpy change of 50.0 grams of condensing water vapor?

4. How much energy is needed to melt 12.4 g of lead? ($\Delta H_{(fus)}$ = 22.4 J/g)

5. Calculate the enthalpy change in joules when 253.00 g of liquid water freezes?

6. What is the enthalpy of vaporization of a substance if it takes 34212 J to vaporize 25.0 g?

7. How many kilocalories does it take to melt 12.9 g of sodium chloride if the heat of fusion is 28.16 kJ/mol?

8. How many kilojoules of heat are absorbed when 0.46 g of chloroethane (C_2H_5Cl, boiling point 12.3°C) vaporizes at its boiling point? ($\Delta H_{(vap)}$ = 26.4 kJ/mol)

9. Given that benzoic acid has a molar mass of 122.1 g/mol and a 52.9 g sample of benzoic acid absorbs 7.83 kJ when it melts, calculate the molar enthalpy of fusion of benzoic acid.

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Answers: 1) 334 J/g 2) 540. cal/g 3) −113 kJ 4) 278 J 5) -8.45×10^4 J 6) 1370 J/g 7) 1.49 kcal 8) 0.19 kJ 9) 18.1 kJ/mol