

**CH 302 Spring 2005**  
**Worksheet 7: Liquids and Solids**

1. Calculate the amount of heat (J) required to convert 180 g of water at 10.0°C to steam at 105.0°C.

$$180 \text{ g H}_2\text{O} \times (4.18 \text{ J/g} \cdot ^\circ\text{C}) \times (100^\circ\text{C} - 10.0^\circ\text{C}) = 6.77 \times 10^4 \text{ J}$$

$$180 \text{ g H}_2\text{O} \times (2.26 \times 10^3 \text{ J/g}) = 4.07 \times 10^5 \text{ J}$$

$$180 \text{ g H}_2\text{O} \times (2.03 \text{ J/g} \cdot ^\circ\text{C}) \times (105.0^\circ\text{C} - 100.0^\circ\text{C}) = 1.8 \times 10^3 \text{ J} = 0.018 \times 10^5 \text{ J}$$

$$\text{Total heat} = 6.77 \times 10^4 \text{ J} + 4.07 \times 10^5 \text{ J} + 0.018 \times 10^5 \text{ J} = 4.76 \times 10^5 \text{ J}$$

2. Predict the order of increasing boiling points for the following:

H<sub>2</sub>S; H<sub>2</sub>O; CH<sub>4</sub>; H<sub>2</sub>; KBr

**H<sub>2</sub>; CH<sub>4</sub>; H<sub>2</sub>S; H<sub>2</sub>O; KBr**

3. The molar heat of fusion,  $\Delta H_{\text{fus}}$ , of Na is 2.6 kJ/mol at its melting point, 97.5°C. How much heat must be absorbed by 5.0g of solid Na at 97.5°C to melt it?

$$5.0 \text{ g Na} \times (1 \text{ mol Na}/23 \text{ g Na}) \times (2.6 \text{ kJ}/1 \text{ mol Na}) = 0.57 \text{ kJ}$$

4. A liquid is heated at atmospheric pressure. For each of the properties listed, predict whether they would increase or decrease.

- |                           |                 |
|---------------------------|-----------------|
| (a) Viscosity             | <b>decrease</b> |
| (b) Density               | <b>decrease</b> |
| (c) Surface Tension       | <b>decrease</b> |
| (d) Vapor Pressure        | <b>increase</b> |
| (e) Tendency to Evaporate | <b>increase</b> |

5. How much heat would be required to convert 234.3 g of solid benzene, C<sub>6</sub>H<sub>6(s)</sub>, at 5.5 °C into benzene vapor, C<sub>6</sub>H<sub>6(g)</sub>, at 100.0 °C?

Benzene has the following molar heat capacities:

$$\text{C}_6\text{H}_6(\text{l}) = 136 \text{ J/mol} \cdot ^\circ\text{C}, \text{ and}$$

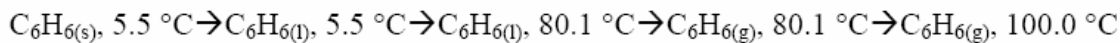
$$\text{C}_6\text{H}_6(\text{g}) = 81.6 \text{ J/mol} \cdot ^\circ\text{C}$$

The molar heat of fusion for benzene is 9.92 kJ/mol and the molar heat of vaporization for benzene is 30.8 kJ/mol.

The melting point of benzene is 5.5 °C; and the boiling point of benzene is 80.1 °C.

Benzene's molecular weight is 78.0 g/mol.

$$234.5 \text{ g} \times \frac{\text{mol}}{78.0 \text{ g}} = 3 \text{ mol}$$



$$\text{Step 1: } \frac{9.92 \text{ kJ}}{\text{mol}} \times (3 \text{ mol}) = 29.8 \text{ kJ}$$

$$\text{Step 2: } \frac{136 \text{ J}}{\text{mol} \cdot ^\circ\text{C}} \times (3 \text{ mol}) \times (80.1 - 5.5)^\circ\text{C} = 30,437 \text{ J} = 30.4 \text{ kJ}$$

$$\text{Step 3: } \frac{30.8 \text{ kJ}}{\text{mol}} \times (3 \text{ mol}) = 92.4 \text{ kJ}$$

$$\text{Step 4: } \frac{81.6 \text{ J}}{\text{mol} \cdot ^\circ\text{C}} \times (3 \text{ mol}) \times (100.0 - 80.1)^\circ\text{C} = 4871.52 \text{ J} = 4.87 \text{ kJ}$$

$$\text{Total: } 29.8 \text{ kJ} + 30.4 \text{ kJ} + 92.4 \text{ kJ} + 4.9 \text{ kJ} = 158 \text{ kJ}$$

6. Calculate the amount of heat that must be absorbed by 50.0 grams of ice at  $-12.0^\circ\text{C}$  to convert it to water at  $20.0^\circ\text{C}$ .

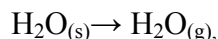
$$50.0 \text{ g} \times (2.09 \text{ J/g} \cdot ^\circ\text{C}) \times (0^\circ\text{C} - -12.0^\circ\text{C}) = 1.25 \times 10^3 \text{ J}$$

$$50.0 \text{ g} \times (334 \text{ J/g}) = 1.67 \times 10^4 \text{ J}$$

$$50.0 \text{ g} \times (4.18 \text{ J/g} \cdot ^\circ\text{C}) \times (20.0^\circ\text{C} - 0^\circ\text{C}) = 0.418 \times 10^4 \text{ J}$$

$$\text{Total heat absorbed} = 2.21 \times 10^4 \text{ J} = 22.1 \text{ kJ}$$

7. For the reaction



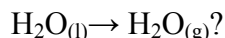
(a) Would  $\Delta H$  be positive or negative? Why?

**Positive, because the gaseous molecules have more energy than molecules in a solid.**

(b) Would  $\Delta S$  be positive or negative? Why?

**Positive, because gaseous compounds are more disordered than solid compounds.**

8. At the normal boiling point of water,  $\Delta H_{\text{vap}} = 40 \text{ kJ/mol}$ . What is the entropy change for



$$\Delta G = 0$$

$$\Delta G = \Delta H - T \Delta S$$

$$\Delta S = \Delta H/T = 40 \text{ kJ} \cdot \text{mol}^{-1} / 373 \text{ K} = 0.107 \text{ kJ/mol} \cdot \text{K}$$

9. What is the number of calories needed to raise the temperature of 200 grams of water from  $20^\circ\text{C}$  to  $50^\circ\text{C}$ ?

$$(4.184 \text{ J/g} \cdot ^\circ\text{C}) \times (200 \text{ g}) \times (30^\circ\text{C}) = 25104 \text{ J}$$

$$25104 \text{ J} \times .23901 \text{ cal/J} = 6000 \text{ calories}$$

10. Put the following compounds in order from lowest boiling point to highest boiling point and justify your answer.



**Boiling point tends to increase with molecular weight, so  $\text{CH}_4$ ;  $\text{C}_2\text{H}_6$ ;  $\text{C}_3\text{H}_8$ ;  $\text{C}_4\text{H}_{10}$ ;  $\text{C}_5\text{H}_{12}$ .**

11. For each solid classify its bonds as ionic, covalent, or metallic:

(a) KF            **ionic**

(b) CsI           **ionic**

(c) Ni            **metallic**

(d)  $\text{C}_6\text{H}_6$        **molecular**

(e)  $\text{H}_2\text{O}$         **molecular**