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 g H_2O x (4.18 J/g.°C) x 100°C – 10.0°C) = 6.77 x 10^4 J
180 g H_2O x (2.26 x 10^3 J/g) = 4.07 x 10^5 J
180 g H_2O x (2.03 J/g. °C) x (105.0°C – 100.0°C) 1.8 x 10^3J = 0.018 x 10^5 J
Total heat = 6.77 x 10^4 J + 4.07 x 10^5 J + 0.018 x 10^5 J = 4.76 x 10^5 J

2. Predict the order of increasing boiling points for the following:
H_2S; H_2O; CH_4; H_2; KBr
H_2; CH_4; H_2S; H_2O; KBr

3. The molar heat of fusion, ΔH_{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 g Na x (1 mol Na/23 g Na) x (2.6 kJ/1 mol Na) = 0.57 kJ

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

(a) Viscosity	**decrease**
(b) Density	**decrease**
(c) Surface Tension	**decrease**
(d) Vapor Pressure	**increase**
(e) Tendency to Evaporate	**increase**

5. How much heat would be required to convert 234.3 g of solid benzene, $C_6H_{6(s)}$, at 5.5 °C into benzene vapor, $C_6H_{6(g)}$, at 100.0 °C?

Benzene has the following molar heat capacities:
$C_6H_6(l)$ = 136 J/mol °C, and
$C_6H_6(g)$ = 81.6 J/mol °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.

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

$C_6H_{6(s)}$, 5.5 °C → $C_6H_{6(l)}$, 5.5 °C → $C_6H_{6(l)}$, 80.1 °C → $C_6H_{6(g)}$, 80.1 °C → $C_6H_{6(g)}$, 100.0 °C

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

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

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

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

Total: 29.8 kJ + 30.4 kJ + 92.4 kJ + 4.9 kJ = 158 kJ

6. Calculate the amount of heat that must be absorbed by 50.0 grams of ice at -12.0°C to convert it to water at 20.0°C.

50.0 g x (2.09 J/g.°C) x (0°C - - 12.0V) = 1.25 x 10^3 J
50.0 g x (334 J/g) = 1.67 x 10^4 J
50.0 g x (4.18 J/g°C x (20.0°C - 0°C) = 0.418 x 10^4 J
Total heat absorbed = 2.21 x 10^4 J = 22.1 kJ

7. For the reaction

$H_2O_{(s)} \rightarrow H_2O_{(g)},$

(a) Would ΔH be positive or negative? Why?

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

(b) Would ΔS be positive or negative? Why?

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

8. At the normal boiling point of water, ΔH_{vap} = 40 kJ/mol. What is the entropy change for

$H_2O_{(l)} \rightarrow H_2O_{(g)}$?

ΔG = 0
ΔG = ΔH – T ΔS
$\Delta S = \Delta H/T = 40\ kJ.mol^{-1}/373K = 0.107\ kJ/mol.K$

9. What is the number of calories needed to raise the temperature of 200 grams of water from 20°C to 50°C?

(4.184 J/g.°C) x (200g) x (30°C) = 25104 J
25104 J x .23901 cal/J = 6000 calories

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

CH_4; C_4H_{10}; C_2H_6; C_3H_8; C_5H_{12}

Boiling point tends to increase with molecular weight, so CH_4; C_2H_6; C_3H_8; C_4H_{10}; C_5H_{12}.

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

(a) KF **ionic**
(b) CsI **ionic**
(c) Ni **metallic**
(d) C_6H_6 **molecular**
(e) H_2O **molecular**