

Phase Change

① bag
220.0g ice
 $T_i = 0^\circ\text{C}$

bag f
220.0g
 $T_f = 21.0^\circ\text{C}$

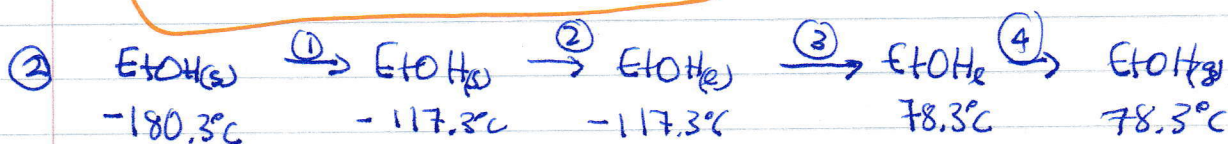
$$q_{\text{ice phase } \Delta} + q_{\text{ice warm}} = \text{total heat}$$

$$+ 333 \frac{\text{J}}{\text{g}} \times 220.0 \text{g} + 4.184 \frac{\text{J}}{\text{g}^\circ\text{C}} \times 220.0 \text{g} \times (21.0^\circ\text{C} - 0.0^\circ\text{C})$$

↑
melting
endothermic

$$73,260 \text{ J} + 19,330 \text{ J} = 92,590 \text{ J}$$

$$q_{\text{total}} = 92.6 \text{ kJ added}$$



$$0.971 \frac{\text{J}}{\text{g}^\circ\text{C}} \times 10.0 \text{g} \times (-117.3 - (-180.3))^\circ\text{C} + 218 \frac{\text{J}}{\text{g}} \times 10.0 \text{g} + 230 \frac{\text{J}}{\text{g}^\circ\text{C}} \times 10.0 \text{g}$$

$$+ 2.30 \frac{\text{J}}{\text{g}^\circ\text{C}} \times 10.0 \text{g} \times (78.3^\circ\text{C} - (-117.3^\circ\text{C})) + 854 \frac{\text{J}}{\text{g}} \times 10.0 \text{g}$$

$$611.73 \text{ J} + 2180 \text{ J} + 4498.8 \text{ J} + 8540 \text{ J}$$

$$q_T = + 15830.53 \text{ J}$$

$$15830 \text{ J} + 15.83 \text{ kJ}$$

Reactions in Calorimeters

①

50.0 mL 0.100 M AgNO_3

50.0 mL 0.100 M HCl

$$T_i = 22.60^\circ\text{C}$$

100.0 mL total volume

$$T_f = 23.40^\circ\text{C}$$

= 100.0 g total mass

$$q_{\text{rxn}} = -q_{\text{sol}}$$

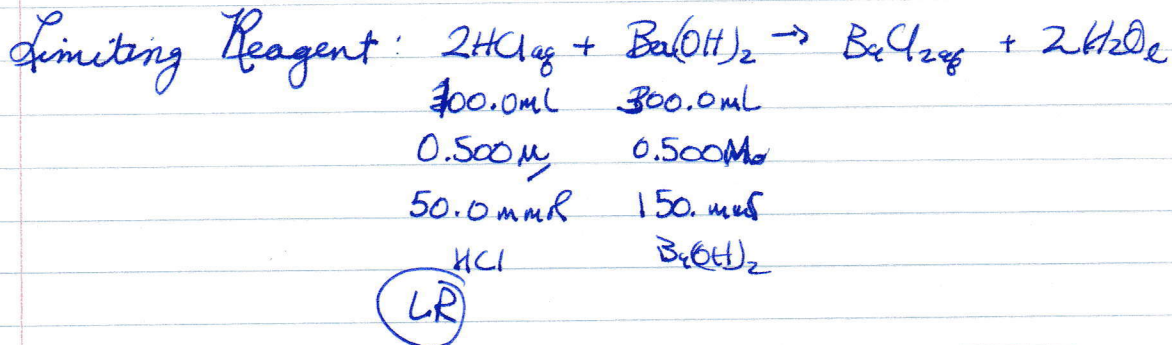
$$= 4.184 \frac{\text{J}}{\text{g}^\circ\text{C}} \times 100.0 \text{ g} \times (23.40^\circ\text{C} - 22.60^\circ\text{C})$$

$$= 334.4 \text{ J} \quad \therefore q_{\text{rxn}} = -334.4 \text{ J}$$

$$\Delta H_{\text{rxn}} = \frac{-334.4 \text{ J}}{0.01 \text{ mol AgCl}} = -33440 \text{ J/mol} = -33.4 \text{ kJ/mol AgCl}$$

The answer should be -334.72 J , this is divided by 0.0500 mol AgCl . $\Delta H = -66944 \text{ J/mol}$. To the correct SF, $\Delta H = -67 \text{ kJ/mol}$

Reactions in Calorimeters



a) $\Delta H_{rxn} = \frac{-118 \text{ kJ} \times 50.0 \times 10^{-3} \text{ mol HCl}}{2 \text{ mol HCl}} = -2.95 \text{ kJ released}$

b) The initial and final masses are the same.
~~Final~~ $\text{Ba}(\text{OH})_2$ ~~Final~~

$$- \frac{4.184 \text{ J}}{\text{g}^\circ\text{C}} \times 400. \text{ g} \times (T_f - 25.00^\circ\text{C}) = -2.95 \text{ kJ}$$

$$-1673.6 T_f + 41,840 \text{ J} = -2.95 \text{ kJ}$$

$$-1673.6 \frac{\text{J}}{^\circ\text{C}} T_f = -44,790 \text{ J}$$

$$T_f = 26.72^\circ\text{C} \Rightarrow 26.7^\circ\text{C}$$

Warming and Cooling

①

$$q_{\text{metal}} + q_{\text{H}_2\text{O}} = 0$$

$$C_{p\text{metal}} \cdot \text{mass}_{\text{metal}} \cdot \Delta T_{\text{metal}} = -C_{p\text{H}_2\text{O}} \cdot \text{mass}_{\text{H}_2\text{O}} \cdot \Delta T_{\text{H}_2\text{O}}$$

$$C_{p\text{metal}} = \frac{-C_{p\text{H}_2\text{O}} \cdot \text{mass}_{\text{H}_2\text{O}} \cdot \Delta T_{\text{H}_2\text{O}}}{\text{mass}_{\text{metal}} \cdot \Delta T_{\text{metal}}}$$

$$= \frac{-\left(\frac{4.184 \text{ J}}{\text{g}^\circ\text{C}} \times 75.0 \text{ g H}_2\text{O} \times (28.34^\circ\text{C} - 24.00^\circ\text{C}) \right)}{26.00 \text{ g} \times (28.34^\circ\text{C} - 82.25^\circ\text{C})}$$

$$= \frac{-1361.9 \text{ J}}{-1401.66 \text{ g}^\circ\text{C}}$$

$$= \boxed{0.972 \frac{\text{J}}{\text{g}^\circ\text{C}}}$$

The problem was misleading. Water in the liquid phase does not exist at 1 atm, and 135°C.

It is now steam. $q(\text{steam})$ provides the energy to warm the 95 degree water, and possibly allow a phase change, but not all of the water can go to steam.

$q_{\text{steam}} = -q_{\text{water}}$

$50.0 \text{ g} \times 1.841 \text{ J/g}^\circ\text{C} \times 35^\circ\text{C} = -3224 \text{ J}$. this is the amount of energy the 95°C water absorbs. $3222 \text{ J} = 4.184 \text{ J/g}^\circ\text{C} \times 70.0 \text{ g} \times 5^\circ\text{C} + \text{energy for phase change}$

$3222 \text{ J} - 1464 \text{ J} = 1758 \text{ J}$ remaining. ONLY much energy is absorbed for the phase change which equates to 0.779g water.

it is the only mass of the 95°C water that can possibly have a T higher than 100°C if there is enough energy to change the temperature.

alas, there is not.

$50.0 \text{ g} \times 1.841 \text{ J/g}^\circ\text{C} \times (T_f - 100) = -0.779 \text{ g} \times 1.841 \text{ J/g}^\circ\text{C} (T_f - 100)$, $T_f = 100$. there is not enough energy to raise the temperature dramatically past 100°C for the steam. all 50.779 g of steam is at 100°C

Bomb Calorimetry

① $-q_{cal} = q_{rxn}$

$$\Delta H_{comb} \cdot \text{mass comb'd} = -C_v \cdot \Delta T_{cal}$$

$$\frac{-5903 \text{ kJ}}{\text{mol}} \left| \frac{1 \text{ mol}}{152.23 \text{ g}} \right| 0.1204 \text{ g camphor} = -4.669 \text{ kJ}$$

$$C_v = \frac{-4.669 \text{ kJ}}{-22.3^\circ\text{C}} = 205 \text{ kJ}/^\circ\text{C}$$

② $\Delta H_{comb} \cdot 0.1964 \text{ g} = \frac{-1.56 \text{ kJ}}{^\circ\text{C}} \times 3.2^\circ\text{C}$

$$\Delta H_{comb} (\text{grams}) = \frac{-1.56 \text{ kJ} \times 3.2^\circ\text{C}}{0.1964 \text{ g}}$$

$$\approx -25 \text{ kJ/g}$$

$$\Delta H_{comb} (\text{mol}) = \frac{-25.4 \text{ kJ}}{\text{g}} \left| \frac{188.1 \text{ g}}{\text{mol}} \right| = -2700 \text{ kJ/mol}$$

Bomb Calorimeter

③ $C_v = ?$

$$\Delta H_{\text{comb}} \cdot \text{mass} = - C_v \Delta T$$

$$\frac{-26.42 \frac{\text{kJ}}{\text{g}} \times 0.1584 \text{ g}}{-2.54^\circ\text{C}} = 1.647 \frac{\text{kJ}}{^\circ\text{C}}$$

ΔH_{comb} vanillin

$$\Delta H_{\text{comb}} = \frac{-\left(1.647 \frac{\text{kJ}}{^\circ\text{C}}\right)(3.25^\circ\text{C})}{0.2130 \text{ g vanillin}} = -25.139 \frac{\text{kJ}}{\text{g}}$$

$$\boxed{-25.1 \frac{\text{kJ}}{\text{g}}}$$