

Today: start ch. 9

November 4th

Tuesday: lab, expt. 10 (logger pro, printer adaptor)

↳ problem club w/ Kendall (7:30-9, Eppley 211)

wednesday: chap. 9 day 2

Thursday: problem club w/ Kendall (7:30-9, Eppley 211)

Friday: lattice energy, chap. 6, review chap. 9

Sunday: problem club w/ Kendall (7:30-9, Eppley 211)

11/11: CK4

Lewis
dot structure

→ ABE → answer

$$E_k = \frac{1}{2}mv^2$$
$$(kg)\left(\frac{m^2}{s^2}\right) \equiv 1J$$

Enthalpy, H heat

$$\Delta H = H_{\text{products}} - H_{\text{reactants}}$$

↗ exothermic

* If enthalpy decreases, heat is given off $\Delta H < 0$

* If it takes heat, $\Delta H > 0$ → endothermic

IS HEAT GIVEN OFF?

or

DOES THIS TAKE HEAT?

ΔH°

standard conditions:

1 atm

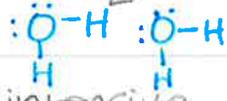
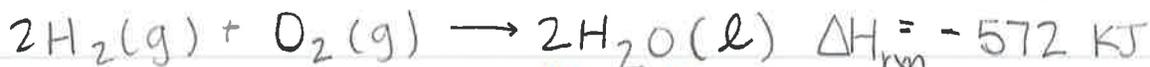
25°C (298K)

{ if it's a sol'n, 1.0M }

$$\Delta H = -41KJ$$

Demonstration:

November 4th



$$\Delta H = \frac{-572 \text{ KJ}}{2 \text{ mol H}_2}$$

intensive property

↳ doesn't matter how much of the stuff you have

$$\Delta H = \frac{-572 \text{ KJ}}{2 \text{ mol H}_2\text{O}}$$

$$\Delta H = \frac{-572 \text{ KJ}}{1 \text{ mol O}_2}$$

We used 2.9 mmol H₂ & excess O₂

(extensive)

↳ q = heat

↳ depends on how much you used!

$$q = \frac{2.9 \text{ mmol H}_2 \mid 1 \times 10^{-3} \text{ mol H}_2}{1 \text{ mol H}_2} \mid \frac{-572 \text{ KJ}}{2 \text{ mol H}_2} = \boxed{-0.83 \text{ KJ}}$$

units of KJ or J

-0.830 J

⊖ means heat was given OFF



↳ vaporization

to break all IMF's in the liquid (H-bonding & LDF)



$$\Delta H_{\text{fusion}} = \frac{+6.0 \text{ KJ}}{\text{mol H}_2\text{O}}$$

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Calorimetry (measuring q in the lab)

* coffee cup calorimetry



calorimetry equations

$$q = C_{\text{mole}} * n * \Delta T \quad \text{or} \quad q = c * m_{\text{sol'n}} * \Delta T$$

\uparrow J/mol·deg * mol * deg = 4.18 J/g·deg
 molar heat capacity specific heat

$m_{\text{H}_2\text{O}} + m_{\text{chemicals}}$

$$C_m = \frac{4.18 \text{ J}}{\text{g} \cdot \text{deg}} \bigg| \frac{18.02 \text{ g}}{1 \text{ mol}} = \frac{75.3 \text{ J}}{\text{mol} \cdot \text{deg}}$$

$$\Delta T = t_{\text{final}} - t_{\text{initial}}$$

$$T_i = 25.0^\circ\text{C}$$

$$T_f = 60.0^\circ\text{C}$$

$$\Delta T = 35 \text{ deg}$$

React 50.0 mL of 1.00M HCl + 50.0 mL of 1.0 M NaOH.
 The density of the resulting sol'n is 1.05 g/mL. $T_i = 25.00^\circ\text{C}$
 and $T_f = 31.38^\circ\text{C}$. Assume $C = 4.18 \text{ J/g} \cdot \text{deg}$

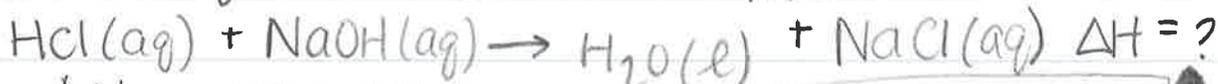
$$q_{\text{cal}} = \frac{4.18 \text{ J}}{\text{g} \cdot \text{deg}} * 105 \text{ g} * (31.38 - 25.00) \text{ deg} = \boxed{2800.2 \text{ J}}$$

$$d = \frac{m}{V} \rightarrow 100 \text{ mL} * 1.05 \text{ g/mL}$$

$$n = M \cdot V$$

$$n_{\text{HCl}} = .050 \text{ mol HCl}$$

$$q_{\text{rxn}} = -q_{\text{cal}} = -2800.2 \text{ J} \quad n_{\text{NaOH}} = .050 \text{ mol NaOH}$$

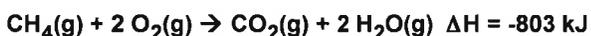


$$\Delta H = \frac{-2800.2 \text{ J}}{0.050 \text{ mol HCl}} \bigg| \frac{1 \text{ kJ}}{10^3 \text{ J}} = \boxed{-56 \text{ kJ/mol HCl}}$$

Chapter 9 Day 1 (Sections 9.1 – 9.7)

1. Which processes are endothermic? Exothermic?
(a) melting candle wax (b) coffee cooling
(c) water vapor condensing into droplets
(d) a covalent bond being broken (e) paper burning
(f) an ionic lattice forming from ions in the gas phase

2. Consider the reaction that we saw in the demo today:



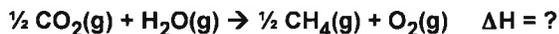
2a. How much heat is given off if 2.25 g methane (CH_4) is burned in excess oxygen?

2b. Express ΔH in terms of kJ/mol H_2O formed.

2c. What is ΔH for the reverse reaction?



2d. What is ΔH for the reaction?



3. How much heat would it take to vaporize 250 g water at its boiling point, 100 °C?



4. The specific heat of water, C , is $4.184 \text{ J g}^{-1} \text{ deg}^{-1}$. How much heat is needed, q , in order to raise the temperature of 275 g water from 25 °C to 75 °C?

$$q = c \times m \times \Delta T$$

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5. Suppose 125 mL hot water at 85 °C is added to 200 mL cold water at 15 °C. Assume the average density of water is 1.00 g/mL. The specific heat of water is 4.18 J/g deg (although you may not need this value in this problem). What is the final temperature of the water?

$$q = c \times m \times \Delta T$$

6. Suppose a 107.0 g sample of aluminum at 97.0 °C is added to 163 g water at 22.8 °C and the final temperature is 31.7 °C. What is the specific heat of aluminum?

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

$$C_{\text{metal}} \times m_{\text{metal}} \times \Delta T_{\text{metal}} = C_{\text{water}} \times m_{\text{water}} \times \Delta T_{\text{water}}$$

7. When 0.187 g C_6H_6 is burned in a bomb calorimeter containing 250.0 g water, the temperature of the water and the calorimeter rise by 4.53 °C. Given the heat capacity of the calorimeter = 525 J/deg, and using the specific heat of water, calculate q_{cal} then $-q_{\text{rxn}}$, then ΔH for this combustion reaction:



Now try these problems from the book:

- Section 9.1 – 9.3 no assigned problems
Section 9.4. (Enthalpy) Problems 38
Section 9.5. (Enthalpy and Chemical Equations) Problems 5, 6.
Section 9.6. (Chemical and physical changes) Problems 7, 8, 66 – 74 (even)
Section 9.7 (Calorimetry) 9, 11, 12, 76 – 90 (even)
Practice Quiz (pg 363): 4, 5, 6, 7, 8, 9, 10

Quick & Easy Thermodynamics

1. Internal Energy = Kinetic Energy + Potential Energy: $E = KE + PE$

2. Change in energy:

In general: $\Delta E = E_{\text{final}} - E_{\text{initial}}$

For reactions: $\Delta E = E_{\text{products}} - E_{\text{reactants}}$

3. First Law of Thermodynamics: (Law of Conservation of Energy)

$$\Delta E = \text{heat} + \text{work} \quad (\text{q} = \text{heat and } \text{w} = \text{work})$$

4. Work, w, is done when there is a change in volume:

$$w = -P\Delta V$$

$$\Delta E = q - P\Delta V$$

5. Chemists don't want to worry about volume changes (we use open beakers - and don't want to measure the gas volumes produced, etc.) so we invented enthalpy, H:

$$H = E + PV$$

$$\Delta H = \Delta E + P\Delta V$$

$$\Delta H = (q - P\Delta V) + P\Delta V = q$$

6. ΔH and ΔE are very similar in value under normal conditions - and are identical when there is no change in volume.

7. The standard state. When values are reported at 298 K and 1 atm and 1 M, a little "o" is added to ΔH to indicate the values are at standard state. Thus, ΔH° indicates the value is at standard state and ΔH indicates that the conditions were not standard conditions.