Non Sibi High School

Andover's Chem 250: Introductory/Basic Chemistry

Chapter 13, Review Quiz 1 Answers

1

If 125 kilograms of methanol, CH_3OH, is burned according to the combustion equation below, how much heat will be released?

$$2CH_3OH(l) + 3O_2(g) \longrightarrow 2CO_2(g) + 4H_2O(l) \quad \Delta H = -1453\,kJ/mol$$

$$125\,kg\left(\frac{1000\,g}{1\,kg}\right)\left(\frac{1\,mol\,CH_3OH}{32.04\,g}\right)\left(\frac{-1453\,kJ}{2\,mol\,CH_3OH}\right) = -2.83\times10^6\,kJ$$

2

If 3.55 kJ of heat are absorbed during the decomposition reaction below, how many milliliters of sulfur trioxide gas, measured at 22°C and 712 mmHg, will decompose?

$$2SO_3(g) \longrightarrow 2SO_2(g) + O_2(g) \quad \Delta H = 198\,kJ/mol$$

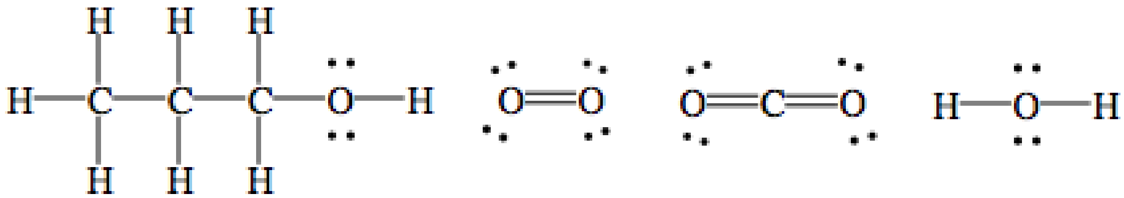
$$3.55\,kJ\left(\frac{2\,mol\,SO_3}{198\,kJ}\right) = 0.03586\,mol\,SO_3$$

$$\frac{0.03586\,mol \times 0.0821\,\frac{L\cdot atm}{mol\cdot K} \times (22+273)\,K}{\frac{712}{760}\,atm} = 0.927\,L\left(\frac{1000\,mL}{1\,L}\right) = 927\,mL\,SO_3$$

3

For the reaction $2C_3H_7OH(g) + 9O_2(g) \longrightarrow 6CO_2(g) + 8H_2O(g)$, estimate ΔH using average bond energies.

Lewis structures:



$$\Delta\text{H (estimated)} =$$
$$(2 \times 7)(\text{C}-\text{H}) + (2 \times 2)(\text{C}-\text{C}) + (2 \times 1)(\text{C}-\text{O}) + (2 \times 1)(\text{O}-\text{H}) + (9 \times 1)(\text{O}=\text{O})$$
$$-(6 \times 2)(\text{C}=\text{O}) - (8 \times 2)(\text{O}-\text{H})$$
$$= 14(414) + 4(347) + 2(360) + 2(464) + 9(498) - 12(745) - 16(464)$$
$$= -3050 \text{ kJ/mol}$$

4

Calculate ΔH for the reaction $C(s) + 2H_2(g) + \frac{1}{2}O_2(g) \longrightarrow CH_3OH(g)$ using the following three reactions:

I) $CO_2(g) \longrightarrow C(s) + O_2(g)$ $\Delta H_I = 394\,kJ/mol$

II) $H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(g)$ $\Delta H_{II} = -242\,kJ/mol$

III) $2CH_3OH(g) + 3O_2(g) \longrightarrow 2CO_2(g) + 4H_2O(g)$ $\Delta H_{III} = -1354\,kJ/mol$

$$C(s) + O_2(g) \longrightarrow CO_2(g) \quad \Delta H = -1(394\,kJ/mol) = -394\,kJ/mol$$
$$2H_2(g) + O_2(g) \longrightarrow 2H_2O(g) \quad \Delta H = 2(-242\,kJ/mol) = -484\,kJ/mol$$
$$CO_2(g) + 2H_2O(g) \longrightarrow CH_3OH(g) + \frac{3}{2}O_2(g) \quad \Delta H = -\frac{1}{2}(-1354\,kJ/mol) = 677\,kJ/mol$$

$$C(s) + 2H_2(g) + \frac{1}{2}O_2(g) \longrightarrow CH_3OH(g) \quad \Delta H = -201\,kJ/mol$$

5

Write the balanced formation reaction, including physical states, for solid sodium iodate, $NaIO_3$.

$$Na(s) + \frac{1}{2}I_2(s) + \frac{3}{2}O_2(g) \longrightarrow NaIO_3(s)$$

Compound	ΔH_f° (kJ/mol)
NO(g)	90.
NO_2(g)	33

6

Calculate ΔH° for the reaction $2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$ using the following information:

$$\Delta H^\circ = 2(33) - 2(90) - 1(0) = -114\,\text{kJ/mol}$$

7

The specific heat of magnesium metal is 1.05 J/g·°C. How much heat in kilojoules is lost when a 225 gram sample of magnesium metal is cooled from 625°C to 125°C?

$$q = 225\,\text{g}\left(\frac{1.05\,\text{J}}{\text{g}\cdot^\circ\text{C}}\right)(125 - 625)^\circ\text{C}\left(\frac{1\,\text{kJ}}{1000\,\text{J}}\right) = -118\,\text{kJ}$$

8

In an insulated calorimeter, a 475 gram piece of tin metal originally at 132°C was added to 135 grams of water originally at 19°C. The final temperature of the tin-water mixture was 36°C. Determine the specific heat of tin.

$$q_{\text{Sn lost}} = -q_{\text{water gained}}$$
$$475\,\text{g}(s_{\text{Sn}})(36 - 132)^\circ\text{C} = -135\,\text{g}\left(\frac{4.18\,\text{J}}{\text{g}\cdot^\circ\text{C}}\right)(36 - 19)^\circ\text{C}$$
$$s_{\text{Sn}} = 0.21\,\text{J/g}\cdot^\circ\text{C}$$

9

The specific heat of tungsten metal is 0.13 J/g·°C. In an insulated calorimeter, a 955 gram piece of tungsten metal originally at 375°C was added to 725 grams of water originally at 18°C. Determine the final temperature of the tungsten-water mixture.

$$q_{\text{W lost}} = -q_{\text{water gained}}$$
$$955\,\text{g}\left(\frac{0.13\,\text{J}}{\text{g}\cdot^\circ\text{C}}\right)(t_{\text{final}} - 375^\circ\text{C}) = -725\,\text{g}\left(\frac{4.18\,\text{J}}{\text{g}\cdot^\circ\text{C}}\right)(t_{\text{final}} - 18^\circ\text{C})$$
$$t_{\text{final}} = 32^\circ\text{C}$$

10

In an insulated calorimeter, 18.2 grams of solid cesium hydroxide at 22.3°C was dissolved in 135.7 grams of water also at 22.3°C, after which the final temperature of the mixed solution was 36.9°C. If the specific heat of the mixed solution was 3.87 J/g·°C, determine ΔH for the dissolving process $CsOH(s) \longrightarrow CsOH(aq)$ in kJ/mol CsOH.

$$q_{rxn\,lost} = -q_{soln\,gained} = -(18.2 + 135.7)\mathrm{g}\left(\frac{3.87\,\mathrm{J}}{\mathrm{g}\cdot^\circ\mathrm{C}}\right)(36.9 - 22.3)^\circ\mathrm{C}\left(\frac{1\,\mathrm{kJ}}{1000\,\mathrm{J}}\right) = -8.696\,\mathrm{kJ}$$

$$n_{CsOH} = 18.2\,\mathrm{g}\left(\frac{1\,\mathrm{mol}}{149.9\,\mathrm{g}}\right) = 0.1214\,\mathrm{mol\,CsOH}$$

$$\Delta H = \frac{-8.696\,\mathrm{kJ}}{0.1214\,\mathrm{mol\,CsOH}} = -71.6\,\mathrm{kJ/mol\,CsOH}$$

11

In an insulated calorimeter, 55.7 mL of 1.91 M acetic acid was mixed with 62.6 mL of 1.83 M sodium hydroxide, with both solutions originally at 18.2°C. The final temperature of the mixed solutions was 30.1°C. The density of the mixed solutions was 1.03 g/mL and the specific heat of the mixed solutions was 3.96 J/g·°C. Write a balanced molecular equation, including physical states, and determine ΔH for the neutralization reaction in kJ/mol of water formed.

$$\mathrm{HCH_3COO(aq) + NaOH(aq) \longrightarrow H_2O(l) + NaCH_3COO(aq)}$$

$$q_{rxn\,lost} = -q_{soln\,gained} = -(55.7 + 62.6)\mathrm{mL}\left(\frac{1.03\,\mathrm{g}}{1\,\mathrm{mL}}\right)\left(\frac{3.96\,\mathrm{J}}{\mathrm{g}\cdot^\circ\mathrm{C}}\right)(30.1 - 18.2)^\circ\mathrm{C}\left(\frac{1\,\mathrm{kJ}}{1000\,\mathrm{J}}\right) = -5.742\,\mathrm{kJ}$$

$$55.7\,\mathrm{mL}\left(\frac{1\,\mathrm{L}}{1000\,\mathrm{mL}}\right)\left(\frac{1.91\,\mathrm{mol\,HCH_3COO}}{1\,\mathrm{L}}\right)\left(\frac{1\,\mathrm{mol\,H_2O}}{1\,\mathrm{mol\,HCH_3COO}}\right) = 0.1064\,\mathrm{mol\,H_2O}$$

$$62.6\,\mathrm{mL}\left(\frac{1\,\mathrm{L}}{1000\,\mathrm{mL}}\right)\left(\frac{1.83\,\mathrm{mol\,NaOH}}{1\,\mathrm{L}}\right)\left(\frac{1\,\mathrm{mol\,H_2O}}{1\,\mathrm{mol\,NaOH}}\right) = 0.1147\,\mathrm{mol\,H_2O}$$

HCH_3COO produces less H_2O, so HCH_3COO is the limiting reagent and 0.1064 mol H_2O is formed.

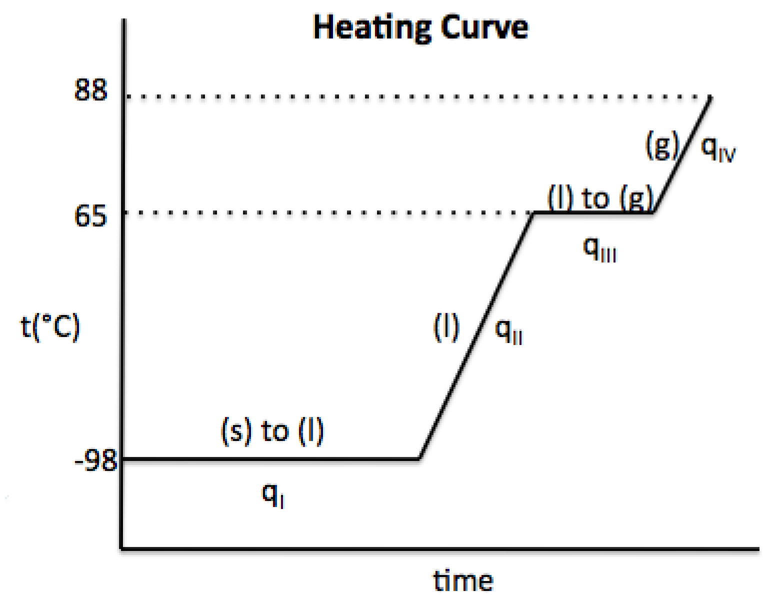
$$\Delta H = \frac{-5.742\,\mathrm{kJ}}{0.1064\,\mathrm{mol\,H_2O}} = -54.0\,\mathrm{kJ/mol\,H_2O}$$

12

Consider the following data for methanol, CH_3OH:

melting point = -98°C
boiling point = 65°C
ΔH_{fusion} = 3.2 kJ/mol
$\Delta H_{vaporization}$ = 38 kJ/mol
specific heat of liquid methanol = 2.5 J/g·°C
specific heat of methanol vapor = 1.7 J/g·°C

Sketch a heating curve that depicts solid methanol at -98°C being heated to 88°C and then calculate the total amount of heat in kilojoules absorbed when 77 grams of methanol undergoes this process.



I) solid methanol at −98°C to liquid methanol at −98°C:

$$q_I = 77\,g\left(\frac{1\,mol}{32.04\,g}\right)\left(\frac{3.2\,kJ}{1\,mol}\right) = 7.69\,kJ$$

II) liquid methanol at −98°C to liquid methanol at 65°C:

$$q_{II} = 77\,g\left(\frac{2.5\,J}{g\cdot^{\circ}C}\right)(65-(-98))^{\circ}C\left(\frac{1\,kJ}{1000\,J}\right) = 31.4\,kJ$$

III) liquid methanol at 65°C to methanol vapor at 65°C:

$$q_{III} = 77\,g\left(\frac{1\,mol}{32.04\,g}\right)\left(\frac{38\,kJ}{1\,mol}\right) = 91.3\,kJ$$

IV) methanol vapor at 88°C to methanol vapor at 88°C:

$$q_{IV} = 77\,\text{g}\left(\frac{1.7\,\text{J}}{\text{g}\cdot^{\circ}\text{C}}\right)(88-65)^{\circ}\text{C}\left(\frac{1\,\text{kJ}}{1000\,\text{J}}\right) = 3.01\,\text{kJ}$$

$$q_{total} = 7.69 + 31.8 + 91.3 + 3.01 = 133\,\text{kJ}$$

Contact: kcardozo@andover.edu