CHEM 1215 Unit 1 Practice Problems - Solutions

1. $kJ = 1.525\ kcal \times \frac{10^3\ cal}{1\ kcal} \times \frac{4.184\ J}{1\ cal} \times \frac{1\ kJ}{10^3\ J} = \boxed{6.381\ kJ}$

2. <u>Given</u>: $q = +125 J$

$w = -0.110\ kJ \times \frac{10^3\ J}{kJ} = -110.\ J$

<u>Find</u>: $\Delta E = q + w = 125\ J + -110.\ J = \boxed{15\ J}$

3. <u>Given</u>: $\left.\begin{matrix} V_f = 4.50\ L \\ V_i = 1.50\ L \end{matrix}\right\} \Delta V = 3.00\ L$

$P = 1.25\ atm$

$\Delta H = 1.515\ kJ$

<u>Find</u>: $\Delta E = \Delta H - P\Delta V$

$$\Delta E = 1.515\ kJ - \left[(1.25\ atm)(3.00\ L)\left(\frac{101.3\ J}{1\ atm \cdot L}\right)\left(\frac{1\ kJ}{10^3\ J}\right)\right]$$

$$= 1.515\ kJ - 0.379875\ kJ = 1.135125\ kJ \Rightarrow \boxed{1.135\ kJ}$$

4. $kJ = 2.5 g\ KClO_3 \times \frac{1\ mol\ KClO_3}{122.55 g\ KClO_3} \times \frac{-89.4\ kJ}{2\ mol\ KClO_3}$

$= -0.91187\ kJ$

$= \boxed{-0.91\ kJ}$

5. <u>Note</u>: this problem asks about the <u>formation</u> of $KClO_3$ – the reverse of the equation given in question 4. Write the thermochemical eq'n for the reverse reaction:

$$2\,KCl\,(s) + 3O_2\,(g) \rightarrow 2\,KClO_3\,(s) \quad \Delta H = +89.4\,kJ$$

So,

$$\Delta H = 7.4\,g\;KClO_3 \times \frac{1\,mol\;KClO_3}{122.55\,g\;KClO_3} \times \frac{+89.4\,kJ}{2\,mol\;KClO_3}$$

$$= 2.6991\,kJ \Rightarrow \boxed{2.7\,kJ}$$

6. <u>Given</u>: $C_s = 0.108\;cal/gK$

$0.250\,mol\;Fe$

$$\left.\begin{array}{l} T_f = 1535\,^\circ C \\ T_i = 25\,^\circ C \end{array}\right\} \Delta T = 1510.\,K$$

<u>Find</u>: q (kJ)

$$q = C_s \times mass \times \Delta T$$

$$q = 0.108\,\frac{cal}{g \cdot K} \times 0.250\,mol \times \frac{55.85\,g}{1\,mol} \times 1510.\,K \times \frac{4.184\,J}{1\,cal}$$

$$\times \frac{1\,kJ}{10^3\,J} = \boxed{9.53\,kJ}$$

7. Given: $q = 1.376\ kJ$

mass $= 55.0g$

$$\left.\begin{array}{l} T_f = 87.5°C \\ T_i = 22.5°C \end{array}\right\} \Delta T = 65.0\ K$$

Find: C_s ($J/g\,K$)

$$C_s = \frac{q}{mass \cdot \Delta T} = \frac{1.376\ kJ}{55.0g \times 65.0K} \times \frac{10^3\ J}{1\ kJ}$$

$$= \boxed{0.385\ J/g \cdot K}$$

8. Given: mass metal $= 26.4g$

T_f (metal) $= 27.0°C$

T_i (metal) $= 99.0°C$

ΔT (metal) $= -72.0°C$

$\mathcal{M}$ (metal) $= 63.5\ g/mol$

mass $H_2O = 25.0g$

$T_f\ (H_2O) = 27.0°C$

$T_i\ (H_2O) = 20.0°C$

$\Delta T\ (H_2O) = 7.0°C$

$C_s\ (H_2O) = 4.18\ J/g\,K$

Find: C_s & C_m

$$q_{H_2O} = C_s(H_2O) \times mass\ H_2O \times \Delta T_{H_2O}$$

$$= 4.18\frac{J}{gK} \times 25.0g \times 7.0K = 731.5\ J$$

$$q_{metal} = -q_{H_2O} = -731.5\ J$$

$$C_s\ (metal) = \frac{-731.5\ J}{26.4g \cdot -72.0K} = \boxed{0.38\ J/g \cdot K}$$

8. (cont)

Since $\mathcal{M}_{metal} = 63.5\,g/mol$:

$$C_m\,(metal) = 0.3848\,\frac{J}{g\cdot K} \times \frac{63.5\,g}{mol} = 24.43$$

$$= \boxed{24\,J/mol\cdot K}$$

(Note: $0.3848\,\frac{J}{g\cdot K}$ was used to minimize rounding error.)

9. Given: mass solute $= 5.0\,g\ KBr$, mass $H_2O = 30.0\,g$ } mass soln $= 35.0\,g$

$T_f = 15.3\,°C$, $T_i = 21.0\,°C$ } $\Delta T_{soln} = -5.7\,K$

$C_s\,(soln) = 4.18\,J/gK$

Find: ΔH_{soln} (kJ/mol)

$$q_{soln} = \frac{4.18\,J}{g\cdot K} \times 35.0\,g \times -5.7\,K = -833.9\,J$$

$$q_{KBr} = -q_{soln} = -(-833.9\,J) = +833.9\,J$$

$$\Delta H_{soln} = \frac{q_{KBr}}{mol\,KBr} = \frac{+833.9\,J}{5.0\,g\,KBr} \times \frac{119.00\,g\,KBr}{1\,mol\,KBr} \times \frac{1\,kJ}{10^3\,J}$$

$$= 19.8468\,\frac{kJ}{mol} \Rightarrow \boxed{20.\,kJ/mol}$$

10. Given: mass = 1.276g C_3H_8
C_{cal} = 7.850 kJ/K
T_f = 29.21°C
T_i = 21.01°C
ΔT = 8.20°C = 8.20 K

Find: ΔH_{comb} (kJ/mol)

$q_{cal} = C_{cal} \times \Delta T$ (notice: No mass term!)

$= 7.850 \frac{kJ}{K} \times 8.20K = 64.37 \, kJ$

$q_{C_3H_8} = -q_{cal} = -64.37 \, kJ$

$\Delta H_{comb} = \frac{-64.37 \, kJ}{1.276 \, g \, C_3H_8} \times \frac{44.09 \, g \, C_3H_8}{1 \, mol \, C_3H_8}$

$= -2224.195 \, kJ/mol \Rightarrow \boxed{-2220 \, kJ/mol}$

11. Target: $2\,CH_4(g) + O_2(g) \rightarrow 2\,CH_3OH(l)$ $\Delta H = ?$

$2\,CH_4(g) + \cancel{2\,H_2O}(g) \rightarrow \cancel{2\,CO}(g) + \cancel{6\,H_2}(g)$ $\Delta H = 2(206.10 \, kJ)$
$\cancel{4\,H_2}(g) + \cancel{2\,CO}(g) \rightarrow 2\,CH_3OH(l)$ $\Delta H = 2(-128.33 \, kJ$
$\cancel{2\,H_2}(g) + O_2(g) \rightarrow \cancel{2\,H_2O}(g)$ $\Delta H = -483.64 \, kJ$

$2\,CH_4(g) + O_2(g) \rightarrow 2\,CH_3OH(l)$ $\boxed{\Delta H = -328.10 \, kJ}$

12. $C(graphite) + 2\,H_2(g) + \frac{1}{2}O_2(g) \rightarrow CH_3OH(l)$

13. $Ag(s) + \frac{1}{2}N_2(g) + \frac{3}{2}O_2(g) \rightarrow AgNO_3(s) \quad \Delta H = -124.4\ kJ$

14. target: $2\,C(s) + 3\,H_2(g) \rightarrow C_2H_6$

given:

$2 \times (C(s) + O_2(g) \rightarrow CO_2(g)) \qquad \Delta H = (-393.5\ kJ) \times 2$

$3 \times (H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)) \qquad \Delta H = (-285.8\ kJ) \times 3$

rev $\times \frac{1}{2}$ $(2\,C_2H_6(g) + 7O_2(g) \rightarrow 4\,CO_2(g) + 6\,H_2O(l))$

$\Delta H = (-3119.6\ kJ) \times -\frac{1}{2}$

So:

$2\,C(s) + \cancel{2O_2(g)} \rightarrow \cancel{2CO_2(g)} \qquad \Delta H = -787.0\ kJ$

$3\,H_2(g) + \cancel{\frac{3}{2}O_2(g)} \rightarrow \cancel{3\,H_2O(l)} \qquad \Delta H = -857.4\ kJ$

$\cancel{2\,CO_2(g)} + \cancel{3\,H_2O(l)} \rightarrow C_2H_6(g) + \cancel{\frac{7}{2}O_2(g)} \qquad \Delta H = +1559.8\ kJ$

$2\,C(s) + 3\,H_2(g) \rightarrow C_2H_6(g) \qquad \boxed{\Delta H = -84.6\ kJ}$

15. $SO_2(g) + 2H_2S(g) \rightarrow \frac{3}{8}S_8(g) + 2H_2O(g) \quad \Delta H = ?$

$$\Delta H^\circ_{rxn} = \left[(3/8\,mol)\left(102.3\,\frac{kJ}{mol}\right) + (2\,mol)\left(-241.82\,\frac{kJ}{mol}\right)\right] - \left[(1\,mol)\left(-296.9\,\frac{kJ}{mol}\right) + (2\,mol)\left(-20.17\,\frac{kJ}{mol}\right)\right]$$

$= (38.36\ kJ + -483.64\ kJ) - (-296.9\ kJ + -40.34\ kJ)$

$= -108.04\ kJ \Rightarrow -108.0\ kJ$

16. $2\,C_6H_6(l) + 15\,O_{2(g)} \rightarrow 12\,CO_2(g) + 6\,H_2O(l)$ $\Delta H_{rxn} = -6534\,kJ$

$\Delta H_f^\circ\,(CO_2(g)) = -393.5\ kJ/mol$
$\Delta H_f^\circ\,(H_2O(l)) = -285.83\ kJ/mol$
$\Delta H_f^\circ\,(O_2(g)) = 0$
$\Delta H_f^\circ\,(C_6H_6(l)) = ?$

$$-6534\,kJ = \left[(12\,mol)\left(-393.5\,\frac{kJ}{mol}\right) + (6\,mol)\left(-285.83\,\frac{kJ}{mol}\right)\right] - \left[(2\,mol\,C_6H_6)\left(\Delta H_f^\circ\,C_6H_6\right)\right]$$

$$-6534\,kJ = -6436.98\,kJ - (2\,mol\,C_6H_6)(\Delta H_f^\circ (C_6H_6))$$

$$(2\,mol\,C_6H_6)(\Delta H_f^\circ\,C_6H_6) = -6436.98\,kJ + 6534\,kJ$$
$$\frac{(2\,mol\,C_6H_6)(\Delta H_f^\circ\,C_6H_6)}{2\,mol\,C_6H_6} = \frac{97.02\,kJ}{2\,mol\,C_6H_6}$$

$$\Delta H_f^\circ (C_6H_6) = 48.51\,\frac{kJ}{mol\,C_6H_6} = \boxed{49\,kJ/mol}$$

17. (a) $NaHCO_3$ (d) $Ca(NO_3)_2$
(b) H_2SO_4 (e) $Al_2(SO_4)_3$
(c) H_3PO_4 (f) $Mg(OH)_2$