Chem 115
Practice Problems for Test 2

1. A 1.45-g sample of acetic acid (m.w. = 60.06 u) was burned in excess oxygen in the bomb of a calorimeter with a heat capacity of 5.81 kJ/°C. The temperature of the calorimeter and its contents rose from 24.32 °C to 27.95 °C. From this experiment, what is the molar heat of combustion of acetic acid?

   Solution:

   $\Delta T = (27.95 - 24.32)\ ^\circ\text{C} = 3.63\ ^\circ\text{C}$

   $q_{cal} = (5.81\ \text{kJ/}^\circ\text{C})(3.63\ ^\circ\text{C}) = 21.0_9\ \text{kJ}$

   $$q_{rxn} = \left(\frac{-21.0_9\ \text{kJ}}{1.45\,\text{g}}\right)\left(\frac{60.06\ \text{g}}{\text{mol}}\right) = -873._{57}\ \text{kJ/mol} = -874\ \text{kJ/mol}$$

2. Given:

   (a) $FeO(s) + H_2(g) \rightarrow Fe(s) + H_2O(g)$ $\quad \Delta H = +24.7$ kJ

   (b) $3\ FeO(s) + \frac{1}{2}\ O_2(g) \rightarrow Fe_3O_4(s)$ $\quad \Delta H = -317.6$ kJ

   (c) $H_2(g) + \frac{1}{2}\ O_2(g) \rightarrow H_2O(g)$ $\quad \Delta H = -241.8$ kJ

   Calculate the value of ΔH for the reaction

   $3\ Fe(s) + 4\ H_2O(g) \rightarrow Fe_3O_4(s) + 4\ H_2(g)$ $\quad \Delta H = ?$

   Solution:

   (–3a) $3\ Fe(s) + 3\ H_2O(g) \rightarrow 3\ FeO(s) + 3\ H_2(g)$ $\quad \Delta H = -74.1$ kJ

   (b) $3\ FeO(s) + \frac{1}{2}\ O_2(g) \rightarrow Fe_3O_4(s)$ $\quad \Delta H = -317.6$ kJ

   (–c) $H_2O(g) \rightarrow H_2(g) + \frac{1}{2}\ O_2(g)$ $\quad \Delta H = +241.8$ kJ

   $3\ Fe(s) + 4\ H_2O(g) \rightarrow Fe_3O_4(s) + 4\ H_2(g)$ $\quad \Delta H = -149.9$ kJ

3. The combustion of hydrazine, $N_2H_4(l)$ in excess oxygen produces $N_2(g)$ and $H_2O(l)$. The standard enthalpy of combustion of $N_2H_4(l)$ is –622.4 kJ, and the standard enthalpy of formation of $H_2O(l)$ is –285.9 kJ. From this information, calculate the standard enthalpy of formation of $N_2H_4(l)$.

   Solution:

   $N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2\ H_2O(l) \qquad \Delta H^\circ_c = -622.4\ \text{kJ}$

   $\Delta H^\circ_c = 2\ \Delta H^\circ_f(H_2O) - \Delta H^\circ_f(N_2H_4)$

   $\Delta H^\circ_f(N_2H_4) = 2\ \Delta H^\circ_f(H_2O) - \Delta H^\circ_c = (2)(-285.9\ \text{kJ}) - (-622.4\ \text{kJ}) = +50.6\ \text{kJ}$

4. (a) How many grams of NaOH (f.w. = 40.00 u) are needed to prepare exactly 250 mL of a 1.25 M solution of NaOH(*aq*)?

   $$\text{g NaOH} = (0.250\ \text{L})\left(\frac{1.25\ \text{mol}}{\text{L}}\right)\left(\frac{40.00\ \text{g}}{\text{mol}}\right) = 12.5\ \text{g}$$

   (b) How many milliliters of 1.25 M NaOH solution are need to prepare exactly 500 mL of 3.50×10^{-3} M NaOH solution?

   $$V = \frac{(500\ \text{mL})(3.50\times10^{-3}\ \text{M})}{1.25\ \text{M}} = 1.40\ \text{mL}$$

   (c) A 25.0-mL sample of 3.50×10^{-3} M NaOH solution is titrated with 5.00×10^{-3} M HCl solution. How many milliliters of the acid solution are needed to reach the equivalence point?

   $HCl(aq) + NaOH(aq) \rightarrow H_2O(l) + NaCl(aq)$

   $$V_{HCl} = \frac{M_{NaOH}V_{NaOH}}{M_{HCl}} = \frac{(3.50\times10^{-3}\ \text{M})(25.00\ \text{mL})}{5.00\times10^{-3}\ \text{M}} = 17.5\ \text{mL}$$

   (d) If titration of a 25.0-mL sample of a solution of KOH of unknown concentration requires 32.5 mL of 0.100 M HCl solution to reach the equivalence point, what is the concentration of the KOH solution?

   $KOH(aq) + HCl(aq) \rightarrow H_2O(l) + KCl(aq)$

   $$M_{KOH} = \frac{V_{HCl}M_{HCl}}{V_{KOH}} = \frac{(32.5\ \text{mL})(0.100\ \text{M})}{25.0\ \text{mL}} = 0.130\ \text{M}$$

(e) What is the nitrate ion concentration in a solution prepared by mixing 40.0 mL of 0.100 M $Ca(NO_3)_2(aq)$ with 30.0 mL of 0.200 M $NaNO_3(aq)$?

$Ca(NO_3)_2(aq) \rightarrow Ca^{2+}(aq) + 2\ NO_3^-(aq)$

mmol NO_3^- = 2 × mmol $Ca(NO_3)_2$ = (2)(40.0 mL)(0.100 M) = 8.00 mmol

$NaNO_3(aq) \rightarrow Na^+(aq) + NO_3^-(aq)$

mmol NO_3^- = mmol $NaNO_3$ = (30.0 mL)(0.200 M) = 6.00 mmol

$$[NO_3^-] = \frac{8.00\ \text{mmol} + 6.00\ \text{mmol}}{70.0\ \text{mL}} = 0.200\ \text{M}$$

5. Indicate whether the following ionic compounds are soluble or insoluble in water. If sparingly soluble, write soluble.

$PbSO_4$	insoluble	$BaCO_3$	insoluble
BaS	soluble	Cs_3PO_4	soluble
$Al(OH)_3$	insoluble	$AgC_2H_3O_2$	soluble

6. Indicate whether the following are strong electrolytes, weak electrolytes, or non-electrolytes.

$H_3PO_4(aq)$	weak electrolyte	$NaNO_3(aq)$	strong electrolyte
$PbS(s)$	strong electrolyte	$C_2H_5NH_2(aq)$	weak electrolyte
$HClO_4(aq)$	strong electrolyte	$C_2H_5OH(aq)$	non-electrolyte

7. Write net ionic equations for each of the following, if a metathetical reaction occurs. If no reaction occurs, write "n. r."

(a) $Hg_2(NO_3)_2(aq) + KBr(aq) \rightarrow$

$Hg_2^{2+}(aq) + 2\ Br^-(aq) \rightarrow Hg_2Br_2(s)$

(b) $Hg(NO_3)_2(aq) + HBr(aq) \rightarrow$

n.r.

(c) $(NH_4)_3PO_4(aq) + BaCl_2(aq) \rightarrow$

$2\ PO_4^{3-}(aq) + 3\ Ba^{2+}(aq) \rightarrow Ba_3(PO_4)_2(s)$

(d) $CaCO_3(s) + HNO_3(aq) \rightarrow$

$CaCO_3(s) + 2\ H^+(aq) \rightarrow Ca^{2+}(aq) + CO_2(g) + H_2O(l)$

(e) $HNO_2(aq) + Ca(OH)_2(aq) \rightarrow$

$HNO_2(aq) + OH^-(aq) \rightarrow H_2O(l) + NO_2^-(aq)$

8. Consider light with a wavelength of 625.6 nm. (speed of light = 2.998×10^8 m·s^{-1}; Planck's constant = 6.626×10^{-34} J·s)

(a) What is the frequency?

$$\nu = \frac{c}{\lambda} = \frac{2.998 \times 10^8\ \text{m}\cdot\text{s}^{-1}}{625.6 \times 10^{-9}\ \text{m}} = 4.792 \times 10^{14}\ \text{s}^{-1}$$

(b) What is the energy of one photon of this light?

$E = h\nu = (6.626 \times 10^{-34}\ \text{J}\cdot\text{s})(4.792 \times 10^{14}\ \text{s}^{-1}) = 3.175 \times 10^{-19}\ \text{J}$

(c) How many photons would supply exactly 100 kJ of energy?

$$\text{photons} = (100\ \text{kJ})\left(\frac{\text{photon}}{3.175 \times 10^{-19}\ \text{J}}\right)\left(\frac{10^3\ \text{J}}{\text{kJ}}\right) = 3.149 \times 10^{23}\ \text{photons}$$