1. (20) a. (5) An experiment requires 250 mL of 1.0 M HNO₃ solution. All you have available is a bottle of 6.0 M HNO₃. How would you prepare the desired solution?

\[ V_c = \frac{M_d V_d}{M_c} = \frac{1.0 \text{ M} \times 250 \text{ mL}}{6.0 \text{ M}} = 41.7 \text{ mL} \]

b. (5) A system absorbs 77.5 kJ of heat while doing 63.5 kJ of work on the surroundings. What is the change in its internal energy?

\[ \Delta E = q + w = 77.5 - 63.5 = +14 \text{ kJ} \]

c. (5) Determine the oxidation number for the indicated element in each of the following substances:

- C in COCl₂ : +4
- S in SO₃ : +6
- Mn in MnO₄⁻ : +7
- Br in HBrO : +1
As in As\textsubscript{4} : 0
O in K\textsubscript{2}O\textsubscript{2} : -1

d. (5) Using data from your data sheet calculate the enthalpy of the thermite reaction:

\[ 2 \text{Al} (s) + \text{Fe}_2\text{O}_3 (s) \rightarrow \text{Al}_2\text{O}_3 (s) + 2 \text{Fe} (s) \]

\[ \Delta H \text{f for Al(s) and Fe(s) is 0.} \]

\[ \Delta H = \Delta H \text{f (Al}_2\text{O}_3 (s)) - \Delta H \text{f (Fe}_2\text{O}_3 (s)) = -1669.8 - (-822.8) = -847 \text{ kJ} \]

2. (15) 6.67 g of Sr(NO\textsubscript{3})\textsubscript{2} is dissolved in water to form 0.750 L solution. A 0.100-L sample is withdrawn from this stock solution and titrated with a 0.0460 M solution of Na\textsubscript{2}CrO\textsubscript{4}. What volume of Na\textsubscript{2}CrO\textsubscript{4} solution is required to precipitate all the Sr\textsuperscript{2+} (aq) as SrCrO\textsubscript{4}?  

\[ \text{Sr(NO}_3\textsubscript{2} (aq) + Na}_2\text{CrO}_4 (aq) \rightarrow \text{SrCrO}_4 (s) + 2 \text{NaNO}_3 (aq) \]

\[ \text{MW of Sr(NO}_3\textsubscript{2} = 87.62 + 2*(14.01+3*16.00) = 211.64 \text{ g/mol} \]

\[ \frac{6.67 \text{ g}}{211.64 \text{ (g/mol)}} = 0.0315 \text{ mol} \times \frac{0.100}{0.750} = 4.20 \times 10^{-3} \text{ mol} \]

\[ 4.20 \times 10^{-3} \text{ mol Sr(NO}_3\textsubscript{2} \times (1 \text{ mol Na}_2\text{CrO}_4/1 \text{ mol Sr(NO}_3\textsubscript{2}) = \]

\[ 4.20 \times 10^{-3} \text{ mol Na}_2\text{CrO}_4 \]

\[ \text{Vol} = \text{n moles/molarity} = 4.20 \times 10^{-3} \text{ mol} / 0.0460 \text{ (mol/L)} = 0.0914 \text{ L} \]

3. (15) Consider the following reaction:

\[ 2 \text{Mg} (s) + \text{O}_2 (g) \rightarrow 2 \text{MgO} (s) \]

\[ \Delta H = -1204 \text{ kJ} \]
a) (3 pts) Is this reaction exothermic or endothermic?

**Exothermic**

b) (6 pts) Calculate the amount of heat transferred when 2.4 g of solid Mg reacts at constant pressure.

\[ 2.4 \text{ g}/24.31 \text{ (g/mol)} = 9.9 \times 10^{-2} \text{ mol Mg} \]

\[ q = 9.9 \times 10^{-2} \text{ mol Mg} \times (1204 \text{ kJ/2 mol Mg}) = 59 \text{ kJ} \]

c) (6 pts) How many grams of MgO are produced during an enthalpy change of 96.0 kJ?

\[ q = 96.0 \text{ kJ} = n \times (1204 \text{ kJ/2 mol MgO}) \Rightarrow n = 0.159 \text{ mol MgO} \]

MW of MgO: 24.31 + 16.00 = 40.31 g/mol

\[ 0.159 \text{ mol} \times 40.31 \text{ g/mol} = 6.41 \text{ g} \]

4. (10) Based on the activity series, what is the outcome of each of the following reactions? (Balance the equations and give the state of each substance)

\[ 2 \text{ Al (s)} + 3 \text{ NiCl}_2 \text{ (aq)} \rightarrow 2\text{AlCl}_3 \text{ (aq)} + 3 \text{ Ni (s)} \]

\[ \text{Ag(s)} + \text{Pb(NO}_3\text{)}_2 \text{ (aq)} \rightarrow \text{no reaction} \]

\[ 2 \text{ Cr(s)} + 3 \text{ NiSO}_4 \text{ (aq)} \rightarrow \text{Cr}_2\text{(SO}_4\text{)}_3 \text{ (aq)} + 3 \text{ Ni (s)} \]

\[ \text{Mn(s)} + 2 \text{ HBr (aq)} \rightarrow \text{MnBr}_2 \text{ (aq)} + \text{H}_2 \text{ (g)} \]

\[ \text{H}_2 \text{ (g)} + \text{CuCl}_2 \text{ (aq)} \rightarrow 2\text{HCl (aq)} + \text{Cu (s)} \]

5. (10) When a 6.50-g sample of solid NaOH dissolves in 100.0 g of water in a coffee-cup calorimeter, the temperature rises from 21.6 °C to 37.8 °C. Assuming that the specific heat of the solution is the same as that of pure
water (4.18 J/gK) calculate ΔH (in kJ/mol of NaOH) for the solution process:

\[
\text{NaOH (s)} \rightarrow \text{Na}^+ (aq) + \text{OH}^- (aq)
\]

6.50 g/ (40.00 g/mol) = 0.163 mol NaOH \hspace{1cm} ΔT = 16.2 K

q = 4.18 J/gK \times 106.5 \text{ g} \times 16.2 \text{ K} = 7.21 \text{ kJ}

\[
7.21 \text{ kJ}/0.163 \text{ mol} = 44.2 \text{ kJ/mol}
\]

ΔH = -44.2 kJ per mol NaOH \hspace{1cm} \text{(the T rises, so exothermic reaction)}

6. (15) Complete the following reactions and write the corresponding net ionic equations. Identify the spectator ion or ions in each reaction:

a) Pb(NO\textsubscript{3})\textsubscript{2} (aq) + Na\textsubscript{2}SO\textsubscript{4} (aq) \rightarrow Pb \text{SO}_4 (s) + 2 NaNO\textsubscript{3} (aq)

Net ionic: Pb\textsuperscript{2+} (aq) + SO\textsubscript{4}\textsuperscript{2-} (aq) \rightarrow Pb \text{SO}_4 (s)

Spectator Ions: Na\textsuperscript{+}, NO\textsubscript{3}\textsuperscript{-}

b) CuBr\textsubscript{2} (aq) + 2 NaOH (aq) \rightarrow Cu(OH) (s) + 2 NaBr (aq)

Net ionic: Cu\textsuperscript{2+} (aq) + 2 OH\textsuperscript{-} (aq) \rightarrow Cu(OH) (s)

Spectator Ions: Na\textsuperscript{+}, Br\textsuperscript{-}

c) AgNO\textsubscript{3} (aq) + KI (aq) \rightarrow AgI (s) + KNO\textsubscript{3} (aq)

Net ionic: Ag\textsuperscript{+} (aq) + I\textsuperscript{-} (aq) \rightarrow AgI (s)
Spectator Ions: K⁺, NO₃⁻

7. (15) From the following enthalpies of reaction:

\[ \text{H}_2 (g) + \text{F}_2 (g) \rightarrow 2 \text{HF} (g) \quad \Delta H = -537 \text{ kJ} \]

\[ \text{C} (s) + 2 \text{F}_2 (g) \rightarrow \text{CF}_4 (g) \quad \Delta H = -680 \text{ kJ} \]

\[ 2 \text{C} (s) + 2 \text{H}_2 (g) \rightarrow \text{C}_2\text{H}_4 (g) \quad \Delta H = +52.3 \text{ kJ} \]

calculate the enthalpy of the reaction:

\[ \text{C}_2\text{H}_4 (g) + 6 \text{F}_2 (g) \rightarrow 2 \text{CF}_4 (g) + 4 \text{HF} (g) \]

**Multiply the first and second by 2, flip the third and add them up:**

\[ (-537) \times 2 + (-608) \times 2 + (-52.3) = -2486.3 \text{ kJ} \]