1. a. (5) Write a balanced chemical equation for the neutralization of Ba(OH)$_2$ by hydrochloric acid indicating the states of each substance (aq,s,l,g).

   $\text{Ba(OH)}_2 \text{(aq)} + 2\text{HCl (aq)} \rightarrow \text{BaCl}_2 \text{(aq)} + 2\text{H}_2\text{O (l)}$

b. (5) Write the net ionic equation for the above reaction

   $\text{OH}^- \text{(aq)} + \text{H}^+ \text{(aq)} \rightarrow \text{H}_2\text{O (l)}$

2. (10) How many liters of oxygen at 25 oC and 750 torr and needed for the combustion of 2.0 g of propane (C$_3$H$_8$. Molar mass=44.09 g/mol)? (R=0.0821 atm L/mol K. 1 atm=760 torr)

   $\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$

   $\frac{2.0 \text{ g}}{44.09 \text{ g/mol}} \times \frac{5 \text{ mol O}_2}{1 \text{ mol C}_3\text{H}_8} = 0.227 \text{ mol O}_2$ are required

   Ideal gas law: $V = nRT/P = \frac{0.227 \text{ mol X 0.0821 atm L/mol K X (273.15+25) K}}{750 \text{ torr X 1atm/760 torr}} = 5.6 \text{ L (2 signif fig)}$
3. (10) What is the standard enthalpy of the following reaction at 25 °C:

$$2C_2H_6 (g) + 7O_2 (g) \rightarrow 4CO_2 (g) + 6H_2O (g)$$

(Hint: use information on your data sheet)

Using the table of enthalpies of formation:
$$\Delta H^0 = 6 \text{ mol} \times (-241.8 \text{ kJ/mol}) + 4 \text{ mol} \times (-393.5 \text{ kJ/mol}) - 2 \text{ mol} \times (-84.68 \text{ kJ/mol}) = -2855.4 \text{ kJ}$$

4. (10) A 20.0 g bar of an unknown metal at 90.0 °C is dropped into 100 mL of water at 25.0 °C. The final temperature of the system is 26.1 °C. Estimate the specific heat of the unknown metal. The density of water is 1.00 g/cm³. (Hints: use information on your data sheet. The heat that the metal loses is equal to the heat that the water gains)

From Table 7.1 the specific heat of water at 25 °C is 4.18 J/g °C
Say S is the specific heat of the unknown metal.
Heat = 100 mL \times 1.00 g/mL \times 4.18 J/g°C \times (26.1-25.0) °C
= 20.0 g \times S \times (90.0-26.1) °C
⇒ S = 0.360 J/g °C

5. (15) 5.0 g of a sample containing CaCl₂ along with other substances is dissolved in water together with potassium sulfite (K₂SO₃) and gives insoluble calcium sulfite, which, after drying, is found to weigh 2.1 g. The molar mass of calcium sulfite is 120.14 g/mol and of CaCl₂ is 110.99 g/mol.

(a) (4) Write a balanced chemical equation for the reaction indicating states

$$\text{CaCl}_2 (aq) + \text{K}_2\text{SO}_3 (aq) \rightarrow \text{CaSO}_3 (s) + 2\text{KCl (aq)}$$

(b) (4) Write the net ionic equation for the reaction

$$\text{Ca}^{2+} (aq) + \text{SO}_3^{2-} (aq) \rightarrow \text{CaSO}_3 (s)$$
(c) (7) Find the percentage by mass of CaCl$_2$ in the original sample.

\[
\frac{2.1 \text{ g}}{120.14 \text{ g/mol}} : \text{ moles of CaSO}_3 = \text{ moles of CaCl}_2
\]
\[
\times 110.99 \text{ g/mol} = 1.94 \text{ g CaCl}_2
\]
\[
\frac{1.94}{5.0} \times 100\% = 39\% \quad (2 \text{ signif. fig.})
\]

6. A gas held at constant pressure of 1 atm is heated with an electrical wire of power 10 Watts for 10 minutes and its volume increases by 0.50 L. (Hints: Electrical energy = Power X time and it is completely converted to heat. 1 Watt = 1J/s) (R = 8.3145 J/mol K = 0.0821 atm L/ mol K)

(a) (5) In the first law of thermodynamics, what is q, w, and ΔE in Joule?

\[
q = 10 \text{ J/s} \times 10 \text{ min} \times 60 \text{ s/min} = +6000 \text{ J}
\]
\[
w = -P\Delta V = -1 \text{ atm} \times 0.5 \text{ L} \times (8.3145\text{ J/0.0821 atm L}) = -51 \text{ J}
\]
\[
\Delta E = q + w = +6000 - 51 = +5949 \text{ J}
\]

(b) (5) What is the change in enthalpy of the gas

\text{It is a constant pressure process, therefore } \Delta H = q = +6000 \text{ J}

7. (15) Calculate the standard enthalpy of the reaction

\[\text{H}_2(\text{g}) + \text{Br}_2(\text{g}) \rightarrow 2\text{HBr (g)}\]

using the following data:

\[
\text{H}_2(\text{g}) \rightarrow 2\text{H}(\text{g}) \quad \Delta H^\circ = +436.0 \text{ kJ}
\]
\[
\text{Br}_2(\text{g}) \rightarrow 2\text{Br} (\text{g}) \quad \Delta H^\circ = +193.9 \text{ kJ}
\]
\[
\text{HBr(g)} \rightarrow \text{H(g)} + \text{Br(g)} \quad \Delta H^\circ = +365.7 \text{ kJ}
\]

\text{Invert the last equation and multiply by 2:}

\[2\text{H(g)} + 2\text{Br(g)} \rightarrow 2\text{HBr(g)} \quad \Delta H^\circ = -2*365.7 \text{ kJ}\]

Then add to the first two equations to get:

\[\text{H}_2(\text{g}) + \text{Br}_2(\text{g}) \rightarrow 2\text{HBr (g)}\]

\[
\Delta H^\circ = +436.0 +193.9 - 2*365.7 = -101.5 \text{ kJ}
\]
8. (10) Mercury(II) oxide (HgO) is heated and decomposed into oxygen gas and mercury (Hg). The oxygen is collected over water to give a total pressure of 730.0 torr at 50 °C in 500 mL volume. How many moles of mercury oxide have decomposed in this reaction? (R=0.0821 atm L/mol K. 1 atm=760 torr) (Hint: use information on your data sheet)

$$2\text{HgO} \rightarrow 2\text{Hg} + \text{O}_2$$

From Table 6.4, $P_{\text{H}_2\text{O}} = 92.51$ torr => $P_{\text{O}_2} = 730.0 - 92.51 = 637.5$ torr

Ideal gas law: $P_{\text{O}_2} V = n_{\text{O}_2} RT$ =>

$$n_{\text{O}_2} = \frac{637.5 \text{ torr} \times 1 \text{ atm/760 torr} \times 0.500L}{0.0821 \text{ atm L/mol K (273.15 + 50)}} = 0.0158 \text{ mol}$$

This corresponds to $2 \times 0.0158 = 0.0316 \text{ mol HgO}$. 

9. (10) A 100 mL solution of 1.50 M KOH was added to a 100 mL solution of 1.50 M HNO$_3$ in a polystyrene cup:

$$\text{HNO}_3 + \text{KOH} \rightarrow \text{KNO}_3 + \text{H}_2\text{O}$$

The enthalpy of reaction is -57.10 kJ/mol. If the resulting temperature change was +9.50 °C, what is the heat capacity of the calorimeter (cup plus water) in J/°C?

\[\text{150 mol/L} \times 0.100 \text{ L} = 0.150 \text{ mol of HNO}_3 \text{ and 0.150 mol of KOH (stoichiometric ratio)}\]

\[q = 0.150 \times 57.10 = 8.565 \text{ kJ} = \text{heat capacity} \times 9.50 \text{ K}\]

\[\Rightarrow \text{heat capacity} = 902 \text{ J/K}\]