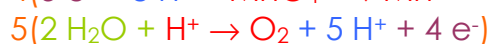
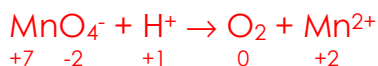


1. Permanganate ion reacts with strong acids in an oxidation-reduction reaction to produce Manganese(II) ions and oxygen gas. Write the **balanced net ionic equation** for this reaction. Using the table given, calculate the **molar enthalpy change** for this reaction. How many **grams of Calcium Permanganate** are needed to have 25.00 kJ of heat transferred?

Substance	$\Delta H_f^\circ$ (kJ mol <sup>-1</sup> )
H <sup>+</sup> <sub>(g)</sub>	1536.3
H <sup>+</sup> <sub>(aq)</sub>	0.00
H <sub>2</sub> O <sub>(g)</sub>	-241.8
H <sub>2</sub> O <sub>(l)</sub>	-285.840
Ca(MnO <sub>4</sub> ) <sub>2(s)</sub>	-1112
MnO <sub>4</sub> <sup>-</sup> <sub>(aq)</sub>	-518.4
Mn <sup>2+</sup> <sub>(aq)</sub>	-219
CO <sub>2(g)</sub>	-393.5

First we balance the redox reaction:



Determine  $\Delta H$

$$\Delta H = \left[ \left( \frac{4 \text{ mol Mn}^{2+}}{\text{mol rxn}} \right) \left( \frac{-219 \text{ kJ}}{\text{mol Mn}^{2+}} \right) + \left( \frac{5 \text{ mol O}_2}{\text{mol rxn}} \right) \left( \frac{0.00 \text{ kJ}}{\text{mol O}_2} \right) + \left( \frac{6 \text{ mol H}_2\text{O}}{\text{mol rxn}} \right) \left( \frac{-285.840 \text{ kJ}}{\text{mol H}_2\text{O}} \right) \right]$$

$$- \left[ \left( \frac{12 \text{ mol H}^+}{\text{mol rxn}} \right) \left( \frac{0.00 \text{ kJ}}{\text{mol H}^+} \right) + \left( \frac{4 \text{ mol MnO}_4^-}{\text{mol rxn}} \right) \left( \frac{-518.4 \text{ kJ}}{\text{mol MnO}_4^-} \right) \right]$$

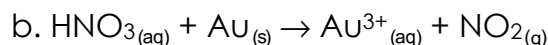
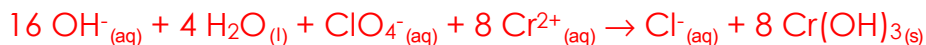
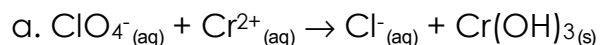
$$= -517.44 \text{ kJ (mol rxn)}^{-1}$$

Stoichiometry:

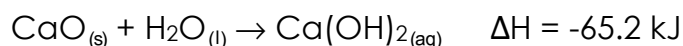
$$? \text{ g Ca(MnO}_4)_2 = -25.00 \text{ kJ} \times \frac{1 \text{ mol rxn}}{-517.44 \text{ kJ}} \times \frac{4 \text{ mol MnO}_4^-}{1 \text{ mol rxn}} \times \frac{1 \text{ mol Ca(MnO}_4)_2}{2 \text{ mol MnO}_4^-} \times \frac{277.95 \text{ g Ca(MnO}_4)_2}{1 \text{ mol Ca(MnO}_4)_2}$$

$$= 26.86 \text{ g Ca(MnO}_4)_2$$

2. **Balance** the following reactions. Give the **molecular equation** when possible.



3. Given the following thermochemical equation,



How many **grams of calcium oxide** are needed to generate enough energy to increase the temperature of 5.00 g of aluminum ( $s = 0.903 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$ ) from 231.4 K to 299.5 K?

Calculate  $q$

$$q = ms\Delta T = (5.00 \text{ g})(0.903 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1})(299.5 \text{ K} - 231.4 \text{ K}) \left( \frac{1 \text{ }^\circ\text{C}}{1 \text{ K}} \right) = 307 \text{ J}$$

Stoichiometry

$$? \text{ g CaO} = -307 \text{ J} \times \frac{1 \text{ mol rxn}}{-65.2 \times 10^3 \text{ J}} \times \frac{1 \text{ mol CaO}}{1 \text{ mol rxn}} \times \frac{56.08 \text{ g CaO}}{1 \text{ mol CaO}} = 0.264 \text{ g CaO}$$

4. Helium gas is found to effuse 6.55 times faster than an unknown gas. Calculate the **molar mass** of the unknown gas. What is the **rms speed** of the unknown gas at standard temperature?

$$\frac{R_{\text{He}}}{R_{\text{unk}}} = \sqrt{\frac{M_{\text{unk}}}{M_{\text{He}}}}$$

$$R_{\text{He}} = 6.55 R_{\text{unk}}$$

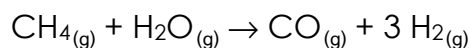
$$\frac{6.55 R_{\text{unk}}}{R_{\text{unk}}} = 6.55 = \sqrt{\frac{M_{\text{unk}}}{M_{\text{He}}}}$$

$$M_{\text{unk}} = (6.55)^2 M_{\text{He}} = (6.55)^2 (4.0026 \text{ g mol}^{-1}) = 172 \text{ g mol}^{-1}$$

$$u_{\text{rms}} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3(8.314 \text{ J mol}^{-1} \text{ K}^{-1})(273.15 \text{ K})}{(172 \times 10^{-3} \text{ kg mol}^{-1})}} = 199.0224 \text{ m s}^{-1}$$

$$= 199 \text{ m s}^{-1}$$

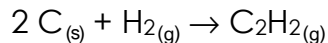
5. Hydrogen,  $\text{H}_2$ , is prepared by *steam reforming*, in which hydrocarbons are reacted with steam. For  $\text{CH}_4$ ,



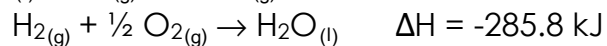
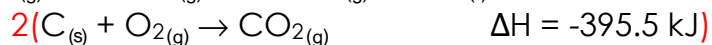
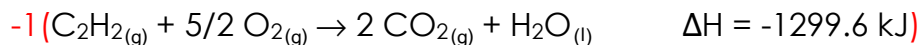
Calculate the **enthalpy change**  $\Delta H^\circ$  for this reaction, using standard enthalpies of formation.

$$\begin{aligned} \Delta H &= \left[ \left( \frac{1 \text{ mol CO}}{1 \text{ mol rxn}} \right) \left( \frac{-110.5 \text{ kJ}}{1 \text{ mol CO}} \right) + \left( \frac{3 \text{ mol H}_2}{1 \text{ mol rxn}} \right) \left( \frac{0.00 \text{ kJ}}{1 \text{ mol H}_2} \right) \right] \\ &\quad - \left[ \left( \frac{1 \text{ mol CH}_4}{1 \text{ mol rxn}} \right) \left( \frac{-74.87 \text{ kJ}}{1 \text{ mol CH}_4} \right) + \left( \frac{1 \text{ mol H}_2\text{O}}{1 \text{ mol rxn}} \right) \left( \frac{-241.8 \text{ kJ}}{1 \text{ mol H}_2\text{O}} \right) \right] \\ &= +206.2 \text{ kJ (mol rxn)}^{-1} \end{aligned}$$

6. Calculate  $\Delta H$  for the reaction



given the following thermochemical equations



$$\Delta H = -(-1299.6 \text{ kJ}) + (2)(-395.5 \text{ kJ}) + (1)(-285.8 \text{ kJ}) = 222.8 \text{ kJ}$$

7. An 18.6-mL volume of hydrochloric acid reacts completely with a solid sample of  $\text{MgCO}_3$ . The reaction is



The volume of  $\text{CO}_2$  formed is 159 mL at  $23^\circ\text{C}$  and 731 mmHg. What is the **molarity of the HCl** solution?

$$? \frac{\text{mol HCl}}{\text{L}} = \frac{\left( \frac{(159 \times 10^{-3} \text{ L})(731 \text{ mmHg})}{(62.364 \text{ L mmHg mol}^{-1} \text{ K}^{-1})(296 \text{ K})} \right)}{18.6 \text{ mL}} \times \frac{1 \text{ mL}}{10^{-3} \text{ L}} \times \frac{2 \text{ mol HCl}}{1 \text{ mol CO}_2} = 0.677 \text{ M HCl}$$