

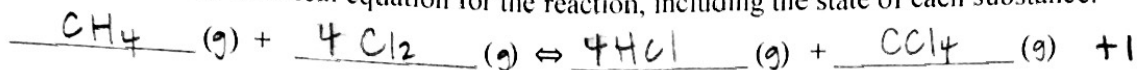
Chemistry HP Final Review Problem

Name: answer key

Period:

Methane gas reacts with chlorine gas to produce hydrochloric acid vapor and gaseous carbon tetrachloride.

(a) Write a balanced chemical equation for the reaction, including the state of each substance.



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(b) The reaction is carried out at 80.0 °C and 8.40 atm with 500 mL of methane. Determine the moles of methane contained in this volume.

$$PV = nRT$$

$$(8.40 \text{ atm})(0.500 \text{ L}) = n(0.0821)(353 \text{ K})$$

Moles of methane: 0.145 moles +1

(c) Determine the moles and mass of chlorine required in the reaction.

$$0.145 \text{ moles CH}_4 \times \frac{4 \text{ mol Cl}_2}{1 \text{ mol CH}_4} = 0.580 \text{ mol Cl}_2$$

Moles Chlorine: 0.580 mol +1

$$0.580 \text{ mol Cl}_2 \times \frac{70.90 \text{ g}}{1 \text{ mol Cl}_2} = 41.1 \text{ g Cl}_2$$

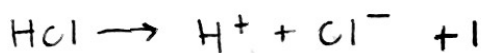
Mass Chlorine: 41.1 g +1

(d) Determine the moles of hydrochloric acid produced. The hydrochloric acid is dissolved in 2.00 L of water. Determine the concentration and pH of the resulting solution.

$$0.580 \text{ mol Cl}_2 \times \frac{4 \text{ mol HCl}}{4 \text{ mol Cl}_2} = 0.580 \text{ mol HCl}$$

$$\frac{0.580 \text{ mol}}{2.00 \text{ L}} = 0.290 \text{ M} = [\text{H}^+]$$

Moles HCl: 0.580 mol +1



[HCl]: 0.290 M +1

$$\text{pH} = -\log(0.290)$$

pH: 0.538 +1

(e) Determine the moles and mass of carbon tetrachloride produced. Calculate the amount of heat required to increase the temperature from 80.0 °C to 95.0 °C (the specific heat capacity of carbon tetrachloride is 0.542 J/g °C)

$$0.580 \text{ mol HCl} \times \frac{1 \text{ mol CCl}_4}{4 \text{ mol HCl}} = 0.145 \text{ mol CCl}_4$$

$$0.145 \text{ mol CCl}_4 \times \frac{153.81 \text{ g CCl}_4}{1 \text{ mol CCl}_4} = 22.3 \text{ g}$$

$$\Delta H = mc\Delta T$$

$$= (22.3 \text{ g})(0.542 \frac{\text{J}}{\text{g}^\circ\text{C}})(95.0 - 80.0^\circ\text{C})$$

$$= 181.299 \text{ J}$$

Moles: 0.145 mol +1

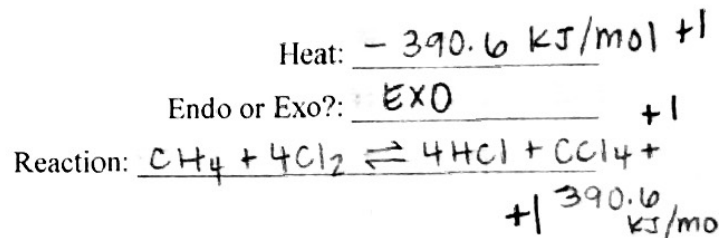
Mass: 22.3 g +1

Heat: 181 J +1

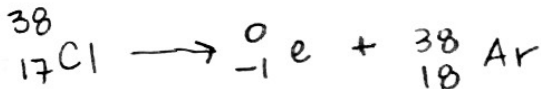
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- (f) Calculate the heat of the reaction from the heats of formation. (The heat of formation of carbon tetrachloride is -96.0 kJ/mol) Is the reaction endothermic or exothermic? Write the reaction to include the heat term on the correct side of the equation.

$$\begin{aligned}\Delta H &= H_{\text{products}} - H_{\text{reactants}} \\ &= -96.0 + 4(-92.3) - [74.6 + 4(0)] \\ &= -390.6 \text{ kJ/mol}\end{aligned}$$

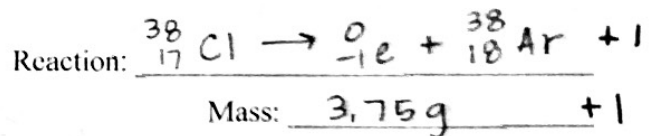


- (g) Chlorine-38 undergoes beta decay. Give an equation for this reaction. Chlorine-38 has a half-life of 37.2 minutes. What mass of a 120 g sample would remain after 186 minutes?

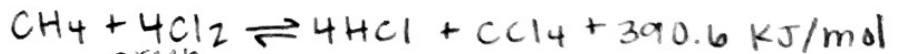


$$\frac{186 \text{ min}}{37.2 \text{ min}} = 5 \text{ half lives}$$

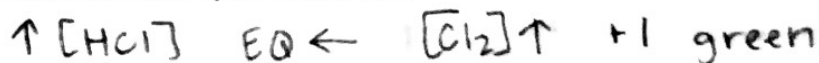
$$120 \xrightarrow{1} 60 \xrightarrow{2} 30 \xrightarrow{3} 15 \xrightarrow{4} 7.5 \xrightarrow{5} 3.75$$



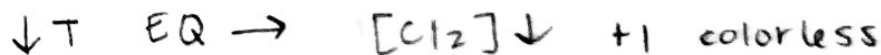
- (h) Chlorine is a green gas. Describe the effect on the concentration of chlorine and the color for each of the following stresses:



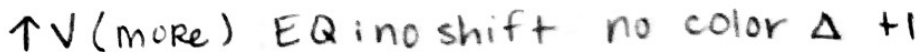
- a. increase the concentration of hydrochloric acid



- b. decrease the temperature



- c. increase the volume.



- (i) Write a K_{eq} expression for the reaction.

$$K_{\text{eq}} = \frac{[\text{HCl}]^4 [\text{CCl}_4]}{[\text{CH}_4] [\text{Cl}_2]^4} + 1$$