Review for Thermodynamics Free Response

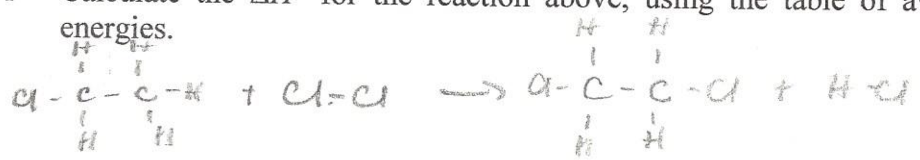
Standard Free Energies of Formation at 298 K	
Substance	ΔG°_f 298 K, kJ mol^{-1}
$C_2H_4Cl_2(g)$	-80.3
$C_2H_5Cl(g)$	-60.5
$HCl(g)$	-95.3
$Cl_2(g)$	0

Average Bond Dissociation Energies at 298 K	
Bond	Energy, kJ mol^{-1}
C-H	414
C-C	347
C-Cl	377
Cl-Cl	243
H-Cl	431

The tables above contain information for determining thermodynamic properties of the reaction below.

$$C_2H_5Cl(g) + Cl_2(g) \rightarrow C_2H_4Cl_2(g) + HCl(g)$$

1 Calculate the ΔH° for the reaction above, using the table of average bond dissociation energies.



C-C + 5C-H + C-Cl + Cl-Cl − C-C + 4C-H + 2C-Cl + HCl

(347 + 5(414) + 377 + 243) − (347 + 4(414) + 2(377) + 431)

3037 − 3188 = $\boxed{-151 \text{ kJ}}$

2 Calculate the ΔS° for the reaction at 298 K, using data from either table as needed.

$\Delta G = (-95.3 + -80.3) - (-60.5) = -115.1$ kJ

$\Delta G = \Delta H + \Delta S T$ $\quad -115.1 = (-151) + \Delta S(298)$

$\frac{35.9}{298} = \Delta S = \boxed{.120 \text{ kJ or } 120 \text{ J}}$

The combustion of carbon monoxide is represented by the equation above.

3 Determine the value of the standard enthalpy change, ΔH°_{rxn} for the combustion of $CO(g)$ at 298 K using the following information.

$C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g)$ $\quad \Delta H^\circ_{298} = -110.5$ kJ mol^{-1}

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\quad \Delta H^\circ_{298} = -393.5$ kJ mol^{-1}

$2CO + O_2 \rightarrow 2CO_2$

$2CO \rightarrow \cancel{2C} + \cancel{O_2}$ $\quad \Delta H = (110.5 \text{ kJ})2$

$\cancel{2C} + \cancel{2}O_2 \rightarrow 2CO_2$ $\quad \Delta H = (-393.5 \text{ kJ})2$

$2CO + O_2 \rightarrow 2CO_2$ $\quad \boxed{-566 \text{ kJ}}$

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Substance	S°_{298} ($J\ mol^{-1}\ K^{-1}$)
$CO_{(g)}$	197.7
$CO_{2(g)}$	213.7
$O_{2(g)}$	205.1

4 Determine the value of the standard entropy change, ΔS°_{rxn}, for the combustion of $CO_{(g)}$ at 298 K using the information in the following table.

$\Delta S = (2 \cdot 213.7) - [(2 \cdot 197.7) + (205.1)]$

$427.4 - 600.5 = \boxed{-173.1\ J}$

5 Determine the standard free energy change, ΔG°_{rxn}, for the reaction at 298 K. Include units with your answer.

$\Delta G = -566 - (-.1731 \times 298)$

$-566 - -51.6 = \boxed{-514.4\ kJ}$

6 Is the reaction spontaneous under standard conditions at 298 K? Justify your answer.

yes, it is since ΔG is negative

7. $3N_2O(g) + 2NH_3(g) \rightarrow 4N_2(g) + 3H_2O(g)$ $\Delta H_{rxn} = -879.6$ kJ

What is the heat of formation for N_2O in kJ/mole?
(heats of formation: NH_3 = -45.9 kJ/mole and H_2O = -241.8 kJ/mole)?

$-879.6 = (3 \cdot -241.8) - [(3x) + (2 \cdot -45.9)$

$-154.2 = -3x + 91.8$

$-246 = -3x$

$\boxed{x = 82\ kJ}$