proprep

Workbook

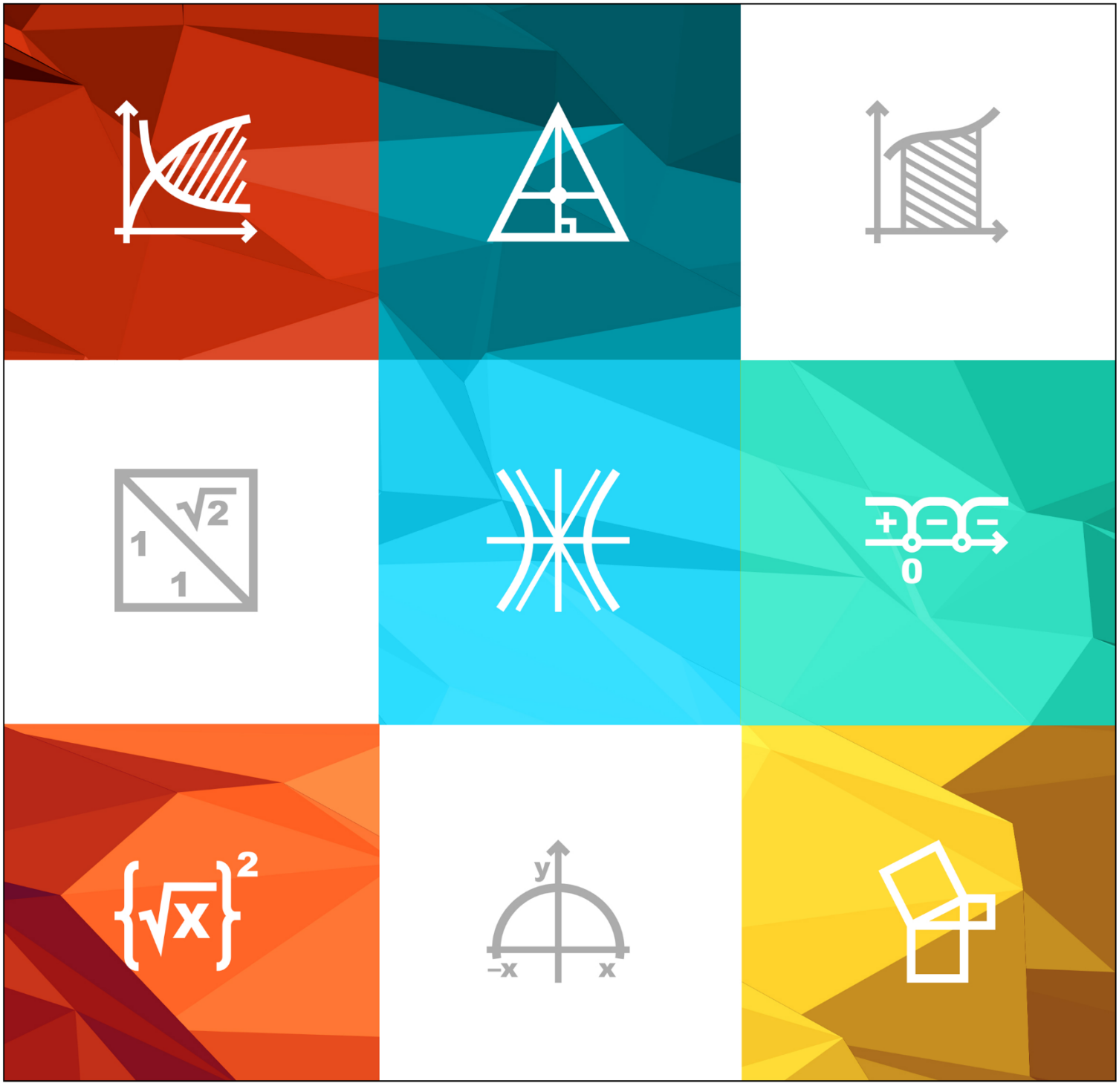

Table of Contents

Thermodynamics Second and Third Law

Global Entropy Change

Questions

1) Would you expect ΔS to be positive or negative for the following reactions? Explain your answer.

   a) $MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$

   b) $C_4H_{10}O(l) \rightarrow C_4H_8(g) + H_2O(g)$

   c) $4C(s) + 4H_2(g) \rightarrow C_4H_8(g)$

   d) $H_2(g) + O_2(g) \rightarrow H_2O_2(l)$

2) Would you expect ΔS to be positive or negative for the following processes?

   a) $Cu\ (s)\ \text{at}\ 350\ ^\circ C\ \text{and}\ 2.5\ atm \rightarrow Cu\ (s)\ \text{at}\ 450\ ^\circ C\ \text{and}\ 2.5\ atm$

   b) $CO_2(g)\ \text{at}\ 25^\circ C\ \text{and}\ 1\ atm \rightarrow CO_2(g)\ \text{at}\ 25^\circ C\ \text{and}\ 10\ mmHg$

   c) $O_2(g),\ 1\ L\ \text{at}\ 25^\circ C \rightarrow O_2(g),\ 0.1\ L\ \text{at}\ 25^\circ C$

3) Which substance would you expect to have the higher molar entropy?
   a) CH_3OH (l) or C_3H_7OH (l)
   b) 1 mol of NO (g) or 1 mol of N_2O_4 (g)
   c) n-pentene or cyclopentane

4) Which substance would you expect to have the higher molar entropy?
   a) CCl_4 (l) or CCl_4 (g)
   b) graphite or diamond
   c) CH_4 (g) or CH_3OH (l)

5) Calculate $\Delta S°$ for the following reaction:

$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$

$S°$ ($KClO_3$) = 143.1 $\frac{J}{mol \cdot K}$, $S°$ (KCl) = 82.59 $\frac{J}{mol \cdot K}$, $S°$ (O_2) = 205.1 $\frac{J}{mol \cdot K}$

6) Calculate $\Delta S°$ for the following reaction:

$S(s) + O_2(g) \rightarrow SO_2(g)$

$S°$ (S) = 31.8 $\frac{J}{mol \cdot K}$, $S°$ (O_2) = 205.1 $\frac{J}{mol \cdot K}$, $S°$ (SO_2) = 248.2 $\frac{J}{mol \cdot K}$

7) Explain why the following reaction is spontaneous.

$C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(g) + heat$

8) The following reaction is spontaneous at 25°C even though $\Delta S_{rxn} < 0$. Explain

$CaO(s) + CO_2(g) \rightarrow CaCO_3(s) + heat$

9) Calculate $\Delta G°$ for the following reaction:

$N_2(g) + O_2(g) \rightarrow 2NO(g)$

ΔG_f° (N_2) = 0 $\frac{kJ}{mol}$, ΔG_f° (O_2) = 0 $\frac{kJ}{mol}$, ΔG_f° (NO) = 86.55 $\frac{kJ}{mol}$ at 25 °C

10) Calculate $\Delta G°$ for the following reaction:

$PCl_3(g) + Cl_2(g) \rightarrow PCl_5(g)$

ΔG_f° (PCl_3) = -267.8 $\frac{kJ}{mol}$, ΔG_f° (Cl_2) = 0 $\frac{kJ}{mol}$, ΔG_f° (PCl_5) = -305.0 $\frac{kJ}{mol}$ at 25 °C

Answer Key

1) a) $\Delta S > 0$

   b) $\Delta S > 0$

   c) $\Delta S < 0$

   d) $\Delta S < 0$

2) a) $\Delta S > 0$
   b) $\Delta S > 0$
   c) $\Delta S < 0$

3) a) C_3H_7OH (l)
   b) 1 mol of N_2O_4 (g)
   c) n-pentene

4) a) CCl_4 (g)
   b) Graphite
   c) CH_4 (g)

5) 494.28 $\frac{J}{K}$

6) 11.3 $\frac{J}{K}$

7) In order for a reaction to be spontaneous, ΔS_{total} needs to be greater than 0.
   $\Delta S_{total} = \Delta S_{system} + \Delta S_{surr.}$
   We can see heat in the products so we know that the reaction is exothermic.
   Therefore, $\Delta S_{surr} > 0$.
   In the reaction, there are 12 moles of gas i the products and 6 moles of gas in the reactants.
   The number of moles of gas increases and therefore, $\Delta S_{sys} > 0$.
   $\Delta S_{total} = \Delta S_{system} + \Delta S_{surr.} > 0$.
   Therefore, the reaction is spontaneous.

8) Even though the system's entropy decreases (the number of moles of gas decreases from reactants to products), the heat released to the surroundings increases the entropy of the surroundings in a greater amount compared to the decrease in entropy of the system.
   $\Delta S_{system.} < 0$, $\Delta S_{surr} > 0$.
   Overall, $\Delta S_{total\ 3} = \Delta S_{system} + \Delta S_{surr.} > 0$.

9) 173.1 kJ

10) -37.2 kJ