Chemistry 12 – Entropy & Enthalpy Worksheet

1) Chemical reactions tend toward a position of minimum enthalpy and maximum entropy.

   a) What is meant by the term *enthalpy*? **(1 mark)**

   A measure of the heat content contained in the system

   b) What is meant by the term *entropy*? **(1 mark)**

   A measure of the randomness/disorder of the system

2) For the forward reaction, how do enthalpy and entropy change for the following equilibrium reactions: **(7 marks)**

Equilibrium	ΔH	ΔS
$4\ HCl_{(g)} + O_{2\ (g)} \rightleftarrows 2\ H_2O_{(g)} + 2\ Cl_{2\ (g)} + 111.4\ kJ$	↓	↓
$CaCO_{3\ (s)} \rightleftarrows CaO_{(s)} + CO_{2\ (g)}$ $\Delta H = +175\ kJ$	↑	↑
$2\ NO_{(g)} + O_{2\ (g)} \rightleftarrows 2\ NO_{2\ (g)} + 113\ kJ$	↓	↓
$2\ N_{2\ (g)} + O_{2\ (g)} + \text{energy} \rightleftarrows 2\ N_2O_{(g)}$	↑	↓
$2\ Li_{(s)} + 2\ H_2O_{(l)} \rightleftarrows 2\ LiOH_{(aq)} + H_{2\ (g)}$ $\Delta H = -433\ kJ$	↓	↑
$2\ NO_{2\ (g)} \rightleftarrows N_2O_{4\ (g)}$ $\Delta H = +59\ kJ$	↑	↓
$2\ H_2O_{(l)} + \text{energy} \rightleftarrows 2\ H_{2\ (g)} + O_{2\ (g)}$	↑	↑

3) For each of the following reactions, decide on the basis of entropy and enthalpy considerations whether a reaction in the direction shown will go to completion, reach a state of equilibrium or not occur at all. (Assume a closed system) **(8 marks)**

Reaction	$\overset{?}{\rightleftarrows}$
$Cl_{2\ (g)} \rightarrow Cl_{2\ (aq)} + 25\ kJ$	Equilibrium since min enthalpy favours → & max entropy favours ←
$Na_{(s)} + H_2O_{(l)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)} + \frac{1}{2} H_{2\ (g)}$ $\Delta H = -184\ kJ$	Completion since min enthalpy favours → & max entropy favours →
$N_{2\ (g)} + O_{2\ (g)} \rightarrow NO_{2\ (g)}$ $\Delta H = +33.8\ kJ$	Not occur since min enthalpy favours ← & max entropy favours ←

$P_{4\,(s)} + 6\ H_{2\,(g)} \rightarrow 4\ PH_{3\,(g)}$ $\Delta H = +\ 37$ kJ	Not occur since min enthalpy favours ← & max entropy favours ←
$Na_2CO_{3\,(s)} + 2\ HCl_{(aq)} \rightarrow 2\ NaCl_{(aq)} + CO_{2\,(g)} + H_2O_{(l)} + 27.7$ kJ	Completion since min enthalpy favours → & max entropy favours →
$C_2H_{2\,(g)} + H_{2\,(g)} \overset{?}{\rightleftarrows} C_2H_{4\,(g)}$ $\Delta H = -175$ kJ	Equilibrium since min enthalpy favours → & max entropy favours ←
$2\ Na_2CO_{3\,(s)} + 2\ HCl_{(aq)} \overset{?}{\rightleftarrows} 2NaCl_{(aq)} + CO_{2\,(g)} + H_2O_{(l)} + 27.7$ kJ	Completion since min enthalpy favours → & max entropy favours →
$N_2O_{(g)} + NO_{2\,(g)} \overset{?}{\rightleftarrows} 3\ NO_{(g)}$ $\Delta H = +156$ kJ	Equilibrium since min enthalpy favours ← & max entropy favours →

4) Two substances are mixed and no reaction occurs. With respect to enthalpy and entropy, explain why no reaction occurs? **(1 mark)**

If no reaction occurs, then both minimum enthalpy and maximum entropy would favour the reactants, therefore in the forward direction the ΔH ↑ & ΔS ↓

5) Two substances are mixed and a spontaneous reaction occurs. With respect to enthalpy and entropy, explain why the reaction goes to completion? **(1 mark)**

If a reaction goes to completion, then both minimum enthalpy and maximum entropy would favour the products, therefore in the forward direction the ΔH ↓ & ΔS ↑

6) Describe how enthalpy and entropy change, in the forward direction, as an exothermic reaction reaches equilibrium. Explain your reasoning. **(2 marks)**

Since this reaction reaches equilibrium, the directions of minimum enthalpy and maximum entropy **must oppose each other**. Since the reaction is exothermic, minimum enthalpy favours the products therefore maximum entropy must favour the reactants. In the forward direction, ΔH ↓ & ΔS ↓.

Students will often think that since the reaction is exothermic and ΔH ↓ (which is correct) therefore the ΔS must ↑ (which is wrong) to be opposite. The important thing to remember is that ↓ & ↑ is not opposing each other since those arrows are showing the changes. The arrows that must oppose each other are the directions that minimum enthalpy and maximum entropy favour, that is ← & →.