Chapter 13
Enthalpy and entropy

Print out and complete this worksheet to generate a summary for Chapter 13.

1 State whether each of the following will result in an increase or decrease in entropy.

a the melting of a solid

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b the precipitation of a solid from a solution

.....

c the formation of ammonia in the Haber process

.....

d the condensation of a gas to a liquid

.....

2 Calculate the entropy change that occurs when hydrogen and oxygen react to form water:

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

$S^{\ominus}(H_2) = 130.6\ J\ mol^{-1}\ K^{-1}$; $S^{\ominus}(O_2) = 204.9\ J\ mol^{-1}\ K^{-1}$; $S^{\ominus}(H_2O) = 70.0\ J\ mol^{-1}\ K^{-1}$

3 Calculate the value of $\Delta G_f^{\ominus}(CuSO_4)$.

$\Delta H_f^{\ominus}(CuSO_4) = -769.9\ kJ\ mol^{-1}$; $S^{\ominus}(CuSO_4) = 113.4\ J\ mol^{-1}\ K^{-1}$

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4 Calculate the value of $\Delta G^{\ominus}$ for the reaction:

$$C_2H_5OH(l) + HBr(g) \rightarrow C_2H_5Br(l) + H_2O(l)$$

$\Delta G_f^{\ominus}(C_2H_5OH) = -174.9\ kJ\ mol^{-1}$; $\Delta G_f^{\ominus}(HBr) = -53.2\ kJ\ mol^{-1}$; $\Delta G_f^{\ominus}(C_2H_5Br) = -27.8\ kJ\ mol^{-1}$; $\Delta G_f^{\ominus}(H_2O) = -237.2\ kJ\ mol^{-1}$

5 The equation for the combustion of propane is:

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$$

Use the following data to calculate the standard free energy of combustion of propane:

$\Delta G_f^{\ominus}(C_3H_8) = -23.5\ kJ\ mol^{-1}$; $\Delta G_f^{\ominus}(O_2) = -61.1\ kJ\ mol^{-1}$; $\Delta G_f^{\ominus}(CO_2) = -394.6\ kJ\ mol^{-1}$; $\Delta G_f^{\ominus}(H_2O) = -237.2\ kJ\ mol^{-1}$

6 Explain how an endothermic reaction can be spontaneous.

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7 State the relationship between ΔH, T and ΔS when a reaction achieves equilibrium.

8 Explain why a reaction for which ΔH is positive and ΔS is negative cannot achieve equilibrium.

9 Calculate the temperature, in °C, at which the reaction $2NO_2(g) \rightarrow N_2O_4(g)$ reaches equilibrium.

$\Delta H_f^{\ominus}(NO_2) = 33.2\ kJ\ mol^{-1}$; $\Delta H_f^{\ominus}(N_2O_4) = 9.2\ kJ\ mol^{-1}$;

$S^{\ominus}(NO_2) = 240.0\ J\ mol^{-1}\ K^{-1}$; $S^{\ominus}(N_2O_4) = 304.2\ J\ mol^{-1}\ K^{-1}$