

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

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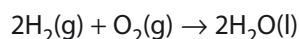
c the formation of ammonia in the Haber process

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d the condensation of a gas to a liquid

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



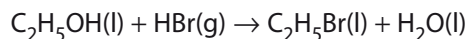
$$S^\ominus(\text{H}_2) = 130.6 \text{ J mol}^{-1} \text{ K}^{-1}; S^\ominus(\text{O}_2) = 204.9 \text{ J mol}^{-1} \text{ K}^{-1}; S^\ominus(\text{H}_2\text{O}) = 70.0 \text{ J mol}^{-1} \text{ K}^{-1}$$

3 Calculate the value of $\Delta G_f^\ominus(\text{CuSO}_4)$.

$$\Delta H_f^\ominus(\text{CuSO}_4) = -769.9 \text{ kJ mol}^{-1}; S^\ominus(\text{CuSO}_4) = 113.4 \text{ J mol}^{-1} \text{ K}^{-1}$$

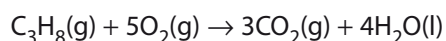
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- 4 Calculate the value of ΔG^\ominus for the reaction:



$\Delta G_f^\ominus(\text{C}_2\text{H}_5\text{OH}) = -174.9 \text{ kJ mol}^{-1}$; $\Delta G_f^\ominus(\text{HBr}) = -53.2 \text{ kJ mol}^{-1}$; $\Delta G_f^\ominus(\text{C}_2\text{H}_5\text{Br}) = -27.8 \text{ kJ mol}^{-1}$;
 $\Delta G_f^\ominus(\text{H}_2\text{O}) = -237.2 \text{ kJ mol}^{-1}$

- 5 The equation for the combustion of propane is:



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

$\Delta G_f^\ominus(\text{C}_3\text{H}_8) = -23.5 \text{ kJ mol}^{-1}$; $\Delta G_f^\ominus(\text{O}_2) = -61.1 \text{ kJ mol}^{-1}$; $\Delta G_f^\ominus(\text{CO}_2) = -394.6 \text{ kJ mol}^{-1}$;
 $\Delta G_f^\ominus(\text{H}_2\text{O}) = -237.2 \text{ kJ mol}^{-1}$

- 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.

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

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- 9** Calculate the temperature, in $^{\circ}\text{C}$, at which the reaction $2\text{NO}_2(\text{g}) \rightarrow \text{N}_2\text{O}_4(\text{g})$ reaches equilibrium.

$$\Delta H_{\text{f}}^{\ominus}(\text{NO}_2) = 33.2 \text{ kJ mol}^{-1}; \Delta H_{\text{f}}^{\ominus}(\text{N}_2\text{O}_4) = 9.2 \text{ kJ mol}^{-1};$$

$$S^{\ominus}(\text{NO}_2) = 240.0 \text{ J mol}^{-1} \text{ K}^{-1}; S^{\ominus}(\text{N}_2\text{O}_4) = 304.2 \text{ J mol}^{-1} \text{ K}^{-1}$$

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