Absolute Entropy 6

Essential Pre-Uni Chemistry G1.6

Subject & topics: Chemistry | Physical | Entropy **Stage & difficulty:** A Level P1

Use the following standard molar entropy values in $\mathrm{J\,K^{-1}\,mol^{-1}}$ to help answer the questions in this section.

$H_2O\,(l)$	69.9	$HCl\,(g)$	186.8	$NaCl\,(s)$	72.1
$H_2O\,(g)$	188.7	$Cl_2\,(g)$	223.1	$ZnCl_2\,(s)$	111.5
$H_2\,(g)$	130.7	$H_2SO_4\,(l)$	156.9	$Zn\,(s)$	41.6
$Na\,(s)$	51.2	$Zn\,(g)$	150.0	$NaHSO_4\,(s)$	113.0
$O_2\,(g)$	205.2	$CO_2\,(g)$	213.6	$C\,(s)$ *graphite*	5.7

Calculate the entropy of $1.00\,\mathrm{kg}$ of solid zinc.

Absolute Entropy 8

Essential Pre-Uni Chemistry G1.8

Subject & topics: Chemistry | Physical | Entropy **Stage & difficulty:** A Level P1

Use the following standard molar entropy values in $\mathrm{J\,K^{-1}\,mol^{-1}}$ to help answer the questions in this section.

$H_2O\,(l)$	69.9	$HCl\,(g)$	186.8	$NaCl\,(s)$	72.1
$H_2O\,(g)$	188.7	$Cl_2\,(g)$	223.1	$ZnCl_2\,(s)$	111.5
$H_2\,(g)$	130.7	$H_2SO_4\,(l)$	156.9	$Zn\,(s)$	41.6
$Na\,(s)$	51.2	$Zn\,(g)$	150.0	$NaHSO_4\,(s)$	113.0
$O_2\,(g)$	205.2	$CO_2\,(g)$	213.6	$C\,(s)$ *graphite*	5.7

Calculate the mass of sodium chloride that has standard entropy of $100\,\mathrm{J\,K^{-1}}$.

Question deck:

STEM SMART Chemistry Week 36

Absolute Entropy 10

Essential Pre-Uni Chemistry G1.10

Subject & topics: Chemistry | Physical | Entropy **Stage & difficulty:** A Level C1

Use the following standard molar entropy values in $\mathrm{J\,K^{-1}\,mol^{-1}}$ to help answer the questions in this section.

$H_2O\,(l)$	69.9	$HCl\,(g)$	186.8	$NaCl\,(s)$	72.1
$H_2O\,(g)$	188.7	$Cl_2\,(g)$	223.1	$ZnCl_2\,(s)$	111.5
$H_2\,(g)$	130.7	$H_2SO_4\,(l)$	156.9	$Zn\,(s)$	41.6
$Na\,(s)$	51.2	$Zn\,(g)$	150.0	$NaHSO_4\,(s)$	113.0
$O_2\,(g)$	205.2	$CO_2\,(g)$	213.6	$C\,(s)$ *graphite*	5.7

Calculate the total entropy of $250\,\mathrm{cm^3}$ of hydrogen and $500\,\mathrm{cm^3}$ of chlorine held separately at room temperature and pressure.

Question deck:

STEM SMART Chemistry Week 36

Entropy Changes 1

Essential Pre-Uni Chemistry G2.1

Subject & topics: Chemistry | Physical | Entropy **Stage & difficulty:** A Level P1

Use the following standard molar entropy values in $\mathrm{J\,K^{-1}\,mol^{-1}}$ to help answer the questions in this section.

$H_2O\,(l)$	69.9	$HCl\,(g)$	186.8	$NaCl\,(s)$	72.1
$H_2O\,(g)$	188.7	$Cl_2\,(g)$	223.1	$ZnCl_2\,(s)$	111.5
$H_2\,(g)$	130.7	$H_2SO_4\,(l)$	156.9	$Zn\,(s)$	41.6
$Na\,(s)$	51.2	$Zn\,(g)$	150.0	$NaHSO_4\,(s)$	113.0
$O_2\,(g)$	205.2	$CO_2\,(g)$	213.6	$C\,(s)$ *graphite*	5.7

Calculate the standard entropy change per mole for the following reactions:

Part A

(a)

$H_2O\,(l) \longrightarrow H_2O\,(g)$ Give your answer to 1 decimal place.

Part B

(b)

$Zn\,(s) + Cl_2\,(g) \longrightarrow ZnCl_2\,(s)$ Give your answer to 1 decimal place.

Part C

(c)

$H_2\,(g) + Cl_2\,(g) \longrightarrow 2\,HCl\,(g)$ Give your answer to 1 decimal place.

Part D

(d)

$NaCl\,(s) + H_2SO_4\,(l) \longrightarrow NaHSO_4\,(s) + HCl\,(g)$ Give your answer to 1 decimal place.

Part E

(e)

$Zn\,(s) + 2\,HCl\,(g) \longrightarrow ZnCl_2\,(s) + H_2\,(g)$ Give your answer to 1 decimal place.

Question deck:

STEM SMART Chemistry Week 36

Entropy Changes 3

Essential Pre-Uni Chemistry G2.3

Subject & topics: Chemistry | Physical | Entropy **Stage & difficulty:** A Level P2

Use the following standard molar entropy values in $\mathrm{J\,K^{-1}\,mol^{-1}}$ to help answer the questions in this section.

$H_2O\,(l)$	69.9	$HCl\,(g)$	186.8	$NaCl\,(s)$	72.1
$H_2O\,(g)$	188.7	$Cl_2\,(g)$	223.1	$ZnCl_2\,(s)$	111.5
$H_2\,(g)$	130.7	$H_2SO_4\,(l)$	156.9	$Zn\,(s)$	41.6
$Na\,(s)$	51.2	$Zn\,(g)$	150.0	$NaHSO_4\,(s)$	113.0
$O_2\,(g)$	205.2	$CO_2\,(g)$	213.6	$C\,(s)$ *graphite*	5.7

The decomposition of hydrogen peroxide has a standard entropy change of $62.9\,\mathrm{J\,K^{-1}\,mol^{-1}}$. Find the standard molar entropy of hydrogen peroxide. Give your answer to 1 decimal place.

Question deck:

STEM SMART Chemistry Week 36

STEM SMART Chemistry Week 36

Entropy Changes 4

Essential Pre-Uni Chemistry G2.4

Subject & topics: Chemistry | Physical | Entropy **Stage & difficulty:** A Level P2

Use the following standard molar entropy values in $\mathrm{J\,K^{-1}\,mol^{-1}}$ to help answer the questions in this section.

$H_2O\,(l)$	69.9	$HCl\,(g)$	186.8	$NaCl\,(s)$	72.1
$H_2O\,(g)$	188.7	$Cl_2\,(g)$	223.1	$ZnCl_2\,(s)$	111.5
$H_2\,(g)$	130.7	$H_2SO_4\,(l)$	156.9	$Zn\,(s)$	41.6
$Na\,(s)$	51.2	$Zn\,(g)$	150.0	$NaHSO_4\,(s)$	113.0
$O_2\,(g)$	205.2	$CO_2\,(g)$	213.6	$C\,(s)$ *graphite*	5.7

The combustion of methane has a standard molar entropy change of $-243.2\,\mathrm{J\,K^{-1}\,mol^{-1}}$. Calculate the standard molar entropy of methane. Give your answer to one decimal place.

Question deck:
STEM SMART Chemistry Week 36

STEM SMART Chemistry Week 36

Reaction Feasibility

Subject & topics: Chemistry | Physical | Energetics **Stage & difficulty:** A Level C1

A process is described as being thermodynamically feasible when it results in an increase in the entropy of the universe. For a chemical reaction to be feasible, the sum of the entropy changes of the reaction system and the surroundings needs to be positive. The entropy change of the surroundings arises as a result of heat flow between the surroundings and the reaction system.

Part A

Universe entropy change

The entropy change of the surroundings is calculated by dividing the heat flowing into the surroundings by the temperature.

For a reaction with an entropy change (of the system) of x and an enthalpy change of y, write down an inequality that needs to hold for the reaction to be spontaneous at a temperature T.

The following symbols may be useful: `>`, `T`, `x`, `y`

Part B

Gibbs Free Energy

Alternatively, chemists often phrase the requirement in terms of Gibbs free energy (G) of the reaction, a function of temperature (T), enthalpy (H) and entropy (S):

$$G = H - TS$$

If the change in Gibbs free energy of the reaction at a given temperature is z, write down an inequality that needs to hold for this reaction to be feasible.

The following symbols may be useful: `<`, `z`

Question deck:

STEM SMART Chemistry Week 36

Free Energy Changes 3

Essential Pre-Uni Chemistry H2.3

Subject & topics: Chemistry | Physical | Entropy **Stage & difficulty:** A Level P2

The standard enthalpy change on decomposition of magnesium carbonate is $100.6\,\mathrm{kJ\,mol^{-1}}$, and the standard entropy change is $174.8\,\mathrm{J\,K^{-1}\,mol^{-1}}$. Find the temperature at which its decomposition becomes spontaneous under standard conditions.

Question deck:
STEM SMART Chemistry Week 36

Free Energy Changes 4

Essential Pre-Uni Chemistry H2.4

Subject & topics: Chemistry | Physical | Entropy **Stage & difficulty:** A Level P2

The standard enthalpy of formation of copper(II) oxide at $290\,^{\circ}\mathrm{C}$ is $-157\,\mathrm{kJ\,mol^{-1}}$. The standard entropy change for the same process is $-41.9\,\mathrm{J\,K^{-1}\,mol^{-1}}$. Find the standard Gibbs free energy change of formation of copper(II) oxide at this temperature.

Question deck:
STEM SMART Chemistry Week 36

Ellingham Diagram

Subject & topics: Chemistry | Physical | Energetics **Stage & difficulty:** A Level C1

Ellingham diagrams are a way of visually representing the temperature dependence of the feasibility of reactions, and hence compound stability. They can also be useful for predicting the conditions required to extract a metal from its ore.

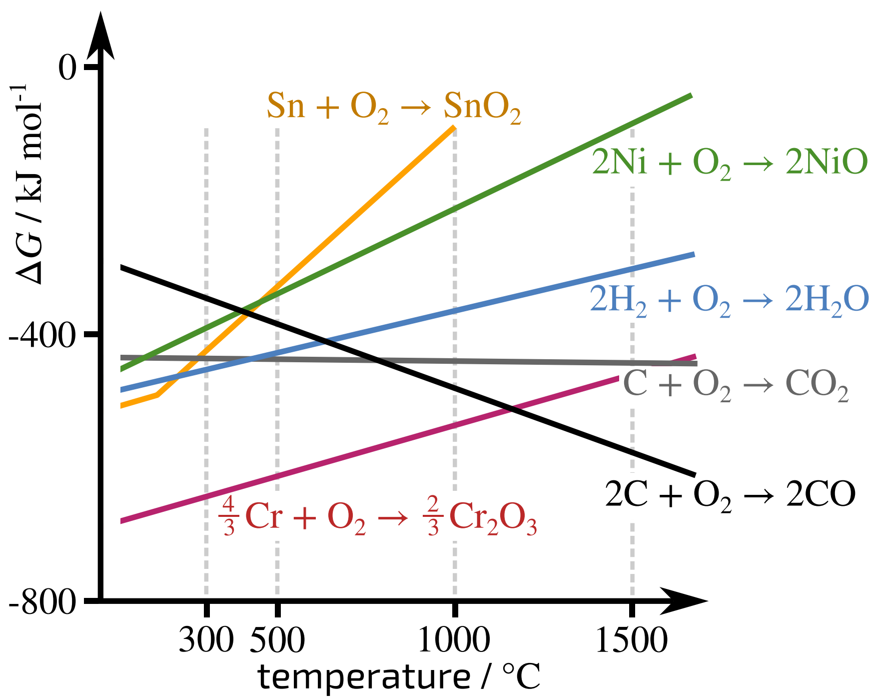

Figure 1: An Ellingham diagram describing the feasibility of different processes at different temperatures. Source: Natural Sciences Admissions Assessment 2020, Section 2, Question 36

Part A

Feasibility and temperature dependence

In order for a reaction to occur, ΔG needs to be ____. $\Delta G =$ ____ $-$ ____ ____ and so the extent of change in ΔG with temperature is largely controlled by the value of ____. For example, for $2\,\mathrm{Ni} + \mathrm{O_2} \longrightarrow 2\,\mathrm{NiO}$, this value is ____, as there are more moles of gas on the ____-hand side of the equation, giving rise to a ____ gradient in the graph above.

Items:

positive | negative | zero | T | ΔH | ΔS | right | left

Part B

Extracting metals

Ellingham diagrams are particularly useful for working out the conditions required for an ore to be reduced in order to extract the metal. Which of the following statements are true based on the diagram? Select all that apply.

- [ ] Carbon can reduce nickel oxide at all the temperatures shown
- [ ] At $1500\,^{\circ}\mathrm{C}$, carbon is able to reduce more metal ores than hydrogen.
- [ ] Tin oxide will spontaneously decompose into tin and oxygen at $500\,^{\circ}\mathrm{C}$
- [ ] At $1000\,^{\circ}\mathrm{C}$, chromium(III) oxide cannot be reduced using carbon.

Part C

Change in gradient

Which of the following is the most likely explanation for the change in gradient seen in the $Sn + O_2 \longrightarrow SnO_2$ line in the diagram?

- A catalyst is added at $232\,^{\circ}C$.
- Sn melts at $232\,^{\circ}C$.
- Sn changes oxidation state at $232\,^{\circ}C$.
- The reaction becomes feasible at $232\,^{\circ}C$.