Enthalpy, Entropy & Free Energy A Level only

Question Paper 1

Level	A Level
Subject	Chemistry
Exam Board	OCR
Module	Physical Chemistry & Transition Elements
Topic	Enthalpy, Entropy & Free Energy
Paper	A Level only
Booklet	Question Paper 1

Time allowed: **32 minutes**

Score: **/24**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E
>85%	73%	60%	47%	34%	21%

Question 1

The table below shows standard entropies, $S^{\ominus}$.

Substance	CO(g)	$H_2(g)$	$CH_3OH(l)$
$S^{\ominus}$ / J mol^{-1} K^{-1}	197.6	130.6	239.7

What is the entropy change, $\Delta S^{\ominus}$, in J mol^{-1} K^{-1}, for the following reaction?

$$CO(g) + 2H_2(g) \rightarrow CH_3OH(l)$$

A –219.1

B –88.5

C +88.5

D +219.1 **[1]**

This question looks at different aspects of entropy.

(a) Three processes are given below.

For each process, state and explain whether the change would be accompanied by an increase or decrease in entropy.

(i) The freezing of water.

increase or decrease .

[1]

(ii) The reaction of calcium carbonate with hydrochloric acid.

increase or decrease

[1]

(iii) The formation of $O_3(g)$ from $O_2(g)$.
increase or decrease

[1]

(b) The enthalpy and entropy changes of a reaction both have a negative sign.

Discuss how the feasibility of this reaction will change as the temperature increases. [2]

(c) The metal tungsten is obtained on a large scale from its main ore, wolframite.
Wolframite contains tungsten(VI) oxide, WO_3.

Tungsten is extracted from wolframite by reduction with hydrogen:

$$WO_3(s) + 3H_2(g) \rightarrow W(s) + 3H_2O(g) \qquad \Delta H = +115\,kJ\,mol^{-1}$$

Standard entropies are given in the table below.

Substance	$WO_3(s)$	$H_2(g)$	W(s)	$H_2O(g)$
$S^{\ominus}$ **J K^{-1} mol^{-1}**	76	131	33	189

(i) Calculate the free energy change, ΔG, in kJ mol^{-1}, for this reaction at 25 °C. [2]

Show your working.

(ii) Calculate the minimum temperature, in K, at which this reaction becomes feasible.

Show your working. [2]

[Total: 9 Marks]

The equation for the reaction of CO_2 and H_2O to produce glucose, $C_6H_{12}O_6$, and O_2 is shown below.

$6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(s) + 6O_2(g)$ $\Delta H = +2879$ kJ mol^{-1}; $\Delta S = -256$ J K^{-1} mol^{-1}

Standard entropies are given in the table below.

Substance	$CO_2(g)$	$H_2O(l)$	$O_2(g)$
$S^{\ominus}$ **/ J K^{-1} mol^{-1}**	214	70	205

(a) (i) Calculate the standard entropy of glucose. [2]

(ii) Calculate ΔG, in kJ mol^{-1}, at 25 °C.

Show all your working. [2]

(iii) Explain why this reaction is **not** feasible at **any** temperature. [1]

(b) Although the reaction between CO_2 and H_2O to form $C_6H_{12}O_6$ and O_2 appears not to be feasible, plants are able to make the reaction take place spontaneously by photosynthesis.

Each year, 3.4×10^{18} kJ of solar energy is taken in by all the plants on the Earth to make photosynthesis take place.

Calculate the mass of carbon dioxide that is removed each year from the atmosphere by photosynthesis on Earth.

[2]

[Total 7 Marks]

A student is asked to calculate ΔG at 25 ºC for the combustion of butan-1-ol. The teacher provides two pieces of information.

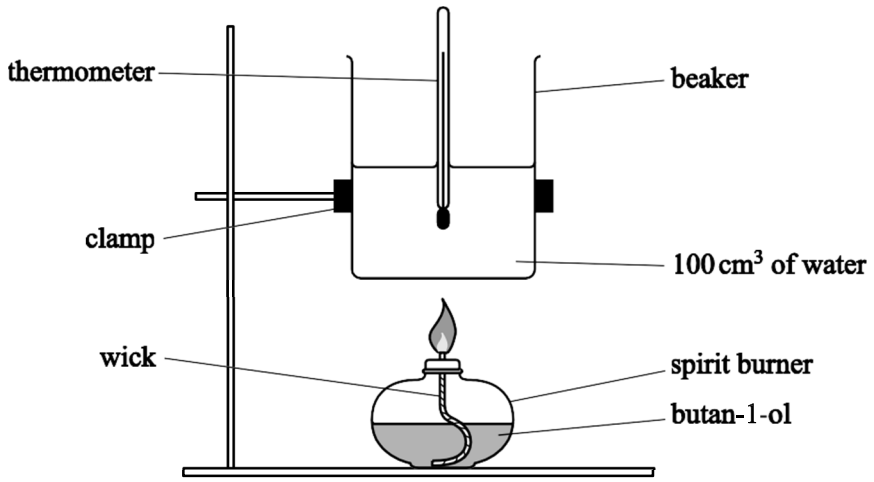
- The equation for the combustion of butan-1-ol.

$CH_3(CH_2)_3OH(l) + 6O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$ **Equation 2**

- Standard entropies of butan-1-ol, oxygen, carbon dioxide and water.

	$CH_3(CH_2)_3OH(l)$	$O_2(g)$	$CO_2(g)$	$H_2O(l)$
S^o/ J K^{-1} mol^{-1}	228	205	214	70

The student carries out an experiment using the apparatus below and obtains the following results. The specific heat capacity of water is 4.18 J g^{-1} K^{-1}.



Mass of burner and butan-1-ol before burning / g	98.997
Mass of burner and butan-1-ol after burning / g	98.738
Initial temperature / ºC	18.5
Maximum temperature reached / ºC	39.0

Use the information on the previous page to calculate ΔG, in kJ mol^{-1}, for the combustion of But an-1-ol according to **Equation 2** at 25 °C. **[7]**

[Total 7 Marks]