15.2 Entropy & Spontaneity

Question Paper

Course	DP IB Chemistry
Section	15. Energetics/Thermochemistry (HL only)
Topic	15.2 Entropy & Spontaneity
Difficulty	Easy

Time allowed: 50

Score: /38

Percentage: /100

Question 1a

a)
State whether there is an increase or decrease in entropy for the following reactions.

i)
$H_2O(l) \rightarrow H_2O(g)$

[1]

ii)
$Cl_2(g) \rightarrow Cl_2(l)$

[1]

iii)
$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

[1]

[3 marks]

Question 1b

b)
State the equation to determine the entropy change, ΔS , of a reaction.

[1]

[1 mark]

Question 1c

c)
Use your answer to part b) and section 12 of the data booklet to determine the standard entropy change, in $J\,K^{-1}\,mol^{-1}$, for water boiling.

$$H_2O(l) \rightarrow H_2O(g)$$

[1]

[1 mark]

Question 1d

d)
Explain why the entropy change of the following precipitation reaction is negative.

$$AgNO_3(aq) + NaCl(aq) \rightarrow NaNO_3(aq) + AgCl(s)$$

[1]

[1 mark]

Question 1e

e)
State the point of a reversible reaction in which the Gibbs free energy is at its lowest.

[1]

[1 mark]

Question 2a

a)
Use section 12 of the data booklet and the information below to determine the following:

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

Compound	ΔH_f (kJ mol^{-1})
$NaHCO_3(s)$	-951
$Na_2CO_3(s)$	-1131

i)
The sum of the enthalpies of formation, ΔH_f, of the products in kJ mol^{-1}.

[1]

ii)
The sum of the enthalpies of formation, ΔH_f, of the reactants in kJ mol^{-1}.

[1]

iii)
Use your answers to part i) and ii) to determine the enthalpy change of reaction, ΔH_r, for the decomposition of sodium hydrogen carbonate, $NaHCO_3(s)$ in kJ mol^{-1}.

[2]

[4 marks]

Question 2b

b)
Use section 12 in the data booklet and the information below to determine the following:

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

Compound	$S\,(J\,K^{-1}\,mol^{-1})$
$NaHCO_3(s)$	+102
$Na_2CO_3(s)$	+135

i)
The sum of the entropies, S, of the products in $J\,K^{-1}\,mol^{-1}$

[1]

ii)
The sum of the entropies, S, of the reactants in $J\,K^{-1}\,mol^{-1}$.

[1]

iii)
Use your answers to part i) and part ii) to determine the standard entropy change for the decomposition of sodium hydrogen carbonate, $NaHCO_3(s)$, in $J\,K^{-1}\,mol^{-1}$.

[2]

[4 marks]

Question 2c

c)
Use your answers to part a) and b) as well as section 1 in the data booklet to determine the free energy change, in kJ mol^{-1}, for the decomposition of sodium hydrogen carbonate, $NaHCO_3$ (s), at 500 K.

[2]

[2 marks]

Question 2d

d)
Use your answer to part c) to state whether the decomposition of sodium hydrogen carbonate is spontaneous at 500K.

[1]

[1 mark]

Question 3a

a)
State the equation which can be used to determine the standard free energy for a reaction change, ΔG, using ΔG formation data.

[1]

[1 mark]

Question 3b

b)
Use section 12 of the data booklet and the equation below to determine the following.

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

i)
The sum of the Gibbs free enthalpy of formation, ΔG_f, of the products in kJ mol^{-1}.

[1]

ii)
The sum of the Gibbs free enthalpy of formation, ΔG_f, of the reactants, kJ mol^{-1}.

[1]

iii)
The Gibbs free energy change, ΔG, for the combustion of propane, kJ mol^{-1}.

[1]

[3 marks]

Question 3c

c)
The reaction of carbon monoxide with water is as follows:

$$CO(g) + H_2O(g) \rightarrow CO_2(g) + H_2(g)$$

The entropy change, ΔS, for this reaction is -135 J K^{-1} mol^{-1} and the enthalpy change, ΔH, for the reaction is -41.4 kJ mol^{-1}.

Determine the free energy change, ΔG, for the reaction at 700 K in kJ mol^{-1}.

[2]

[2 marks]

Question 3d

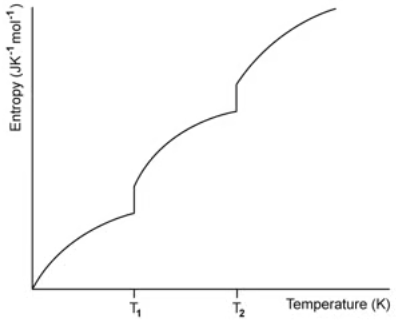
d)
Use your answer to part b) state whether the reaction of carbon monoxide and water is spontaneous at 700 K.

[1]

[1 mark]

Question 4a

a)
The image below shows how the entropy of compound **Y** varies with temperature



State the changes occurring at T_1 and T_2.

[2]

[2 marks]

Question 4b

b)

Study the reaction of methane, CH_4, with water shown.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

Use sections 12 and 13 of the data booklet to determine the following.

i)

The sum of the enthalpies of formation, ΔH_f, of the products in kJ mol^{-1}.

[1]

ii)

The sum of the enthalpies of formation, ΔH_f, of the reactants in kJ mol^{-1}.

[1]

iii)

Use your answers to part i) and ii) to determine the enthalpy change of reaction, ΔH_r, for the reaction kJ mol^{-1}.

[2]

[4 marks]

Question 4c

c)
The standard entropy of hydrogen gas is 131.0 $J\,K^{-1}\,mol^{-1}$.

Use section 12 in the data booklet to determine the following for the reaction in part a).

i)
The sum of the entropies, S , of the products in $J\,K^{-1}\,mol^{-1}$

[1]

ii)
The sum of the entropies, S , of the reactants in $J\,K^{-1}\,mol^{-1}$.

[1]

iii)
Use your answers to part i) and part ii) to determine the reaction given in part a) in $J\,K^{-1}\,mol^{-1}$.

[2]

[4 marks]

Question 4d

d)
We can use the equation $\Delta G = \Delta H - T\Delta S$ to determine the temperature, in K, at which a reaction becomes feasible.

Use your answers to part b) and c) as well as section 1 of the data booklet to determine the following.

The equation required to determine the temperature at which a reaction becomes spontaneous

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The temperature at which the reaction of methane, CH_4 , and water becomes spontaneous

.....

[3]

[3 marks]