15.2 Entropy & Spontaneity

Question Paper

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

Time allowed: 50

Score: /41

Percentage: /100

Question 1a

a)
The equations for two separate reversible reactions are as follows:

Reaction **A** $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

Reaction **B** $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$

Use the information in the following table to determine the enthalpy change, ΔH_r, for reaction **A**.

	SO_2	O_2	SO_3	H_2
$\Delta H^{\ominus}_f$ / kJ mol^{-1}	-296.8	0	-395.7	0
$S^{\ominus}$ / J K^{-1} mol^{-1}	248.2	205.1	256.8	130.6

[2]

[2 marks]

Question 1b

b)
Using the information from the table in part a), calculate the standard entropy change, ΔS, of reaction **A**.

[2]

[2 marks]

Question 1c

c)
Use your answer to parts a) and b) to determine the temperature at which reaction **A** becomes feasible.

[2 marks]

Question 1d

d)
By using the data from part a) and section 12 of the data booklet, deduce if reaction **B** is feasible at a low temperature.

[4]

[4 marks]

Question 2a

a)
Magnesium carbonate decomposes at a relatively high temperature.

	$MgCO_3$	MgO
$\Delta H^{\ominus}_f$ / kJ mol^{-1}	-1095.8	-601.7
$\Delta S^{\ominus}$ / J mol^{-1}	65.7	26.9

i)
Write an equation for the decomposition and use section 12 of the data booklet and the information given to determine the enthalpy change for the decomposition of magnesium carbonate.

[3]

ii)
Use section 12 of the data booklet and the information given to determine the standard entropy change for the decomposition of magnesium carbonate.

[2]

[5 marks]

Question 2b

b)
Using your answer to part a) to determine if the decomposition of magnesium carbonate is feasible at 280 ℃.

[1]

[1 mark]

Question 2c

c)
Using your answer to part b) to determine the temperature, in ℃, at which the decomposition of magnesium carbonate becomes feasible.

[3]

[3 marks]

Question 3a

a)
Used in the production of polymers, methanol is manufactured in large quantities.

i)
State the equation for the combustion of methanol.

[1]

ii)
Comment on the entropy change of the reaction.

[2]

[3 marks]

Question 3b

b)
Use section 12 of the data booklet to determine the enthalpy change, ΔH_r, for the production of methanol from carbon monoxide and hydrogen.

[3]

[3 marks]

Question 3c

c)
Use your answer to part b) and section 12 of the data booklet to calculate the free energy change, ΔG, for the formation of methanol from carbon monoxide and hydrogen at 300 K.

[3]

[3 marks]

Question 3d

d)
A student states that if the temperature is lowered for the formation of methanol, the reaction will become non-spontaneous. Comment on the student's statement.

[4]

[4 marks]

Question 4a

a)
The Ostwald process to produce nitric acid involves the oxidation of ammonia. The equation is shown below:

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g) \quad \Delta H_r = -905.2\ kJ\ mol^{-1}$$

	$NH_3(g)$	$O_2(g)$
$S^{\ominus}$ **(J K^{-1} mol^{-1})**	192.5	205

The free energy change, $\Delta G^{\ominus}$, for the oxidation of ammonia at 298 K is -959 kJ mol^{-1}.
Use section 12 of the data booklet, to calculate the entropy change for the oxidation of ammonia in J K^{-1} mol^{-1}.

[3]

[3 marks]

Question 4b

b)
Use your answer to part a) and section 12 of the data booklet to determine the standard entropy of nitric oxide gas.

[3]

[3 marks]

Question 4c

c)
A 1.00 mol sample of NOCl was placed in reactor and heated to 227°C until the system reached equilibrium. The value for the equilibrium constant at this temperature is K_c is 4.5×10^{-4} mol dm^{-3}.

$$2NOCl\,(g) \rightleftharpoons 2NO\,(g) + Cl_2\,(g)$$

Write an expression for K_c.

[1]

[1 mark]

Question 4d

d)
Using section 1 and 2 in the data booklet determine the value for the free energy change, $\Delta G^{\ominus}$, in kJ mol^{-1} for the reaction in part c).

[2]

[2 marks]