17.1 The Equilibrium Law

Question Paper

Course	DP IB Chemistry
Section	17. Equilibrium (HL only)
Topic	17.1 The Equilibrium Law
Difficulty	Easy

Time allowed: 30

Score: /22

Percentage: /100

Question 1a

a)
State Le Chatelier's principle.

[2]

[2 marks]

Question 1b

b)
Sulfur trioxide, SO_3, decomposes to establish an equilibrium producing sulfur dioxide, SO_2, and oxygen as shown in the reaction.

$$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g) \quad \Delta H = +196\ kJ\ mol^{-1}$$

State the effect on the yield of sulfur dioxide if the concentration of sulfur trioxide is increased.

[1]

[1 mark]

Question 1c

c)
Give the expression for K_c for the reaction outlined in part (b).

[1]

[1 mark]

Question 1d

d)

For the reaction outline in part (a), at dynamic equilibrium, the concentrations of each compound are given in the table below when the temperature is 600°C.

	SO_3	SO_2	O_2
Concentration at equilibrium (mol dm^{-3})	0.093	0.100	0.200

Calculate the value of K_c to 3 significant figures.

[2]

[2 marks]

Question 2a

a)

The reaction below shows the decomposition of dinitrogen tetroxide, N_2O_4, into two molecules of nitrogen dioxide, NO_2.

$$N_2O_4(g) \rightarrow 2NO_2(g) \quad \Delta H = +58\ kJ\ mol^{-1}$$

A dynamic equilibrium is reached at a temperature of 298K. The concentrations of each of the compounds at equilibrium are shown in the table below.

	N_2O_4	NO_2
Concentration at equilibrium (mol dm^{-3})	0.0647	0.0206

Give the expression for K_c for this reaction.

[1]

[1 mark]

Question 2b

b)
Calculate a value for K_c to three significant figures.

[2]

[2 marks]

Question 2c

c)
State the units for K_c for the reaction outlined in part (a).

[1]

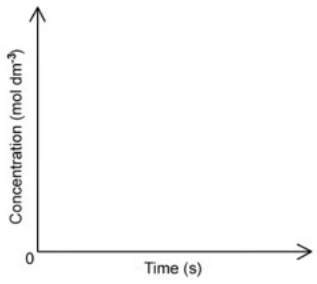
[1 mark]

Question 2d

d)
At the start of the reaction outlined in part (a) dinitrogen tetroxide, N_2O_4, is the only compound present.

Sketch two lines on the graph shown below to show the change in concentration for both dinitrogen tetroxide, N_2O_4, and nitrogen dioxide, NO_2 as the reaction reaches
dynamic equilibrium.

You should make reference to the information given in the table in part (a).



[3]

[3 marks]

Question 3a

a)
The following reaction was allowed to reach equilibrium at 761 K.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H^{\theta} < 0$$

State the equilibrium constant expression, K_c, for this reaction.

[1]

[1 mark]

Question 3b

b)
The following equilibrium concentrations, in mol dm^{-3}, were obtained at 761 K.

$[H_2(g)]$	$[I_2(g)]$	$[HI(g)]$
8.72×10^{-4}	2.72×10^{-3}	1.04×10^{-2}

Calculate the value of the equilibrium constant at 761 K.

[1]

[1 mark]

Question 3c

c)
Determine the value of ΔG^{θ}, in kJ, for the above reaction at 761 K using section 1 of the data booklet.

[1]

[1 mark]

Question 3d

d)
Comment on whether this reaction is feasible.

[1]

[1 mark]

Question 4a

a)
Methanoic acid and methanol react to form the ester methyl methanoate and water as follows:

$$H_2COOH\ (l) + CH_3OH\ (l) \rightleftharpoons HCOOCH_3\ (l) + H_2O\ (l)$$

At 35 °C, the free energy change, ΔG, for the reaction is -3.79 kJ mol^{-1}.

Using sections 1 and 2 of the data booklet, calculate the value of K_c for this reaction to 2 decimal places.

[2]

[2 marks]

Question 4b

b)
Using your answer to part (a), predict and explain the position of the equilibrium.

[2]

[2 marks]

Question 4c

c)
The value for ΔG = -4.21 kJ mol^{-1} as the temperature is increased to 50 °C.

State what happens to the value of the equilibrium constant.

[1]

[1 mark]