17.1 The Equilibrium Law

Question Paper

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

Time allowed: 50

Score: /40

Percentage: /100

Question 1a

a)

A 0.680 mol sample of SO_3 is introduced into a 3.04 dm^3 reaction container and allowed to reach equilibrium at temperature *T*.

32% of the SO_3 had decomposed.

Calculate the value for K_c in this reaction, giving your answer to 2 significant figures.

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

[6]

[6 marks]

Question 1b

b)

The size of the container for the reaction in part (a) is decreased.

State the effect if any on the equilibrium constant, K_c, and the position of equilibrium. Justify your answer.

[4]

[4 marks]

Question 1c

c)
The temperature of the reaction in part (a) is increased.
State the effect, if any, on the equilibrium constant, K_c, and the position of equilibrium. Justify your answer.

[3]

[3 marks]

Question 1d

d)
Comment on whether the reaction in part (a) is likely to take place spontaneously at temperature *T*.

[2]

[2 marks]

Question 2a

a)
A mixture of 1.32 moles of *E*, 1.49 moles of *F* and 0.752 moles of *G* were placed into a 5.0 dm^3 container at temperature, *T*, and allowed to reach equilibrium. At equilibrium, the number of moles of *E* was 1.86.

Calculate the value of the equilibrium constant, K_c, to 3 significant figures.

$$2E(g) \rightleftharpoons 2F(g) + G(g) \quad \Delta H = -143\ kJ\ mol^{-1}$$

[5]

[5 marks]

Question 2b

b)

Reactants *G* and *H* react together to form products *J* and *K* according to the equation

$$3G + H \rightleftharpoons 4J + K$$

A beaker contained 35 cm^3 of 0.18 mol dm^{-3} of an aqueous solution of *G*.

8.41×10^{-3} moles of *H* and 3.1×10^{-3} moles of *J* were also added to the beaker. The equilibrium mixture contained 4.1×10^{-3} moles of *G*.

Calculate the number of moles of *H*, *J* and *K* at equilibrium.

[5]

[5 marks]

Question 2c

c)
Using sections 1 and 2 of the data booklet, calculate the equilibrium constant at 300 K for the oxidation of iron:

$$2Fe(s) + \frac{3}{2}O_2(g) \rightarrow Fe_2O_3(s)$$

$$\Delta H^{\Theta} = -824.2\ kJ\ mol^{-1}$$

$$\Delta S^{\Theta} = -270.5\ J\ mol^{-1}$$

[3]

[3 marks]

Question 2d

d)
Suggest what the value for K_c calculated in part (c) suggests about the equilibrium position for the oxidation of iron.

[1]

[1 mark]

Question 3a

a)
Diesters are compounds often used as synthetic lubricants for machinery such as compressors. The reaction below shows the formation of a diester from propanoic acid and propane-1,3–diol.

$$2CH_3CH_2COOH + HOCH_2CH_2CH_2OH \rightleftharpoons C_9H_{16}O_4 + 2H_2O$$

At equilibrium, the reaction mixture contained 3.25 moles of CH_3CH_2COOH, 1.15 moles of $HOCH_2CH_2CH_2OH$, and 1.18 moles of $C_9H_{16}O_4$.

The value for K_c at temperature, T, is 1.29.
Calculate the concentration of water in the reaction mixture at equilibrium. Give your answer to 3 significant figures.

[3]

[3 marks]

Question 3b

b)
A student deduced that in order to calculate the value of K_c for the reaction in part (a) you must work out the concentrations using the overall volume.

Is the student correct? Justify your answer.

[2]

[2 marks]

Question 3c

c)
Using sections 1 and 2 of the data booklet, determine the value for ΔG for the reverse reaction in part(a) given that temperature T = 30 °C. Give your answer, in kJ, to 2 significant figures.

[2]

[2 marks]

Question 3d

d)
The reverse reaction in part (a) is slightly endothermic. At a different temperature, T_2, the value for ΔG decreases to -0.52 kJ $mol^{-1.}$

State whether the new temperature, T_2, is higher or lower than the original temperature.
Justify your answer.

[4]

[4 marks]