IB Chemistry – HL

Topic 7 Questions

1. For the reaction below

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$
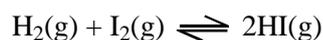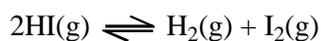
at a certain temperature, the equilibrium concentrations are (in mol dm^{-3})
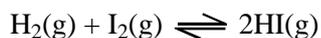
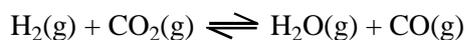$$[H_2] = 0.30, [I_2] = 0.30, [HI] = 3.0$$

What is the value of K?

A.   5.0   B.   10   C.   15   D.   100

2. The value of the equilibrium constant for the reaction

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

is 0.25 at 440°C. What would the value of the equilibrium constant be for the following reaction at the same temperature?

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

A.   0.25   B.   0.50

C.   2.0   D.   4.0

3. Hydrogen and carbon dioxide react as shown in the equation below.

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

For this reaction the values of K_c with different temperatures are

Temperature / K	K_c
500	7.76×10^{-3}
700	1.23×10^{-1}
900	6.01×10^{-1}

Which statement for the reaction is correct?

A.   The forward reaction is endothermic.

B. $H_2O(g)$ and $CO(g)$ are more stable than $H_2(g)$ and $CO_2(g)$.

C. The reaction goes almost to completion at high temperatures.

D. The reverse reaction is favoured by high temperatures.

4. The expression for the equilibrium constant for a reaction is

$$K_c = \frac{[B][C]}{[A]^2}$$

At a certain temperature the values of [A], [B] and [C] are all 0.2 mol dm^{-3}. What happens to the value of K_c when all three values are doubled to 0.4 mol dm^{-3}?

A. It is halved.

B. It does not change.

C. It doubles.

D. It increases by a factor of four.

5. A 1.0 dm^3 reaction vessel initially contains 6.0 mol of **P** and 6.0 mol of **Q**. At equilibrium 4.0 mol of **R** is present. What is the value of K_c for the following reaction?

$$P(g) + Q(g) \rightleftharpoons R(g) + S(g)$$
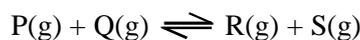
A. 0.11   B. 0.25

C. 0.44   D. 4.00

6. For the reaction below:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$
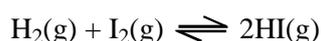
at a certain temperature, the equilibrium concentrations, in mol dm^{-3}, are

$$[H_2(g)] = 0.30, [I_2(g)] = 0.30, [HI(g)] = 3.0$$

What is the value of K?

A. 1.0×10^{-2}

B. 10

C. 33

D. 1.0×10^2

7. A liquid and its vapour are at equilibrium inside a sealed container. Which change will alter the equilibrium vapour pressure of the liquid in the container?

A. Adding more liquid

B.   Adding more vapour

C.   Decreasing the volume of the container

D.   Decreasing the temperature

8.   The equilibrium between nitrogen dioxide (dark brown) and dinitrogen tetroxide (colourless) is represented by the following equation.

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \qquad \Delta H = \text{negative } K_c = 1 \text{ at 328K}$$

(a)   Write the equilibrium constant expression, K_c.

    ....
    (1)

(b)   State and explain the effect of an increase in temperature on the value of K_c.

    ....

    ....

    ....
    (2)

(c)   State and explain the visible change that takes place as a result of a decrease in pressure, after equilibrium is re-established.
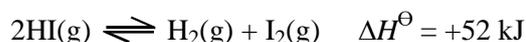
    ....

    ....

    ....
    (2)

(d)   Two moles of $NO_2(g)$ and two moles of $N_2O_4(g)$ were placed in an empty 1 dm^3 container and allowed to come to equilibrium at 328 K. Predict, with reference to the value of K_c, whether the equilibrium mixture would contain more or less than two moles of $NO_2(g)$.

    ....

    ....
    (2)
    (Total 7 marks)

9.   (a)   The equation for the decomposition of hydrogen iodide is

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g) \qquad \Delta H^{\ominus} = +52 \text{ kJ}$$

   Predict and explain the effect on the position of equilibrium of

(i) increasing the pressure, at constant temperature.

(2)

(ii) increasing the temperature, at constant pressure.

(2)

(iii) adding a catalyst, at constant temperature and pressure.

(2)

(b) Deduce the expression for K_c for the forward reaction.

(1)

(c) The equilibrium formed during this reaction was investigated in two experiments carried out at different temperatures. The results are shown in the table below.

Experiment number	Initial concentration / mol dm^{-3}			Equilibrium concentration / mol dm^{-3}		
	[HI]	[H$_2$]	[I$_2$]	[HI]	[H$_2$]	[I$_2$]
1	0.06	0.00	0.00		0.01	
2	0.00	0.04	0.04	0.04		

(i) For each experiment, deduce the concentrations of the other species present at equilibrium. Calculate the values of K_c for the forward reaction for each experiment.

(6)

(ii) Use the two calculated values of K_c to deduce which of the two experiments was carried out at the higher temperature, and explain your choice. (If you were not able to calculate the values of K_c in (c)(i), assume that the values are 0.1 for experiment 1 and 0.2 for experiment 2, although these are not the correct values.)

(2)
(Total 15 marks)

10. The equation for another reaction used in industry is

$$CO(g) + H_2O(g) \rightleftharpoons H_2(g) + CO_2(g) \qquad \Delta H^{\ominus} = -42 \text{ kJ}$$
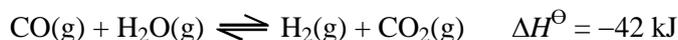
(i) Under certain conditions of temperature and pressure, 2.0 mol of carbon monoxide and 3.2 mol of steam were left to reach equilibrium. At equilibrium, 1.6 mol of both hydrogen and carbon dioxide were present.
Calculate the amounts of carbon monoxide and steam at equilibrium and the value of K_c.

(3)

(ii) Under the same conditions of temperature and pressure, 2.0 mol of carbon monoxide and 2.0 mol of steam were left to reach equilibrium.
Calculate the amounts of each reactant and product at equilibrium.
(If you were unable to calculate a value for K_c in (i) use the value 9.0, although this is not the correct value.)

(2)
(Total 5 marks)