CHEM1001 Worksheet 11 – Answers to Critical Thinking Questions

The worksheets are available in the tutorials and form an integral part of the learning outcomes and experience for this unit.

Model 1: The Equilibrium Constant

1. K_c (A) = $\frac{[N_2O_4(g)]}{[NO_2(g)]^2}$ K_c (B) = $\frac{[N_2O_4(g)]^{1/2}}{[NO_2(g)]}$

   K_c (C) = $\frac{[NO_2(g)]^2}{[N_2O_4(g)]}$ K_c (D) = $\frac{[NO_2(g)]}{[N_2O_4(g)]^{1/2}}$

2. (a) K_c (B) = $\sqrt{K_c\ (A)}$ (b) K_c (A) = 1/K_c (C)

3. K_c (A) = 0.078, K_c (B) = 0.28, K_c (C) = 13. These values agree with the mathematical analysis in Q2.

Model 2: The Reaction Quotient

1. The reaction will shift to the right to decrease [NO_2(g)].
2. The reaction will shift to the left to increase [NO_2(g)].
3. (a) [NO_2(g)] = 2.00 M and [N_2O_4] = 0.20 M: Q_c = 0.050

   (b) [NO_2(g)] = 1.00 M and [N_2O_4] = 0.20 M: Q_c = 0.20.
4. (a) If $Q_c < K_c$, the reaction will shift to the right.

   (b) If $Q_c > K_c$, the reaction will shift to the left.

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	Mark
• Consider the following reaction at equilibrium. $CH_3OH(g) \rightleftharpoons CO(g) + 2H_2(g)$ $K_c = 1.30 \times 10^{-2}$ What is the concentration of CO(g) when [CH_3OH(g)] = 3.49×10^{-1} M and [H_2(g)] = 1.76×10^{-1} M?	2

The equilibrium constant for the reaction is given by $K_{eq} = \frac{[CO(g)][H_2(g)]^2}{[CH_3OH(g)]} = 1.30 \times 10^{-2}$

When [CH_3OH(g)] = 3.49×10^{-1} M and [H_2(g)] = 1.76×10^{-1} M,

$$[CO(g)] = \frac{K_{eq}[CH_3OH(g)]}{[H_2(g)]^2} = \frac{(1.30 \times 10^{-2})(3.49 \times 10^{-1})}{(1.76 \times 10^{-1})^2}\ \text{M} = 0.146\ \text{M}$$

Answer: **0.146 M**

Mark
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- The value of the equilibrium constant, K_c, for the following reaction is 0.118.

$$2CO_2(g) + N_2(g) \rightleftharpoons 2CO(g) + 2NO(g)$$

What is the equilibrium concentration of CO(g) if the equilibrium concentration of $[CO_2(g)]$ = 0.492 M, $[N_2(g)]$ = 0.319 M and [NO(g)] = 0.350 M?

The equilibrium constant for the reaction is given by $K_{eq} = \frac{[CO(g)]^2[NO(g)]^2}{[CO_2(g)]^2[N_2(g)]} = 0.118$

When $[CO_2(g)]$ = 0.492 M, $[N_2(g)]$ = 0.319 M and [NO(g)] = 0.350 M,

$$[CO(g)]^2 = \frac{K_{eq}[CO_2(g)]^2[N_2(g)]}{[NO(g)]^2} = \frac{(0.118)(0.492)^2(0.319)}{(0.350)^2}\ M^2 = 0.0744\ M^2$$

[CO(g)] = 0.273 M

Answer: **0.273 M**

Model 3: Equilibrium calculations

1. As there was no $O_2(g)$ or $H_2(g)$ at the beginning ("initial"), the reaction *had* to proceed to the right. The amount of $H_2O(g)$ had to decrease so the "change"

2. The 'ICE' table and calculation is shown below.

	$N_2(g)$ +	$O_2(g)$ ⇌	$2NO(g)$
[I]	0.033	0.0081	0
[C]	$-x$	$-x$	$+2x$
[E]	$0.033-x$	$0.0081-x$	$2x$

$$K_c = \frac{[NO(g)]^2}{[N_2(g)][O_2(g)]} = \frac{4x^2}{(0.033-x)(0.0081-x)}$$

If K_c is very small, x will be very small and so $0.033 - x \approx 0$ and $0.0081 - x \approx 0$. Hence:

$$K_c = \frac{4x^2}{(0.033\times0.0081)}$$

$$x = \sqrt{(4.8\times10^{-31}\times0.033\times0.0081/4)}$$

$$x = 5.7\times10^{-18}$$

[NO(g)] at equilibrium = $2x = 1.1 \times 10^{-17}$ M.

3. $[CO] = [H_2O]$ = 0.0332 M; $[CO_2] = [H_2]$ = 0.0668 M

4. $[CO] = [H_2O]$ = 0.0530 M; $[CO_2] = [H_2]$ = 0.107 M

5. K_c = 64