Chemistry 12

CALCULATIONS INVOLVING THE EQUILIBRIUM CONSTANT K_{EQ})

1. Given the equilibrium equation below:

$$A_{2(g)} + B_{2(g)} \rightleftarrows 2AB_{(g)}$$

If, *at equilibrium*, the concentrations are as follows:

$[A_2] = 3.45$ M, $[B_2] = 5.67$ M and $[AB] = 0.67$ M

a) Write the **expression** for the equilibrium constant, K_{eq}

b) Find the **value** of the equilibrium constant, K_{eq} at the temperature that the experiment was done.

2. Given the equilibrium equation:

$$X_{2(g)} + 3Y_{2(g)} \rightleftarrows 2XY_{3(g)}$$

at a temperature of 50°C, it is found that when equilibrium is reached that:

$[X_2] = 0.37$ M, $[Y_2] = 0.53$ M and $[XY_3] = 0.090$ M

a) Write the **equilibrium constant expression** (K_{eq})

b) Calculate the **value** of K_{eq} at 50°C.

3. For the reaction: $A_{2(g)} + B_{(g)} \rightleftarrows 2C_{(g)}$

it is found that by adding 1.5 moles of C to a 1.0 L container, an equilibrium is established in which 0.30 moles of B are found. (*Hint: Make a table and use it to answer the questions below.*)

a) What is [A] at equilibrium? _____

b) What is [B] at equilibrium? _____

c) What is [C] at equilibrium? _____

d) Write the **expression** for the equilibrium constant, K_{eq} .

e) Calculate the **value** for the equilibrium constant at the temperature the experiment was done.

4. Considering the following equilibrium:

$$2AB_{3(g)} \rightleftarrows A_{2(g)} + 3B_{2(g)}$$

If 0.87 moles of AB_3 are injected into a 5.0 L container at 25°C , at equilibrium the final $[A_2]$ is found to be 0.070 M.(*Hint: Make a table and use it to answer the questions below.*)

a) Calculate the equilibrium concentration of AB_3. _____

b) Calculate the equilibrium $[A_2]$. _____

c) Calculate the equilibrium $[B_2]$. _____

5. Consider the reaction:

$$A_{(g)} + B_{(g)} \rightleftarrows C_{(g)}$$

a) In an equilibrium mixture the following concentrations were found:

[A] = 0.45M, [B] = 0.63M and [C] = 0.30M. Calculate the value of the equilibrium constant for this reaction.

b) At the same temperature, another equilibrium mixture is analyzed and it is found that [B] = 0.21 M and [C] = 0.70 M. From this and the information above, calculate the *equilibrium [A]*.

c) In another equilibrium mixture at the same temperature, it is found that [A] = 0.35 M and the [C] = 0.86 M. From this and the information above, calculate the *equilibrium [B]*.

$$A_{(g)} + B_{(g)} \rightleftarrows C_{(g)}$$

6. Two mole of gaseous NH_3 are introduced into a 1.0 L vessel and allowed to undergo partial decomposition at high temperature according to the reaction:

$$2NH_{3(g)} \rightleftarrows N_{2(g)} + 3H_{2(g)}$$

At equilibrium, 1.0 mole of $NH_{3(g)}$ remains.
(*Make a table and use it to answer the questions below:*)

a) What is the equilibrium $[N_2]$? _____

b) What is the equilibrium $[H_2]$? _____

c) Calculate the **value** of the equilibrium constant at the temperature of the experiment.

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7. At a high temperature, 0.50 mol of HBr was placed in a 1.0 L container and allowed to decompose according to the reaction:

$$2HBr_{(g)} \rightleftarrows H_{2(g)} + Br_{2(g)}$$

At equilibrium the $[Br_2]$ was measured to be 0.13 M. What is K_{eq} for this reaction at this temperature?

8. When 1.0 mol of $NH_{3(g)}$ and 0.40 mol of $N_{2(g)}$ are placed in a 5.0 L vessel and allowed to reach equilibrium at a certain temperature, it is found that 0.78 mol of NH_3 is present. The reaction is:

$$2NH_{3(g)} \rightleftarrows 3H_{2(g)} + N_{2(g)}$$

a) Calculate the **equilibrium concentrations** of all three species.

$[NH_3]$ = _____ $[H_2]$ = _____ $[N_2]$ = _____

b) Calculate the **value** of the equilibrium constant at this temperature.

c) How many **moles** of H_2 are present at equilibrium?

d) How many **moles** of N_2 are present at equilibrium?

9. When 0.40 mol of PCl_5 is heated in a 10.0 L container, an equilibrium is established in which 0.25 mol of Cl_2 is present. (*Make a table and answer the questions below. Be sure to read all questions a-d before making your table!:*)

$$PCl_{5(g)} \rightleftarrows PCl_{3(g)} + Cl_{2(g)}$$

a) Calculate the **equilibrium concentration** of each species.

$[PCl_5]$ = _____ $[PCl_3]$ = _____ $[Cl_2]$ = _____

b) Calculate the **value** of the equilibrium constant, K_{eq} at the temperature of the experiment.

c) What **amount** (moles) of PCl_3 is present at equilibrium?

d) What **amount** (moles) of PCl_5 is present at equilibrium?

10. A mixture of H_2 and I_2 is allowed to react at 448°C. When *equilibrium* is established, the concentrations of the participants are found to be:

$[H_2]$ = 0.46 M, $[I_2]$ = 0.39 M and [HI] = 3.0 M.

The equation is: $H_{2(g)} + I_{2(g)} \rightleftarrows 2HI_{(g)}$

a) Calculate the **value** of K_{eq} at 448°C.

b) In another equilibrium mixture of the *same* participants at 448°C , the concentrations of I_2 and H_2 are both 0.050 M. What is the *equilibrium concentration* of HI?

11. The K_{eq} for the reaction:

$$PCl_{5(g)} \rightleftarrows PCl_{3(g)} + Cl_{2(g)}$$

at 250°C is found to be ***0.042.*** In an *equilibrium mixture* of these species, it is found that $[PCl_5] = 0.012$ M, and $[Cl_2] = 0.049$ M. What is the equilibrium $[PCl_3]$ at 250°C ?

12. At a certain temperature the reaction:

$$CO_{(g)} + 2H_{2(g)} \rightleftarrows CH_3OH_{(g)}$$

has a Keq = ***0.500***. If a reaction mixture at equilibrium contains 0.210 M CO and 0.100 M H_2 , what is the *equilibrium* $[CH_3OH]$?

13. At a certain temperature the reaction: $CO_{(g)} + H_2O_{(g)} \rightleftarrows CO_{2(g)} + H_{2(g)}$

has a K_{eq} = ***0.400***. Exactly *1.00 mol* of each gas was placed in a 100.0 L vessel and the mixture was allowed to react. Find the **equilibrium concentration** of each gas.

14. The reaction: $2XY_{(g)} \rightleftarrows X_{2(g)} + Y_{2(g)}$

has a K_{eq} = ***35*** at 25°C. If 3.0 moles of XY are injected into a 1.0 L container at 25°C , find the equilibrium $[X_2]$ and $[Y_2]$.

15. The equilibrium constant for the reaction:

$$H_{2(g)} + I_{2(g)} \rightleftarrows 2HI_{(g)} \qquad \text{at } 448°C \text{ is } \boldsymbol{50}.$$

a) If 1.0 mol of H_2 is mixed with 1.0 mol of I_2 in a 0.50 L container and allowed to react at 448°C , what is the **equilibrium** [HI]?

b) How many **moles** of HI are formed at equilibrium? (Actual yield)

16. Given K_{eq} for the reaction:

$$PCl_{5(g)} \rightleftarrows PCl_{3(g)} + Cl_{2(g)}$$

is ***0.042*** at 250°C , what will happen if 2.50 mol of PCl_5, 0.600 mol of Cl_2 and 0.600 mol of PCl_3 are placed in a 1.00 flask at 250°C ? (*Will the reaction shift left, right, or not occur at all?*)

17. Given the equilibrium equation: $H_{2(g)} + I_{2(g)} \rightleftarrows 2HI_{(g)}$

at 448°C, K_{eq} = ***50.*** If 3.0 mol of HI, 2.0 mol of H_2, and 1.5 mol of I_2 are placed in a 1.0 L container at 448°C, will a reaction occur?

If so, which way does the reaction shift? _____

18. Given the equilibrium equation: $H_{2(g)} + I_{2(g)} \rightleftarrows 2HI_{(g)}$

at 448°C, K_{eq} = ***50.*** If 5.0 mol of HI, 0.7071 mol of H_2, and 0.7071 mol of I_2 are placed in a 1.0 L container at 448°C, will a reaction occur? (*Round any answers off to 3 significant digits!*)

If so, which way does the reaction shift? _____

19. Determine the equilibrium constant for the reaction: $H_{2(g)} + I_{2(g)} \rightleftarrows 2HI_{(g)}$ given that an equilibrium mixture is analyzed and found to contain the following concentrations: $[H_2]$ = 0.0075 M, $[I_2]$ = 0.000043 M and [HI] = 0.0040 M

20. Given the equilibrium equation: $3A_{(g)} + B_{(g)} \rightleftarrows 2C_{(g)}$

If 2.50 moles of A and 0.500 moles of B are added to a 2.00 L container, an equilibrium is established in which the [C] is found to be 0.250 M.

a) Find [A] and [B] at equilibrium.

b) Calculate the value of the equilibrium constant K_{eq} .

21. At 800°C, the equilibrium constant K_{eq} , for the reaction:

$$CO_{2(g)} + H_{2(g)} \rightleftarrows CO_{(g)} + H_2O_{(g)} \quad \text{is } 0.279$$

If 1.50 moles of CO_2 and 1.50 moles of H_2 are added to a 1.00 L container, what would the [CO] be at equilibrium?

22. Given that the equilibrium constant K_{eq} for the reaction:

$$A_{(g)} + B_{(g)} \rightleftarrows C_{(g)} + D_{(g)} \quad \text{is } \textbf{\textit{0.015}} \text{ at } 25^{o}C,$$

if 1.0 mole of each gas is added to a 1.0 L container at 25°C, which way will the equation shift in order to reach equilibrium?

23. Calculate the **equilibrium constant** K_{eq} for the following reaction:

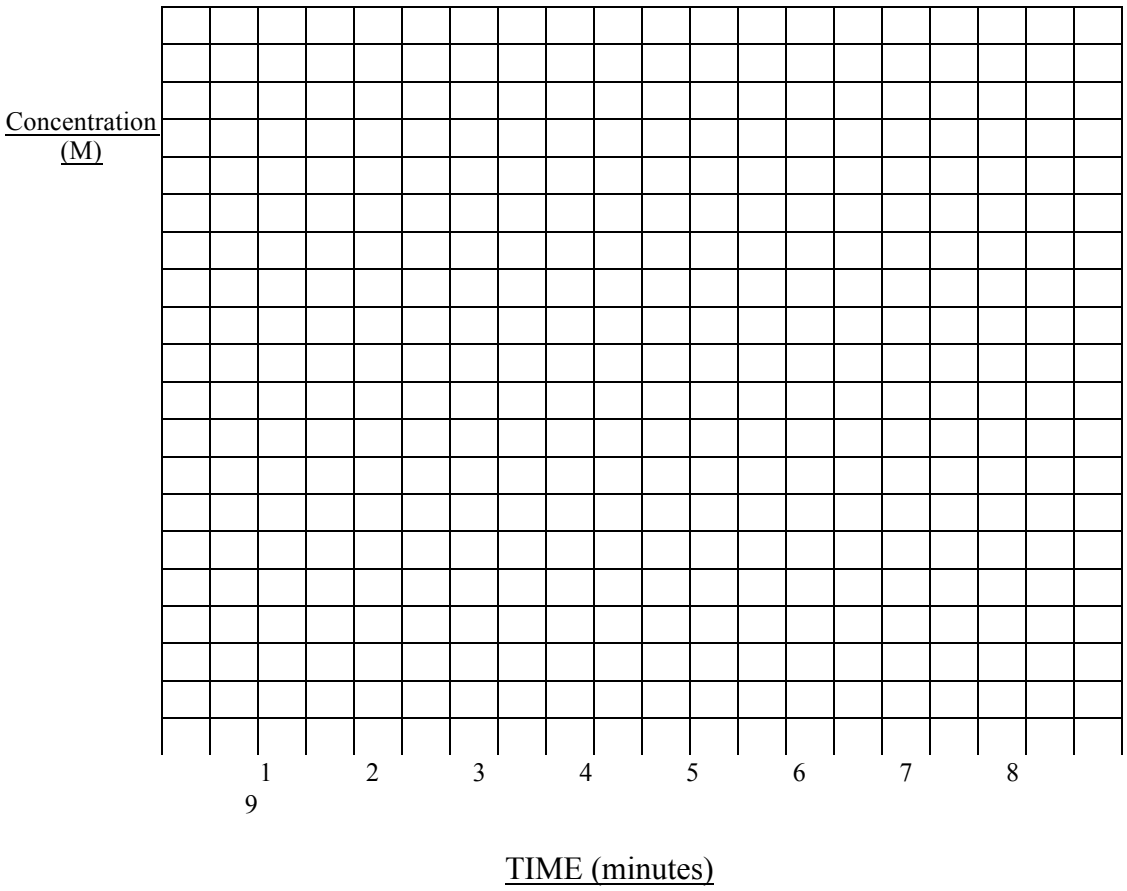
$$2A_{2(g)} + 3B_{2(g)} \rightleftarrows 2A_2B_{3(g)}$$

given that the *partial pressure* of each substance at equilibrium is as follows:

Partial Pressure of A_2 = 20.0 kPa, Partial Pressure of B_2 = 30.0 kPa, Partial Pressure of A_2B_3 = 5.00 kPa.

24. Consider the following equilibrium system: $A_{(g)} + B_{(g)} \rightleftarrows C_{(g)}$

1.0 mole of A and 2.0 moles of B are simultaneously injected into an empty 1.0 L container. At equilibrium (after 5.0 minutes), [C] is found to be 0.20 M. Make calculations and draw graphs to show how each of [A], [B] and [C] change with time over a period of 10.0 minutes. (*HINT: You have to make a table first.*)



25. Given the reaction:

$$4HCl_{(g)} + O_{2(g)} \rightleftarrows 2H_2O_{(g)} + 2Cl_{2(g)} \qquad \Delta H = -113 \text{ kJ}$$

How will the value of the equilibrium constant K_{eq} at 550°C compare with it's value at 450°C? _____

Explain your answer. _____

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26. The following system is at equilibrium, in a closed container:

$$4NH_{3(g)} + 3O_{2(g)} \rightleftarrows 6H_2O_{(g)} + 2N_{2(g)} + \text{Heat}$$

a) How is the *amount of N_2* in the container affected if the ***volume*** of the container is ***doubled***? _____

b) How is the rate of the **forward reaction** affected if more water vapor is introduced into the container? _____

c) How is the amount of O_2 in the container affected if a *catalyst* is added?

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27. At a certain temperature, K_{eq} for the reaction:

$$3C_2H_2 \rightleftarrows C_6H_6 \quad \text{is} \quad \mathbf{5.0}.$$

If the *equilibrium concentration* of C_2H_2 is 0.40 moles/L, what is the *equilibrium concentration* of C_6H_6?