Student Name: _____

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CHEMISTRY 2024

Unit 3
Key Topic Test 6 – Equilibria

Recommended writing time*: 45 minutes
Total number of marks available: 50 marks

QUESTION BOOK

* The recommended writing time is a guide to the time students should take to complete this test. Teachers may wish to alter this time and can do so at their own discretion.

Conditions and restrictions

- Students are permitted to bring into the room for this test: pens, pencils, highlighters,
- Permitted items include pens, pencils, erasers, sharpeners, rulers and VCAA Chemistry Data Book.
- Students are NOT permitted to bring into the room for this test: blank sheets of paper and/or white out liquid/tape.
- A scientific calculator is permitted in this test.

Materials supplied

- Question and answer book of 12 pages.

Instructions

- Print your name in the space provided on the top of the front page.
- All written responses must be in English.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic communication devices into the room for this test.

SECTION A – Multiple-choice questions

Instructions for Section A
Answer **all** questions. Choose the response that is **correct** or **best answers** the question. A correct answer scores 1, an incorrect answer scores 0. No mark will be given if more than one answer is completed for any question. Marks will **not** be deducted for incorrect answers.

Question 1

$$2\ NO(g) + Cl_2(g) \rightleftharpoons 2\ NOCl(g)\ \ K_c = 6.3 \times 10^4 @\ T°C$$

The value of the equilibrium constant for the above reaction if all coefficients were doubled would be:

A. 1.0

B. 3.9×10^9

C. 6.3×10^{10}

D. 6.3×10^4

The following information is to be used for Questions 2, 3 and 4

A student was investigating the equilibrium reaction between NO_2 (brown gas) and N_2O_4 (colourless gas) by collecting the gases in a gas syringe. The equation for the reaction is:

$N_2O_4\ (g) \rightleftharpoons 2\ NO_2\ (g)$

Question 2

When the syringe was placed in cold water it was found that the brown colour intensified and when the syringe was placed in hot water the colour faded. From this information it can be assumed that the reaction is:

A. Incomplete

B. Exothermic

C. Endothermic

D. Redox

Question 3

When the plunger was pushed in on the syringe the colour was found to

A. Intensify and then fade

B. Lighten and then lighten further

C. Intensify then darken further

D. Lighten then darken

Question 4

The plunger was then drawn back and the colour was found to

A. Intensify and then fade

B. Lighten and then lighten further

C. Intensify then darken further

D. Lighten then darken

The following information is used for questions 5 and 6.

The Haber process is an important process in industry to produce ammonia. The equation for the reaction is:

N_2 (g) + 3 H_2 (g) ⇌ 2 NH_3 (g) ΔH is negative.

Question 5

How will the system adjust to re-establish equilibrium if ammonia is removed?

A. A net forward reaction will occur, increasing the value of the equilibrium constant.
B. A net forward reaction will occur, decreasing the value of the equilibrium constant.
C. A net forward reaction will occur and ΔH will be positive.
D. A net forward reaction will occur and there will be no change to the value of the equilibrium constant or ΔH.

Question 6

How will the system adjust to re-establish equilibrium if the reaction vessel is cooled?

A. A net forward reaction will occur, increasing the value of the equilibrium constant.
B. A net forward reaction will occur, decreasing the value of the equilibrium constant.
C. A net forward reaction will occur and ΔH will be positive.
D. A net forward reaction will occur and there will be no change to the value of the equilibrium constant or ΔH.

The following information is to be used for Questions 7 and 8

$2\ AB\ (g) \rightleftharpoons 2\ A\ (g) + B_2(g)$ $\quad K_c = 3.0 \times 10^{-5}$@ T°C $\quad \Delta H = 60.5\ kJmol^{-1}$

Question 7

What will be the K_c value for the reverse reaction at T°C?

A. -3.0×10^{-5}
B. 3.3×10^{4}
C. -3.3×10^{4}
D. 9.00×10^{-3}

Question 8

What will be the K_c value for the reaction at a temperature higher than T°C?

A. 3.0×10^{-5}
B. $> 3.0 \times 10^{-5}$
C. $< 3.0 \times 10^{-5}$
D. The exact temperature is needed to calulate the K_c value

Question 9

A reaction occurs according to the equation X (g) + 2 Y (g) ⇌ Z (g) $K_c = 9.0 \times 10^{-3}$ @ T K

Another reaction between X and Y is undertaken this time with a catalyst. The effect of this is:

A. Equilibrium will be reached earlier and there will be no change to the value of K_c.
B. Equilibrium will be reached earlier and as a result the value of K_c will be greater.
C. Equilibrium will be reached earlier and as a result the value of Kc will be lower.
D. Equilibrium will be reached earlier and there is a net forward reaction.

Question 10

Benzoic acid is a weak acid which only partially ionises in water. The reaction equation is:

HC_7H_5O (aq) + H_2O (l) ⇌ $C_7H_5O_2^-$ (aq) + H_3O^+ (aq)

A further 10.0 mL of 0.1 M benzoic acid is added to a 50.0 mL solution of 0.1 M benzoic acid. What effect will the addition of acid have on the amount of benzoic acid and the position of equilibrium?

A. amount increases, net back reaction
B. amount unchanged, net back reaction
C. amount decreases, net forward reaction
D. amount increases, net forward reaction

SECTION B

Instructions

Answer **all** questions in the spaces provided.
Where a numerical answer is required give your answer to the correct number of significant figures.
In questions where more than one mark is available, appropriate working **must** be shown.
Unless otherwise indicated, any diagrams in this book are **not** drawn to scale.

Question 1 (4 marks)

Carbon monoxide (CO) is an odourless, colourless, and poisonous gas. Both oxygen and carbon monoxide are transported throughout the body by binding with haemoglobin (Hb), however carbon monoxide can bind more strongly to haemoglobin than can oxygen. The two equations involved are:

1. $Hb_4 + 4\ O_2 \rightleftharpoons Hb_4(O_2)_4$
2. $Hb_4 + 4\ CO \rightleftharpoons Hb_4(CO)_4$

The treatment for carbon monoxide poisoning is the administration of oxygen rich air. Explain, with reference to the equilibria equations, how this treatment can reverse the effects of the poisoning.

Question 2 (7 marks)

An important industrial reaction is depicted by the following equation:

$X\ (g) + 2\ Y\ (g) \rightleftharpoons XY_2\ (g)$ ΔH = negative

The manufacturer wants to increase the yield of XY_2 while at the same time increasing the rate of the reaction. Describe how this might be achieved, and any conflicts that might occur.

Question 3 (10 marks)

Nitric oxide reacts with chlorine gas according to the following reaction:

$$2\ NOCl\ (g) \rightleftharpoons 2\ NO\ (g) + Cl_2\ (g)$$

2.0 mol of NOCl (g) was added to an empty 2.0 L vessel at T K. At equilibrium the concentration of Cl_2 (g) was found to be 0.0085 M.

a. Determine the equilibrium concentrations of NOCl and NO.

4 marks

b. Calculate the equilibrium constant for the reaction at T K.

2 marks

c. How is a system at equilibrium described in terms of the rate of reaction?

2 marks

d. How is a system at equilibrium described in terms of the concentrations of reactants and products?

2 marks

Question 4 (9 marks)

$X + Y \rightleftharpoons Z$ ΔH = negative

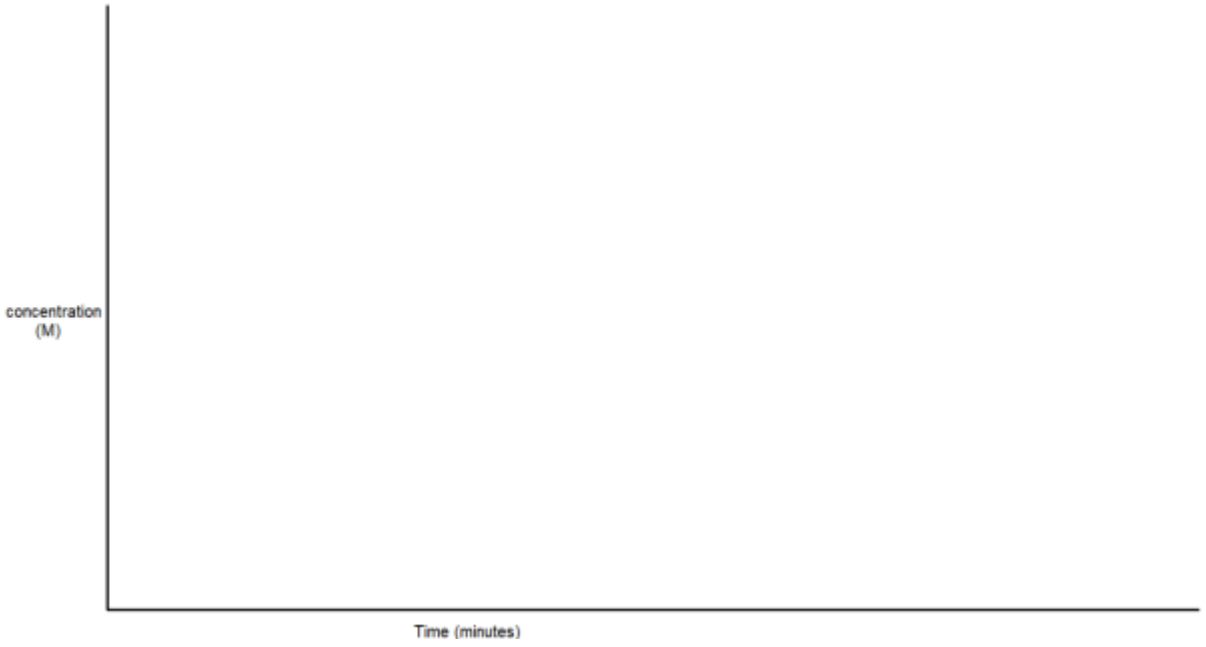
At t_0, equal amounts of X and Y were added to an empty vessel and allowed to reach equilibrium. Several changes were made to the equilibrium system after this time, these were:

t_1. - Y was added to the reaction vessel

t_2. -The volume of the reaction vessel was halved

t_3. - The temperature was increased

a. On the following pair of axes show how the changes made to the system would affect the concentrations of X, Y and Z.



6 marks

b. Explain how the changes made to the system at t_1, t_2 and t_3 would affect the value of K.

3 marks

Question 5 (2 marks)

How does the addition of a catalyst affect a system at equilibrium?

Question 6 (5 marks)

Methanol is a fuel that can be produced from the reaction between carbon monoxide and hydrogen.

$$CO\ (g) + 2\ H_2\ (g) \rightleftharpoons CH_3OH\ (g)$$

0.79 mol of CO and 0.25 mol of H_2 were added to an empty 700 mL container and allowed to reach equilibrium. At equilibrium the mixture was found to contain 0.12 mol of methanol.

a. Calculate the equilibrium constant K_c for this reaction.

3 marks

When equilibrium had been reached both ethanol and carbon monoxide were added to the container. The volume and temperature were kept constant. A sample of the mixture was taken after 10 minutes, and the reaction quotient (Q) was found to be 0.50 M^{-2}.

b. Has equilibrium been re-established? Explain.

2 marks

Question 7 (3 marks)

Many chemical reactions that are important to the needs of society are equilibrium reactions. List three methods that a manufacturer may employ that will ensure a greener alternative while maintaining profitability.

3 marks

Total 50 marks

END OF KEY TOPIC TEST