**Unit 3 Topic test: Rates and equilibrium Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Mark: /50**

**SECTION A – Multiple-choice questions**

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

**Question 1**

Which of the following changes will definitely lead to a faster reaction rate?

**A**. lower temperature, addition of a catalyst and higher concentrations

**B**. higher temperature, lower concentrations and the addition of a catalyst

**C**. greater surface area, higher temperatures and higher concentrations

**D**. greater surface area, lower temperatures and lower concentrations

*Use the following equation to answer Questions 2 and 3*

A series of reactions are conducted to compare the reaction rates between calcium carbonate and hydrochloric acid. The time taken for each reaction to produce 80 mL of gas is recorded.

|  |  |  |  |
| --- | --- | --- | --- |
|  | HCl concentration | Mass of CaCO3 added | Time to produce 80 mL |
| Experiment 1 | 1.0 M | 2 g | 34 sec |
| Experiment 2 | 2.0 M | 2 g | 22 sec |
| Experiment 3 | 2.0 M | 4 g | 28 sec |
|  |  |  |  |

**Question 2**

Which of the following is unlikely to be a useful method for monitoring the rate of this reaction?

**A**. Monitoring the colour change occurring during the reaction.

**B**. Measuring the volume of gas evolved.

**C**. Monitoring the mass of the flask.

**D**. Monitoring the pH of the solution.

**Question 3**

In a comparison of experiment 2 and experiment 3, it is likely that

**A**. the temperature in experiment 3 was higher than that of experiment 2.

**B**. the calcium carbonate particle size in experiment 3 is larger than experiment 2.

**C**. the rate of reaction in experiment 3 was greater due to the increased calcium carbonate mass.

**D**. the rate of reaction in both reactions should have been the same as the HCl concentration was the same.

**Question 4**

The equilibrium expression shown refers to which equation?

*K* = 

**A**. 4NH3(g) + 5O2(g) ⇄4NO(g) + 6H2O(g)

**B**. 4NO(g) + 6H2O(g) ⇄ 4NH3(g) + 5O2(g)

**C**. NH3(g) + O2(g) ⇄NO(g) + H2O(g)

**D**. 4NH3(g) + 6O2(g) ⇄4NO(g) + 5H2O(g)

*Use the following information to answer Questions 5, 6 and 7*

The reaction between sulfur dioxide and oxygen is

2SO2(g) + O2(g) ⇄ 2SO3(g)

The numerical value of *K* for this reaction at 100 0C is 12.4

**Question 5**

The concentrations in a mixture of the above gases at 100 0C, are

[SO2] = 0.4 M, [O2] = 0.4 M and [SO3] = 0.4 M

**A**. This reaction mixture is at equilibrium.

**B**. The forward reaction needs to occur more than the back reaction to reach equilibrium.

**C**. The back reaction needs to occur more than the forward reaction to reach equilibrium.

**D**. The back reaction will stop until equilibrium is reached.

**Question 6**

4.8 mole of SO2 and 3.0 mole of O2 is introduced to an empty reactor. When equilibrium is reached

**A**. 4.8 mole of SO3 will have formed.

**B**. 6.0 mole of SO3 will have formed.

**C**. SO2 will not be present as it is the scarce reagent.

**D**. The amount of SO3 formed will equal the amount of SO2 reacted.

**Question 7**

The correct unit for the equilibrium constant in this reaction will be

**A**. M-1

**B**. M1

**C**. M2

**D**. no unit at all since the number of product molecules will equal the reactant molecules.

**Question 8**

Hydrogen and iodine can react in a reversible reaction:

H2(g) + I2(g) ⇄ 2HI(g)

If the value of *K* for this reaction at 50 0C is 34.4, what is the value of *K* at the same temperature for the reaction

HI(g) ⇄ ½ H2(g) + ½ I2(g)

**A**. 0.029

**B**. 0.170

**C**. 17.2

**D**. 34.4

**Question 9**

In the decomposition of NOCl, the reaction is

2NOCl(g) ⇄ 2NO(g) + Cl2(g) K = 1.2 × 10-5 M at 30 0C.

In an equilibrium mixture at 30 0C, the amount of

**A**. Cl2 is half the amount of NOCl

**B**. NO will equal the amount of NOCl

**C**. NO is far less than the amount of NOCl

**D**. NO added to the amount of Cl2 will give the amount of NOCl.

**Question 10**

A catalyst is added to an equilibrium mixture of gases. The catalyst will

**A**. increase the rate of the forward reaction, changing the value of *K*.

**B**. increase the rate of the forward reaction but *K* is unchanged.

**C**. increase the rate of both the forward and back reactions.

**D**. have no impact on the mixture.

**SECTION B- Short-answer questions**

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| **Instructions for Section B**  Questions must be answered in the spaces provided in this book.  To obtain full marks for your responses you should   * Give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full marks. * Show all workings in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.   Make sure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example, H2(g); NaCl(s) |

**Question 1** (8 marks)

When sodium thiosulfate solution is added to iron (III) nitrate solution a dark brown colour forms. The solution then becomes colourless. The equation for the reaction is

2Fe3+(aq) + 2S2O32-(aq) 🡪 2Fe2+(aq) + S4O62-(aq)

*brown colourless*

This reaction is often used to investigate the impact of various factors on reaction rates. The time it takes for the solution to go colourless is recorded as a measure of reaction rate.

**a**. The results for a set of experiments are shown below.

|  |  |  |
| --- | --- | --- |
| Experiment | Conditions 0C | Time to go colourless (sec) |
| 1 | 20 | 240 |
| 2 | 30 | 180 |
| 3 | 40 | 110 |
| 4 | 50 | 45 |
| 5 | 60 | 19 |

Explain clearly

**i**. What the data is demonstrating. 2 marks

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**ii**. The reason for this effect. 2 marks

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**b**. Identify in part a. 2 marks

**i**. the independent variable \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**ii**. the dependent variable \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**c**. 20 mL of both solutions are mixed at 35 0C and the time taken for the solution to become colourless is

timed at 1 min 25 secs. The experiment is repeated but this time 5 drops of 1.0M CuSO4 are included. The

time for the reaction is now 19 secs.

Explain clearly what has happened. 2 marks

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**Question 2** ( 7 marks)

The graph below monitors the concentration of gases in an equilibrium system.

A graph of a graph

Description automatically generated with medium confidence

**a**. Write a balanced equation for the reaction this graph is monitoring. 1 mark

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**b**. **i**. Determine the value of the equilibrium constant. 3 marks

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**ii**. Will the value of the equilibrium constant change after equilibrium is established after the 10 minute

mark? 1 mark

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**c**. Explain the change occurring at the 10 minute mark and the response of the system to this change.

2 marks

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**Question 3** (8 marks)

The equation for the decomposition of nitrosyl bromide is

2NOBr(g) ⇄ 2NO(g) + Br2(g)

The equilibrium constant at 350 0C is 0.032 M-1

**a**. Determine the value of *K* for each of the following reactions 2 marks

**i.** 4NOBr(g) ⇄ 4NO(g) + 2Br2(g) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**ii**. NO(g) + ½ Br2(g) ⇄ NOBr(g) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**b**. A 2.0 litre reactor contains 4 mole of NOBr, 4 mole of NO and 2 mole of Br2.

Which way does the reaction have to favour for equilibrium to be reached, or is the mixture

already at equilibrium? 2 maks

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**c**. 5.0 mole of NOBr is introduced to an empty reactor. 2 marks

**i**. Will 2.5 mole of Br2 form? Explain your answer.

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**ii**. If the amount of NO to form was found to be 0.20 mole, what amount of Br2 was formed?

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**d**. 10 mole of NO and 1 mole of Br2 are added to an empty reactor. Will all the Br2 be used up

when equilibrium is reached? Justify your answer. 2 marks

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**Question 4** (9 marks)

The reaction between nitrogen monoxide and chlorine is a reversible one

2NO(g) + Cl2(g) ⇄ 2NOCl(aq)

In a 20.0 L reactor, the equilibrium amounts of the three chemicals are

NO = 3.6 mol Cl2 = 2.8 mol NOCl = 3.2 mol

**a**. Calculate the value of *K* for this mixture. Include units in your answer. 4 marks

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**b. i**. In another 20.0 L equilibrium mixture at the same temperature, the concentration of NOCl

is found to be 0.56 M and the concentration of Cl2 is 0.40 M.

Determine the concentration of the NO. 3 marks

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**ii**. Calculate the amount of NO present. 1 mark

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**c**. What is the value of K for the reverse reaction? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ 1 mark

**Question 5** (8 marks)

An equilibrium can form between dinitrogen tetroxide and nitrogen dioxide.

N2O4(g) ⇄ 2NO2(g)

A sample of N2O4 is added to an empty reactor.

**a**. The rate of the forward reaction is shown. Draw in the rate of the back reaction.

*rate*

*time*  1 mark

**b**. The concentration of the N2O4 is shown on the graph below.

Draw in the concentration of the NO2. 1 mark

*concentration*

*Time*

**c**. What do the two graphs suggest about the numerical value of *K*? 1 mark

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**d. i**. Write an expression for *K*. 1 mark

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**ii**. Write an expression for the equilibrium constant of the reverse reaction. 1 mark

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**e.** 1 mole of N2O4 is added to an empty 1.0 L reactor.

At equilibrium the concentration of N2O4 is x.

**i**. Write an expression in terms of x for the amount of NO2 present at equilibrium. 1 mark

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**ii**. Write an expression in terms of x for the equilibrium constant. 2 marks

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**END OF TOPIC TEST**