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| **Name:** |  |
| **Your Score:** |  |
| **Maximum Score:** | **40** |

**AP CHEMISTRY**

**UNIT 05ABCDEFGHIJK TEST**

## Instructions

* **Write your name at the top of this page**
* **You are provided with an equations & constants sheet, and a periodic table**
* **In SECTION A you will find multiple-choice questions. Answer these by choosing the one letter that corresponds to the best answer**
* **In SECTION B you will find a number of free response questions. Write your answers in the spaces provided. The number of points for each part of each question is shown in parentheses**
* **Attempt ALL the questions**
* **Where appropriate show ALL working and pay attention to units and significant figures**
* **Present all your work as neatly as possible**

**SECTION A: Multiple-Choice (Select the best answer)**

1. Collision theory predicts which of the following? (5.5)

(A) That a reaction will only occur if in the collision the collision geometry is correct, and that the activation energy is met or exceeded

(B) That more successful collisions will occur with increasing activation energy

(C) That a reaction will occur if the reactants do not collide

(D) That frequency of collisions will decrease with increasing temperature

2. In a reaction where the activation energy for the backward reaction is greater than the activation for the forward reaction, we know that (5.6)

(A) Products have greater enthalpy (energy) than reactants

(B) Products have less enthalpy (energy) than reactants

(C) Products have the same enthalpy (energy) as the reactants

(D) More information is needed to determine anything about the enthalpy (energy) of the reactants and products

3. Which of the following will increase the value of the rate constant k, for a reaction? (5.1, 5.2)

(A) Increasing the concentration of the reactants

(B) Increasing the concentration of the products

(C) Increasing the temperature

(D) Decreasing the size of the container

4. A sealed, rigid container holds two gases which react together in a reaction that is second order overall. If additional moles of each gas are added to the container while keeping the temperature constant, what can be said of reaction under these new conditions? (5.1, 5.2)

(A) The rate of reaction will increase as will the rate constant, k

(B) The rate of reaction will remain unchanged as will the rate constant, k

(C) The rate of reaction will increase but the rate constant, k will remain unchanged

(D) The rate of reaction will remain unchanged, but the rate constant, k will increase

5. Consider the chemical reaction below. What does the balanced chemical equation tell us about the rate law? (5.1)

N2 + 3H2 🡺 2NH3

(A) That the reaction is first order with respect to H2

(B) That the reaction is second order with respect to NH3

(C) That the reaction is 4th order overall

(D) Nothing, either the mechanism or experimental data must be used to determine anything about the rate law

6. The rate of a chemical reaction will be increased by (5.1)

(A) The presence of a large activation energy

(B) The presence of a catalyst

(C) A decrease in temperature

(D) Using large lumps of solid reactant instead of a powder

7. In the Maxwell-Boltzmann distribution plot for a given reaction at two different temperatures, what can be said about the total area underneath the two curves when comparing the curve for the relatively high temperature to the curve for the relatively low temperature? (5.5)

(A) The total area under the higher temperature curve is greater since more particles possess the minimum activation energy required

(B) The total area under the lower temperature curve is greater since more particles possess the minimum activation energy required

(C) The total areas are the same under both curves since the number of moles of gas do not change as a result of heating or cooling

(D) The total areas are the same under both curves since gases occupy the same space regardless of their temperature

Questions 8 and 9 relate to the reaction below, and require the use of the following table of data.

2A + B + 2C 🡺 D

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Experiment** | **Initial [A]**  **in mol L-1** | **Initial [B]**  **in mol L-1** | **Initial [C]**  **in mol L-1** | **Initial rate of production of D**  **in mol L-1min-1** |
| 1 | 0.004 | 0.004 | 0.004 | 2.1 x 10-4 |
| 2 | 0.008 | 0.004 | 0.004 | 2.1 x 10-4 |
| 3 | 0.004 | 0.012 | 0.004 | 6.3 x 10-4 |
| 4 | 0.008 | 0.004 | 0.008 | 4.2 x 10-4 |

8. What is the order with respect to C? (5.2)

(A) ½

(B) 0

(C) 1

(D) 2

9. The units of the rate constant k are (5.2)

(A) mol L-1 min-1

(B) (mol L-1)-2 min-1

(C) (mol L-1)2 min-1

(D) (mol L-1)-1 min-1

10. What is the overall order of the reaction? (5.2)

(A) 0

(B) 1

(C) 2

(D) 3

11. The reaction X + Y 🡺 Z has the rate law, Rate = k[X]2 [Y]. If the concentration of X and Y are both increased by a factor of two (both doubled) what would be in the increased in the rate? (5.2)

(A) Doubled

(B) Quadrupled

(C) Increased by a factor of 8

(D) No change, since the two doublings cancel one another out

12. Which answer choice correctly matches the integrated rate law shown below? (5.3)

ln [A]t = - k t + In [A]0

(A) A zero-order reaction where a plot of ln [A]t (y-axis) versus t (x-axis) will yield a linear line with slope = - k

(B) A first order reaction where a plot of ln [A]t (y-axis) versus t (x-axis) will yield a linear line with slope = k

(C) A first order reaction where a plot of ln [A]t (y-axis) versus t (x-axis) will yield a linear line with slope = -k

(D) A second order reaction where a plot of 1/[A]t (y-axis) versus t (x-axis) will yield a linear line with slope = k

13. The slow step in a reaction mechanism is significant because? (5.7, 5.8)

(A) It is always the first step

(B) It needs a catalyst

(C) It will be the step that is rate determining

(D) Collision only occur in the slow step

14. Which of the following mechanisms is consistent with a rate law of, Rate = k[NO2]? (5.7, 5.8)

(A) NO2 + NO2 ⇌ N2O4 fast   
 N2O4 + 2CO → 2NO + 2CO2 slow

(B) NO2 + CO → NO + CO2 slow   
  
(C) NO2 → NO + O slow   
 CO + O → CO2 fast   
  
(D) NO2 + NO2 → NO3 + NO slow   
 NO3 + CO → NO2 + CO2 fast

**ANSWERS**

**1. A**

**2. B**

**3. C**

**4. C**

**5. D**

**6. B**

**7. C**

**8. C**

**9. D**

**10. C**

**11. C**

**12. C**

**13. C**

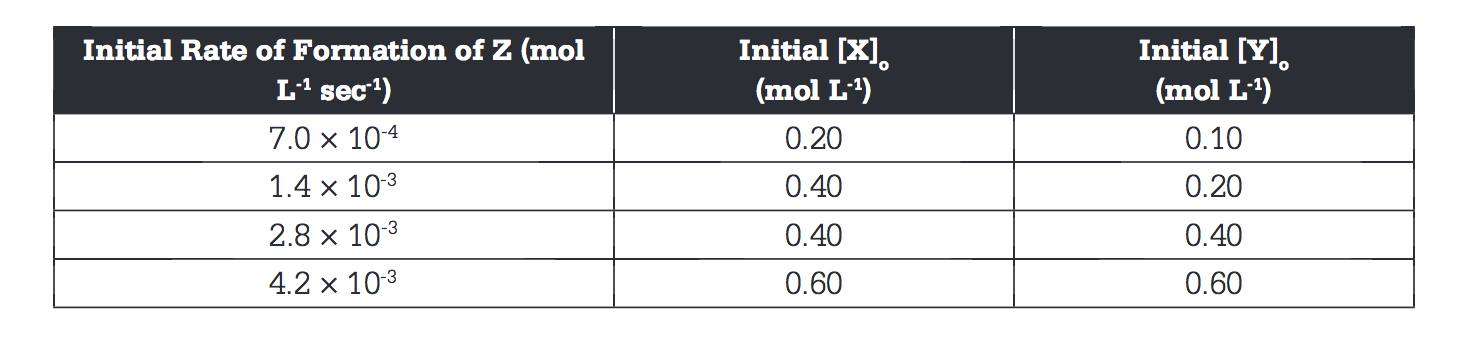
**14. C**

**SECTION B Free Response Questions (Write answers in the spaces provided)**

**Question 1 (Based on 1984, 2)**

2X + Y → Z

For the reaction above, the following initial rate data were collected at a single temperature.



(a) Give the rate law for this reaction from the data above. (1) (5.2)

Rate = k [Y]

(b) Calculate the specific rate constant and specify units. (1) (5.2)

Using data from experiment #1;

7.0 x 10-4 mol L-1 sec-1 = k (0.10 mol L-1)

k = 7.0 x 10-3 sec-1

(c) How long must the reaction proceed to produce a concentration of Z equal to 0.20 molar, if the initial reaction concentrations are [X]0 = 0.80 molar, [Y]0 = 0.60 molar and [Z]0 = 0 molar? (3) (5.3)

ln[A]t – ln[A]0 = -k t

ln[0.4] – ln[0.6] = -7.0 x 10-3 t

t = 58 sec

(d) Select from the mechanisms below, the one most consistent with the observed data, and *explain your choice*. (2) (5.7, 5.8)

C. Since the rate expression only includes [Y], it is the only reactant in a slow step. Also, overall

stoichiometry of the mechanism matches that of the overall reaction

|  |  |  |
| --- | --- | --- |
| (A)  X + Y 🡺 M (slow)  X + M 🡺 Z (fast) | (B)  X + X 🡸🡺 M (fast)  Y + M 🡺 Z (slow) | (C)  Y 🡺 M (slow)  M + X 🡺 N (fast)  N + X 🡺 Z (fast) |

**Question 2 (Based on 2005, 3)**

The catalyzed decomposition of A, is represented by the following equation.

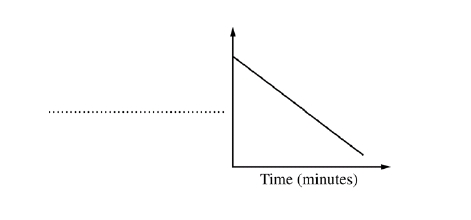
|  |  |  |
| --- | --- | --- |
|  | catalyst |  |
| A(aq) | 🡺 | Products |

The kinetics of the decomposition reaction were studied and the analysis of the results show that

It is a first-order reaction. Some of the experimental data are shown in the table below.

|  |  |
| --- | --- |
| [A]  (mole/L) | Time  (minutes) |
| 1.00 | 0.0 |
| 0.78 | 5.0 |
| 0.61 | 10.0 |

(c) During the analysis of the data, the graph below was produced.



(i) Label the vertical axis of the graph. (1) (5.3)

ln [A]

(ii) What are the units of the rate constant, k, for the decomposition of H2O2(aq)? (1) (5.2)  
min-1

(iii) On the graph, draw the line that represents the plot of the *uncatalyzed* first-order decomposition of A. (1) (5.11)

Starts at same origin but still linear but with a less steep slope (ignore finishing position)

**Question 3 (Based on 2004B, 3(b))**

2H2O2(aq) 🡺 2H2O(l) + O2(g)

The graphs below show results from a study of the decomposition of H2O2.

A screenshot of a cell phone

Description automatically generated

(a) Write the rate law for the reaction. Justify your answer. (2) (5.3)

Rate = k [H2O2]. The plot of ln [H2O2] versus time is a linear one.

(b) Determine the half-life of the reaction. (1) (5.3)

Read from the graph on the left, approx. 600 - 700 mins (allow a range)

(c) Calculate the value of the rate constant with units. (2) (5.2)

k = 0.693/t½  (answer will depend upon (b))

(d) Determine [H2O2] after 4,000 minutes. (2) (5.3)

ln [H2O2]4000 – ln [H2O2]0 = -k (4000) (answer will depend upon (c))

(e) In a related (but different) decomposition reaction, a single reactant is found to have an order of 2 in the rate equation. What should be plotted on the x and y axis, to achieve a graph that is identical in shape to the ln[H2O2] versus time graph above? (2) (5.3)

1/[reactant] on y-axis versus time on the x-axis

**Question 4 (1991, 3)**

2ClO2*(g)* + F2*(g)* 🡺 2ClO2F*(g)*

The following results were obtained when the reaction represented above was studied at 25°C.

|  |  |  |  |
| --- | --- | --- | --- |
| Experiment | Initial [ClO2]  (mol.L-1) | Initial [F2] (mol.L-1) | Initial Rate of Increase of [ClO2F]  (mol.L-1.sec-1) |
| 1 | 0.010 | 0.10 | 2.4 x 10-3 |
| 2 | 0.010 | 0.40 | 9.6 x 10-3 |
| 3 | 0.020 | 0.20 | 9.6 x 10-3 |

(a) Write the rate law expression for the reaction above. (2) (5.2)

Rate = k [ClO2] [F2]

(b) Calculate the numerical value of the rate constant and specify the units.(2) (5.2)

k = (2.4 x 10-3)/((0.01)(0.1)) = 2.4 M-1 sec-1

(c) In experiment 2, what is the initial rate of decrease of [F2]? (1) (5.1)

Via stoichiometry, ½ of 9.6 x 10-3 = 4.8 x 10-3

(d) Which of the following reaction mechanisms is consistent with the rate law developed in (a). Justify your choice. (2) (5.7)

I. Slow step matches rate equation, and overall stoichiometry of the whole mechanism matches the overall

equation.

I. ClO2 + F2 🡸🡺 ClO2F2 (fast)

ClO2F2 🡺 ClO2F + F (slow)

ClO2 + F 🡺 ClO2F (fast)

II. F2 🡺 2 F (slow)

2 (ClO2 + F 🡺 ClO2F) (fast)