SI Chemistry - Full Discipline Demo

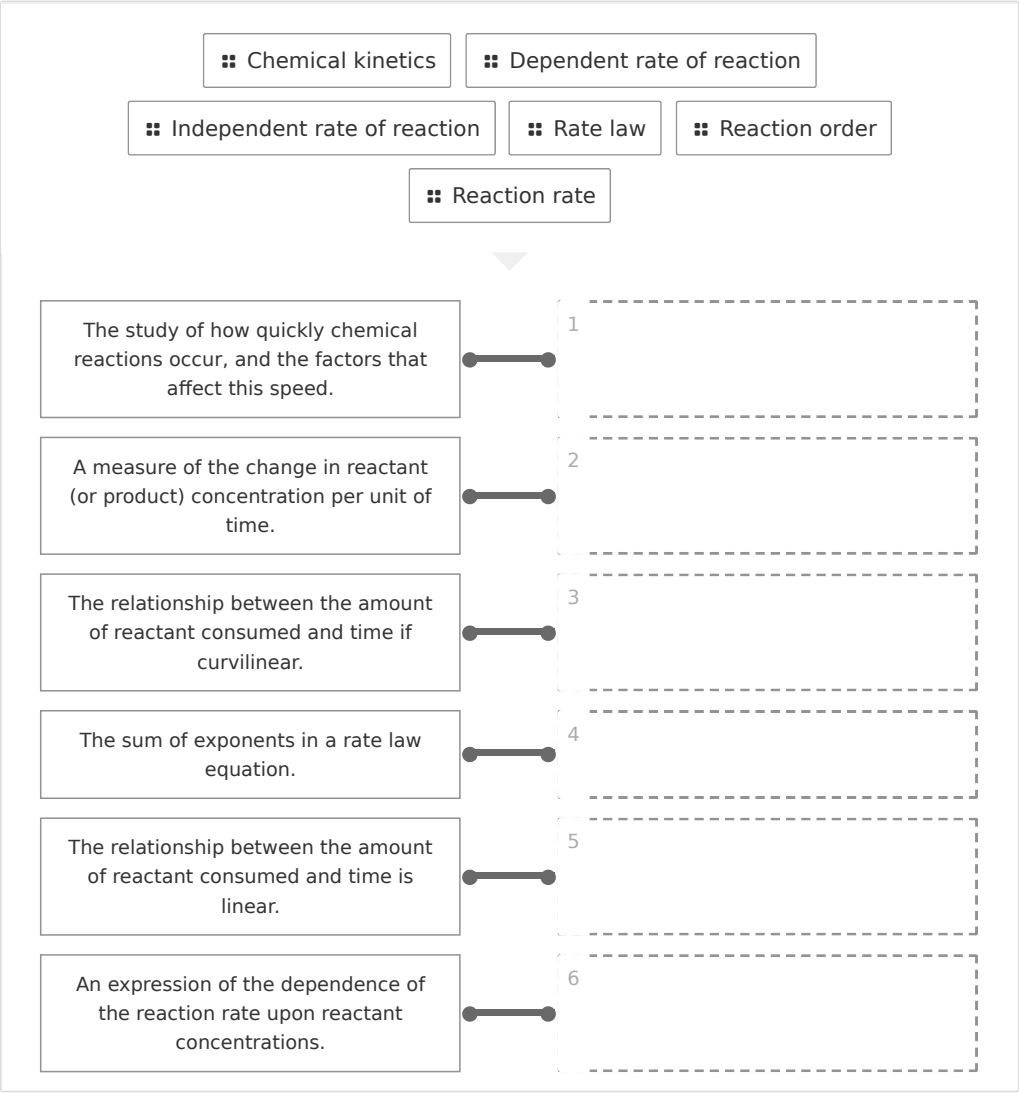
Reaction Order and Rate Laws

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Chemistry - Full Discipline Demo
Course	SI Chemistry - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Match each term with the best description.

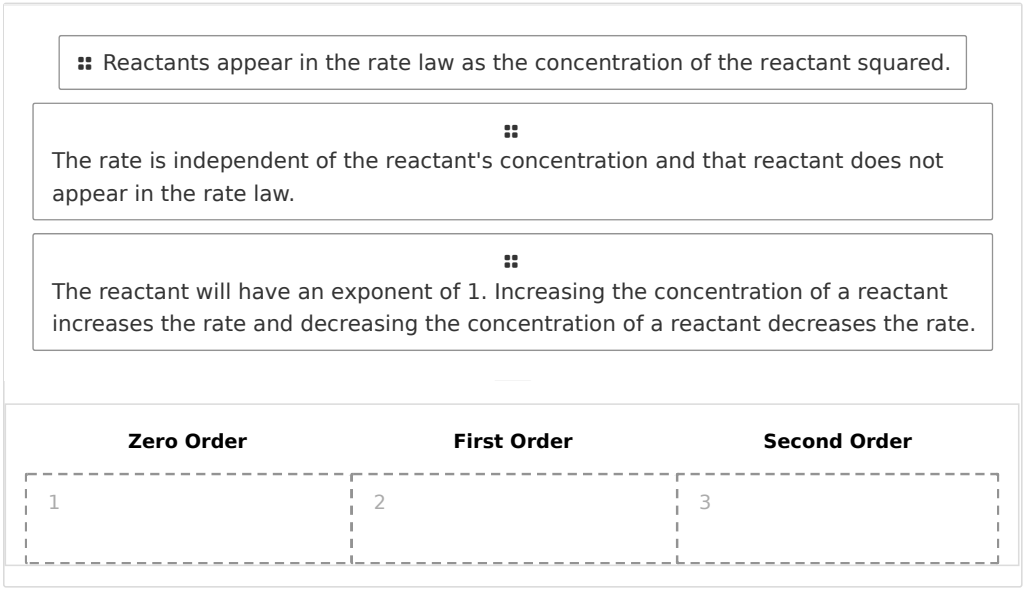


Correct answers:

1 Chemical kinetics 2 Reaction rate 3 Dependent rate of reaction

4 Reaction order 5 Independent rate of reaction 6 Rate law

Categorize the descriptions as zero, first, or second order.



Correct answers:

1

The rate is independent of the reactant's concentration and that reactant does not appear in the rate law.

2

The reactant will have an exponent of 1. Increasing the concentration of a reactant increases the rate and decreasing the concentration of a reactant decreases the rate.

3

Reactants appear in the rate law as the concentration of the reactant squared.

Exploration

Reaction rate is the measure of the change in reactant concentration per unit of time.

- True ✔
- False

Reaction rates may be almost instantaneous or may be billions of years long.

- [x] True ✔
- [ ] False

A _____ graph is representative of a dependent reaction rate, whereas a _____ graph is indicative of an independent reaction rate.

- [ ] linear; curvilinear
- [x] curvilinear; linear ✔

A first order reactant has an exponent of _____.

- [x] 1 ✔
- [ ] 2
- [ ] 3
- [ ] 4

Exercise 1

Determine the reaction order for HCl using calculations described in the background section. Show your work. Note that your answer will probably not be a whole number as it is in the examples, so round to the nearest whole number.

The students are using “ln” to determine exponents, and using a subjective measure of the time that the “X” disappears, thus the values could be quite a bit different from where they should be. As long as the students show their work, it allows you to know that the student understands the concept, and the correct calculations to get to the exponential values of the rate law. See background for calculations. For HCl, the approximate calculation was 0.33 (our calculations ranged from 0.27-0.46).

Determine the reaction order for $Na_2S_2O_3$ using calculations described in the background section. Show your work. Note that your answer will probably not be a whole number as it is in the examples.

The students are using “ln” to determine exponents, and using a subjective measure of the time that the “X” disappears, thus the values could be quite a bit different from where they should be. As long as the students show their work, it allows you to know that the student understands the concept, and the correct calculations to get to the exponential values of the rate law. See background for calculations. For $Na_2S_2O_3$, the approximate calculation was 1.3 (our calculations ranged from 1.136-1.6).

Write the rate law for the reaction between HCl and $Na_2S_2O_3$.

Should be similar to: Rate = $k[HCl]^0[Na_2S_2O_3]^1$

Using the following rate law and the experimental values given in the question figures, calculate k (with units):

$$\text{Rate} = k[F_2][ClO_2]$$

	$[F_2]$ (M)	$[ClO_2]$ (M)	Initial Rate (M/s)
Experiment 1	0.50	0.50	0.300
Experiment 2	0.80	0.80	0.768
Experiment 3	0.50	0.80	0.480

They can use any of the trials to calculate k and they should get the answer of 1.2 $M^{-1}s^{-1}$

Describe sources of error in this experiment.

Potential errors in this experiment include: subjectivity (when the “X” disappears), some small droplets may remain in the pipet or wells when transferring the chemical from one well to another well of the 24-well plate, unequal drop size, or the timer may not always be pushed at exactly the same time that the pipet is squeezed (may be just a little off because of human error).

Data Table 1: Varying Concentrations of HCl
(SAMPLE ANSWER BELOW)

	Well #C1, D1	Well #C2, D2	Well #C3, D
# of Drops of HCl	12	6	4
# of Drops of H_2O	0	6	8
# of Drops of $Na_2S_2O_3$	8	8	8
Concentration (M) of HCl Stock Solution	1.0	1.0	1.0
Concentration (M) of $Na_2S_2O_3$ Stock Solution	0.30	0.30	0.30
Reaction Concentration (M) of HCl after Mixing in Well	0.60	0.30	0.20
Reaction Concentration (M) of $Na_2S_2O_3$ after Mixing in Well	0.12	0.12	0.12
Trial 1 Reaction Time (sec)	46.59	50.56	67.78
Trial 2 Reaction Time (sec)	49.91	48.66	62.81
Average Reaction Time (sec)	48.25	49.61	65.14
Reaction "Rate" (sec^{-1})	0.021	0.020	0.015

Data Table 2: Varying Concentrations of Na2S2O3
(SAMPLE ANSWER BELOW)

	Well #C4, D4	Well #C5, D5	Well #C6, D6
# of Drops of HCl	8	8	8
# of Drops of H_2O	0	6	8
# of Drops of $Na_2S_2O_3$	12	6	4
Concentration (M) of HCl Stock Solution	1.0	1.0	1.0
Concentration (M) of $Na_2S_2O_3$ Stock Solution	0.30	0.30	0.30
Reaction Concentration (M) of HCl after Mixing in Well	0.40	0.40	0.40
Reaction Concentration (M) of $Na_2S_2O_3$ after Mixing in Well	0.18	0.090	0.060
Trial 1 Reaction Time (sec)	25.12	56.53	104.59
Trial 2 Reaction Time (sec)	24.87	53.57	103.69
Average Reaction Time (sec)	25.00	55.05	104.14

Reaction "Rate" (sec^{-1})	0.040	0.018	0.0096

Competency Review

Reaction rates may be _____ on the concentration of a reactant.

- dependent
- independent
- dependent or independent ✔

The rate constant and the exponents of the rate law equation can be determined merely by looking at a balanced chemical equation.

- True
- False ✔

Determining the reaction rate of a chemical reaction is useful for the development of drugs and the manufacturing of chemicals.

- True ✔
- False

The speed of a chemical reaction is called _____.

- chemical kinetics
- the reaction rate ✔
- the reaction order

Reactants that are _____ will appear in the rate law as the concentration of the reactant squared.

- zero order
- first order
- second order ✔
- fourth order

For the reaction of hydrochloric acid and sodium thiosulfate, the rate law is written as _____.

- Rate = k $[HCl]^m$ $[Na_2S_2O_3]^n$ ✔
- Rate = k [HCl + $Na_2S_2O_3$]
- Rate = t $[HCl]^a$ $[Na_2S_2O_3]^x$
- Rate = t [HCl + $Na_2S_2O_3$]

Extension Questions

In the lab activity, the reaction rate was determined by the appearance of a product. However, the reaction rate can also be determined by the disappearance of a reactant.

$$\text{Rate} = \frac{\Delta[\text{Product}]}{\Delta t} \; or \; \text{Rate} = \frac{-\Delta[\text{Reactant}]}{\Delta t}$$

In each situation below, you are given a rate measured by the appearance of one component of the reaction and are asked to predict the rate of appearance or disappearance of another component, based on logic and stoichiometric relationships. For example, if the reaction is as follows:

$$\text{A} + 2\text{B} \rightarrow \text{Products}$$

For every mole of A that is used, 2 moles of B are used so the rate of disappearance of B is twice the rate of the disappearance of A. This may be expressed as:

$$\text{Rate} = \frac{-\Delta[\text{B}]}{\Delta t} = \frac{-2[\text{A}]}{\Delta t}$$

Apply this information to the following scenarios:

$$\text{N}_2(\text{g}) + 3\text{H}_2\ (\text{g}) \rightarrow 2\text{NH}_3(\text{g})$$

The reaction rate is measured as 0.032 M NH_3/s. Determine the rate of disappearance of N_2 and the rate of disappearance H_2. Explain how you arrived at your answers.

$$\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$$

The reaction rate is measured as -2.6 M CH_4/s. Determine the rate of appearance of CO_2 and the rate of appearance of H_2O. Explain how you arrived at your answers.

(SAMPLE ANSWER BELOW)

One mole of N_2 is used for every 2 moles of ammonia that appear, making the rate of disappearance of nitrogen half the rate of appearance of ammonia. Rate = 0.016M N_2/s. Three moles of hydrogen are used for every 2 moles of ammonia that appear, which makes the rate of disappearance of hydrogen 3/2 the rate of appearance of ammonia. Rate = 0.048 M H_2/s
One mole of carbon dioxide is produced for every mole of methane that is used. Rate = 2.6 M CO_2/s. Two moles of water are produced for every mole of methane that is used. Rate = 5.2 M

H_2O/s.