Dependence of the reaction velocity on the type of substance (Item No.: P1149100)

Curricular Relevance

Area of Expertise: ILIAS

Education Level: Chemie

Topic: Klasse 10-13

Subtopic: Physikalische Chemie

Experiment: Kinetik chemischer Reaktionen

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	20 Minutes	1 Student

Additional Requirements:

Experiment Variations:

Keywords:

Reaction velocity, Dependence of the reaction velocity, Chemical reaction

Task and equipment

Task

Principle

According to the fundamental laws of chemistry, a chemical reaction is spontaneous when it is exothermic; i.e. release energy (usually in the form of heat) to the environment.

The reaction velocity of a reaction is dependent on the reaction temperature and the concentration of the starting materials (an increase in the reaction temperature or the concentration of the starting materials leads to an increase in the reaction velocity).

Moreover, the reaction velocity also depends on the degree of separation of the starting materials. If, for example, a starting material is highly dispersed, the surface of the substance is increased. This increases the number of reactive particles on the surface, which react with other particles of the material. An increase of the reaction velocity results.

Task

In this experiment is shown that at the same temperature, the same concentration and a comparable surface of the starting materials, nevertheless a difference in the reaction velocity can be observed in comparable "reaction mechanisms".

Therefore, magnesium or zinc is brought into contact with concentrated hydrochloric acid and the resulting amount of hydrogen is examined. Both reactions take place according to the same scheme ("metal + acid -> salt + hydrogen"), however a different reaction velocity of both reactions are observed (on the basis of the amount of hydrogen being formed). Although the reaction temperature, initial concentration and surface of the starting materials are approximately the same, the reaction of magnesium with zinc take place distinctly faster.

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Student's Sheet

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Equipment

Position No.	Material	Order No.	Quantity
1	Support base DEMO	02007-55	1
2	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	2
3	Right angle clamp	37697-00	2
4	Universal clamp	37715-00	1
5	Gas-syringe holder with stop	02058-00	1
6	Gas syringe, 100 ml, with 3-way cock	02617-00	1
7	Glass beaker DURAN®,tall, 150 ml	36003-00	1
8	Round flask, 100 ml, 3-n., 3 x GL25	35677-15	1
9	Closure caps,10, GL25	41221-03	1
10	Gasket for GL25, 8mm hole, 10 pcs	41242-03	1
11	Glass tube, straight, l=80 mm, 10/pkg.	36701-65	1
12	Rubber caps, pack of 20	02615-03	1
13	Rubber tubing, i.d. 6 mm	39282-00	1
14	Magnetic stirrer without heating, 3 ltr., 230 V	35761-99	1
15	Magnetic stirring bar 15 mm, cylindrical	46299-01	1
16	Magnetic stirring bar 30 mm, cylindrical	46299-02	1
17	Magnetic stirring bar, 50 mm, cylindrical	46299-03	1
18	Separator for magnetic bars	35680-03	1
19	Tweezers,straight,blunt, 200 mm	40955-00	1
20	Scissors, straight,180 mm	64798-00	1
21	Graduated cylinder 100 ml	36629-00	1
22	Glass rod,boro 3.3,l=300mm, d=7mm	40485-05	1
23	Precision Balance, Sartorius ENTRIS623-1S, 620 g / 0.001 g	49294-99	1
24	Cork rings for flasks 10-100ml	38554-00	1
25	Funnel, glass, top dia. 55 mm	34457-00	1
26	Stop clock, demo.; diam. 13 cm	03075-00	1
27	Syringe 10ml, Luer, 10 pcs	02590-03	1
28	Cannula 0.9x70mm, Luer, 20 pcs	02597-04	1
29	Wash bottle, plastic, 500 ml	33931-00	1
30	Hydrochloric acid 37 %, 1000 ml	30214-70	1
31	Magnesium, ribbon, roll, 25 g	30132-00	1
32	Zinc, granul., 99.5%, 500 g	31998-50	1
33	Water, distilled 5 l	31246-81	1

Student's Sheet

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Safety information

During the experiment all persons in the room must wear protective goggles!

Hazards

H- and P-statements

Hydrochloric acid, concentrated

- H314 Causes severe skin burns and eye damage
- H335 May cause respiratory irritation
- H290 May be corrosive to metals

- P280 Wear protective gloves/protective clothing/eye protection/face protection
- P301 + P330 + P331 IF SWALLOWED: rinse mouth. Do NOT induce vomiting
- P309 + 310 IF exposed or if you feel unwell: Call a POISON CENTER or doctor/physician
- P305 + P351 + P338 Rinse cautiously with water for several minutes. Remove contact lenses if present and easy to do. Continue rinsing
- P501 Dispose of contents/container to accepted waste disposal facility

Magnesium, ribbon

- H228 Flammable solid
- P501 Dispose of contents/container to accepted waste disposal facility

Safety information

Concentrated acids are highly caustic. They destroy skin and textiles. When diluting, first the water, then the acid (protective goggles, laboratory coats, gloves).

First aid
Affected skin, eyes with well-opened eyelid gap, textiles etc. should be rinsed thoroughly with plenty of water. In case of eye injuries consult the doctor immediately.

Disposal
Dilute remaining acids with water, neutralize (pH 6 to 8) and then flush away. Collect solutions containing heavy metal salts in a container provided for this purpose.

Set-up and procedure

The apparatus is compiled as shown in Figure 1. Approximately 100 mg (= 4.11 mmol) of magnesium ribbon is weighed in the round flask to 1 mg and is connected to the gas syringe. The second lateral neck of the round flask is closed with an 8 mm glass tube with a rubber cap. Through this rubber cap, 5 ml of an approximately 5 molar hydrochloric acid (concentrated hydrochloric acid 1: 1) is injected then as quickly as possible, and the stopwatch is started at the same time. The volume on the gas syringe is read off and recorded at intervals of 10 to 15 seconds. The measurement is repeated with the same molar mass of zinc (4.11 mmol $\hat{=}$ 269 mg zinc), whereby the rasped piece of zinc should have approximately the same size and shape of the piece of magnesium ribbon.

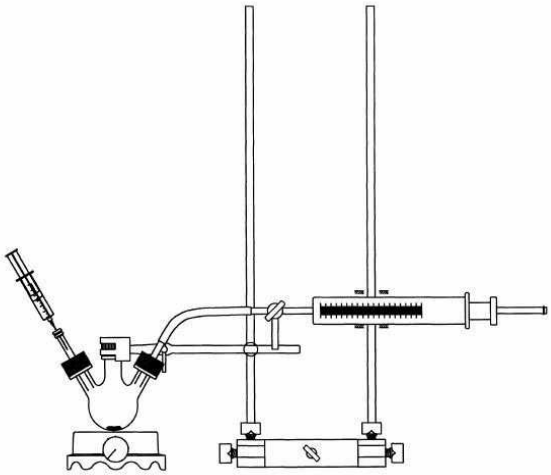

Fig. 1

Observation and evaluation

Observation

The reaction of the hydrochloric acid with the magnesium ribbon proceeds considerably more rapidly than with the zinc strip. About 100 ml of gas are generated in the reaction of hydrochloric acid with magnesium in about 2.5 minutes. During the reaction with zinc, approximately 10 ml of gas are produced in the same time.

Evaluation

Due to its position in the electrochemical series of elements, magnesium has a much more negative potential than hydrogen compared to zinc. As a result it should react more violent, i.e. faster with hydrochloric acid than zinc. Since both reactions as a heterogeneous reaction occur only at the phase boundary solid-liquid, for a comparison the surfaces of both metals must be approximately equal. In the case of very pure zinc, the overvoltage of the hydrogen on this metal also occurs as a reaction-inhibiting problem. Thereby, at the beginning, hydrogen ions are discharged from the zinc.
However, the hydrogen being formed does not dissolve or dissolve very slowly from the electrode surface, so that a "hydrogen coat" surrounds the zinc which hinders further reduction of the hydrogen ions.

Table 1: Molar masses

Substance	Molar mass [g/mol]
Magnesium	24,305
Zinc	65,38

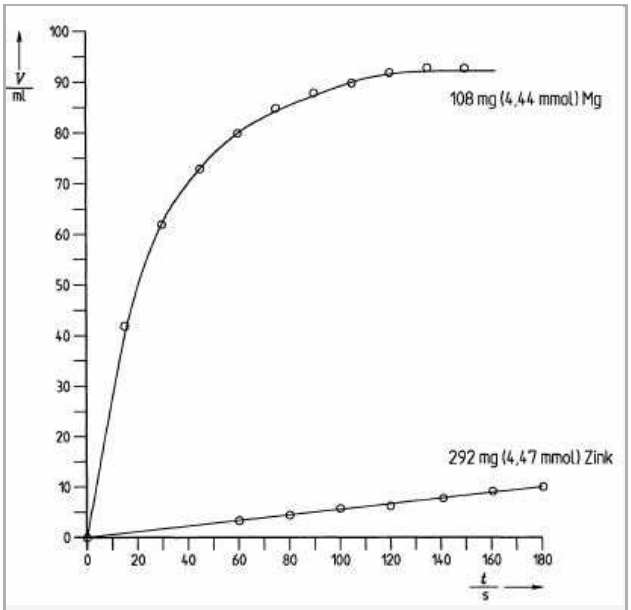

Fig. 2: Hydrogen formation of metals with hydrochloric acid