Dependence of reaction rate on temperature I (acetic acid - magnesium)

This can be easily demonstrated by reacting magnesium with acetic acid at different temperatures and measuring the quantities of hydrogen formed per unit of time. A comparison of the initial rates of the reactions shows, in a first approximation, about a doubling of the reaction rate with a temperature increase of 10 K.

Chemistry > General Chemistry > Chemical reactions > Basics of chemical reaction

Chemistry > Organic chemistry > Biochemistry

Chemistry > Physical chemistry > Chemicalkinetics

Biology > Biochemistry

Applied Science > Medicine > Biochemistry

Difficulty level	Group size	Preparation time	Execution time
medium	1	10 minutes	20 minutes

This content can also be found online at:

http://localhost:1337/c/616596dd454b1b0003d88a3a

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General information

Application

Experiment setup

In general, the reaction rate depends on the temperature and the concentration of the starting materials. The reaction rate generally increases with increasing temperature as well as with increasing concentration of the starting materials. The temperature thus represents a regulator of the reaction rate, which must be taken into account in many practical applications, such as cooking food.

The experiment offers a didactically clear introduction to the kinetics of chemical reactions.

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Other information (1/2)

Previous knowledge

- Factors influencing the reaction kinetics, such as temperature, concentration of the starting material or the degree of fragmentation of the starting materials.
- Chemical reactions occur spontaneously when they are exergonic.

Scientific principle

In this experiment, acetic acid and magnesium are reacted with each other and the hydrogen produced is collected. The concentration or volume of the acetic acid used is the same for each experiment, as is the mass of the magnesium strip. Only the temperature of the starting materials is varied during the experiment, so the (temperature-dependent) reaction behaviour of acetic acid and magnesium is investigated at three different temperatures with the aid of a water bath.

Other information (2/2)

Learning objective

In this experiment, students observe that the rate of a chemical reaction is strongly influenced by temperature.

Tasks

The task in this experiment is to measure the respective amounts of hydrogen formed per unit time by the reaction of acetic acid and magnesium at different temperatures. A subsequent comparison of the initial rates of the reactions shows, in a first approximation, about a doubling of the reaction rate with a temperature increase by 10°C.

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Safety instructions

The general instructions for safe experimentation in science lessons apply to this experiment.

For H- and P-phrases please refer to the safety data sheet of the respective chemical.

Theory

According to the fundamental laws of chemistry, a chemical reaction is spontaneously voluntary if it is exergonic, i.e. thermodynanically favourable. The reaction rate of a reaction depends 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 rate). Thus, the starting materials have a higher (internal) energy at a higher temperature. Thus, the material particles move faster and collide more often, which explains a higher reaction speed at higher temperature.

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Equipment

Position	Material	Item No.	Quantity
1	Magnetic stirrer with heater MRHei-Tec	35752-93	1
2	Supp.rod stainl.st.,50cm,M10-thr.	02022-20	1
3	Right angle boss-head clamp	37697-00	3
4	Universal clamp	37715-01	1
5	Retort stand, h = 750 mm	37694-00	1
6	Gas-syringe holder with stop	02058-00	1
7	Gas syringe, 100 ml, with 3-way cock	02617-00	1
8	Three neck round bottom flask, 100 ml	MAU-27220501	1
9	Gasket for GL25, 8mm hole, 10 pcs	41242-03	1
10	Glass tube, straight, l=80 mm, 10/pkg.	36701-65	1
11	Nozzle for glass screwthread	43903-01	1
12	Thermometer -10...+50 °C	38034-00	1
13	Cristallizing dish, boro3.3, d = 125 mm	46244-00	1
14	Magnetic stirring bar 15 mm, cylindrical	46299-01	1
15	Magnetic stirring bar 30 mm, cylindrical	46299-02	1
16	Magnetic stirring bar, 50 mm, cylindrical	46299-03	1
17	Separator for magnetic bars	35680-03	1
18	Volumetric flask 1000ml, IGJ24/29	36552-00	1
19	Graduated cylinder, Borosilicate, 100 ml	36629-00	1
20	Funnel, glass, top dia. 50 mm	34457-00	1
21	Wash bottle, plastic, 500 ml	33931-00	1
22	Stop clock, demo.; diam. 13 cm	03075-00	1
23	Rubber tubing, i.d. 6 mm	39282-00	1
24	Iron rods, flexible, 5 off	45127-00	1
25	Scissors, straight,180 mm	64798-00	1
26	Tweezers,straight,blunt, 200 mm	40955-00	1
27	Precision Balance, Sartorius, 620 g : 1 mg	49311-99	1
28	Pasteur pipettes, 250 pcs	36590-00	1
29	Rubber caps, 10 pcs	39275-03	1
30	Acetic acid 99...100%, pure 1 l	31301-70	1
31	Magnesium, ribbon, roll, 25 g	30132-00	1
32	Water, distilled 5 l	31246-81	1

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Structure and implementation

Set-up

Experiment setup

The apparatus is assembled according to the adjacent figure.

The gaskets of the screw connections on the three-necked piston are replaced by those with an 8 mm bore. One end of an iron rod is bent to form an eye or hook and the other end is pushed through the rubber cap which closes a small glass tube in the side neck of the piston.

Add about 30 to 40 ml of a 1-molar acetic acid (55.6 ml conc. acetic acid to 1000 ml) to the flask and temper it to a value set on the temperature sensor with the aid of the water bath (crystallizing dish, temperature sensor).

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Procedure

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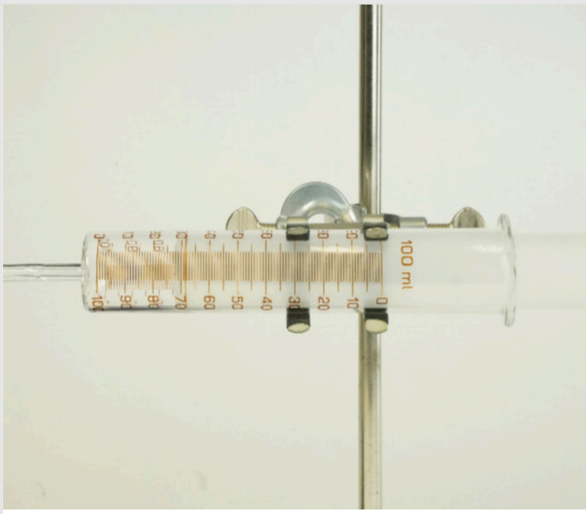

Gas syringe

As soon as the reaction temperature is reached, a piece of magnesium ribbon (about 0.1 g) weighed to the nearest 1 mg is suspended from the eyelet (or hook).

After a final tightness check of the apparatus, the magnesium is added to the acetic acid solution with the aid of the iron wire and a stopwatch is started at the same time. The experiment is repeated with equal quantities at three to four different temperatures (e.g. 20°C, 30°C, 40°C, 50°C).

The quantities of gas produced can be quantified using the scale on the gas syringe.

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Evaluation

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Evaluation (1/4)

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Temperaturen / Zeit(s)	entstandene Gasvolumina in ml bei 20 °C	30 °C	40 °C	50 °C
15	5	8	16	22
30	11	16	32	39
45	17	26	45	51
60	22,5	34	52	60
75	28	42	59	66
90	33	48	67	72
105	38	54	72	76
120	42	58,5	76	79,5
135	46	63	79	81
150	50	66	81	83,5
165	53	70	83	86
180	56	73	85	88
195	59	75	86,5	89
210	61	77	87,5	89,5
225	64	79	88,5	90

Acetic acid reacts with magnesium to produce gas.

As the temperature rises, the gas evolution becomes faster.

The table on the left shows a measurement example.

Evaluation (2/4)

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The speed of chemical reactions depends not only on the concentration but also on the temperature. The measurement example shows that temperature increases of only 10 K are already noticeable in a clear acceleration of the gas evolution. Exact values can be calculated if one assumes that the reaction proceeds according to the first order with respect to hydrogen evolution. The comparison of the initial velocities (in first approximation of the initial volumes) shows approximately a doubling of the reaction velocity with a temperature increase of 10 K.

These measurement results also confirm the so-called RGT rule (reaction rate-temperature rule), which states that the reaction rate of a chemical reaction doubles to quadruples with a temperature increase of 10 °C (degrees Celsius). This "rule of thumb" applies to many chemical reactions.

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Evaluation (3/4)

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The Arrhenius equation describes the relationship between the reactance constant k and the temperature T. Evaluate the following statements about the Arrhenius equation.

The Arrhenius equation describes the relationship between the reactance constant k and the temperature T.

- Correct
- False

Evaluation (4/4)

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The equilibrium constant k takes...

- [ ] ...for endothermic reactions with increasing temperature.
- [ ] ...for exothermic reactions decreases with increasing temperature.
- [ ] ...for endothermic reactions decreases with increasing temperature.
- [ ] ...for exothermic reactions with decreasing temperature.

Check

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Slide	Score / Total
Slide 14: The Arrhenius equation	**0/5**
Slide 15: Equilibrium constant \(k\)	**0/3**

Total score 0 / 8

Show solutions

Repeat

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