

Let's make a chemical clock

Activity 1: Answer sheet

Why does iodine immediately turn colourless in the presence of vitamin C?

Vitamin C reduces molecular iodine (dark red) to the colourless iodide ion.

Why can the oscillating mechanism only be noticed if the decomposition of hydrogen peroxide is catalysed by the iodide generated by the reaction with vitamin C and not by the iodide resulting from the dissociation of a salt?

The intermediates formed by the presence of vitamin C give rise to parallel reaction pathways, which are responsible for the fluctuations in the concentrations of certain chemical species (that cause the oscillatory mechanism). Evidently, these intermediates do not form when iodide is supplied directly via potassium iodide (and not generated by vitamin C).

Observe reaction (A): how can you prove that ascorbic acid is oxidised without calculating the formal charge of each atom?

Ascorbic acid oxidation can be seen by the increase in double bonds between carbon and oxygen, a highly electronegative atom.

Observe reaction (B): Why is it a hydrolysis reaction?

The etymology of the word 'hydrolysis' indicates a lysis (breakdown) by water. In this case, the water molecule breaks a bond between the oxygen and carbon of the cyclic part of ascorbic acid.

Perform the hydrogen peroxide decomposition reaction by adding potassium iodide. Since it acts as a catalyst, the iodide reforms. However, a small amount of molecular iodine is also produced. How can you detect this?

Catalysis requires very limited concentrations of catalyst, in this case iodide ion. However, by adding a greater amount of iodide to the hydrogen peroxide, you can notice the slightly reddish colour of the mixture due to the production of molecular iodine.^[1]

Repeat the procedure of the clock reaction using water at different temperatures. Report your observations in respect of the time you measured and try to formulate a hypothesis if there is a difference.

By repeating the reaction with water at increasing temperatures, a progressive shortening of the oscillation time is observed. Consequently, the reaction mixture will darken every time in a shorter period. The opposite happens when decreasing the temperature.

What is the difference between an equilibrium reaction and a clock reaction?

There are numerous and profound differences between the two types of reaction. We list just a few of them. An equilibrium reaction is a reversible reaction in which the rate of the forward reaction is equal to the rate of the reverse reaction. The concentrations of reactants and products are governed by an equilibrium constant, whose value changes only with temperature. The composition of the equilibrium mixture remains constant. Equilibrium reactions can proceed in the opposite direction as soon as a certain amount of product has accumulated. A clock reaction is regulated by a specific type of chemical kinetics involving intermediate autocatalytic and/or autoinhibitory stages that produce periodic variations in the concentrations of some chemical species (destined to expire in a more or less long time). The action of these intermediate species delays the formation of products. Once the products are formed, the reverse reaction does not occur.

Give the definition of autocatalytic reaction and autoinhibitory mechanism.

An autocatalytic reaction is a chemical reaction in which a product (or a reaction intermediate) also functions as a catalyst. When one of the reaction products (or intermediates) decreases the rate of the chemical reaction itself, the phenomenon should be referred to as an autoinhibition.

References

[1] Kelter P (1994) [Are Our Demonstration-Based Workshops Doing More Harm Than Good?](#) *J. Chem. Educ.* 71: 109-110. doi: 10.1021/ed071p109