

Temperature Dependency of Rate of Reaction

Equipment:

3 goblets
3 beakers (250 mL)
3 beakers (100 mL)
3 glass rods
measuring cylinders
Dewar vessel or plastic bowl
laboratory heating plate

Chemicals:

potassium permanganate solution (0.1 M)
oxalic acid solution (0.5 M)
sulfuric acid (4 M)
deionized water
crushed ice

Safety:

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potassium permanganate (KMnO₄):



H272, H302, H410
P210, P273

oxalic acid (H₂C₂O₄):



H302 + H312
P262, P302 + P352

sulfuric acid (H₂SO₄):



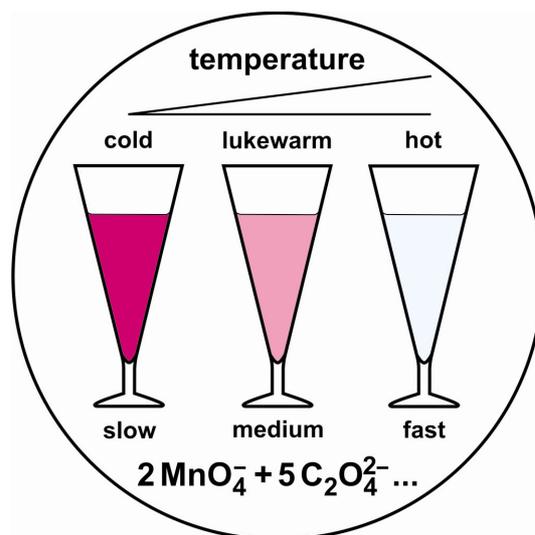
H290, H314
P301 + P330 + P331, P305 + P351 + P338

It is necessary to wear safety goggles and protective gloves, because every contact with eyes or skin should be avoided.

Procedure:

Preparation: 15 mL of oxalic acid solution, 30 mL of sulfuric acid and 60 mL deionized water are filled in each of the three 250-mL beakers, 15 mL of potassium permanganate solution in each of the 100-mL beakers. One 250-mL and one 100-mL beaker are cooled down to approx. 0 °C in an ice bath, a second pair of beakers is heated to approx. 50 °C in a water bath on the laboratory heating plate, the last pair of beakers remains at room temperature.

Procedure: The acidified oxalic acid solutions with different temperatures are filled into the goblets. Subsequently, the ice cold, then the lukewarm and finally the hot potassium



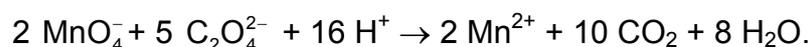
permanganate solution is added rapidly to the corresponding oxalic acid solution and the solutions are stirred up.

Observation:

The solutions change their color from purple to claret-red and tawny and finally to colorless; simultaneously, a slight effervescence can be observed. The decolorisation of the hot solution is completed after approx. 0.5 min, that of the lukewarm solution after approx. 2.5 min and that of the ice cold solution after approx. 15 min.

Explanation:

Purple permanganate ions are reduced in acidic solution by oxalate ions to the nearly colorless manganese(II) ions, whereas the oxalate ions are oxidized to gaseous carbon dioxide:



The reaction rate depends obviously on the temperature. An increase in temperature normally results in an acceleration of the reaction. An old rule of thumb used by chemists says that the rate of a reaction roughly doubles with each ten-degree temperature increase (the factor varies in fact between 1.5 and 4). A more detailed theoretical treatment requires the consideration of the so-called ARRHENIUS equation of the rate coefficient, which was the starting point for the two most important theories of the reaction rate, the collision theory and the transition state theory.

Disposal:

The solutions are poured into the container for heavy-metal waste.