Name of the project:	**Digitization of chemistry experiments to improve the quality and support chemistry teaching in secondary schools**
Acronym:	**ChemIQSoc**
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Tittle: Bengal flames

Work instructions

Task: Use concentrated sulfuric acid to induce a strongly exothermic disproportionation of potassium chlorate, which ignites the sucrose. Colour the oxidation flame of sucrose with the appropriate nitrate of the *s* or *p* element.

Theory

Potassium chlorate is decomposed by concentrated acid in a highly exothermic manner according to the Eq

$$3\ KClO_3 + 3\ H_2SO_4 \rightarrow 2\ ClO_2 + HClO_4 + 3\ KHSO_4 + H_2O \quad (1)$$

produces chlorine dioxide, a highly reactive oxidising agent, which decomposes into oxygen and chlorine

$$2\ ClO_2 \rightarrow Cl_2 + 2\ O_2 \quad (2)$$

The high temperature of reaction (1) also causes the thermal decomposition of potassium chlorate

$$2\ KClO_3 \rightarrow 2\ KCl + 3\ O_2 \quad (3)$$

Until sufficient oxygen is formed, potassium chlorate forms an explosive mixture with sucrose, which explodes at high temperature or pressure even in the absence of oxygen according to the Eq

$$8\ KClO_3 + C_{12}H_{22}O_{11} \rightarrow 8\ KCl + 12\ CO_2 + 11\ H_2O \quad (4)$$

When the entire amount of potassium chlorate has reacted, sucrose is oxidized by the oxygen produced by the preceding reactions, or from the air while burning with a flame in which the nitrate is also vaporized, and the corresponding nitrate cation stains the flame.

$$C_{12}H_{22}O_{11} + 12\ O_2 \rightarrow 12\ CO_2 + 11\ H_2O \quad (5)$$

The colouring of the flame by the cations present can be determined from the following table

Cation	Flame color
K^+	pink-purple
Sr^{2+}	crimson-red
Cu^{2+}	blue

Cation	Flame color
Na^+	yellow

Equipment: mortar and pestle, spoon, beaker, pipette, protective shield, fume hood

Chemicals: potassium chlorate, sucrose, concentrated sulfuric acid, potassium nitrate, sodium nitrate, strontium nitrate, copper nitrate

Procedures:

1. Put 2 spoons of $KClO_3$, 2 spoons of sugar, 1 spoon of the corresponding nitrate into a mortar.
2. Mix the mixture well. Wear gloves and a shield during this operation, as the mixture may spontaneously ignite with pressure.
3. Using a pipette, add a few drops of concentrated sulfuric acid.
4. The mixture will ignite, a small explosion will occur, and then the mixture will begin to burn with a colored flame depending on the cation of the nitrate used.

Management of chemical substances

Chemicals	Form	H-statements	P-statements
$KClO_3$	Solid	H271, H302 + H332, H411	P210, P220, P261, P273, P280
H_2SO_4	Liquid, 96%	H290, H315, H319	P260, P280, P302 + P352, P305 + P351 + P338, P337, P313
Sucrose, commercial	Solid	---	---
KNO_3	Solid	H272	P220
$NaNO_3$	Solid	H272, H319	P220, P280, P305 + P351 + P338, P337 + P313
$Sr(NO_3)_2$	Solid	H271, H318	P210, P280, P305 + P351 + P338, P310
$Cu(NO_3)_2 \cdot 3H_2O$	Solid	H272, H302, H315, H318, H400	P220, P273, P290, P305 + P351 + P338

Sources of risk and assessment of risk severity

Possibility of burns and eye damage.

Waste management method

Certified chemical waste disposal company.

Risk reduction measures

Lab coat, gloves, shield, keeping a safe distance.

Worksheet

Calculations

1. Calculate the volume of chlorine dioxide formed by the reaction of 1 g of potassium chlorate with sulphuric acid at 20°C and pressure 101.3 kPa.
   Reaction: $3\ KClO_3 + 3\ H_2SO_4 \rightarrow 2\ ClO_2 + HClO_4 + 3\ KHSO_4 + H_2O$
   $M(KClO_3)$ = ... $g.mol^{-1}$

Observation

1. Describe the experiment Bengal flames

Questions

1. Stechiometrically modify the given reactions that take place in the implementation of the Bengal flames experiment. Write the oxidation and reduction half-reactions.

   $KClO_3 + H_2SO_4 \rightarrow ClO_2 + HClO_4 + KHSO_4 + H_2O$
   Oxidation:
   Reduction:

   $ClO_2 \rightarrow Cl_2 + O_2$
   Oxidation:
   Reduction:

   $KClO_3 \rightarrow KCl + O_2$
   Oxidation:
   Reduction:

2. Explain how different flame colours can be achieved in Bengali fires.

3. Explain why it is recommended in a chemistry laboratory to carry out the experiment in a fume hood.

Conclusion

Instructions to elaborate conclusions:

1. Briefly summarise the aim of the demonstration experiment. What was the experiment trying to find out or prove??
2. Describe what you observed during the experiment. What were the most important results and what connections did you notice?
3. Explain the results using theory. How do the results confirm or refute the assumed principles?
4. Think about the practical meaning. How can the findings from the experiment be used in real life or in further study?

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