Which sodium salt is which?

Time

1–1.5 h.

Curriculum links

Tests for sulfur dioxide. Sulfur chemistry – students can find much of this in text

books.

Group size

2– 4.

Materials and equipment

Materials per group

1 g of each of the following:
- sodium metabisulfite ($NaHSO_3$) (harmful if swallowed, causes serious eye damage, contact with acids liberates toxic gas)
- sodium sulfate ($Na_2SO_4.10H_2O$) (no significant hazard)
- sodium peroxodisulfate ($Na_2S_2O_8$) (Skin/respiratory sensitiser, skin/eye/respiratory irritant, harmful if swallowed)
- sodium sulfite ($Na_2SO_3.7H_2O$) (harmful if swallowed, causes serious eye damage, contact with acids liberates toxic gas)
- sodium thiosulfate ($Na_2S_2O_3.5H_2O$) (No significant hazard)
- 2 mol dm^{-3} hydrochloric acid (No significant hazard)
- acidified potassium dichromate(VI) solution (1% solution in 1 M sulphuric acid) (Carcinogen, mutagen, reproductive toxin, harmful if inhaled, skin/eye irritant)
- 0.5 mol dm^{-3} potassium iodide solution (No significant hazard)
- 0.5 mol dm^{-3} iron(III) chloride solution (Corrosive to skin/eyes, harmful if swallowed, hazardous to the aquatic environment)
- 0.2 mol dm^{-3} iodine in aqueous potassium iodide (No significant hazard but will stain skin and clothing)
- 0.1 mol dm^{-3} silver nitrate solution (Skin/eye irritant)
- 2 mol dm^{-3} sodium hydroxide solution (corrosive to skin and eyes)
- 3% hydrogen peroxide solution (No significant hazard)
- deionised water
- litmus paper
- strips of filter paper
- safety goggles
- protective gloves.

Equipment per group

- 10 test-tubes
- test-tube rack
- test-tube holders
- Bunsen burner
- wood splints
- spatula
- wash bottle of deionised water
- dropping pipettes
- safety goggles.

Safety

Eye protection must be worn.

Some of the tests produce sulphur dioxide (corrosive, toxic - asthmatics are especially sensitive so it should only be handled in a fume cupboard).

Warming with dilute HCl produces chlorine (toxic if inhaled) this too should be carried out in a fume cupboard or on a very small scale. Do not inhale the gas.

Disposal: Silver solutions should be kept for recycling/ disposal. The other test tube reactions can be washed to waste with plenty of water.

Risk assessment

It is the responsibility of the teacher to carry out a suitable risk assessment.

This is an open-ended problem solving activity, so the guidance given here is necessarily incomplete. Teachers need to be particularly vigilant, and a higher degree of supervision is needed than in activities which have more closed outcomes. Students must be encouraged to take a responsible attitude towards safety, both their own and that of others. In planning an activity students should always include safety as a factor to be considered. Plans should be checked by the teacher before implementing them.

You must always comply with your employer's procedures and in some cases may decide that a particular activity is inappropriate in your situation. Further information on Health and Safety should be obtained from reputable sources such as CLEAPSS [http://science.cleapss.org.uk/] in England, Wales and Northern Ireland and, in Scotland, SSERC [https://www.sserc.org.uk/].

Commentary

Students should be encouraged to predict the reactions of the salts and then draw up a systematic plan for the experiment. The following scheme is set out in the *Independent learning project for advanced chemistry*.[1] It identifies all of the sulfur oxo-anions except the metabisulfite.

Test	**Na_2SO_3**	**Na_2SO_4**	**$Na_2S_2O_3$**	**$Na_2S_2O_8$**
1. Warm with dilute hydrochloric acid	No reaction in cold. Bubbles of gas on warming. Choking smell. $K_2Cr_2O_7$ paper turned green(SO_2 produced).	No visible reaction.	Solution turned slightly cloudy. Denser when warm. Choking smell. $K_2Cr_2O_7$ turned green(SO_2 produced).	No reactions in cold. Bubbles of gas on warming. Choking smell. Litmus paper bleached (Cl_2 produced).
2. Add silver nitrate solution	Initial white ppt. dissolved on shaking. With more $AgNO_3$ a dense white ppt remained.	No reaction at first, then a faint white ppt. appeared.	Initial white ppt. dissolved on shaking. With more $AgNO_3$ the ppt. remained and turned yellow, brown and black.	Blackish ppt. formed slowly.
3. Add iodine solution (in aqueous	The brown colour was immediately discharged. (Iodine reduced.)	No visible reaction.	The brown colour was immediately discharged. (Iodine reduced.)	The brown colour become darker. (Iodide oxidised.)

potassium iodide)				
4. Add potassium iodide solution	No visible reaction.	No visible reaction.	No visible reaction.	A dark brown solution was formed. (Iodide oxidised.)
5. Add iron (III) chloride solution and dilute acid. Warm and add sodium hydroxide solution.	A dark red-brown solution was formed which became almost colourless when hot. Addition of alkali gave a green ppt. (Fe^{3+} reduced.)	A yellow solution was formed which darkened a little on warming. Addition of alkali gave a red-brown ppt. (Fe^{3+} not reduced.)	A dark purple solution was formed which cleared when hot and then became cloudy. Addition of alkali gave a green ppt. (Fe^{3+} reduced.)	A yellow solution was formed which darkened a little on warming. Addition of alkali gave a red-brown ppt. (Fe^{3+} not reduced.)
6. Heat a small portion of the solid salt.	Crystals turned white and gave off a steamy vapour which condensed on the upper tube (H_2O). White residue turned yellow on strong heating.	A colourless liquid was rapidly formed, which boiled to give off a steamy vapour (H_2O) and a white residue. No further reaction.	A colourless liquid was rapidly formed, which boiled to give off a steamy vapour (H_2O). The yellowish residue turned brown and gave a black viscous liquid.	The solid melted to a colourless liquid. Bubbles of gas relit a glowing splint (O_2).

A procedure for distinguishing between sulfites and metabisulfites is given in Vogel[2] as follows:

Aqueous sulfite shows an alkaline reaction with litmus paper, because of hydrolysis:

$SO_3^{2-}(aq) + H_2O(l) \rightarrow HSO_3^-(aq) + OH^-(aq)$

while aqueous metabisulfite is neutral. On adding a neutral solution of dilute hydrogen peroxide to aqueous sulfite, sulfate ions are formed and the solution becomes neutral:

$SO_3^{2-}(aq) + H_2O_2(aq) \rightarrow SO_4^{2-}(aq) + H_2O(l)$

with aqueous metabisulfite hydrogen peroxide yields hydrogen ions with the same test:

$HSO_3^-(aq) + H_2O_2(aq) \rightarrow SO_4^{2-}(aq) + H^+(aq) + H_2O(l)$

and the solution shows a definite acid reaction.

References

1. *Independent learning project for advanced chemistry, (ILPAC) I 6, Selected pblock elements*. London: John Murray, 1984.
2. Vogel's *Qualitative inorganic analysis*, 6th edn. London: Longman, 1988.

Credits

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