The transition elements

Topic

Transition elements – variable oxidation state, redox and precipitation reactions, and complex compounds. Chemistry and colour.

Timing

20 min.

Apparatus (per group)

- One student worksheet
- One clear plastic sheet (*eg* ohp sheet)
- Magnifying glass.

Chemicals (per group)

Solutions contained in plastic pipettes, see 'Apparatus and techniques for microscale chemistry' handout.

- Potassium chromate 0.2 mol dm^{-3}
- Potassium manganate(VII) 0.2 mol dm^{-3}
- Cobalt nitrate 0.5 mol dm^{-3}
- Ammonia solution 3 mol dm^{-3}
- Ammonium vanadate(V) 0.2 mol dm^{-3}
- Hydrochloric acid 1 mol dm^{-3}
- Sodium hydroxide 1 mol dm^{-3}
- Copper(II) sulphate 0.2 mol dm^{-3}
- Iron(II) sulphate 0.2 mol dm^{-3}
- Iron(III) nitrate 0.2 mol dm^{-3}
- Silver nitrate 0.2 mol dm^{-3}
- Potassium thiocyanate 0.1 mol dm^{-3}
- Potassium iodide 0.2 mol dm^{-3}
- Starch solution (freshly made)
- Zinc metal granules.

Observations

Vanadium
Bubbles (of hydrogen) are seen. The yellow colour of the ammonium vanadate (vanadium(V) ions) gradually changes (as the vanadium is reduced) to blue due to the formation of the vanadium(IV) ions (VO^{2+}). The colour changes to green due to vanadium(III) ions (V^{3+}) and possibly to lilac due to vanadium(II) ions (V^{2+}) (although this species is a strong reducing agent and is very air-sensitive).

Chromium
A red precipitate of silver chromate(VI) is seen. This is an interesting example of the modification of the colour of a coloured anion (yellow chromate(VI) by a colourless cation (silver(I)).

Manganese
The deep purple colour of the potassium manganate(VII) gradually fades, first to the brown manganese(IV) oxide then to the very pale pink manganese(II) ions.

(Manganese(II) compounds in solution usually appear virtually colourless. However, a bottle of a solid manganese(II) salt – *eg* the sulphate – is pink.)

Iron
A yellowish colour (due to iodine) starts to form as the iron(II) oxidises the iodide. Addition of starch produces the characteristic intense blue-black colour of the starch– iodine complex.

Cobalt
The addition of one drop of ammonia gives a deep green precipitate. Addition of further ammonia gives a green or brown solution.

Copper
The addition of ammonia gives a light blue precipitate of copper(II) hydroxide together with the deep blue tetra-amminocopper(II) ion.

Zinc
A white precipitate of zinc hydroxide is observed. (Zinc is not a transition metal because it only has one oxidation state in its compounds and the Zn^{2+} ion has a full d-sub-shell.)

Health & Safety

Students must wear suitable eye protection (Splash resistant goggles to BS EN166 3).

Potassium chromate, 0.2 mol dm^{-3} K_2CrO_4 is a carcinogen, mutagen and skin sensitiser. It is also toxic to aquatic life. Wear splash-proof eye-protection if transferring large amounts. Avoid skin contact.

Potassium manganate(VII) 0.2 mol dm^{-3} is hazardous to the aquatic environment. Avoid direct contact and store in the dark, stains glass, plastic, clothing and skin.

Ammonia solution, 3 mol.dm^{-3} NH_3 (aq) is CORROSIVE and a respiratory irritant.

Ammonium vanadate(V), 0.2 mol dm^{-3} NH_4VO_3 (acidified with sulphuric acid) is a mutagen and very toxic if inhaled (but not by other routes).

Sodium hydroxide solution, 1 mol dm^{-3} NaOH (aq), is CORROSIVE.

Cobalt nitrate 0.5 mol dm^{-3} is a carcinogen, mutagen, reproductive toxin, skin and respiratory sensitiser and hazardous to the aquatic environment.

Copper(II) sulphate solution, 0.2 mol dm^{-3}, $CuSO_4$ (aq) causes eye damage and is hazardous to the aquatic environment.

Hydrochloric acid 1 mol dm^{-3} HCl (aq), Potassium thiocyanate 0.1 mol dm^{-3}, KSCN (aq), Potassium iodide 0.2 mol dm^{-3}, starch solution, Iron(III) nitrate 0.2 mol dm^{-3}, $Fe(NO_3)_3.9H_2O$ (aq) and Iron(II) sulphate 0.2 mol dm^{-3}, $FeSO_4.7H_2O$ (aq) are of low hazard

Silver nitrate, 0.1 mol dm^{-3}, $AgNO_3$ (aq) is a skin/eye irritant. Keep separate from organic waste containers.

Zinc powder, Zn (s) is FLAMMABLE and hazardous to the aquatic environment.

Credits

Health & safety checked May 2018

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