Some reactions of nitrogen dioxide – teacher notes

Topic
Gases

Timing
20 minutes

Apparatus
- Eye protection
- Clear plastic sheet (eg OHP sheet)
- Plastic Petri dish (base + lid), 9 cm
- Plastic pipette
- Scissors

Chemicals
Solutions should be contained in plastic pipettes. See the accompanying guidance on apparatus and techniques for microscale chemistry, which includes instructions for preparing a variety of solutions here https://rsc.li/3E2J8D1

- Nitric acid (concentrated HNO₃) diluted 1:1 with water ca 5M
- Full-range indicator solution diluted 1:1 with deionised water
- Potassium iodide, 0.2 mol dm⁻³
- Potassium iodate(V), 0.1 mol dm⁻³
- Potassium bromide, 0.2 mol dm⁻³
- Potassium bromate(V), 0.1 mol dm⁻³
- Ammonia solution, 3 mol dm⁻³
- Copper turnings

Method
Copper turnings + nitric acid generates first nitric oxide, which then reacts with air to give nitrogen dioxide:

\[ 3\text{Cu}(s) + 8\text{HNO}_3(\text{aq}) \rightarrow 3\text{Cu(NO}_3)_2(\text{aq}) + 2\text{NO}(g) + 4\text{H}_2\text{O}(l) \]
then: \[ 2\text{NO}(g) + \text{O}_2(g) \rightarrow 2\text{NO}_2(g) \]

Results
Full-range indicator turns from green to yellow-red indicating that nitrogen dioxide is an acidic gas.
The iodate/iodide solution turns black due to:

\[ \text{IO}_3^-(aq) + 5\text{I}^-(aq) + 6\text{H}^+(aq) \rightarrow 3\text{I}_2(g) + 3\text{H}_2\text{O}(l) \]
also indicating the acidic nature of the gas.
A similar reaction occurs with bromide/bromate.

Health, safety and technical notes
- Read our standard health and safety guidance here https://rsc.li/3LV0UbN
- Students must wear suitable eye protection (Splash resistant goggles to BS EN166 3).
- Nitrogen dioxide is extremely toxic and corrosive if inhaled, with sometimes delayed effects. It is important to ensure that the amount of NO$_2$ generated does not result in significant leakage from the Petri dish (see CLEAPSS Hazcard HC068b). No more than 2 copper turnings should be used.
- Concentrated Nitric acid, HNO$_3$(aq), 5 mol dm$^{-3}$, is CORROSIVE and gives of toxic fumes (see CLEAPSS Hazcard HC067).
- Potassium iodate(V), KIO$_3$(aq), 0.1 mol dm$^{-3}$, Potassium bromate(V), KBrO$_3$(aq), 0.1 mol dm$^{-3}$ (see CLEAPSS Hazcard HC080), Potassium bromide, KBr(aq), 0.2 mol dm$^{-3}$ and Potassium iodide, KI(aq), 0.2 mol dm$^{-3}$ are low hazard (see CLEAPSS Hazcard HC047b).
- Ammonia solution, NH$_3$(aq), 3 mol dm$^{-3}$ is corrosive and a respiratory IRRITANT (see CLEAPSS Hazcard HC006).