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| Microscale Chemistry |
| The chemistry of nitrogen dioxide |

**A simple method for investigating the reactions of ammonia. Using a technique which can be applied to many other reactions.**

**CfE Level 3**

Through experimentation, I can identify indicators of chemical reactions having occurred. I can describe ways of controlling the rate of reactions and can relate my findings to the world around me.

SCN 3-19a

**National 5** – Chemistry in Society

Fertilisers

**Introduction**

Nitrogen dioxide is a common atmospheric pollutant, produced by the burning of nitrogen containing fossil fuels, especially diesel.

It is extremely irritating to the lungs (especially for asthmatics) and should normally be handled only in a fume cupboard. In this experiment, however, the very small amounts produced are contained within the petri dish, thus limiting exposure.

**Health & Safety**

* Wear eye protection.
* Do not add more than the stated amount of sodium/potassium nitrite and do not remove the lid and smell the gas.
* Sulphur dioxide gas is toxic and corrosive – work in a well-ventilated area

Although we can detect the gas by our sense of smell, the ammonia levels will be below the Short Term Exposure Level.

Ensure that theSO2 water is (reasonably) freshly prepared.

**You will need**

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| 1 x petri dish | 0.5 mol l-1sulphuric acid |
| Universal indicator solution | Potassium manganate(VII) solution |
| Potassium bromide 0.1 mol l-1  | Potassium iodide 0.1 mol l-1 |
| Iron(II) sulphate solution, 0.1 mol l-1 | Barium chloride solution, 0.1 mol l-1 |
| Sodium or potassium nitrate(II) (nitrite) solid | SO2 water – bubble SO2 through distilled water (in a fume cupboard) |
| 1 cm3 Pasteur pipettes | tweezers |
| Laminated reaction sheet – or non laminated inside a plastic wallet. | Small watch glass or ‘blister’ from tablet pack |

**Instructions**

1. If not already laminated, place the reaction sheet in a plastic wallet/folder.
2. Place a 9 cm diameter Petri dish on the thick (blue) line circle on the sheet. Remove the lid.
3. Place the test solutions/papers in the Petri dish in the numbered positions, **1 – 6**, as described below.
	1. Universal indicator solution
	2. Potassium permanganate.
	3. Potassium bromide (4 drops).
	4. Potassium iodide, 0.1 mol l-1 (4 drops)
	5. Iron(II) salt solution, 0.1 mol l-1 (4 drops)
	6. Barium chloride solution, 0.1 mol l-1 (4 drops)
	7. Barium chloride solution 0.1 mol l-1 (4 drops) + SO2 water, (1 drop)
4. Also place 1-2 drops of solutions 2-6 **in the matching outer-ring circles** (i.e. outside the Petri dish) - you will then be able to compare with those inside the Petri dish to see what effect the ammonia has.
5. Place an empty ‘reaction vessel’ (eg, small watch glass) in the ‘RV’ circle.
6. To generate the nitrogen dioxide gas

Use tweezers to place a few granules of sodium or potassium nitrate(III) (nitrite) in the reaction vessel (gas generator). Add 0.5 cm3 (approximately 10 drops) of 0.5 mol l-1 sulphuric acid to the reaction vessel. **Immediately place the lid on the Petri dish**.

1. Watch carefully and record your observations over the next 5-10 minutes *(eg, take photographs).*
2. Explain as much of the chemistry going on in the Petri dish as you can.

**Disposal**: put petri dish in a bowl of water. Wash solution to waste with cold running water.

**Results & explanations**

1. Indicator paper indicates goes red - indicating a pH of around 1 due to the formation of a mixture of nitric and nitrous acids.

2 NO2 (N2O4) + H2O → HNO2 + HNO3

1. Nitrogen dioxide reacts with potassium permanganate and water to produce nitric acid, manganese(II) nitrate and potassium nitrate

5NO2 + KMnO4 + H2O → 2HNO3 + Mn(NO3)2 + KNO3

1. The potassium bromide goes yellow/red due to the formation of bromine. (There are various reactions involved but at room temperature and pressure it is mainly this one)

NO2 + 2 H++ 2Br- →  NO + H2O + Br2

1. The potassium iodide goes yellow/orange due to the formation of iodine. (There are various reactions involved but at room temperature and pressure it is mainly this one)

NO2 + 2 H++ 2I- →  NO + H2O + I2

1. The Iron III sulphate

6FeSO4 + 4NO2 + 3H2SO4 → N2 + 3Fe2(SO4)3 + 2HNO3 + 2H2O

1. The Barium chloride solution does nothing.
2. The Barium chloride solution with sulphur dioxide solution produces a white precipitate. The nitrogen dioxide acts as a catalyst for oxidising the sulphur dioxide to sulphur trioxide which combines with the water to produce sulphuric acid. The barium ions then combine with the sulphate ions to precipitate out insoluble barium sulphate.

a SO2 + NO2 →  SO3 + NO\*

b SO3 + H2O →  H2SO4

c BaCl2 + H2SO4 →  BaSO4 + 2 HCl

\* in the atmosphere, the NO2 is regenerated by reaction with oxygen.

 2 NO + O2 → 2 NO2

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| **A picture containing text, room, vector graphics, gambling house  Description automatically generated** | **Nitrogen dioxide chemistry** |
|  | **Wear eye protection. Work in a well-ventilated lab.*** If not already laminated, place this sheet in a plastic wallet/folder.
* Place a 9 cm diameter Petri dish on the thick (blue) line circle (left). Remove lid.
* Place the test solutions/papers in the Petri dish in the numbered positions, **1 – 7**, as described below.
* Also place 1-2 drops of solutions **1**-**7** in the matching outer-ring circles (i.e. outside the Petri dish) - you will then be able to compare with those inside the Petri dish to see what effect the nitrogen dioxide has.
	1. Universal indicator solution
	2. Potassium permanganate.
	3. Potassium bromide (4 drops).
	4. Potassium iodide, 0.1 mol l-1 (4 drops)
	5. Iron(II) salt solution, 0.1 mol l-1 (4 drops)
	6. Barium chloride solution, 0.1 mol l-1 (4 drops)
	7. Barium chloride solution 0.1 mol l-1 (4 drops) + SO2 water, (1 drop)
* Place an empty ‘reaction vessel’ (eg,) in the ‘RV’ circle.
* To generate nitrogen dioxide gas (TOXIC): use tweezers to place a few grains of sodium (or potassium) nitrate III (nitrite) in the gas generator).Add 0.5 cm3 (approximately 10 drops) of 0.5 mol l-1 sulphuric acid to the reaction vessel. **Immediately place the lid on the Petri dish**.
* Watch carefully and record your observations over the next 5-10 minutes (eg, *take photographs*).
* Explain as much of the chemistry going on in the Petri dish as you can.
* **Disposal**: put petri dish in a bowl of water. Wash solution to waste with cold running water.
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