RSC | Advancing the Chemical Sciences

Reactions of positive ions with sodium hydroxide



Index 7.1
3 sheets
Index 7.2
2 sheets

This activity is a microscale version of a common test-tube practical. The main advantages of the microscale version are the tiny quantities of chemicals consumed and the lack of test-tubes to wash up.

Two student sheets are provided:

- **Reactions of positive ions with sodium hydroxide**
- **Reactions of transition metal ions with sodium hydroxide** – a shorter version of the positive ion activity using only transition metal ions.

The student sheet should be laminated or placed inside a plastic document wallet. It can then be wiped clean over the sink and the residues washed away with plenty of water.

Equipment required

Bottles of those chemicals from the list below that are appropriate to the student sheet you have chosen to use will be required for each group of students. If enough bottles are supplied, students will not need to wander around looking for the reagents they need. Dropper bottles are best. The concentrations are not crucial, and all are minimal hazard at the concentrations specified but the sodium hydroxide should be **below** 0.5 mol dm^{-3} to minimise the hazard. Exactly which salt is used is also not critical.

- Laminated worksheets, or photocopied worksheets and plastic wallets
- Red litmus paper
- Sodium hydroxide < 0.5 mol dm^{-3} (**Irritant**)
- Iron(II) sulfate 0.2 mol dm^{-3}
- Iron(III) nitrate 0.2 mol dm^{-3}
- Copper(II) sulfate 0.2 mol dm^{-3}
- Aluminium sulfate 0.2 mol dm^{-3}
- Calcium chloride 0.2 mol dm^{-3}

- Magnesium chloride 0.2 mol dm^{-3}
- Ammonium chloride 0.2 mol dm^{-3}

Health and safety

Eye protection should be worn.

Answers

Teachers should select the answers appropriate to the student sheet chosen from those given below.

1.

Positive ion solution	Sodium hydroxide
Iron(II), Fe^{2+}	Grey-green solid formed
Iron(III), Fe^{3+}	Orange solid formed
Copper(II), Cu^{2+}	Light blue solid formed
Aluminium, Al^{3+}	White solid formed. Dissolves in excess sodium hydroxide.
Calcium, Ca^{2+}	White solid formed
Magnesium, Mg^{2+}	White solid formed
Ammonium, NH_4^+	A gas is evolved that turns damp red litmus paper blue.

Table 1 Sample observations

2. A solid formed by reacting two solutions is a precipitate.

3. The solids made are: iron(II) hydroxide, iron(III) hydroxide, copper(II) hydroxide, aluminium hydroxide, calcium hydroxide and magnesium hydroxide.

4. Students could give any three of the following equations:

$Fe^{3+} + 3\ OH^- \rightarrow Fe(OH)_3$

$Cu^{2+} + 2\ OH^- \rightarrow Cu(OH)_2$

$Al^{3+} + 3\ OH^- \rightarrow Al(OH)_3$

$Ca^{2+} + 2\ OH^- \rightarrow Ca(OH)_2$

$Mg^{2+} + 2\ OH^- \rightarrow Mg(OH)_2$

5. The gas formed by the reaction between the ammonium and hydroxide ions is ammonia.

6. $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$

Reactions of positive ions with sodium hydroxide

You are going to investigate the reactions that occur between positive metal ions and sodium hydroxide in solution. As you work, try to decide what is happening and what reaction is taking place.

If this sheet is not laminated, put it into a plastic pocket.

Onto each of the empty boxes in the table below put one drop of the positive ion solution and add one drop of sodium hydroxide solution. Observe what happens.

Hold a piece of damp red litmus paper over the ammonium and sodium hydroxide box and note your observations.

After you have observed the aluminium and sodium hydroxide reaction, add a few more drops of sodium hydroxide and observe what happens.

Health and safety

Wear eye protection.

Test table

Positive ion solution	Sodium hydroxide
Iron(II), Fe^{2+}	
Iron(III), Fe^{3+}	
Copper(II), Cu^{2+}	
Aluminium, Al^{3+}	
Calcium, Ca^{2+}	
Magnesium, Mg^{2+}	
Ammonium, NH_4^+	

Questions

1. Write down your observations for each of the reactions above.

Positive ion solution	Sodium hydroxide
Iron(II), Fe^{2+}	
Iron(III), Fe^{3+}	
Copper(II), Cu^{2+}	
Aluminium, Al^{3+}	
Calcium, Ca^{2+}	
Magnesium, Mg^{2+}	
Ammonium, NH_4^+	

2. What is the name given to a solid made by a reaction between two solutions?

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3. Suggest names for each of the solids made in the reactions above.

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4. The first reaction can be simplified to:
$Fe^{2+} + 2\ OH^- \rightarrow Fe(OH)_2$
Write similar equations for three of the other reactions.

5. Which gas is made in the reaction between ammonium ions and hydroxide ions?

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6. Complete and balance the equation below.

$NH_4^+ \quad + \quad OH^- \quad \rightarrow$

Reactions of transition metal ions with sodium hydroxide

You are going to investigate the reactions that occur between transition metal ions and sodium hydroxide in solution. As you work, try to decide what is happening and what reaction is taking place.

If this sheet is not laminated, put it into a plastic pocket.

Onto each of the empty boxes in the table below put one drop of the transition metal ion solution and add one drop of sodium hydroxide solution. Observe what happens.

Health and safety

Wear eye protection.

Test table

Transition metal ion solution	Sodium hydroxide
Iron(II), Fe^{2+}	
Iron(III), Fe^{3+}	
Copper(II), Cu^{2+}	

Questions

1. Write down your observations for each of the three reactions above.

Transition metal ion solution	Sodium hydroxide
Iron(II), Fe^{2+}	
Iron(III), Fe^{3+}	
Copper(II), Cu^{2+}	

2. What is the name given to a solid made by a reaction between two solutions?

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3. Suggest names for each of the solids made in the reactions above.

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4. The first reaction can be simplified to:
$Fe^{2+} + 2\ OH^- \rightarrow Fe(OH)_2$
Write similar equations for the other two reactions you have observed.