**Reaction evidence**

Some hydrochloric acid is added to some sodium hydroxide solution (an alkali).

The chemical equation for the reaction is:

HCl (aq) + NaOH (aq) →NaCl(aq) + H2O (l)

A close up of a logo

Description automatically generated

For this reaction, what provides evidence of a chemical reaction?

For each statement, tick (✓) **one** column to show what you think*.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| **A** | Change in temperature |  |  |  |  |
| **B** | Formation of bubbles |  |  |  |  |
| **C** | Change in pH |  |  |  |  |
| **D** | Change in colour |  |  |  |  |

*Chemistry > Big idea CCR: Chemical reactions > Topic CCR4: Acids and alkalis > Key concept CCR4.1: Neutralisation*

|  |
| --- |
| **Diagnostic question** |
| **Reaction evidence** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | A salt is formed from a neutralisation reaction between an acid and a base. |
| Observable learning outcome: | Suggest evidence that an acid has reacted with an alkali. |
| Question type: | confidence grid |
| Key words: | acid, alkali, temperature, pH |

**What does the research say?**

Research (Sheppard, 2006) found that students taking part in the study confidently described neutralisation as ‘some form of interaction between an acid and base’. About a third of the students described the process as the physical mixing of an acid with a base rather than recognising that a chemical reaction was taking place. Alternative ideas about what takes place during neutralisation fell into categories of Andersson’s classification of misunderstandings about chemical reactions (Andersson, 1990) such a ‘modification’ where the original substance keeps its identity but changes its properties (in this case pH).

Another paper (Schmidt, 1995) notes that historically neutralisation used to be defined as the reaction between an acid and a base which then ‘consume’ each other (from the Latin ‘neuter’ meaning neither of the two). However according to more modern definitions, the products of neutralisation do not necessarily have a pH of 7 (for example if reacting a weak base with a strong acid or vice versa). It should be noted that neutralisation reactions that are likely to be first encountered by students in the laboratory are usually between strong acids (hydrochloric, sulfuric or nitric) and strong bases (sodium hydroxide or potassium hydroxide) and therefore the products will have a pH of 7.

Responses to test items showed that students were influenced by the term ‘neutralisation’ in the question and interpreted it as its original meaning.

This question therefore focuses on the formation of a new product with different properties (pH) rather than the terminology associated with this type of reaction.

**Ways to use this question**

Students should complete the question individually. This could be a pencil and paper exercise, or you could use an electronic ‘voting system’ or mini white boards and the PowerPoint presentation.

The answers to the question will show you whether students understood the concept sufficiently well to apply it correctly.

If there is a range of answers, you may choose to respond through structured class discussion. Ask one student to explain why they gave the answer they did; ask another student to explain why they agree with them; ask another to explain why they disagree, and so on. This sort of discussion gives students the opportunity to explore their thinking and for you to really understand their learning needs.

*Differentiation*

You may choose to read the questions to the class, so that everyone can focus on the science. In some situations, it may be more appropriate for a teaching assistant to read for one or two students.

**Expected answers**

Students should be confident that the pH will change.

Temperature should also change (although this change could be very small if the solutions are dilute).

A colour change could be a sign of a chemical reaction but not in this case. Sodium chloride solution is colourless.

In this case neither product is in the gas state so no bubbles will be observed.

**How to respond - what next?**

A student who is confident that a colour change is a sign of the reaction may be generalising rather than considering this specific example of a reaction.

Confidence that bubbles will be observed indicates that the student may be recalling another familiar acid reaction (for example reaction of a metal carbonate with an acid) rather than considering carefully the reactants in this case (and what possible products could be).

A lack of confidence that temperature change is an indication of a chemical reaction may suggest that students would benefit from revisiting key concept CCR3.1: Exothermic and endothermic reactions.

If students have misunderstandings about the change in pH following neutralisation, it may help to encourage them to consider the pH of each reactant and product. This should support them in linking pH change to a difference in properties of reactants and products. The following BEST ‘response activities’ could be used in follow-up to this diagnostic question:

* Reactant and product pH

**Acknowledgments**

Developed by Helen Harden (UYSEG

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**References**

Andersson, B. (1990). Pupils' conceptions of matter and its transformations (age 12-16). *Studies in Science Education,* 18**,** 53-85.

Schmidt, Hans-Jürgen (1995). Students' misconceptions- looking for a pattern. *Science Education,* 81**,** 123-135.

Sheppard, K. (2006). High school students' understanding of titrations and related acid-base phenomena. *Chemistry Education Research and Practice,* 7(1)**,** 32-45.