

Why should we believe in the reactivity series? Teacher notes

Education in Chemistry

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Experiment	Observations	What hypothesis is confirmed by the evidence? Is the experiment 'good' evidence for the hypothesis?	How much does this evidence support the overall theoretical idea of a 'reactivity series'?
Add Cu to a solution of conc. AgNO ₃	<i>Example: The copper gets smaller and silver forms on the surface. The colourless solution turns blue.</i>	<i>Copper is more reactive than silver. The experiment has only been completed once, so might not be reliable.</i>	<i>Not very much: only two metals were used and this is only one way to compare their reactivity.</i>
Add Li, Na and K to water and repeat each experiment three times	The reactions become more vigorous down the group. Students should be able to give accurate experimental details.	The reactivity of K is more than Na, which is more than Li. This experiment supports the hypothesis that reactivity increases down Group 1. This would be good evidence for the former (the experiment was carried out reliably) and provides some evidence for the broader hypothesis.	It shows the order of reactivity for three elements, so some support is provided because it allows for direct comparisons.
Burn Li, Mg, Fe, and Cu in air and in oxygen	Li: red flame, brighter in O ₂ Mg: bright white light, very intense in O ₂ Fe: glows in air, bright sparks in O ₂ Cu: no reaction	The trend in reactivity is not very clear from these experiments because Mg appears to give out more energy than Li. At best this confirms the hypothesis that Cu is not very reactive. The comparison of air and oxygen is a red herring in this case because the difference is not relevant to the reactivity series.	Very limited evidence: the trend is not clear, and the brightness of the magnesium flame challenges the proposed order of reactivity. You can get students to discuss ways of making this experiment more useful, eg using a calorimeter or spectroscope.
Count the bubbles produced in the reaction of metals (Fe, Mg, Zn, Cu) with dil. hydrochloric acid	Order from most to fewest bubbles: Mg, Zn, Fe, Cu (no bubbles)	That the order of reactivity for these four metals is Mg, Zn, Fe, Cu. This experiment would provide some quantitative data, which can make it easier to compare the vigour of the reaction more objectively. However, the reliability is limited.	The experiment shows the order of reactivity for four of the elements, so it does provide some support because it allows for direct comparison. But this experiment is less reliable than the Li, Na and K experiment above.

Experiment	Observations	What hypothesis is confirmed by the evidence? Is the experiment 'good' evidence for the hypothesis?	How much does this evidence support the overall theoretical idea of a 'reactivity series'?
Add Mg, Zn and Fe to a solution of CuSO ₄	Copper will form on the surface of the metal in all three cases. The blue solution will become colourless for Mg and Zn, but yellow for Fe.	It confirms that Mg, Zn and Fe are all more reactive than Cu, but not the order of reactivity. [All this experiment really does is confirm that these metals displace copper, the idea that a more reactive metal displaces a less reactive metal is another theoretical idea.] For this limited hypothesis the experiment provides fairly good evidence but it needs to be repeated.	Fairly limited evidence: the experiment only confirms that Mg, Zn and Fe are more reactive than Cu, but doesn't allow for any comparison between them. This is another experiment in which students could be pushed to give ideas about how the experiment could provide better evidence of the idea of a 'reactivity series', eg by measuring the temperature changes in each reaction and comparing how much heat energy is given out.

1. Are there any aspects of the reactivity series that are not supported by *any* of the experiments?

Yes! Firstly, Ca, Al, Au and Pt all appear in the reactivity series but not in any of the experiments, so assigning them a position cannot be achieved on the basis of this evidence. Secondly, there is no way to compare the reactivity of the Group 1 metals with Mg, Zn, Fe, Cu and Ag, so from this evidence you cannot work out if they are all more reactive than Mg, if there is overlap, or if they are much less reactive. Comparing the reactivity of water and acid draws on another theoretical idea – that metals react more vigorously with acid than with water – which has not been established in these experiments.

4. Do you think you should 'believe' in the reactivity series? Why, or why not?

Some examples of ideas students may have about whether or not to believe in the reactivity series:

For	Against	Ambivalent
The use of a range of different experiments to confirm the hypothesis makes it more likely to be 'true'. Scientists have carried these experiments out thousands of times, we don't need to question their reliability.	The reactivity series cannot be conclusively proved because no one experiment can be used to compare all of the different metals directly. Working out the reactivity series required chemists to use different theoretical ideas, which haven't been proved either.	The reactivity series is useful, it doesn't matter whether it is 'true' or not, what matters is being able to use it to solve real world problems.