

Background information

This question looks at the changing theories of acids over time. Because it contains Lewis theory which is part of the AHL programme it could be argued that this is a Higher Level only question. However sufficient information is given in the data for the question to be accessible to Standard Level students too, especially as the Brønsted-Lowry definition is part of the core programme. The question also involves considerable international-mindedness.

Parts **(a)** and **(b)** address the ‘*What is science and what is the scientific endeavour?*’ part of Nature of Science which covers theories and hypotheses. These are used to make predictions that can be tested. From the results of these tests theories can be supported or opposed. This can lead to theories being modified or superseded by new theories.

Part **(c)** addresses the ‘*Scientific literacy and the public understanding of science*’ part of Nature of Science which covers the use of appropriate terminology. Often words that scientists use to communicate with other scientists have a different meaning in everyday life (an obvious example in chemistry is the word *spontaneous*). For this reason scientists need to be careful when communicating with the public during scientific discourse.

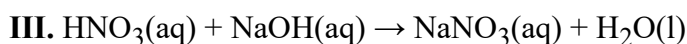
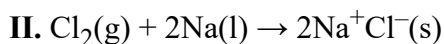
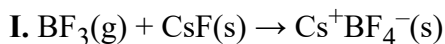


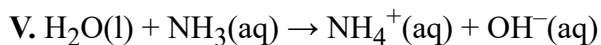
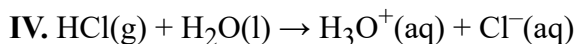
There is clear overlap in part **(b)** with Popper’s theory of falsification which is covered in TOK and part **(c)** is really an example of the importance of language as one of the TOK ways of knowing.

SL HL NoS Question 2 on Acids

Over the years the ways in which the definition of an acid has changed provide a good example of International Mindedness in chemistry. In Roman times acids, such as vinegar and citric acid, were associated with a sour taste. This definition lives on in the German and Norwegian words for acid which are *sauer* and *syre* respectively. The first chemical definition of an acid was by the Frenchman Lavoisier who in the late 1770s defined an acid as being an oxide of a non-metal in water. A new theory of acids, the ionic theory was proposed in the 1880s by the Swedish chemist Arrhenius. This was followed by the Brønsted-Lowry definition in 1923. Brønsted, a Dane, and Lowry from the UK worked independently. In the same year the American Gilbert Lewis proposed a different theory which gave rise to the concept of a Lewis acid in which an acid is a substance that can accept a pair of electrons. In the 1930s an even more general theory was proposed by Mikhail Usanovich from the USSR. Usanovich defined an acid as anything that accepts negative species or donates positive species.

(a) The following five species can all be defined as acids: boron trifluoride, BF_3 , chlorine, Cl_2 , nitric acid, HNO_3 , hydrogen chloride, HCl , and water, H_2O . Consider the acidic behaviour of each of these species in the following five reactions:





Deduce which equation contains: (Each equation may only be used once)

1. The only acid that fits the Lavoisier definition.
2. An acid that fits the Arrhenius, Brønsted-Lowry, Lewis and Usanovich definitions.
3. An acid that fits the Brønsted-Lowry, Lewis and Usanovich definitions.
4. An acid that fits the Lewis and Usanovich definitions.
5. An acid that only fits the Usanovich definition. [5]

(b) In the early 1800s Humphrey Davy analysed hydrochloric acid. His conclusion was, “There may be oxygen in hydrochloric acid but I can find none”.

In the light of what was known at the time about acids discuss why Davy’s work on hydrochloric acid is significant. [3]

(c) Hydrofluoric acid, HF, can be used to etch the registration numbers of cars on their windows to help prevent crime. The pK_a of hydrofluoric acid is 3.17. Construct a sentence about a solution of $0.010 \text{ mol dm}^{-3}$ hydrofluoric acid that contains the following three words: *dilute*, *weak*, and *corrosive*. Your sentence should show that the three words are being used in their correct context. [3]

To see the answers click on the 'eye'
