Baggie Science – Teacher Notes

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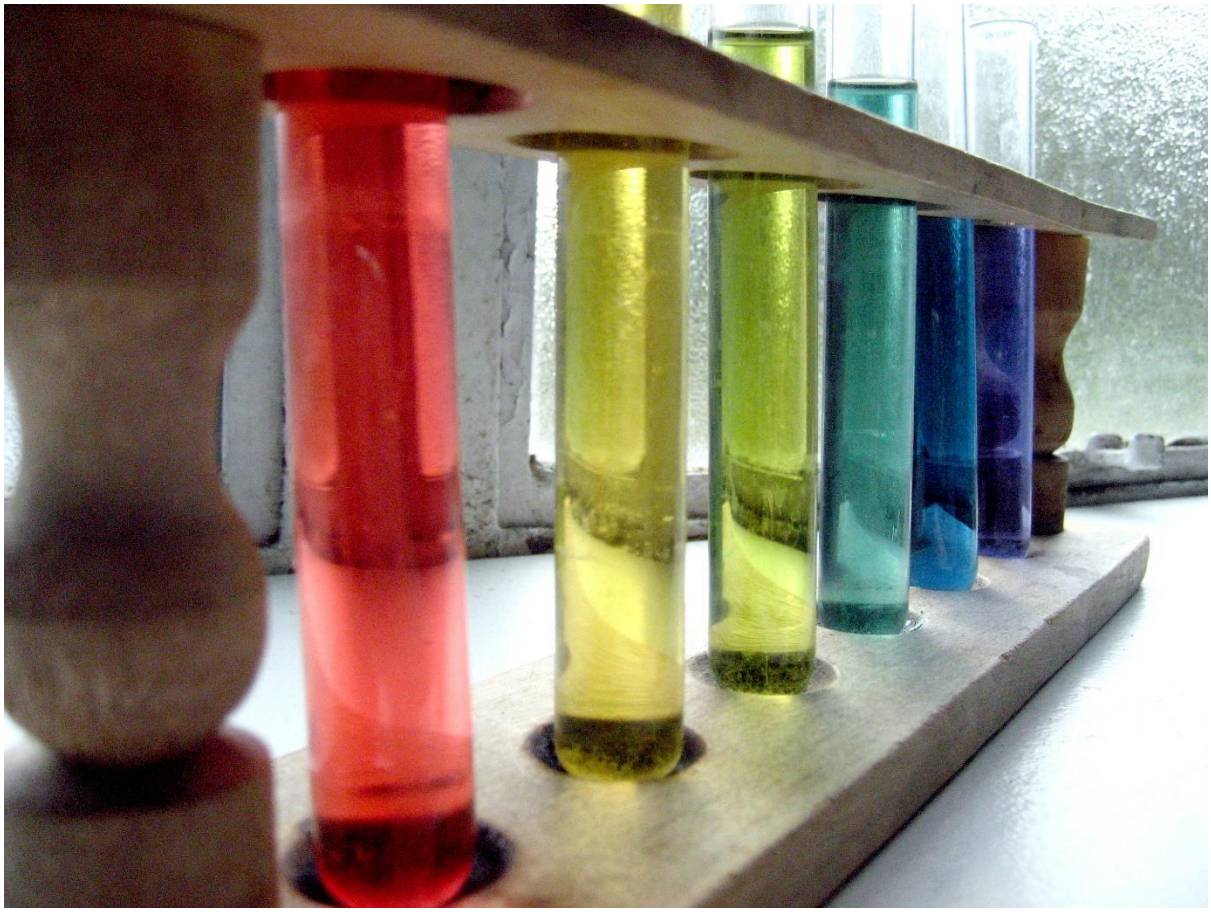

Figure 1: pH colour change for universal indicator

Aim

Chemistry is the branch of science which studies the properties and composition of matter and the changes occurring during chemical interactions. In chemical reactions, new substances may be created. These newly formed substances are called the products whereas pre-existing substances are called reactants. In this experiment, students will add reactants together and observe changes happening. These changes are a proof that a chemical reaction is taking place and that new products are being formed.

Plan

Engage students by watching a clip https://www.youtube.com/watch?v=WPmYlBk_utE on chemical reactions. This clip will help students make predictions and identify if a chemical change has occurred and a new product has been formed.

Before starting the experiment, discuss with students the safety precautions they need to take in order to protect themselves during the experiment. Students will be using two powder chemicals and a liquid chemical. The first powder chemical is sodium bicarbonate (sodium hydrogen carbonate) and is labelled A. The second powder chemical is anhydrous calcium chloride and is labelled B. The liquid chemical is a universal indicator which changes colour ranging from red for

strong acids to dark purple for strong bases. It is a non-toxic substance, and can be readily purchased as 'Red Cabbage Indicator'.

Sodium hydrogen carbonate is classified as being not hazardous, however it is not recommended to inhale it or to bring it in contact with eyes [(2)].

Anhydrous calcium chloride is hazardous [(3)] and can cause:

- Cough and sore throat if inhaled.
- Dry skin and redness if there is a skin contact.
- Irritation of eyes.
- Burning sensation, nausea and vomiting if ingested.
- It dissolves violently in water with liberation of much heat.

This experiment is suitable for stages 4, 5 and 6 with modifications suitable to achieve the learning outcomes designed for each stage.

Conduct

The experiment is designed to be a mix of structured and open inquiry. Students will sharpen the question, discuss their plan with the teacher and conduct the experiment. Students are expected to analyse their data, formulate conclusions and justify their findings and conclusions.

Students are given a recipe to conduct the experiment where they will mix the two given compounds (anhydrous calcium chloride and sodium hydrogen carbonate) and the universal indicator inside a zipped plastic bag, after releasing the air inside the bag. They are asked to write down their observations and discuss with their group and with the rest of the class. Students can make alterations to the experiment in order to study the changes happening in more detail. Some of the extension experiments that can be done are listed below.

1. The reaction of calcium carbonate with water is very exothermic and it produces a considerable amount of heat. The reaction of sodium hydrogen carbonate is endothermic which means it absorbs heat from the surrounding causing a decrease in temperature. Students can design a way to confirm the identity of the powders used using the property of heat release or absorption when dissolved in water. They can even do this experiment inside the bag. A useful clip to watch is https://www.youtube.com/watch?v=3Qi8AAulYcQ
2. Students can study the effect of dissolving each separate compound in the universal indicator and observe the colour change. This colour change can be compared with the colour change of the indicator when the two compounds are mixed together.
3. They can study the conservation of mass by weighing the mass of each individual component including the plastic bag and the indicator inside the vial before and after the reaction.
4. For stage 6, they can measure the heat released per mole of calcium chloride dissolved. This is defined as the molar heat of solution.

Analyse

Students will analyse their results for the main experiment and for any extension experiments. Using tables is a very reliable method where students can list their observations together with any comments.

The main experiment

Chemical/Material	Observations before mixing	Observations after mixing
Anhydrous Calcium chloride		
Sodium hydrogen carbonate		
Universal indicator		
Shape of plastic bag		

Checking the identity of the chemical

Chemical in water	Exothermic/Endothermic	Conclusion
Chemical A		
Chemical B		

Colour change of universal indicator

Chemical in universal indicator	Colour change of universal indicator
Anhydrous calcium chloride	
Sodium hydrogen carbonate	
Mixture of both	

Conservation of Mass

Start		End			
		Bag closed		Bag open	
Mass of calcium chloride (g)					
Mass of sodium hydrogen carbonate (g)					
Mass of empty bag (g)					
Mass of vial + indicator (g)					
Total mass (sum of above) (g)		Mass of bag (g)		Mass of bag (g)	

To measure the heat of solution of calcium chloride

Molecular weight of calcium chloride (M_{CaCl2}) (g mol^{-1})	Mass of calcium chloride (m_{CaCl2}) (g)	Mass of water (m_W) (g)	Specific heat capacity of water (C_W) ($Jg^{-1}K^{-1}$)	Initial temperature (^0C)	Final temperature (^0C)	Change in temperature (ΔT) (^0C) = final temperature – initial temperature

To calculate the molar heat of solution ΔH/mole:

$$\frac{\Delta H}{mole}(Jmole^{-1}) = \frac{m_w \times C_w \times \Delta T \times M_{CaCl_2}}{m_{CaCl_2}}$$

Problem solving and discussion

In this experiment, chemicals react together to form a final product. This chemical reaction can be recognized through one of four simple ways.

- If there is a colour change, this is an indication that a new substance is present.
- The formation of a gas which can emerge from a solution as bubbles.
- The formation of a precipitate which is an insoluble product.
- Energy change, where heat can either be released or produced.

Students will be able to observe some of the above changes and confirm the occurrence of a chemical reaction.

They will start with two basic (alkaline) compounds, calcium chloride and sodium hydrogen carbonate. Basic compounds would change the colour of the universal indicator from green to blue. After reacting together in the presence of universal indicator, carbon dioxide is released which causes the solution to be acidic and change the colour of the universal indicator to yellow. The evolution of carbon dioxide gas can be observed and this will fill the previously emptied plastic bag (with no air inside) with a newly formed gas. Students should be able to relate the fizziness to the release of carbon dioxide and to understand that hydrogen carbonate is the source of carbon dioxide.

Students can also observe the change in temperature associated with dissolving one of the compounds or the mixture in the universal indicator. The temperature will only drop in the case of sodium hydrogen carbonate, and it will rise in the case of calcium chloride or the mixture of both compounds.

In the case of verifying the conservation of mass, the total mass of all the ingredients, including the bag and the vial, should be equal before and after the reaction if the bag is fully emptied and thoroughly sealed. The difference in mass when the bag is open is due to the escape of the carbon dioxide gas.

For the stage 6 extension, students should be able to find the amount of heat released per mole of calcium chloride and compare it to the published value of approximately -80 kJ/mole. Discrepancies

in the value could be due to a number of factors which include loss of heat to the atmosphere, using the mass of water and ignoring the mass of dissolved solute, uncertainties in measurements of mass and temperature and the room temperature at which the experiment is conducted.

Students may also write the chemical equation for the reaction.

$$CaCl_{2\,(aq)} + 2NaHCO_{3(aq)} \rightarrow CaCO_{3\,(s)} + CO_{2(g)} + H_2O_{(l)} + 2NaCl_{(aq)}$$

The solid calcium carbonate is called a precipitate, chalk is made of calcium carbonate which is also found in eggshells, seashells and coral.

Conclusion

Students will state if their hypothesis has been supported. They can take photos of their experiment to include in their final presentation. One possible way of presenting the experiment is a poster which showcases their achievements.

References

1. Link to figure 1 https://www.flickr.com/photos/bhikku/4608657906/in/photolist-82fzr5-7nuELM-juQ4GB-edDjhW-ncaee4-qiGdH6-9J2Kus-q2fLDx-qiGdG4-qiCNzE-JY77Y-qiGdSK-qiwab2-pmGSRQ-qiCNHW-q29jCN-JY7bo-qiCNAG-q29jem-pmWuR8-qiCP2m-qgq3j5-pmGT4U-qiw9Kx-pmGT3w-q2fLNR-pmGTjd-q2fLK4-q29jtQ-qiCNXo-qiCPbE-qiwatX-5LTMDn-qgq3kY-qiCNYq-qiCNSU-qiw9JR-qiCNCL-q2fLna-qiGdgK-JYgWv-q28G1C-JY7a7-WoryJj-JY7iU-JY8dY-C9v6KH-JYivc-JYfZi-JY6sy Author Duca di Spinaci Licence https://creativecommons.org/licenses/by-nc/2.0/
2. https://www.brecklandscientific.co.uk/v/vspfiles/MSDS/S0001318.pdf
3. https://www.cdc.gov/niosh/ipcsneng/neng1184.html
4. https://www.ch.ntu.edu.tw/~genchem99/msds/potentiometric-titration-of-acid-base/4.%E5%BB%A3%E7%94%A8%E6%8C%87%E7%A4%BA%E5%8A%91.pdf
5. https://pubchem.ncbi.nlm.nih.gov/compound/Calcium_dichloride#section=Health-Hazard