

Theme 2: Acids, Bases and Salts



Prior Knowledge

It is recommended that you revise the following topics before you start working on these questions.

- Chemical properties of acids and bases
- Reaction of acids and bases with metals
- Reaction between acid and base
- Importance of pH in everyday life
- pH of salts



Forwarded Messages

What is easier, typing 100 words or clicking one button to forward a message having 100 words? It is not a surprise that there are many users on messaging applications who forward more messages than composing their own. Have a look at the message below which was forwarded multiple times at the beginning of the COVID period in 2020.

Keep in mind that the pH of the coronavirus ranges from 5.5 to 8.5. So all we have to do to eliminate the virus is to eat more alkaline foods.

- Bananas → 9.9 pH
- Yellow lemon → 8.2 pH
- Egg white → 9.2 pH
- Garlic → 13.2 pH
- Mango → 8.7 pH
- Mandarin → 8.5 pH
- Carrot → 7 pH
- Pineapple → 12.7 pH
- Watercress → 22.7 pH

DO NOT keep this information just for yourself, give it to all your family and friends.

What would you do if you received a similar message? Since most items this message recommends are food items and not chemicals, it is tempting to follow the recommendation without verifying. Your thoughts may go in the following direction:

- I am fond of bananas or mango or garlic anyways.
- I don't lose/spend much by eating one extra banana!
- This message seems to be harmless even if it is not based on verified facts.
- These are fruits/vegetables and hence not owned by any one company. If someone is trying to spread rumours, what will they gain by doing this?
- This message seems to be based on scientific evidence, since technical terms like pH are used in it.

Is the above message actually harmless? For a pandemic like COVID 19, isn't it important for society that each human has a correct understanding about the disease? In general, when we have false messages, forwarded on social media, what do you think could be the motive? If you want to verify the above message, how would you do it?

Case Study A - pH of Food & Corona Virus

Given below are excerpts from 2 articles - 1 from a news agency and 1 from a popular medical journal. The sources of both articles have also been mentioned.

"A virus itself does not have a pH," said Sarah Stanley, associate professor of infectious diseases and vaccinology at the University of California, Berkeley School of Public Health. Stanley explained in an email that "pH is something that applies to a water based solution, which a virus is not." In addition, she said, it's not possible for diet to change the pH of blood, cells or tissues. The body regulates pH levels, it's not something a person would want to change.

Source: [AP News](#)

We also tested the virucidal effects of disinfectants by adding 15 μL of SARS-CoV-2 culture (~ 7.8 log unit of TCID₅₀ per mL) to 135 μL of various disinfectants at working concentrations (appendix p 1). With the exception of a 5-min incubation with hand soap, no infectious virus could be detected after a 5-min incubation at room temperature (22°C). Additionally, we also found that SARS-CoV-2 is extremely stable in a wide range of pH values at room temperature (pH 3–10; appendix p 1). Overall, SARS-CoV-2 can be highly stable in a favourable environment, but it is also susceptible to standard disinfection methods.

Alex W H Chin, Julie T S Chu, et al. published through The Lancet

Published: April 02, 2020, DOI: [https://doi.org/10.1016/S2666-5247\(20\)30003-3](https://doi.org/10.1016/S2666-5247(20)30003-3)

Question 1

By reading the excerpts of the articles, what part of the WhatsApp message can you conclude for sure to be correct or incorrect? Justify your answer. Write your answer in the space given below.

Answer

Question 2

pH data was collected for different food items by using pH paper. The original colour of the pH paper is yellow. Its colour changes to those shown in Fig. 2.1 when it is dipped in a solution of the corresponding pH.

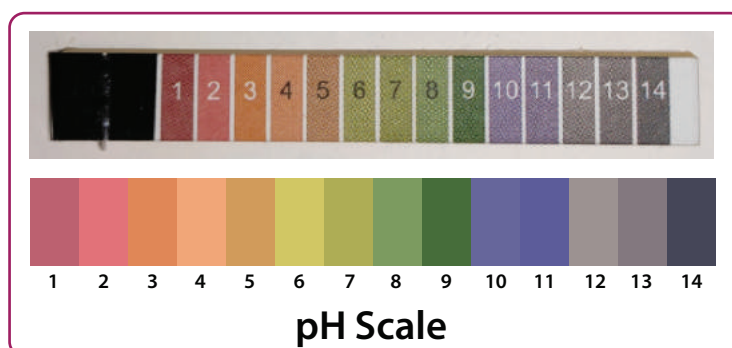
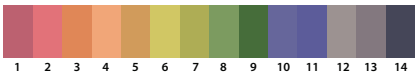


Fig. 2.1, Colour code on the pH strip

Given below is the data on the colour of the pH paper after water extract was dropped on the pH paper for different food items. For the items which do not contain water, it was soaked in water for some time and the water thus collected was used.

Food items	Colour of the pH paper after dipping in the food items	pH scale for reference
Yellow lemon		 pH Scale

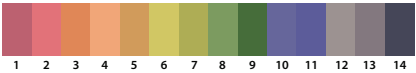
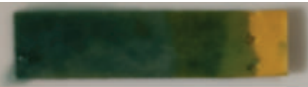
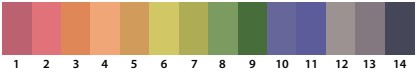
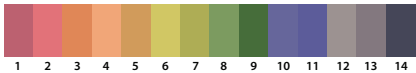
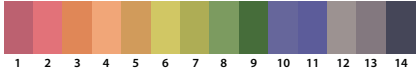
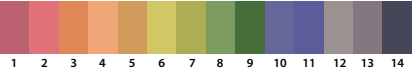
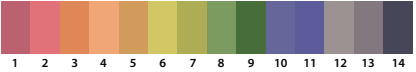
Garlic		 pH Scale
Egg white		 pH Scale
Mango		 pH Scale
Banana		 pH Scale
Mandarin		 pH Scale
Carrot		 pH Scale

Table 2.1, Colour of the pH paper after water extract was dropped on the pH paper for different food items.

- i. Name any two items whose pH level has been incorrectly mentioned in the WhatsApp message.

Answer

- ii. Name any two items, whose pH level has been mentioned correctly.

Answer

- iii. Name any one item in the original message for which you could have concluded that the pH is incorrect without the experiment data. State the basis of your conclusion.

Answer

Case Study B - Model of Chloralkali Process

In the absence of pH paper (or any other industry manufactured acid-base indicator), one can also use turmeric to test if a solution is acidic or basic. The colour of turmeric changes from **yellow** to **vermilion** (deep orangish-red) when an alkaline solution is added. The colour of vermilion changes to yellow when an acidic solution is added to it. Fig. 2.2 shows a setup where common salt (NaCl) was dissolved in water and electric current was passed through it after adding turmeric. The container carries 30 ml of water with 3 g of common salt and 0.5 g of turmeric dissolved in it.

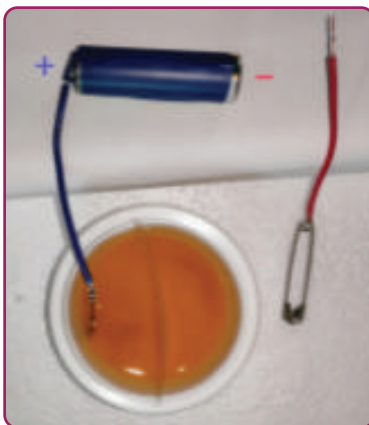


Fig. 2.2, Experimental setup before the current was passed through common salt solution

Fig. 2.3 and 2.4 show the situation after the setup is left undisturbed for some time. Note that there is a plastic sheet inserted in the middle of the container to create two separate chambers. This plastic sheet has a few small holes, which allow movement of ions across the two chambers.

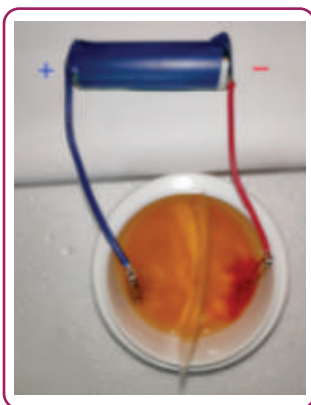


Fig. 2.3, Setup after 2 minutes



Fig. 2.4, Setup after 5 minutes

Question 3

- i. What can you infer about the pH of the products at the two terminals? Support your answer with appropriate arguments. Write your answer in the box below.

Answer

- ii. Write the chemical formula and the name of the product at the negative terminal in the space below.

Answer

Question 4

The above process, also known as the chloralkali process, is used to make different products from common salt. At industrial scale, so as to make products with a sizable concentration, one has to increase the rate of reaction. The following parameters were varied, and for each the time taken for the first colour change to be visible was observed.

Parameter varied	Possible values
Battery voltage	1.5V, 3.0 V, 9.0 V
Salt concentration	3 g, 6 g, 9 g
Turmeric quantity	0.5 g, 1.0 g, 1.5 g
Temperature of water	Ice cold, room temperature, warm water

Table 2.2, Possible values of the parameters that can be varied in the chloralkali process model

- i. When the battery voltage is varied in order to study its effect on the rate of reaction, what should be the value of salt concentration?
- a. Varied between 3 g and 9 g
 - b. Fixed to a maximum value of salt, which can be dissolved in 30 ml of water
 - c. Same as in the original setup, i.e. 3 g
 - d. Does not matter - we can choose it randomly

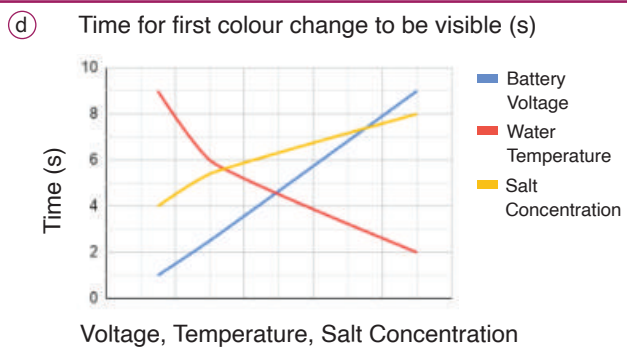
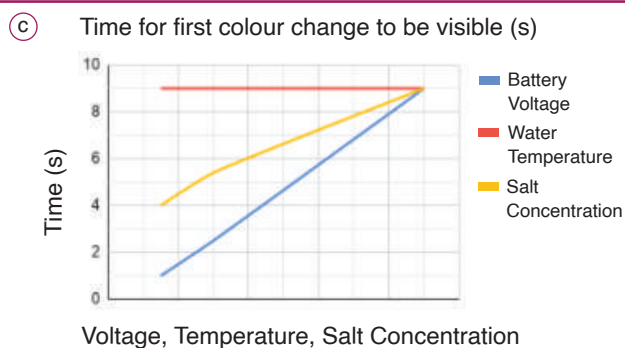
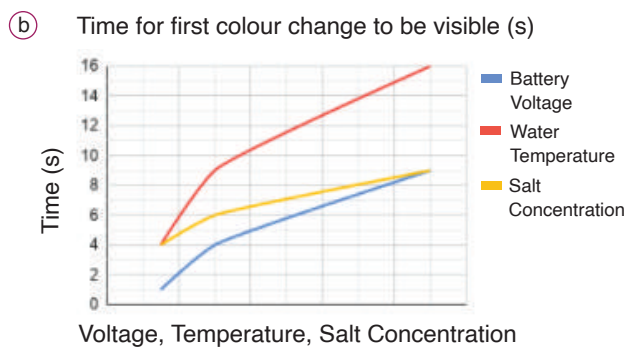
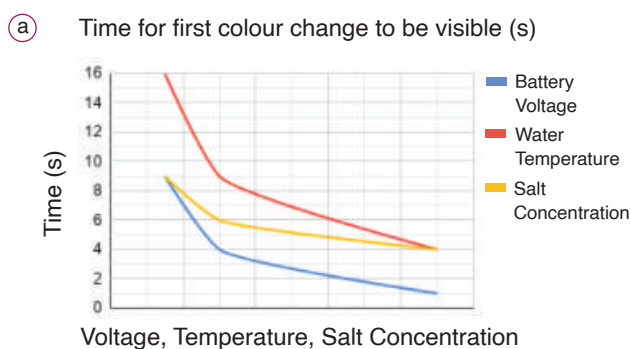
Answer

ii. Justify your answer to the previous question (part i).

Answer

Question 5

- i. It was observed that as the following quantities were increased, the rate of reaction increased - battery voltage, salt concentration and temperature of the solution. Based on this information, which of the following graphs correctly represents the data collected? Since three different quantities have been varied and plotted on a single graph, the x-axis does not show the actual values or unit of the quantities. You may assume that each of the three quantities - battery voltage, salt concentration and temperature - increases as you move towards the right on the x-axis.



Answer

ii. Why does the amount of turmeric not affect the time taken for first change to be visible?

Answer

Case Study C - Coconut

The coastal region fruit - Coconut - is unique in its own ways, like many other fruits. It is heavy enough to harm an animal if it falls directly on the animal from the tree. In spite of such a big mass, its seed is dispersed through water bodies, which cannot happen unless it can float on water. The eagerness of the tree to drop its fruit straight into the water body is visible in the picture in Fig. 2.9.



Fig. 2.9, Coconut tree at sea side, Image by Walkerssk via pixabay.com

Coconut has a wide variety of uses and applications as well. Tender coconut has nutritious water and dry coconut is widely used in a variety of food items and cosmetic products. The coconut's composition is dependent on several factors, such as age, varieties, growing seasons, geographical locations and environmental conditions, including rainfall and temperature. Some of the properties relevant in this context are given in table 2.3. Fig. 2.10 shows the nutrients in 100 grams of fresh coconut.

Composition of tender coconut			
Property	Coconut maturity stage (months)		
	5-6	8-9	>12
Volume of water (mL)	684	518	332
pH	4.78	5.34	5.71
Total Phenolic Content ** (mg/L)	54.0	24.6	25.7

Table 2.3, Composition of tender coconut.

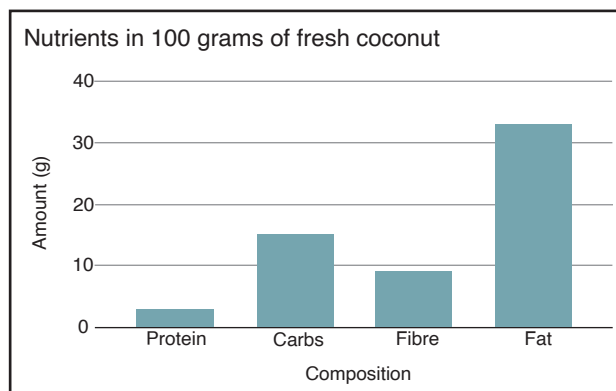


Fig. 2.10, Nutrients in 100 grams of fresh coconut.

** Phenol (or phenolics) is a class of chemical compounds made from 3 elements - carbon, hydrogen and oxygen - which have some special properties. Simplest example of a phenol is C_6H_5OH

Question 6

Aakash and his friends went to explore a coconut farm. They purchased some coconut products from the farm owner who showed them some of the old coconut products, which had an unpleasant smell and warned them not to keep the fresh products they had bought, for a long duration.

Given below are statements related to the unpleasant smell from the coconut products. Which ones do you think are correct?

- Coconut products have compounds of carbon. Carbon present in the food turns to CO_2 when exposed to air. CO_2 has an unpleasant smell.
- Coconut has fats and oils. When they are oxidised, they become rancid and their smell changes
- Coconut has fats and oils and hence they are acidic. Acids smell bad if they are exposed to air for long periods.
- To prevent oxidation of coconut snacks, nitrogen gas can be filled in the bag containing snacks

a. A and D

b. B and C

c. B and D

d. A and C

Answer

Question 7

While roaming around the field, Aakash and his friends opened the snacks that they had taken to the field. In one of the boxes, sliced apples had turned brown in colour. Aakash explained the theory that he had recently read and noted.

The total phenolic content in the apples, or any other plant product, causes browning. Most plant products have polyphenols, but in some fruits like apples, peaches, bananas, avocado, etc., the amount is relatively more and browning can be observed easily.

Coconut Testa, a thin layer of coat covering the coconut seed, changes its colour if exposed to air. By observing the opened tender coconut shells, Aakash could conclude the relative maturity of the tender coconuts.

Which of the following coconut testa, in terms of its age (in months), takes the least amount of time to turn into a dark brown colour?

a. 5-6	b. 8-9	Answer
c. 9-12	d. >12	

Question 8

Coconut husk and dry leaves are highly flammable. So wherever you are working with dry coconut material, like at a coir factory or in a coconut thatched building, it is always advisable to have a fire extinguisher at hand. While talking about the dangers of a fire in such circumstances, Aakash introduced his recently brought magic substances to his friends. "Mixing them releases CO_2 gas, which can be used to extinguish a fire", he told them.

Choose the balanced chemical equation which represents the reaction between the two magic ingredients:

- a. $\text{NaCO}_3 + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O} + \text{CO}_2$
- b. $\text{Na}_2\text{CO}_3 + 2 \text{HCl} \rightarrow 2 \text{NaCl} + \text{H}_2\text{O} + \text{CO}_2$
- c. $\text{Na}_2\text{CO}_3 + 2 \text{HCl} \rightarrow \text{Na}_2\text{Cl}_2 + \text{H}_2\text{O} + \text{CO}_2$
- d. $\text{Ca}(\text{OH})_2 + \text{CO}_2 \rightarrow \text{CaO} + \text{CO}_2 + \text{H}_2\text{O}$

Answer

Question 9

While returning, the group of friends carried tender coconut water in their water bottles. Aakash had a copper water bottle. After 4 hours, the coconut water stored in the copper bottle tasted bad and caused Aakash to vomit. Choose the correct statement/s from the following options.

- A. Coconut water is acidic, which is harmful to the stomach
- B. Coconut water is basic and causes vomiting if consumed
- C. Acidic coconut water reacts with copper, forming a salt which is not consumable for humans
- D. Aakash was suffering from acidity. Stomach acids are expelled out from the body when alkaline coconut water is consumed.
- E. Alkaline tender coconut water neutralises stomach acids causing vomiting

a. A, C

b. C

c. B, D

d. E

Answer

Question 10

The same group of students visited the coconut farm after a year. Unfortunately, the sight of the lively green plants had changed to dying yellow trees, despite having adequate water. This implies that adding more water did not help the trees. After having a detailed discussion with the farmer, it appeared that the region got affected by acid rain, and generally acid rain has a pH between 4.2 and 4.4. Coconut trees tolerate soil pH from 5.0-8.0. But for optimum growth, a pH range of 5.5-6.5 is ideal. If you were in that group of students, which of the following suggestions (option A to D) would you give to the farmer?

- A. Coconut yield is high in coastal regions as these trees are near salty water. Salt (NaCl) must be added to the plants as a fertiliser to bring the pH level of the soil back to normal / almost neutral
- B. Lime (calcium oxide/hydroxide) can help to bring the soil pH back to neutral by neutralising the acidic environment of the soil
- C. Hydrochloric acid can be used to bring the soil pH back to neutral
- D. Add more water to the plants to dilute the acids present in the soil

a. A and D

b. B and D

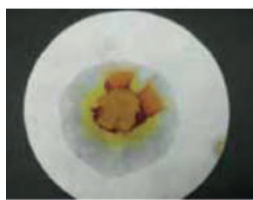
c. C and D

d. B only

Answer

Exploration Pathway

To explore this theme in an experiential manner you may work on the following hands-on activities:



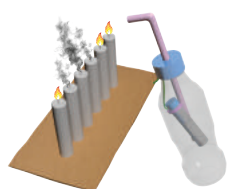
Acids-Bases -
Turmeric Indicator

There are many wonderful natural acid-base indicators. One such ubiquitous food item in Indian households is turmeric powder. The dazzling yellow of turmeric turns a deep red when exposed to a basic/alkaline substance. However, it remains yellow if the test sample is neutral or acidic. The deep red powder created by exposing turmeric to a basic substance is nothing but vermilion, which is now your natural acid indicator, as it will turn back to yellow (turmeric) when exposed to an acidic solution, but will remain a deep red when exposed to a basic or neutral substance. Enjoy testing various household items, edible and non-edible, for their acidity or alkalinity!



Digestion - Protein

pH plays a significant role in digestion. While the mouth is alkaline to digest carbohydrates, the stomach is highly acidic to activate Pepsin, the enzyme that digests protein. In this TACTivity, we create an artificial stomach where we use citric acid and pepsin to help digest milk.



Fire Extinguisher Model

Fires kill more than a hundred thousand people every year worldwide. The numbers would be far higher were there no fire extinguishers and fire persons to deal with them. How are they extinguished? What can be done to save more lives, if help is not near at hand? Fire requires 3 key ingredients: material to burn, oxygen and an initial temperature high enough to ignite the material. Take any one of these 3 out, and you have yourself a potentially effective fire extinguisher. In this experiment, we produce carbon dioxide using a classic reaction, and use that to douse a candle flame by literally "pouring" it over the flame.



DIY Base (Membrane)

Commercially, sodium hydroxide is made through the electrolysis of brine solution. Here, we do the same, albeit on a much smaller scale, to make your own sodium hydroxide, the quintessential base, with hydrogen and chlorine as by-products.



Reaction - Acid and Metal

Acids react with most metals to form salt and hydrogen gas. In this TACTivity, we react magnesium with citric acid to liberate some hydrogen gas. Inflate a balloon with the hydrogen gas and enjoy seeing the balloon float in air. Add a cotton thread to the bottom of the balloon and play around with the length of the thread to see the balloon go up and down.