

SNC2D/2P Chemical Reactions/Chemical Reactions and their Practical Applications

Teacher Demo: Turning Water into Wine into Milk into Beer

Topics	Timing
evidence of chemical change types of chemical reactions acid/base indicators	preparation: 10-15 min demonstration: 10-20 min

Specific Expectations

SNC2D

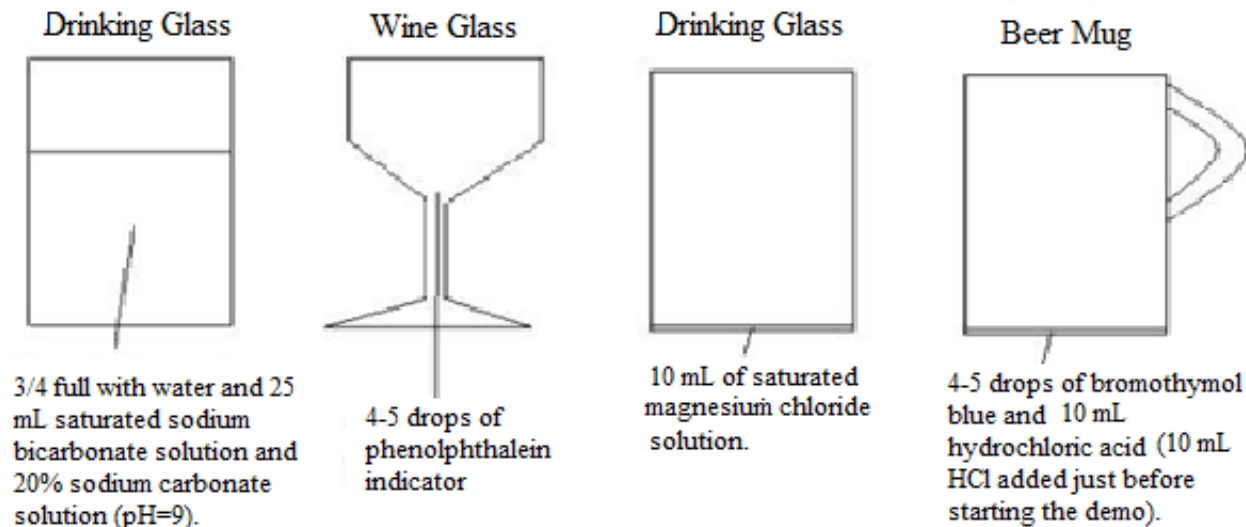
- A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions
- C3.3** describe the types of evidence that indicate chemical change (e.g., changes in colour, the production of a gas, the formation of a precipitate, the production or absorption of heat, the production of light).
- C3.4** write word equations and balanced chemical equations for simple chemical reactions (e.g., $2 \text{H}_2 + \text{O}_2 \rightarrow 2 \text{H}_2\text{O}$)
- C3.5** describe, on the basis of observation, the reactants in and products of a variety of chemical reactions, including synthesis, decomposition, and displacement reactions (e.g., reactions occurring when magnesium burns or in the production of oxygen from hydrogen peroxide; the reaction of iron and copper sulphate; reactions occurring when fossil fuels burn)
- C3.6** describe the process of acid–base neutralization (i.e., an acid reacts with a base to form a salt and often water)

SNC2P

- A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions
- C3.3** write word equations and balanced chemical equations for simple chemical reactions (e.g., $2 \text{H}_2 + \text{O}_2 \rightarrow 2 \text{H}_2\text{O}$)
- C3.4** describe the process of neutralization for simple acid–base reactions (i.e., an acid reacts with a base to form a salt and often water)

Introduction

Turning water into wine and then into beer and finally milk is an extremely versatile chemistry demonstration. It can be used to introduce or reinforce several important concepts in chemistry including evidence for chemical change and types of chemical reactions - by simply pouring a liquid from one glass to another, four different “beverages” are instantly created!



Materials

chemical safety goggles

lab coat or apron

protective gloves

water

25 mL mixture of saturated baking soda (sodium hydrogen carbonate), $\text{NaHCO}_3(\text{aq})$, and 20 % sodium carbonate, $\text{Na}_2\text{CO}_3(\text{aq})$, solution, (pH = 9)

4–5 drops phenolphthalein indicator

10 mL saturated magnesium chloride, $\text{MgCl}_2(\text{aq})$

4–5 drops of bromothymol blue indicator

10 mL 2.0 mol/L hydrochloric acid, $\text{HCl}(\text{aq})$

4 drinking glasses: 1 wine glass, 1 beer glass, 2 water/juice glasses

25 mL graduated cylinder

two 10 mL graduated cylinders

eye dropper or 1 mL plastic pipette

Safety Considerations

- Provide MSDS sheets for all chemicals used.
- 2 mol/L hydrochloric acid is corrosive and poisonous. Avoid skin or eye contact. Safety goggles, gloves, and apron/lab coat should be worn when handling hydrochloric acid. Wash your hands and flush your eyes immediately if you come into contact with it. Students should not handle this solution.
- The phenolphthalein solution is flammable and should be in a dropper bottle. Keep it away from any heat sources and open flames.
- If you use regular household drinking glasses instead of lab glassware, ensure that these glasses are kept separate from any that are actually used for beverages.

Hazardous Materials Identification System Rating

(0-minimal 1-slight 2-moderate 3-serious 4-severe)

2.0 mol/L
hydrochloric acid
HMIS (0 to 4)

Health	2
Fire Hazard	0
Reactivity	1

phenolphthalein pH
indicator solution
HMIS (0 to 4)

Health	1
Fire Hazard	3
Reactivity	0

bromothymol blue
indicator solution
HMIS (0 to 4)

Health	0
Fire Hazard	0
Reactivity	0

magnesium chloride
hexahydrate solution
HMIS (0 to 4)

Health	1
Fire Hazard	0
Reactivity	0

sodium carbonate
HMIS (0 to 4)

Health	1
Fire Hazard	0
Reactivity	0

Procedure

Wear appropriate PPE: chemical safety goggles, lab coat or apron, and protective gloves.

Prepare the following materials before class:

1. Glass #1 (water): Fill the glass $\frac{3}{4}$ full with water. Add approximately 25 mL of the saturated sodium bicarbonate/sodium carbonate solution (pH = 9).
2. Glass #2 (wine): Place 4–5 drops of phenolphthalein in the glass.
3. Glass #3 (milk): Pour approximately 10 mL saturated magnesium chloride solution into the glass.
4. Glass #4 (beer): Place 4–5 drops of bromothymol blue in the glass. Immediately before performing the demonstration, add 5–7 mL of 2.0 mol/L hydrochloric acid to the glass.

During class:

Ensure that all participants are wearing appropriate PPE: chemical safety goggles, lab coat or apron, and protective gloves.

5. Line up the four glasses in order.
6. **Observe**
Ask students to record their observations in the chart provided when the “water” from the first glass is transferred to each subsequent glass.
7. Pour the solution from the first glass (water) into the second glass (wine). Then pour the resulting solution into the third glass (milk). Finally, pour the resulting mixture into the fourth glass (beer). Provide time for students to record their observations.
8. **Explain**
Ask the students to try and explain how each of the “drinks” was created.

Disposal

Sodium bicarbonate or sodium carbonate may be used to neutralize any excess acid in the final solution prior to disposal. Follow disposal procedures that are consistent with school board protocol and appropriate for your municipality.

What happens?

The clear solution in the first glass (water) turns into a pink/red solution when poured into the second glass (wine). The solution then turns into a cloudy white mixture in the third glass (milk) and finally turns into a fizzy pale yellow solution in the fourth glass (beer).

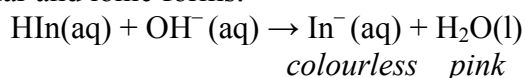
How does it work?

Water

The “water” is not actually water. It is a solution of sodium carbonate, $\text{Na}_2\text{CO}_3(\text{aq})$ and sodium bicarbonate, $\text{NaHCO}_3(\text{aq})$. The result is a weakly basic solution, which is required for the “milk” reaction in the third glass.

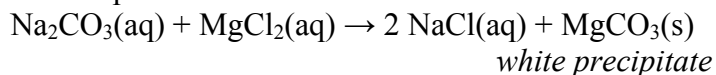
Wine

When the sodium carbonate/sodium bicarbonate solution is poured into the second glass (the wine glass), the phenolphthalein indicator already present in the glass reacts and turns pink in the basic solution. An indicator is a substance that is one colour at a certain pH and a different colour at another pH. Phenolphthalein is colourless when the pH is below 8.2 and pink in basic solutions, when the pH is above 8.2. The formulas $\text{HIn}(\text{aq})$ and $\text{In}^-(\text{aq})$ can be used to represent phenolphthalein in its molecular and ionic forms.



Milk

When the new “wine” solution is poured into the milk glass, the sodium carbonate/sodium bicarbonate solution reacts with the magnesium chloride solution already present in the glass. This produces magnesium carbonate, a white solid that is only slightly soluble. It therefore forms a precipitate in this double displacement reaction.

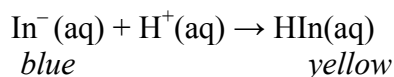


Beer

Finally, when the “milk” solution is poured into the beer glass, the magnesium carbonate reacts with the hydrochloric acid already present in the glass. This neutralization reaction produces carbon dioxide gas, giving the solution a fizzy appearance and some “head” or foam will form. The bromothymol blue is an indicator that turns yellow in an acidic solution in which the pH is less than 6.0, so as long as excess hydrochloric acid is present, the solution will appear pale yellow.



The formulas $\text{HIn}(\text{aq})$ and $\text{In}^-(\text{aq})$ can be used to represent bromothymol blue in its molecular and ionic forms.



Teaching Suggestions/Hints

1. You can prepare the solutions ahead of time, but pour liquids into glasses immediately before your class.

2. An alternative name for this demonstration could be “Turning Water into Fruit Juice into Milk into Ginger Ale”.
3. You can use a less concentrated solution of hydrochloric acid to reduce risk, but then you will need to increase the volume used in order to produce enough of a reaction for the fourth solution to have the “beer”-like appearance.
4. A guided observation and explanation table could be completed by students in groups of 2 to 4 as they observe the demonstration. (See BLM: Turning Water into Wine into Milk into Beer.) Alternatively, this information could be recorded on chart paper instead of on the BLM.
5. Possible follow-up discussion questions include:
 - a. What made the colourless solution turn red in the “wine”?
 - b. What chemicals produced a white precipitate in the “milk”?
 - c. What chemicals produced a gas in the “beer”?
 - d. Could we turn the “beer” back into milk? Is this a one-way or reversible reaction?
 - e. What reversible reactions do you know?

Next Steps

This demonstration can be an introduction to evidence of chemical reactions, classifying types of reactions, acids and bases, or it could be used to reinforce any of these concepts. It could also be demonstrated prior to students investigating various types of chemical reactions. As an extension, you could also have students write word equations and/or balanced chemical equations for each of the reactions that take place, including state symbols.

Additional Resources

1. To prepare saturated sodium bicarbonate and 20 % sodium carbonate solution, start by adding 6.25 g of sodium carbonate to 25 mL of distilled water, and then slowly add sodium bicarbonate until no more solid dissolves.
2. To make saturated magnesium chloride solution, start by adding 4 g of magnesium chloride to 10 mL of distilled water, and then slowly add more until no more solid dissolves.
3. To prepare 2.0 mol/L hydrochloric acid slowly dilute 2 mL of concentrated hydrochloric acid in 10 mL of water. Be sure to add acid to water. Work in a fume hood.

BLM

Turning Water into Wine into Milk into Beer

Complete the following observations for each reaction observed.

	Reaction #1 Water into wine	Reaction #2 Wine into milk	Reaction #3 Milk into beer
Observations BEFORE			
Observations AFTER			
Evidence of chemical reaction			
Reactants			
Products			
Word equation			
Chemical equation			
Type of reaction			