Test Course

Titration for Acetic Acid in Vinegar

Final Report - Answer Guide

Institution	SI Curriculum Development University
Session	Test Course
Course	Test Course
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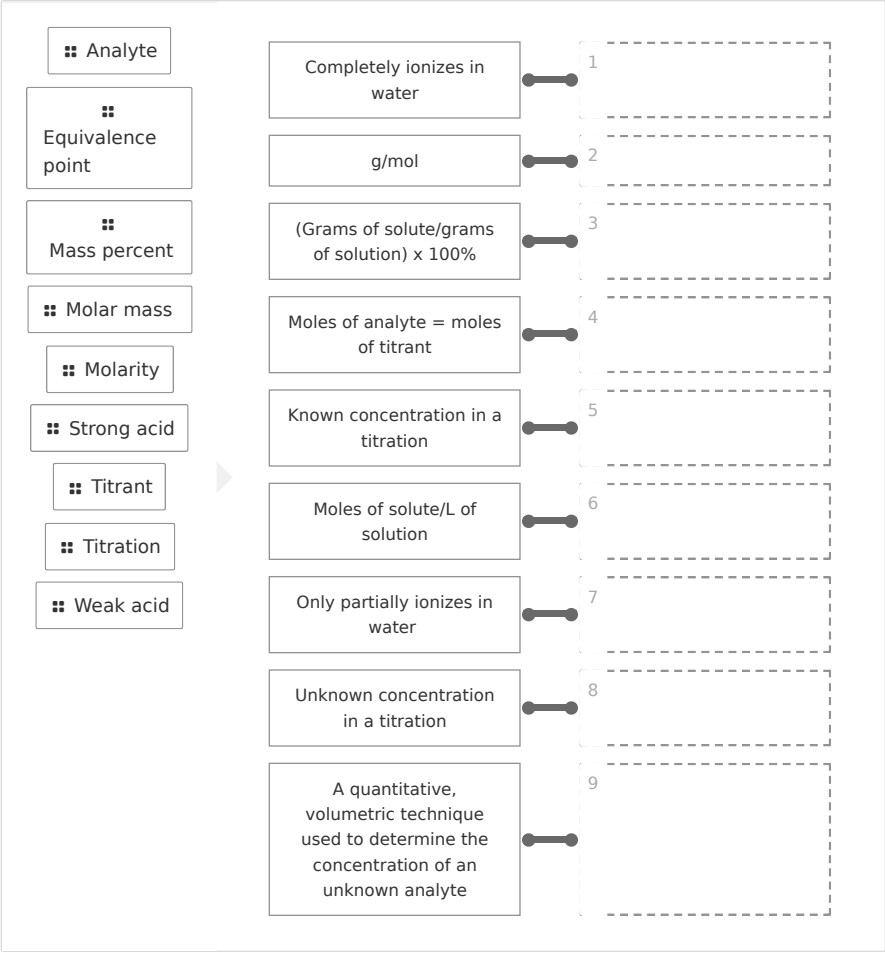
Test Your Knowledge

Match each term with the appropriate definition.

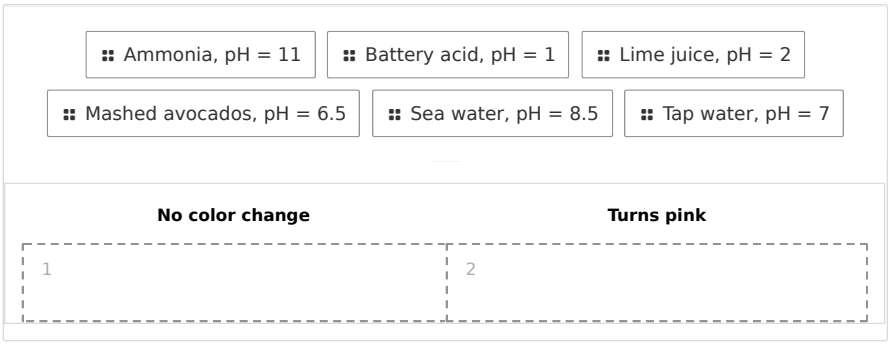


Correct answers:

1 Strong acid 2 Molar mass 3 Mass percent 4 Equivalence point

5 Titrant 6 Molarity 7 Weak acid 8 Analyte 9 Titration

Determine whether each chemical substance would remain the same color or turn pink in the presence of phenolphthalein.

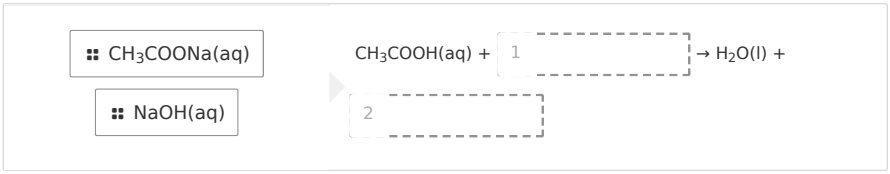


Correct answers:

1 Battery acid, pH = 1 Lime juice, pH = 2 Mashed avocados, pH = 6.5 Tap water, pH = 7

2 Sea water, pH = 8.5 Ammonia, pH = 11

Complete the chemical equation.



Correct answers:

1 NaOH(aq) 2 $CH_3COONa(aq)$

Exploration

A weak acid completely ionizes in water to produce both a conjugate base and a H_3O^+ ion.

- True
- False ✔

A titration is useful for determining the concentration of a given substance.

- True ✔
- False

Phenolphthalein is an effective pH indicator because equivalence points in titrations are marked by the analyte changing in color from _____ in acidic and neutral solutions, to _____ in basic solutions.

- light yellow; purple
- bright pink; colorless
- colorless; bright pink ✔
- white; bright purple

During a titration, a known concentration of titrant is added to an analyte of an unknown concentration.

- True ✔
- False

Exercise 1

If the manufacturer of the vinegar used in the experiment stated that the vinegar contained 5.0% acetic acid, what would the percent error between your result and the manufacturer's statement be? Show your work.

The percent error between a 5% acetic acid as stated on the bottle, and the % calculated through experimentation is calculated below:

$$\% \text{ Error} = \left|\frac{(5.0-4.86)}{5.0}\right| \text{x } 100 = 2.8\%$$

What challenges would you encounter with the titration if you had used apple cider vinegar or balsamic vinegar as the analyte instead of distilled white vinegar?

The challenges in using apple cider or balsamic vinegar would have resulted from the color of the vinegars. The experiment was performed with white vinegar which is colorless and allows for ease

in observing the change in color from the indicator. If the vinegar had the deep black-purple color of balsamic vinegar or the caramel color of apple cider vinegar, viewing the change in indicator color, and noting the endpoint of the titration would be very challenging.

How would your experimentally determined vinegar concentration have differed if the tip of the titrator was not filled with NaOH before the initial volume reading was recorded? Explain your answer.

If the tip of the titrator was not filled with NaOH prior to reading and recording the initial volume of NaOH, the amount of NaOH required to reach the endpoint would have been incorrect. If more NaOH was used than needed, the resulting vinegar concentration would be too high.

How would your experimentally determined vinegar concentration have differed if you had over-titrated (added drops of NaOH to the analyte beyond the stoichiometric equivalence point)?

If the sample was over-titrated, the stoichiometric equivalence point would have been over-shot. This means that the experiment would suggest that there was a higher concentration of CH_3COOH in the vinegar sample than was actually present.

If a 7.0 mL sample of vinegar was titrated to the stoichiometric equivalence point with 7.5 mL of 1.5M NaOH, what is the mass percent of CH_3COOH in the vinegar sample? Show your work.

$$\frac{\text{moles } CH_3COOH}{\text{L}} = \frac{(1.5 \text{ M } NaOH) \text{ x } (7.5 \text{ mL } NaO}{7.0 \text{ mL of vinegar sample}}$$

$$\% \, CH_3COOH = \frac{1.61 \text{ mol } CH_3COOH}{1 \text{ L}} \text{ x } \frac{1 \text{ L}}{1000 \text{ mL}} \text{ x } \frac{1 \text{ mL vinegar}}{1.00 \text{ g vinegar}} \text{ x } \frac{60.05 \text{ g } CH_3COOH}{1 \text{ mol } CH_3COOH}$$

Why is it important to do multiple trials of a titration, instead of only one trial?

When performing science experiments, it is always important to do multiple trials. Scientists want their results to be both accurate and precise, which results from achieving reproducible data/results under the same conditions.

Data Table 1: NaOH Titration Volume
(SAMPLE ANSWER BELOW)

	Initial NaOH Volume (mL)	Final NaOH Volume (mL)	Total volume of NaOH used (mL)
Trial 1	9.0	1.2	7.8
Trial 2	9.4	1.2	8.2
Trial 3	9.6	1.3	8.3
	Average Volume of NaOH Used (mL) :	8.1	

Data Table 2: Concentration of CH3COOH in Vinegar
(SAMPLE ANSWER BELOW)

Average volume of NaOH used (mL)	Concentration of CH_3COOH in vinegar (mol/L)	% CH_3COOH in vinegar
8.1	0.81	4.9

Competency Review

Titration is a quantitative, volumetric technique where a solution with a known concentration is added to a solution of an unknown concentration until the equivalence point is reached.

- True ✔
- False

During a titration, the solution with the unknown concentration is called the _____.

- analyte ✔
- titrant
- equivalence point
- indicator

The moment in a titration where exactly enough titrant has been added to completely react with the analyte is called _____.

- the equivalence point
- the stoichiometric point
- both the equivalence point and the stoichiometric point ✔
- None of the above

In the presence of a strong acid, phenolphthalein remains colorless.

- True ✔
- False

When designing a titration between a titrant and an analyte, it is important to ensure the chemical equation is balanced.

- True ✔
- False

A strong acid completely ionizes in water to produce _____.

- a conjugate acid and H^+ ions
- a conjugate base and H^+ ions ✔
- a conjugate acid and OH^- ions
- a conjugate base and OH^- ions

During titration, a stopcock is used to _____.

- clamp and secure the titrator
- measure exactly 5 mL of titrant
- release one drop at a time from the titrator ✔
- add NaOH to the titrator

The volume of titrant used during a titration will always be the exact same throughout three trials.

- True
- False ✔

The concentration of acetic acid in vinegar is represented by the units _____.

- mL/mol
- mol/L ✔
- mL
- mol

Extension Questions

A student did not read the directions to the experiment properly and mixed up where to place the NaOH solution and the vinegar. He put the vinegar in the titrator and the measured amount of NaOH in the beaker. He then added a drop of the phenolphthalein to the solution in the beaker.

Does the student need to empty out all of the solutions and start over again or can he go ahead and run the titration? If he runs the titration using the solutions as given above, what should he expect to see happen for results?

(SAMPLE ANSWER BELOW)

The student could indeed run the titration in reverse. The solution in the beaker (containing the NaOH and the phenolphthalein) will initially be pink. The color will begin to fade as the titration proceeds and will turn colorless at the equivalence point.