University of Michigan Science Olympiad
2021 Invitational Tournament

Chemistry Lab C

Test length: 50 Minutes

Team name: KEY

Student names: KEY

Tiebreakers will be scored like regular questions and will only be used as tiebreakers when ties arise. The following questions will be used as tiebreakers in the order they are listed (highlighted in answer key):

1. Free Response: Question 4c
2. Free Response: Question 2d
3. Free Response: Question 1
4. Multiple Choice: Question 22
5. Multiple Choice: Question 16
6. Multiple Choice: Question 8
7. Multiple Choice: Question 5
8. Multiple Choice: Question 2

Instructions

Make sure you have a stable internet connection and are ready to compete!

For this test, you are allowed the following resources:

- A Google Meet/Zoom/Skype/phone/video call with your partner
- A cheat sheet/binder printed or in pdf format on your computer
- Programmable/non-programmable calculator
- Scratch paper

You **MAY NOT** take advantage of the following resources.

- ANY internet resource **except** those provided within the test
- Help from any person other than your partner
- A printed version of the test

Doing so will result in a disqualification plus 30 points added to your team's overall score.

This test will use an online simulation, so please make sure you have a stable internet connection before opening and running the simulation.

This test consists of 40 questions, and you will have 50 minutes to complete it.

This exam has four sections to it:

1. Multiple-Choice
2. Fill-In-The-Blank
3. Calculation
4. Simulation

The first three are pretty self-explanatory and will have their own instructions at the beginning of each of their respective parts of the exam.

The last section of this exam, the simulation section, will be the "lab" portion of this exam. You will be asked to do a chemistry simulation and perform specific tasks during it! Please start loading the simulation now, using this link here.

This simulation takes a long time to load, so it is highly recommended that one team member opens up and loads the simulation in a new tab while the other works on the test until the simulation fully loads. This software does not require Adobe Flash Player. In the event that the software doesn't open, please use Google Chrome.

The simulation activity itself may take some time. If a team member wants to start the activity, please refer to the instructions in the final section of the exam.

For questions that require work to be shown, please use this google form to turn in pictures of your work. This may be submitted shortly after you finish your Scilympiad test, though your work will only count toward partial credit if it matches the answer given on Scilympiad.

If you experience technical difficulties during the test...

Immediately contact the event supervisor through the classroom feature on Scilympiad, stating clearly what issue you are having.

If your work is not saving/submitting, take screenshots of your answers on Scilympiad and submit them to this google form. Try to stay within your allotted 50 minutes.

Final notes before you begin!!!

You are expected to use all the given information found within this test and within the four informational websites whose links are below.

All reactions and situations will be taking place at **room temperature** unless otherwise specified within a question.

Please use this website for K_{sp} values, if necessary.

Please use this website for pK_a values, if necessary.

Please use this website for the periodic table.

Please use this website for any additional information.

We highly recommend opening these websites in separate tabs for convenience.

Note: If the use of one of these sites is necessary, there is a high chance our answer key will be based on the numbers from these websites for those questions.

Other than that, good luck!!! :)

UMSO Division C Chemistry Lab Test

Multiple Choice: Strong and Weak Acids and Bases (2 questions)

1. Which of the following reactions will result in a completion reaction after which the products will completely dissociate and not form an equilibrium?

    a. One liter of 0.5M acetic acid is added to one liter of 0.05M ammonium hydroxide.
    b. One liter of 0.05M hydrochloric acid is added to one liter of 0.5M sodium hydroxide.
    c. One liter of 0.5M acetic acid is added to one liter of 0.005M lithium hydroxide.
    d. One liter of 0.005M ascorbic acid is added to one liter of 0.005M potassium hydroxide.
    e. Both b and d.
    f. None of the above.

2. Which of the following lists of ions contain exactly four neutral ions, two acidic ions, and two basic ions?

    a. Na^+, NO_3^-, NH_4^+, NO_2^-, Cl^-, ClO_3^-, ClO_4^-,and CH_2COO^-
    b. Li^+, Na^+, K^+, NO_3^-, Fe^{2+}, MnO_4^-, I^-, and CH_2COO^-
    c. K^+, NO_3^-, NO_2^-, F^-, Mg^{2+}, I^-, Cl^-, and Ag^+
    d. Rb^+, Fr^+, ClO_2^-, NO_3^-, Ba^{2+}, I^-, Cl^-, and ClO_4^-
    e. Fr^+, Ba^{2+}, Ra^{2+}, Sr^{2+}, ClO^-, ClO_2^-, MnO_4^-, and F^-
    f. Rb^+, NO_2^-, Ca^{2+}, I^-, F^-, Cl^-, MnO_4^-, and NH_4^+

Multiple Choice: Colligative Property (2 questions)

3. In a beaker, 13 grams of ammonium dichromate is dissolved in 2.0 liters of water. Which of the following is the freezing point of the solution? Use the fact that water's density is about 1.00 g/cm^3.

    a. 0.14 ℃
    b. -0.14 ℃
    c. 0.048 ℃
    d. -0.048 ℃
    e. 0.00014 ℃
    f. -0.000048 ℃

4. Which of the following solutions has the highest boiling point?

    a. A solution formed from adding one liter of water to 170 grams of sucrose.
    b. A solution formed from adding two liters of water to 340 grams of sucrose.
    c. A solution formed from adding one liter of water to 37 grams of calcium chloride.
    d. A solution formed from adding two liters of water to 30 grams of table salt.
    e. Both a and b.
    f. All of the above except for c.

Multiple Choice: ppm, ppb, Molality, and Osmolarity (1 question)

5. An aqueous solution of ferric nitrate was prepared by dissolving 3 mg of solid ferric nitrate in 650 mL of water. Which of the following statements are **true**, regarding the concentration of the ferric nitrate solution? Use 1.0 g/mL for the density of water.

    I. The ppm of the solution is 4.62
    II. The ppb of the solution is 4620
    III. the osmolarity of the solution is 7.63×10^{-5}
    IV. The molality of the solution is 1.91×10^{-5}

    a. Only I
    b. I and III
    c. I, II, and III
    d. III and IV
    e. II, III, and IV
    f. All of the statements are true

Multiple Choice: Common Ion Effect (2 questions)

6. The following reaction was done in a lab…

   $AgNO_{3\,(aq)} + NaCl_{(aq)} \rightarrow AgCl_{(s)} + NaNO_{3\,(aq)}$

   If lithium chloride was added, how would the reaction change?

   a. More precipitate would dissolve.
   b. More precipitate would form.
   c. The concentration of sodium ions would increase.
   d. The pH of the solution would increase.
   e. Both b and d.
   f. All of the above except for a.

7. In a lab, 20 mL of 0.5 M pyridinium chloride were added to 30 mL of 1.0 M ammonia. If ammonium iodide was added after the reaction reached equilibrium, then…

   a. More ammonium ions would form
   b. More pyridine would form
   c. Less pyridinium ions would form
   d. Less ammonia would form
   e. **More pyridinium ions would form**
   f. Both d and e

Multiple Choice: Equilibrium and Solubility (6 - 8 questions)

8. Which of the following reaction mixtures will favor the formation of the reactants?

   a. 50 mL of 0.5 M hydrochloric acid and 25 mL of 0.25 M sodium hydroxide.
   b. 75 mL of 1.5 M pyridinium chloride and 25 mL of 2.0 M sodium acetate.
   c. 50 mL of 0.25 M acetic acid and 25 mL of 0.75 M sodium methoxide.
   d. 30 mL of 0.75 M phosphoric acid and 45 mL of 0.50 M sodium dihydrogen phosphate.
   e. All of the reactions will favor the reactants.
   f. None of the reactions will favor the reactants .

9. Which of the following statements about the following equilibrium is INCORRECT?

$$HA^+ + :B \rightleftharpoons :A + HB^+$$

I. The reaction will favor the side with the stronger acid
II. The reaction will favor the side with the stronger conjugate base
III. The reaction will favor the side with the weaker conjugate base
IV. The reaction will favor the side with the weaker acid

a. Only I
b. I and II
c. II and IV
d. III and IV
e. I, II and IV
f. All statements are true

The following reagents were mixed together in the same beaker…

75 mL of 15 mM acetic acid and 25 mL of 50 mM ammonia

The following 3 questions are about this reaction mixture above …

10. If the reaction is allowed to go to completion and reaches equilibrium, which of the following statements are **TRUE**?

I. The reaction will favor the reactants over the products
II. The reaction will favor the products over the reactants
III. The pH of the solution will be acidic

a. Only I
b. Only II
c. I and II
d. I and III
e. II and III
f. All statements are true.

11. What is the K_{eq} for this reaction?
    a. $10^{-3.7}$
    b. $10^{-1.2}$
    c. $10^{1.4}$
    d. $10^{2.3}$
    e. $10^{4.4}$
    f. Cannot be determined

12. How would the K_{eq} for the reaction change if 40 mL of 25 mM pyridine was added instead of the ammonia?

    a. The K_{eq} would increase and favor the products still
    b. The K_{eq} would decrease but favor the products still
    c. The K_{eq} would decrease and favor the reactants now
    d. The K_{eq} would increase but favor the reactants now
    e. There would be no change in the K_{eq} because you are still using a base
    f. None of the above.

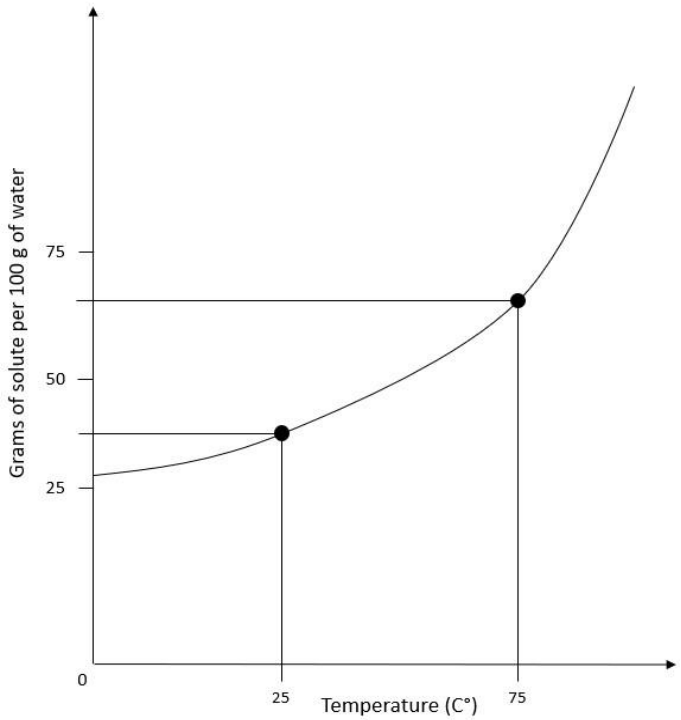
13. Which of the following are **not** completely soluble in water?

    I. Ferrous hydroxide
    II. Ammonium oxalate
    III. Silver acetate
    IV. Barium sulfate

    a. Only I
    b. Only II
    c. I and III
    d. I, III, and IV
    e. **I and IV**
    f. II and IV

The following 2 questions will refer to this graph…

Mystery compound solubility curve



14. If 30.0 grams of this mystery compound were added to 100. grams of water at 40 °C, the solution would be...

    a. undersaturated
    b. unsaturated
    c. saturated
    d. concentrated
    e. oversaturated
    f. supersaturated

15. If a saturated solution of this mystery compound is formed at 75 °C, which of the following statements are **incorrect**?

I. Increasing the temperature of the solution will supersaturate the solution.
II. Decreasing the temperature will unsaturate the solution.
III. Decreasing the temperature will supersaturate the solution.

a. Only I
b. Only III
c. II and III
d. I and II
e. I and III
f. All are correct

Multiple Choice: pH, pOH, etc. (6 - 8 questions)

16. Read the following statements. Select all statements that **must be true** for the following situation. 50 mL of 0.50M acetic acid is at equilibrium in a 100 mL beaker in a lab that is at 20°C.

I. pH and pOH always sum to 14.
II. The pH of the solution is 2.52.
III. The molality is 0.515 m.

a. None of these statements are true.
b. I only
c. II only
d. III only
e. I and II only
f. All of these statements are true.

17. Read the following statements. Select all statements that **must be false** for the following situation. In a titration, the equivalence point has a pH below 7.

I. The titration involves a weak acid being titrated against a strong base.
II. The titration involves a weak base being titrated against a strong acid.
III. The half-equivalence point occurs after the equivalence point.
IV. The equivalence point occurs after the half-equivalence point.
V. The situation has multiple equivalence points.

a. I, III, and V only
b. II, IV, and V only
c. I and III only
d. II and IV only
e. III only
f. V only

18. Which of the following statements is/are correct?

a. At the half-equivalence point where a weak acid is being titrated against a strong base, the concentration of the weak acid and its conjugate are equal.
b. At the half-equivalence point where a weak acid is being titrated against a strong base, pH equals pK_a and pOH equals pK_b.
c. If the half-equivalence point is determined, it is possible to determine the identity of a mysterious weak acid analyte being titrated against a strong base.
d. At the half-equivalence point where a weak acid is being titrated against a strong base, the sum pH and pOH equals the sum of pK_a and pK_b.
e. All of the above except for c.
f. All of the above except for e.

The following two questions will refer to this situation: A scientist was working very late one night in a lab and accidentally poured 50 mL of an unknown acid into an Erlenmeyer flask. The scientist knows that this acid is weak and monoprotic, so to figure out the identity of the acid, he decided to do a titration! He grabbed some 0.50M sodium hydroxide, added a small volume of phenolphthalein, and proceeded to titrate the weak acid against the strong base.

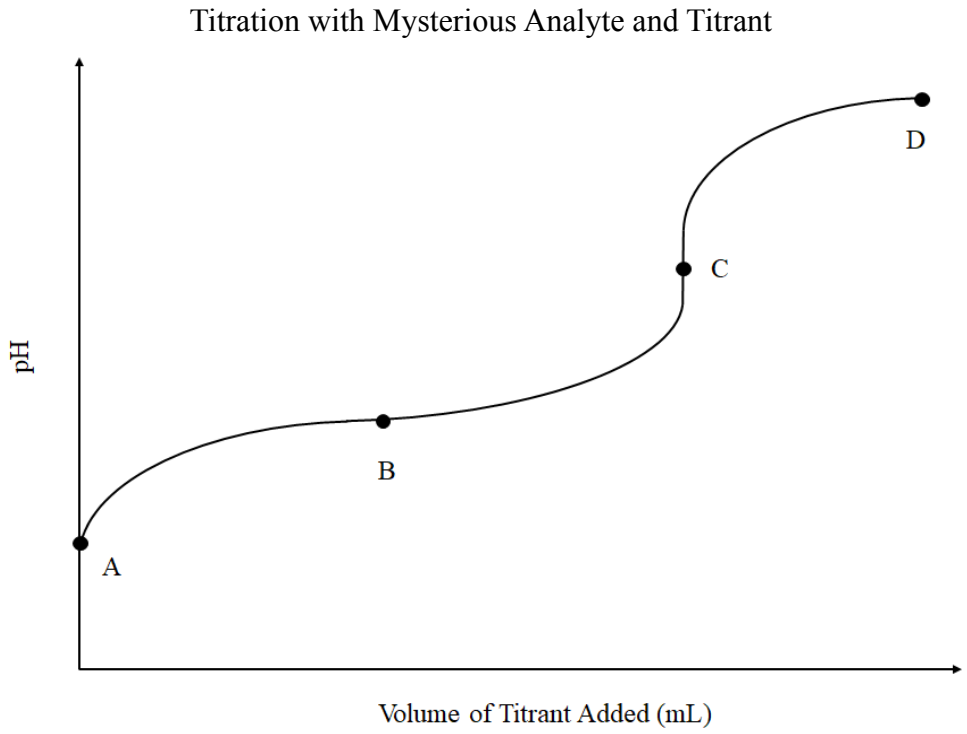
19. At the half-equivalence point, the scientist added 35 mL of sodium hydroxide. What was the original concentration of the unknown acid in the flask?

    a. 0.035M
    b. 0.18M
    c. 0.35M
    d. 0.70M
    e. 1.1M
    f. 1.4M

20. Recall that at the half-equivalence point, the scientist had added 35 mL of sodium hydroxide. The scientist measured the pH of the solution to be around 3.11. What could be a possible analyte?

    a. Nitric acid
    b. Nitrous acid
    c. Acetic acid
    d. Hypochlorous acid
    e. Chlorous acid
    f. Hydrofluoric acid

The following two questions will refer to this graph:



21. Which of the following statements could be true?

I. A weak acid is being titrated against a strong base.
II. A weak acid is being titrated against a weak base.
III. A strong acid is being titrated against a strong base.
IV. A strong acid is being titrated against a weak base.

a. I
b. II
c. III
d. IV
e. I and II
f. I, II, and IV

22. Which of the following statements are true?

I. Point B is the half-equivalence point while Point C is the equivalence point.
II. If phenolphthalein was used as an indicator, then at point B, point C, and point D, it would be clear, light pink, and magenta, respectively.
III. At point A, the solution acts like a buffer, and at point B, the buffer is broken.

a. I
b. II
c. III
d. I and II
e. I and III
f. All of these statements are true.

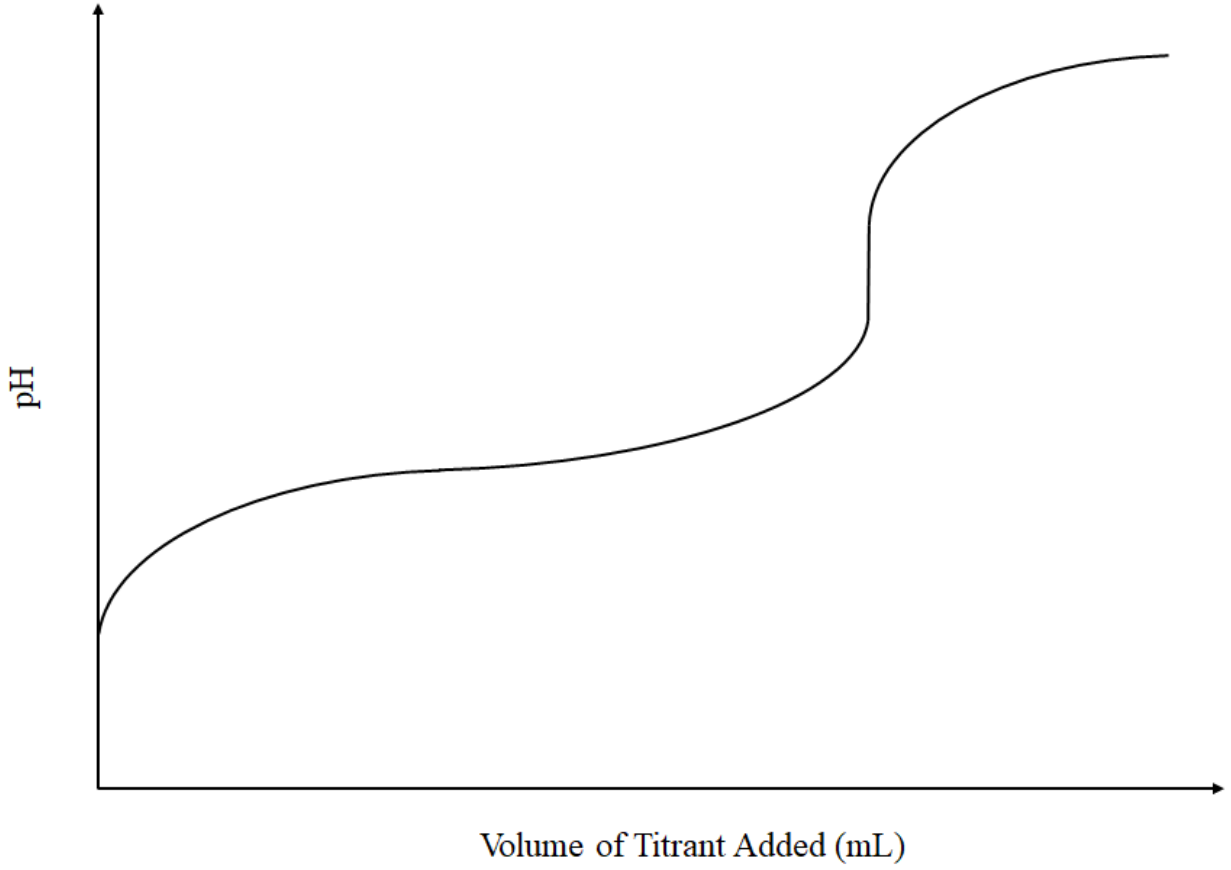
23. 10.0 mL of 0.800M acetic acid is in a 250 mL beaker. If 90.0 mL of water is safely added to the solution, by how much will the pH increase?

a. 0.5022
b. 1.044
c. 1.364
d. 1.986
e. 2.422
f. 2.924

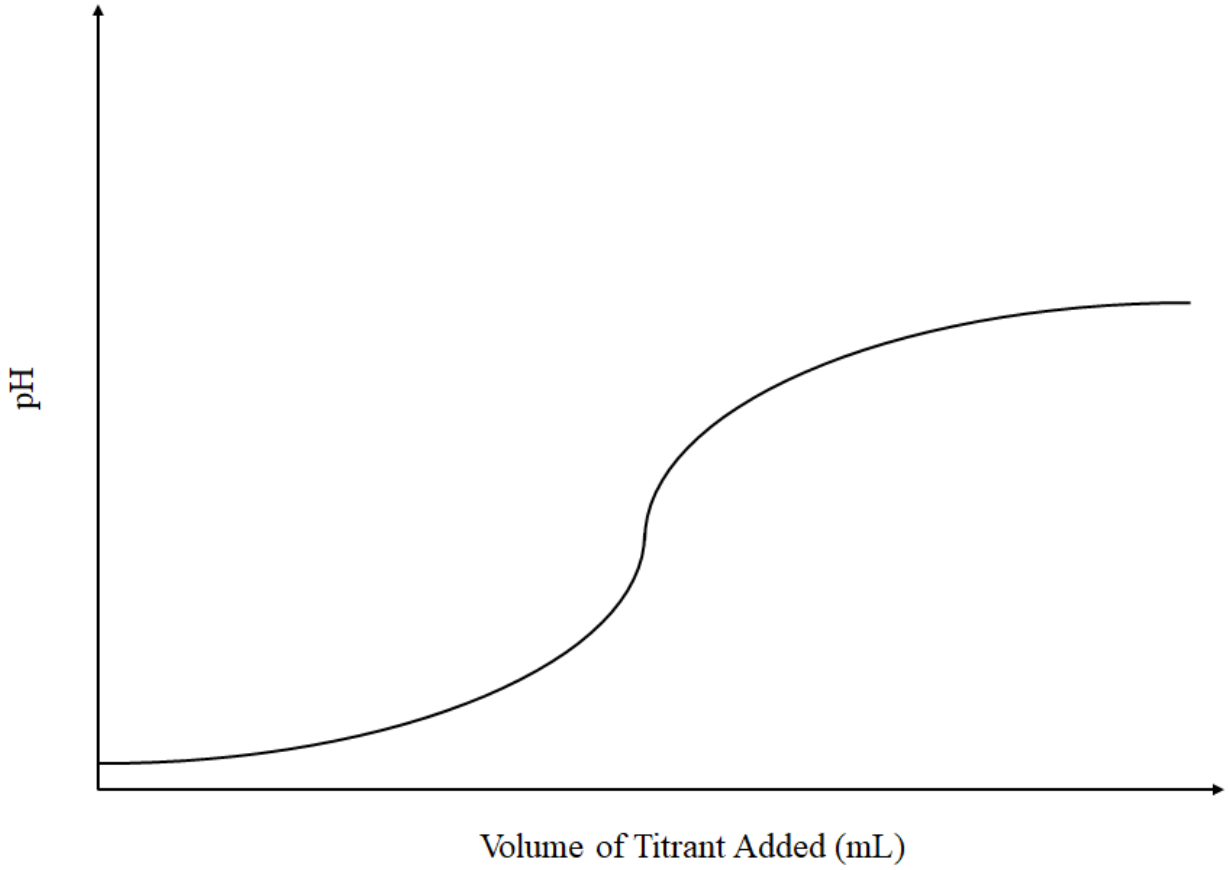
FILL IN THE BLANK

Instructions: For the following titration graphs, please fill in the blanks using the following rules. Each blank requires three words, **all lowercase** and **separated by a single space**. The **order matters**. The first word will either be "weak" or "strong." The second word will either be "monoprotic" or "polyprotic." The third and final word will be "acid" or "base." You **should not include the punctuation**; the punctuation was included in these instructions to follow standard grammatical conventions. No matter what, this is what an acceptable entry will look like: ___weak monoprotic acid___.
For the actual graphs, the location of the label pH roughly corresponds to a pH of 7. Furthermore, assume that all strong acids and bases are monoprotic.

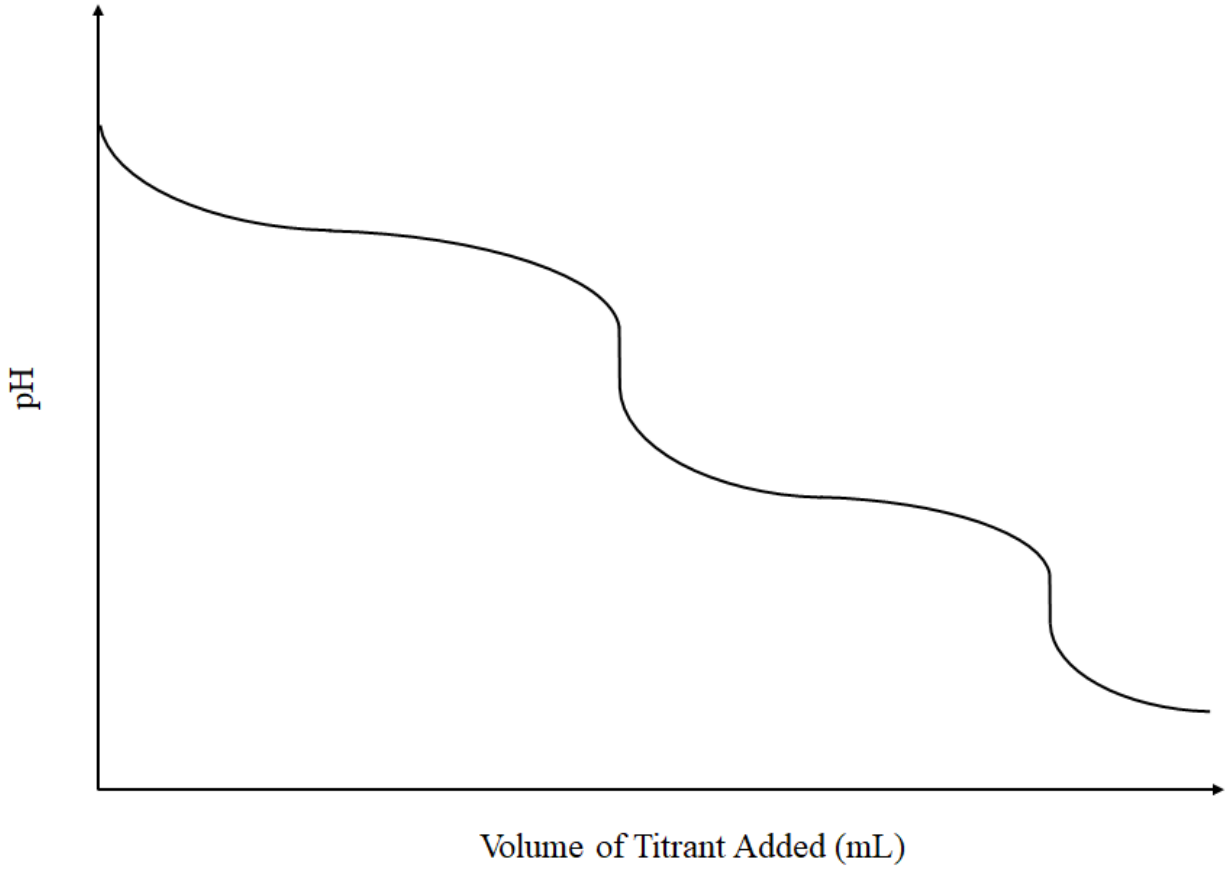
1. A _____ is titrated against a _____.



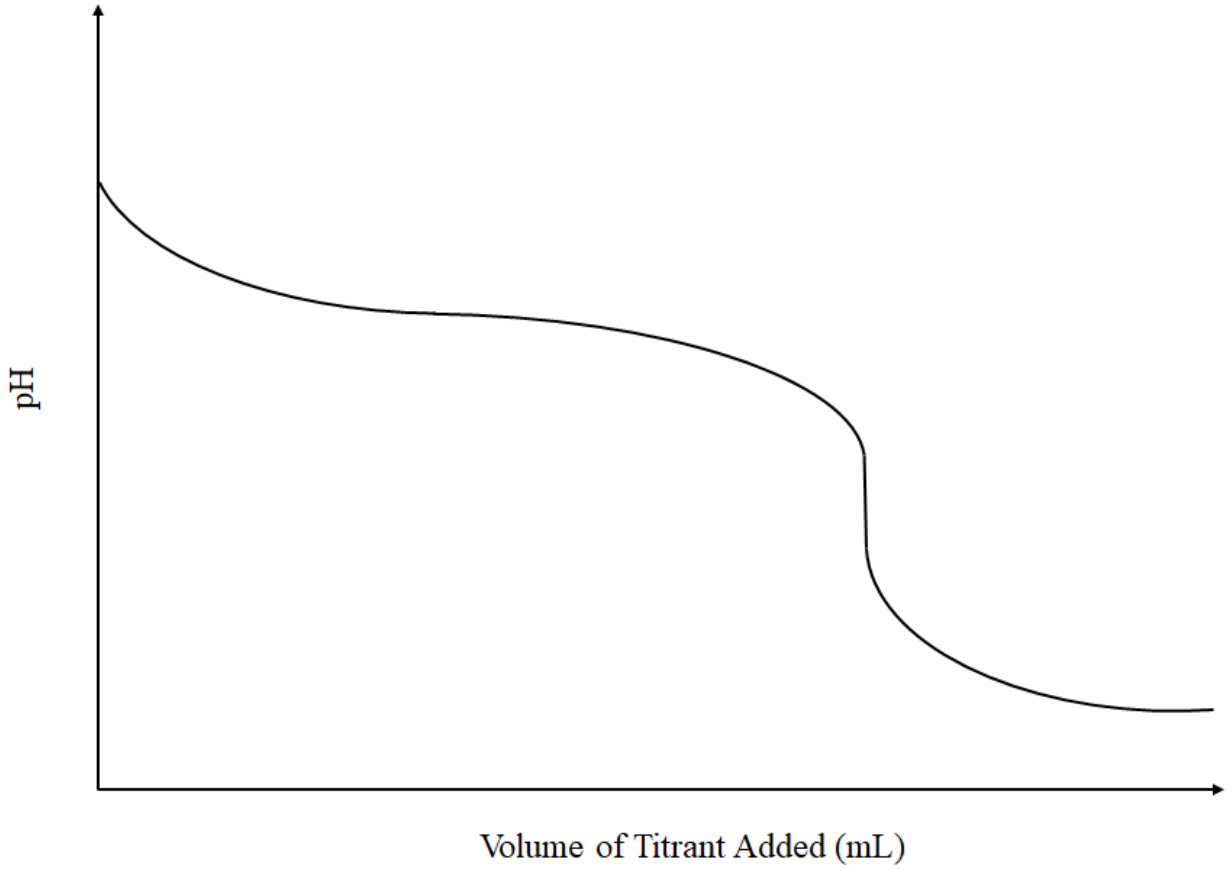
2. A _____ is titrated against a _____.



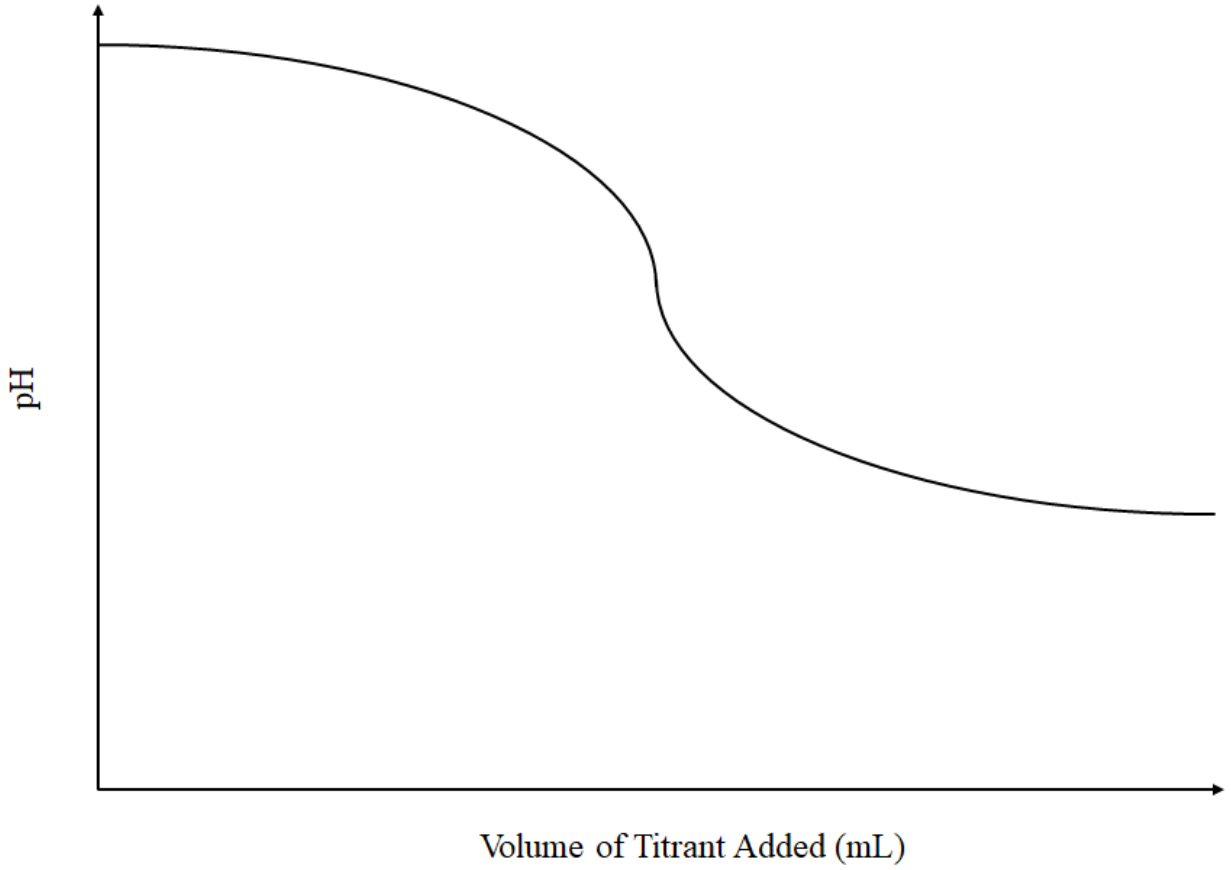
3. A _____ is titrated against a _____.



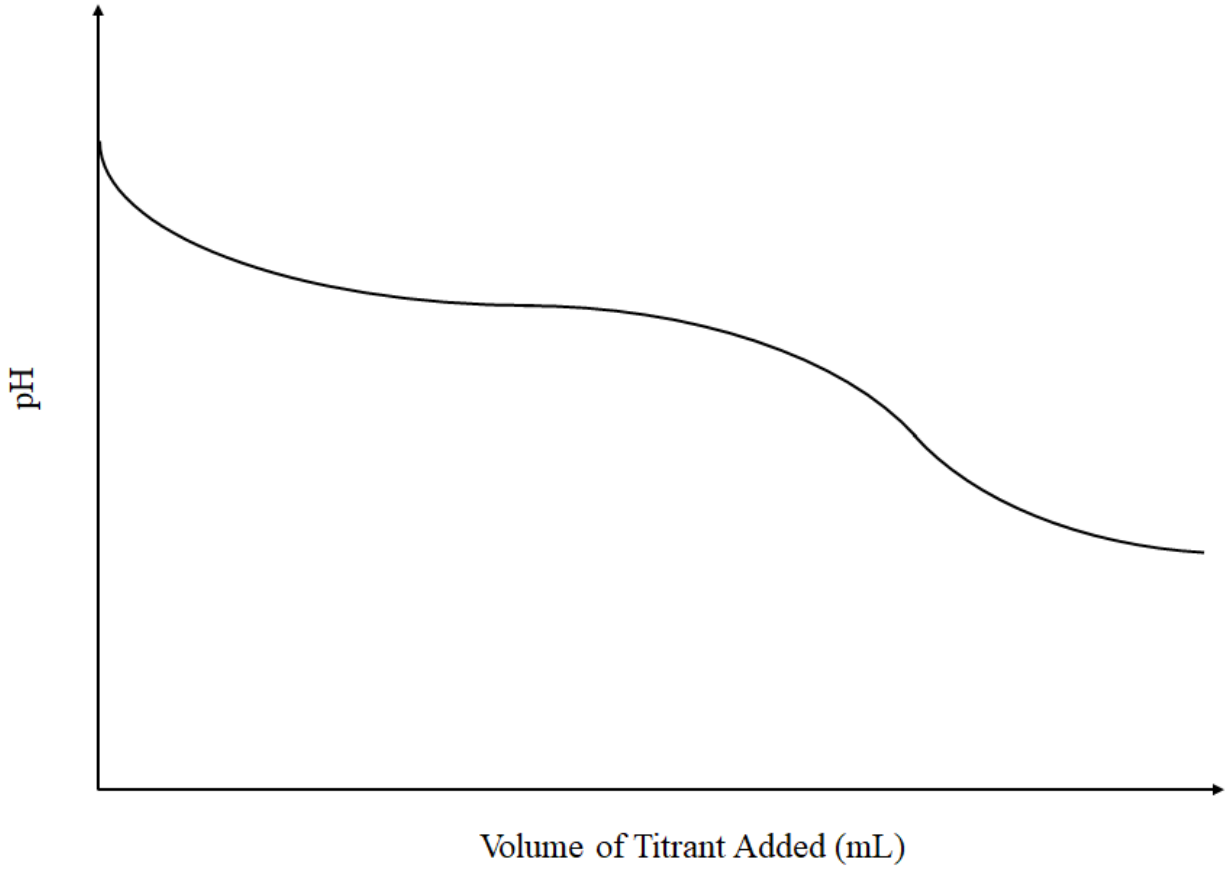
4. A _____ is titrated against a _____.



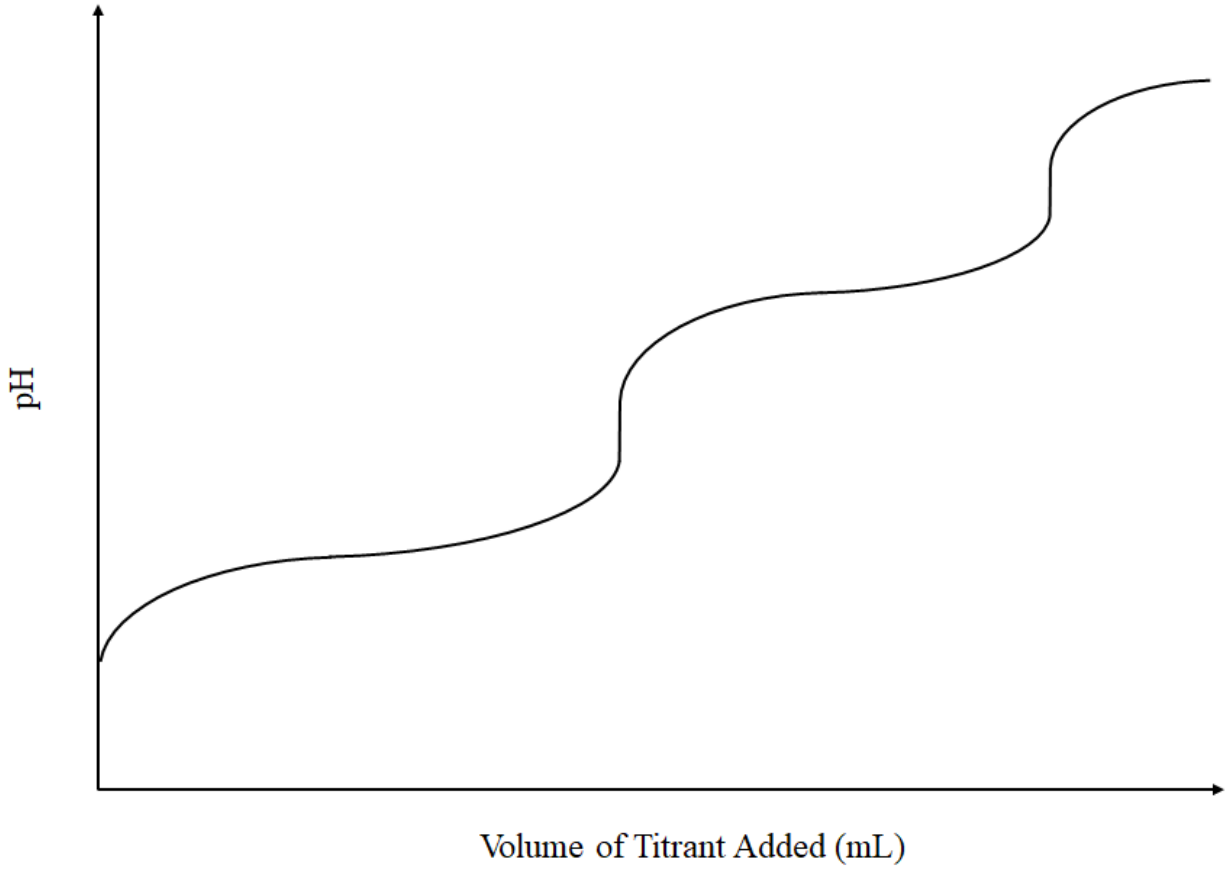
5. A _____ is titrated against a _____.



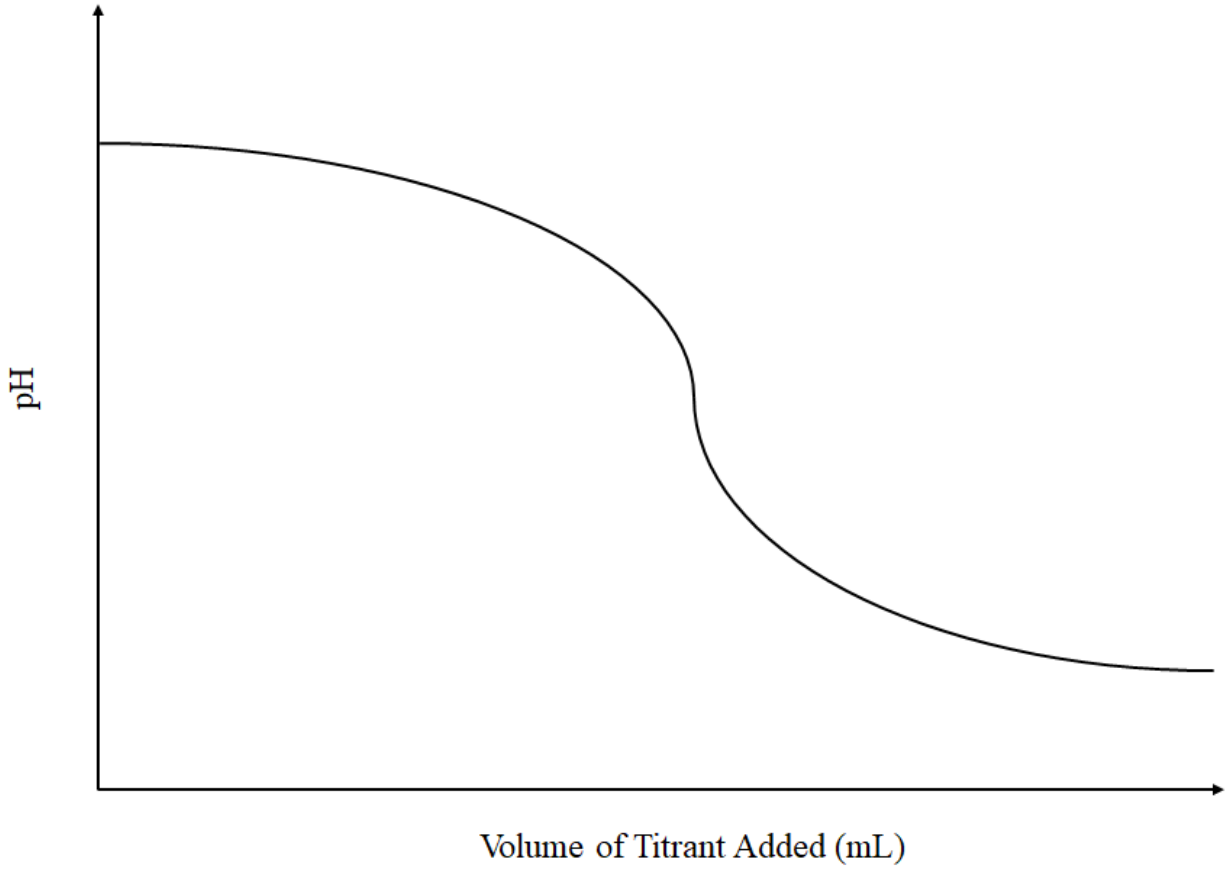
6. A _____ is titrated against a _____.



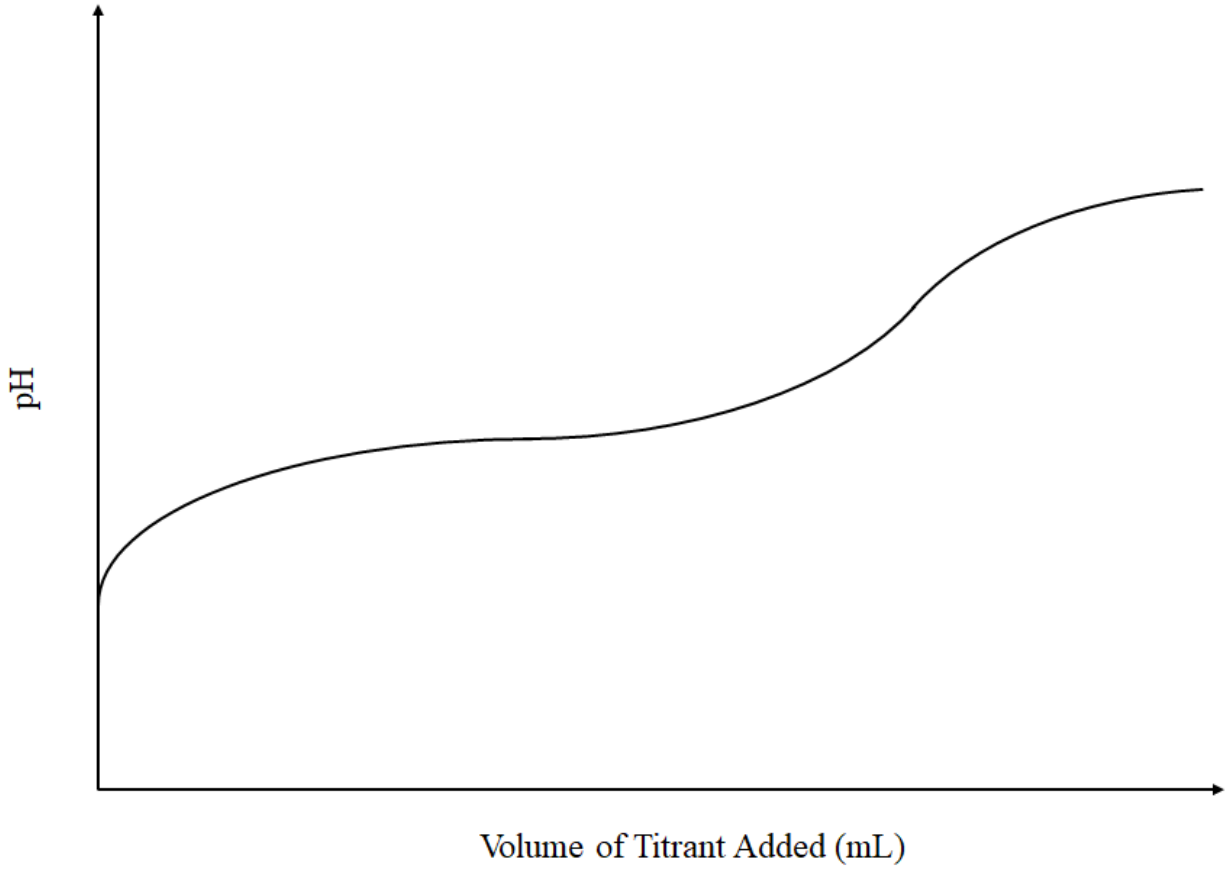
7. A _____ is titrated against a _____.



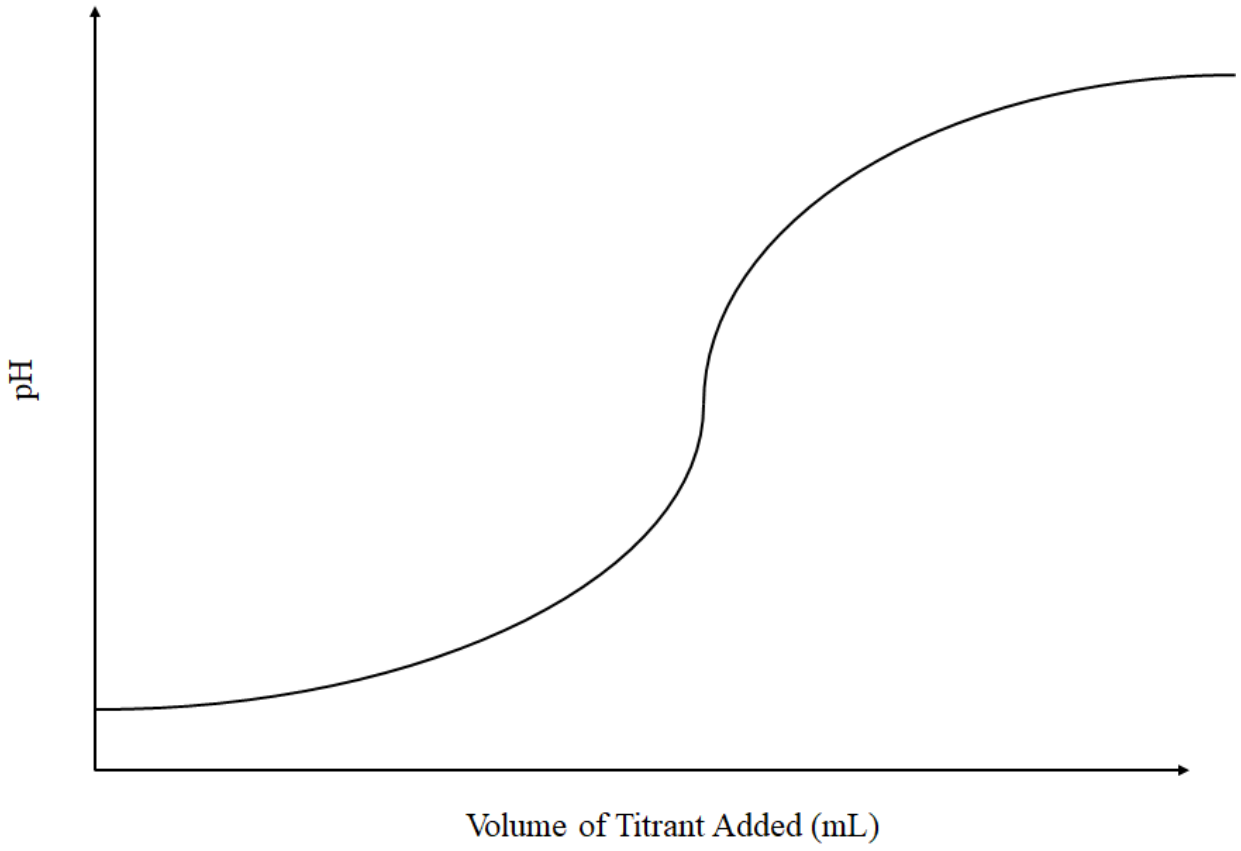
8. A _____ is titrated against a _____.



9. A _____ is titrated against a _____.



10. A _____ is titrated against a _____.



1. **weak monoprotic acid; strong monoprotic base**
2. **strong monoprotic acid; weak monoprotic base**
3. **weak polyprotic base; strong monoprotic acid**
4. **weak monoprotic base; strong monoprotic acid**
5. **strong monoprotic base; weak monoprotic acid**
6. **weak monoprotic base; weak monoprotic acid**
7. **weak polyprotic acid; strong monoprotic base**
8. **strong monoprotic base; strong monoprotic acid**
9. **weak monoprotic acid; weak monoprotic base**
10. **strong monoprotic acid; strong monoprotic base**

FREE RESPONSE

Make sure to show all work for full credit. Significant figures are important and will be considered for scoring. For logarithms, please add one significant figure. For exponentials, please add one significant figure *only if* a measured value is in the exponent. **IMPORTANT: Please use full unrounded values for all calculations. Only round when reporting answers. Only answers that are circled/boxed will be graded.** Boxes in ICE tables do not count. For submissions, please feel free to write digitally, type, or upload an image. Please email a copy if the Scilympiad text box gives an error message.

For sig figs…If the answer is off by 1 sig fig in either direction, take off ½ a point.
For units, if there are no units provided for an answer, take off ½ a point.
For rounding, if the answer is off by ±0.01, take off a ¼ of a point. If the answer is off

1. 100. mL of 3.00 M citric acid is added to an Erlenmeyer flask and is allowed to reach equilibrium. For citric acid, $pK_{a1} = 3.15$, $pK_{a2} = 4.77$, and $pK_{a3} = 5.19$. Calculate the K_a values for citric acid. Also, calculate the pH, pOH, **and** equilibrium concentrations for **every** species in the flask. **For this question only, please use three significant figures for the concentrations. This may or may not apply to the other quantities asked for in this question. (Providing OH concentrations is tiebreaker)**
    - $K_{a1} = 7.079 \times 10^{-4}$
        - **1 point total**
    - $K_{a2} = 1.698 \times 10^{-5}$
        - **1 point total**
    - $K_{a3} = 6.457 \times 10^{-6}$
        - **1 point total**
    - $[C_6H_5O_7^{3-}] = 2.39 \times 10^{-9}$ M
        - **1 point total**
    - $[HC_6H_5O_7^{2-}] = 1.70 \times 10^{-5}$ M
        - **1 point total**
    - $[H_2C_6H_5O_7^{-}] = 0.0457$M or 4.57×10^{-2} M
        - **1 point total**
    - $[H_3C_6H_5O_7] = 2.95$M
        - **1 point total**
    - $[H_3O^+]$ or $[H^+] = 0.0457$M or 4.57×10^{-2} M
        - **2 points total**
        - They should have $[H_3O^+]$ or $[H^+]$, not both or neither
            - If just one is provided with the correct concentration, full credit
            - If just one is provided with an incorrect concentration, no credit is given

        - If both are provided with the correct concentrations, take off ½ point
        - If both are provided with at least one incorrect concentration, no credit is given
        - If neither is provided, no credit is given
- $[OH^-] = 2.19 \times 10^{-13}$ M
    - **2 points total**
- pH = 1.340
    - **2 points total**
- pOH = 12.66
    - **2 points total**

2. An unknown ionic compound dissociates into 4 total ions in 100. mL of water, and the equilibrium concentrations for the ionic species are 0.0291M and 0.0861M, respectively.

    a. Calculate the K_{sp} for the ionic compound.
        - **7 points total**
        - 1.86×10^{-5} (1.857×10^{-5} without rounding)
        - If the final answer is incorrect…
            - 4 points for equilibrium expression
                - Correct Equilibrium Expression: $(0.0291)^1(0.0861)^3 = K_{sp}$
                - 1 point for (0.0291) in expression
                - 1 point for (0.0861) in expression
                - 2 points for correct exponents in expression (note: they do not need to write the exponent of 1)
                    - Only give 1 point if exponents are switched
                    - Only give 1 point if both exponents are 2
                    - No credit for any other pair of exponents
                - Incorrect exponents are zero points

    b. Make an educated guess as to what the ionic compound could be.
        - **3 points total**
        - Aluminum hydroxide or $Al(OH)_3$

    c. Calculate the total grams of the compound dissolved.
        - **6 points total**
        - If both concentrations are considered…
            - 0.0785 grams of Aluminum
            - 0.1464 grams of Hydroxide

        - 0.225 grams of Aluminum Hydroxide (0.2249 grams without rounding)
    - If only the Aluminum concentration is considered…
        - 0.0785 grams of Aluminum
        - 0.1485 grams of Hydroxide
        - 0.227 grams of Aluminum Hydroxide (0.2269 grams without rounding)
    - If only the Hydroxide concentration is considered…
        - 0.0774 grams of Aluminum
        - 0.01464 grams of Hydroxide
        - 0.224 grams of Aluminum Hydroxide (0.2238 grams without rounding)
    - Special Grading Cases
        - If final answer is wrong,
            - 2 points for correct grams of Al^{3+}
            - 2 points for correct grams of OH^-
        - If off by factors of ten, gives half the total points earned in Question 2 Part c

    - **Acceptable Answer Range** (0.2235 - 0.2270 grams, but answers must only be three significant figures)

d. Calculate the molality of each species in the solution. Please provide units for molality (don't write "m"). Assume the density of the solution is 1.00 g/cm^3.
    - In this case, since the solvent is water, the molality will be the same as the molarity, so…
        - **4 points total (must have both parts)**
            - 2 points for correct Al^{3+} molality
                - 1 point for being off by exactly a factor of 10 in either direction
            - 2 points for correct OH^- molality
                - 1 point for being off by exactly a factor of 10 in either direction
        - Molality for Al^{3+} = 0.0291 mol/kg
        - Molality for OH^- = 0.0861 mol/kg

3. A new compound J_4X_3 partially dissociates in water. If the compound has a K_{sp} of 1.2 x 10^{-13} and has a molar mass of 244.36 g/mol, calculate the concentration of J^{3+} and X^{4-} ions if 123 grams of J_4X_3 is added to 88 mL of water.

- **10 points total**
    - 5 points for correct J^{3+} concentration
    - 5 points for correct X^{4-} concentration
- $[J^{3+}] = 0.016M$ or 1.6×10^{-2} M (0.0161M without rounding)
- $[X^{4-}] = 0.012M$ or 1.2×10^{-2} M (0.0121M without rounding)
- If at least one of the final answer(s) are wrong…
    - 5 points for correct equilibrium expression
        - Correct equilibrium expression: $(4x)^4(3x)^3 = 1.2 \times 10^{-13}$
        - Any simplified expression (the actual variable they choose does not matter so long as it matches the expression and are consistent with it) get all 5 points for this part
        - 1 point for (4x)
        - 1 point for (3x)
        - 1 point for exponent of 4
        - 1 point for exponent of 3
        - 1 point for correct K_{sp} of 1.2×10^{-13}
        - If simplified…
            - 2 points for coefficient of 6912
            - 2 points for exponent of 7
            - 1 point for correct K_{sp} of 1.2×10^{-13}
    - 1 point for correct x value in equilibrium expression
        - $x = 0.0040332387$ (ignore sig.figs. for this part)
    - 2 points for correct J^{3+} concentration
        - 1 point only if answer is x or 3x
    - 2 points for correct X^{4-} concentration
        - 1 point only if answer is x or 4x

4. 800.0 mL of 1.500M calcium nitrate was mixed with 450.0 mL of 1.850 M sodium phosphate. The solution was agitated and allowed to reach equilibrium. A precipitate was observed. Answer the following questions about this reaction:

    a. Write out the balanced molecular, ionic, **and** net ionic equations. Make sure to include correct states of matter (e.g. $J_4X_{3\,(s)}$).
        - **3 points**
            - 1 point for balanced molecular equation
            - 1 point for balanced ionic equation
            - 1 point for balanced net ionic equation
        - Balanced Molecular Equation:
            - $3Ca(NO_3)_{2\,(aq)} + 2Na_3PO_{4\,(aq)} \rightarrow 6NaNO_{3\,(aq)} + Ca_3(PO_4)_{2\,(s)}$
            - If it doesn't match exactly, it gets no credit

        - NOTE: The states of matter do not need to be written as a subscript. So long as it is beside the species, the answer is eligible for full credit.
    - Balanced Ionic Equation:
        - $3Ca^{2+}_{(aq)} + 6NO_3^-{}_{(aq)} + 6Na^+_{(aq)} + 2PO_4^{3-}{}_{(aq)} \rightarrow 6Na^+_{(aq)} + 6NO_3^-{}_{(aq)} + Ca_3(PO_4)_{2\,(s)}$
        - If it doesn't match exactly, it gets no credit
        - NOTE: The states of matter do not need to be written as a subscript. So long as it is beside the species, the answer is eligible for full credit.
    - Balanced Net Ionic Equation:
        - $3Ca^{2+}_{(aq)} + 2PO_4^{3-}{}_{(aq)} \rightarrow Ca_3(PO_4)_{2\,(s)}$
        - If it doesn't match exactly, it gets no credit
        - NOTE: The states of matter do not need to be written as a subscript. So long as it is beside the species, the answer is eligible for full credit.

b. Determine which reagent is in excess. By how much is it in excess? Give your answer in grams.
    - **4 points**
        -
    - Na_3PO_4 is in excess
        - by 5.33g

c. What are the concentrations of **all** the species in the solution at equilibrium? Also, give the pH and pOH of the solution. Report all values for this part with four significant figures regardless of the standard rules.
    - **33 points**
        - 3 points for each correct value
    - $[Ca^{2+}] = 2.141 \times 10^{-6}$ M
    - $[NO_3^-] = 1.920$M
    - $[Na^+] = 1.998$M
    - $[PO_4^{3-}] = 0.01032$M or 1.032×10^{-2} M
        - If incorrect, 1 point for 0.02600M
    - $[HPO_4^{2-}] = 0.01568$M or 1.568×10^{-2} M
    - $[H_2PO_4^-] = 1.587 \times 10^{-7}$ M
    - $[H_3PO_4] = 1.426 \times 10^{-17}$ M
    - $[OH^-] = 0.01568$ or 1.568×10^{-2} M
    - $[H_3O^+]$ or $[H^+] = 6.379 \times 10^{-13}$ M
    - pOH = 1.805

- pH = 12.20

d. How many grams of precipitate are theoretically formed?
    - **3 points**
    - 124.1 grams Calcium Phosphate formed (124.0696 grams without rounding)

e. What is the percent yield for this reaction if 81.64 grams of precipitate actually formed?
    - **2 points**
    - 65.80% is the percent yield

SIMULATION

Welcome to the Simulation portion of the exam!! :)

Use the simulation link in the instructions at the beginning of the entire exam and complete the three tasks. Each task is valued at 7 points and requires a labelled screenshot. Please label your image with which type of solution you have created and which salt you have used. Please paste your images into the short answer text box or type a response for the following three questions. If you would like to or need to email, please see the guidelines for emailing in the instructions at the top of the page (beginning of the exam).

1. Please create an unsaturated solution. If not possible, please explain in the box below instead of uploading an image.
    - **7 points**
        - 1 point for uploading an image of the simulation
        - 1 point for solution labelled “unsaturated” (spelling and capitalization can be forgiven)
        - 1 point for salt used labelled (can be any valid salt so long as the label is present)
        - 4 points for creating a solution **without** noticeable undissolved chunks of the salt of their choice
        - **If they explain instead of an image…**
            - 2 points for saying an unsaturated solution can continue to dissolve more salt until no more salt dissolves (anything along those lines)

2. Please create a saturated solution. If not possible, please explain in the box below instead of uploading an image.
    - **7 points**
        - 1 point for uploading an image of the simulation
        - 1 point for solution labelled “saturated” (spelling and capitalization can be forgiven)
        - 1 point for salt used labelled (can be any valid salt so long as the label is present)
        - 4 points for creating a solution **with** noticeable undissolved chunks of the salt of their choice
        - **If they explain instead of an image…**
            - 2 points for saying a saturated solution cannot continue to dissolve more salt and any additional salt will be in solid form (anything along those lines)

3. Please create a supersaturated solution. If not possible, please explain in the box below instead of uploading an image.
    - **7 points**
        - 1 point for an explanation
        - 2 points for explaining that temperature changes cannot be simulated in the software (along those lines)
        - 4 points for saying a supersaturated solution can be created by changing the temperature of the solution such that more solute will dissolve and reverting the temperature such that more solute is currently dissolved than would normally dissolve to create a regular saturated solution (along those lines; all four points or nothing)
        - **If they upload an image instead of explaining…**
            - 1 point for following all the correct saturated solution image guidelines even though it is incorrect (they tried)