1. What colour would 1.0 M HCl be in an indicator mixture consisting of phenol red and thymolphthalein?
   A red
   B blue
   C yellow
   D colourless

2. During a titration, what volume of 0.500 M KOH is necessary to completely neutralize 10.0 mL of 2.00 M CH₃COOH?
   A 10.0 mL
   B 20.0 mL
   C 25.0 mL
   D 40.0 mL

3. Which indicator has a $K_a = 1.0 \times 10^{-6}$?
   A neutral red
   B thymol blue
   C thymolphthalein
   D chlorophenol red

4. Acid is added to a buffer solution. When equilibrium is reestablished the buffering effect has resulted in $[H_3O^+]$
   A increasing slightly
   B decreasing slightly
   C increasing considerably
   D decreasing considerably

5. A buffer solution will form when 0.10 M NaF is mixed with an equal volume of
   A 0.10 M HF
   B 0.10 M HCl
   C 0.10 M NaCl
   D 0.10 M NaOH

6. What is the $[H_3O^+]$ at the equivalence point for the titration between HBr and KOH?
   A $1.0 \times 10^{-9}$ M
   B $1.0 \times 10^{-7}$ M
   C $1.0 \times 10^{-5}$ M
   D 0.0 M

7. Which of the following would form a buffer solution when equal moles are mixed together?
   A HCl and NaCl
   B HCN and NaCN
   C KNO₃ and KOH
   D Na₂SO₄ and NaOH

8. Which of the following will dissolve in water to produce an acidic solution?
   A CO₂
   B CaO
   C MgO
   D Na₂O
9. In a titration, which of the following has a pH = 7.00 at the equivalence point?
   A NH₃ and HNO₃  
   B KOH and HCl  
   C NaF and HCl  
   D Ca(OH)₂ and CH₃COOH

10. What is the approximate Ka value for the indicator chlorophenol red?
   A 1 x 10⁻¹⁴  
   B 1 x 10⁻⁸  
   C 1 x 10⁻⁶  
   D 1 x 10⁻³

11. Which of the following titrations will always have an equivalence point at a pH > 7.00?
   A weak acid with a weak base  
   B strong acid with a weak base  
   C weak acid with a strong base  
   D strong acid with a strong base

12. A buffer solution may contain equal moles of
   A weak acid and strong base  
   B strong acid and strong base  
   C weak acid and its conjugate base  
   D strong acid and its conjugate base

13. A gas which is produced by burning coal and also contributes to the formation of acid rain is
   A H₂  
   B O₃  
   C SO₂  
   D C₃H₈

14. When the indicator thymol blue is added to 0.10 M solution of an unknown acid, the solution is red. The acid could be
   A HF  
   B H₂S  
   C HCN  
   D HNO₃

15. Consider the following graph for the titration of 0.1 M NH₃ with 1.0 M HCl.

   ![Graph of pH vs. Volume HCl added]

   A buffer solution is present at point
   A. I  
   B. II  
   C. III  
   D. IV
16. Consider the following equilibrium system for an indicator: \( \text{HInd} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{Ind}^- \)
Which two species must be of two different colours in order to be used as an indicator?

A. HInd and \( \text{H}_2\text{O} \)  
B. HInd and \( \text{Ind}^- \)  
C. \( \text{H}_3\text{O}^+ \) and \( \text{Ind}^- \)  
D. Hind and \( \text{H}_3\text{O}^+ \)

17. Which of the following indicators is yellow at pH 10.0?

A. methyl red  
B. phenol red  
C. thymol blue  
D. methyl violet

18. A sample containing \( 1.20 \times 10^{-2} \) mole HCl is completely neutralized by 100.0 mL of \( \text{Sr(OH)}_2 \). What is the [\( \text{Sr(OH)}_2 \)]?

A. \( 6.00 \times 10^{-3} \) M  
B. \( 6.00 \times 10^{-2} \) M  
C. \( 1.20 \times 10^{-1} \) M  
D. \( 2.4 \times 10^{-1} \) M

19. Which of the following titrations will have the highest pH at the equivalence point?

A. HBr with \( \text{NH}_3 \)  
B. HNO\(_2\) with KOH  
C. HCl with \( \text{Na}_2\text{CO}_3 \)  
D. HNO\(_3\) with NaOH

20. The pH of 0.10 M KOH solution is

A. 0.10  
B. 1.00  
C. 13.00  
D. 14.10

21. An indicator changes colour in the pH range 9.0 to 11.0. What is the value of the Ka for the indicator?

A. \( 1 \times 10^{-13} \)  
B. \( 1 \times 10^{-10} \)  
C. \( 1 \times 10^{-7} \)  
D. \( 1 \times 10^{-1} \)

22. Which of the following always applies at the transition point for the indicator Hind?

A. \([\text{Ind}^-] = [\text{OH}^-]\)  
B. \([\text{HInd}] = [\text{Ind}^-]\)  
C. \([\text{Ind}^-] = [\text{H}_3\text{O}^+]\)  
D. \([\text{HInd}] = [\text{H}_3\text{O}^+]\)

23. Consider the following equilibrium for an indicator: \( \text{HInd} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{Ind}^- \)
In a solution of pH of 6.8, the colour of bromthymol blue is

A. blue because \([\text{HInd}] = [\text{Ind}^-]\)  
B. green because \([\text{HInd}] = [\text{Ind}^-]\)  
C. green because \([\text{HInd}] < [\text{Ind}^-]\)  
D. yellow because \([\text{HInd}] > [\text{Ind}^-]\)

24. The indicator with \( \text{Ka} = 4 \times 10^{-8} \) is

A. neutral red  
B. methyl red  
C. indigo carmine  
D. phenolphthalein
25. In a titration a 25.00 mL sample of Sr(OH)$_2$ is completely neutralized by 28.60 mL of 0.100 M HCl. The concentration of the Sr(OH)$_2$ is

A. $1.43 \times 10^{-3}$ M
B. $2.86 \times 10^{-3}$ M
C. $5.72 \times 10^{-2}$ M
D. $1.14 \times 10^{-1}$ M

**Sec 4.14 – 4.15 Ka and Kb Calculations**

1. Calculate the [$H^+$], [$OH^-$], pH, and pOH for 0.20 M HCN.

\[
[H^+] = \ldots \quad [OH^-] = \ldots \quad pH = \ldots \quad pOH = \ldots
\]

2. Calculate the [$H^+$], [$OH^-$], pH, and pOH for 2.20 M HF.

\[
[H^+] = \ldots \quad [OH^-] = \ldots \quad pH = \ldots \quad pOH = \ldots
\]

3. Calculate the [$H^+$], [$OH^-$], pH, and pOH for 0.805 M CH$_3$COOH.

\[
[H^+] = \ldots \quad [OH^-] = \ldots \quad pH = \ldots \quad pOH = \ldots
\]

4. Calculate the [$H^+$], [$OH^-$], pH, and pOH for 1.65 M H$_3$BO$_3$.

\[
[H^+] = \ldots \quad [OH^-] = \ldots \quad pH = \ldots \quad pOH = \ldots
\]

5. Calculate the pH of a saturated solution of Mg(OH)$_2$. **tough one!**

6. Calculate the pH of a 0.200 M weak diprotic acid with a $Ka = 1.8 \times 10^{-6}$.

7. 350.0 mL of 0.20 M Sr(OH)$_2$ is diluted by adding 450.0 mL of water, calculate the pH of the solution.

8. How many grams of CH$_3$COOH are dissolved in 2.00 L of a solution with pH = 2.45?

**Sec 4.16, 4.18 Titration**

1. Calculate the volume of 0.200M H$_2$SO$_4$ required to neutralize 25.0 ml of 0.100M NaOH.

2. Describe how a primary standard is used.________________________________________
   _______________________________________________________________________
   _______________________________________________________________________
3. Consider the following reaction: \[ 2\text{HCl} + \text{Ba(OH)}_2 \rightarrow \text{BaCl}_2 + 2\text{H}_2\text{O} \]

When 3.16g samples of \( \text{Ba(OH)}_2 \) were titrated to the equivalence point with an \( \text{HCl} \) solution, the following data was recorded.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Volume of HCl added</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>37.80 mL</td>
</tr>
<tr>
<td>#2</td>
<td>35.49 mL</td>
</tr>
<tr>
<td>#3</td>
<td>35.51 mL</td>
</tr>
</tbody>
</table>

Calculate the original [HCl]

4. What type of titration curves are buffer regions found? Why? ___________________________
_________________________________________________________________________________
_________________________________________________________________________________

5. What indicator would be used if the equivalence point has a pH of 4.5? Why? ________________
_________________________________________________________________________________
_________________________________________________________________________________

6. Draw the following titration curves. Accurately label the initial and final pH and the equivalence point. Label the axis.

\textbf{Strong acid – Strong Base} \hspace{5cm} \textbf{Weak Acid - Strong Base}

\begin{align*}
\text{Initial pH} &= \phantom{0}\phantom{0}\phantom{0}\phantom{0}\phantom{0} \\
\text{pH at EP} &= \phantom{0}\phantom{0}\phantom{0}\phantom{0}\phantom{0} \\
\text{final pH} &= \phantom{0}\phantom{0}\phantom{0}\phantom{0}\phantom{0}
\end{align*}

\begin{align*}
\text{Initial pH} &= \phantom{0}\phantom{0}\phantom{0}\phantom{0}\phantom{0} \\
\text{pH at EP} &= \phantom{0}\phantom{0}\phantom{0}\phantom{0}\phantom{0} \\
\text{final pH} &= \phantom{0}\phantom{0}\phantom{0}\phantom{0}\phantom{0}
\end{align*}
Weak Base – Strong Acid

Initial pH = ________________  
pH at EP = ________________  
final pH = ________________

Strong Base – Strong Acid

Initial pH = ________________  
pH at EP = ________________  
final pH = ________________

The following titration curve results from titrating 25.0 mL of a 0.10 M Weak Acid HA with a Strong Base KOH:

a.) Use this graph to estimate the $K_a$ of the acid HA.

b.) Use this graph to calculate the [KOH].
### Sec 4.17 Indicators

1. Definition

2. Equilibrium equation

3. Colors for methyl orange

4. Compare the relative sizes of [HInd] and [Ind⁻] at the following pH’s for methyl orange.

<table>
<thead>
<tr>
<th>pH</th>
<th>Color</th>
<th>Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. HCl is added to methyl orange, describe if each increases or decreases.

<table>
<thead>
<tr>
<th></th>
<th>[H⁺]</th>
<th>[HInd]</th>
<th>[Ind⁻]</th>
<th>Color Change</th>
</tr>
</thead>
</table>

6. NaOH is added to methyl orange, describe if each increases or decreases.

<table>
<thead>
<tr>
<th></th>
<th>[H⁺]</th>
<th>[HInd]</th>
<th>[Ind⁻]</th>
<th>Color Change</th>
</tr>
</thead>
</table>

7. State two equations that are true at the transition point of an indicator.

8. What indicator has a $K_a = 4 \times 10^{-8}$

9. What is the $K_a$ for methyl orange?

10. A solution is pink in phenolphthalein and colorless in thymolphthalein. What is the pH of the solution?

11. A solution is blue in bromothymol blue, red in phenol red, and yellow in thymol blue. What is the pH of the solution?

### Sec 4.19 Buffers

1. Definition
2. Acid | Conjugate Base | Salt
---|---|---
HCN | | KHCO₃
 | NH₃ | 
HF | | NaCH₃COO
 | HC₂O₄⁻ | 

3. Write an equation for the first three buffer systems above.

4. Which buffer could have a pH of 4.0? Which buffer could have a pH of 10.0?
   a) HCl & NaCl  b) HF & NaF  c) NH₃ & NH₄Cl

5. Predict how the buffer of pH = 9.00 will change. Your possible answers are 9.00, 8.98, 9.01, 2.00, and 13.00
   a) 2 drops of 0.10 M HCl are added
   b) 1 drop of 0.10 M NaOH is added
   c) 10 mL of 0.10 M HCl are added

6. Write an equation for the carbonic acid, sodium hydrogencarbonate buffer system. A few drops of HCl are added. Describe the shift and each concentration change.

   Equation: 

   Shift \[ [H^+] = [H_2CO_3] = [HCO_3^-] = \]

Sec 4.20 – 2.21 Anhydrides, Acid Rain

1. State whether the following compounds will act as acids (A) or bases (B) when added to water. (10 marks)
2. a) Define a **basic anhydride** (1 mark) -

3. a) Define an **acidic anhydride** (1 mark) -

4. Normal (unpolluted) rain water usually has a pH of about _________. This is less than 7 due to _________gas dissolving in the air

5. “Acid rain” could be defined as rain having a pH below _________.

6. Give two formula equations which show how sulphurous acid can be produced starting with sulphur. (2 marks)

   1.

   2.

7. Give three formula equations which show how sulphuric acid can be produced starting with sulphur. (3 marks)

   1.

   2.

   3.

12. Give the balanced equation for the formation of NO\textsubscript{2} from its elements. (1 mark)

   \[ \text{ _____________ } \]

13. Give the balanced equation for the formation of nitrous and nitric acid from NO\textsubscript{2} dissolving in rain water. (1 mark)

   \[ \text{ _____________ } \]