1) The pH of a solution that contains 0.818 M acetic acid \((K_a = 1.76 \times 10^{-5})\) and 0.172 M sodium acetate is _______.
   A) 4.077  B) 5.434  C) 8.571  D) 8.370  E) 9.922

2) The \(K_a\) of acetic acid is \(1.76 \times 10^{-5}\). The pH of a buffer prepared by combining 50.0 mL of 1.00 M potassium acetate and 50.0 mL of 1.00 M acetic acid is _______.
   A) 1.705  B) 0.851  C) 3.406  D) 4.754  E) 2.383

3) The \(K_b\) of ammonia is \(1.77 \times 10^{-5}\). The pH of a buffer prepared by combining 50.0 mL of 1.00 M ammonia and 50.0 mL of 1.00 M ammonium nitrate is _______.
   A) 4.63  B) 9.25  C) 4.74  D) 9.37  E) 7.00

4) Calculate the pH of a solution prepared by dissolving 0.370 mol of formic acid \((HCO_2H)\) and 0.230 mol of sodium formate \((NaCO_2H)\) in water sufficient to yield 1.00 L of solution. The \(K_a\) of formic acid is \(1.77 \times 10^{-4}\).
   A) 2.099  B) 10.463  C) 3.546  D) 2.307  E) 3.952

5) Calculate the pH of a solution prepared by dissolving 0.750 mol of NH\(_3\) and 0.250 mol of NH\(_4\)Cl in water sufficient to yield 1.00 L of solution. The \(K_b\) of ammonia is \(1.77 \times 10^{-5}\).
   A) 5.22  B) 4.27  C) 9.73  D) 8.78  E) 0.89

6) Calculate the pH of a solution prepared by dissolving 0.250 mol of benzoic acid \((C_7H_5O_2H)\) and 0.150 mol of sodium benzoate \((NaC_7H_5O_2)\) in water sufficient to yield 1.00 L of solution. The \(K_a\) of benzoic acid is \(6.50 \times 10^{-5}\).
   A) 4.411  B) 2.395  C) 3.965  D) 10.084  E) 4.190

7) Calculate the pH of a solution prepared by dissolving 0.150 mol of benzoic acid \((HBz)\) and 0.300 mol of sodium benzoate in water sufficient to yield 1.00 L of solution. The \(K_a\) of benzoic acid is \(6.50 \times 10^{-5}\).
   A) 2.516  B) 3.892  C) 4.488  D) 10.158  E) 4.195

8) A 25.0 mL sample of 0.723 M HClO\(_4\) is titrated with a 0.273 M KOH solution. What is the \([H^+]\) (molarity) before any base is added?
   A) 0.439  B) 1.00 \times 10^{-7}  C) 0.723  D) 2.81 \times 10^{-13}  E) 0.273

9) The pH of a solution prepared by dissolving 0.350 mol of solid methylamine hydrochloride \((CH_3NH_3Cl)\) in 1.00 L of 1.10 M methylamine \((CH_3NH_2)\) is _______. The \(K_b\) for methylamine is \(4.40 \times 10^{-4}\). (Assume the final volume is 1.00 L.)
   A) 1.66  B) 2.86  C) 10.28  D) 11.14  E) 10.61
10) The pH of a solution prepared by mixing 50.0 mL of 0.125 M KOH and 50.0 mL of 0.125 M HCl is

A) 6.29  B) 7.00  C) 8.11  D) 5.78  E) 0.00

11) The concentration of iodide ions in a saturated solution of lead (II) iodide is ________ M. The solubility product constant of PbI₂ is $1.4 \times 10^{-8}$.

A) $3.8 \times 10^{-4}$  B) $3.0 \times 10^{-3}$  C) $1.5 \times 10^{-3}$  D) $3.5 \times 10^{-9}$  E) $1.4 \times 10^{-8}$

12) The solubility of lead (II) chloride (PbCl₂) is $1.6 \times 10^{-2}$ M. What is the $K_{sp}$ of PbCl₂?

A) $5.0 \times 10^{-4}$  B) $4.1 \times 10^{-6}$  C) $3.1 \times 10^{-7}$  D) $1.6 \times 10^{-5}$  E) $1.6 \times 10^{-2}$

13) The solubility of manganese (II) hydroxide (Mn(OH)₂) is $2.2 \times 10^{-5}$ M. What is the $K_{sp}$ of Mn(OH)₂?

A) $1.1 \times 10^{-14}$  B) $4.3 \times 10^{-14}$  C) $2.1 \times 10^{-14}$  D) $4.8 \times 10^{-10}$  E) $2.2 \times 10^{-5}$

14) Determine the $K_{sp}$ for magnesium hydroxide (Mg(OH)₂) where the solubility of Mg(OH)₂ is $1.4 \times 10^{-4}$ M.

A) $2.7 \times 10^{-12}$  B) $1.1 \times 10^{-11}$  C) $2.0 \times 10^{-8}$  D) $3.9 \times 10^{-8}$  E) $1.4 \times 10^{-4}$

15) Calculate the maximum concentration (in M) of silver ions (Ag⁺) in a solution that contains 0.025 M of CO₃²⁻. The $K_{sp}$ of Ag₂CO₃ is $8.1 \times 10^{-12}$.

A) $1.8 \times 10^{-5}$  B) $1.4 \times 10^{-6}$  C) $2.8 \times 10^{-6}$  D) $3.2 \times 10^{-10}$  E) $8.1 \times 10^{-12}$

16) What is the solubility (in M) of PbCl₂ in a 0.15 M solution of HCl? The $K_{sp}$ of PbCl₂ is $1.6 \times 10^{-5}$.

A) $2.0 \times 10^{-3}$  B) $1.1 \times 10^{-4}$  C) $1.8 \times 10^{-4}$  D) $7.1 \times 10^{-4}$  E) $1.6 \times 10^{-5}$
17) The $K_{sp}$ for Zn(OH)$_2$ is $5.0 \times 10^{-17}$. Determine the molar solubility of Zn(OH)$_2$ in a buffer solution with a pH of 11.5.
   A) $5.0 \times 10^6$
   B) $1.2 \times 10^{-12}$
   C) $1.6 \times 10^{-14}$
   D) $5.0 \times 10^{-12}$
   E) $5.0 \times 10^{-17}$

18) A solution containing which one of the following pairs of substances will be a buffer solution?
   A) NaI, HI
   B) KBr, HBr
   C) RbCl, HCl
   D) CsF, HF
   E) none of the above

19) The Henderson–Hasselbalch equation is ___________.
   A) $[H^+] = K_a \frac{[\text{base}]}{[\text{acid}]}$
   B) $pH = pK_a - \log \frac{[\text{base}]}{[\text{acid}]}$
   C) $pH = pK_a + \log \frac{[\text{base}]}{[\text{acid}]}$
   D) $pH = pK_a + \log \frac{[\text{acid}]}{[\text{base}]}$
   E) $pH = \log \frac{[\text{acid}]}{[\text{base}]}$

20) In a solution, when the concentrations of a weak acid and its conjugate base are equal,
   A) the system is not at equilibrium.
   B) the buffering capacity is significantly decreased.
   C) the $-\log$ of the $[H^+]$ and the $-\log$ of the $K_a$ are equal.
   D) all of the above are true.

21) The addition of hydrofluoric acid and ___________ to water produces a buffer solution.
   A) HCl
   B) NaNO$_3$
   C) NaF
   D) NaCl
   E) NaBr

22) Of the following solutions, which has the greatest buffering capacity?
   A) 0.821 M HF and 0.217 M NaF
   B) 0.821 M HF and 0.909 M NaF
   C) 0.100 M HF and 0.217 M NaF
   D) 0.121 M HF and 0.667 M NaF
   E) They are all buffer solutions and would all have the same capacity.
23) The primary buffer system that controls the pH of the blood is the ________ buffer system.
   A) carbon dioxide, carbonate
   B) carbonate, bicarbonate
   C) carboxylic acid, carbon dioxide
   D) carbonate, carboxylic acid
   E) carboxylic acid, bicarbonate

24) What are the principal organs that regulate the pH of the carbonic acid-bicarbonate buffer system in the blood?
   A) kidneys, liver
   B) lungs, kidneys
   C) spleen, liver
   D) lungs, skin
   E) brain stem, heart

25) The pH of a solution prepared by mixing 45.0 mL of 0.183 M KOH and 65.0 mL of 0.145 M HCl is ________
   A) 1.314
   B) 2.923
   C) 0.744
   D) 1.966
   E) 7.148

26) Which one of the following will cause hemoglobin to release oxygen?
   A) increase in pH
   B) decrease in pH
   C) decrease in temperature
   D) decrease in CO₂ concentration
   E) increase in O₂ concentration

Consider the following table of K_{sp} values.

<table>
<thead>
<tr>
<th>Name</th>
<th>Formula</th>
<th>K_{sp}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadmium carbonate</td>
<td>CdCO₃</td>
<td>5.2 x 10⁻¹²</td>
</tr>
<tr>
<td>Cadmium hydroxide</td>
<td>Cd(OH)₂</td>
<td>2.5 x 10⁻¹⁴</td>
</tr>
<tr>
<td>Calcium fluoride</td>
<td>CaF₂</td>
<td>3.9 x 10⁻¹¹</td>
</tr>
<tr>
<td>Silver iodide</td>
<td>AgI</td>
<td>8.3 x 10⁻¹⁷</td>
</tr>
<tr>
<td>Zinc carbonate</td>
<td>ZnCO₃</td>
<td>1.4 x 10⁻¹¹</td>
</tr>
</tbody>
</table>

27) Which compound listed below has the greatest molar solubility in water?
   A) CdCO₃
   B) Cd(OH)₂
   C) AgI
   D) CaF₂
   E) ZnCO₃

28) A result of the common-ion effect is ________.
   A) that some ions, such as Na⁺ (aq), frequently appear in solutions but do not participate in solubility equilibria
   B) that common ions, such as Na⁺ (aq), don't affect equilibrium constants
   C) that the selective precipitation of a metal ion, such as Ag⁺, is promoted by the addition of an appropriate counterion (X⁻) that produces a compound (AgX) with a very low solubility
   D) that ions such as K⁺ and Na⁺ are common ions, so that their values in equilibrium constant expressions are always 1.00
   E) that common ions precipitate all counter-ions
29) Which one of the following pairs cannot be mixed together to form a buffer solution?
   A) NH₃, NH₄Cl
   B) NaC₂H₃O₂, HCl (C₂H₃O₂⁻ = acetate)
   C) RbOH, HBr
   D) KOH, HF
   E) H₃PO₄, KH₂PO₄

30) Which one of the following pairs cannot be mixed together to form a buffer solution?
   A) C₅H₅N, C₅H₅NHCl
   B) HC₂H₃O₂, NaOH (C₂H₃O₂⁻ = acetate)
   C) KOH, HI
   D) NH₂CH₃, HCl
   E) NaClO, HNO₃

31) Which of the following could be added to a solution of sodium acetate to produce a buffer?
   A) acetic acid only
   B) acetic acid or hydrochloric acid
   C) hydrochloric acid only
   D) potassium acetate only
   E) sodium chloride or potassium acetate

32) The pH of a solution prepared by mixing 55.0 mL of 0.183 M KOH and 50.0 mL of 0.145 MHC₂H₃O₂ is __________.
   A) 1.31  B) 7.00  C) 7.74  D) 9.97  E) 12.43

33) In which one of the following solutions is silver chloride the most soluble?
   A) 0.181 M HCl
   B) 0.0176 M NH₃
   C) 0.744 M LiNO₃
   D) pure water
   E) 0.181 M NaCl

34) For which salt should the aqueous solubility be most sensitive to pH?
   A) Ca(NO₃)₂  B) CaF₂  C) CaCl₂  D) CaBr₂  E) CaI₂

35) The molar solubility of __________ is not affected by the pH of the solution.
   A) Na₃PO₄  B) NaF  C) KNO₃  D) AlCl₃  E) MnS

36) Calculate the pH of a solution that is 0.210 M in nitrous acid (HNO₂) and 0.290 M in potassium nitrite (KNO₂). The acid dissociation constant of nitrous acid is 4.50 × 10⁻⁴.
   A) 13.86  B) 3.487  C) 4.562  D) 10.51  E) 3.210
37) A solution is prepared by dissolving 0.23 mol of chloroacetic acid and 0.27 mol of sodium chloroacetate in water sufficient to yield 1.00 L of solution. The addition of 0.05 mol of HCl to this buffer solution causes the pH to drop slightly. The pH does not decrease drastically because the HCl reacts with the _________ present in the buffer solution. The $K_a$ of chloroacetic acid is $1.36 \times 10^{-3}$.
   A) $H_2O$
   B) This is a buffer solution: the pH does not change upon addition of acid or base.
   C) chloroacetate ion
   D) chloroacetic acid
   E) $H_3O^+$

38) A solution of NaF is added dropwise to a solution that is 0.0144 M in $Ba^{2+}$. When the concentration of $F^-$ exceeds _________ M, $BaF_2$ will precipitate. Neglect volume changes. For $BaF_2$,
   $K_{sp} = 1.7 \times 10^{-6}$.
   A) $5.9 \times 10^{-5}$
   B) $1.2 \times 10^{-4}$
   C) $1.1 \times 10^{-2}$
   D) $2.4 \times 10^{-8}$
   E) $2.7 \times 10^{-3}$

39) In which of the following aqueous solutions would you expect AgBr to have the lowest solubility?
   A) 0.10 M AgNO$_3$
   B) 0.10 M LiBr
   C) 0.15 M KBr
   D) 0.20 M NaBr
   E) pure water

40) What change will be caused by addition of a small amount of HCl to a solution containing fluoride ions and hydrogen fluoride?
   A) The concentration of fluoride ion will decrease and the concentration of hydrogen fluoride will increase.
   B) The concentration of fluoride ions will increase as will the concentration of hydronium ions.
   C) The concentration of hydronium ions will increase significantly.
   D) The fluoride ions will precipitate out of solution as its acid salt.
   E) The concentration of hydrogen fluoride will decrease and the concentration of fluoride ions will increase.