THE “OFFICIAL” CHEMISTRY 12 ACID BASE STUDY GUIDE

Multiple Choice Section: This study guide is a compilation of questions from provincial exams since April 1994. I urge you to become intimately familiar with question types. You will notice that questions from one year to another are very similar in their composition. Identification of question types will allow you to be more efficient in answering these questions on the provincial examination. My recommendations for using this study guide are as follows :

1. **DO ALL THE QUESTIONS** in this booklet. These are actual Provincial Exam questions! Your own provincial exam and unit test will include questions similar to the ones in this booklet!
2. **RESIST THE URGE TO LOOK AT THE ANSWER KEY** until you have given all the questions in the section your best effort. Don’t do one question, then look at the key, then do another and look at the key, and so on. Each time you look at one answer in the study guide, your eye will notice other answers around them, and this will reduce the effectiveness of those questions in helping you to learn.
3. **LEARN FROM YOUR MISTAKES**! If you get a question wrong, **figure out why**! If you are having difficulty, **talk to your study partner**, or maybe **phone someone in your Peer Tutoring group**. Get together with group members or other students from class and work on these questions together. Explain how you got your answers to tough questions to others. In explaining yourself to someone else, you will learn the material better yourself (try it!) Ask your teacher to explain the questions to you during tutorial or after school. **Your goal should be to get 100% on any Chemistry 12 multiple choice test**- learning from your mistakes in this booklet will really help you in your efforts to meet this goal!
4. **This is REALLY CRUCIAL**: **DO NOT mark the answer anywhere on the questions themselves**. For example, do not circle any of options A B C or D-instead use a different sheet of paper to place your answers on. By avoiding this urge, you can re-use this study guide effectively again, when preparing for your final exam. In the box to the left, put an asterisk or small note to yourself to indicate that you got the question wrong and need to come back to it. If you got the question correct initially, a check mark might be assurance that you understand this type of question and therefore can concentrate on other questions that present a challenge to you.
5. **Check Off the STATUS box on the PRESCRIBED LEARNING OUTCOMES sheet**. I have tried to organize the questions in the identical sequence to which they appear on your Acid Base Prescribed Learning Outcome sheet. By doing this, you can be confident that you know everything you need to know for both the UNIT EXAM and PROVINCIAL EXAM !

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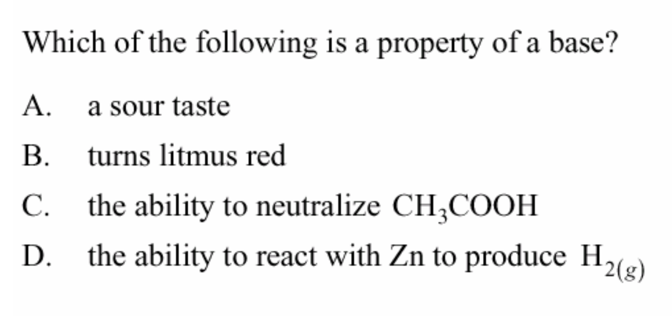
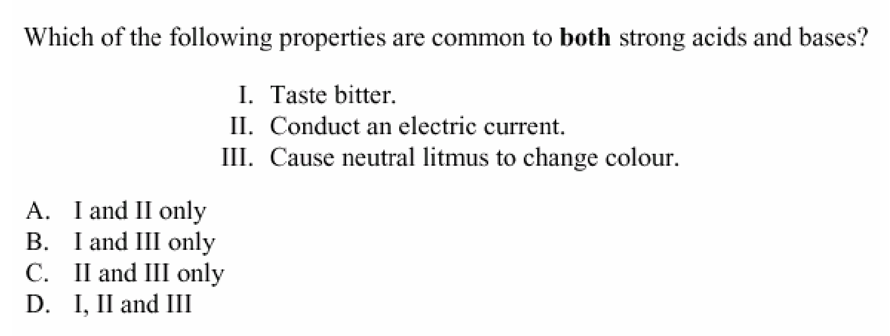
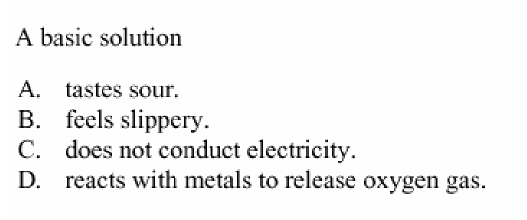
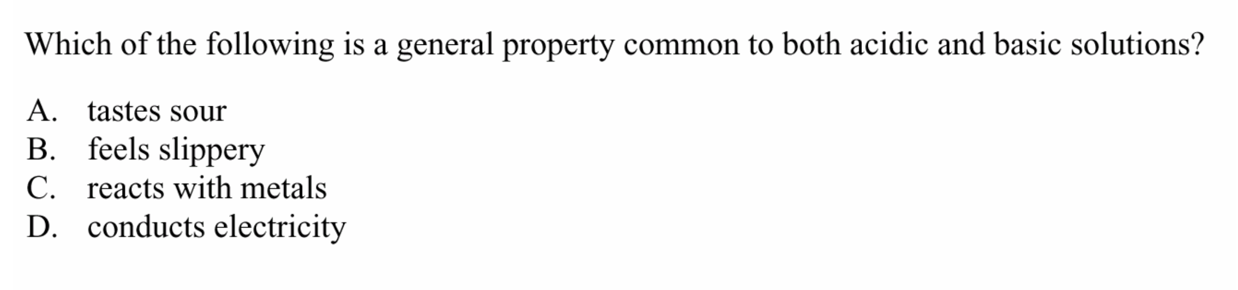
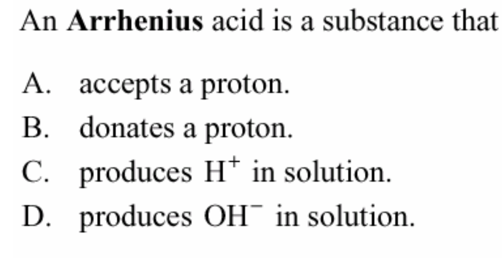
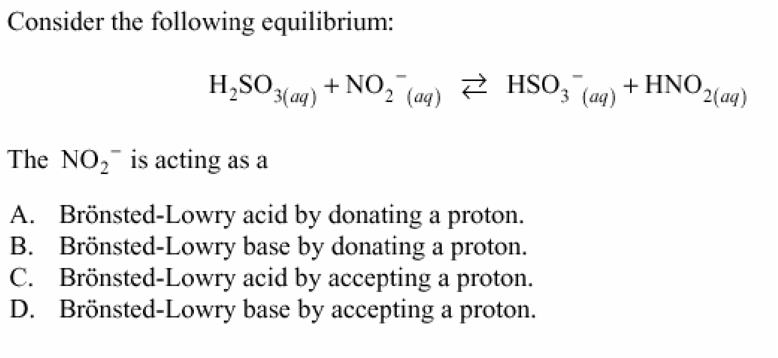
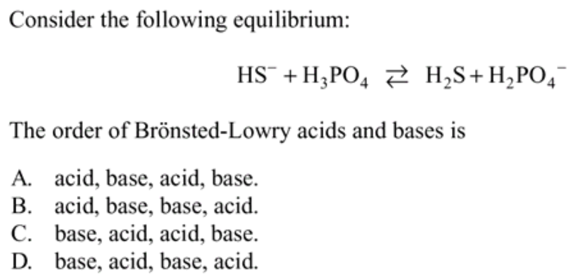
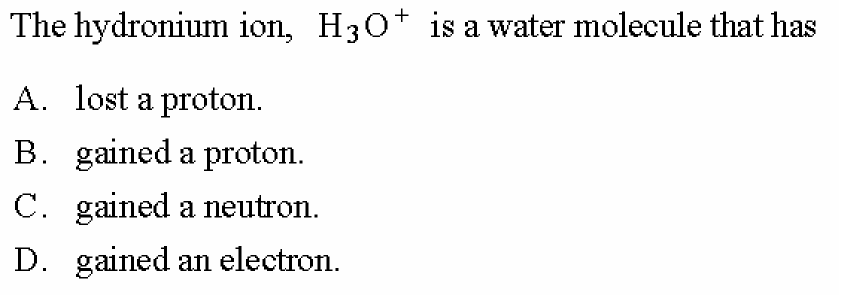
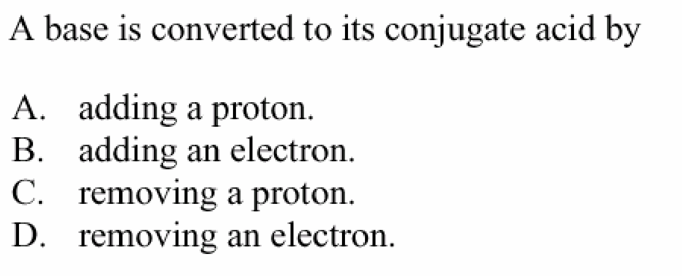
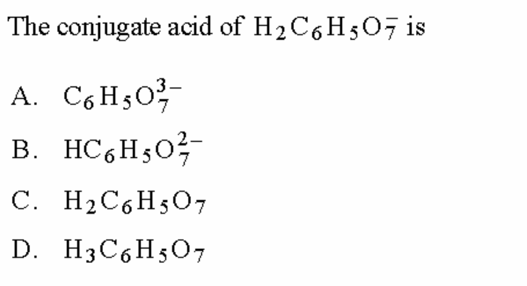
PROPERTIES AND DEFINITIONS

J01	1.	A test that could be safely used to distinguish a strong base from a weak base is A. taste. B. touch. C. litmus paper. D. electrical conductivity.
J01	2.	To distinguish between a strong acid and a strong base, an experimenter could use A. odour. B. magnesium. C. a conductivity test. D. the common ion test.

J02	3.	 Which of the following is a property of a base? A. a sour taste B. turns litmus red C. the ability to neutralize CH_3COOH D. the ability to react with Zn to produce $H_{2(g)}$
J02	4.	 Which of the following properties are common to **both** strong acids and bases? I. Taste bitter. II. Conduct an electric current. III. Cause neutral litmus to change colour. A. I and II only B. I and III only C. II and III only D. I, II and III
J02	5.	 A basic solution A. tastes sour. B. feels slippery. C. does not conduct electricity. D. reacts with metals to release oxygen gas.
J02	6.	 Which of the following is a general property common to both acidic and basic solutions? A. tastes sour B. feels slippery C. reacts with metals D. conducts electricity
J02	7.	Which of the following is a general property of bases? A. taste sour B. turn litmus red C. conduct electric current in solution D. concentration of H_3O^+ is greater than concentration of OH^-
J04	8.	 An **Arrhenius** acid is a substance that A. accepts a proton. B. donates a proton. C. produces H^+ in solution. D. produces OH^- in solution.

J04	9.	An Arrhenius base is defined as a substance which A. donates protons. B. donates electrons. C. produces H^+ in solution. D. produces OH^- in solution.
J05	10	Caustic soda, NaOH, is found in A. fertilizers. B. beverages. C. toothpaste. D. oven cleaners.
J05	11	The acid used in the lead-acid storage battery is A. HCl B. HNO_3 C. H_2SO_4 D. CH_3COOH
J05	12	**Drano**®, a commercial product used to clean drains, contains small bits of aluminum metal and A. ammonia. B. acetic acid. C. hydrochloric acid. D. sodium hydroxide.
J07	13	Identify the two substances that act as Bronsted-Lowry bases in the equation $HS^- + SO_4^{2-} \rightleftarrows S^{2-} + HSO_4^-$ A. HS^- and S^{2-} B. SO_4^{2-} and S^{2-} C. HS^- and HSO_4^- D. SO_4^{2-} and HSO_4^-
J07	14	In the equilibrium system: $H_2BO_{3(aq)}^- + HCO_{3(aq)}^- \rightleftarrows H_2CO_{3(aq)} + HBO_3{}^{2-}{}_{(aq)}$ The two species acting as Brönsted-Lowry acids are A. $HCO_3{}^-$ and H_2CO_3 B. $H_2BO_3{}^-$ and H_2CO_3 C. $HCO_3{}^-$ and $HBO_3{}^{2-}$ D. $H_2BO_3{}^-$ and $HBO_3{}^{2-}$

<table>
<tr><td>J07</td><td>15</td><td>Consider the following equilibria:
<table><tr><td>I</td><td>$HCO_3^- + H_2O \rightleftarrows H_2CO_3 + OH^-$</td></tr><tr><td>II</td><td>$NH_4^+ + H_2O \rightleftarrows H_3O^+ + NH_3$</td></tr><tr><td>III</td><td>$HSO_3^- + H_3O^+ \rightleftarrows H_2O + H_2SO_3$</td></tr></table>Water acts as a Brönsted-Lowry base in
A. III only.
B. I and II only.
C. II and III only.
D. I, II and III.</td></tr>
<tr><td>J07</td><td>16</td><td>Consider the following acid-base reaction:
$HSO_3^- + HF \rightleftarrows H_2SO_3 + F^-$
The order of Brönsted-Lowry acids and bases in this equation is
A. acid + base ⇄ acid + base
B. acid + base ⇄ base + acid
C. base + acid ⇄ base + acid
D. base + acid ⇄ acid + base</td></tr>
<tr><td>J07</td><td>17</td><td>Consider the following equilibrium:
$CH_3COOH_{(aq)} + NH_{3(aq)} \rightleftarrows CH_3COO^-_{(aq)} + NH_4^+{}_{(aq)}$
The sequence of Brönsted-Lowry acids and bases in the above equilibrium is
A. acid, base, base, acid.
B. acid, base, acid, base.
C. base, acid, base, acid.
D. base, acid, acid, base.</td></tr>
<tr><td>J07</td><td>18</td><td>Consider the following equilibrium:
$H_2SO_3 + NO_2^- \rightleftarrows HSO_3^- + HNO_2$
The Brönsted-Lowry acids and bases are, respectively,
A. acid, base, base, acid.
B. acid, base, acid, base.
C. base, acid, base, acid.
D. base, acid, acid, base.</td></tr>
</table>

J07	19	 Consider the following equilibrium: $H_2SO_{3(aq)} + NO_2{}^-{}_{(aq)} \rightleftarrows HSO_3{}^-{}_{(aq)} + HNO_{2(aq)}$ The $NO_2{}^-$ is acting as a A. Brönsted-Lowry acid by donating a proton. B. Brönsted-Lowry base by donating a proton. C. Brönsted-Lowry acid by accepting a proton. D. Brönsted-Lowry base by accepting a proton.
J07	20	 Consider the following equilibrium: $HS^- + H_3PO_4 \rightleftarrows H_2S + H_2PO_4{}^-$ The order of Brönsted-Lowry acids and bases is A. acid, base, acid, base. B. acid, base, base, acid. C. base, acid, acid, base. D. base, acid, base, acid.
J09	21	 The hydronium ion, H_3O^+ is a water molecule that has A. lost a proton. B. gained a proton. C. gained a neutron. D. gained an electron.
J10	22	 A base is converted to its conjugate acid by A. adding a proton. B. adding an electron. C. removing a proton. D. removing an electron.
J11	23	 The conjugate acid of $H_2C_6H_5O_7^-$ is A. $C_6H_5O_7^{3-}$ B. $HC_6H_5O_7^{2-}$ C. $H_2C_6H_5O_7$ D. $H_3C_6H_5O_7$

J11	24	The conjugate acid of OH^- is A. H^+ B. O^{2-} C. H_2O D. H_3O^+
J11	25	The conjugate base of $H_2BO_3^-$ is A. BO_3^{3-} B. H_3BO_3 C. HBO_3^{2-} D. $H_3BO_3^-$
J11	26	Which of the following is a conjugate acid-base pair? A. H_3PO_4 and PO_4^{3-} B. $H_2PO_4^-$ and PO_4^{3-} C. H_3PO_4 and HPO_4^{2-} D. $H_2PO_4^-$ and HPO_4^{2-}
J11	27	The conjugate acid of $H_2PO_4^-$ is A. PO_4^{3-} B. H_3PO_4 C. HPO_4^{2-} D. $H_3PO_4^+$
J11	28	The conjugate acid of $C_6H_5O^-$ is A. $C_6H_4O^-$ B. C_6H_5OH C. $C_6H_4O^{2-}$ D. $C_6H_5OH^+$

STRONG/WEAK ACIDS AND BASES

K01	29.	Which of the following 0.10 M solutions will have the **greatest** electrical conductivity? A. HF B. NH_3 C. NaOH D. C_6H_5COOH
K01	30.	The 0.10 M solution with the **greatest** electrical conductivity is A. H_2S B. H_2SO_4 C. H_2SO_3 D. H_2CO_3
K01	31.	Which of the following solutions will have the greatest electrical conductivity? A. 1.0 M HCl B. 1.0 M HNO_2 C. 1.0 M H_3BO_3 D. 1.0 M HCOOH
K01	32.	Which of the following 1.0 M solutions will have the greatest electrical conductivity? A. HI B. H_2S C. HCN D. H_3PO_4
K05	33.	The equation representing the reaction of ethanoic acid with water is A. $CH_3COO^- + H_2O \rightleftarrows CH_3COOH + OH^-$ B. $CH_3COO^- + H_2O \rightleftarrows CH_2COO^{2-} + H_3O^+$ C. $CH_3COOH + H_2O \rightleftarrows CH_3COO^- + H_3O^+$ D. $CH_3COOH + H_2O \rightleftarrows CH_3COOH_2^+ + OH^-$
K06	34.	How many acids from the list below are known to be weak acids? HCl, HF, H_2SO_3, H_2SO_4, HNO_3, HNO_2 : A. 2 B. 3 C. 4 D. 5

K06	35.	Which of the following is the **strongest** acid? A. acetic acid B. oxalic acid C. benzoic acid D. carbonic acid
K06	36.	In the following Brönsted-Lowry acid-base equation: $NH_{4(aq)}^{+} + H_2O_{(l)} \rightleftarrows NH_{3(aq)} + H_3O_{(aq)}^{+}$ The stronger base is A. $NH_4{}^{+}$ B. H_2O C. NH_3 D. H_3O^{+}
K06	37.	Consider the following equilibrium: $HS^{-} + H_2C_2O_4 \rightleftarrows HC_2O_4{}^{-} + H_2S$ The stronger acid is A. HS^{-} B. $H_2C_2O_4$ C. $HC_2O_4{}^{-}$ D. H_2S
K06	38.	Which of the following is the weakest acid? A. HCOOH B. C_6H_5OH C. $H_3C_6H_5O_7$ D. CH_3COOH
K06	39.	Which of the following is the weakest acid? A. HIO_3 B. HCN C. HNO_2 D. C_6H_5COOH
K06	40.	The 1.0 M acidic solution with the highest pH value is A. H_2S B. HNO_2 C. HNO_3 D. H_3BO_3

K07	41.	Which of the following is the strongest base in water? A. OH^- B. H_2O C. NH_3 D. HO_2^-
K08	42.	Consider the following equilibrium system: $OCl^-_{(aq)} + HC_7H_5O_{2(aq)} \rightleftarrows HOCl_{(aq)} + C_7H_5O^-_{2(aq)} \qquad K_{eq} = 2.1 \times 10^3$ At equilibrium, A. products are favoured and HOCl is the stronger acid. B. reactants are favoured and HOCl is the stronger acid. C. products are favoured and $HC_7H_5O_2$ is the stronger acid. D. reactants are favoured and $HC_7H_5O_2$ is the stronger acid.
K09	43.	The 1.0 M acid solution with the largest $\left[H_3O^+\right]$ is A. HNO_2 B. H_2SO_3 C. H_2CO_3 D. H_3BO_3
K10	44.	An amphiprotic substance can act as A. a base only. B. an acid only. C. both an acid and a base. D. neither an acid nor a base.
K11	45.	Which one(s) of the following substances is/are amphiprotic? (1) H_3PO_4 (2) $H_2PO_4^-$ (3) HPO_4^{2-} A. 2 only B. 3 only C. 1 and 2 D. 2 and 3
K11	46.	Which of the following is amphiprotic in water? A. SO_2 B. SO_3^{2-} C. HSO_3^- D. H_2SO_3

<table>
<tr><td>K11</td><td>47.</td><td>
Consider the following:
<table>
<tr><td>I</td><td>H_3PO_4</td></tr>
<tr><td>II</td><td>$H_2PO_4^-$</td></tr>
<tr><td>III</td><td>HPO_4^{2-}</td></tr>
<tr><td>IV</td><td>PO_4^{3-}</td></tr>
</table>
Which of the above are amphiprotic in an aqueous solution?
A. I and II only
B. II and III only
C. I, II and III only
D. II, III and IV only
</td></tr>
<tr><td>K12</td><td>48.</td><td>
Water acts as a base when it reacts with
A. CN^-
B. NH_3
C. NO_2^-
D. NH_4^+
</td></tr>
<tr><td>K12</td><td>49.</td><td>
Water will act as a Brönsted-Lowry acid with
A. NH_3
B. H_2S
C. HCN
D. HNO_3
</td></tr>
<tr><td>K12</td><td>50.</td><td>
Water will act as an acid with which of the following?
<table>
<tr><td>I.</td><td>H_2CO_3</td></tr>
<tr><td>II.</td><td>HCO_3^-</td></tr>
<tr><td>III.</td><td>CO_3^{2-}</td></tr>
</table>
A. I only.
B. III only.
C. I and II only.
D. II and III only.
</td></tr>
</table>

K_W, pH, pOH

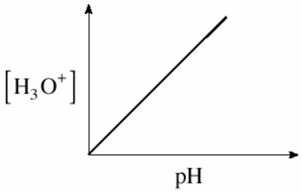
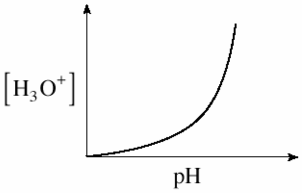
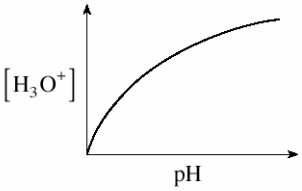
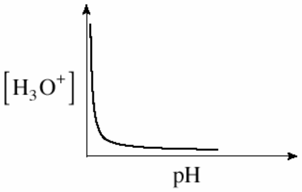
L01	51.	At 25°C, the equation representing the ionization of water is A. $H_2O + H_2O \rightleftarrows 2H_2 + O_2$ B. $H_2O + H_2O \rightleftarrows H_2O_2 + H_2$ C. $H_2O + H_2O \rightleftarrows 4H^+ + 2O^{2-}$ D. $H_2O + H_2O \rightleftarrows H_3O^+ + OH^-$
L02	52.	Consider the following equilibrium system: $H_2O_{(l)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + OH^-_{(aq)}$ The equilibrium constant for this system is referred to as A. K_w B. K_a C. K_b D. K_{sp}
L03	53.	If OH^- is added to a solution, the $\left[H_3O^+\right]$ will A. remain constant. B. adjust such that $\left[H_3O^+\right] = \frac{\left[OH^-\right]}{K_w}$ C. increase such that $\left[H_3O^+\right]\left[OH^-\right] = K_w$ D. decrease such that $\left[H_3O^+\right]\left[OH^-\right] = K_w$
L03	54.	Consider the following equilibrium: $H_2O + H_2O \rightleftarrows H_3O^+ + OH^-$ When a solution of $Sr(OH)_2$ is added, the equilibrium shifts A. left and $\left[H_3O^+\right]$ increases. B. left and $\left[H_3O^+\right]$ decreases. C. right and $\left[H_3O^+\right]$ increases. D. right and $\left[H_3O^+\right]$ decreases.

L03	55.	Consider the following: $$H_2O_{(1)} \rightleftarrows H^+_{(aq)} + OH^-_{(aq)}$$ When a small amount of 1.0 M KOH is added to the above system, the equilibrium A. shifts left and $\left[H^+\right]$ decreases. B. shifts left and $\left[H^+\right]$ increases. C. shifts right and $\left[H^+\right]$ decreases. D. shifts right and $\left[H^+\right]$ increases.
L03	56.	An acid is added to water and a new equilibrium is established. The new equilibrium can be described by A. $pH < pOH$ and $K_w = 1 \times 10^{-14}$ B. $pH < pOH$ and $K_w < 1 \times 10^{-14}$ C. $pH > pOH$ and $K_w = 1 \times 10^{-14}$ D. $pH > pOH$ and $K_w > 1 \times 10^{-14}$
L03	57.	Consider the following equilibrium: $$2H_2O_{(\ell)} + \text{energy} \rightleftarrows H_3O^+_{(aq)} + OH^-_{(aq)}$$ The $\left[H_3O^+\right]$ will decrease and the K_w will remain constant when A. a strong acid is added. B. a strong base is added. C. the temperature is increased. D. the temperature is decreased.
L04	58.	The $\left[OH^-\right]$ is greater than the $\left[H_3O^+\right]$ in A. $HCl_{(aq)}$ B. $NH_{3(aq)}$ C. $H_2O_{(aq)}$ D. $CH_3COOH_{(aq)}$
L04	59.	An aqueous solution that contains more hydronium ions than hydroxide ions is a(n) A. basic solution. B. acidic solution. C. neutral solution. D. standardized solution.

L06	60.	Consider the following equilibrium: $2H_2O_{(\ell)} \rightleftarrows H_3O^+{}_{(aq)} + OH^-{}_{(aq)} \qquad \Delta H = +114\ \text{kJ}$ At $10°C$ the value of K_w is A. equal to 1.00×10^{-7} B. equal to 1.00×10^{-14} C. less than 1.00×10^{-14} D. greater than 1.00×10^{-14}
L06	61.	Consider the following equilibrium: $2H_2O_{(\ell)} + 57\ \text{kJ} \rightleftarrows H_3O^+{}_{(aq)} + OH^-{}_{(aq)}$ When the temperature is decreased, the water A. stays neutral and $\left[H_3O^+\right]$ increases. B. stays neutral and $\left[H_3O^+\right]$ decreases. C. becomes basic and $\left[H_3O^+\right]$ decreases. D. becomes acidic and $\left[H_3O^+\right]$ increases.
L06	62.	Consider the following: $2H_2O_{(\ell)} + 57\ \text{kJ} \rightleftarrows H_3O^+{}_{(aq)} + OH^-{}_{(aq)}$ When the temperature of the above system is increased, the equilibrium shifts A. left and K_w increases. B. left and K_w decreases. C. right and K_w increases. D. right and K_w decreases.
L07	63.	An aqueous solution at room temperature is analyzed and the $[H_3O^+]$ is found to be 2.0×10^{-3} M. The $[OH^-]$ is A. 5.0×10^{-12} M B. 2.0×10^{-11} M C. 4.0×10^{-6} M D. 2.0×10^{-3} M

L07	64.	The $\left[OH^-\right]$ in 0.050 M HNO_3 at 25°C is A. 5.0×10^{-16} M B. 1.0×10^{-14} M C. 2.0×10^{-13} M D. 5.0×10^{-2} M
L07	65.	In a solution at 25°C, the $\left[H_3O^+\right]$ is 3.5×10^{-6} M. The $\left[OH^-\right]$ is A. 3.5×10^{-20} M B. 2.9×10^{-9} M C. 1.0×10^{-7} M D. 3.5×10^{-6} M
L07	66.	In a 100.0 mL sample of 0.0800 M NaOH the $\left[H_3O^+\right]$ is A. 1.25×10^{-13} M B. 1.25×10^{-12} M C. 8.00×10^{-3} M D. 8.00×10^{-2} M
L07	67.	The $\left[OH^-\right]$ in an aqueous solution always equals A. $K_w\times\left[H_3O^+\right]$ B. $K_w-\left[H_3O^+\right]$ C. $\frac{K_w}{\left[H_3O^+\right]}$ D. $\frac{\left[H_3O^+\right]}{K_w}$
L08	68.	Sodium potassium tartrate ($NaKC_4H_4O_6$) is used to raise the pH of fruit during processing. In this process, sodium potassium tartrate is being used as a/an A. salt. B. acid. C. base. D. buffer.

<table>
<tr><td>L08</td><td>69.</td><td>
A student records the pH of 0.1 M solutions of two acids:
<table>
<tr><th>Acid</th><th>pH</th></tr>
<tr><td>X</td><td>4.0</td></tr>
<tr><td>Y</td><td>2.0</td></tr>
</table>
Which of the following statements can be concluded from the above data?
A. Acid X is stronger than acid Y.
B. Acid X and acid Y are both weak.
C. Acid X is diprotic while acid Y is monoprotic.
D. Acid X is 100 times more concentrated than acid Y.
</td></tr>
<tr><td>L08</td><td>70.</td><td>
A students adds 10.0 mL of 1.0 M $HClO_4$ into 990.0 mL of water. The pH of the solution has changed by
A. 0.01
B. 1
C. 2
D. 100
</td></tr>
<tr><td>L09</td><td>71.</td><td>
The pH scale is
A. direct.
B. inverse.
C. logarithmic.
D. exponential.
</td></tr>
<tr><td>L09</td><td>72.</td><td>
Which of the following equations correctly relates pH and $\left[H_3O^+\right]$?
A. $pH = \log \left[H_3O^+\right]$
B. $pH = 14 - \left[H_3O^+\right]$
C. $pH = -\log \left[H_3O^+\right]$
D. $pH = pK_w - \left[H_3O^+\right]$
</td></tr>
<tr><td>L09</td><td>73.</td><td>
The pOH of an aqueous solution is equal to
A. $14 + pH$
B. $pK_w - pH$
C. $-\log\ pK_w$
D. $-\log\left[H_3O^+\right]$
</td></tr>
</table>

L09	74.	Which of the following graphs describes the relationship between $[H_3O^+]$ and pH ? A.  B.  C.  D. 
L09	75.	When the $[H_3O^+]$ in a solution is increased to twice the original concentration, the change in pH could be from A. 1.7 to 1.4 B. 2.0 to 4.0 C. 5.0 to 2.5 D. 8.5 to 6.5
L10	76.	Which of the following statements concerning pK_w are true? I. $pK_w = -\log K_w$ II. $pK_w = pH + pOH$ III. $pK_w = [H_3O^+][OH^-]$ A. I and II only B. I and III only C. II and III only D. I, II and III
L11	77.	The pH of an aqueous solution is 4.32. The $[OH^-]$ is A. 6.4×10^{-1} M B. 4.8×10^{-5} M C. 2.1×10^{-10} M D. 1.6×10^{-14} M

L11 78.

The pOH of a 0.025 M $HClO_4$ solution is

A. 0.94
B. 1.60
C. 12.40
D. 13.06

L11 79.

A solution is prepared by adding 100 mL of 10 M of HCl to a 1 litre volumetric flask and filling it to the mark with water. The pH of this solution is

A. –1
B. 0
C. 1
D. 7

L11 80.

The pH of 0.15 M HCl is

A. 0.15
B. 0.71
C. 0.82
D. 13.18

L11 81.

The pH of 0.20 M HNO_3 is

A. 0.20
B. 0.63
C. 0.70
D. 1.58

L11 82.

Consider the following data:

SOLUTION	INITIAL pH	FINAL pH
1	1.0	4.0
2	2.0	6.0
3	6.0	3.0
4	9.0	3.0

In which solution has the $\left[H_3O^+\right]$ increased 1000 times ?

A. 1
B. 2
C. 3
D. 4

L11 83.

Calculate the pOH of 3.50 M NaOH.

A. -14.54
B. -0.54
C. 0.54
D. 13.46

L11	84.	Calculate the pH of 4.0×10^{-4} M KOH. A. 3.40 B. 4.60 C. 9.40 D. 10.60
L11	85.	A beaker contains 200.0 mL of 0.40 M HNO_3. The calculation for pH is A. $pH = -\log(0.40\ M)$ B. $pH = -\log(10^{-14} \div 0.40\ M)$ C. $pH = -\log(0.40\ M \times 0.200\ L)$ D. $pH = -\log(0.40\ M \div 0.200\ L)$
L11	86.	The pH of 100.0 mL of 0.0050 M NaOH solution is A. 2.30 B. 3.30 C. 10.70 D. 11.70
L11	87.	A solution of 1.0 M HF has A. a lower pH than a solution of 1.0 M HCl B. a higher pOH than a solution of 1.0 M HCl C. a higher $[OH^-]$ than a solution of 1.0 M HCl D. a higher $[H_3O^+]$ than a solution of 1.0 M HCl
L11	88.	The pOH of 0.050 M HCl is A. 0.30 B. 1.30 C. 12.70 D. 13.70
L12	89.	The $[H_3O^+]$ in a solution of pH 0.60 is A. 4.0×10^{-14} M B. 2.2×10^{-1} M C. 2.5×10^{-1} M D. 6.0×10^{-1} M

L12	90.	In a solution with a pOH of 4.22, the $\left[OH^-\right]$ is A. 1.7×10^{-10} M B. 6.0×10^{-5} M C. 6.3×10^{-1} M D. 1.7×10^{4} M
L12	91.	The $\left[H_3O^+\right]$ in a solution with pOH of 0.253 is A. 5.58×10^{-15} M B. 1.79×10^{-14} M C. 5.58×10^{-1} M D. 5.97×10^{-1} M

K_a and K_b PROBLEM SOLVING

M01	92.	The equilibrium constant expression for sulphurous acid is A. $K_a=\left[H^+\right]\left[HSO_3^-\right]$ B. $K_a=\dfrac{\left[H^+\right]\left[HSO_3^-\right]}{\left[H_2SO_3\right]}$ C. $K_a=\dfrac{\left[2H^+\right]\left[SO_3^{2-}\right]}{\left[H_2SO_3\right]}$ D. $K_a=\dfrac{\left[H^+\right]\left[SO_3^{2-}\right]}{\left[H_2SO_3\right]}$
M01	93.	Which of the following is represented by a K_b expression? A. $Al(OH)_{3(s)} \rightleftarrows Al^{3+}_{(aq)} + 3OH^-_{(aq)}$ B. $HF_{(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + F^-_{(aq)}$ C. $Cr_2O_{7(aq)}^{2-} + 2OH^-_{(aq)} \rightleftarrows 2CrO_{4(aq)}^{2-} + H_2O_{(l)}$ D. $CH_3NH_{2(aq)} + H_2O_{(l)} \rightleftarrows CH_3NH^+_{3(aq)} + OH^-_{(aq)}$
M01	94.	The K_b expression for $HPO_4{}^{2-}$ is A. $K_b=\dfrac{\left[PO_4{}^{3-}\right]\left[H_3O^+\right]}{\left[HPO_4{}^{2-}\right]}$ B. $K_b=\dfrac{\left[HPO_4{}^{2-}\right]\left[OH^-\right]}{\left[H_2PO_4{}^-\right]}$ C. $K_b=\dfrac{\left[H_2PO_4{}^-\right]\left[OH^-\right]}{\left[HPO_4{}^{2-}\right]}$ D. $K_b=\dfrac{\left[HPO_4{}^{2-}\right]\left[H_3O^+\right]}{\left[PO_4{}^{3-}\right]}$

M01 95. Consider the following equilibrium constant expression:

$$K = \frac{[H_2S][OH^-]}{[HS^-]}$$

This expression represents the

A. K_b for H_2S
B. K_a for H_2S
C. K_b for HS^-
D. K_a for HS^-

M01 96. The relationship $\frac{[H_2P_2O_7{}^{2-}][H_3O^+]}{[H_3P_2O_7{}^-]}$ is the

A. K_a for $H_3P_2O_7{}^-$
B. K_b for $H_3P_2O_7{}^-$
C. K_a for $H_2P_2O_7{}^{2-}$
D. K_b for $H_2P_2O_7{}^{2-}$

M02 97. In water, the hydrogen sulphide ion, HS^-, will act as

A. an acid because the $K_a < K_b$
B. an acid because the $K_a > K_b$
C. a base because the $K_a < K_b$
D. a base because the $K_a > K_b$

M02 98. The concentration, K_a and pH values of four acids are given in the following table:

Acid	Concentration	K_a	pH
HA	3.0 M	2.0×10^{-5}	2.1
HB	0.7 M	4.0×10^{-5}	2.3
HC	4.0 M	1.0×10^{-5}	2.2
HD	1.5 M	1.3×10^{-5}	2.4

Based on this data, the **strongest** acid is

A. HA
B. HB
C. HC
D. HD

<table>
<tr>
<td>M02</td>
<td>99.</td>
<td>Consider the following data table:
<table>
<tr><th></th><th>HCO_3^-</th><th>HSO_3^-</th></tr>
<tr><td>K_a</td><td>5.6×10^{-11}</td><td>1.0×10^{-7}</td></tr>
<tr><td>K_b</td><td>2.3×10^{-8}</td><td>6.7×10^{-13}</td></tr>
</table>
Which of the following statements is correct?
A. HCO_3^- is a stronger acid than HSO_3^-
B. HCO_3^- is a stronger base than HSO_3^-
C. HCO_3^- is stronger as an acid than as a base
D. HSO_3^- is stronger as a base than as an acid</td>
</tr>
<tr>
<td>M02</td>
<td>100</td>
<td>Which of the following favours products?
A. $C_6H_5OH + CH_3COO^- \rightleftarrows C_6H_5O^- + CH_3COOH$
B. $H_2C_2O_4 + H_2C_6H_5O_7^- \rightleftarrows HC_2O_4^- + H_3C_6H_5O_7$
C. $C_6H_5COOH + HCOO^- \rightleftarrows C_6H_5COO^- + HCOOH$
D. $CH_3COOH + C_6H_5COO^- \rightleftarrows CH_3COO^- + C_6H_5COOH$</td>
</tr>
<tr>
<td>M02</td>
<td>101</td>
<td>Consider the following equilibrium:
$HF_{(aq)} + NH_{3(aq)} \rightleftarrows NH_4^+{}_{(aq)} + F^-{}_{(aq)}$
Which of the following statements is true?
A. The products are favoured because HF is a stronger acid than NH_4^+
B. The products are favoured because NH_4^+ is a stronger acid than HF
C. The reactants are favoured because HF is a stronger acid than NH_4^+
D. The reactants are favoured because NH_4^+ is a stronger acid than HF</td>
</tr>
<tr>
<td>M02</td>
<td>102</td>
<td>The hydrogen oxalate ion, $HC_2O_4^-$, is amphiprotic.
$K_a = 6.4 \times 10^{-5}$
$K_b = 1.7 \times 10^{-13}$
The predominant reaction is
A. $HC_2O_4^- + H_2O \rightleftarrows OH^- + H_2C_2O_4$ because $K_a < K_b$
B. $HC_2O_4^- + H_2O \rightleftarrows H_3O^+ + C_2O_4^{2-}$ because $K_a < K_b$
C. $HC_2O_4^- + H_2O \rightleftarrows OH^- + H_2C_2O_4$ because $K_a > K_b$
D. $HC_2O_4^- + H_2O \rightleftarrows H_3O^+ + C_2O_4^{2-}$ because $K_a > K_b$</td>
</tr>
</table>

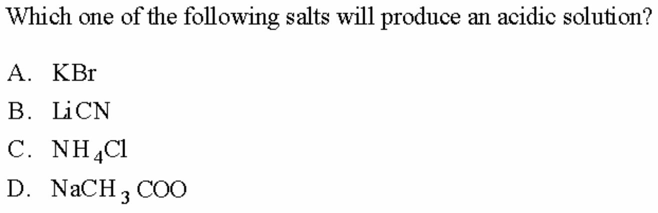
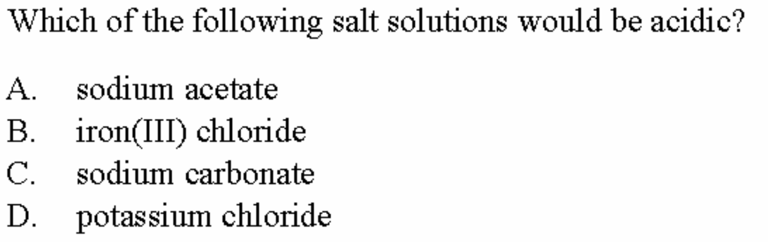
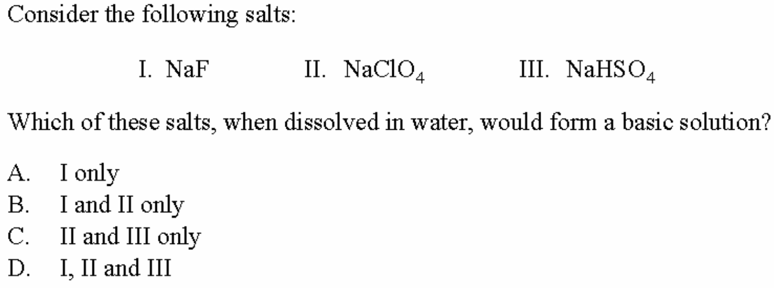
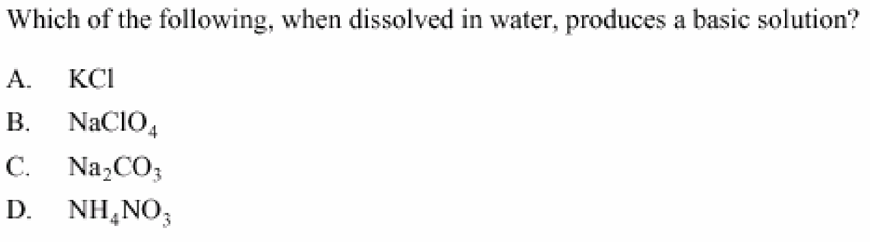
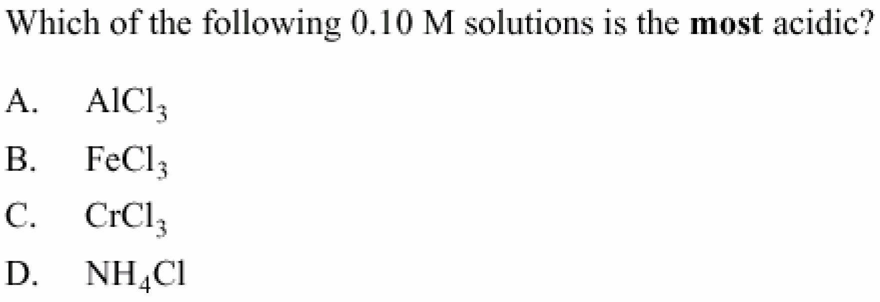
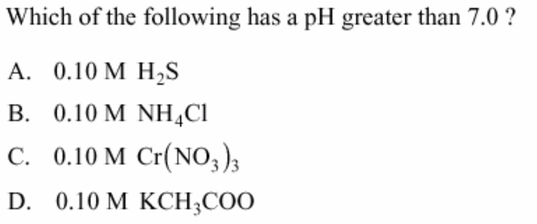
<table>
<tr><td>M02</td><td>103</td><td>Which of the following solutions has the highest pH?
A. 1.0 M $NaIO_3$
B. 1.0 M Na_2CO_3
C. 1.0 M Na_3PO_4
D. 1.0 M Na_2SO_4</td></tr>
<tr><td>M02</td><td>104</td><td>The equation for the predominant reaction between HSO_3^- and H_2O is
A. $HSO_3^- + H_2O \rightleftarrows H_2SO_4 + H^+$
B. $HSO_3^- + H_2O \rightleftarrows SO_3^{2-} + H_3O^+$
C. $HSO_3^- + H_2O \rightleftarrows H_2SO_3 + OH^-$
D. $HSO_3^- + H_2O \rightleftarrows H_2SO_4 + \frac{1}{2}H_2$</td></tr>
<tr><td>M02</td><td>105</td><td>Which of the following describes the relationship between acid strength and K_a value for weak acids?
<table>
<tr><th></th><th>Acid Strength</th><th>K_a</th></tr>
<tr><td>A.</td><td>increases</td><td>increases</td></tr>
<tr><td>B.</td><td>increases</td><td>decreases</td></tr>
<tr><td>C.</td><td>decreases</td><td>increases</td></tr>
<tr><td>D.</td><td>decreases</td><td>remains constant</td></tr>
</table></td></tr>
<tr><td>M02</td><td>106</td><td>If reactants are favoured in the following equilibrium, the stronger base must be
$HCN + HS^- \rightleftarrows H_2S + CN^-$
A. H_2S
B. HS^-
C. CN^-
D. HCN</td></tr>
<tr><td>M02</td><td>107</td><td>When added to water, the hydrogen carbonate ion, HCO_3^-, produces a solution which is
A. basic because K_b is greater than K_a
B. basic because K_a is greater than K_b
C. acidic because K_a is greater than K_b
D. acidic because K_b is greater than K_a</td></tr>
</table>

M03	108	The pH of a 0.3 M solution of NH_3 is approximately A. 14.0 B. 11.0 C. 6.0 D. 3.0
M03	109	The approximate pH of a 0.06 M solution of CH_3COOH is A. 1 B. 3 C. 11 D. 13
M03	110	Which of the following solutions will have the largest $\left[H_3O^+\right]$? A. 1.0 M HNO_2 B. 1.0 M H_3BO_3 C. 1.0 M $H_2C_2O_4$ D. 1.0 M HCOOH
M04	111	The K_b for the dihydrogen phosphate ion is A. 1.4×10^{-12} B. 6.3×10^{-8} C. 1.6×10^{-7} D. 7.1×10^{-3}
M04	112	Consider the following equilibrium: $HPO_4^{2-} + H_2O \rightleftarrows H_2PO_4^- + OH^-$ The value of the base ionization constant is A. 2.2×10^{-13} B. 6.2×10^{-8} C. 1.6×10^{-7} D. 4.5×10^{-2}

M04	113	The value of K_b for HPO_4^{2-} is A. 2.2×10^{-13} B. 6.2×10^{-8} C. 1.6×10^{-7} D. 4.5×10^{-2}

HYDROLYSIS OF SALTS

N02	114	The net ionic equation for the hydrolysis of the salt, Na_2S, is A. $Na_2S \rightleftarrows 2Na^+ + S^{2-}$ B. $S^{2-} + H_2O \rightleftarrows OH^- + HS^-$ C. $Na_2S + 2H_2O \rightleftarrows 2NaOH + H_2S$ D. $2Na^+ + S^{2-} + 2H_2O \rightleftarrows 2Na^+ + 2OH^- + H_2S$
N02	115	The net ionic equation for the hydrolysis reaction occurring in a solution of NaF is A. $F^-_{(aq)} + H_2O_{(\ell)} \rightleftarrows HF_{(aq)} + OH^-_{(aq)}$ B. $NaF_{(s)} + H_2O_{(\ell)} \rightleftarrows NaOH_{(aq)} + HF_{(aq)}$ C. $NaF_{(s)} + 2H_2O_{(\ell)} \rightleftarrows H_3O^+_{(aq)} + OH^-_{(aq)} + Na^+_{(aq)} + F^-_{(aq)}$ D. $Na(H_2O)_6{}^+_{(aq)} + H_2O_{(\ell)} \rightleftarrows H_3O^+_{(aq)} + Na(H_2O)_5(OH)^+_{(aq)}$
N02	116	The net ionic equation for the predominant hydrolysis reaction of $KHSO_4$ is A. $HSO_4^- + H_2O \rightleftarrows SO_4^{2-} + H_3O^+$ B. $HSO_4^- + H_2O \rightleftarrows H_2SO_4 + OH^-$ C. $KHSO_4 + H_2O \rightleftarrows K^+ + SO_4^{2-} + H_3O^+$ D. $KHSO_4 + H_2O \rightleftarrows K^+ + H_2SO_4 + OH^-$
N02	117	The equilibrium constant expression for the predominant hydrolysis reaction in 1.0 M K_2HPO_4 is A. $K_{eq} = \frac{[H_2PO_4^-][OH^-]}{[HPO_4^{2-}]}$ B. $K_{eq} = \frac{[H_3PO_4][OH^-]}{[H_2PO_4^-]}$ C. $K_{eq} = \frac{[K^+][KHPO_4^-]}{[K_2HPO_4]}$ D. $K_{eq} = \frac{[K^+]^2[HPO_4^{2-}]}{[K_2HPO_4]}$

N03	118	 Which one of the following salts will produce an acidic solution? A. KBr B. LiCN C. NH_4Cl D. $NaCH_3COO$
N03	119	 Which of the following salt solutions would be acidic? A. sodium acetate B. iron(III) chloride C. sodium carbonate D. potassium chloride
N03	120	 Consider the following salts: I. NaF II. $NaClO_4$ III. $NaHSO_4$ Which of these salts, when dissolved in water, would form a basic solution? A. I only B. I and II only C. II and III only D. I, II and III
N03	121	 Which of the following, when dissolved in water, produces a basic solution? A. KCl B. $NaClO_4$ C. Na_2CO_3 D. NH_4NO_3
N03	122	 Which of the following 0.10 M solutions is the **most** acidic? A. $AlCl_3$ B. $FeCl_3$ C. $CrCl_3$ D. NH_4Cl
N03	123	 Which of the following has a pH greater than 7.0 ? A. 0.10 M H_2S B. 0.10 M NH_4Cl C. 0.10 M $Cr(NO_3)_3$ D. 0.10 M KCH_3COO

<table>
<tr><td>N03</td><td>124</td><td>Arrange the following 0.10 M solutions in order of increasing $\left[H_3O^+\right]$.

NaBr NH_4Cl LiCN

A. LiCN, NaBr, NH_4Cl
B. NH_4Cl, NaBr, LiCN
C. NH_4Cl, LiCN, NaBr
D. NaBr, LiCN, NH_4Cl</td></tr>
<tr><td>N03</td><td>125</td><td>List the following 1.0 M solutions in order of decreasing pH.

$CaBr_2$ $FeCl_3$ NaF

A. $NaF > CaBr_2 > FeCl_3$
B. $FeCl_3 > CaBr_2 > NaF$
C. $CaBr_2 > NaF > FeCl_3$
D. $FeCl_3 > NaF > CaBr_2$</td></tr>
<tr><td>N03</td><td>126</td><td>An aqueous solution of NH_4CN is

A. basic because $K_a < K_b$
B. basic because $K_a > K_b$
C. acidic because $K_a < K_b$
D. acidic because $K_a > K_b$</td></tr>
<tr><td>N03</td><td>127</td><td>Consider the following:
<table><tr><td>I</td><td>ammonium nitrate</td></tr><tr><td>II</td><td>calcium nitrate</td></tr><tr><td>III</td><td>iron(III) nitrate</td></tr></table>
When dissolved in water, which of these salts would form a neutral solution?

A. II only
B. III only
C. I and III only
D. I, II and III</td></tr>
<tr><td>N03</td><td>128</td><td>A 1.0 M solution of sodium dihydrogen phosphate is

A. acidic and the $pH < 7.00$
B. acidic and the $pH > 7.00$
C. basic and the $pH < 7.00$
D. basic and the $pH > 7.00$</td></tr>
</table>

N03 129

The solution with the highest pH is

A. 1.0 M $NaCl$
B. 1.0 M $NaCN$
C. 1.0 M $NaIO_3$
D. 1.0 M Na_2SO_3

N03 130

Which of the following 1.0 M solutions would have a pH greater than 7.00?

A. HCN
B. KNO_3
C. NH_4Cl
D. $NaCH_3COO$

N04 131

Consider the following:

I	$H_2CO_3 + F^- \rightleftarrows HCO_3^- + HF$
II	$HCO_3^- + HC_2O_4^- \rightleftarrows H_2CO_3 + C_2O_4^{2-}$
III	$HCO_3^- + H_2C_6H_5O_7^- \rightleftarrows H_2CO_3 + HC_6H_5O_7^{2-}$

The HCO_3^- is a base in

A. I only
B. I and II only
C. II and III only
D. I, II and III

N04 132

The amphiprotic ion $HSeO_3^-$ can undergo hydrolysis according to the following equations:

$HSeO_3^- + H_2O \rightleftarrows H_2SeO_3 + OH^-$	K_1
$HSeO_3^- + H_2O \rightleftarrows SeO_3^{2-} + H_3O^+$	K_2

An aqueous solution of $HSeO_3^-$ is found to be acidic. This observation indicates that when it is added to water, $HSeO_3^-$ behaves **mainly** as a

A. proton donor, and K_1 is less than K_2
B. proton donor, and K_1 is greater than K_2
C. proton acceptor, and K_1 is less than K_2
D. proton acceptor, and K_1 is greater than K_2

INDICATORS

O01 133

The indicator methyl red is red in a solution of NaH_2PO_4. Which of the following equations is consistent with this observation?

A. $H_2PO_4^- + H_2O \rightleftarrows HPO_4^{2-} + H_3O^+$
B. $H_2PO_4^- + H_2O \rightleftarrows H_3PO_4 + OH^-$
C. $HPO_4^{2-} + H_2O \rightleftarrows PO_4^{3-} + H_3O^+$
D. $HPO_4^{2-} + H_2O \rightleftarrows H_2PO_4^- + OH^-$

O01 134

An indicator, HInd, produces a yellow colour in 0.1 M HCl solution and a red colour in 0.1 M HCN solution. Therefore, in the following equilibrium

$$\mathrm{HCN + Ind^- \rightleftarrows HInd + CN^-}$$

A. products are favoured and the stronger acid is HInd.
B. products are favoured and the stronger acid is HCN.
C. reactants are favoured and the stronger acid is HInd.
D. reactants are favoured and the stronger acid is HCN.

O01 135

Consider the following acid-base indicator:

$$\mathrm{HInd \rightleftarrows H^+ + Ind^-}$$

When this indicator is added to different solutions, the following data are obtained:

Solution	1.0 M HCl	1.0 M HA_1	1.0 M HA_2
Colour	yellow	blue	yellow

The acids HA_1, HA_2 and HInd listed in the order of **decreasing** acid strength is

A. HA_2, HInd, HA_1
B. HInd, HA_1, HA_2
C. HA_2, HA_1, HInd
D. HA_1, HInd, HA_2

O02 136

Consider the following acid-base indicator equilibrium:

$$\mathrm{HInd}_{(aq)} + \mathrm{H_2O}_{(l)} \rightleftarrows \mathrm{H_3O^+}_{(aq)} + \mathrm{Ind^-}_{(aq)}$$

Which of the following statements describes the conditions that exist in an indicator equilibriur system at its transition point?

A. $[\mathrm{HInd}] = [\mathrm{Ind^-}]$
B. $[\mathrm{Ind^-}] = [\mathrm{H_3O^+}]$
C. $[\mathrm{HInd}] = [\mathrm{H_3O^+}]$
D. $[\mathrm{H_3O^+}] = [\mathrm{H_2O}]$

O02 137

Which of the following acid-base indicators has a transition point between pH 7 and pH 9 ?

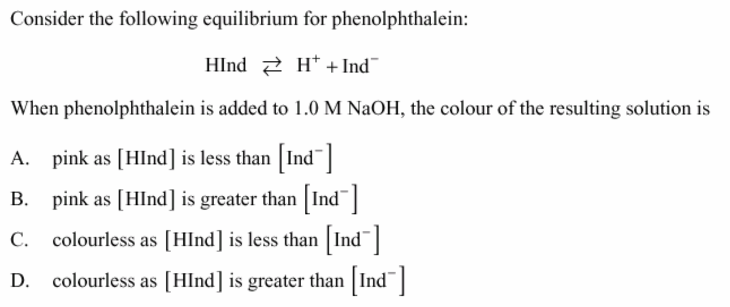
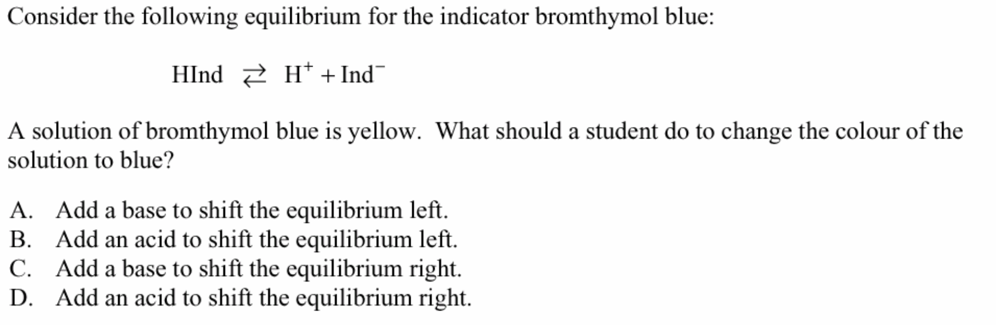
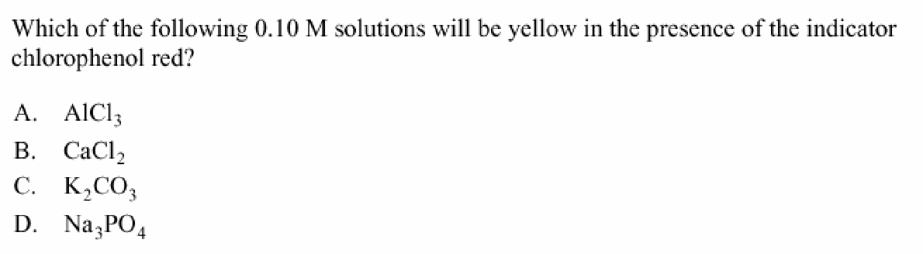
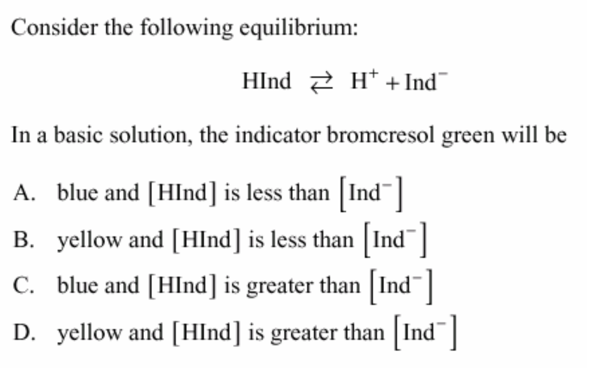
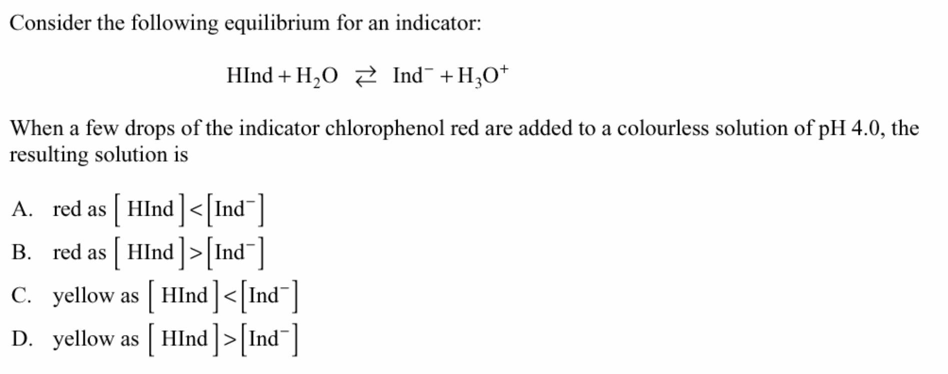
A. ethyl red, $K_a = 8.0 \times 10^{-2}$
B. congo red, $K_a = 9.0 \times 10^{-3}$
C. cresol red, $K_a = 1.0 \times 10^{-8}$
D. alizarin blue, $K_a = 7.0 \times 10^{-11}$

O02 138

Identify the indicator that is blue in a solution when $[\mathrm{H_3O^+}] = 2.5 \times 10^{-6}$.

A. thymol blue
B. thymolphthalein
C. bromthymol blue
D. bromcresol green

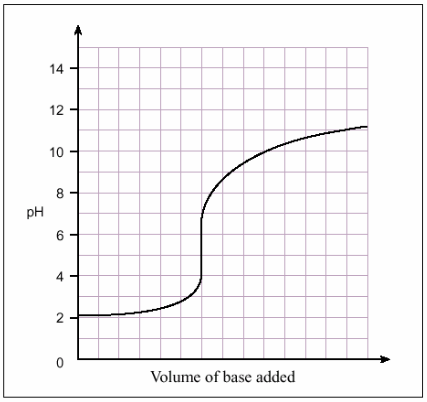
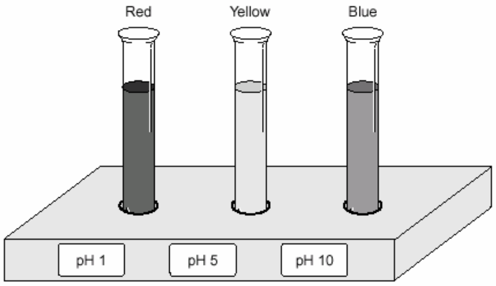
O02	139	Consider the following equilibrium: $HInd \rightleftarrows H^+ + Ind^-$ Which of the following relationships is true for an indicator at the transition point? A. $\left[H^+\right] = K_w$ B. $\left[H^+\right] = pH$ C. $\left[H^+\right] = K_a$ D. $\left[H^+\right] = \left[OH^-\right]$
O02	140	Consider the following equilibrium for an indicator: $HInd + H_2O \rightleftarrows Ind^- + H_3O^+$ At the transition point, A. $[HInd] > \left[Ind^-\right]$ B. $[HInd] = \left[Ind^-\right]$ C. $[HInd] < \left[Ind^-\right]$ D. $[HInd] = \left[H_3O^+\right]$
O03	141	A new indicator, “B.C. Blue (HInd),” is red in bases and blue in acids. Describe the shift in equilibrium and the resulting colour change if 1.0 M HIO_3 is added to a neutral, purple solution of this indicator. $HInd + H_2O \rightleftarrows H_3O^+ + Ind^-$ A. Equilibrium shifts left, colour becomes red. B. Equilibrium shifts left, colour becomes blue. C. Equilibrium shifts right, colour becomes red. D. Equilibrium shifts right, colour becomes blue.
O03	142	Consider the following equilibrium for an acid-base indicator: $HInd \rightleftarrows H^+ + Ind^- \qquad K_a = 1.0 \times 10^{-10}$ Which of the following statements is correct at pH 7.0 ? A. $\left[Ind^-\right] < \left[HInd\right]$ B. $\left[Ind^-\right] = \left[HInd\right]$ C. $\left[Ind^-\right] > \left[HInd\right]$ D. $\left[Ind^-\right] = \left[H^+\right] = [HInd]$

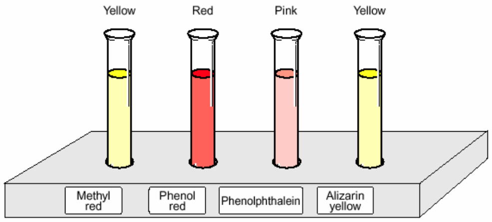
O03	143	 Consider the following equilibrium for phenolphthalein: $\mathrm{HInd} \rightleftarrows \mathrm{H^+} + \mathrm{Ind^-}$ When phenolphthalein is added to 1.0 M NaOH, the colour of the resulting solution is A. pink as $[\mathrm{HInd}]$ is less than $[\mathrm{Ind^-}]$ B. pink as $[\mathrm{HInd}]$ is greater than $[\mathrm{Ind^-}]$ C. colourless as $[\mathrm{HInd}]$ is less than $[\mathrm{Ind^-}]$ D. colourless as $[\mathrm{HInd}]$ is greater than $[\mathrm{Ind^-}]$
O03	144	 Consider the following equilibrium for the indicator bromthymol blue: $\mathrm{HInd} \rightleftarrows \mathrm{H^+} + \mathrm{Ind^-}$ A solution of bromthymol blue is yellow. What should a student do to change the colour of the solution to blue? A. Add a base to shift the equilibrium left. B. Add an acid to shift the equilibrium left. C. Add a base to shift the equilibrium right. D. Add an acid to shift the equilibrium right.
O03	145	 Which of the following 0.10 M solutions will be yellow in the presence of the indicator chlorophenol red? A. $AlCl_3$ B. $CaCl_2$ C. K_2CO_3 D. Na_3PO_4
O03	146	 Consider the following equilibrium: $\mathrm{HInd} \rightleftarrows \mathrm{H^+} + \mathrm{Ind^-}$ In a basic solution, the indicator bromcresol green will be A. blue and $[\mathrm{HInd}]$ is less than $[\mathrm{Ind^-}]$ B. yellow and $[\mathrm{HInd}]$ is less than $[\mathrm{Ind^-}]$ C. blue and $[\mathrm{HInd}]$ is greater than $[\mathrm{Ind^-}]$ D. yellow and $[\mathrm{HInd}]$ is greater than $[\mathrm{Ind^-}]$
O03	147	 Consider the following equilibrium for an indicator: $\mathrm{HInd} + \mathrm{H_2O} \rightleftarrows \mathrm{Ind^-} + \mathrm{H_3O^+}$ When a few drops of the indicator chlorophenol red are added to a colourless solution of pH 4.0, the resulting solution is A. red as $[\mathrm{HInd}] < [\mathrm{Ind^-}]$ B. red as $[\mathrm{HInd}] > [\mathrm{Ind^-}]$ C. yellow as $[\mathrm{HInd}] < [\mathrm{Ind^-}]$ D. yellow as $[\mathrm{HInd}] > [\mathrm{Ind^-}]$

O03	148	Consider the following equilibrium for an indicator: $$HInd + H_2O \rightleftarrows Ind^- + H_3O^+$$ When a few drops of the indicator methyl red are added to 1.0 M HCl, the colour of the resulting solution is A. red and the products are favoured. B. red and the reactants are favoured. C. yellow and the products are favoured. D. yellow and the reactants are favoured.
O04	149	What is the pH at the transition point of an indicator if its K_a is 7.9×10^{-3} ? A. 0.98 B. 2.10 C. 7.00 D. 11.90
O04	150	What is the pH at the transition point for an indicator with a K_a of 2.5×10^{-4} ? A. 2.5×10^{-4} B. 3.60 C. 7.00 D. 10.40
O05	151	The approximate K_a for the indicator phenolphthalein is A. 6×10^{-19} B. 8×10^{-10} C. 6×10^{-8} D. 2×10^{-2}

NEUTRALIZATIONS OF ACIDS AND BASES

P01	152	Which of the following indicators would be used when titrating a weak acid with a strong base? A. methyl red B. methyl violet C. indigo carmine D. phenolphthalein

P01	153	Which of the following indicators would be yellow at pH 7 and blue at pH 10 ? A. thymol blue B. methyl violet C. bromthymol blue D. bromcresol green
P01	154	 31. Which of the following indicators should be used in the titration represented by the above titration curve? A. orange IV B. methyl red C. phenolphthalein D. alizarin yellow
P01	155	An indicator was added to solutions of different pH and the following was observed:  The indicator is A. methyl red. B. thymol blue. C. methyl orange. D. bromthymol blue.
P01	156	Which of the following standardized solutions should a chemist select when titrating a 25.00 mL sample of 0.1 M NH_3, using methyl red as an indicator? A. 0.114 M HCl B. 6.00 M HNO_3 C. 0.105 M NaOH D. 0.100 M CH_3COOH

P01	157	Which of the following indicators should be used when 1.0 M HNO_2 is titrated with $NaOH_{(aq)}$? A. methyl red B. thymol blue C. methyl orange D. indigo carmine
P02	158	A 0.10 M solution was tested with **four** indicators and the following was observed.  The $[OH^-]$ in this solution is A. 1×10^{-10} M B. 1×10^{-8} M C. 1×10^{-6} M D. 1×10^{-4} M
P02	159	In a titration, 10.0 mL of $H_2SO_{4(aq)}$ is required to neutralize 0.0400 mol of NaOH. From this data, the $[H_2SO_4]$ is A. 0.0200 M B. 2.00 M C. 4.00 M D. 8.00 M
P02	160	The stoichiometric point of a titration is reached when 35.50 mL 0.40 M HBr is added to a 25.00 mL sample of LiOH. The original [LiOH] is A. 0.014 M B. 0.024 M C. 0.28 M D. 0.57 M
P02	161	The equivalence point in a titration is reached when 20.0 mL of H_2SO_4 is added to 20.0 mL of 0.420 M KOH. The $[H_2SO_4]$ in the original solution is A. 0.00840 M B. 0.210 M C. 0.420 M D. 0.840 M
P03	162	How many moles of $Mg(OH)_2$ are required to neutralize 30.00 mL of 0.150 M HCl ? A. 2.25×10^{-3} mol B. 4.50×10^{-3} mol C. 5.00×10^{-3} mol D. 9.00×10^{-3} mol

P03 163

What volume of 0.100 M NaOH is required to neutralize a 10.0 mL sample of 0.200 M H_2SO_4 ?

A. 5.0 mL
B. 10.0 mL
C. 20.0 mL
D. 40.0 mL

P03 164

Consider the following data table:

BEAKER	VOLUME	CONTENTS
1	15 mL	0.1 M $Sr(OH)_2$
2	20 mL	0.2 M NH_4OH
3	25 mL	0.1 M KOH
4	50 mL	0.2 M NaOH

Identify the beaker that requires the smallest volume of 0.1 M HCl for complete neutralization.

A. beaker 1
B. beaker 2
C. beaker 3
D. beaker 4

P03 165

What volume of 0.250 M H_2SO_4 is required to neutralize 25.00 mL of 2.50 M KOH?

A. 125 mL
B. 150 mL
C. 250 mL
D. 500 mL

P03 166

The volume of 0.200 M $Sr(OH)_2$ needed to neutralize 50.0 mL of 0.200 M HI is

A. 10.0 mL
B. 25.0 mL
C. 50.0 mL
D. 100.0 mL

P03 167

The volume of 0.450 M HCl needed to neutralize 40.0 mL of 0.450 M $Sr(OH)_2$ is

A. 18.0 mL
B. 20.0 mL
C. 40.0 mL
D. 80.0 mL

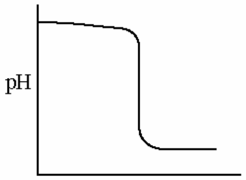
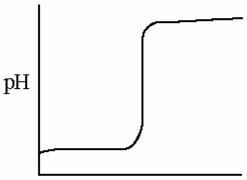
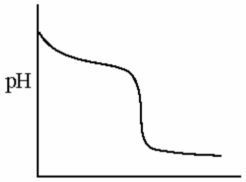
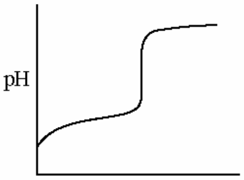
P03 168

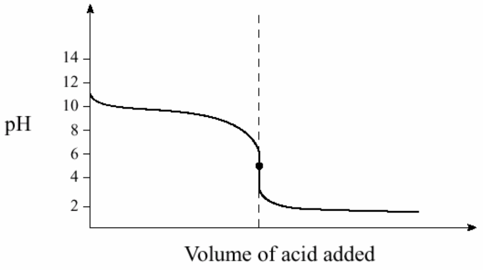
What volume of 0.100 M NaOH is required to completely neutralize 15.00 mL of 0.100 M H_3PO_4 ?

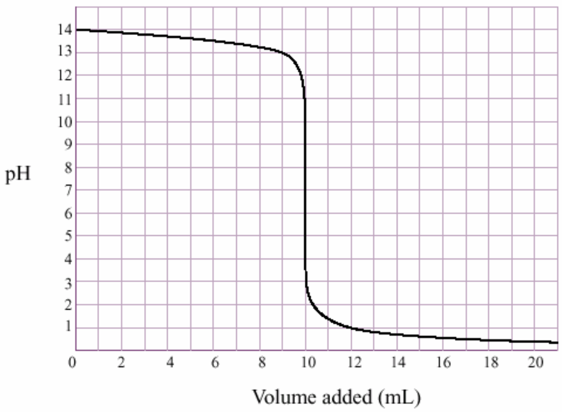
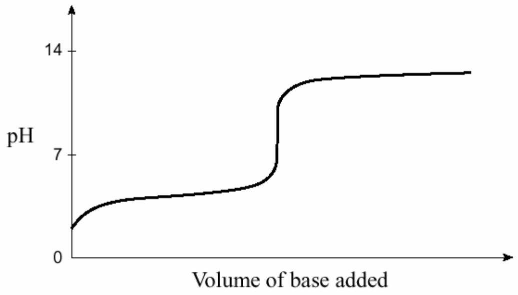
A. 5.00 mL
B. 15.0 mL
C. 30.0 mL
D. 45.0 mL

P04	169	The **net** ionic equation for the neutralization of HBr by $Ca(OH)_2$ is A. $H^+_{(aq)} + OH^-_{(aq)} \rightleftarrows H_2O_{(l)}$ B. $Ca^{2+}_{(aq)} + 2Br^-_{(aq)} \rightleftarrows CaBr_{2(s)}$ C. $2HBr_{(aq)} + Ca(OH)_{2(aq)} \rightleftarrows 2H_2O_{(l)} + CaBr_{2(s)}$ D. $2H^+_{(aq)} + 2Br^-_{(aq)} + Ca^{2+}_{(aq)} + 2OH^-_{(aq)} \rightleftarrows 2H_2O_{(l)} + Ca^{2+}_{(aq)} + 2Br^-_{(aq)}$
P04	170	The **complete** ionic equation for the neutralization of acetic acid by sodium hydroxide is A. $H^+ + OH^- \rightleftarrows H_2O$ B. $CH_3COOH + OH^- \rightleftarrows CH_3COO^- + H_2O$ C. $CH_3COOH + NaOH \rightleftarrows NaCH_3COO + H_2O$ D. $CH_3COOH + Na^+ + OH^- \rightleftarrows Na^+ + CH_3COO^- + H_2O$
P04	171	A net ionic equation for the reaction between CH_3COOH and KOH is A. $CH_3COO^-_{(aq)} + K^+_{(aq)} \rightleftarrows CH_3COOK_{(aq)}$ B. $CH_3COOH_{(aq)} + OH^-_{(aq)} \rightleftarrows H_2O_{(l)} + CH_3COO^-_{(aq)}$ C. $CH_3COOH_{(aq)} + KOH_{(aq)} \rightleftarrows H_2O_{(l)} + CH_3COOK_{(aq)}$ D. $CH_3COOH_{(aq)} + K^+_{(aq)} + OH^-_{(aq)} \rightleftarrows H_2O_{(l)} + KCH_3COO_{(aq)}$
P04	172	Which equation represents a neutralization reaction? A. $Pb^{2+}_{(aq)} + 2Cl^-_{(aq)} \rightarrow PbCl_{2(s)}$ B. $HCl_{(aq)} + NH_{3(aq)} \rightarrow NH_4Cl_{(aq)}$ C. $BaI_{2(aq)} + MgSO_{4(aq)} \rightarrow BaSO_{4(s)} + MgI_{2(aq)}$ D. $MnO^-_{4(aq)} + 5Fe^{2+}_{(aq)} + 8H^+_{(aq)} \rightarrow Mn^{2+}_{(aq)} + 5Fe^{3+}_{(aq)} + 4H_2O_{(l)}$
P04	173	The reaction of a strong acid with a strong base produces A. a salt and water. B. a base and an acid. C. a metallic oxide and water. D. a non-metallic oxide and water.

P04	174	The net ionic equation for the titration of $HClO_{4(aq)}$ with $LiOH_{(aq)}$ is A. $H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(\ell)}$ B. $HClO_{4(aq)} + OH^-_{(aq)} \rightarrow ClO_4{}^-{}_{(aq)} + H_2O_{(\ell)}$ C. $HClO_{4(aq)} + LiOH_{(aq)} \rightarrow LiClO_{4(aq)} + H_2O_{(\ell)}$ D. $H^+_{(aq)} + ClO_4{}^-{}_{(aq)} + Li^+_{(aq)} + OH^-_{(aq)} \rightarrow LiClO_{4(aq)} + H_2O_{(\ell)}$
P04	175	The balanced formula equation for the neutralization of H_2SO_4 by KOH is A. $H_2SO_4 + KOH \rightarrow KSO_4 + H_2O$ B. $H_2SO_4 + KOH \rightarrow K_2SO_4 + H_2O$ C. $H_2SO_4 + 2KOH \rightarrow K_2SO_4 + H_2O$ D. $H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$
P05	176	A student combines 0.25 mol of NaOH and 0.20 mol of HCl in water to make 2.0 litres of solution. The pH of this solution is A. 1.3 B. 1.6 C. 12.4 D. 12.7
P05	177	What is the pH of a solution prepared by adding 0.50 mol KOH to 1.0 L of 0.30 M HNO_3? A. 0.20 B. 0.70 C. 13.30 D. 13.80
P05	178	Calculate the pH of a solution formed when 50.0 mL of 4.0 M HCl is added to 50.0 mL of 2.0 M NaOH. A. 0.00 B. 1.00 C. 2.00 D. 7.00
P05	179	The pH at the equivalence point of a strong acid–strong base titration is A. equal to 0.00 B. less than 7.00 C. equal to 7.00 D. greater than 7.00

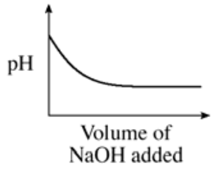
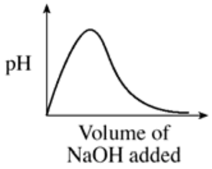
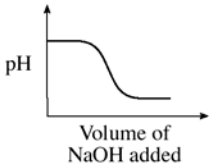
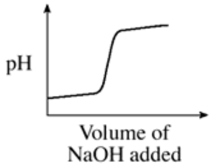
P05	180	What is the pH of the solution formed when 0.060 moles NaOH is added to 1.00 L of 0.050 M HCl? A. 2.00 B. 7.00 C. 12.00 D. 12.78
P06	181	Which of the following curves **best** represents the titration of sodium hydroxide with hydrochloric acid? A.  B.  C.  D. 
P06	182	At the equivalence point in a titration involving 0.1 M solutions, which of the following combinations would have the **lowest** conductivity? A. nitric acid and barium hydroxide B. acetic acid and sodium hydroxide C. sulphuric acid and barium hydroxide D. hydrochloric acid and sodium hydroxide
P06	183	Which of the following titrations would have an equivalence point less than pH 7 ? A. NH_3 and HCl B. NaOH and HNO_3 C. $Ba(OH)_2$ and H_2SO_4 D. KOH and CH_3COOH
P06	184	Consider the following 0.100 M solutions: I. H_2SO_4 II. HCl III. HF The equivalence point is reached when 10.00 mL of 0.100 M NaOH has been added to 10.00 mL of solution(s) A. II only. B. I and II only. C. II and III only. D. I, II, and III.

P06	185	Which of the following acid-base pairs would result in an equivalence point with pH greater than 7.0 ? A. HCl and LiOH B. HNO_3 and NH_3 C. $HClO_4$ and NaOH D. CH_3COOH and KOH
P06	186	 Which pair of 0.10 M solutions would result in the above titration curve? A. HF and KOH B. HCl and NH_3 C. H_2S and NaOH D. HNO_3 and KOH
P06	187	A suitable indicator for the above titration is A. methyl violet. B. alizarin yellow. C. thymolphthalein. D. bromcresol green.
P06	188	Which of the following solutions **should** be used when titrating a 25.00 mL sample of CH_3COOH that is approximately 0.1 M? A. 0.150 M NaOH B. 0.001 M NaOH C. 3.00 M NaOH D. 6.00 M NaOH

P06	189	Consider the following titration curve:  This curve represents the titration of a A. strong base by adding a weak acid. B. strong acid by adding a weak base. C. strong acid by adding a strong base. D. strong base by adding a strong acid.
P06	190	In a titration between a weak acid and a strong base, the pH at the equivalence point is A. 3 B. 5 C. 7 D. 9
P06	191	Consider the following titration curve:  Which pair of solutions would result in the above curve? A. HCl and NH_3 B. HCl and NaOH C. CH_3COOH and NH_3 D. CH_3COOH and NaOH

BUFFERS

Q01	192	A few drops of strong acid are added to 1.0 L of a pH 8.0 buffer solution. The resulting solution will have an approximate pH of A. 5.6 B. 7.0 C. 7.9 D. 8.1

Q01	193	Which of the following graphs describes the relationship between the pH of a buffer and the volume of NaOH added to the buffer? A.  B.  C.  D. 
Q02	194	Which one of the following combinations would act as an acidic buffer? A. HCl and NaOH B. KOH and KBr C. NH_3 and NH_4Cl D. CH_3COOH and $NaCH_3COO$
Q02	195	Which of the following compounds, when added to a solution of ammonium nitrate, will result in the formation of a buffer solution? A. ammonia B. nitric acid C. sodium nitrate D. ammonium chloride
Q02	196	Consider the following acid solutions: I. H_2CO_3 II. $HClO_4$ III. HF Which of the above acids would form a buffer solution when its conjugate base is added? A. I only B. II only C. I and III only D. I, II and III
Q02	197	Consider the following equilibrium: $HF_{(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + F^-_{(aq)}$ The above system will behave as a buffer when the $[F^-]$ is approximately equal to A. K_a B. $[HF]$ C. $[H_2O]$ D. $[H_3O^+]$

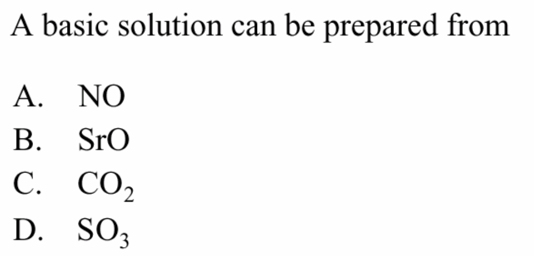
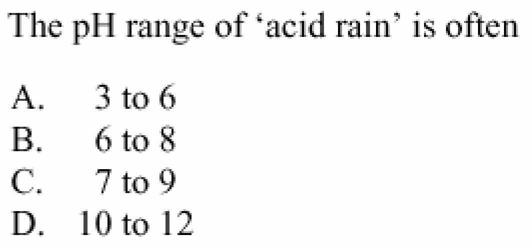
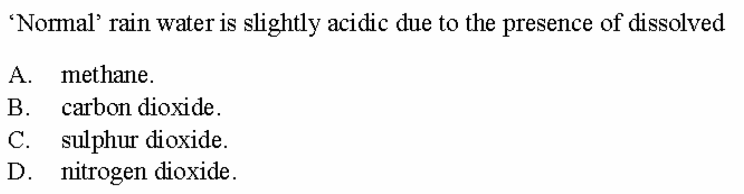
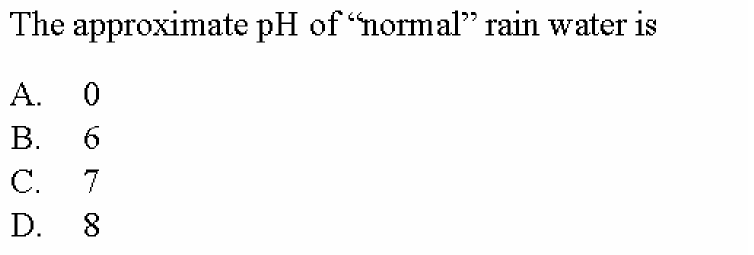
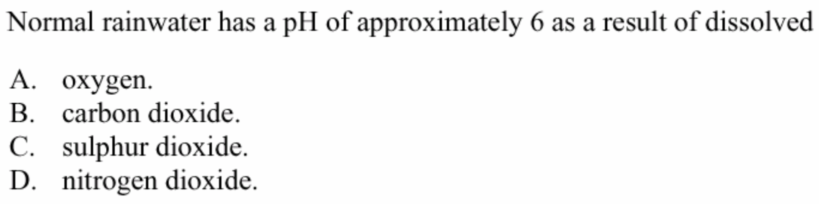
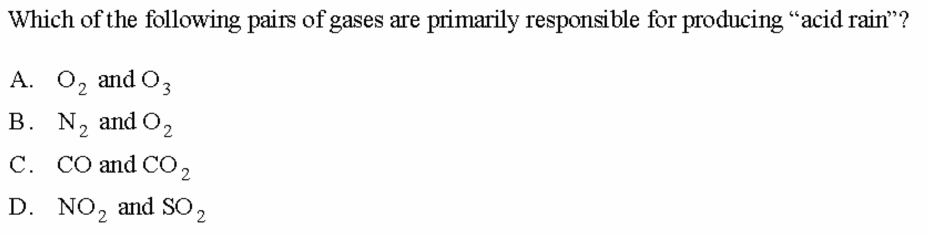
Q02	198	Which of the following represents a buffer equilibrium? A. $HI + H_2O \rightleftarrows H_3O^+ + I^-$ B. $HCl + H_2O \rightleftarrows H_3O^+ + Cl^-$ C. $HCN + H_2O \rightleftarrows H_3O^+ + CN^-$ D. $HClO_4 + H_2O \rightleftarrows H_3O^+ + ClO_4^-$
Q03	199	A **basic** buffer solution can be prepared by mixing equal numbers of moles of A. NH_4Cl and HCl B. NaCl and NaOH C. Na_2CO_3 and $NaHCO_3$ D. $NaCH_3COO$ and CH_3COOH
Q03	200	Which of the following would produce a buffer solution when added to 1.0 M NH_3? A. HNO_3 B. KNH_2 C. NaOH D. NH_4Cl
Q03	201	A buffer solution is prepared by adding 1.0 mol of $NaCH_3COO$ to 1.0 L of 1.0 M CH_3COOH. The molar concentration of CH_3COO^- is approximately A. 0.0 B. 0.5 C. 1.0 D. 2.0
Q03	202	A buffer solution can be prepared from A. nitric acid and sodium nitrate. B. sulphuric acid and sodium hydroxide. C. hydrocyanic acid and sodium cyanide. D. sodium hydroxide and sodium chloride.
Q05	203	A student prepares a buffer by placing ammonium chloride in a solution of ammonia. Equilibrium is established according to the equation: $NH_3 + H_2O \rightleftarrows NH_4^+ + OH^-$ When a small amount of base is added to the buffer, the base reacts with the A. NH_3 and the pH decreases. B. NH_4^+ and the pH decreases. C. NH_3 to keep the pH relatively constant. D. NH_4^+ to keep the pH relatively constant.

Q05	204	Consider the following equilibrium for a buffer solution: $NH_4{}^+{}_{(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+{}_{(aq)} + NH_{3(aq)}$ When a few drops of HCl are added, A. both the $[NH_3]$ and the $[NH_4{}^+]$ increase. B. both the $[NH_3]$ and the $[NH_4{}^+]$ decrease. C. the $[NH_3]$ decreases and the $[NH_4{}^+]$ increases. D. the $[NH_3]$ increases and the $[NH_4{}^+]$ decreases.
Q05	205	Consider the following: $CH_3COOH + H_2O \rightleftarrows CH_3COO^- + H_3O^+$ A buffer solution is prepared by adding $NaCH_3COO_{(s)}$ to $CH_3COOH_{(aq)}$. When a few drops of NaOH solution are added to the buffer, the equilibrium A. shifts left and $[CH_3COO^-]$ increases. B. shifts left and $[CH_3COO^-]$ decreases. C. shifts right and $[CH_3COO^-]$ increases. D. shifts right and $[CH_3COO^-]$ decreases.
Q06	206	Which of the following pairs of substances form a buffer system for human blood? A. HCl and Cl^- B. NH_3 and $NH_2{}^-$ C. H_2CO_3 and $HCO_3{}^-$ D. $H_3C_6H_5O_7$ and $HC_6H_5O_7{}^{2-}$

ACID RAIN

R01	207	Which of the following oxides will form the most acidic solution? A. SO_2 B. MgO C. Na_2O D. Al_2O_3
R01	208	The balanced equation for the reaction between sodium oxide and water is A. $Na_2O + H_2O \rightarrow 2NaOH$ B. $Na_2O + H_2O \rightarrow 2NaH + O_2$ C. $Na_2O + H_2O \rightarrow 2Na + H_2O_2$ D. $Na_2O + H_2O \rightarrow 2Na + H_2 + O_2$

R01	209	Which of the following oxides would hydrolyze to produce hydroxide ions? A. NO B. SO_2 C. Cl_2O D. Na_2O
R01	210	Which of the following oxides would hydrolyze to produce hydronium ions? A. CaO B. SO_2 C. MgO D. Na_2O
R01	211	Which of the following oxides forms a basic solution? A. K_2O B. CO_2 C. SO_3 D. NO_2
R01	212	Which of the following is the **weakest** acid? A. HClO B. $HClO_2$ C. $HClO_3$ D. $HClO_4$
R01	213	Sulphur dioxide gas forms an acidic solution. The equation representing this reaction is A. $SO_{2(g)} + H_2O_{(\ell)} \rightarrow H_2SO_{3(aq)}$ B. $SO_{2(g)} + 2H_2O_{(\ell)} \rightarrow H_2SO_{4(aq)} + H_{2(g)}$ C. $SO_{2(g)} + H_2O_{(\ell)} \rightarrow SO_3{}^{2-}{}_{(aq)} + 2H^+{}_{(aq)}$ D. $SO_{2(g)} + H_2O_{(\ell)} \rightarrow HSO_2{}^+{}_{(aq)} + OH^-{}_{(aq)}$
R01	214	The equation for the reaction of Cl_2O with water is A. $Cl_2O + H_2O \rightleftarrows 2HClO$ B. $Cl_2O + H_2O \rightleftarrows 2ClO + H_2$ C. $Cl_2O + H_2O \rightleftarrows Cl_2 + H_2O_2$ D. $Cl_2O + H_2O \rightleftarrows Cl_2 + O_2 + H_2$

R01	215	 A basic solution can be prepared from A. NO B. SrO C. CO_2 D. SO_3
R02	216	 The pH range of 'acid rain' is often A. 3 to 6 B. 6 to 8 C. 7 to 9 D. 10 to 12
R03	217	 'Normal' rain water is slightly acidic due to the presence of dissolved A. methane. B. carbon dioxide. C. sulphur dioxide. D. nitrogen dioxide.
R03	218	 The approximate pH of "normal" rain water is A. 0 B. 6 C. 7 D. 8
R03	219	 Normal rainwater has a pH of approximately 6 as a result of dissolved A. oxygen. B. carbon dioxide. C. sulphur dioxide. D. nitrogen dioxide.
R04	220	 Which of the following pairs of gases are primarily responsible for producing "acid rain"? A. O_2 and O_3 B. N_2 and O_2 C. CO and CO_2 D. NO_2 and SO_2

R04	221	Which of the following gases results in the formation of acid rain? A. H_2 B. O_3 C. SO_2 D. NH_3
R05	222	Which of the following is primarily responsible for acid rain? A. HCl B. H_2SO_4 C. $HClO_4$ D. CH_3COOH
R05	223	A gas which is produced by internal combustion engines and contributes to the formation of acid rain is A. H_2 B. O_3 C. CH_4 D. NO_2

ANSWERS TO STUDY GUIDE QUESTIONS:

PROPERTIES AND DEFINITIONS

1. D
2. B
3. C
4. C
5. B
6. D
7. B
8. C
9. D
10. D
11. C
12. D
13. B
14. B
15. C
16. D
17. A
18. A
19. D
20. C
21. B
22. A
23. D
24. C
25. C
26. D
27. B
28. B

STRONG/WEAK ACIDS AND BASES

29. C
30. B
31. A
32. A
33. C
34. B
35. B
36. C
37. B
38. B
39. B
40. D
41. A
42. C
43. B
44. C
45. D
46. C
47. B
48. D
49. A
50. D

K_w, pH, pOH

51. D
52. A
53. D
54. B
55. A
56. A
57. A
58. B
59. B
60. C
61. B
62. C
63. A
64. C
65. B
66. A
67. C
68. C
69. B
70. C
71. C
72. C
73. B
74. D
75. A
76. A
77. C
78. C
79. B
80. C
81. C
82. C
83. B
84. D
85. A
86. D
87. C
88. C
89. C
90. B
91. B

K_a and K_b PROBLEM SOLVING

92. B
93. D
94. C
95. C
96. A
97. C
98. B
99. B
100. B
101. A
102. D
103. C
104. B
105. A
106. C
107. A
108. B
109. B
110. C
111. A
112. C
113. C

HYDROLYSIS OF SALTS

114. B
115. A
116. B

117. A
118. C
119. B
120. A
121. C
122. B
123. D
124. A
125. A
126. A
127. A
128. A
129. B
130. D
131. D
132. A

INDICATORS

133. A
134. C
135. A
136. A
137. C
138. D
139. C
140. B
141. B
142. A
143. A
144. C
145. A
146. A
147. D
148. B
149. B
150. B
151. B

NEUTRALIZATIONS OF ACIDS AND BASES

152. D
153. A
154. B
155. B
156. A
157. B
158. D
159. B
160. D
161. B
162. A
163. D
164. C
165. A
166. B
167. D
168. D
169. A
170. D
171. B
172. B
173. A
174. A
175. D
176. C
177. C
178. A
179. C
180. C
181. A
182. C
183. A
184. C
185. D
186. B
187. D
188. A
189. D
190. D
191. D

BUFFERS

192. C
193. D
194. D
195. A
196. C
197. B
198. C
199. C
200. D
201. C
202. C
203. D
204. C
205. C
206. C

ACID RAIN

207. A
208. A
209. D
210. B
211. A
212. A
213. A
214. A
215. B
216. A
217. B
218. B
219. B
220. D
221. C
222. B
223. D