PENRHOS COLLEGE

STRIVE FOR THE HIGHEST

Acids and Bases Test

NAME:_____   **TIME ALLOWED: 60 MINUTES**

Section One: Multiple Choice Questions   **(10 marks)**

1. Which of the following statements concerning the Bronsted theory of acids and bases is FALSE?
    a) In aqueous solutions, bases are those cations, anions or molecules that donate protons to other species.
    b) The ability to accept protons from other species in aqueous solutions is a property of bases.
    c) A base is produced when a cation, anion or molecule donate a proton in aqueous solution.
    d) When a proton is donated by one species to another in aqueous solution, the reaction is classified as acid-base.

2. Which of the following lists includes only acidic oxides?
    a) SO_3, MgO, Li_2O, P_4O_{10}
    b) CO_2, N_2O_5, SrO, GeO_2
    c) N_2O_5, Cl_2O_7, CO_2, SO_2
    d) Li_2O, Na_2O, K_2O, CaO

3. In which of the following reactions is the hydrogencarbonate ion acting as an acid?
    a) $HCO_3^-{}_{(aq)}$ + $H_2O_{(l)}$ $\rightleftharpoons$ $H_2CO_{3(aq)}$ + $OH^-{}_{(aq)}$
    b) $HCO_3^-{}_{(aq)}$ + $HSO_4^-{}_{(aq)}$ $\rightleftharpoons$ $H_2CO_{3(aq)}$ + $SO_4^{2-}{}_{(aq)}$
    c) $HCO_3^-{}_{(aq)}$ + $PO_4^{3-}{}_{(aq)}$ $\rightleftharpoons$ $CO_3^{2-}{}_{(aq)}$ + $HPO_4^{2-}{}_{(aq)}$
    d) $HCO_3^-{}_{(aq)}$ + $CH_3COOH_{(aq)}$ $\rightleftharpoons$ $H_2O_{(l)}$ + $CO_{2(g)}$ + $CH_3COO^-{}_{(aq)}$

4. Which of the following possibilities best describes the acidity/basicity of a solution of the following compounds when dissolved in distilled water?

	Sulfur dioxide	Ammonium nitrate	Sodium carbonate	Calcium oxide
a)	Acidic	Basic	Basic	Neutral
b)	Acidic	Acidic	Basic	Basic
c)	Acidic	Acidic	Neutral	Basic
d)	Basic	Basic	Acidic	Neutral

5. Which of the following would NOT change the pH of 10.0mL of a dilute hydrochloric acid solution when it is added to the acid?
   a) 10.0mL of pure water
   b) 10.0mL of sodium hydroxide solution
   c) 10.0mL of concentration hydrochloric acid solution
   d) 10.0mL of the same hydrochloric acid solution

6. Which of the following best described 10 $molL^{-1}$ ammonia?
   a) A dilute solution of a weak base
   b) A concentrated solution of a weak base
   c) A dilute solution of a strong base
   d) A concentrated solution of a strong base

7. 0.050 mole of $Ba(OH)_2$ is dissolved in a 0.100$molL^{-1}$ hydrochloric acid solution. The pH of the resulting solution will be;
   a) Less than 7
   b) Equal to 7
   c) Greater than 7
   d) Impossible to determine from the information given

8. A drop of phenolphthalein is added to a colourless aqueous solution and the resulting mixture turns pink. What is the best estimate of the solution's pH?
   a) 3
   b) 5
   c) 7
   d) 9

9. Water ionises according to the following reaction:

$$H_2O_{(\ell)} + HEAT \rightleftharpoons H^+_{(aq)} + OH^-_{(aq)}$$
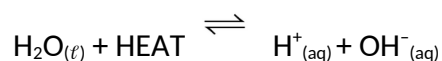
At 25°C the pH of pure water is 7.0. Which of the statements below best explains what would happen to the pH of the pure water if it were heated above 25°C?

(a)   It would increase, as the concentration of H^+ would increase.
(b)   It would stay the same, as the concentrations of $H^+_{(aq)}$ and $OH^-_{(aq)}$ would still be equal to each other.
(c)   It would decrease, as the concentration of H^+ would increase.
(d)   It would increase, as the concentration of OH^- would increase.

10. A sodium hydroxide solution for use in the Bayer Process was analysed as follows. About 20mL was transferred from the process tank to a 100mL bottle. From this 1.000mL was transferred by pipette to a 250mL conical flask and titrated with standard 0.2083 molL^{-1} hydrochloric acid from a burette.

All items of glassware were washed, and given a final rinse before use.
Which one of the following lists the appropriate liquids for the final rinses?

Option	The 100mL bottle	The 1.00mL pipette	The 250mL conical flask	The burette
a)	Water	Water	The NaOH solution	Water
b)	The NaOH solution	The NaOH solution	Water	The 0.2083 molL^{-1} HCl
c)	Water	Water	The NaOH solution	The 0.2083 molL^{-1} HCl
d)	Water	The NaOH solution	The NaOH solution	Water

End of Section One

Section Two: Short Answer Questions **(15 marks)**

1. Examine the equation below. [2 Marks]

$$HCO_3^-{}_{(aq)} \ + \ HSO_{4\,(aq)} \ \rightleftharpoons \ H_2CO_{3\,(aq)} \ + \ SO_4^{2-}{}_{(aq)}$$

Identify the conjugate acid/base pairs:

PAIR 1:

$HCO_3^-{}_{(aq)}$ and $H_2CO_{3\,(aq)}$

PAIR 2:

$HSO_{4\,(aq)}$ and $SO_4^{2-}{}_{(aq)}$

2. Explain the difference between the following terms: [4 Marks]
    a) The end point and the equivalence point of an acid/base titration.

    End point: when a colour change first occurs in a conical flask. This signals the change in pH.
    Equivalence Point: when equivalent stoichiometric amounts of acid and base have combined. This is the point when the titration should be stopped. Equivalence is not always achieved at the end point.

    b) Explain why the pH at the equivalence point of a titration of ammonia and hydrochloric acid is acidic. Include equations to support your reasoning.
    $NH_{3\,(aq)} + HCl_{(aq)} \Leftrightarrow NH_4Cl_{(aq)}$
    $NH_4^+{}_{(aq)} + H_2O_{(l)} \rightarrow NH_{3\,(aq)} + H_3O^+{}_{(aq)}$
    $NH_4Cl_{(aq)}$ is an acidic salt.
    The $NH_4^+{}_{(aq)}$ ions undergo a hydrolysis reaction and result in the solution being acidic as seen by the presence of the $H_3O^+{}_{(aq)}$ ions.

3. Are the following salts acidic, basic or neutral? Justify your answer by writing relevant chemical equations. [4 Marks]
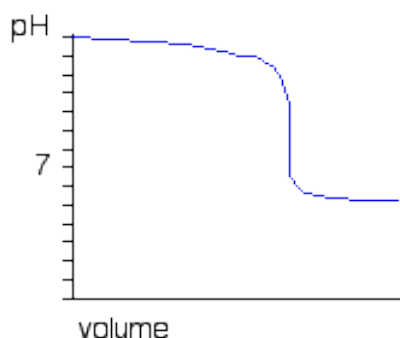   a) Sodium ethanoate
    $CH_3COO^-{}_{(aq)} + H_2O_{(l)} \Leftrightarrow CH_3COOH_{(aq)} + OH^-{}_{(aq)}$
    The presence of the $OH^-{}_{(aq)}$ ions makes the solution basic.

    b) Aluminium sulfate
    $Al_3SO_{4\,(aq)} + H_2O_{(l)} \Leftrightarrow [Al_3SO_3(OH)]^{2+} + H_3O^+{}_{(aq)}$
    The presence of the $H_3O^+{}_{(aq)}$ makes the solution acidic.

4. Shrena obtained the following pH curve during a titration experiment using 0.100 mol L^{-1} solutions. [5 Marks]

a) Name a base that she could have used in this titration.

NaOH

b) Name an acid that she could have used in this titration. Justify your answer.

CH_3COOH. It is a weak acid and from the graph the equivalence point is higher than 7 and is therefore basic.

c) Would methyl orange be a suitable indicator for this titration? Explain.

No methyl orange would not be a suitable indicator because it has a colour change at a pH of around 4. This pH of this solution is greater than that and so would require an indicator with a basic pH range such as phenolphthalein.

End of Section Two

Section Two: Extended Answer Questions   (15 marks)

1. Calculate the pH of a 0.0100 mol L^{-1} solution of barium hydroxide.   [2 marks]

$[OH^-]$ = 2 × 0.0100   = 0.0200 mol L^{-1}

$[H^+]$ = 1.00 × 10^{-14} / 0.0200

= 5.00 × 10^{-13} *[1]*

pH   = −log(5.00 × 10^{-13})

pH   = 12.3   [1]

2. Calculate the pH of the solution formed when 200 mL of a 2.00 mol L^{-1} solution of sodium hydroxide was added to 350 mL of 3.50 mol L^{-1} hydrochloric acid. [4 marks]

$n(OH^-)$ = c × V   = 2.00 × 0.200   = 0.400 mol

$n(H^+)$ = c × V = 3.50 × 0.350 = 1.225 mol *[1]*

$H^+ + OH^- \rightarrow H_2O$

H^+ in excess.

$n(H^+)_{used}$ = 0.400

$n(H^+)_{excess}$ = 1.225 − 0.400 = 0.825 mol *[1]*

V = 0.350 + 0.200 = 0.550 L

$c(H^+)$ = 0.825 / 0.550 = 1.50 mol L^{-1} *[1]*

pH = −log(1.5)

pH = − 0.18 *[accept - 0.2 if all working correct]* *[1]*

3. The acidity of wine is due to the grape acid tartaric acid HOOCCHOHCHOHCOOH(aq). A wine producer wishes to determine the percentage of tartaric acid in a sample of wine. Tartaric acid is a weak diprotic acid which ionizes according to the following equation:

$$HOOCCHOHCHOHCOOH_{(aq)} \rightarrow {}^-OOCCHOHCHOHCOO^-_{(aq)} + 2H^+_{(aq)}$$
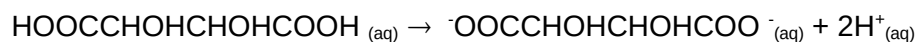
She takes a 20.0 mL sample of the wine and dilutes it to 250 mL in a volumetric flask. The diluted wine is then placed in a burette and is titrated against 20.0 mL samples of a standardized 0.0125 mol L-1 sodium hydroxide solution in a conical flask to which a suitable indicator has been added.

The results of four titrations of the diluted wine are shown in the following table:

	Titration 1	Titration 2	Titration 3	Titration 4
Initial volume (mL)	0.0	0.5	1.2	0.0
Final volume (mL)	13.5	12.5	13.1	12.1
Titre volume (mL)				

(a) Determine the appropriate average titre of diluted wine in this experiment. [1 mark]

Disregard Titration 1 since the titre volume is more than 0.2 mL above the lowest titre volume. Hence, average titre volume = [(12.0 + 11.9 + 12.1) mL] / 3 = 12.0 mL.

(b) Calculate the concentration of tartaric acid in the undiluted wine in mol L-1. [6 marks]

The reaction is: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

$n(OH^-) = n(NaOH) = c.V = (0.0125$ mol $L^{-1})(0.020L) = 2.50$ x 10^{-4} mol.   [1]

$n(H^+)$ (in 12.0 mL diluted wine) = 2.50 x 10^{-4} mol.   [1]

$n(H^+)$ (in 250 mL diluted wine) = (250 / 12) x (2.50 x 10^{-4} mol) = 5.208 x 10^{-3} mol. [1]

$n(H^+)$ (in 20 mL undiluted wine) = 5.208 x 10^{-3} mol.

$n(C_4H_6O_6) = (1/2)$ $n(H^+)$ = 2.604 x 10^{-3} mol.   [1]

(This is because <u>one</u> mole of tartaric acid releases <u>two</u> moles of H^+ in the titration

reaction!)

$c(C_4H_6O_6) = n / V = (2.604$ x 10^{-3} mol) / (0.020L) = 0.1302 mol L^{-1} [1]

<u>Ans (b): The concentration of tartaric acid in the undiluted wine is 1.30 x 10^{-1} mol L^{-1}</u>[1]

(c) Calculate the percentage by mass of tartaric acid in the wine given that
1.00 mL of the wine weighs 1.00 g.   [2 marks]

Consider 1.00 L of the original wine.

$n(C_4H_6O_6) = 0.1302$ mol.

$m(C_4H_6O_6) = n.M = (0.1302$ mol$)(150.088$ g mol$^{-1}) = 19.54$ g (per litre)

$\%(C_4H_6O_6) = [m(C_4H_6O_6) / m(1.00$ L wine$)]$ x 100   [1]

= [(19.54 g) / (1000 g)] x 100 = 1.95%

<u>Ans (c): The wine is 1.95% by mass tartaric acid.</u>   [1]

<u>**End of section Three**</u>