TRIAL TEST 2: ACIDS AND BASES

Time allowed:	70 minutes	Section 1 – Multiple Choice	20 marks
Total marks:	80	Section 2 – Short & Extended Answer	60 marks

SECTION 1 – MULTIPLE CHOICE (20 MARKS)

Section 1 – Multiple Choice (20 marks)

1. Which one of the following equations shows water behaving as a base?

(a) $CO_{(g)} + H_2O_{(g)} \rightarrow CO_{2(g)} + H_{2(g)}$
(b) $2Na_{(s)} + 2H_2O_{(l)} \rightarrow 2Na^+_{(aq)} + 2OH^-_{(aq)} + H_{2(g)}$
(c) $O^{2-}_{(aq)} + H_2O_{(l)} \rightarrow 2OH^-_{(aq)}$
(d) $NH_4^+{}_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + NH_{3(aq)}$

2. When phenolphthalein was added to a solution, a pink colour resulted. Which of the following statements could be correct for that solution?

(a) The solution was formed when 50.0 mL of 2.00 mol L^{-1} nitric acid was added to 50.0 mL of 2.00 mol L^{-1} sodium hydroxide.
(b) The solution was formed by the addition of 50.0 mL of 2.00 mol L^{-1} ethanoic acid to 50.0 mL of 2.00 mol L^{-1} potassium hydroxide.
(c) The solution was formed at the end point of a titration between a strong acid and a weak base.
(d) The solution was formed when 3.75g of ammonium chloride was dissolved in 20.0 mL of water.

3. Which one of the following statements is true?

(a) The hydrogen ion concentration of a neutral solution is dependent on the temperature of the solution.
(b) The equivalence point of a titration occurs when equal numbers of moles of acid and base have been mixed.
(c) A buffer solution can be produced by mixing equal quantities of a strong acid and strong base to ensure a plentiful supply of H^+ ions and OH^- ions.
(d) The salt produced when hydrochloric acid is reacted with sodium carbonate is weakly acidic.

4. A 2.50×10^{-2} mol L^{-1} ethanoic acid solution will have a pH of:

(a) 1.60
(b) -2.50
(c) more than 1.60 but less than 7.00
(d) dependent on the temperature of the water but always more than the pH of a hydrochloric acid solution with the same hydrogen ion concentration

5. Which of the following lists contains one acidic, one basic, and one neutral salt?

(a)	ammonium chloride	sodium hydrogensulfate	barium chloride
(b)	calcium nitrate	sodium chloride	ammonium chloride
(c)	barium nitrate	sodium phosphate	ammonium nitrate
(d)	barium sulfide	sodium fluoride	ammonium chloride

6. A buffer solution with a pH of approximately 4.7 was made by mixing 500 mL of 0.500 mol L^{-1} CH_3COOH with 500 mL of 0.500 mol L^{-1} $NaCH_3COO$.

$$CH_3COOH_{(aq)} + H_2O_{(l)} \prod H_3O^+_{(aq)} + CH_3COO^-_{(aq)}$$

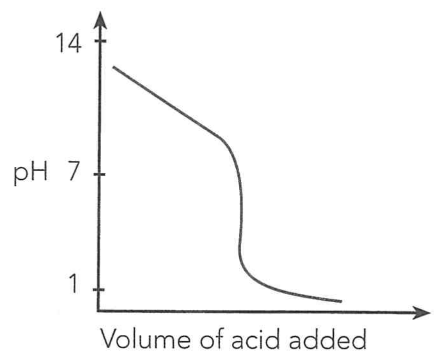
(a) The addition of a 10 mL of 0.01 mol L^{-1} $NaOH_{(aq)}$ would raise the pH of the buffer solution by consuming the H_3O^+ ions.
(b) The additional of small quantities of hydrochloric acid will force the equilibrium to shift to the left by favouring the reaction that partially counteracts the increased pH.
(c) The addition of any amount of sodium hydroxide solution will not greatly change the pH because this is a buffer solution.
(d) The addition of 10.0 mL of 0.01 mol L^{-1} HNO_3 would not greatly alter the pH of the solution but the concentration of the CH_3COO^- ions would decrease.

7. Sulfuric acid is not suitable for use as a primary standard because:
(a) In its manufacture, there is uncertainty about how much SO_3 is dissolved in each litre of water.
(b) It is a strong acid and so will react too rapidly.
(c) It does not have a sufficiently high molar mass.
(d) It produces sulfate salts which are sometimes insoluble.

8. A solution was produced by blending 500 g of celery, boiling it for 20 minutes in water and then straining the mixture. Analysis found it to have a pH of 4.2. The hydroxide ion concentration of this solution would be closest to which value stated below?
(a) 3×10^{8} mol L^{-1}
(b) 2×10^{-10} mol L^{-1}
(c) 4×10^{-12} mol L^{-1}
(d) 5×10^{-13} mol L^{-1}

9. A student prepared a sodium hydroxide solution by dissolving 1.15 g of sodium hydroxide pellets in enough water to make exactly 50.0 mL of solution. This 50.0 mL of solution was then titrated against a 0.995 mol L^{-1} HCl solution. The end point of the titration was noted when 22.5 mL of the acid had been added instead of the expected 28.9 mL. The most likely cause of this lower then expected result would be:
(a) the student chose methyl orange as an indicator instead of phenolphthalein.
(b) the sodium hydroxide pellets had absorbed water from the atmosphere prior to weighing.
(c) the student rinsed the burette with a small quantity of HCl solution before filling it with HCl solution.
(d) the 50.0 mL volumetric flash was rinsed with distilled water before the sodium hydroxide pellets were added.

10. The results of an acid base titration are shown in the graph to the right. Which of the following statements would be true about the titration?



(a) The titration was between 0.01 mol L^{-1} NaOH and 0.01 mol L^{-1} HCl.
(b) Phenolphthalein could be used as an indicator.
(c) Phenolphthalein or methyl orange could be used as an indicator.
(d) The titration involved a strong acid.

SECTION 2 – SHORT AND EXTENDED ANSWER (60 MARKS)

Answer each question in the space provided.

11. Give a chemical test and subsequent observations that could be used to distinguish between the following pairs of substances. You must clearly state the expected observation for each substance tested. No equations need to be given.

(a) 1 mol L^{-1} H_2SO_4 and 1 mol L^{-1} HNO_3

TEST ______________________________

OBSERVATION ______________________________

____

(b) Two white powders: magnesium carbonate and magnesium hydroxide

TEST ______________________________

OBSERVATION ______________________________

____

(c) Two colourless solutions: potassium ethanoate and potassium chloride

TEST ______________________________

OBSERVATION ______________________________

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[12 marks]

12. Write balanced ionic equations for the following:

(a) $Ba(OH)_{2(aq)} + H_2SO_{4(aq)}$

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(b) $KOH_{(aq)} + H_3PO_{4(aq)}$

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(c) $CaCO_{3(s)} + HCl_{(aq)}$

____

[6 marks]

13. Use equations to help explain why a 0.01 mol L^{-1} HCl solution has a lower pH than a 0.01 mol L^{-1} CH_3COOH solution

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[4 marks]

14. Write ionic equations for the process that occurs when the following acids are dissolved in water.

(a) carbonic acid: ______________________

(b) phosphoric acid: ______________________

(c) sulfuric acid: ______________________

[6 marks]

15. (a) Explain what hydrolysis of a salt is.

(b) Write equations to show the hydrolysis of the following salts. State if the result is an acidic, basic or neutral solution

(i) Na_2CO_3 ______________________

(ii) $(CH_3COO)_2Ca$ ______________________

(iii) NH_4NO_3 ______________________

[8 marks]

16. (a) State four characteristics of a primary standard.

(b) NaOH is deliquescent. Explain what this means.

(c) Explain the difference between the end point and the equivalence point of a titration.

[8 marks]

17. A solution was prepared by mixing 800 mL of 0.150 mol L^{-1} NaH_2PO_4 with 800 mL of 0.650 mol L^{-1} Na_2HPO_4. The solution was found to have a pH of approximately 7.2.

(a) Write the equation for the equilibrium that would be established between the $H_2PO_4^-$ and HPO_4^{2-} ions.

____

[1 mark]

(b) Use Le Châtelier's Principle to predict what would happen to the pH of the solution if 30 mL of 0.01 mol L^{-1} sodium hydroxide solution was added.

____

____

[3 marks]

(c) Explain (qualitatively) what would happen to the pH of the solution if 200 mL of 2 mol L^{-1} hydrochloric acid solution were added.

____

[2 marks]

18. In an experiment, a student was required to standardise a solution of hydrochloric acid using the primary standard, sodium carbonate. The sodium carbonate solution was prepared by dissolving 2.23 g of anhydrous sodium carbonate in enough distilled water to correctly fill a 500.0 mL volumetric flask. 20.0 mL aliquots of this solution were then titrated against a solution of hydrochloric acid. The volume of HCl used in the titrations is shown in the table below:

Titration	1	2	3	4	5
Initial reading (mL of HCl)	0.00	3.10	4.00	2.60	1.90
Final reading (mL of HCl)	42.50	44.80	45.30	44.00	43.20
Volume added					

Determine the concentration of the hydrochloric acid solution.

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____

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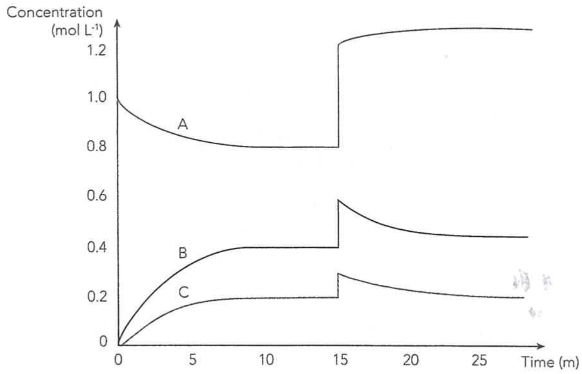
[10 marks]

END OF TEST (80 MARKS)

(d) *Pressure was increased by reducing volume of the containing vessel.*

(e)



(f) *The equilibrium will shift so as to compensate for the greater imposed pressure. Moves right as there are less molecules. Concentration of the H_2 affected most as there are two molecules of it. The other reactants affected equally (one molecule of each) but in opposite directions.*

[16]

TRIAL TEST 2:
Acids and Bases

Section 1

1. d	6. d
2. b	7. a
3. a	8. b
4. c	9. b
5. c	10. d

[20]

Section 2

11.

(a) *Test: Add $Ba(NO_3)_{2(aq)}$ to both solutions*
Observation: white precipitate forms in the H_2SO_4, no change in the HNO_3

(b) *Test: Add powders to HCl solutions*
Observation: $MgCO_3$ will fizz as bubbles of gas are produced, $Mg(OH)_2$ will simply dissolve

(c) *Test: Add universal indicator to both*
Observation: KCl solution will turn green, KCH_3COO will form orange/yellow.

[12]

12.

(a) $Ba^{2+}(aq) + 2OH^-(aq) + 2H^+(aq) + SO_4^{2-}(aq) \rightarrow BaSO_{4(s)} + 2H_2O(l)$

(b) $3OH^-(aq) + H_3PO_{4(aq)} \rightarrow PO_4^{3-}(aq) + 3H_2O(l)$

(c) $CaCO_{3(s)} + 2H^+(aq) \rightarrow Ca^{2+}(aq) + CO_2(g) + H_2O(l)$

[6]

13. *HCl is a strong acid and is completely ionized when in solution*

$HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$

For HCl, the $[H^+] = [HCl]$

CH_3COOH is a weak acid and so only a small percentage of molecules ionise

$CH_3COOH(aq) \rightleftharpoons H^+(aq) + CH_3COO^-(aq)$

For CH_3COOH, the $[H^+] < [CH_3COOH]$
Therefore, $[H^+]$ in HCl is > $[H^+]$ in CH_3COOH and pH of 0.01 mol L^{-1} HCl is less

[4]

14. (a) $H_2CO_{3(aq)} \rightleftharpoons H^+(aq) + HCO_3^-(aq)$

(b) $H_3PO_{4(aq)} \rightleftharpoons H^+(aq) + H_2PO_4^-(aq)$

(c) $H_2SO_{4(aq)} \rightleftharpoons H^+(aq) + HSO_4^-(aq)$

[6]

15.

(a) *Hydrolysis is the reaction between a salt and water to produce either H_3O^+ ions or OH^- ions.*

(b)

(i) $CO_3^{2-}(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + OH^-(aq)$; *basic*

(ii) $CH_3COO^-(aq) + H_2O(l) \rightleftharpoons CH_3COOH(aq) + OH^-(aq)$; *basic*

(iii) $NH_4^+(aq) + H_2O(l) \rightleftharpoons NH_{3(aq)} + H_3O^+(aq)$; *acidic*

[8]

16.

(a) *be obtained pure; have a known formula; not react with surroundings; have a high molar mass*

(b) *deliquescent: absorbs water from the atmosphere and dissolves in the water*

(c) *end point: the point at which the titration is stopped because the desired colour change is observed*
equivalence point: reactants have been mixed in stoichiometrically equivalent amounts

[8]

17.

(a) $H_2PO_4^-(aq) + H_2O(l) \rightleftharpoons HPO_4^{2-}(aq) + H_3O^+(aq)$

(b) *The OH^- ions will reduce the concentration of the H_3O^+ ions. The forward reaction would be favoured to partially counteract this change and the pH would remain reasonably constant.*

(c) *The buffer capacity of the solution would be exceeded and the pH would drop considerably.*

[6]

18. $2HCl + Na_2CO_3 \rightarrow 2NaCl + CO_2 + H_2O$

2 mol *1 mol*

$M(Na_2CO_3) = 45.98 + 12.01 + 48.00 = 105.99$

$n(Na_2CO_3)$ in 500 mL $= \frac{m}{M} = \frac{2.23}{105.99}$
$= 0.0210$ mol

$c(Na_2CO_3) = \frac{n}{V} = 0.0421 \text{ mol L}^{-1}$

$n(Na_2CO_3)$ used in titration $= cV$

$= 0.0421 \times 0.0200 = 8.42 \times 10^{-4}$ mol

$n(HCl) = 2n(Na_2CO_3)$

$= 2 \times 8.42 \times 10^{-4} = 1.68 \times 10^{-3}$

$c(HCl) = \frac{n}{V} = \frac{1.68 \times 10^{-3}}{0.0413}$

$= 4.08 \times 10^{-2} \text{ mol L}^{-1}$

TRIAL TEST 3: Oxidation and Reduction

Section 1

1. d	6. d
2. c	7. a
3. d	8. a
4. a	9. b
5. c	10. a

[20]

Section 2

11.

(a) Equation: $Br_{2(aq)} + 2I^-_{(aq)} \rightarrow 2Br^-_{(aq)} + I_{2(aq)}$
Observation: straw yellow solution turns a red/brown colour

(b) Equation: $Zn_{(s)} + Cu^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$
Observation: metal turns black and then black coloured crystals grow on it.
Solution loses blue colour

(c) Equation: $2Na_{(s)} + 2H_2O_{(l)} \rightarrow 2Na^+_{(aq)} + 2OH^-_{(aq)} + H_{2(g)}$
Observation: silver coloured metal fizzes around on top of water, colourless, colourless gas produced

(d) Equation: $2MnO_4^-{}_{(aq)} + 5H_2O_{2(aq)} + 6H^+_{(aq)} \rightarrow 2Mn^{2+}_{(aq)} + 5O_{2(g)} + 8H_2O_{(l)}$
Observation: purple solution goes colourless and bubbles of colourless odourless gas produced

[12]

12.

(a)

(i) Oxidation $Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^-$
Reduction $2H^+_{(aq)} + 2e^- \rightarrow H^2_{(g)}$

(ii) Oxidation $Mg_{(s)} \rightarrow Mg^{2+}_{(aq)} + 2e^-$
Reduction $2H_2O_{(l)} + 2e^- \rightarrow 2OH^-_{(aq)} + H_{2(g)}$

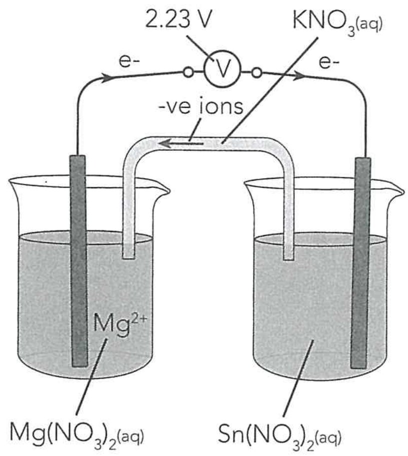
(b)

(i) Oxidation $Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^-$
Reduction $(Ag^+_{(aq)} + e^- \rightarrow Ag_{(s)}) \times 2$
Redox $Zn_{(s)} + 2Ag^+_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Ag_{(s)}$

(ii) Oxidation $Mg_{(s)} \rightarrow Mg^{2+}_{(s)} + 2e^-$
Reduction $Cl_{2(g)} \rightarrow 2Cl^-_{(s)}$
Redox $Mg_{(s)} + Cl_{2(g)} \rightarrow MgCl_{2(s)}$

[10]

13.



ANODE: $Mg \rightarrow Mg^{2+} + 2e^-$
CATHODE: $Sn^{2+} + 2e^- \rightarrow Sn$

[12]

14.

(a) Anode: $Fe \rightarrow Fe^{2+} + 2e^-$
Cathode: $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$
Rust formation: $2Fe(OH)_3 \rightarrow Fe_2O_3.H_2O + 2H_2O$

(b) (i) Coat the windmill with a paint to stop the oxygen and water coming in contact with the iron. This will prevent the cathodic reaction.
(ii) Connect another metal of higher oxidation potential to the windmill so that the iron acts as a cathode and the other metal an anode. For example if the other metal is zinc it will oxidise instead of the iron.

[12]

15.

(a)

(i) $(Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2e^-) \times 2$ *anodic reaction*
$O_{2(g)} + 2H_2O_{(l)} + 4e^- \rightarrow 4OH^-_{(aq)}$ *cathodic reaction*

$2Fe_{(s)} + O_{2(g)} + 2H_2O_{(l)} \rightarrow 2Fe(OH)_{2(s)}$

(ii) $4Fe(OH)_{2(s)} + 2H_2O_{(l)} + O_{2(g)} \rightarrow 4Fe(OH)_{3(s)}$
(iii) $2Fe(OH)_{3\,(s)} \rightarrow Fe_2O_3\,.\,H_2O + 2H_2O_{(l)}$

(b) Any two of the following:

- Painting or plating the iron. This excludes air and/or water hence reaction prevented.
- Using a sacrificial anode such as galvanising