UNIT 3BCHE

ACIDS AND BASES **Answer all questions**

Section One: Multiple Choice (10 marks)

Q1. Which of the following volumes of a 0.040 mol L^{-1} potassium hydroxide solution is required to react exactly with 20.0 mL of a 0.010 mol L^{-1} diprotic acid?

A. 1.0 mL

B. 5.0 mL

C. 10.0 mL

D. 20.0 mL

Q2. Phosphorus pentoxide reacts with water to form phosphoric acid according to the following equation.

$$P_2O_{5(s)} + 3H_2O_{(l)} \rightarrow 2H_3PO_{4(aq)}$$

Phosphoric acid reacts with sodium hydroxide according to the following equation.

$$H_3PO_{4(aq)} + 3NaOH_{(aq)} \rightarrow Na_3PO_{4(aq)} + 3H_2O_{(l)}$$

A student reacted 1.42 g of phosphorus pentoxide with excess water.

What volume of 0.30 mol L^{-1} sodium hydroxide would be required to neutralise all the phosphoric acid produced?

A. 0.067 L

B. 0.10 L

C. 0.20 L

D. 5.0 L

Q3. Which of the following is most **UNLIKELY** to act as both a Bronsted - Lowry acid and base?

A. OH^-

B. HPO_4^{2-}

C. HS^-

D. NH_4^+

Q4. Which statement best describes the equivalence point in a titration between a strong acid and a strong base?

A. The point at which the first sign of a colour change occurs

B. The point at which equal moles of acid and base have been added together

C. The point at which equal moles of H^+ ions and OH^- ions have been added together

D. The point at which the rate of the forward reaction equals the rate of the reverse reaction

Q5. In a titration of a strong base with a weak acid, the following procedure was used:

1. ***A burette was rinsed with water and then filled with the standard base.***
2. ***A pipette was rinsed with some acid solution.***
3. ***A conical flask was rinsed with some acid solution.***
4. ***A pipette was used to transfer a measured volume of acid solution into the conical flask.***
5. ***Indicator was added to the acid sample and it was titrated to the endpoint with the base.***

Which statement is correct?

A. The calculated acid concentration will be correct.

B. The calculated acid concentration will be too high.

C. The calculated acid concentration will be too low.

D. No definite conclusion can be reached about the acid concentration.

Q6. Sulfuric acid (H_2SO_4) and nitric acid (HNO_3) are both strong acids. Ethanoic acid (CH_3COOH) is a weak acid.

20.00 mL solutions of 0.10 M concentration of each of these three acids were separately titrated with a 0.10 M solution of sodium hydroxide (NaOH).

In order to react completely

A. all three acids would require the same amount of NaOH.

B. HNO_3 would require more NaOH than CH_3COOH but less than H_2SO_4.

C. H_2SO_4 and HNO_3 would require the same amount of NaOH but CH_3COOH would require less.

D. CH_3COOH and HNO_3 would require the same amount of NaOH but H_2SO_4 would require more.

Q7. Which of the following examples represents an acid-base reaction?

A. $NH_4^+{}_{(aq)} + OH^-{}_{(aq)} \rightarrow NH_{3(aq)} + H_2O_{(l)}$

B. $2NO_3^-{}_{(aq)} + 2H^+{}_{(aq)} + 3H_2O_{2(aq)} \rightarrow 2NO_{(g)} + 3O_{2(g)} + 4H_2O_{(l)}$

C. $2K_{(s)} + 2H_2O_{(l)} \rightarrow 2K^+{}_{(aq)} + 2OH^-{}_{aq)} + H_{2(g)}$

D. $Ca^{2+}{}_{(aq)} + CO_3^{2-}{}_{(aq)} \rightarrow CaCO_{3(s)}$

Q8. Methanoic acid and azoic acid are both weak acids with the following acidity constants (equilibrium constants).

		Ka in M at 25^0C
methanoic acid	(HCOOH)	1.82×10^{-4}
azoic acid	(HN_3)	1.91×10^{-5}

Two separate solutions were prepared,
one of 0.1 M methanoic acid and the other of 0.1 M azoic acid.
Which one of the following would be present in the highest concentration at 25^0C?

A. HN_3 in the azoic acid solution

B. N_3^- in the azoic acid solution

C. HCOOH in the methanoic acid solution

D. $HCOO^-$ in the methanoic acid solution

Q9. Acid *X* is 0.1 mol L^{-1} hydrochloric acid. Acid *Y* is 1.0 mol L^{-1} acetic acid (ethanoic acid).

How does acid *X* compare with acid *Y*?

A. *X* is weaker and more dilute than *Y.*

B. *X* is stronger and more dilute than *Y.*

C. *X* is weaker and more concentrated than *Y.*

D. *X* is stronger and more concentrated than *Y.*

Q10. Pure water undergoes self-ionisation. The equilibrium constant for the reaction at 95^oC is 4.8×10^{-13}. This corresponds to a pH of 6.2. Which of the following statements is true?

A. The pH has been worked out incorrectly.

B. At 95^oC the water is acidic.

C. At 95^oC the water is basic.

D. At 95^oC the water is neutral.

END OF PART A

Section Two: Short Answer (15 marks)

Q11. Write equations for any reactions that occur in the following procedures. If no reaction occurs write 'no reaction'.

In each case describe **in full** what you would observe, including any

- colours
- odours
- precipitates (give the colour)
- gases evolved (give the colour or describe as colourless).

If no change is observed, you should state this.

A. Ammonia gas is bubbled through dilute nitric acid solution.

Net Ionic Equation: ____

Observation: ____

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B. A 3 cm strip of magnesium ribbon is added to 5 mLs of sulfuric acid solution.

Net Ionic Equation: ____

Observation: ____

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C. Sodium hydroxide solution is added to ammonium chloride solid.

Net Ionic Equation: ____

Observation: ____

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D. Dilute hydrochloric acid is added to solid nickel carbonate.

Net Ionic Equation: ____

Observation: ____

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Section Two (contd.)

Q12. You performed a first-hand investigation to identify the pH of a range of salt solutions.

Identify an acidic salt you used. _______________________________

Explain the acidic nature of the salt you selected. Include a balanced chemical equation in your answer.

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Balanced chemical equation

Q13. Correct swimming pool maintenance requires regular monitoring of the pH level of the water. Another part of swimming pool maintenance is adjusting chlorine levels in the pool. 'Liquid chlorine' is a solution of sodium hypochlorite ($NaOCl$) which can be used to do this. Upon addition of sodium hypochlorite to the pool, the following equilibrium reaction occurs:

$$OCl^-_{(aq)} + H_2O_{(l)} \qquad HOCl_{(aq)} + OH^-_{(aq)}$$

A. State a reason for the regular chlorination of swimming pool water.

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B. Explain how the addition of sodium hypochlorite will affect the pH of the water in the pool.

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Q14

A. CH_3NH_2, is a colourless gas with a pungent, choking odour. It is very soluble in water and the resulting solution is alkaline.
Assign or give CH_3NH_2 an IUPAC or systematic name.

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B. Write an equation to account for the production of an alkaline solution when CH_3NH_2 dissolves in water.

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C. In the above reaction CH_3NH_2 is acting as a base.
Draw an electron dot or Lewis diagram of CH_3NH_2 and of the species it becomes in B above.

CH_3NH_2	Species formed when CH_3NH_2 dissolves in water.

D. What property of CH_3NH_2 allows it to act as a base?

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Q15. **Section Three: Extended Answer (15 marks)**

The calculations are to be set out in detail. Marks will be allocated for correct equations and clear setting out, even if you cannot complete the problem. When questions are divided into sections, clearly distinguish each using (a), (b), and so on. Express your final numerical answers to three (3) significant figures where appropriate, and provide units where applicable. Information which may be necessary for solving the problems is located on the separate Chemistry Data Sheet. Show clear reasoning: if you don't, you will lose marks.

11.732 g sodium hydrogen carbonate was dissolved in water and made up to exactly 500 mL. 25 mL of this solution was titrated with sulfuric acid solution and required 33.8 mL.

A. Calculate the concentration of the sulfuric acid solution.

An approximately 0.2 $molL^{-1}$ sodium hydroxide solution was then standardised by titrating 25 mL of it with this sulfuric acid solution; 26.2 mL of the acid was required.

B. Calculate the concentration of the hydroxide solution.
C. Calculate the pH of the hydroxide solution.

A. Calculate the concentration of the sulfuric acid solution.

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B. Calculate the concentration of the hydroxide solution.

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Calculation continued overleaf

C. Calculate the pH of the hydroxide solution.

Q16.

A. List the characteristics of a Primary Standard?

B. Name 2 substances (name or formula) which could be used as primary standards.

Substance 1 Substance 2

C. Name 1 substance which cannot be used as a primary standard and give reasons to support you choice in each case.

Substance 1

Reason

D. Explain how you would prepare an accurate solution of a primary standard, mentioning all precautions you would take.

End of test

UNIT3BCHE SOLUTIONS

ACIDS AND BASES: Answer all questions

Section One: Multiple Choice (10 marks)

1C	2C	3D	4C	5B	6D	7A	8A	9B	10D

Section Two: Short Answer (15 marks)

11.

A. $NH_{3(g)} + H^+_{(aq)} \rightarrow NH_4^+{}_{(aq)}$
The colourless pungent gas dissolves.

B. $Mg_{(s)} + 2H^+_{(aq)} \rightarrow Mg^{2+}_{(aq)} + H_{2(g)}$
The silver/grey metal dissolves, a colourless, odourless gas is produced.

C. $NH_4Cl_{(s)} + OH^-_{(aq)} \rightarrow NH_{3(aq)} + H_2O_{(l)} + Cl^-_{(aq)}$
White solid dissolves, colourless pungent gas produced.

B. $NiCO_{3(s)} + 2H^+_{(aq)} \rightarrow Ni^{2+}_{(aq)} + CO_{2(g)} + H_2O_{(l)}$
The green solid dissolves, colourless gas produced, colourless solution turns green.

12. Ammonium chloride (NH_4Cl)
The salt undergoes hydrolysis i.e. it reacts with water where the cation from a weak base donates a proton (acts as a Bronsted – Lowry acid) to water forming hydronium ions.
$NH_4^+{}_{(aq)} + H_2O_{(l)} \rightarrow NH_{3(aq)} + H_3O^+_{(aq)}$

13.

A. Chlorine is added to swimming pools for sanitation purposes i.e. it kills pathogens (disease causing organisms). Chlorine in the form of OCl^- acts as an oxidant (oxidising agent) stripping electrons from pathogens and killing (inactivating) them.

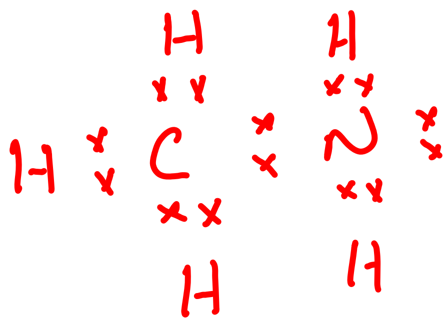
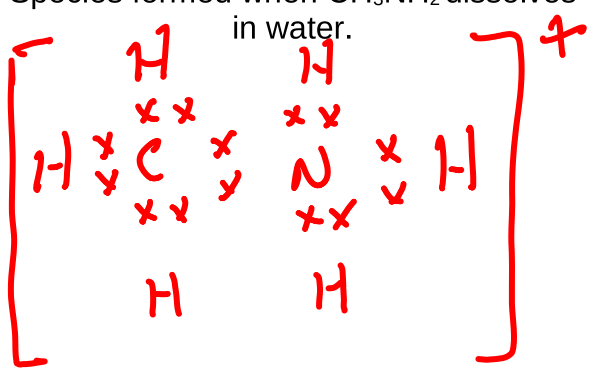
B. According to Le Chatelier's Principle the addition of OCl^- will push the position of equilibrium to the right to partially counteract the addition of OCl^- by removing some of it. This leads to an increase in $[OH^-]$ ions. Consequently the pH increases.

14.

A. Methanamine

B. $CH_3NH_2 + H_2O \rightarrow CH_3NH_3^+ + OH^-$

C.

CH_3NH_2	Species formed when CH_3NH_2 dissolves in water.
	

D. It has a lone pair of electrons which can accept a proton (H^+ ion) and form a coordinate or dative bond

Section Three: Extended Answer (15 marks)

15.

A. $n(NaHCO_3)$ = m/M = 11.732 g ÷ 84.008 g = 0.13965 mol
$[NaHCO_3]$ = n/V = 0.13965 ÷ 0.5 = 0.2793 $molL^{-1}$
$2NaHCO_3 + H_2SO_4 = 2Na^+ + 2CO_2 + SO_4^{2-} + 2H_2O$
$n(NaHCO_3)$ = cV = 0.2793 x 0.025 = 0.00698
$n(H_2SO_4)$ = ½ x $n(NaHCO_3)$ = ½ x 0.00698 = 0.00349
$[H_2SO_4]$ = n/V = 0.00349 ÷ 0.0338 = 0.1032
= 0.103 $molL^{-1}$

B. $n(H_2SO_4)$ = cV = 0.103 x 0.0262 = 0.002706 mol
$2NaOH + H_2SO_4 \rightarrow$
n(NaOH) = 2 x $n(H_2SO_4)$ = 2 x 0.002706 = 0.005412 mol
[NaOH] = n/V = 0.005412 ÷ 0.025 = 0.2164
= 0.216 $molL^{-1}$

C. $[OH^-]$ = 0.216 $molL^{-1}$
$[H^+] \times [OH^-]$ = 10^{-14}
$[H^+]$ = $10^{-14} \div [OH^-] = 10^{-14} \div 0.216 = 4.629 \times 10^{-14}$
pH = $-\log 4.629 \times 10^{-14}$
= 13.3

alternatively

$[OH^-]$ = 0.216 $molL^{-1}$
pOH = $-\log [OH^-]$ = = $-\log 0.216$ = 0.6655
pH + pOH = 14
pH = 14 – pOH = 14 – 0.6655
= 13.3

16.

A. It is easily obtainable in a very pure form and have a known formula
It does not react with oxygen or carbon dioxide of the air.
It does not absorb moisture from the air i.e. it is not deliquescent or hydroscopic.
It has a reasonably high relative molar mass M_r in order to minimise weighing errors
Its reaction with the substance to be analysed is complete and the equation for the resaction is known.
It is soluble under the conditions of use.

B. Anhydrous sodium carbonate Na_2CO_3
sodium hydrogen sulfate $NaHSO_4$
oxalic acid (ethandioic acid) $(COOH)_2.2H_2O$ (Redox titrations)

C. Sodium hydroxide
It is deliquescent i.e. it reacts with H_2O of the air. It also reacts with CO_2 of the air, hence its mass constantly changes.

D. Rinse volumetric flask with distilled water
Accurately weigh out the pure solid
Dissolve the pure solid in some distilled water
Transfer all of the dissolved solid + rinsings to the volumetric flask

Bring solution volume up to the mark with distilled water making sure that the meniscus sits on the mark

Invert the volumetric flask a number of times to ensure the concentration is even throughout