

# SEMESTER 1 EXAMINATION 2011

## QUESTION/ANSWER BOOKLET

## CHEMISTRY Stage 3

NAME: \_\_\_\_\_

CLASS: \_\_\_\_\_

### TIME ALLOWED FOR THIS PAPER

Reading time before commencing work: Ten minutes  
Working time for paper: Two and a half hours

### MATERIAL REQUIRED/RECOMMENDED FOR THIS PAPER

#### *TO BE PROVIDED BY THE SUPERVISOR*

This Question/Answer Booklet  
Separate Multiple Choice Answer Sheet  
Chemistry Data Sheet

#### *TO BE PROVIDED BY THE CANDIDATE*

*Standard Items:* Pens, pencils, eraser, correction fluid, ruler, highlighters

*Special Items:* Non-programmable calculators satisfying the conditions set by the Curriculum Council for this course

### **\*\* IMPORTANT NOTE TO CANDIDATES \*\***

**No other items may be taken into the examination room.**

**It is your responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor BEFORE reading any further.**

## STRUCTURE OF PAPER

Section	Number of questions available	No of Questions to be answered	Suggested working time ( minutes)	Marks available	Percentage of exam
Part One: Multiple-choice	25	25	40	25	20
Part Two: Short answer	8	8	45	50	40
Part Three: Calculator	4	4	45	40	32
Part Four: Extended answer	2	1	20	10	8
					100

## INSTRUCTIONS TO CANDIDATES

1. The rules for the conduct of Tuart College Examinations are detailed in the College Diary. Sitting this examination implies that you agree to and abide by these rules.

2. Answer the questions according to the following instructions:

Section One: Answer all questions on the separate Multiple-choice Answer Sheet provided. For each question shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square, do not erase or use correction fluid, and shade your new answer. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Sections Two and Three: Write answers in this Question/Answer booklet

3. When calculating numerical answers, show your working or reasoning clearly unless instructed otherwise. For some questions full marks will not be awarded for an answer without supporting working. The working must show concise logical steps.
4. Numerical answers are to be given to the appropriate number of significant figures.
5. For full marks, chemical equations should refer only to those species consumed in the reaction and new species produced. These species may be ions [for example  $\text{Ag}^+(\text{aq})$ ], molecules [for example  $\text{NH}_3(\text{g})$ ,  $\text{NH}_3(\text{aq})$ ,  $\text{CH}_3\text{COOH}(\text{l})$ ,  $\text{CH}_3\text{COOH}(\text{aq})$ ] or solids [for example  $\text{BaSO}_4(\text{s})$ ,  $\text{Cu}(\text{s})$ ,  $\text{Na}_2\text{CO}_3(\text{s})$ ].

**Part One: Multiple Choice (25 marks)**

This section has **25** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square, do not erase or use correction fluid, and shade your new answer. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time for this section is 40 minutes

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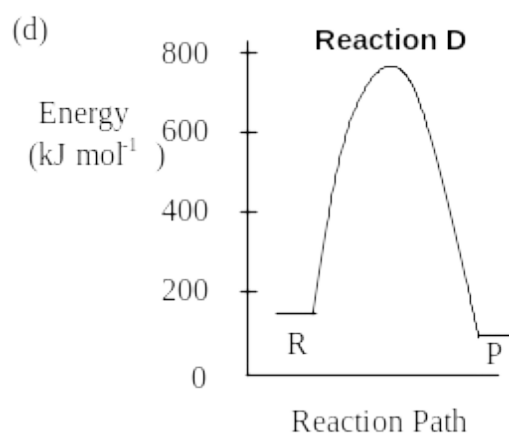
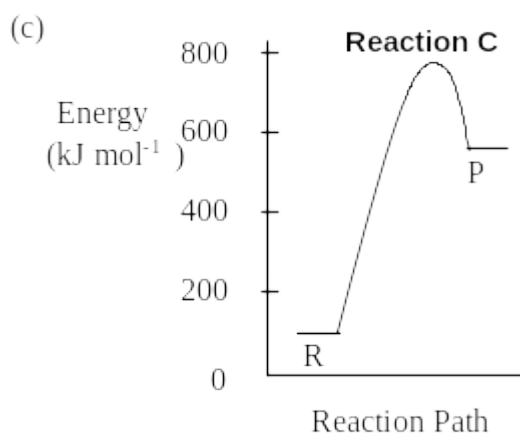
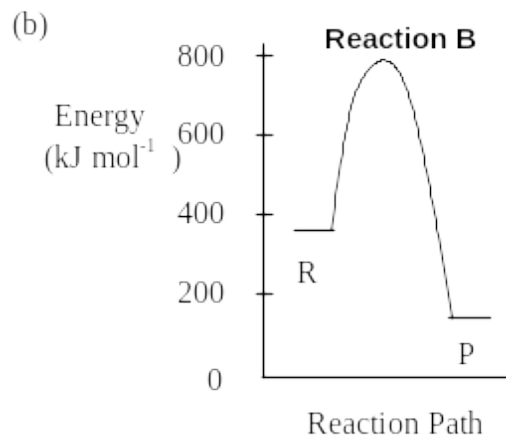
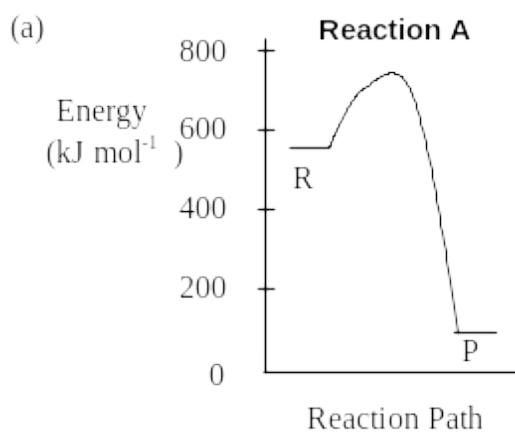
1. Which one of the following statements best describes the halogens?
  - (a) They are monatomic molecules that form  $X^{2-}$  ions
  - (b) They are diatomic molecules that form  $X^-$  ions
  - (c) They are monatomic molecules that form  $X^-$  ions
  - (d) They are monatomic molecules that form  $X_2^-$  ions
  
2. Which one of the following **best** explains why metals conduct electricity?
  - (a) All metals are strongly electronegative
  - (b) In a metal crystal lattice, the metal atoms are not bonded strongly to each other
  - (c) Metal atoms have two electrons in their valence shells and these are easily removed
  - (d) The valence electrons of a metal do not belong to a particular atom but to the crystal or liquid as a whole.
  
3. Which one of the following best explains the polarity of carbon dioxide?
  - (a) The  $CO_2$  molecule is non-polar because, although the carbon to oxygen bond is polar, the molecule is linear.
  - (b) The  $CO_2$  molecule is non-polar because O is more electronegative than C.
  - (c) The  $CO_2$  molecule is non-polar because the molecule is bent or V-shaped.
  - (d) The  $CO_2$  molecule is non-polar because the molecule is bent or V-shaped and O is more electronegative than C.
  
4. Which one of the following pairs of substances forms a buffer in aqueous solution?
  - (a)  $H_2CO_3$  (aq) and  $HCO_3^-$  (aq)
  - (b)  $H_3O^+$  (aq) and  $OH^-$  (aq)
  - (c)  $HCl$  (aq) and  $Cl^-$  (aq)
  - (d)  $NaOH$  (aq) and  $HNO_3$  (aq)
  
5. The inert gas element with the lowest boiling point is:
  - (a) Helium
  - (b) Neon

- (c) Argon  
(d) Chlorine
6. The set that contains a molecule, an ionic solid and a network solid (not necessarily in that order) is:
- (a)  $\text{NaCl}$ ,  $\text{MgO}$  and  $\text{Al}_2\text{O}_3$   
(b)  $\text{NaCl}$ ,  $\text{SiO}_2$  and  $\text{CO}_2$   
(c)  $\text{HCl}$ ,  $\text{H}_2\text{O}$  and  $\text{SiO}_2$   
(d)  $\text{NaCl}$ ,  $\text{MgO}$  and  $\text{SiC}$
7. Which one of the following pairs of reagents would give **no** observable evidence of a chemical reaction when mixed?
- (a) Lead (II) nitrate solution and potassium iodide solution  
(b) Potassium and water  
(c) Sodium hydroxide and warm ammonium chloride solution  
(d) Barium hydroxide solution and potassium chloride solution
8. Identify the strongest base in the following equilibrium. The concentration of products is much higher than the concentration of reactants.
- $$\text{HTe}^- + \text{NH}_3 \rightleftharpoons \text{H}_2\text{Te} + \text{NH}_2^-$$
- (a)  $\text{HTe}^-$   
(b)  $\text{NH}_3$   
(c)  $\text{H}_2\text{Te}$   
(d)  $\text{NH}_2^-$
9. Which one of the following statements is true concerning the titration of a  $0.100 \text{ mol L}^{-1}$  hydrochloric acid solution with  $20.00 \text{ mL}$  of an approximately  $0.1 \text{ mol L}^{-1}$  sodium carbonate solution?
- (a) The equivalence point would be somewhat acidic  
(b) You would expect to use exactly  $20.00 \text{ mL}$  of acid  
(c) You would expect to use approximately  $20 \text{ mL}$  of acid  
(d) A suitable indicator would be phenolphthalein
10. A  $1.00 \text{ L}$  solution contains  $1.5 \text{ mol}$  of  $\text{Ca}(\text{NO}_3)_2$  and  $2.0 \text{ mol}$  of  $\text{NaNO}_3$ . The concentration of nitrate ions in this solution is:
- (a)  $5.0 \text{ mol L}^{-1}$   
(b)  $3.5 \text{ mol L}^{-1}$   
(c) less than  $3.5 \text{ mol L}^{-1}$   
(d) between  $3.5 \text{ mol L}^{-1}$  and  $5.0 \text{ mol L}^{-1}$
11. Which one of the following statements does **not** apply to  $1.00 \text{ mol}$  of hydrogen gas molecules?
- 1.00 mol of hydrogen molecules,
- (a) contains  $6.022 \times 10^{23}$  molecules

- (b) occupies 22.41 L at S.T.P.
- (c) contains  $1.2044 \times 10^{24}$  atoms
- (d) has a mass of 1.008 g

The following information applies to questions 12,13, and 14:

Each diagram below shows the energy change for four different reactions:



12. An endothermic reaction is:

- (a) A
- (b) B
- (c) C
- (d) D

13. The reaction with enthalpy change of about  $-50 \text{ kJ mol}^{-1}$  is:

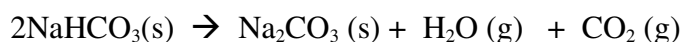
- (a) A
- (b) B
- (c) C
- (d) D

14. The reaction with the highest activation energy is:

- (a) A
- (b) B
- (c) C

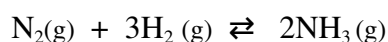
(d) D

15. Sodium hydrogencarbonate decomposes on heating as shown below:



If 0.40 mole of sodium hydrogencarbonate is heated, the total number of moles of gaseous products will be

- (a) 0.20 mol  
 (b) 0.40 mol  
 (c) 0.60 mol  
 (d) 0.80 mol
16. Which one of the following statements about the following reversible reaction is true?

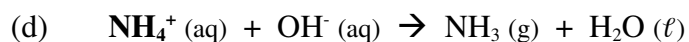


- (a)  $K = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$   
 (b)  $K$  is constant under all conditions  
 (c) A catalyst increases the yield of ammonia by increasing  $\Delta H$   
 (d) Increasing the pressure increases  $K$
17. Barium hydroxide dissociates completely in water. The pH of a  $0.0005 \text{ mol L}^{-1}$  solution of barium hydroxide in water is:
- (a) 3.0  
 (b) 3.3  
 (c) 10.7  
 (d) 11.0
18. Which one of the following aqueous solutions would have a pH greater than 7.00 at  $25^\circ\text{C}$ ?
- (a)  $2.00 \text{ mol L}^{-1}$  sodium ethanoate solution  
 (b)  $2.00 \text{ mol L}^{-1}$  sodium chloride solution  
 (c)  $2.00 \text{ mol L}^{-1}$  ammonium chloride solution  
 (d)  $2.00 \text{ mol L}^{-1}$  hydrogen chloride solution

19. In which one of the following reactions is the **boldly highlighted** substance acting as an acid?

- (a)  $\text{C}_6\text{H}_5\text{COO}^- (\text{aq}) + \text{H}_2\text{SO}_3 (\text{aq}) \rightarrow \text{HSO}_3^- (\text{aq}) + \text{C}_6\text{H}_5\text{COOH} (\text{s})$   
 (b)  $2\text{Na} (\text{s}) + 2\text{H}_2\text{O} (\ell) \rightarrow 2\text{Na}^+ (\text{aq}) + 2\text{OH}^- (\text{aq}) + \text{H}_2 (\text{g})$   
 (c)  $\text{HCO}_3^- (\text{aq}) + \text{H}_2\text{O} (\ell) \rightarrow \text{H}_2\text{CO}_3 (\text{aq}) + \text{OH}^- (\text{aq})$

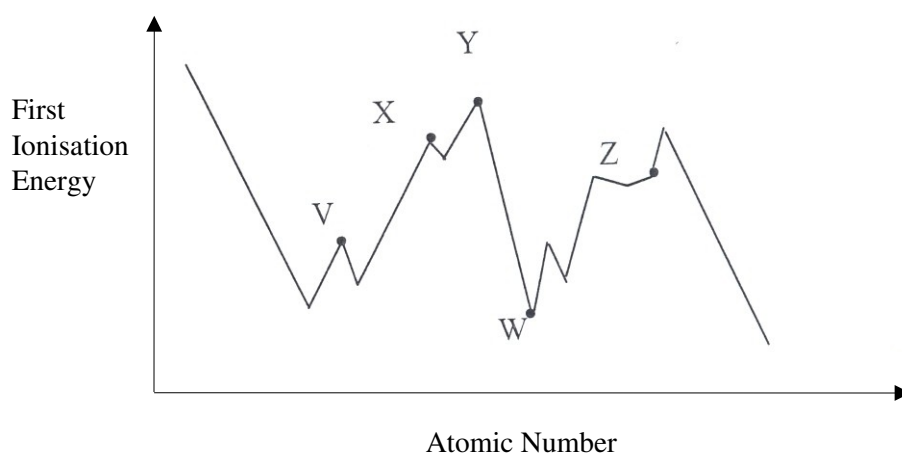




20. Which one of the following elements has an oxide which reacts with water to form an acidic solution?

- (a) Iron
- (b) Phosphorus
- (c) Magnesium
- (d) Aluminium

21. Consider the elements labelled V to Z on the diagram below. Which pair of these is most likely to form a covalent compound?



- (a) X and Y
- (b) X and V
- (c) X and Z
- (d) V and Z

22. Which one of the following correctly indicates the shapes of the respective molecules?

T = triangular or trigonal planar

P = pyramidal

L = linear

B = bent or V-shaped

	$\text{H}_2\text{CO}$	$\text{NH}_3$	$\text{BF}_3^*$	$\text{H}_2\text{S}$
(a)	T	T	P	B
(b)	T	P	T	B
(c)	P	P	T	L

(d) P P P L

\* does not obey the octet rule

23. “Saline solution”, which is used in hospitals, has a sodium chloride concentration of  $0.154 \text{ mol L}^{-1}$

The mass of sodium chloride required to prepare 0.500 L of this solution is:

- (a) 14.9 g
  - (b) 4.50 g
  - (c) 4.50 mg
  - (d) 1.49 mg
24. Which one of the following formulae for the fluorides of the elements in the second row of the periodic table is **incorrect**?
- (a) LiF
  - (b)  $\text{CF}_4$
  - (c)  $\text{NF}_5$
  - (d)  $\text{OF}_2$
25. Hydrogen iodide decomposes according to the reaction:



If equimolar amounts of  $\text{H}_2$ ,  $\text{I}_2$  and HI were mixed at this temperature,

- (a) the amount of iodine would be reduced
- (b) the concentration of HI in the mixture would decrease
- (c) the value of K would increase to 1.0
- (d) the number of molecules of gas would increase

**END OF MULTICHOICE SECTION**



**Part Two: Short Answer (50 marks)**

This section has 8 questions. Answer all questions. Write your answers in the spaces provided

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1. Write equations for any reactions that occur in the following procedures. If no reaction occurs, write “no reaction”. Reactions must relate to the actual species reacting. 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 a reaction occurs but is not visible, you should state this.

- (a) Dilute hydrochloric acid is added to silver nitrate solution

Reaction:

Observation:

(4 marks)

- (b) A dilute solution of barium chloride is added to a dilute solution of potassium hydroxide

Reaction:

Observation:

(4 marks)

2. Use the Bronsted-Lowry Theory to write equations to illustrate the following reactions in water:

(a) The hydrogencarbonate ion acting as a base:

(b) The hydrogensulfate ion acting as an acid:

(4 marks)

3. In the Thermite process, a finely divided mixture of aluminium powder and iron(III) oxide can react to produce white-hot molten iron. The mixture initially needs to be ignited with burning magnesium.

(a) On the axes below, draw a potential energy diagram for the reaction between aluminium and iron(III) oxide

(b) Label the vertical axis as well as the activation energy and  $\Delta H$  term

(c) In the box below, write the equation for this reaction:



EQUATION:

(5 marks)

4. Explain the following data:

## Boiling Points (°C)

**Group 14 hydrides**

CH <sub>4</sub>	-162
SiH <sub>4</sub>	-111
GeH <sub>4</sub>	-88
SnH <sub>4</sub>	-52
PbH <sub>4</sub>	-13

**Group 17 hydrides**

HF	20
HCl	-85
HBr	-67
HI	-35

(4 marks)

5. Complete the following table:

Species	Electron Dot diagram	Shape (Drawing)	Name of shape
SO <sub>2</sub>			
H <sub>2</sub> S			
CH <sub>2</sub> Cl <sub>2</sub>			

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(9 marks)

6. **Name** a substance whose properties match those described below:

- (a) A highly polar molecular substance that is very soluble in water. Individual molecules are described as having a pyramidal shape.
- (b) Combines with another element by sharing one pair of valence electrons. When combined with hydrogen it forms molecules that exhibit hydrogen bonding and are acidic.
- (c) Has a very first high ionisation energy, a very low boiling point and does not form bonds with the two elements immediately before or after it in the periodic table.
- (d) In its pure form it is very malleable and ductile and reacts vigorously with water. Salts containing this ion are always soluble.

(4 marks)

7. (a) Some compounds behave as buffers, that is, they have a buffering capacity.

- (i) Explain qualitatively the concept of buffering capacity, and state one factor on which buffering capacity depends.

(2 marks)

- (ii) Explain how buffers respond to the addition of  $\text{H}^+$  and  $\text{OH}^-$  ions.

(2 marks)

- (iii) How would the buffering capacity of a  $0.01 \text{ mol L}^{-1} \text{ NH}_3 / 0.01 \text{ mol L}^{-1} \text{ NH}_4\text{NO}_3$  solution differ, if at all, from a  $0.01 \text{ mol L}^{-1} \text{ NH}_3 / 0.01 \text{ mol L}^{-1} \text{ NH}_4\text{Cl}$  solution?

In other words, would the buffering capacity of the  $0.01 \text{ mol L}^{-1} \text{ NH}_3 / 0.01 \text{ mol L}^{-1} \text{ NH}_4\text{NO}_3$  solution be greater than, less than or the same as the  $0.01 \text{ mol L}^{-1} \text{ NH}_3 / 0.01 \text{ mol L}^{-1} \text{ NH}_4\text{Cl}$  solution? Explain your answer.

Circle the correct answer      Greater than      Less than      Same as

Explanation:

(3 marks)

8. Complete the following table:

Pairs of substances	Substance with the higher boiling point	most significant intermolecular force	Reason why this force is greater for the substance with the higher boiling point
$\text{CH}_3\text{OH}$ and $\text{CH}_3\text{NH}_2$			
$\text{C}_{15}\text{H}_{32}$ and $\text{C}_5\text{H}_{12}$			
$\text{CH}_3\text{COOH}$ and $\text{CH}_3\text{CH}_2\text{OH}$			



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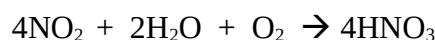
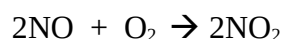
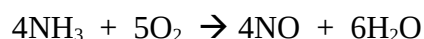
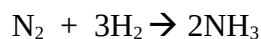
(9 marks)

**END OF PART TWO****Part 3 (40 marks)**

**Answer all questions in part 3.** The calculations are to be set out in detail in this Question/Answer Booklet. 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 section 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.

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1. The reactions involved in the manufacture of nitric acid can be represented as follows:



- (a) Calculate the mass of nitrogen required to manufacture 1.00 tonne ( $1.00 \times 10^3$  kg) of nitric acid

(4 marks)

- (b) Calculate the volume of nitrogen gas at 130 kPa and 25.0 °C used to manufacture 1.00 tonne of nitric acid

( 3 marks)



2. 11.2 g of anhydrous sodium hydroxide is dissolved in  $5.80 \times 10^2$  mL of a  $0.560 \text{ mol L}^{-1}$  hydrochloric acid solution.

- (a) Calculate the pH of the final solution, assuming the volume does not change on adding the solid to the acid.

(5 marks)

- (b) A student was then given a pH meter to measure the pH of the final solution above and discovered that the solution was not neutral. To make the final solution neutral the student needed to use either more solid KOH **or** some  $0.102 \text{ mol L}^{-1}$  nitric acid. Determine which of the reagents (solid KOH or  $0.102 \text{ mol L}^{-1}$  nitric acid) is required to neutralise the solution. If it is the solid, calculate the mass required(in g). If it is the nitric acid, calculate the volume required (in mL).

(6 marks)



3. Salinity in soil is a serious problem in many areas of Western Australia. In an effort to monitor changes in the sodium chloride content of soil a technician from Agriculture WA collected a soil sample for analysis. The technician carried out the following analysis.

A 500.0 g sample of soil was mixed with enough water to dissolve all the sodium chloride in the sample. The mixture was filtered, then made up to 1.00 L. 100.0 mL samples of this solution were then titrated with a standardised  $4.998 \times 10^{-3} \text{ mol L}^{-1}$  silver nitrate solution using potassium chromate as an indicator of when all the chloride ions had been precipitated.

After several trials the average volume of silver nitrate solution used was found to be 23.65 mL. Assume that the only source of chloride ions was sodium chloride.

- (a) Calculate the concentration of sodium chloride in the soil measured in parts per million (ppm).

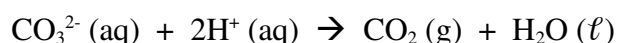
(7 marks)

- (b) What is the concentration (in  $\text{mol L}^{-1}$ ), of sodium ions in the 1.00 L of sodium chloride solution?

(4 marks)

4. One brand of concrete-cleaning liquid consists essentially of a mixture of water, hydrochloric acid and a small amount of detergent which has no acid-base properties. The concentration of hydrochloric acid in the liquid may be determined by titrating it with a base. A chemist analysed the liquid using anhydrous sodium carbonate as a base, according to the following method:

10.6 g of anhydrous sodium carbonate was made up to 250.0 mL in a volumetric flask. After thorough mixing, 25.0 mL of this solution was pipetted into a dry conical flask. The concrete-cleaning liquid was added slowly from a burette until the end point of the reaction was reached. Methyl orange indicator was used to indicate the completion of the reaction,



The volumes of cleaning liquid titrated from the burette were:

21.89 mL ( rough titration) , 22.03 mL, 25.09 mL, 21.99 mL, 22.00 mL

- (a) Use the data provided to calculate the concentration of hydrochloric acid in the cleaning liquid. Express your answer in  $\text{mol L}^{-1}$ .

(7 marks)

(b) Would the value of the concentration determined in (a) above be increased, decreased or unchanged if she had

- (i) Washed the conical flask with water, but not dried it prior to pipetting in the sodium carbonate solution?

(2 marks)

ANSWER: ( Write “ increased” , “decreased” or “unchanged”)

REASON FOR ANSWER:

- (ii) Unknowingly used hydrated sodium carbonate (  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ ) instead of the anhydrous form of sodium carbonate?

(2 marks)

ANSWER: ( Write “ increased” , “decreased” or “unchanged”)

REASON FOR ANSWER:

**END OF PART 3****Part 4 (10 marks)**

Answer ONE of the following extended answer questions. Where applicable use equations, diagrams and illustrative examples of the chemistry you are describing. Marks are awarded for the relevant chemical content of your answer, but you will lose marks if what you write is presented in point form. As a guide, a minimum of two pages is required.

1. “An understanding of the three dimensional structure of a covalent molecule enables its polarity and intermolecular forces to be predicted”.

Expand on this statement by discussing the following topics.

- (i) electron pair repulsion theory
- (ii) shapes of molecules
- (iii) molecular polarity
- (iv) intermolecular forces.

You may use water, methane, carbon dioxide, ammonia and any other appropriate molecules as examples.

**OR**

Write on BOTH the following fundamental aspects of chemistry:

- (a) Consider the elements of the Periodic Table in the row from sodium to argon. For each of these elements discuss the relationship that exists between the electronic configuration, valency and the type of bonding exhibited by the element.
- (b) Describe the nature of the bonding present in an ionic solid, in a metal and in a network solid by reference to one specific example of each type. Relate this to the physical properties of melting point and electrical conductivity exhibited by each of the solids.

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