Hornsby Girls' High School

Trial 2019

HSC Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 180 minutes
- Write using blue or black pen
- Draw graphs, diagrams and tables using a 2B pencil
- NESA Board-approved calculators may be used
- A Periodic Table and Data sheets are provided
- Write your student number at the top of each page
- Attempt all questions
- Marks are as indicated in brackets

Total marks – 100

- Section I - Multiple Choice   20 marks

- Section II – Written Response   80 marks

Multiple choice	Mark
1	
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4	
5	
6	
7	
8	
9	
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11	
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14	
15	
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18	
19	
20	
Total	

21a	b	c	d	22	23	24a	b	c	d	e
/1	/3	/1	/3	/2	/2	/2	/1	/2	/2	/2

25a	b	c	d	26a	b	27a	b	28a	b
/2	/1	/1	/1	/3	/1	/3	/3	/2	/1

29a	b	30	31a	b	32a	b	c	d	33
/2	/1	/6	/4	/3	/4	/2	/2	/1	/4
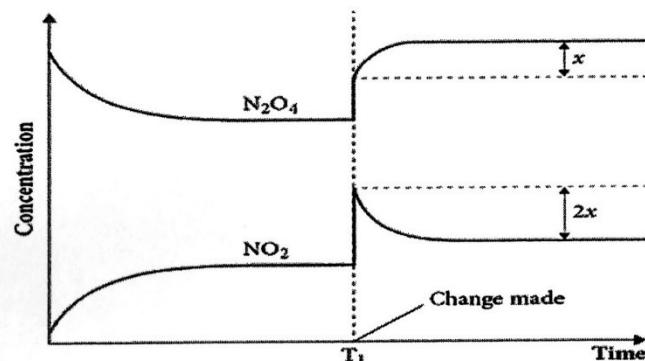
| 34a	b	c	d	35	TOTAL /100
/1	/1	/1	/3	/6	

Section I (20 marks)

Multiple choice questions: Use multiple choice answer sheet for Question 1-20.

1. Consider the reaction: $2NO_2(g) \rightleftharpoons N_2O_4(g)$

   The imposed change at T1 is most likely to be:

   A. An addition of NO_2.

   B. An addition of N_2O_4.

   C. An increase in the volume of the container.

   D. A decrease in the volume of the container.

2. Which of the following statements about acids and bases is FALSE?

   A. Acids are able to produce hydrogen ions in solutions.

   B. A hydrogen ion attached to water forms a hydronium ion.

   C. Bases are able to produce hydroxide ions in solution.

   D. All oxides are basic

3. Which of following alcohols have been classified correctly?

	Names of alcohols and their classification		
	Primary, 1°	**Secondary, 2°**	**Tertiary, 3°**
A.	Propan-1-ol	Pent-3-ol	2-methylpropan-2-ol
B.	Butan-2-ol	2-methylpropan-1-ol	2-methylpropan-2-ol
C.	2,2-dimethylpropan-1-ol	Butane-1,4-diol	Ethanol
D.	Propan-2-ol	Butan-2-ol	Pentan-3-ol

4. The equilibrium expression for the K_{sp} of $CaCO_3$ is:

   A. $[Ca^{2+}][CO_3^{2-}]/[CaCO_3]$

   B. $1/[Ca^{2+}][CO_3^{2-}]$

   C. $[Ca^{2+}][CO_3^{2-}]$

   D. $[CaCO_3]/[Ca^{2+}][CO_3^{2-}]$

5. Which of the following hydrocarbons have the molecular formula $C_5H_{10}O$?

   (I) Pentanoic Acid

   (II) Pentan-3-ol

   (III) Pentanal

   (IV) Pentan-3-one

   A. I, II and III.

   B. I, III and IV.

   C. IV only.

   D. III and IV.

6. The equation describes an equilibrium reaction occurring in a closed system.

$$X(g) + Y(g) \rightleftharpoons 4Z(g); \qquad \Delta H = +58 \text{ kJ mol}^{-1}$$

Under which set of conditions would the highest yield of $Z(g)$ be obtained?

	Temperature ($^{\circ}C$)	Pressure (kPa)
A.	50	100
B.	50	200
C.	300	100
D.	300	200

7. A student uses their data table to find out that the heat of combustion of propan-1-ol is 2021 kJ mol^{-1}. What value would the student calculate for the heat of combustion of propan-1-ol in kJ g^{-1}?

A. 23.0

B. 27.3

C. 33.6

D. 43.9

8. The concentration of reactants and products was studied for the following reactions:

$$H_2(g) + F_{2(g)} \rightleftharpoons 2HF(g); \qquad K_{eq} = 313 \text{ at } 25^{\circ}C \text{ and } 100 \text{ kPa}$$

In an experiment, the initial concentrations of the gases was
$[H_2] = 0.0120$ M, $[F_2] = 0.0200$ M, and $[HF] = 0.500$ M.

When the reaction reaches equilibrium at 25°C, the concentration of HF will be:

A. 0.550 M

B. 0.25 M

C. less than 0.500 M

D. between 0.0500 M and 0.550 M
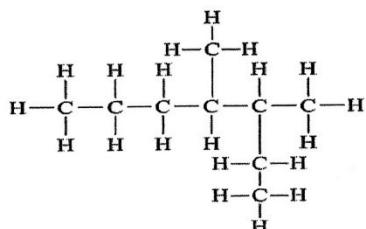
9. A group of students performed acid-base titrations to determine the mass of aspirin in some tablets. The manufacturer guaranteed the true aspirin content was between 300mg and 303 mg per tablet.

Which set of results for the mass of aspirin in the tablets tested would be described as of relatively high precision and relatively low accuracy?

A. 278 mg, 280 mg, 279 mg, 281 mg

B. 301mg, 299 mg, 302 mg, 300 mg

C. 295 mg, 301mg, 306 mg, 299 mg

D. 282 mg 312 mg, 289 mg, 306 mg
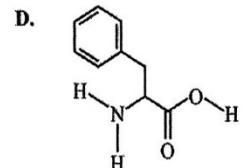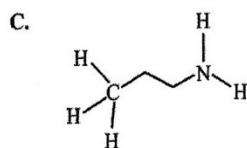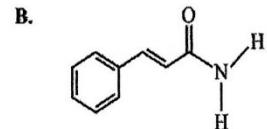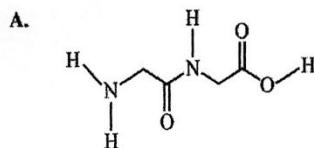
10. What is the correct IUPAC systematic name for the compound shown below?

A. 4, 5-dimethylheptane

B. 3,4-dimethylheptane

C. 4-methyl-5-ethylhexane

D. 2-ethyl-3-methylhexane

11. Which one of the following skeletal structures presents a primary amide?

A.

B.

C.

D.

Ruby standardised a citric acid $C_6H_8O_7$ solution against a previously standardised sodium hydroxide NaOH solution. The equation for the titration reaction was

$$C_6H_8O_7(aq) + 3NaOH(aq) \rightarrow Na_3C_6H_5O_7(aq) + 3H_2O(l)$$

12. Ruby's results are shown in the table below

Quantity	Measurement
volume of NaOH solution	20.00 mL
molarity of NaOH solution	0.125 M
mean titre of $C_6H_8O_7$ solution	23.6 mL

What was the concentration of citric acid in the solution

A. 0.035 M

B. 0.049 M

C. 0.105 M

D. 0.316 M

13. Unknown to Ruby, the NaOH had absorbed some carbon dioxide from the air. CO_2 is weakly acidic and reacts with NaOH. Will this effect the validity or reliability of the results and how will it effect the mean titre of the citric acid ?

What will it effect	Likely effect on the mean titre of the citric acid
A. Reliability	Greater than would be if no contamination had occurred
B. Reliability	Lower than would be if no contamination had occurred
C. Validity	Greater than would be if no contamination had occurred
D. Validity	Lower than would be if no contamination had occurred

14. Which of the following is not true about low density polyethylene?

    A. Chemically inert

    B. Rigid

    C. Poor conductor of electricity

    D. Highly branched structure

15. What is the Ka value for a 0.05 M solution of propanoic acid which has a pH of 3.09

    A. 8×10^{-4}

    B. 1.3×10^{-5}

    C. 1.6×10^{-2}

    D. 78125

16. Which of the following reactions would represent a dynamic equilibrium?

    A. Steel wool being burnt in a Bunsen Burner flame

    B. Granulated zinc being placed into a beaker with 100.00 mL of 1.0 molL^{-1} HCl

    C. 100.00 mL of 1.0 molL^{-1} HCl is reacted with 100.00 mL of 1.0 molL^{-1} NaOH

    D. 5 drops of 0.1 molL^{-1} lead nitrate is reacted with 5 drops of 0.1 molL^{-1} sodium chloride.

17. Four students analysed a sample of fertiliser to determine its percentage of sulfate.

    Each student:

    - Weighed an amount of fertiliser
    - dissolved this amount in 100 mL of water;
    - added aqueous barium nitrate;
    - filtered, dried and weighed the barium sulfate precipitate.

    Their results and calculations are shown in the table.

Student	Mass of fertiliser used (g)	Mass of BaSO$_4$ weighed (g)	Percentage of sulfate in fertiliser (%)
A	11.6	19.5	69.2
B	10.4	16.9	66.9
C	10.268	22.612	90.6
D	11.1	18.2	67.5

The percentage of sulfate calculated by Student C was significantly higher than that of the other students. Which is the most likely reason for this?

    A. Student C did not dry the sample for long enough.

    B. Student C added more Ba(NO$_3$)$_2$ solution than the other students.

    C. Student C used a balance capable of measuring weight to more decimal places.

    D. Student C waited longer than the other students for the Ba(NO$_3$)$_2$ to react completely with the sulfate.

18. Which option below correctly identifies how the glassware should be prepared when titrating standard 0.1038 molL^{-1} solution of HCl with an unknown concentration of ammonia. Ammonia will be the titrant and HCl will be delivered as 25.00 mL aliquots.

	Burette	Pipette	Conical flask
A.	Washed with Distilled water only	Washed with Distilled water only	Washed with Distilled water only
B.	Washed with Distilled water then the ammonia solution	Washed with Distilled water then the hydrochloric acid solution	Washed with Distilled water then the hydrochloric acid solution
C.	Washed with Distilled water then the hydrochloric acid solution	Washed with Distilled water then the ammonia solution	Washed with Distilled water then the ammonia solution
D.	Washed with Distilled water then the ammonia solution	Washed with Distilled water then the hydrochloric acid solution	Washed with Distilled water only

19. Which type of bonding forms between the monomers that react together to form nylon polymers?

A. amide bonds

B. ester bonds

C. ionic bonds

D. hydrogen bonds

20. Which of the following are not isomers?
   A. Hexan-2-ol and 2,2-dimethylbutan-1-ol
   B. Methyl ethanoate and propanoic acid
   C. Butene and cyclobutane
   D. Butan-2-one and 2-methylpropan-1-ol

Section II (80 marks)

Short and Long Response questions

Question 21 (8 marks)

Carbonic acid is formed when carbon dioxide dissolves in water. Carbonic acid plays a major part in the buffering of human blood, which has a typical pH of 7.40. One way to show the ionisation of carbonic acid is

$$H_2CO_3(aq) \rightleftharpoons HCO_3^-(aq) + H^+(aq).$$

(a) Write an expression for the equilibrium constant (Keq) for this reaction.

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(b) Buffers play a role in many natural systems.
Using human blood, or another relevant example, explain why buffers are important.

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(c) What is the typical hydrogen ion concentration in human blood? Show your working.

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(d) HCO_3^- is considered amphiprotic. Explain this with equations.

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Question 22 (2 marks)
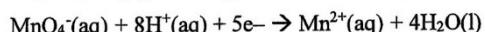
Use your knowledge of solubility equilibria to explain how Aboriginal and Torres Strait Islander Peoples remove toxins in cycad fruit?

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Question 23 (2 marks)

The oxidation of ethanol by permanganate ions can be represented by the half equations:

$CH_3CH_2OH(aq) + H_2O(l) \rightarrow CH_3COOH(aq) + 4H^+(aq) + 4e^-$

$MnO_4^-(aq) + 8H^+(aq) + 5e- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$
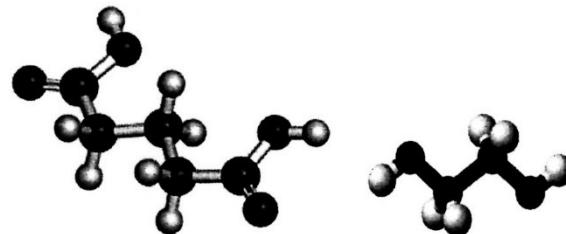
What volume (in mL) of 0.02 M $KMnO_4$ is required to completely oxidise a solution containing 0.02 mol of ethanol?

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Question 24 (9 marks)

Below are two models of organic compounds

Black is Carbon ●
White is Hydrogen ○
Red is Oxygen ●

(a) Draw the full structural formulae for both these compounds. /2

(b) Write the structural formula for the polymer that is formed when these compounds react.

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(c) What type of polymer reaction is this? What other compound is formed?

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(d) Explain why these monomers are soluble in water, but the polymer is not.

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(e) Outline one advantage and one disadvantage of a ball and stick model compared to a structural formula model?

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Question 25 (5 marks)

During your course of study, you carried out a first-hand investigation to compare the enthalpy of combustion of alcohols. A student recorded a temperature increase of $9.5°C$ when 1.4 grams of methanol was combusted to heat 200 mL of water.

(a) Calculate the experimental enthalpy of combustion of methanol assuming complete combustion occurs.

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(b) Identify a risk present in this investigation and outline the safety precaution required to minimise this risk.

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(c) The theoretical enthalpy of combustion of methanol is 726 kJ mol^{-1}.
Explain the difference in the theoretical and experimental values.

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(d) Discuss one way you could change the experimental set up to get a more accurate result.

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Question 26 (4 marks)

A 0.1045 molL^{-1} solution of sodium hydroxide was used to determine the concentration of an unknown solution of acetic acid. The acetic acid was prepared by mixing 10.00 mL Cornwall's Vinegar with 90.00 mL of distilled water.

(a) Using the results recorded below calculate the concentration of acetic acid in the bottle of Cornwall's Vinegar when 25.00 mL pipettes were used to deliver the vinegar into the conical flask. ./3

Titre	Volume of Sodium Hydroxide (mL)
1	24.99
2	25.10
3	28.50
4	24.96

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(b) Which pH indicator would be appropriate for this practical?

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Question 27 (6 marks)

(a) Lead(II) chloride is sparingly soluble in water. An equilibrium is set up between the solid and its ions in solution. Calculate the concentration of Pb^{2+} and Cl^- in the solution at 25 °C.

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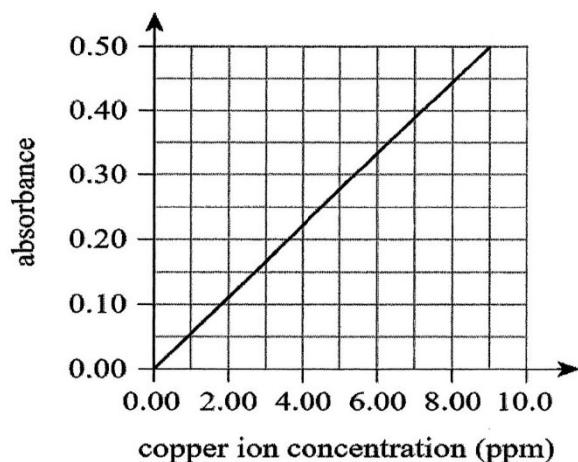
(b) Calculate and compare the solubility of the lead(II) chloride when dissolved in 0.25 molL^{-1} of NaCl.

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Question 28 (3 marks)

A copper mine was monitoring copper ion concentration in a stream. Five samples were collected from the stream and the absorbance of each sample was measured with AAS. The results are shown in the table. A series of standard $Cu(NO_3)_2$ solutions was prepared and absorbance measured. The measurements were graphed to obtain the standard curve shown.

Sample	Absorbance
1	0.37
2	0.39
3	0.40
4	0.14
5	0.39

(a) Using the absorbance data and standard curve provided, determine a reliable value for the concentration of copper ions in ppm in the stream.

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(b) What is the molarity of the copper ions in the stream?

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Question 29 (3 marks)

The sulfate content of a fertiliser was measured by dissolving 1.63 g of the fertiliser in 300 ml of water, then slowly adding a solution of barium chloride until no further precipitation occurred. After filtration and drying the mass of the precipitate was 1.81g.

(a) Calculate the percentage of sulfate in the fertiliser.

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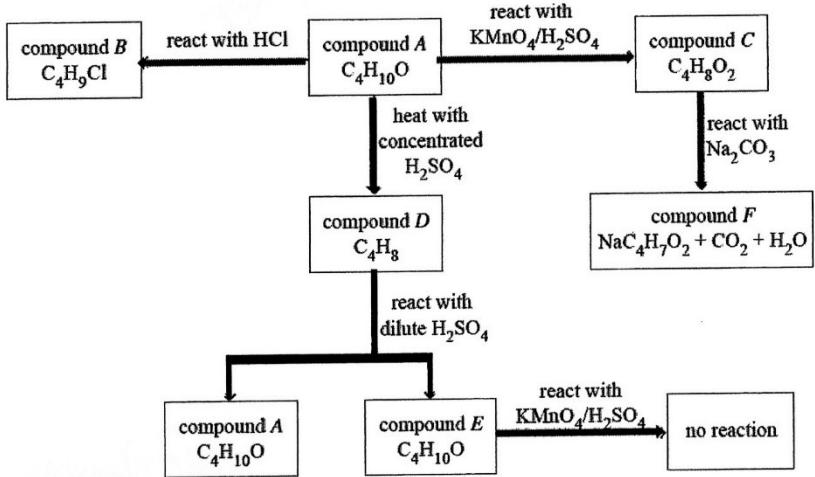
(b) List one error that has occurred in this method.

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Question 30 (6 marks)

The flow chart shows the reactions of six different organic compounds.

Complete the table by drawing the structural formulae for the compounds and justifying your answers with reference to the information provided

Compound	Structural formula	Justification
Compound A $C_4H_{10}O$		
Compound B C_4H_9Cl		

Compound	Structural formula	Justification
Compound C $C_4H_8O_2$		
Compound D C_4H_8		
Compound E $C_4H_{10}O$		
Compound F $NaC_4H_7O_2$		

Question 31 (7 marks)

The boiling points of six carboxylic acids and their related primary amines are listed in the table below.
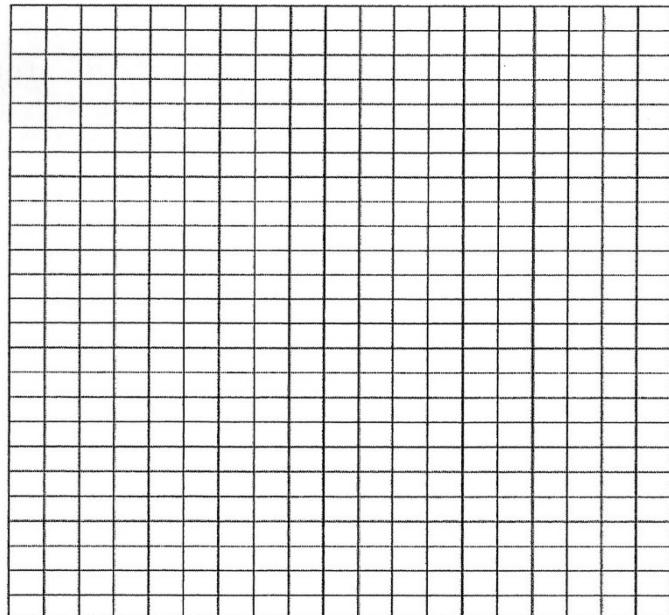
Number of carbon atoms	Carboxylic acid	Carboxylic acid Boiling point (°C)	Amine	Amine Boiling point (°C)
1	Methanoic acid	101	Methanamine	-6.3
2	Ethanoic acid	118	Ethanamine	18
3	Propanoic acid	141	Propanamine	49
4	Butanoic acid	164	Butanamine	78
5	Pentanoic acid	186	Pentanamine	104
6	Hexanoic acid	205	Hexanamine	131

(a) On the graph below, label the horizontal axis "Number of carbon atoms" and the veritcal axis "Boiling point (°C)". Plot a line of best fit for the carboxylic acids a separate distinct line of best fit for the amines onto this graph. /4

(b) Explain the trends that are evident in these graphs

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Question 32 (9 marks)

A flask containing a mixture of 0.200 mol of ethanoic acid and 0.110 mol of ethanol was maintained at 25 °C until the following equilibrium had been established.

$$CH_3COOH(l) + C_2H_5OH(l) \rightleftharpoons CH_3COOC_2H_5(l) + H_2O(l)$$

The ethanoic acid present at equilibrium required 72.5 ml of a 1.50 M solution of sodium hydroxide for complete reaction.

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(a) Calculate the value of the equilibrium constant, K_{eq}, for this reaction at 25 °C.

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(b) Justify why is refluxing used in this reaction

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(c) Outline one physical and one chemical method of purifying the product.

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(d) Explain the effect of adding more sulfuric acid on the yield of the ester

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Question 33 (4 marks)

A student measured the pH of three solutions X, Y, Z with a pH probe. The student stirred the solution constantly and the measurements were all recorded at 25.0°C. Unfortunately, the student did not label their beakers but her teacher said she should be able to identify from the pH recorded. The measurements were 6.9; 8.7; 5.3

The solutions were sodium chloride, ammonium nitrate and sodium acetate. Identify solutions X, Y and Z and justify your answer.

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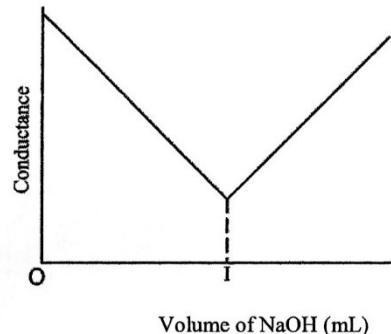
Question 34 (6 marks)

Below is a graph of a conductometric titration of an acid with a base (NaOH).

Volume of NaOH (mL)

(a) Identify point I in the graph.

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(b) Identify the substance in the burette.

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(c) Identify the acid as strong or weak.

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(d) Describe the shape of the graph explaining the conductivity changes.

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Question 35 (6 marks)

Discuss the need for monitoring inorganic chemicals in the environment. Discuss the importance of monitoring one ion and a method of monitoring it quantitatively and qualitatively.

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