VIRILE AGITUR

Student Number: …………………………………

Teacher's Name: …………………………………

2019

Task 4: Trial Examination

Weighting: 30%

HSC Chemistry

General Instructions

- Reading time - 5 minutes
- Working time - 3 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A data sheet, formulae sheets and Periodic Table are provided at the back of this paper
- For questions in Section II, show all relevant working in questions involving calculations
- This paper MUST NOT be removed from the examination room.

Subject Teachers: Ms Disney, Mrs Goddard, Ms Dreesbeimdieke, Mr Weeding, Mr Pimentel

Total marks - 100

Section I - 20 marks (pages 3-15)

- Attempt Questions 1-20
- Allow about 35 minutes for this section

Section II - 80 marks (pages 16-37)

- Attempt Questions 21-34
- Allow about 2 hours and 25 minutes for this part

Section I
20 marks

Attempt Questions 1-20
Allow about 35 minutes for this section

Use the multiple-choice answer sheet for Questions 1-20

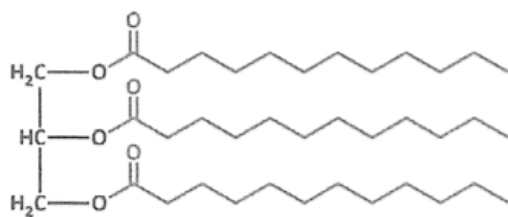1.   What flame colour is produced by calcium ions in a flame test?

   A.   Red

   B.   Blue

   C.   Green

   D.   Purple

2.   A, B, C and D are 0.10 mol L^{-1} solutions containing acids of varying pH, with the values of pH for each solution being shown below.

   Identify which of the solutions A-D below is a diprotic acid.

   A.   0.69

   B.   1.00

   C.   2.87

   D.   3.45

3. The structure of an organic compound is shown below.

The compound is:

A. glycerol

B. a fatty acid

C. a triglyceride

D. an alkyl carboxylate

4. Which of the following molecules is most likely to undergo condensation polymerisation with another identical molecule?

A. $(CH_3)_3COH$

B. $H_2N(CH_2)_6NH_2$

C. $ClOC(CH_2)_4COCl$

D. $H_2N(CH_2)_5COOH$

5. Excess barium nitrate solution is added to 200 mL of 0.200 mol L^{-1} sodium sulfate.

What is the mass of the solid formed?

A. 4.65 g

B. 8.69 g

C. 9.33 g

D. 31.5 g

6. The percentage of sodium chloride in a food sample can be determined as follows:

- Completely dissolve the food sample using an appropriate solvent.
- Add an excess of silver nitrate solution to the dissolved food sample to precipitate all chloride ions.
- Wash and dry the resulting precipitate.

A student carried out this experiment and recorded the following results.

- Mass of original food sample = 22.0 g
- Mass of dried precipitate = 0.396 g

What is the percentage of sodium chloride in the food?

A. 0.147%

B. 0.734%

C. 1.47%

D. 4.42%

7. Polypropylene is made by the polymerisation of propene, $CH_3CH=CH_2$. One sample of this polymer is found to have a molar mass of approximately 1.05×10^5 g mol^{-1}.

The number of carbon atoms in one molecule of this polymer would be closest to:

A. 2500

B. 2900

C. 7500

D. 8750

8.   The pH values and concentrations of four acids are given in the table below.

Acids	pH	Concentration
I	2.73	0.20
II	2.06	0.10
III	3.77	1.00
IV	4.78	0.50

Which acid is the weakest?

A.   Acid I

B.   Acid II

C.   Acid III

D.   Acid IV

9.   Three flasks were prepared, each containing a mixture of 25 mL of water and 10 mL of ethanol. An aspirin tablet was dissolved in each flask. The aspirin in each solution was titrated with a standardised NaOH solution of concentration 0.1003 mol L^{-1} according to the following equation:

$$C_9H_8O_{4\ (aq)} + NaOH_{\ (aq)} \rightarrow C_9H_7O_4Na_{\ (aq)} + H_2O_{\ (l)}$$
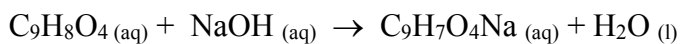
The titration results shown below were obtained.

Tablet	Volume (mL)
1	16.70
2	16.60
3	16.65

The average mass of aspirin per tablet in mg is:

A.   30.09

B.   89.71

C.   300.9

D.   993.8

10. A closed system consisting of a mixture of the gases CO, Cl₂ and COCl₂ was monitored over time and is shown on the graph below. The decomposition of COCl₂ is an endothermic process.

$$COCl_2 (g) \rightleftharpoons CO(g) + Cl_2(g)$$
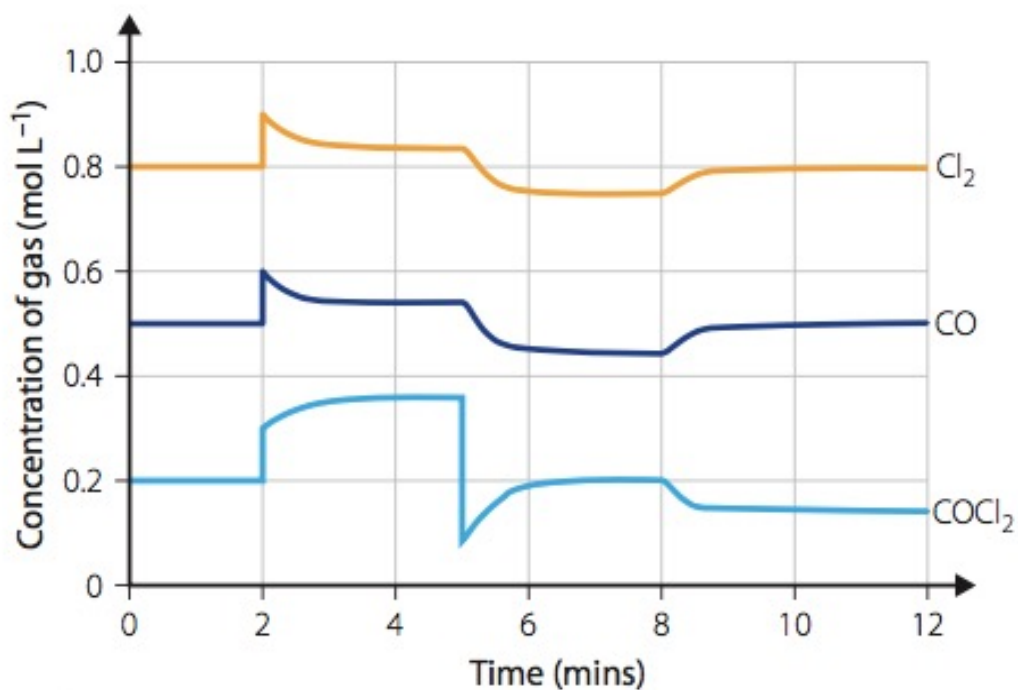
What changes occurred at 2 minutes, 5 minutes and 8 minutes respectively?

	2 minutes	5 minutes	8 minutes
A.	volume increased	CO removed	temperature decreased
B.	volume increased	CO removed	temperature increased
C.	volume decreased	COCl₂ removed	temperature decreased
D.	volume decreased	COCl₂ removed	temperature increased

11. Different indicators change colour over different pH ranges as shown in the table below.

Indicator	Highly acidic	Slightly acidic	Neutral	Slightly alkaline	Highly alkaline
Radish	orange	pink	green	green	green
Blueberries	red	purple	green	green	green
Red Cabbage	red	pink	purple	blue	green
Curry powder	colourless	colourless	colourless	yellow	red

Four different solutions (W, X, Y and Z) were tested with different indicators.

- Solution W was colourless in curry powder
- Solution X was red in red cabbage
- Solution Y was green in radish
- Solution Z was purple in blueberries

Which of the solutions could be neutral?

A. Solutions W and X

B. Solutions X and Y

C. Solutions Y and Z

D. Solutions W and Y

12. A reaction commonly used industrially as a source of hydrogen is:

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$
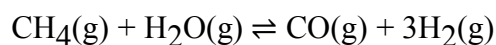
The equilibrium constant is 0.26 at 1200 K. In a particular reaction mixture, the concentrations were:

$[CH_4] = 0.045$ mol L^{-1}

$[H_2O] = 0.24$ mol L^{-1}

$[H_2] = 0.50$ mol L^{-1}

$[CO] = 0.060$ mol L^{-1}

Which statement regarding this mixture is correct?

A.   The mixture is at equilibrium and no shift will occur.

B.   The mixture is not at equilibrium and the reaction will shift to the left.

C.   The mixture is not at equilibrium and the reaction will shift to the right.

D.   The mixture is at equilibrium and the reaction will shift to both the right and left.

13. Hydrogen cyanide gas is highly toxic. It dissolves in water to form a weak acid. The reaction is:

$$HCN(aq) + H_2O(l) \rightleftharpoons CN^-(aq) + H_3O^+ (aq)$$
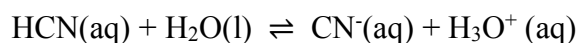
The acid dissociation constant is 6.3×10^{-10}. The pH of a solution of HCN of concentration 0.00010 mol L^{-1} is:

A.   2.51

B.   3.30

C.   6.30

D.   6.60

14. Four bottles (W, X, Y, Z) containing colourless liquids were found on the laboratory shelf with no labels. The bottles are known to contain 1-hexene, 1-propanol, ethanoic acid and hexane.

Bottle	Solubility in water	Decolourises bromine water in the absence of UV light	Reacts with sodium hydrogen carbonate to form a gas
W	very low	no	no
X	high	no	no
Y	high	no	yes
Z	very low	yes	no

Which row of the table best identifies the compounds?

	W	X	Y	Z
A.	1-propanol	hexane	ethanoic acid	hexene
B.	hexene	ethanoic acid	1- propanol	hexane
C.	hexane	1- propanol	ethanoic acid	hexene
D.	hexene	1- propanol	hexane	ethanoic acid

15. The IUPAC systematic name for the compound whose structure is given here is:
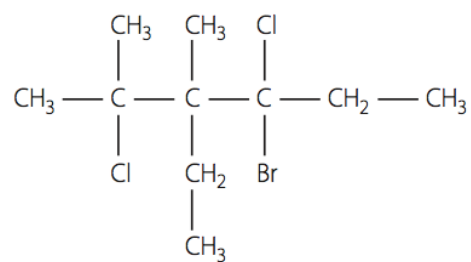
A. 4-bromo-2,4-dichloro-2,3-dimethyl-3ethylhexane

B. 4-bromo-2,4-dichloro-3-ethyl-2,3-dimethylhexane

C. 3-bromo-3,5-dichloro-4-ethyl-3,4-dimethylhexane

D. 3-bromo-1,3-dichloro-2-ethyl-1,1,2-trimethylhexane

16. Atomic absorption spectroscopy has been used to determine the amount of mercury in various types of seafood. Calibration of the apparatus was carried out by spraying samples of standard solutions containing known amounts of mercury into a flame. The results are shown in the graph below.
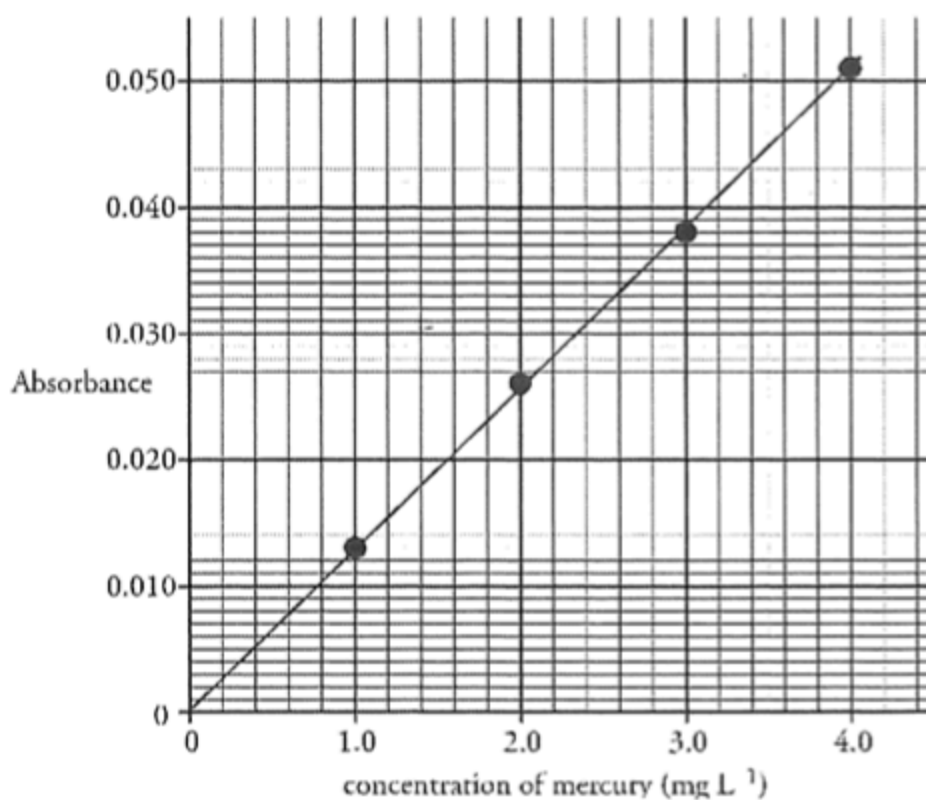
The mercury content of a sample of fish was determined by taking 20.00 g of the fish and heating it with 10 mL of nitric acid in a closed container. The resulting liquid was filtered and sprayed into the flame.

The absorbance reading obtained was 0.034. The concentration of mercury in the fish in ppm is:

A.   1.3

B.   2.6

C.   3.4

D.   26.0

17. An unknown substance was analysed with mass spectroscopy. The mass spectrum is below.

Mass spectrum of unknown substance
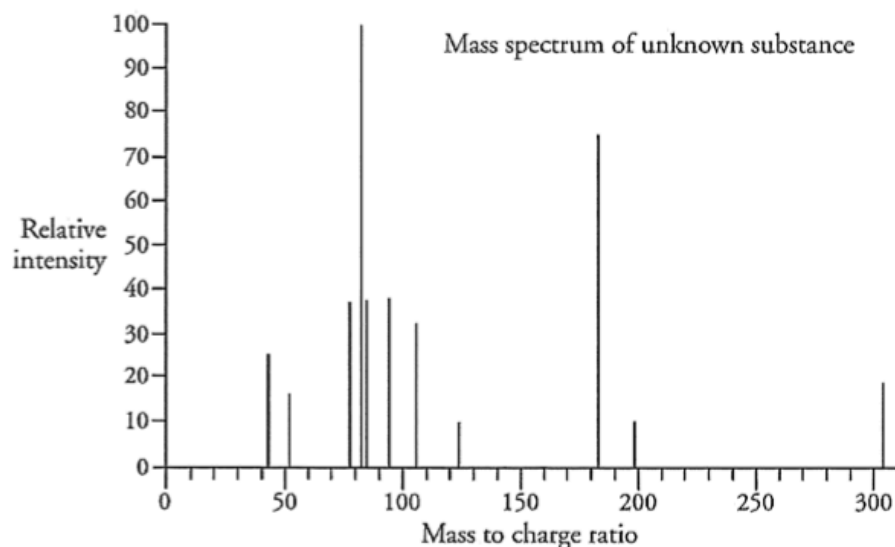
The table below shows the mass to charge ratio of a selection of fragments in the mass spectrum for four compounds of interest in forensic investigations.

Compound name	Significant fragments (mass to charge ratio)
Caffeine	67 109 194
Cocaine	82 94 182
Paracetamol	43 109 151
Amphetamine	91 119 136

Using the information in the table and the mass spectrum, identify the unknown substance.

A.   Caffeine

B.   Cocaine

C.   Paracetamol

D.   Amphetamine

18. Which one of the anions below will produce a precipitate with each of the solutions I, II and III?

    (I) Silver nitrate

    (II) Barium nitrate

    (III) Copper(II) nitrate

A. Cl^-

B. OH^-

C. SO_4^{2-}

D. CO_3^{2-}

19. The diagram shows the infrared spectrum of a compound.
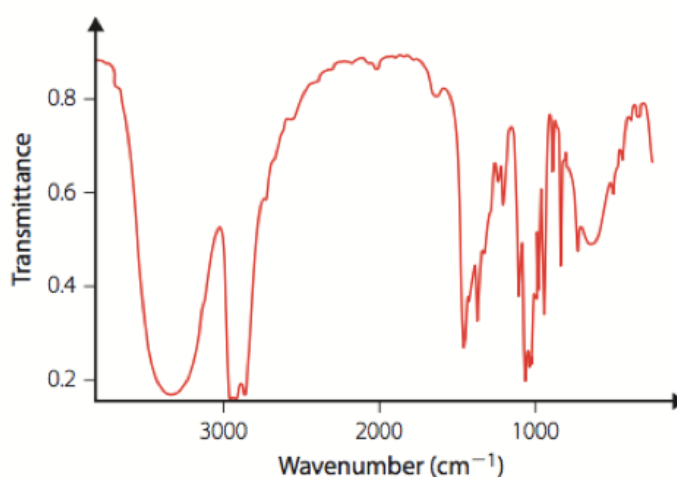
Identify the compound that would produce a spectrum to match the one shown.

A. Butane

B. Butanal

C. Butanol

D. Butanoic acid

20. Consider the following solubility data for various chromates at 25°C.

Chromate	K_{sp}
Ag_2CrO_4	9.0×10^{-12}
$BaCrO_4$	2.0×10^{-10}
$PbCrO_4$	1.8×10^{-14}
Tl_2CrO_4	9.8×10^{-15}

The chromate that is the most soluble in water at 25°C is:

A. $PbCrO_4$

B. $BaCrO_4$

C. Tl_2CrO_4

D. Ag_2CrO_4

Section II (80 marks)

Questions: 21 – 34
Marks: 80
Time: Allow approximately 2 hours and 25 minutes for this Part.

Instructions:
Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Show all relevant working in questions involving calculations.

Extra writing booklets are available upon request. If you use a booklet, clearly indicate which question you are answering and indicate in this paper that a booklet has been used. Use a new booklet for each question.

Question 21 (2 marks)

The biological process of respiration can be represented by the equation: **2**

$$C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$$
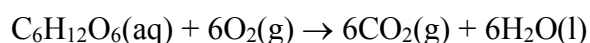
Given the following data for the reaction, calculate $\Delta G°$ and hence determine whether respiration is a spontaneous process at 25°C.

$\Delta H° = -2803 \text{ kJ mol}^{-1}$

$\Delta S° = +212 \text{ J mol}^{-1} \text{ K}^{-1}$

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Question 22 (4 marks)

Neutralisation is a process used in many every day or industrial situations.

(a)   Calculate the pH and pOH of a 0.600 mol L^{-1} solution of NaOH.   **2**

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(b)   With the use of an equation, describe an application of a neutralisation reaction in   **2**
either everyday life or an industrial process.

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Question 23 (5 marks)

Knowledge of equilibrium has been used by Indigenous peoples for centuries

(a)   Explain how a food item was detoxified by Indigenous Australians.   **2**

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(b)   Modern chemists also use equilibrium processes, such as the production of nitric acid.   **3**

During one part of the synthesis of nitric acid, dinitrogen tetroxide is in equilibrium
with nitrogen dioxide. Initially 0.540 mol of N_2O_4 was placed in a 2.00 L vessel under
constant pressure and temperature. When equilibrium was achieved, 0.280 mol of NO_2
was present.

Calculate the value of the equilibrium constant.

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Question 24 (7 marks)

The heat of combustion of ethanol is 1367 kJ mol^{-1}. When students conduct an investigation to measure the heat of combustion, their results are often very inaccurate but often reliable.

(a)   Calculate the mass of ethanol that must be burnt to increase the temperature of 210 g   **4**
        of water by 45°C if exactly half the heat released by this combustion is lost to the
        surroundings.

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(b)   Analyse possible reasons why this investigation is inaccurate but reliable.   **3**

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Question 25 (3 marks)

Predict whether a precipitate will form when 0.0010 g of silver carbonate is added to 100 mL   **3**
of water.

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Question 26 (13 marks)

Consider the following flowchart that shows possible reactions involving ethanol.
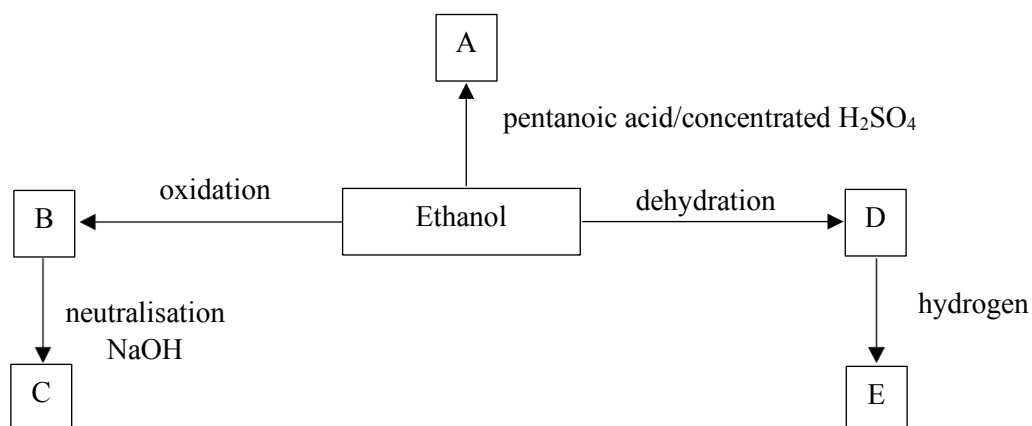
(a)   Draw the structural formula of B and C and justify your choice.   **3**

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(b)   Explain, with the use of an equation, the formation of E from ethanol.   **3**

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(c)(i) Write an equation, using structural formula, for the formation of A.   **2**

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  (ii) Outline a method that could be used to prepare chemical A.   **5**

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Question 27 (4 marks)

The pH range for human blood is 7.35-7.45. **4**

Explain the role of the conjugate acid/base pair H_2CO_3/HCO_3^- in maintaining the pH in blood.

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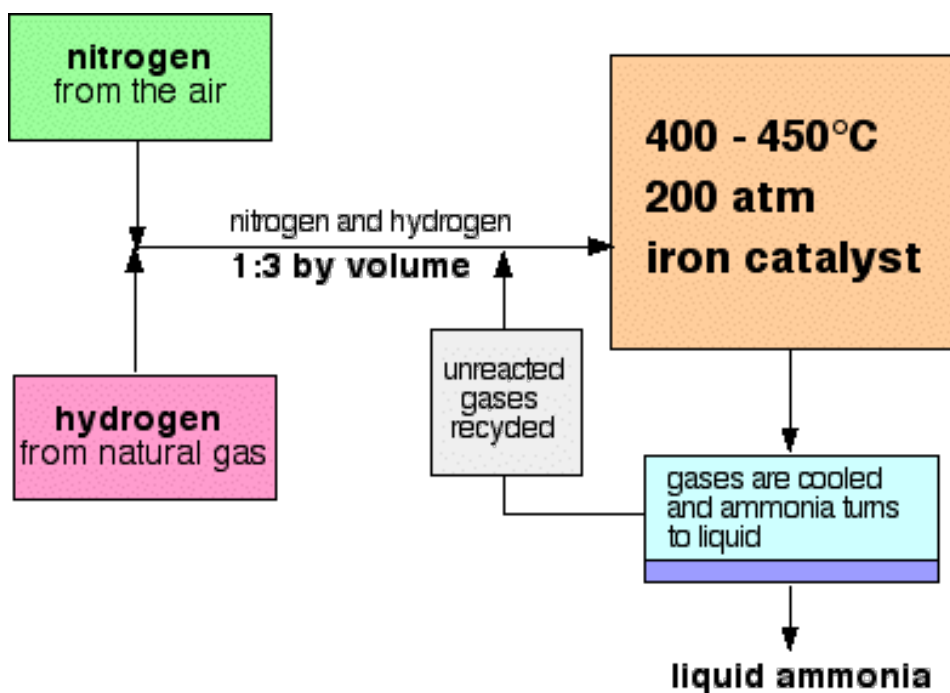……………………………………………………………………………………………………

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Question 28 (6 marks)

The flowchart below shows the simplified version of the formation of ammonia by the Haber Process.

(a) Given the formation of ammonia is an equilibrium reaction, write a balanced equation **2** for the formation of ammonia.

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(b)   The formation of ammonia is exothermic. Assess the use of a moderate temperature in   **4**
this process.

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Question 29 (5 marks)

To determine the concentration of a sodium hydroxide solution, a student determined through titration that 25.0 mL of 0.200 mol L^{-1} hydrochloric acid reacted with 10.0 mL of the sodium hydroxide solution.

(a)   Identify a piece of equipment that could be used to accurately measure pH changes.   **1**

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(b)   Use the information provided to sketch the conductivity and pH curves on the   **4**
following grids. In answering this:

- Put appropriate values for the volume of sodium hydroxide on both the conductivity and pH graphs.
- Put appropriate pH values on the pH graph.
- Start the conductivity graph at the point indicated.

Conductivity

Conductivity (µS)
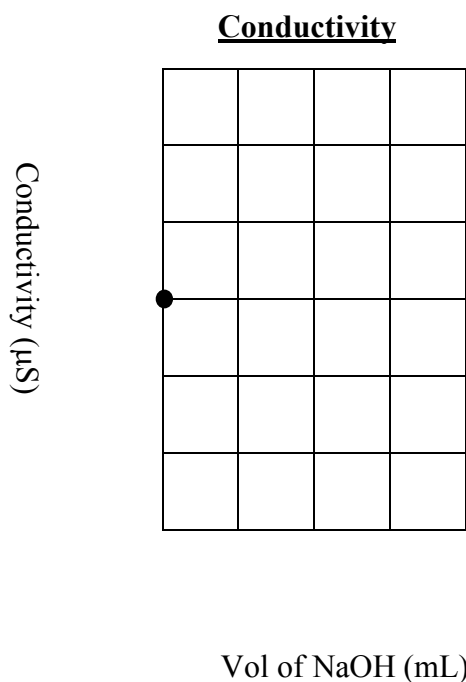
Vol of NaOH (mL)

pH

pH

Vol of NaOH (mL)

Question 30 (7 marks)

Inter and intra electrostatic forces play an important role in determining the properties of chemical substances.

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Analyse the impact of electrostatic attractions on the following:

- Solubility of ions in a water body in determining the water hardness
- Flexibility of LDPE polyethylene compared with polyvinyl chloride
- Completeness of combustion of ethanol compared to 1-pentanol

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Question 31 (5 marks)

With the aid of a diagram, explain the differences in boiling points between the three compounds in the table below.

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	Molecular mass (g mol⁻¹)	Boiling Point (°C)
1-propanamine	59.11	47.8
Butane	58.1	-1.0
Ethanoic Acid	60.052	118.1

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Question 32 (6 marks)

A 100.0 mL solution is known to contain iodide ions. To determine the concentration of iodide ions in the solution, the following investigation was conducted by a student.

Step 1: 50.0 mL of 0.05619 mol L^{-1} silver nitrate solution was added so that all the iodide ions formed a precipitate. This precipitate was filtered and separated from the final solution.

Step 2: The excess silver ions in the final solution were titrated against 0.05322 mol L^{-1} potassium thiocyanate (KSCN) using iron(III) ions as the indicator. 35.14 mL of potassium thiocyanate was required to reach the endpoint.

(a)   During the investigation, the burette was filled with thiocyanate solution. Identify what   **1**
        the burette was rinsed with prior to filling.

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(b)   Determine the concentration of the iodide ions in the original solution.   **3**

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(c)   Explain why a deep red colour forms at the endpoint.   **2**

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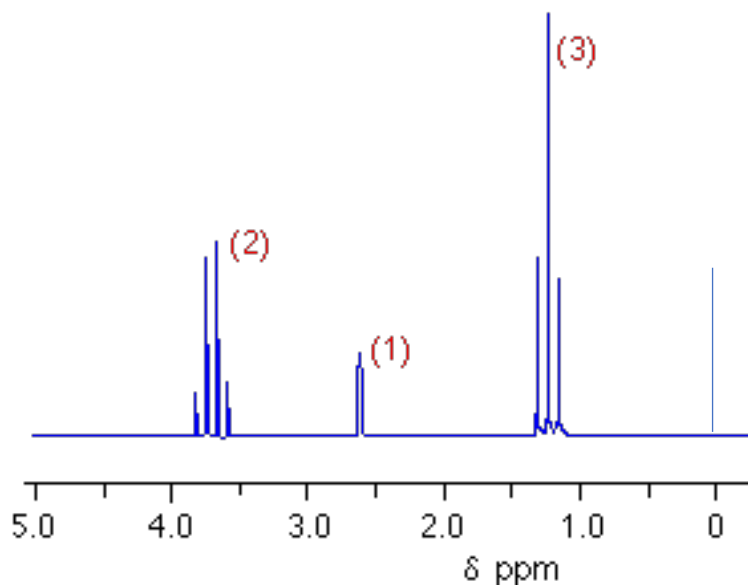
Question 33 (4 marks)

The following diagram shows a high resolution proton NMR spectrum for ethanol.

TYPE OF PROTON	CHEMICAL SHIFT (ppm)	TYPE OF PROTON	CHEMICAL SHIFT (ppm)
Alkane CH$_3$	0.9	R—NH$_2$ RCH=CH$_2$	Variable, about 1.5–4 4.6–6.0
R—CH$_2$—R	1.3	R—O—CH$_3$ or ROCH$_2$R	3.3
R—C=OCH$_3$	2.1	R—OH	Variable, about 1–6
R—CH$_2$—X (X = F, Cl, Br or I)	3–4	Ar—OH	Variable, about 4–7
CH$_3$–COOR	2.0	R—COOH	9–13
RCH$_2$OH RCH=CH—CH$_3$	3.3–4.5 1.6–1.9	R—C(O)H	9–10

Explain how the features of the NMR spectrum represent the different parts of the ethanol molecule.   **4**

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Question 34 (9 marks)

The use of carbon based chemicals can lead to significant negative environmental effects.

Analyse the impact of carbon based chemicals upon the environment by examining THREE different negative effects.

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