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Student Number



Barker
College

2023

TRIAL HIGHER SCHOOL
CERTIFICATE EXAMINATION

Chemistry

PM TUESDAY 8th AUGUST

90 copies

Write your Student Number at the top of this page

Section I - Multiple Choice

Choose the best response and fill in the response oval completely

Start
Here →

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

- 11 A ○ B ○ C ○ D ○
12 A ○ B ○ C ○ D ○
13 A ○ B ○ C ○ D ○
14 A ○ B ○ C ○ D ○
15 A ○ B ○ C ○ D ○
16 A ○ B ○ C ○ D ○
17 A ○ B ○ C ○ D ○
18 A ○ B ○ C ○ D ○
19 A ○ B ○ C ○ D ○
20 A ○ B ○ C ○ D ○

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Barker
College

2023

**TRIAL HIGHER SCHOOL
CERTIFICATE EXAMINATION**

Chemistry

Staff Involved:

PM TUESDAY 8th AUGUST

- NJD* - Mr Dumbleton
- DLM - Mrs McGuinness
- RJP - Mr Paynter
- KMT - Dr Terrett

TIME: 3 hours

90 copies

**General
Instructions:**

- Write your Student Number on all answer pages
- Reading time - 5 minutes
- Working time - 3 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A separate Periodic Table and Data Sheet are provided with this paper
- For questions in Section II, show all relevant working in questions involving calculations

**Total marks:
100**

Section I - 20 marks (pages 3 - 10)

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

Section II - 80 marks (pages 11 - 36)

- Attempt Questions 21 - 38
- Allow about 2 hours and 25 minutes for this section

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

Sample	2 + 4 =	A	2	B	6	C	8	D	9
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A ○ B ○ C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A B C D

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows.

A ● B ~~●~~ C ○ D ○

correct

1. Consider the following pH values for a range of substances.

pH	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Substance	Battery acid	Stomach acid	Lemon juice	Orange juice	Beer	Black coffee	Milk	Blood	Sea water	Toothpaste	Laundry detergent	Bathroom cleaner	Hair straightener	Oven cleaner	Drain cleaner

Based on these pH values, which one of the following statements about the concentration of hydronium ions is true?

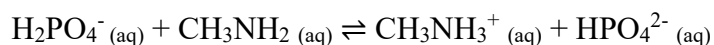
- A. It is 1000 times greater in sea water than in bathroom cleaner.
- B. It is twice as great in beer as it is in lemon juice.
- C. It is three times greater in beer than in hair straightener.
- D. It is 1,000,000 times greater in hair straightener than in milk.
2. The following table provides the indicator colours and colour change range for a selection of indicators and the colour of each indicator in an unknown solution.

Indicator	Acidic Colour	pH Range	Basic Colour	Colour in unknown solution
Phenolphthalein	Colourless	8.3-10.0	Pink	Colourless
Bromothymol Blue	Yellow	6.0-7.6	Blue	Green
Phenol Red	Yellow	6.8-8.0	Red	Orange
Methyl Orange	Red	3.2-4.4	Yellow	Yellow

What is the pH range of the unknown solution?

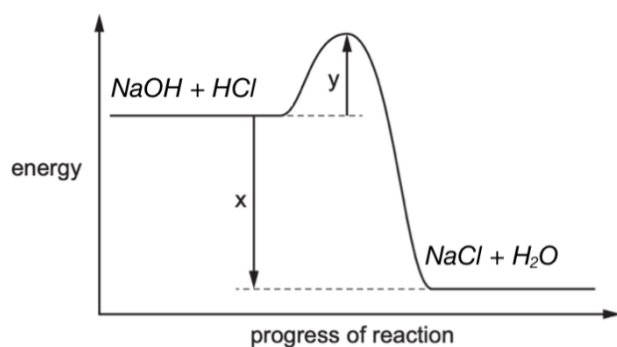
- A. 6.0 - 7.6
- B. 6.8 – 8.0
- C. 6.8 – 7.6
- D. 4.4 - 7.6

3. Identify a conjugate acid-base pair in the reaction represented by the following equation:



- A. $\text{H}_2\text{PO}_4^- (\text{aq})$ and $\text{CH}_3\text{NH}_2 (\text{aq})$
- B. $\text{CH}_3\text{NH}_3^+ (\text{aq})$ and $\text{HPO}_4^{2-} (\text{aq})$
- C. $\text{H}_2\text{PO}_4^- (\text{aq})$ and $\text{HPO}_4^{2-} (\text{aq})$
- D. $\text{H}_2\text{PO}_4^- (\text{aq})$ and $\text{CH}_3\text{NH}_3^+ (\text{aq})$
4. Which of the following shows two products from the fermentation of glucose?
- A. Ethanol and oxygen
- B. Carbon dioxide and water
- C. Ethanol and carbon dioxide
- D. Cellulose and water
5. What is the pH of a solution of the strong base $\text{Mg}(\text{OH})_2$ with a concentration of 0.027 M?
- A. 1.57
- B. 12.73
- C. 1.27
- D. 12.43
6. When the temperature of a particular reaction is increased by 10°C (e.g. from 20°C to 30°C) the rate of the reaction approximately doubles. What is the most significant reason for this increase?
- A. A different mechanism for the reaction
- B. An increase in percentage of molecules with correct orientation
- C. More collisions have energy greater than the activation energy
- D. A reduced activation energy for the reaction

7. A reaction pathway diagram for the reaction of aqueous sodium hydroxide and dilute hydrochloric acid is shown.



What is the value of the enthalpy change of neutralisation per 1 mole of water, in kJ/mol?

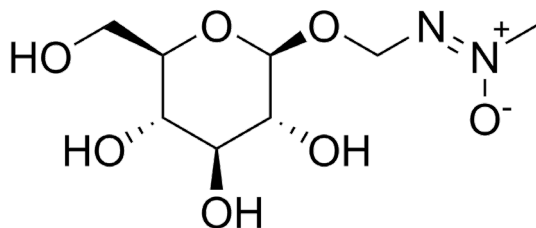
- A. x
- B. $x - y$
- C. y
- D. $x + y$

8. A mixture contains magnesium carbonate and barium carbonate only. A sample of the mixture is dissolved in nitric acid to produce a solution. How could this solution be processed into a magnesium compound and a separate barium compound?

- A. Add $\text{HCl}_{(\text{aq})}$, filter off the solid barium chloride.
- B. Add $\text{HCl}_{(\text{aq})}$, filter off the solid magnesium chloride.
- C. Add $\text{H}_2\text{SO}_{4(\text{aq})}$, filter off the solid barium sulfate.
- D. Add $\text{H}_2\text{SO}_{4(\text{aq})}$, filter off the solid magnesium sulfate.

9. Aboriginal and Torres Strait Islander peoples have long used the principles of equilibrium systems and solubility to process potential food sources to make them suitable for human consumption.

One such food source is the seeds of Cycads. The structure of the main toxic chemical in cycads, cycacin, is shown below:



Which option correctly identifies the reason why it is possible to detoxify cycad seeds by placing them in running water for a few days?

- A. Diffusion of water into the cycad to dilute the cycacin before consumption.
- B. Reaction of water with cycacin to break down the toxin
- C. Solubility of cycacin in water to draw it out of the seeds
- D. Hydration of cycacin in the seeds to deactivate the toxin
10. Three separate samples of 25.0 ml of 0.1 mol/L NaOH(aq) are added to each of three different acid solutions, as described. The temperature of each of the solutions was 298K before mixing.

<i>sample</i>	<i>acid</i>	<i>Type of acid</i>	<i>Concentration (mol/L)</i>	<i>Volume (ml)</i>
1	H ₂ SO ₄	strong	0.05	25
2	HCl	strong	0.05	25
3	CH ₃ COOH	weak	0.05	25

Which statement describes the temperature rises that occur on mixing each of these three acids separately with NaOH?

- A. The temperature rise in all three mixtures is the same.
- B. The temperature rise using H₂SO₄ and HCl is the same.
- C. The temperature rise using CH₃CO₂H is greater than using HCl.
- D. The greatest temperature rise occurs using H₂SO₄.

11. Certain organic compounds can be oxidised to form different compounds using acidified potassium dichromate. The reaction mixture changes colour as the oxidising agent is reduced. Which option is correct for the final reaction mixture colour seen when acidified potassium dichromate is added to the following organic compounds?

	<i>propan-1-ol</i>	<i>pentanal</i>	<i>Butan-2-ol</i>	<i>2-methylpropan-2-ol</i>
A.	green	orange	green	orange
B.	green	green	green	orange
C.	purple	orange	purple	colourless
D.	colourless	colourless	colourless	purple

12. Which statement about acids and bases is always correct?

- A. An acid with two H atoms per molecule will be stronger than an acid with one H atom per molecule.
- B. A concentrated solution of a strong acid will have a lower pH than a dilute solution of a weak acid.
- C. A concentrated solution of a strong base will have a lower pH than a dilute solution of a weak base.
- D. A strong acid is more dissociated in solution than a strong base.

13. Consider the acids listed in the following table.

Name	Formula	K_a (25 °C)
bromoacetic acid	CH_2BrCOOH	1.38×10^{-3}
dibromoacetic acid	CHBr_2COOH	3.31×10^{-2}
tribromoacetic acid	CBr_3COOH	1.91×10^{-1}

Which of the following identifies the strongest acid and classifies it correctly as monoprotic, diprotic or triprotic?

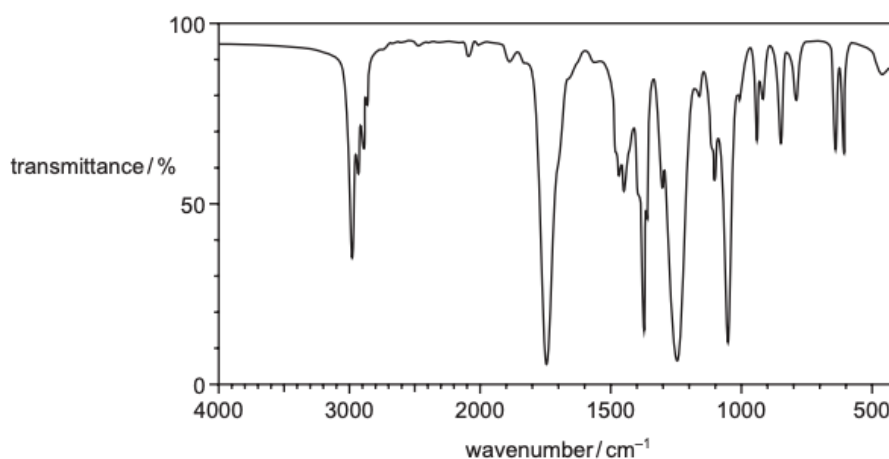
	<i>Strongest acid</i>	<i>Classification</i>
A.	bromoacetic acid	monoprotic
B.	dibromoacetic acid	diprotic
C.	tribromoacetic acid	monoprotic
D.	tribromoacetic acid	triprotic

14. A scientist chooses either infrared spectroscopy or mass spectrometry to find a particular piece of information. In which row has the best choice been made?

	<i>Main target information</i>	<i>Analytical method used</i>
A.	Identities of functional groups in organic compound	IR spectroscopy
B.	Identities of functional groups in organic compound	Mass spectroscopy
C.	Identifies the structure of the compound	IR spectroscopy
D.	Identifies the structure of the compound	Mass spectroscopy

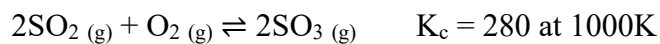
15. Compound X produces the IR spectrum shown below.

Which molecule is most likely to give this IR spectrum?



- A. Methan-1-one
 B. Methanol
 C. Methyl methanoate
 D. Methanoic acid
16. What is the molar solubility of solid iron (III) hydroxide ($K_{sp} = 2.79 \times 10^{-39}$) in a 0.15 M iron (III) nitrate solution?
- A. 8.83×10^{-14} mol/L
 B. 4.55×10^{-20} mol/L
 C. 2.65×10^{-13} mol/L
 D. 1.86×10^{-38} mol/L

17. The reaction between sulfur dioxide and oxygen is reversible.



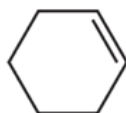
In a mixture at equilibrium at 1000K the sulfur trioxide concentration is 6 mol/L. The sulfur dioxide concentration is twice the oxygen concentration.

What is the sulfur dioxide concentration?

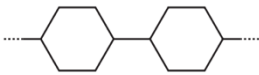
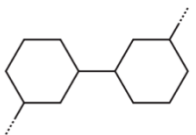
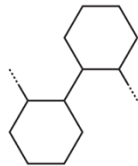
- A. 0.175 mol/L
- B. 0.252 mol/L
- C. 0.318 mol/L
- D. 0.636 mol/L

18. Cyclohexene, as shown in the diagram, can form an addition polymer.

cyclohexene

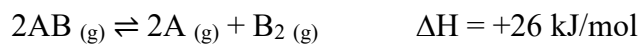


Which structure represents a section of the polymer?

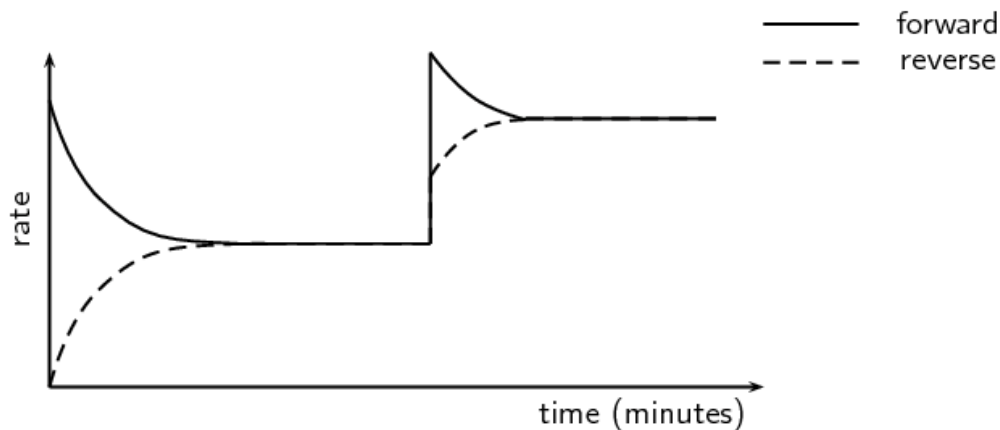
- | | |
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| A. |  |
| B. |  |
| C. |  |
| D. |  |

(Not in 2024 trial exam)

19. For the reaction:



The following graph can be plotted:



What stress has occurred in this system?

- A. Decreased volume
- B. Decreased temperature
- C. Increased temperature
- D. Added more reactant AB

20. Use the following K_a , pK_a and $[\text{H}_3\text{O}^+]$ values to correctly order the acids from weakest to strongest.

<i>Acid (1M)</i>	<i>K_a</i>	<i>pK_a</i>	<i>[H₃O⁺]</i>
HF (hydrofluoric acid)		3.17	
HCN (hydrocyanic acid)			2.5×10^{-5}
HOCl (hypochlorous acid)		7.54	
HN ₃ (hydrazoic acid)	1.9×10^{-5}		

- A. HF, HCN, HOCl, HN₃
- B. HN₃, HOCl, HCN, HF
- C. HF, HN₃, HOCl, HCN
- D. HCN, HOCl, HN₃, HF

End of Section I

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Student Number



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2023

TRIAL HIGHER SCHOOL
CERTIFICATE EXAMINATION

Chemistry

Section II Answer Booklet

80 marks

Attempt Questions 21 – 38

Allow about 2 hours and 25 minutes for this section.

Instructions

- Write your Student Number on all answer pages.
- 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 space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Question 21 (2 marks)

The reaction of solid barium hydroxide, Ba(OH)_2 with ammonium nitrate (NH_4NO_3) is endothermic.

Calculate the minimum temperature at which the reaction of Ba(OH)_2 with NH_4NO_3 becomes spontaneous. Show all relevant working.

2



$$\Delta H = +132 \text{ kJ/mol}$$

$$\Delta S = +616 \text{ J/K/mol}$$

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Student Number

Question 22 (10 marks)

Ammonia gas can react with hydrogen chloride gas to form solid ammonium chloride.

- (i) Write a correctly balanced chemical equation, including states, for this reaction.

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- (ii) Assess the suitability of the Arrhenius and Bronsted-Lowry models of acids and bases for explaining the equation in (i)

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Question 22 continues on page 14

Question 22 (continued)

- (iii) If the ammonium chloride salt formed from the neutralisation reaction between ammonia gas and hydrogen chloride gas is dissolved in water, the pH of the resulting solution will be due to the nature of the salt. Classify the salt as either acidic or basic and provide an equation/s and explanation to support your classification.

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- (iv) Under certain conditions, the hydrogen carbonate ion (HCO_3^-) can act as an amphiprotic substance. Define amphiprotic.

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- (v) Use equations to demonstrate the amphiprotic nature of the hydrogen carbonate ion.

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End of Question 22

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Question 23 (5 marks)

Student Number

- (i) Scientific models can be very useful in helping to explain complicated Chemistry concepts.

Explain the concept of strong and weak, concentrated and dilute acids. As part of your explanation, include a series of diagrams.

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Question 23 continues on page 16

Question 23 (continued)

- (ii) Outline one advantage and one disadvantage of using scientific models to help explain Chemistry concepts.

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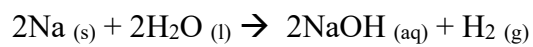
End of Question 23

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Student Number

Question 24 (3 marks)

When 1.08×10^{-2} mol of sodium is placed in water the following reaction occurs:



Assuming complete reaction, calculate the pH of the resulting 500 mL solution at 25°C.

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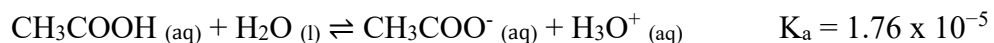
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Question 25 (2 marks)

Ethanoic acid is a weak acid:



An ethanoic acid solution contains the following concentrations:

$$[\text{CH}_3\text{COO}^-_{(\text{aq})}] = 1.2 \times 10^{-3} \text{ mol/L}$$

$$[\text{H}_3\text{O}^+_{(\text{aq})}] = 8.3 \times 10^{-6} \text{ mol/L}$$

$$[\text{CH}_3\text{COOH}_{(\text{aq})}] = 1.5 \times 10^{-3} \text{ mol/L}$$

Show that this solution is not at equilibrium.

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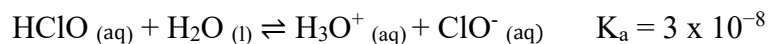
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Student Number

Question 26 (5 marks)

Hydrogen and chlorine, often with oxygen, form acids such as hydrochloric acid and hypochlorous acid. Consider a solution of hypochlorous acid (HClO):



- (i) Outline what this K_{a} value indicates about the strength of hypochlorous acid and use it to state which of the component/s of the equilibrium mixture of hypochlorous acid has the greatest concentration.

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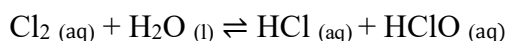
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Aqueous chlorine reacts with water to form an equilibrium mixture containing hydrochloric acid and hypochlorous acid solutions.



- (ii) Household bleach is an equilibrium mixture containing $\text{Cl}_{2(\text{aq})}$, $\text{HClO}_{(\text{aq})}$ and $\text{ClO}^-_{(\text{aq})}$ as well as other ions. The relative quantities of these three chemical species in the equilibrium mixture is pH dependent.

Using the equations provided in (i) and (ii) and by considering the position of the equilibrium when the pH is below 2, predict which of the three chemical species is most abundant. Explain.

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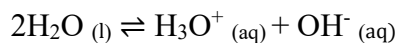
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Question 27 (5 marks)

Water can self-ionise, as shown by the following equation:



The reaction equilibrium and the pH of water are both affected by changes in temperature. The data in the following table show how changing the temperature affects the pH of pure water.

<i>Temperature (°C)</i>	<i>pH of water</i>
0	7.47
25	7.00
50	6.63
75	6.35

- (i) Explain how the tabulated data and Le Chatelier's Principle can be used to deduce whether the self-ionisation of water is exothermic or endothermic.

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Question 27 continues on page 21

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Student Number

Question 27 (continued)

- (ii) Calculate the pH of pure water at 100.0°C given that K_w is equal to 5.25×10^{-13} at that temperature.

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End of Question 27

Question 28 (7 marks) (Not assessed in 2024 trial)

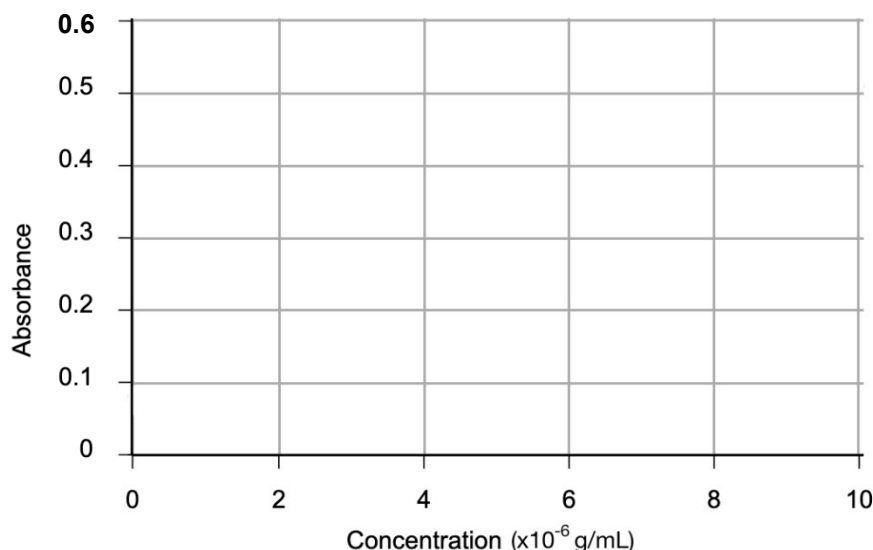
Iron is one of the most abundant elements on Earth. Iron ores contain various iron compounds and impurities such as aluminium oxide. Iron and its compounds have a broad range of uses.

The percentage of iron in a sample of ore can be determined using AAS. One spectrometer was calibrated using several solutions of known concentrations of iron (II) ions.

- (i) Plot the data shown in the table on the graph below and include a line of best fit.

2

Concentration ($\times 10^{-6}$ g/mL)	Absorbance
0	0.00
2	0.05
4	0.13
6	0.22
8	0.34
10	0.41



- (ii) A solution of a sample of one iron ore was analysed using AAS. The absorbance of this solution was 0.30. Calculate the concentration of iron in the sample of ore in ppm ($1\text{ mg/L} = 1\text{ ppm}$).

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Question 28 continues on page 23

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Student Number

Question 28 (continued)

- (iii) Referring to the principles of AAS, explain why the presence of aluminium oxide in the sample solution does not affect the value of the iron concentration determined by AAS. **3**

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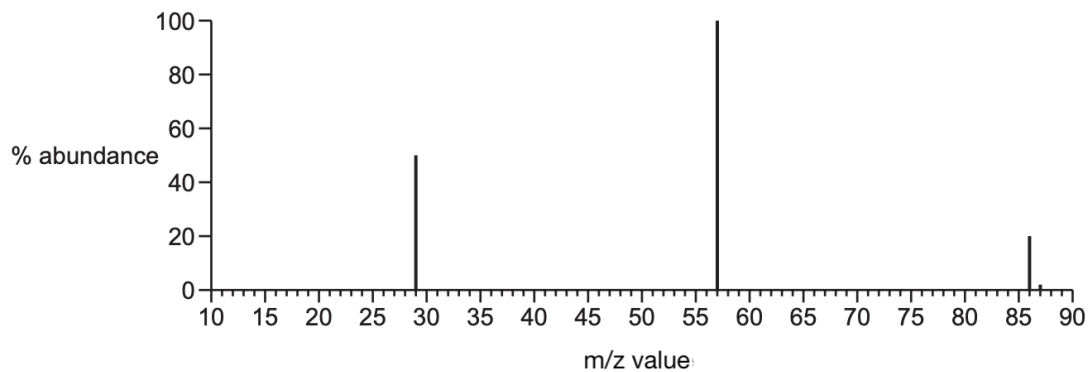
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End of Question 28

Question 29 (3 marks)

The figure below shows the mass spectrum of ketone Z, $C_5H_{10}O$.



- (i) Use the information in the figure to suggest the formulae of the fragments with m/z peaks at 29 and 57. Deduce the identity of Z. **3**

$m/z = 29$

$m/z = 57$

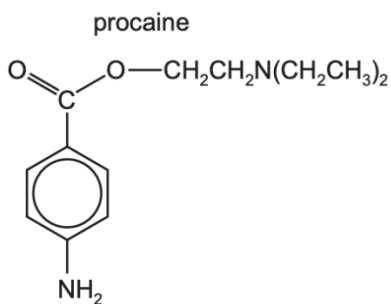
identity of Z

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Question 30 (4 marks)

Student Number

Procaine is used as an anaesthetic in medicine.



- (i) Name two functional groups present in procaine.

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- (ii) Explain why procaine can act as a base.

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Question 31 (4 marks)

The solubility of $\text{Be}(\text{OH})_2$ in water is $2.40 \times 10^{-6} \text{ g/L}$ at 298K.

(i) Write an expression for the solubility product, K_{sp} , of $\text{Be}(\text{OH})_2$.

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(ii) Calculate the numerical value of K_{sp} for $\text{Be}(\text{OH})_2$ at 298K.

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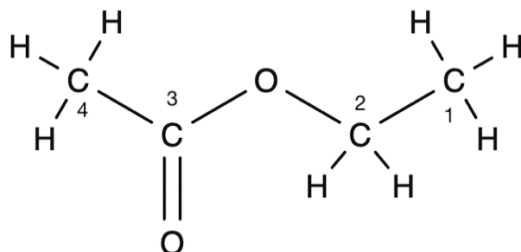
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Student Number

Question 32 (4 marks)

Ethyl ethanoate is an ester formed from ethanol and ethanoic acid.



Separate samples of ethyl ethanoate are analysed using carbon-13 and proton (^1H) NMR spectroscopy.

- (i) Predict the number of unique chemical environments seen in the carbon-13 and proton (^1H) NMR spectra of ethyl ethanoate. 2

	Carbon-13 NMR	proton (^1H) NMR
Number of unique chemical environments		

- (ii) For the carbon labelled number 2 in the diagram above, indicate if the signal for these hydrogens will be a singlet, doublet, triplet or quartet, providing a justification for your answer. 2

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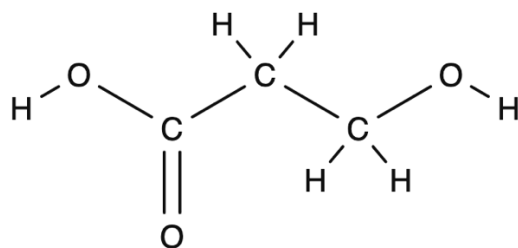
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Question 33 (2 marks)

The monomer 3-hydroxypropanoic acid shown below can form the condensation polymer poly(3-hydroxypropanoic acid).



Draw a section of poly(3-hydroxypropanoic acid), showing three repeating units.

2

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Student Number

Question 34 (4 marks)

25.0 mL of 0.135 mol/L standardised barium hydroxide solution was titrated with nitric acid. The results are recorded in the following table.

<i>Titration</i>	<i>Volume of nitric acid used (mL)</i>
1	21.10
2	21.90
3	21.70
4	21.80

- (i) Write the balanced equation for the reaction of barium hydroxide with nitric acid.

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- (ii) Calculate the concentration of the nitric acid.

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Question 35 (4 marks)

Some common solids used to make acid or base solutions are not suitable to use as primary standards. Using sodium hydroxide as an example, evaluate the effect that the use of a poor primary standard has on the validity and reliability of the results of a titration.

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Student Number

Question 36 (3 marks)

In class you have completed a number of tests using organic compounds, including bromine water to detect the presence of alkenes, oxidation of alcohols and esterification. There were a number of hazards relating to the safe storage and handling of organic compounds when completing these tests.

State TWO hazards associated with the use of organic compounds and identify the measures taken to reduce these hazards.

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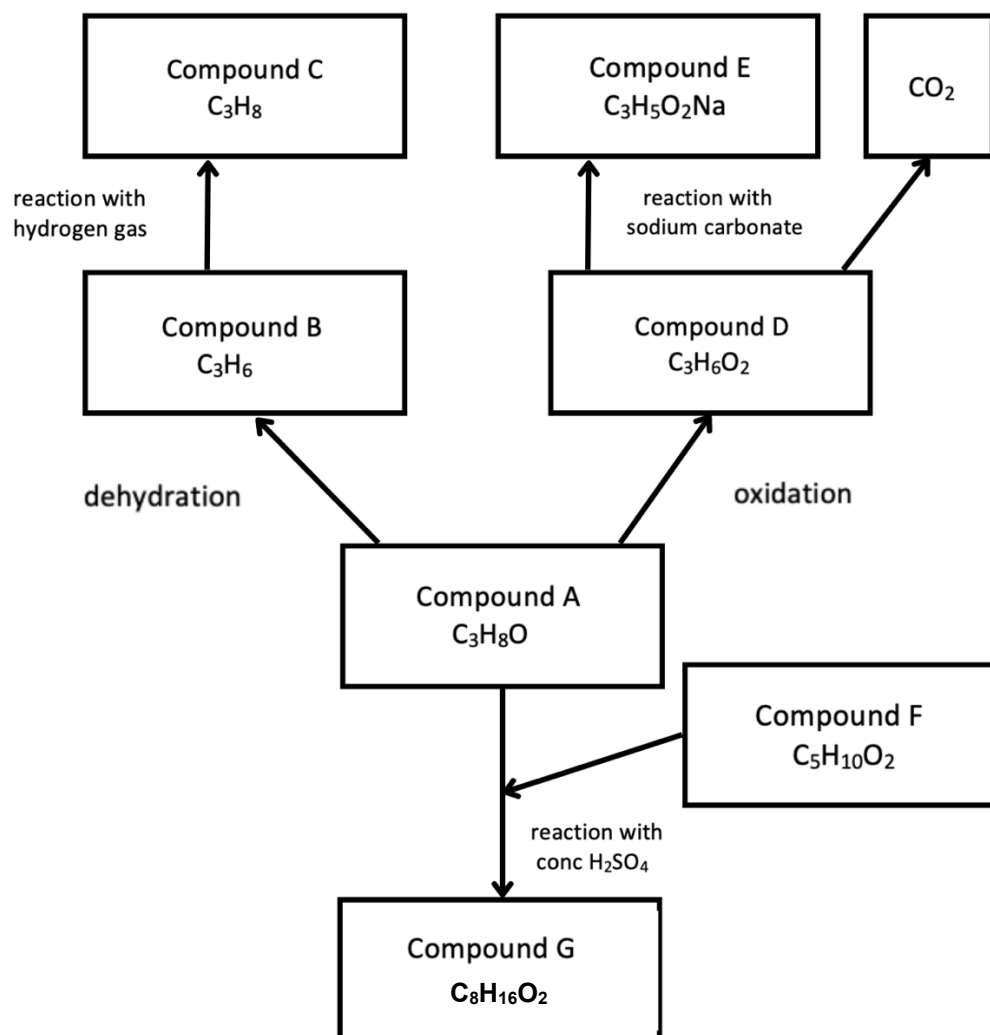
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Question 37 (7 marks)

The flowchart below shows compound A (an alcohol) undergoing several different reactions which form compounds B to G.



Question 37 continues on page 33

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Student Number

Question 37 (continued)

- (i) Draw the structures of compounds A to G in the corresponding space provided.

5

A	
B	
C	
D	
E	
F	
G	

Question 37 continues on page 34

Question 37 (continued)

(ii) State the reaction conditions for the following TWO processes:

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Dehydration of compound A to B:

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Oxidation of compound A to D:

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End of Question 37

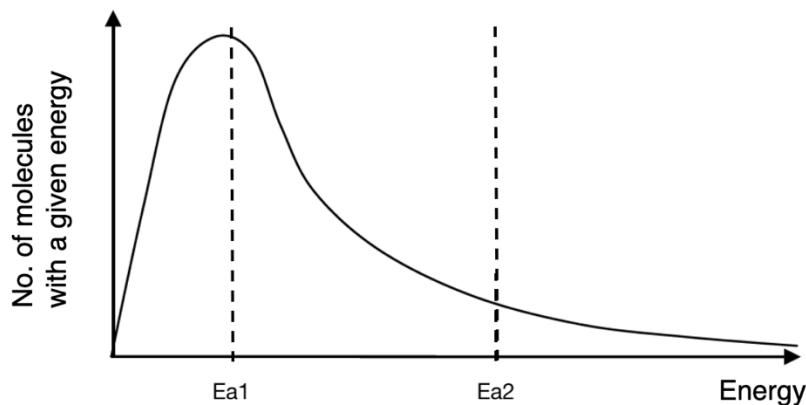
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Student Number

Question 38 (6 marks)

The following Maxwell Boltzmann diagram shows the distribution of molecular energies for particles involved in an equilibrium reaction. The diagram contains two activation energy (E_a) levels, E_{a1} and E_{a2} .

For any equilibrium reaction, the exothermic and endothermic reactions will have different activation energy levels.



- (i) For the two activation energy levels shown on the diagram, state which E_a is for the exothermic reaction and which is for the endothermic reaction, providing a reason for your choice.

2

E_{a1}

E_{a2}

Reason

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Question 38 continues on page 36

Question 38 (continued)

- (ii) Temperature is the only factor which affects the value of K for an equilibrium reaction.

Sketch a curve on the diagram above to show how the distribution of molecular energies changes when the temperature increases.

1

- (iii) Explain why an equilibrium reaction will always shift in the endothermic direction when temperature is increased.

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