SHORE

Exam Number: _____

2022

YEAR 12 TRIAL EXAMINATION

Chemistry

General instructions:

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Board approved calculators may be used
- A data sheet and a Periodic Table are provided at the back of this paper
- Write your Student Exam Number where required
- **Note:** Any time you have remaining should be spent revising your answers

Total marks – 100

Section 1

20 marks

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

Section 2

80 marks

- Attempt Questions 21 - 31
- Allow about 2 hours and 25 minutes for this section

DO NOT REMOVE THIS PAPER FROM THE EXAMINATION ROOM.

Section 1 – 20 marks
Attempt Questions 1–20
Allow about 35 minutes for this part

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

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1 What is the principal intermolecular force that must be overcome when hexane (C_6H_{14}, BP = 69°C) is vaporised?

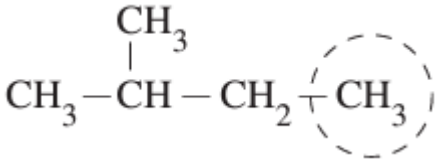
A. Hydrogen bonding

B. Covalent bonding between carbon atoms

C. Dipole-dipole forces

D. Dispersion

2 The structure of 2-methylbutane is shown. A CH_3 group is shown.

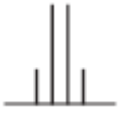


Which of the following splitting patterns would be observed in the ^1H NMR spectrum for the CH_3 group circled?

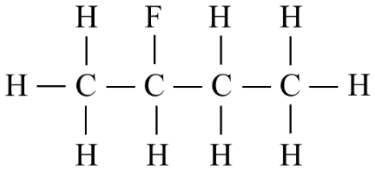
A. 

B. 

C. 

D. 

3 This is a structural formula of a haloalkane.



How many carbon chemical environments are found in this molecule?

A. 1

B. 2

C. 3

D. 4

4 Which of the following statement is false for mass spectroscopy?

A. This technique is used to identify unknown compounds within a sample.

B. This technique can be used on all states of matter.

C. This technique studies the effect of ionising energy on molecules.

D. Particle are characterised by their mass to charge ratios (m/z) and relative abundances.

5 Barium fluoride has $K_{sp} = 1.8 \times 10^{-7}$.

What is the maximum fluoride ion concentration possible in a solution with $[Ba^{2+}] = 5.0 \times 10^{-4}$ mol L^{-1}?

A. 3.6×10^{-4} mol L^{-1}

B. 3.6×10^{-3} mol L^{-1}

C. 9.5×10^{-3} mol L^{-1}

D. 1.9×10^{-2} mol L^{-1}

6 Which one of the following techniques could be used to distinguish between 1,1,1-trichloropropane and 1,2,3-trichloropropane?

A. proton NMR spectroscopy

B. atomic absorption spectroscopy

C. UV-visible spectroscopy

D. Infrared spectroscopy

7 The following table shows the value of the ionisation constant of pure water at various temperatures and at a constant pressure.

Temperature (°C)	0	25	50	75	100
K_w	1.1×10^{-15}	1.0×10^{-14}	5.5×10^{-14}	2.0×10^{-13}	5.6×10^{-13}

Given this data, which one of the following statements about pure water is correct?

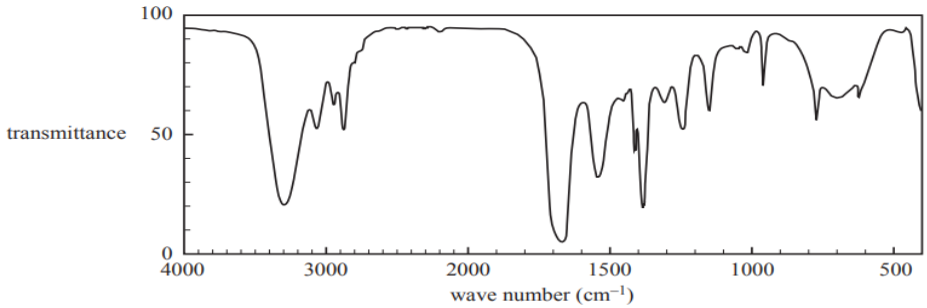
A. The $[OH^-]$ will decrease with increasing temperature.

B. The $[H_3O^+]$ will increase with increasing temperature.

C. Its pH will increase with increasing temperature.

D. Its pH will always be exactly 7 at any temperature.

8 Shown below is the infrared spectrum of an organic compound.



Data: SDBS Web, <http://sdbs.db.aist.go.jp>,
National Institute of Advanced Industrial Science and Technology

The organic compound that produces this spectrum is most likely a

A. aldehyde.

B. alcohol.

C. amide.

D. ester.

9 Which one of the following statements about 10.0 mL of 0.10 M HCl and 10.0 mL of 0.10 M CH_3COOH solutions is true?

A. Each solution will react completely with 10.0 mL of 0.10 M NaOH solution.

B. Each solution will have the same electrical conductivity.

C. Each solution will react at the same rate with 1.00 g of magnesium ribbon.

D. The concentration of H_3O^+ ions will be greater in the CH_3COOH solution.

10 If Solution X has a pH of 3 and Solution Y has a pH of 6, we can conclude that

A. $[H^+]$ in Solution X is 1000 times that of $[H^+]$ in Solution Y.

B. $[H^+]$ in Solution X is half that of $[H^+]$ in Solution Y.

C. $[OH^-]$ in Solution Y is twice that of $[OH^-]$ in Solution X.

D. Solution Y must contain a stronger acid than Solution X.

11 Which response correctly outlines a chemical test that can be used to identify the presence of the hydroxyl functional group in a secondary alcohol?

	Functional group tested for	*Reaction with*	*Observations*
A.	hydroxyl	sodium metal	no reaction
B.	hydroxyl	limewater	colour change from clear to cloudy white
C.	hydroxyl	$H^+/Cr_2O_7^{2-}$ solution	colour change from orange to green
D.	hydroxyl	bromine water	colour change from orange-red to clear

12 To determine the amount of phosphate in a sample of polluted water, a coloured solution is produced by adding excess molybdovanadate reagent to the water sample. Which technique would be used to determine the concentration of phosphate in the water?

A. atomic absorption spectroscopy

B. colourimetry

C. ^{1}H NMR spectroscopy

D. ^{13}C NMR spectroscopy

13 Which of the following will decrease $[Cl^-]$ in a saturated solution of $PbCl_2$ in contact with excess solid lead (II) chloride?

I. Addition of a small amount of water (allowed to reach equilibrium)
II. Addition of a small amount of $AgNO_{3(aq)}$ (allowed to reach equilibrium)

A. I only

B. II only

C. Both I and II

D. Neither I nor II

Questions 14 and 15 refer to the following equilibrium:

Propanone (C_3H_6O) can be made from propan-2-ol using a copper-zinc catalyst.

$$C_3H_8O_{(g)} \rightleftharpoons C_3H_6O_{(g)} + H_{2(g)} \qquad \Delta H = -54 \text{ kJ mol}^{-1}$$

14 At equilibrium at a particular temperature, 10% of the propan-2-ol is converted to propanone. In order to increase the percentage yield of propanone at equilibrium, you should

A. lower the temperature and lower the pressure.

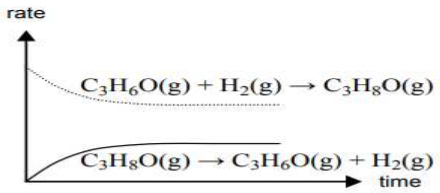
B. lower the temperature and raise the pressure.

C. raise the temperature and lower the pressure.

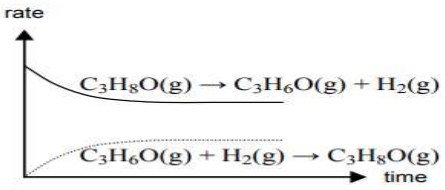
D. raise the temperature and raise the pressure.

15 When propan-2-ol is introduced into an empty flask, it reacts and forms an equilibrium mixture with propanone and hydrogen. Which one of the following best represents how the rates of the forward and backwards reactions change over time?

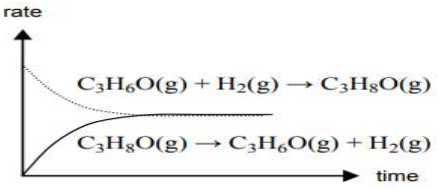
A.



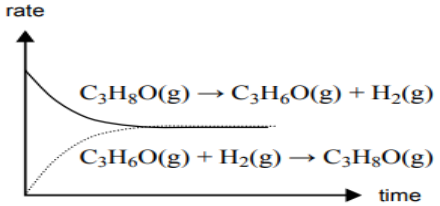
B.



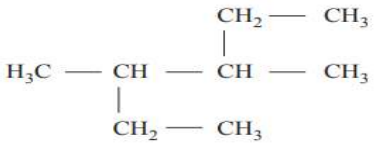
C.



D.



16 What is the correct systematic name for the following compound?



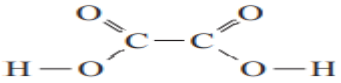
A. 2-ethyl-3-methylpentane

B. 3-methyl-4-ethylpentane

C. 3,4-dimethylhexane

D. 2,3-diethylbutane

17 The structure of oxalic acid is shown.



A 25.0 mL solution of oxalic acid reacts completely with 15.0 mL of 2.50 M NaOH. The concentration of the oxalic acid solution is

A. 0.667 M

B. 0.750 M

C. 1.33 M

D. 1.50 M

18 Barium carbonate, $BaCO_3$, is stable at room temperature, but decomposes to barium oxide and carbon dioxide at higher temperatures.

$$BaCO_{3(s)} \rightleftharpoons BaO_{(s)} + CO_{2(g)}$$

At a certain temperature, this system is in equilibrium in a closed system and contains appreciable amounts of both solid compounds.

Which changes will lead to an increase in the pressure of CO_2 present at equilibrium?

I. Adding more $BaCO_3(s)$
II. Increasing the volume of the container

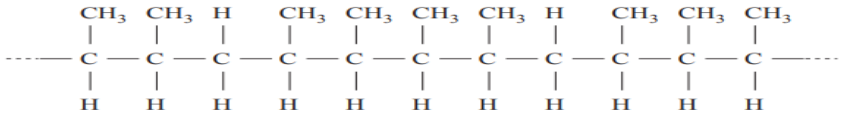
A. Both I and II

B. Neither I nor II

C. I only

D. II only

19 Copolymers are obtained when two or more different monomers are allowed to polymerise together. Part of a copolymer chain is shown below.



The two alkenes that could react together to form this polymer are

A. propene and but-2-ene.

B. propene and but-1-ene.

C. but-1-ene and but-2-ene.

D. pent-2-ene and but-2-ene.

20 Phosphoric acid (H_3PO_4) is a triprotic acid. It dissociates in water in three stages as shown.

Stage 1: $H_3PO_4(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + H_2PO_4^-(aq)$ $\quad K_{a1} = 7.3 \times 10^{-3}$

Stage 2: $H_2PO_4^-(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HPO_4^{2-}(aq)$ $\quad K_{a2} = 6.3 \times 10^{-8}$

Stage 3: $HPO_4^{2-}(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HPO_4^{3-}(aq)$ $\quad K_{a3} = 4 \times 10^{-13}$

A student wants to calculate the approximate pH of a 0.1 mol L–1 solution of phosphoric acid. Which value(s) of the dissociation constants should the student use?

A. K_{a1} only

B. $K_{a1} + K_{a2} + K_{a3}$

C. $K_{a1} - K_{a2} - K_{a3}$

D. $K_{a1} \times K_{a2} \times K_{a3}$

End of Section A

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Question 21 (11 marks)

In an experiment, 1.0 mol of pure phosgene, $COCl_2$, is placed in a 3.0 L flask where the following reaction takes place:

$$COCl_{2(g)} \rightleftharpoons CO_{(g)} + Cl_{2(g)} \qquad K_{eq} = 2.1 \times 10^{-8}$$

(a) It can be assumed that, at equilibrium, the amount of unreacted $COCl_2$ is approximately equal to 1.0 mol. On the basis of the data provided, explain why this assumption is justified. **2**

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(b) Calculate the equilibrium concentration, in mol L^{-1}, of carbon monoxide, CO. Assume that the amount of unreacted $COCl_2$ is approximately equal to 1.0 mol. **3**

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(c) What is the equilibrium concentration of chlorine gas? **1**

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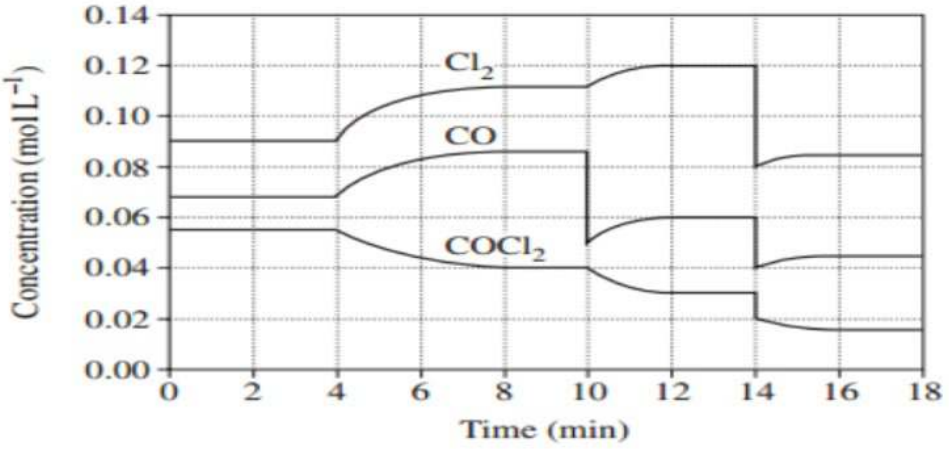
Question 21 continues on the next page

Question 21 (continued)

In another experiment, carbon monoxide and chlorine were placed in a sealed flask and allowed to reach equi1ibrium. Phosgene was formed.
The temperature, pressure and volume were initially the same as in part (a) above.

$$Cl_{2(g)} + CO_{(g)} \rightleftharpoons COCl_{2(g)} \qquad \Delta H = -108 \text{ kJ}$$



(d) Given the information in part (a), what is the equilibrium constant for this reaction? **1**

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(e) Identify the changes applied to the equilibrium at: **1**

Time = 10 minutes ……

Time = 14 minutes ……

(f) Explain, using collision theory, the reason for the change at time = 4 minutes. **3**

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Question 22 (4 marks)

A saturated aqueous solution of $Ca(OH)_2$ has pH = 12.40.

(a) What is the concentration of hydroxide ion in this solution? **2**

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(b) What is the K_{sp} of $Ca(OH)_2$? **2**

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Question 23 (4 marks)

The K_a of benzoic acid, C_6H_5COOH, is 6.5×10^{-5}.

(a) What is the K_b of the benzoate ion $C_6H_5COO^-$?

…… **1**

(b) What is the pH of a 0.20 M solution of sodium benzoate, NaC_6H_5COO? **3**

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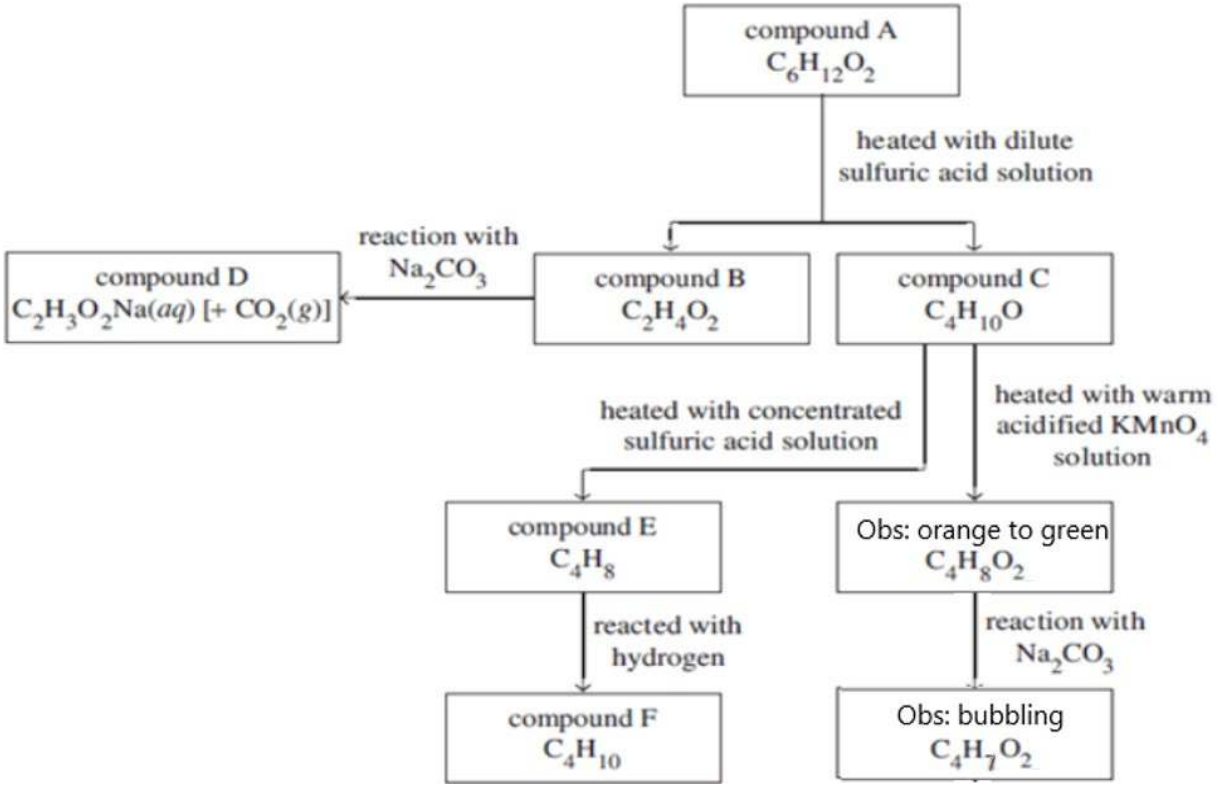
Question 24 (9 marks)

This flowchart shows reactions involving six different organic compounds, A-F. Compound A is sweet smelling.



(a) Draw the structural formula of compound A-F and use the information provided to justify your answer **7**

Compound	*Structural Formula*	*Justification*
A		
B		

C		
D		
E		
F		

(b) Compound A can undergo saponification and produce a carboxylate ion. **2**
Justify whether this carboxylate could be used to remove oil droplets from a surface.

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Question 25 (9 marks)

Kevlar is a very strong, high-density copolymer. It is made from the following monomers which combine in a condensation reaction, producing hydrogen chloride gas.

Benzene-1,4-diamine

+

Benzene-1,4-dicarbonyl dichloride

(a) Draw these two monomers combined (i.e. draw the monomer of Kevlar). **1**

(b) Explain how the structure of this polymer gives rise to the stated properties. **3**

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Question 25 continues on the next page

Exam Number: _____

Question 25 (continued)

(c) A scientist wanted to determine the percentage of benzene-1,4-diamine (BDA) in a bullet-proof vest. They dissolved the vest using a strong acid which chemically separated the Kevlar into its individual monomers. Benzenesulfonyl chloride, a chemical known to react with the monomer benzene-1,4-diamine, was then added in excess and formed 42.3 g of a white precipitate. Determine the %(w/w) of BDA in the 165 g bullet-proof vest. **3**

Word Equation	benzene-1,4-diamine	+	benzenesulfonyl chloride	➡	white precipitate	+	hydrogen chloride gas
MM (g mol^{-1})	108.14		176.62		248.30		36.46

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(d) The other monomer benzene-dicarboxylic acid has a MM = 166.14 g mol^{-1}. What would be the molar mass of a polymer of Kevlar that is 1000 monomers long? **2**

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Question 26 (6 marks)

A student carried out an experiment to determine the molar heat of neutralisation when 150.0 mL of 2.500 M of potassium hydroxide is mixed with 120.0 mL of 1.400 sulfuric acid. The temperature changed from 18.50 °C to 36.65 °C. Assume that the heat capacity of the solution is 4.18×10^3 J kg^{-1} K^{-1}.

(a) Calculate the molar heat of neutralisation given this data. **4**

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(b) Sketch an energy diagram for this reaction **2**

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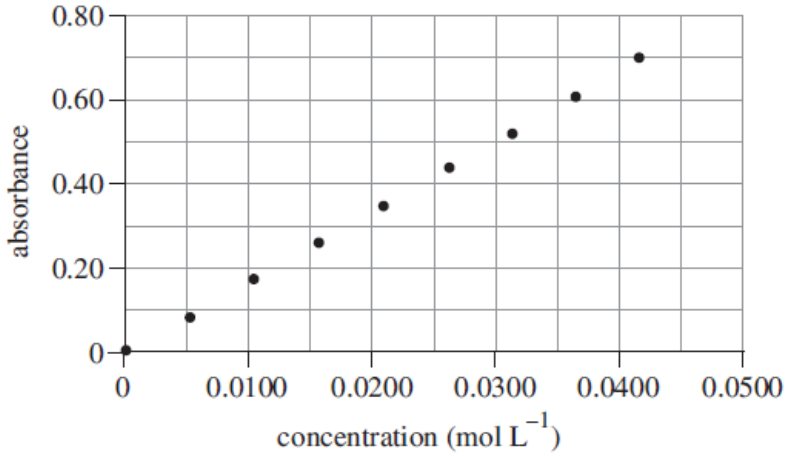
Question 27 (5 marks)

A colourimeter with an orange filter was used to analyse the concentration of copper ions in a solution. To calibrate the colourimeter, a distilled water blank and eight standards of Cu^{2+} were prepared. Their absorbances were measured to give the calibration curve shown. **4**



A 20.0 mL sample of a copper solution of unknown concentration was diluted to a total of volume of 80.0 mL. This diluted solution recorded an absorbance of 0.500.

(a) Use the graph to determine the mass of the copper ions contained in the 20.0 mL sample.

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(b) Given the information provided, sketch a possible UV-Vis spectrum for Cu^{2+} **1**

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Exam Number: _____

Question 28 (9 marks)

(a) Draw a flowchart which could be used to distinguish between the following organic liquids, using chemical reactions in the laboratory. Include all reagents used and observations made. **4**

- Hex-1-ene
- Hexane
- Propan-1-ol
- Butanoic acid

Question 28 continues on the next page

Question 28 (continued)

(b) Write equations for 2 reactions used in your flowchart. **2**

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(c) Identify a liquid (out of the four) which contains a carbon where the bonding around it is described as trigonal planar. Draw the structure of the compound, identifying the relevant carbon, and briefly explain why is called trigonal planar. **3**

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Exam Number: _____

Question 29 (8 marks)

(a) Outline a laboratory method which could be used to distinguish between dilute solutions of iron (II) nitrate, iron (III) nitrate and lead (II) nitrate. Include observations for reactions you describe. **3**

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(b) Outline a laboratory method which could be used to distinguish between dilute solutions of sodium acetate, sodium carbonate and sodium chloride. **2**

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Question 29 continues on the next page

Question 29 (continued)

(c) A sample of an unknown metal salt is to be analysed. **3**

The cation in the metal salt is known to be one of Ba^{2+}, Ca^{2+}, Mg^{2+} or Cu^{2+} and the anion is known to be one of Cl^-, OH^-, CO_3^{2-} or SO_4^{2-}.

The metal salt is dissolved in water and the resulting colourless solution is divided into four equal samples to be tested, labelled A, B, C and D. The results of the tests are shown in the table.

	Test(s) conducted	*Result*
Sample A	A solution of NaOH is added.	A white precipitate forms.
Sample B	Test 1: A dilute solution of HNO_3 is added.	There is no visible reaction.
	Test 2: A dilute solution of $AgNO_3$ is added	There is no visible reaction.
	Test 3: A more concentrated solution of $AgNO_3$ is added	A white precipitate forms.
Sample C	Test 1: A dilute solution of $BaCl_2$ is added	A white precipitate forms.
	Test 2: A dilute solution of HCl is added	There is no visible reaction.
Sample D	A small sample of the solution was heated in the flame of a Bunsen burner	No change in flame colour.

Identify the metal salt and justify your answer

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Exam Number: _____

Question 30 (6 marks)

(a) Some salts display amphiprotic behaviour. Using a suitable example, explain what is meant by 'amphiprotic'. Support your answer with chemical equations. **4**

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(b) The following is an example of an acid-base reaction that the theory of Brønsted-Lowry does not account for: **2**

$$BF_3 + F^- \rightarrow [BF_4]^-$$

Explain why their theory falls short, yet it is still widely accepted.

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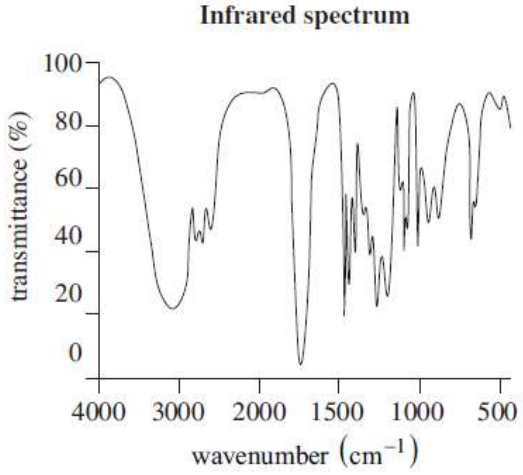
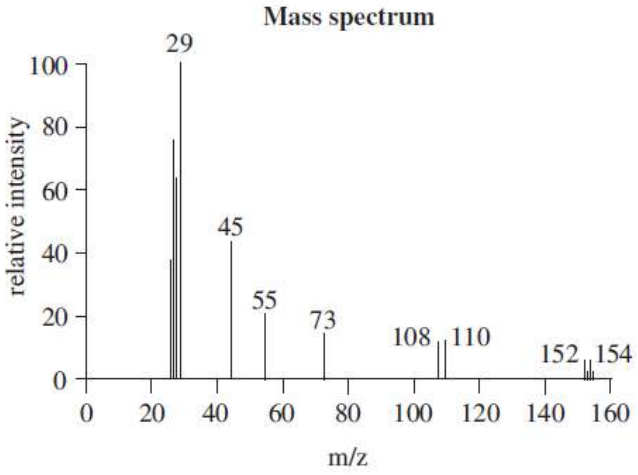
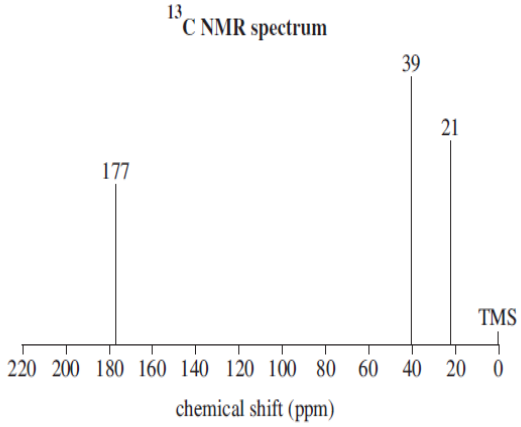
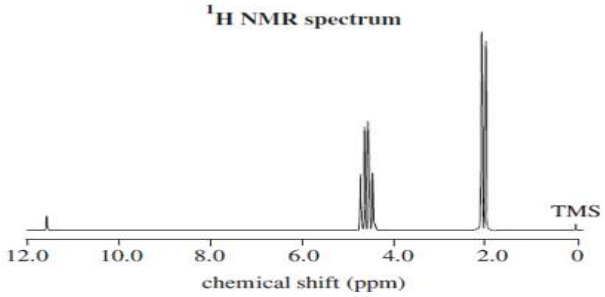
Question 31 (9 marks)

A series of preliminary tests on a small, water-soluble organic molecule revealed that it contained a halogen. The mass, infrared, ^{1}H NMR and ^{13}C NMR spectra of the unknown molecule are shown. **9**









Chemical shift (ppm)	*Peak splitting*	*Relative peak area*
1.9	doublet	3
4.4	quartet	1
11.5	singlet	1

Draw a structural formula for the unknown molecule that is consistent with all of the information provided. Justify your answer by referencing the information provided.

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Question 31 continues on the next page

Exam Number: _____

Question 31 (continued)

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End of Examination