

STUDENT:

TEACHER:

## UNIT 3

**CHEMISTRY**

Total time allowed for test: 90 minutes

**QUESTION AND ANSWER BOOKLET****Structure of booklet**

Section	Number of questions	Marks
A	20	20
B	8	48

**Instructions**

- Students are permitted to bring into the test room: pens, pencils, highlighters, erasers, sharpeners, rulers and a scientific calculator.
- Write your name in the space provided above.
- All written responses must be in English.
- Marks are awarded for correct setting out.
- Significant figures are considered as part of a correct numerical answer.

## Section A Multiple Choice

Specific Instructions for Section A

Section A consists of 20 multiple-choice questions.

Choose the response that is the correct or best answer to the question, and mark your choice on the multiple-choice answer sheet according to the instructions on that sheet.

### Question 1

There are two types of stationary phases used in thin layer chromatography. One stationary phase is made of aluminium oxide. Which of the following molecules would be expected to have the smallest  $R_f$  using aluminium oxide as the stationary phase on the glass slide?

- (a)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{COOH}$
- (b)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
- (c)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2$
- (d)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$

### Question 2

Which of the following statements about volumetric analysis is INCORRECT?

- (a) All titrations need an indicator added in order to detect the end point.
- (b) The end point can occur after the equivalence point.
- (c) Pipettes deliver an aliquot.
- (d) Rinsing the burette with the solution it will deliver will not alter the result.

### Question 3

IR spectroscopy is an analytical tool often used in organic chemistry. Which of the following could be distinguished from the other molecules due to the absence of a particularly distinct and characteristic peak?

- (a)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
- (b)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$
- (c)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2$
- (d)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOCH}_3$

**Question 4**

Which of the following would produce the  $^1\text{H}$  NMR peak pattern shown below.



- (a)  $\text{CH}_3\text{CH}_2\text{OH}$
- (b)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
- (c)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$
- (d)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$

**Question 5**

A mass spectrum had a prominent peak corresponding to a mass of 15. Which of the following molecules would explain this peak?

- (a)  $\text{CH}_2\text{CH}_2$
- (b)  $\text{CH}_3\text{OH}$
- (c)  $\text{HCOOH}$
- (d)  $\text{CCl}_3\text{H}$

**Question 6**

The Victorian EPA (Environmental Protection Authority) has recently monitored an oil slick sample. By this means the agency was able to identify the ship that had illegally discharged its bilge water into the bay. Which of the following combinations of instrumental analytical techniques would provide the most useful information to identify the hydrocarbons in the oil slick?

- (a) IR and NMR
- (b) GC and mass spectroscopy
- (c) IR and AAS
- (d) UV-visible and HPLC

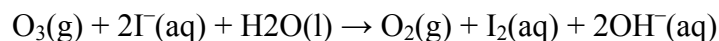
**Question 7**

In a titration, 0.055 g of a monoprotic acid was neutralised by 9.17 mL of  $0.100 \text{ mol L}^{-1}$  KOH. The monoprotic acid must be:

- (a) HCl
- (b)  $\text{HNO}_3$
- (c)  $\text{CH}_3\text{COOH}$
- (d)  $\text{CH}_3\text{CH}_2\text{COOH}$

**Questions 8 and 9 refer to the following information.**

The Environmental Protection Authority determines the concentration of ozone in the air by passing an air sample through a solution containing iodide ions. These react according to the equation:

**Question 8**

From the equation above, the half-reaction involving the reductant is:

- (a)  $2\text{I}^-(\text{aq}) + 2\text{e}^- \rightarrow \text{I}_2(\text{aq})$
- (b)  $2\text{I}^-(\text{aq}) \rightarrow \text{I}_2(\text{aq}) + 2\text{e}^-$
- (c)  $\text{O}_3(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{O}_2(\text{g}) + 2\text{OH}^-(\text{aq}) + 2\text{e}^-$
- (d)  $\text{O}_3(\text{g}) + \text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{O}_2(\text{g}) + 2\text{OH}^-(\text{aq})$

**Question 9**

If  $2.592 \times 10^{-3}$  g of ozone were present in the air sample, what volume of  $0.0035 \text{ mol L}^{-1}$  KI solution would be required to fully react with it?

- (a) 1.9 mL
- (b) 3.8 mL
- (c) 15 mL
- (d) 31 mL

**Question 10**

In which of the following is there an element with the same oxidation number as sulfur in  $\text{HSO}_4^-$ ?

- (a)  $\text{P}_4\text{O}_{10}$
- (b)  $\text{K}_2\text{Cr}_2\text{O}_7$
- (c)  $\text{KMnO}_4$
- (d)  $\text{VO}^{2+}$

**Question 11**

A chemist analyses a 5.0 g ore sample of chalcopyrite,  $\text{CuFeS}_2$ . A gravimetric analysis is carried out so that all the sulfur in  $\text{CuFeS}_2$  is precipitated as  $\text{BaSO}_4$ . The amount of  $\text{BaSO}_4$  is determined to be 0.10 mol. What is the percentage mass of sulfur in the ore?

- (a) 3.2%
- (b) 12.8%
- (c) 32%
- (d) 64%

**Question 12**

A chemist used high-performance liquid chromatography to analyse the esters present in a perfume. The rate at which the ester molecules moved down the column was different from the rate at which the solvent moved. The retention time would NOT be influenced by the:

- (a) extent that the ester is adsorbed onto the stationary phase packed in the column.
- (b) concentration of the ester.
- (c) flow of the solvent or mobile phase.
- (d) temperature used.

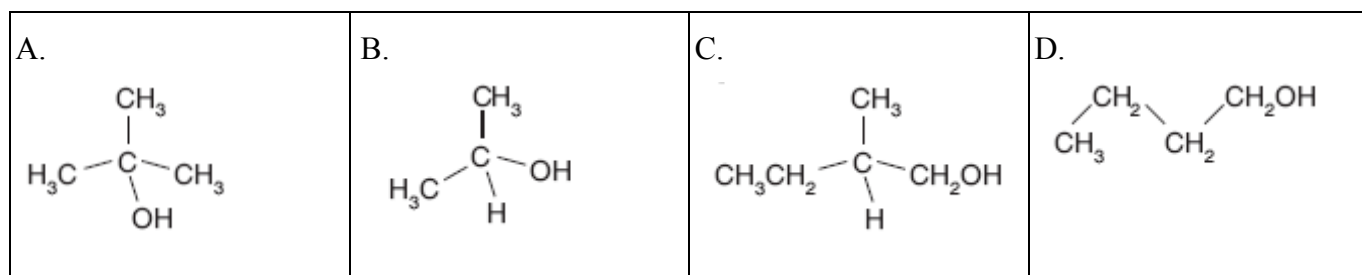
**Question 13**

The molecule that could be oxidised to form propanoic acid is:

- (a)  $\text{CH}_3\text{CH}_2\text{OH}$
- (b)  $\text{CH}_3\text{CH}_2\text{COOH}$
- (c)  $(\text{CH}_3)_2\text{CHOH}$
- (d)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$

**Question 14**

The structure of 2-methylbutan-1-ol is:

**Question 15**

The reaction of salicylic acid that results in the synthesis of aspirin is described as:

- (a) a hydrolysis reaction.
- (b) a substitution reaction.
- (c) an addition reaction.
- (d) an esterification reaction.

**Question 16**

Which of the following chemicals would be needed to synthesise 2,3-dichlorobutane?

- (a) butane and  $\text{HCl}$
- (b) propane and chloromethane
- (c) butene and  $\text{HCl}$
- (d) butene and  $\text{Cl}_2$

**Question 17**

A chemist needs to separate a mixture of organic compounds by fractional distillation. Which of the following chemicals would distill at the highest temperature?

- (a) butan-1-ol
- (b) butane
- (c) pentane
- (d) ethene

**Question 18**

The structure of glycine in aqueous conditions is dependent on the pH of the solution. Glycine is most likely to exist as:

<p>A.</p> $\begin{array}{c} \text{NH}_2 \\   \\ \text{H}-\text{C}-\text{COOH} \\   \\ \text{H} \end{array} \quad \text{at } \text{pH} = 12$	<p>B.</p> $\begin{array}{c} ^+\text{NH}_3 \\   \\ \text{H}-\text{C}-\text{COOH} \\   \\ \text{H} \end{array} \quad \text{at } \text{pH} = 9$
<p>C.</p> $\begin{array}{c} ^+\text{NH}_3 \\   \\ \text{H}-\text{C}-\text{COOH} \\   \\ \text{H} \end{array} \quad \text{at } \text{pH} = 2$	<p>D.</p> $\begin{array}{c} ^+\text{NH}_3 \\   \\ \text{H}-\text{C}-\text{COO}^- \\   \\ \text{H} \end{array} \quad \text{at } \text{pH} = 4$

**Question 19**

The compound  $\text{CH}_3\text{COOCH}_2\text{CH}_3$  is named:

- (a) methyl ethanoate.
- (b) ethyl ethanoate.
- (c) methyl methanoate.
- (d) ethyl methanoate.

**Question 20**

Sections of DNA that contain more AT base pairs than GC base pairs can be identified because the section of DNA will have:

- (a) a higher melting point due to AT having three H-bonds between the A and T nucleotides.
- (b) a lower melting point due to AT having three H-bonds between the A and T nucleotides.
- (c) a lower melting point due to AT having two H-bonds between the A and T nucleotides.
- (d) a higher melting point due to AT having two H-bonds between the A and T nucleotides.

**End of Section A**

**Section B Written section**

**Question 1**

A laboratory technician was given three organic liquids labelled A, B and C. Elemental analysis revealed that the molecular formula of liquids B and C was  $C_4H_{10}O$ . When liquid A was added to a sodium carbonate solution, carbon dioxide was detected. Mass spectroscopy determined the molecular formula of liquid A as  $C_3H_6O_2$ . When liquids B and C were warmed with liquid A in the presence of a few drops of concentrated sulfuric acid, a fruity aroma was produced by the reaction with liquid B but not liquid C.

(a) Suggest the type of organic compound formed when A and B reacted.

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(b) Write a balanced chemical equation to describe the reaction between A and B.

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(c) Draw the semi-structural formula of the product formed in reaction **b**.

(d) Draw the structural formula of the compound A.



(e) What type of chemical reaction occurred between A and B?

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(f) What type of chemical reaction would reverse the reaction stated in question e?

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(g) What organic chemical term describes the relationship between molecules B and C?

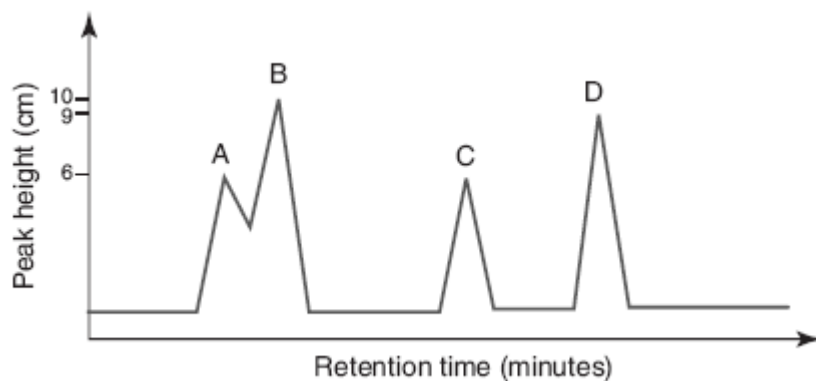
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7 marks

### Question 2

The following HPLC chromatogram was obtained when a sample of perfume was tested.



(a) Which molecule spent most time in the stationary phase?

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(b) What is the percentage of C in the mixture?

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- (c) Suggest two ways the instrument could be modified to improve the separation of molecules A and B.

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- (d) Why was HPLC used in preference to GC in this analysis?

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- (e) It was known that two substances present in the mixture were pentyl butanoate and hexyl butanoate. Which of the four peaks is most likely to be pentyl butanoate? Why?

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- (f) It is suspected that peak C is amyl nitrate. How can this be verified?

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- (g) Mass spectroscopy GC is a common research tool in biological research. Which instrumental technique is used before the other one? Why?

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7 marks

### Question 3

An analysis of nickel ore was carried out by dissolving 3.600 g of the ore in 30.00 mL of concentrated nitric acid. This was then transferred to a 100.0 mL volumetric flask and made up to the mark with distilled water. AAS was then used to determine the concentration of the nickel ions. Calibration was needed prior to the analysis.

(a) Describe the correct technique for preparation of a standard nickel solution.

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(b) A series of standard anhydrous nickel nitrate solutions was prepared. What mass of nickel nitrate is needed to prepare of 100.0 mL of 0.100 mol L<sup>-1</sup> nickel nitrate solution? Include your calculations.

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(c) A calibration curve was created. Describe what part of the instrument must be changed if it were previously being used to analyse sodium in soy sauce.

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(d) Even though traces of iron and copper ions were present in the ore sample, AAS will give an accurate determination of the nickel concentration. Why?

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(e) The determination gave a concentration of 300 mg L<sup>-1</sup> in the volumetric flask. What was the mass of nickel ions in the original sample?

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(f) What is the percentage by mass of the nickel in the ore sample?

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**6 marks**

**Question 4**

A sample of soft drink was analysed for the quantity of phosphoric acid,  $\text{H}_3\text{PO}_4$ . A 25.00 mL aliquot of the soft drink was diluted in a 250.0 mL volumetric flask. A 20.00 mL aliquot of this diluted soft drink was titrated against  $0.0887 \text{ mol L}^{-1}$  potassium hydroxide, KOH. The titre required to reach the end point was 22.34 mL.

- (a) What is the full chemical equation for the above reaction?

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- (b) How many moles of potassium hydroxide were needed for the reaction?

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- (c) What amount (in moles) of phosphoric acid reacted with the KOH?

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- (d) What is the molarity of phosphoric acid in the original soft drink?

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- (e) What is the concentration of phosphoric acid in the original soft drink in  $\text{g L}^{-1}$ ?

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**5 marks**

**Question 5**

An analysis involving mass spectroscopy and gas chromatography of an industrial discharge containing two hydrocarbons revealed two peaks in the GC and a maximum peak of 58 for each compound in the MS. No functional groups were detected.

- (a) Name two instrumental techniques not mentioned in the above question that could indicate an absence of a functional group.

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- (b) Write the semi-structural formulae for two hydrocarbons that correspond to the instrumental data supplied by the analysis.

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- (c) To what homologous series does the instrumental data indicate that these molecules belong?

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- (d) Write a full chemical equation for when one of the molecules undergoes a substitution reaction with chlorine gas.

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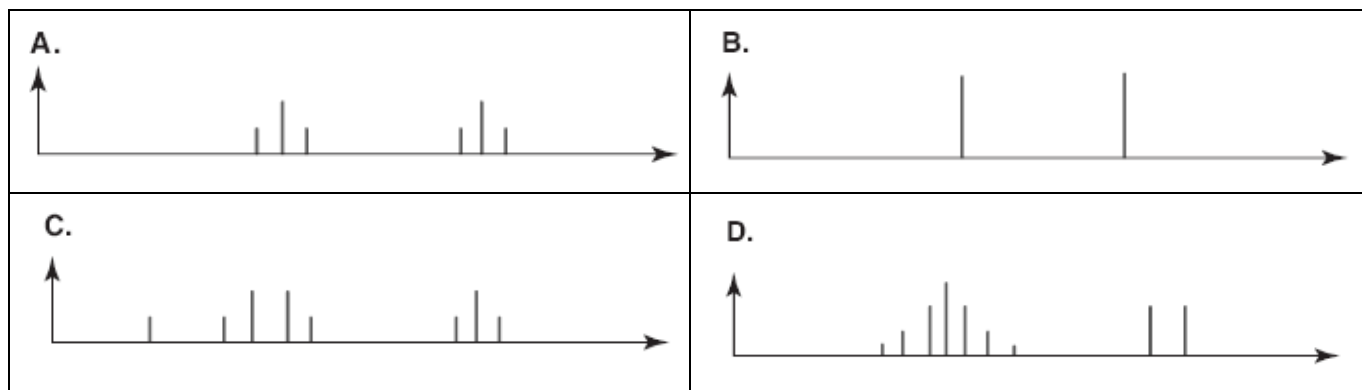
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**4 marks**

**Question 6**

Match the following organic molecules with the  $^1\text{H}$  NMR spectra below.



Molecule	Corresponding NMR
$\text{CH}_2\text{FCH}_2\text{Cl}$	
$\text{CH}_3\text{COOCH}_3$	
$(\text{CH}_3)_2\text{CHCl}$	
$\text{CH}_3\text{CH}_2\text{OH}$	

4 marks

**Question 7**

A chemist isolated an unknown substance that contained the elements carbon, hydrogen and chlorine. The compound had the formula  $\text{C}_2\text{H}_5\text{Cl}$ .

(a) Name the next member of this homologous series.

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(b) Another molecule containing the elements carbon, hydrogen and chlorine has a molecular formula of  $\text{C}_4\text{H}_9\text{Cl}$ . With the information given, why is not possible to accurately give the structural formula of this molecule?

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(c) Write a balanced chemical equation for the reaction where ethene reacted with another substance to produce  $C_2H_5Cl$ .

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(d) A sample of  $C_2H_5Cl$  was boiled in  $0.5 \text{ mol L}^{-1}$  sodium hydroxide. Write the balanced equation for this reaction.

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(e) What type of chemical reaction occurred in reaction **d**?

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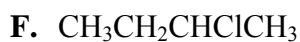
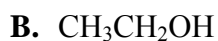
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5 marks

### Question 8

Consider the following molecules.



(a) Name the first three compounds.

1. \_\_\_\_\_

2. \_\_\_\_\_

3. \_\_\_\_\_

(b) Which of the above molecules is formed by fermentation of glucose?

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(c) Which of the above molecules can undergo a condensation reaction?

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(d) Which of the above molecules can undergo addition polymerisation?

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(e) Write a chemical equation for the reaction between  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$  and chlorine gas.

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(f) Which of the molecules could be identified by the bromine test?

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(g) Which of the molecules could undergo a hydrolysis substitution reaction?

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(h) Which of the molecules would be most soluble in water?

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**10 marks**

**End of Section B**

**Notes:**