MARKER CODE

Student Personal Identification Number

South Pacific Form Seven Certificate

CHEMISTRY

2022

QUESTION and ANSWER BOOKLET

Time allowed: Three hours

(An extra 10 minutes is allowed for reading this paper.)

INSTRUCTIONS

1. Write your **Student Personal Identification Number (SPIN)** in the space provided on the top right-hand corner of this page.
2. Answer **ALL QUESTIONS**. Write your answers in the spaces provided in this booklet. For **Multiple Choice Questions**, circle the letter that represents the **BEST** answer.
3. If you need more space for answers, ask the Supervisor for extra paper. Write your SPIN on all extra sheets used and clearly number the questions. Attach the extra sheets at the appropriate places in this booklet.

Major Learning Outcomes (Achievement Standards)	Skill Level & Number of Questions				Weight/ Time
	Level 1 *Uni-structural*	Level 2 *Multi-structural*	Level 3 *Relational*	Level 4 *Extended Abstract*	
Strand 1: Atomic Structure, Bonding and Related Properties Interpret information about selected properties of elements and compounds in relation to atomic structure.	5	1	3	1	20% 51 min
Strand 2: Energy Changes in Chemical and Physical Processes Use thermochemical data to determine energy changes in chemical and physical processes.	3	1	1	-	8% 21 min
Strand 3: Aqueous Equilibrium Systems Relate the properties of aqueous solutions to the nature and concentration of dissolved species.	5	3	1	-	14% 36 min
Strand 4: Oxidation–Reduction Reactions Apply oxidation–reduction principles to electrochemical cells and compare the relative strength of oxidants and reductants, and deduce the direction of spontaneous reactions.	-	2	-	-	4% 10 min
Strand 5: Organic Chemistry Use information about the structure and reactions of organic molecules to solve problems in organic chemistry.	5	6	1	1	24% 62 min
TOTAL	**18**	**13**	**6**	**2**	**70% 180 min**

Check that this booklet contains pages 2–17 in the correct order and that none of these pages are blank.

HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

STRAND 1: ATOMIC STRUCTURE, BONDING AND RELATED PROPERTIES

1.1	**Atomic Structure and Bonding**	*Assessor's use only*

1.1a

The ground state electronic configuration of iron (Fe, Atomic No. = 26) is represented as _____.

A. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$

B. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8$

C. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^7$

D. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$

Unistructural	
1	
0	
NR	

1.1b

According to the Valence Shell Electron Pair Repulsion (VSEPR) Theory, the repulsion between valence electron pairs in the outer shell of the central atom determines the shape of the molecule.

Which of the following, regarding repulsive interaction of electron pairs, is correct?

A. Lone pair-Lone pair is greater than Lone pair-Bond pair

B. Lone pair-Lone pair is less than Bond pair-Bond pair

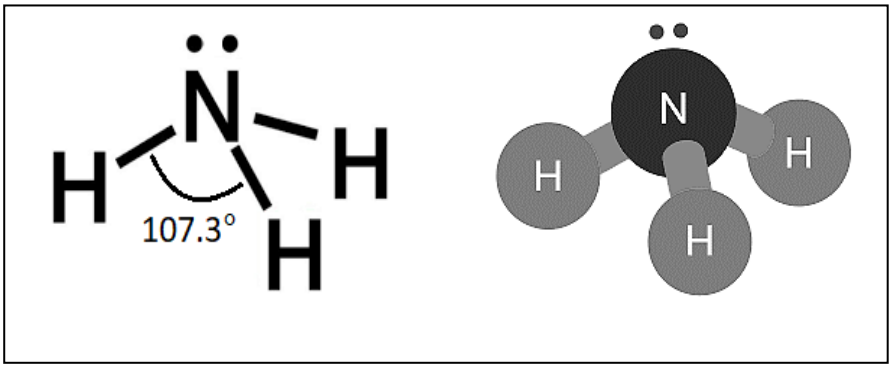
C. Lone pair-Bond pair is greater than Lone pair-Lone pair

D. Lone pair-Bond pair is less than Bond pair-Bond pair

Unistructural	
1	
0	
NR	

1.1c

The shape of the ammonia (NH_3) molecule is shown below.



Explain how the polarity of ammonia is determined by its shape. You may use diagrams to support your response.

_____

_____

_____

_____

_____

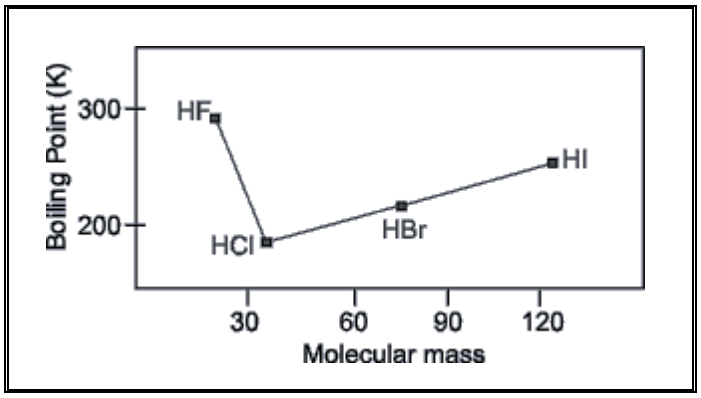
_____

Assessor's use only

		Relational
		3
		2
		1
		0
		NR

Assessor's use only

1.1d The figure below shows the relationship between the molecular mass and boiling points of four compounds: HF, HCl, HBr and HI.



Explain the trend in boiling points as seen above. In your response, refer to the strength of intermolecular forces of attraction that are present in the four compounds.

Relational	
3	
2	
1	
0	
NR	

Assessor's use only

1.2 Nuclear Chemistry

1.2a Define **fusion reaction**.

Unistructural	
1	
0	
NR	

1.2b Complete the following equation for the **beta** ($_{-1}^{0}e$) decay of carbon-14.

$$^{14}_{6}C \longrightarrow \square + {}^{0}_{-1}e$$

Unistructural	
1	
0	
NR	

1.2c Radioactive substances give off three types of radiation; **alpha particles**, **beta particles** and **gamma rays**, as shown in the table below.

Type	Symbol	Mass number	Charge
Alpha particle	$^{4}_{2}He$ or α	4	+2
Beta particle	$_{-1}^{0}e$ or β	0	-1
Gamma ray	γ	0	0

Evaluate these types of radiation in terms of their **penetration strength** and **real-life application**. You may use suitable diagrams to support your response.

Extended Abstract	
4	
3	
2	
1	
0	
NR	

1.3 Transition Metals

Assessor's use only

Use the information below to answer questions 1.3a and 1.3b.

The table below gives some examples of coloured complexes formed by copper (Cu).

Complex	Colour of Solution
$[CuCl_4]^{2-}$	Green
$[Cu(H_2O)_6]^{2+}$	Light blue
$[Cu(NH_3)_4]^{2+}$	Deep blue

1.3a Name **$[CuCl_4]^{2-}$** using the IUPAC Nomenclature System.

Unistructural	
1	
0	
NR	

1.3b List **two** factors that enable Cu to form coloured complexes.

Multistructural	
2	
1	
0	
NR	

1.3c During an experiment, a student added a few drops of concentrated ammonia (NH_3) solution to a test tube containing copper(II) sulfate, $CuSO_4$, solution. After noting the formation of a light blue precipitate, the student then proceeded to add more drops of the ammonia solution until a clear deep blue solution was obtained.

Explain the student's observations using balanced chemical equations.

Relational	
3	
2	
1	
0	
NR	

STRAND 2: ENERGY CHANGES IN CHEMICAL AND PHYSICAL PROCESSES

2.1	Thermochemical Principles and Enthalpy Change	*Assessor's use only*

2.1a

The amount of energy needed for one gram of a solid to melt without any change in temperature is known as enthalpy of _____.

A. fusion
B. reaction
C. solution
D. neutralisation

Unistructural	
1	
0	
NR	

2.1b

Which of the following shows the chemical reaction for the standard enthalpy of formation of liquid water, $H_2O_{(\ell)}$?

A. $H_2O_{(g)} \rightarrow H_2O_{(\ell)}$
B. $H_2O_{(s)} \rightarrow H_2O_{(\ell)}$
C. $\frac{1}{2}O_{2(g)} + H_{2(g)} \rightarrow H_2O_{(\ell)}$
D. $O_{2(g)} + 2H_{2(g)} \rightarrow 2H_2O_{(\ell)}$

Unistructural	
1	
0	
NR	

2.1c

The amount of energy change in a reaction depends on the amount of bonds that are broken and formed.

Which of the following statements is correct?

A. Bond breaking is exothermic while bond forming is endothermic.
B. Bond breaking is endothermic while bond forming is exothermic.
C. Both bond breaking and bond forming are exothermic processes.
D. Both bond breaking and bond forming are endothermic processes.

Unistructural	
1	
0	
NR	

2.1d

The standard enthalpy of vaporisation, $\Delta_{vap}H°$, of ethanol, C_2H_5OH, is 42.3 kJ mol^{-1}.

Write a thermochemical equation for the $\Delta_{vap}H°$ of ethanol.

_____

_____

_____

_____

_____

Multistructural	
2	
1	
0	
NR	

Assessor's use only

2.1e

The enthalpy of combustion ($\Delta_c H$) of magnesium is represented by the equation:

$$Mg_{(s)} + \tfrac{1}{2} O_{2\,(g)} \rightarrow MgO_{(s)} \qquad \Delta_c H = ?$$

This equation can be obtained by combining the following three equations:

$$MgO_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2\,(aq)} + H_2O_{(\ell)} \qquad \Delta H = -74.66 \text{ kJ}$$

$$Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2\,(aq)} + H_{2\,(g)} \qquad \Delta H = -427.99 \text{ kJ}$$

$$H_{2\,(g)} + \tfrac{1}{2}O_{2\,(g)} \rightarrow H_2O_{(\ell)} \qquad \Delta H = -285.50 \text{ kJ}$$

Using the above information and Hess's Law, calculate the enthalpy of combustion ($\Delta_c H$) of magnesium.

Relational	
3	
2	
1	
0	
NR	

STRAND 3: AQUEOUS EQUILIBRIUM SYSTEMS

3.1	**Equilibrium Principles, Acids and Bases**	*Assessor's use only*
3.1a	A buffer is a solution that _____. A. undergoes a large increase in pH upon the addition of a base B. undergoes a large decrease in pH upon the addition of an acid C. resists a change in pH upon the addition of an acid or base D. resists a change in volume upon the addition of an acid or base	**Unistructural** 1 ☐ 0 ☐ NR ☐
3.1b	Basic buffer solutions are commonly made from a weak base and one of its salts. In the laboratory, a student prepares a basic buffer solution by mixing together ammonia (NH_3) solution and ammonium chloride (NH_4Cl) solution. Describe the action of this buffer when an acid such as HCl is added to this buffer solution. _____ _____ _____ _____ _____	**Multistructural** 2 ☐ 1 ☐ 0 ☐ NR ☐
	Use the information below to answer questions 3.1c and 3.1d. Vinegar is essentially a dilute solution of ethanoic acid (CH_3COOH) in water. The equation for the dissociation of ethanoic acid in water can be represented as: $CH_3COOH_{(aq)} + H_2O_{(\ell)} \rightleftharpoons CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$	
3.1c	Which of the following **best** describes ethanoic acid? A. weak diprotic acid B. strong diprotic acid C. weak monoprotic acid D. strong monoprotic acid	**Unistructural** 1 ☐ 0 ☐ NR ☐
3.1d	The concentration of ethanoic acid in vinegar is 0.667 mol L^{-1}. Calculate the pH of vinegar. Note that K_a of CH_3COOH is 1.8×10^{-5}. _____ _____ _____ _____ _____ _____ _____ _____	

Assessor's use only

		Relational 3 ☐ 2 ☐ 1 ☐ 0 ☐ NR ☐
3.1e	Sodium hydroxide (NaOH) and hydrochloric acid (HCl) are strong electrolytes. In a titration of HCl with NaOH, what will be the pH at the equivalence point?	**Unistructural** 1 ☐ 0 ☐ NR ☐
3.1f	Phosgene ($COCl_2$), used in the manufacture of polyurethane plastics, is prepared from CO and Cl_2. $CO_{(g)} + Cl_{2\ (g)} \rightleftharpoons COCl_{2\ (g)}$ An equilibrium mixture at 395°C contains 0.012 mol L^{-1} CO and 0.025 mol L^{-1} Cl_2 as well as $COCl_2$. Calculate the concentration of $COCl_2$ if K_c is 1.23×10^3 at 395°C.	**Multistructural** 2 ☐ 1 ☐ 0 ☐ NR ☐

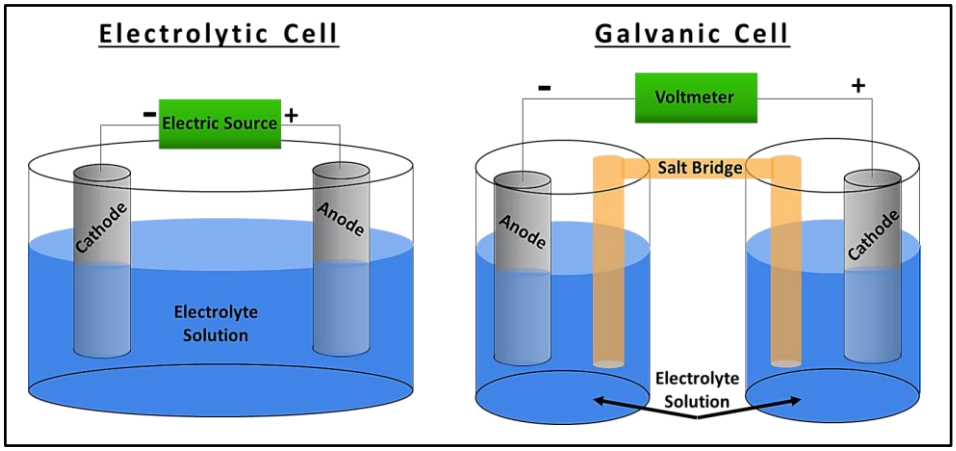
3.2	**Solubility**	*Assessor's use only*
	Use the information below to answer questions 3.2a–3.2c. When calcium sulfate ($CaSO_4$) is added to water, the net ionic equation for the resulting chemical equilibrium is as follows: $$CaSO_{4\,(s)} \rightleftharpoons Ca^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$$ Since $CaSO_4$ is slightly soluble, most of the Ca^{2+} and SO_4^{2-} exist in the solid form of $CaSO_4$ at equilibrium. Furthermore, the Le Chatelier's Principle can be used for increasing or decreasing the solubility of $CaSO_4$.	
3.2a	Define the term **solubility**. _____ _____ _____	**Unistructural** 1 0 NR
3.2b	The solubility product constant (K_{sp}) of $CaSO_4$ is 2.4×10^{-5} mol^2 L^{-2} at 25°C. Calculate the molar solubility of $CaSO_4$ at 25°C. _____ _____ _____ _____ _____ _____ _____ _____	**Multistructural** 2 1 0 NR
3.2c	Suppose the soluble ionic compound, sodium sulfate (Na_2SO_4), was added to the $CaSO_4$ solution at equilibrium. State the effect of this addition on the solubility of $CaSO_4$. _____ _____ _____	**Unistructural** 1 0 NR

STRAND 4: OXIDATION–REDUCTION REACTIONS

4.1	**Redox Titrations and Electrochemical Cells**	*Assessor's use only*

Use the information below to answer questions 4.1a and 4.1b.

The diagrams of two types of electrochemical cells, **electrolytic cell** and **galvanic cell,** are given below.



Source: https://www.expii.com/t/electrochemical-cell-definition-overview-8451

4.1a Using arrows, show the direction of electrons flow in the **electrolytic cell** and **galvanic cell** diagrams given above.

Multistructural	
2	
1	
0	
NR	

4.1b List examples of everyday application for:

i. **Galvanic cell**

_____

_____

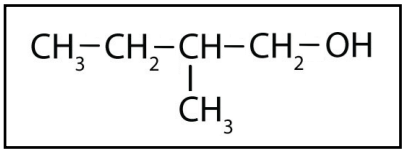
ii. **Electrolytic cell**

_____

_____

Multistructural	
2	
1	
0	
NR	

STRAND 5: ORGANIC CHEMISTRY

5.1	**Structure and Isomerism**	*Assessor's use only*
	Use the information below to answer questions 5.1a–5.1c. The condensed structural formula of a compound, A, is given below. There are several isomers possible for this compound.  **Compound A**	
5.1a	Name **Compound A** using the IUPAC nomenclature system. In your response, show the steps used to obtain the name.	**Relational** 3 2 1 0 NR
5.1b	Define the term **isomer**.	**Unistructural** 1 0 NR

Assessor's use only

5.1c Draw the structures of any **two** isomers of **Compound A**.

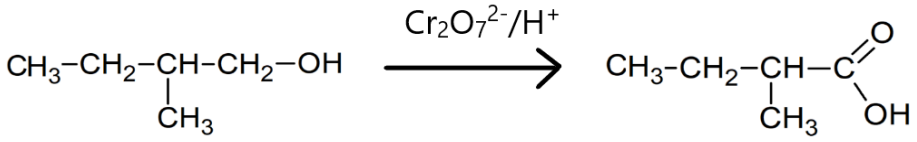
Multistructural	
2	
1	
0	
NR	

5.2 Reactions

Assessor's use only

Use the information below to answer questions 5.2a–5.2c.

Compound A can be converted to **Compound B** using acidified potassium dichromate, $Cr_2O_7^{2-}/H^+$:



Compound A **Compound B**

5.2a Name the type of reaction shown above.

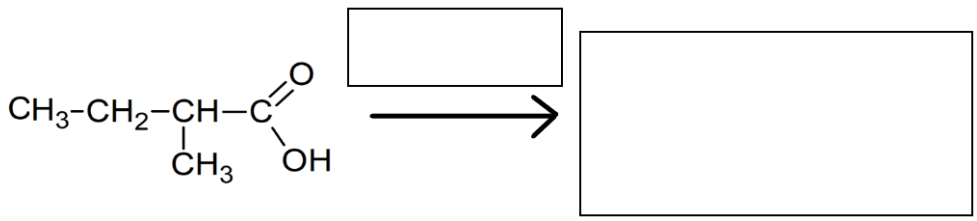
Unistructural	
1	
0	
NR	

5.2b State another suitable reagent that can be used in place of $Cr_2O_7^{2-}/H^+$ in the above reaction.

Unistructural	
1	
0	
NR	

5.2c **Compound B** can be further converted to an **acyl chloride**.

Complete the equation for this reaction below by indicating a suitable reagent that can be used and the structure of the acyl chloride formed.

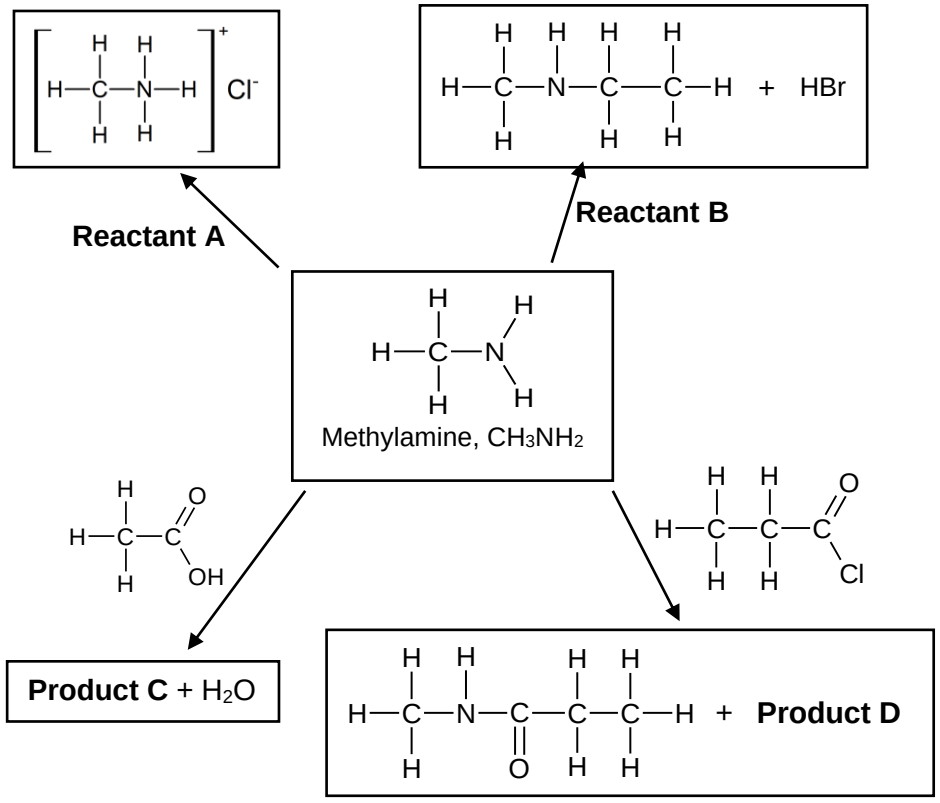


Multistructural	
2	
1	
0	
NR	

Assessor's use only

Use the information below to answer questions 5.2d and 5.2e.

Amines are derived from ammonia, NH_3, in which one or more of the hydrogens has been replaced by an alkyl group. Some common reactions of an amine (methylamine, CH_3NH_2) are given in the reaction map below.



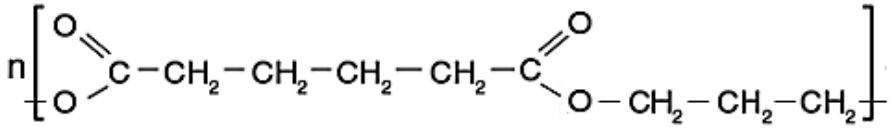
5.2d Determine **Reactant A** and **Reactant B**. The structures of compounds may be given but are not necessary.

Multistructural	
2	
1	
0	
NR	

5.2e Determine **Product C** and **Product D**. The structures of compounds may be given but are not necessary.

Multistructural	
2	
1	
0	
NR	

Assessor's use only

5.2f	Describe a laboratory test that can be used to distinguish between an aldehyde and a ketone. Your response should include the reagent required for the test and the expected observations. _____ _____ _____ _____ _____ _____	**Multistructural** 2 ☐ 1 ☐ 0 ☐ NR ☐
	Use the information below to answer questions 5.2g–5.2i. Polyester is a type of polymer that is made of long chains of monomers. The formation of a polyester follows the same procedure as that of an ester, as shown in the diagram below.  **Polyester**	
5.2g	Identify the **ester link** in the polyester above by placing a circle around it.	**Unistructural** 1 ☐ 0 ☐ NR ☐
5.2h	Polyesters are examples of condensation polymers. Define **condensation polymerisation**. _____ _____ _____	**Unistructural** 1 ☐ 0 ☐ NR ☐
5.2i	Draw the structures of the **two** molecules (monomers) that would form the above polyester.	**Multistructural** 2 ☐ 1 ☐ 0 ☐ NR ☐

Assessor's use only

5.2j

The properties of **aldehydes** have led to their use in several important applications, which are beneficial to both the industry and society.

With an example, discuss **aldehydes** with respect to the following:

- Their functional group
- One common reaction with the reagent and main product
- An everyday application

Extended Abstract	
4	
3	
2	
1	
0	
NR	

THE END