MARKER CODE

Student Personal Identification Number

South Pacific Form Seven Certificate

CHEMISTRY

2021

QUESTION and ANSWER BOOKLET

Time allowed: Three hours

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

INSTRUCTIONS

Write your **Student Personal Identification Number (SPIN)** in the space provided on the top right-hand corner of this page.

Answer **ALL QUESTIONS**. Write your answers in the spaces provided in this booklet.

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.	**6**	**2**	**2**	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.	**4**	**2**	**2**	-	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 2–19 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

Assessor's use only

1.1 Which of the following equations correctly shows the **first electron affinity** of fluorine? Write the letter of your choice in the given box.

A. $F^-_{(g)} \rightarrow F_{(g)} + e^-$

B. $F_{(g)} \rightarrow F^+_{(g)} + e^-$

C. $F_{(g)} + e^- \rightarrow F^-_{(g)}$

D. $F^+_{(g)} + e^- \rightarrow F_{(g)}$

Unistructural	
1	
0	
NR	

1.2 The ground state electron configuration of the Chromium atom (Cr) is $[Ar]3d^5 4s^1$ instead of the expected $[Ar]3d^4 4s^2$.

Explain the reason for this electron configuration.

Relational	
3	
2	
1	
0	
NR	

1.3 The graph below shows values of the first ionisation energy of Group 1 elements.

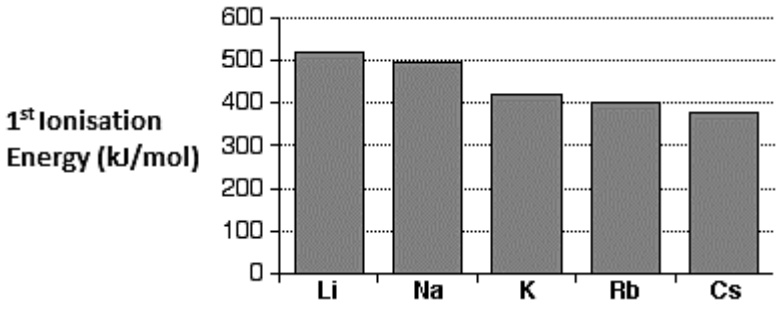


Figure source: *https://chem.libretexts.org/*

The ionisation energy depends on the force of attraction between the nucleus and valence electron of each element.

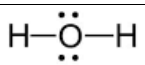
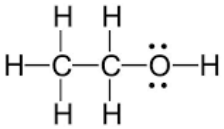
List **two** factors that affect the force of attraction.

Multistructural	
2	
1	
0	
NR	

Assessor's use only

Use the information below to answer questions 1.4a and 1.4b.

There has been an increased demand for hand sanitisers during the COVID-19 pandemic. Many hand sanitiser products contain a mixture of water and ethanol, the structures of which are given below.

	Molecular Formula	Lewis Structure	Shape
Water	H_2O		
Ethanol	C_2H_5OH		Tetrahedral

1.4a State the shape of the H_2O molecule.

Unistructural	
1	
0	
NR	

1.4b If 250 mL of water is mixed with 250 mL of ethanol, only about 480 mL of solution results instead of 500 mL.

By referring to the properties of the water and ethanol molecules, discuss the causes for the observed volume reduction. Your response should include the following concepts:

- molecular shapes;
- molecular polarities; and
- intermolecular forces of attraction.

You may use suitable diagrams to illustrate the ideas in your response.

Assessor's use only

Extended Abstract	
4	
3	
2	
1	
0	
NR	

Use the information below to answer questions 1.5a and 1.5b.

Uranium minerals contain a number of radioactive elements, each emitting one or more types of radiation. The following figure shows the separation of the radiation from a uranium mineral into ***α***, ***β*** and ***γ*** rays when it passes through an electric field.

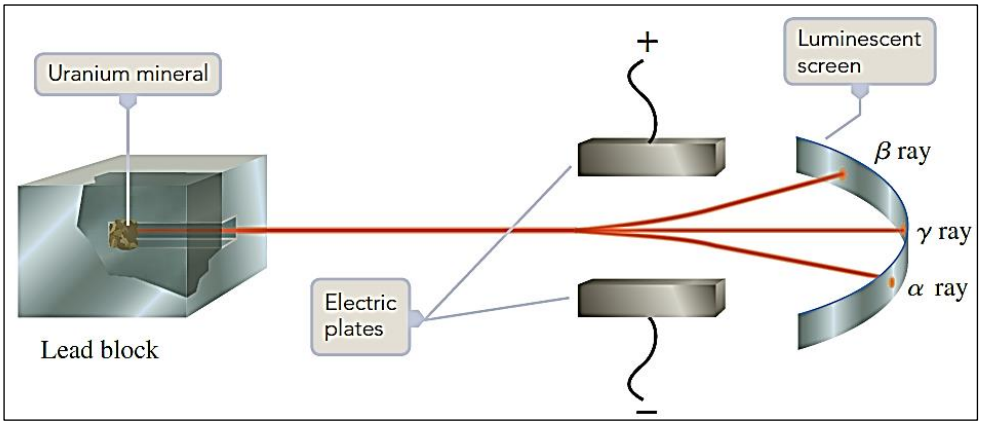


Figure source: Darrell D. Ebbing and Steven D. Gammon, General Chemistry, 11th Edition, 2017, Cengage Learning, USA.

1.5a Which property of the *β* ray causes it to be deflected when passing through an electric field?

Unistructural	
1	
0	
NR	

Assessor's use only

1.5b	Uranium-235 ($^{235}_{92}U$) is an isotope of uranium that can sustain a nuclear fission reaction. Define **nuclear fission reaction**.	**Unistructural** 1 0 NR
1.5c	Half-life ($t_{½}$) is the amount of time needed for half of a radioactive material to decay. Uranium-234 ($^{234}_{92}U$) has a half-life of 245,000 years. How long will it take for 20.0 grams of Uranium-234 to decay to 2.5 grams?	**Relational** 3 2 1 0 NR

Assessor's use only

Use the information below to answer questions 1.6a and 1.6b.

To identify the metal ion present in an aqueous solution, a student carried out three separate tests and tabulated the observations as shown below.

	TEST 1	TEST 2	TEST 3
Colour of aqueous solution	Addition of sodium hydroxide (NaOH)	Addition of ammonia (NH_3)	Addition of potassium thiocyanate (KSCN)
Green	Formation of green precipitate, which turned brown when exposed to air	Formation of green precipitate, which turned brown when exposed to air	Formation of intense blood-red colour, which is stable for some time

1.6a The first conclusion the student makes is that the aqueous solution contains a transition metal ion.

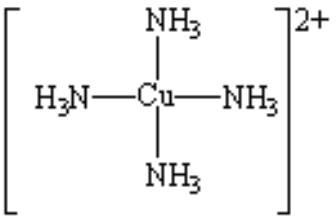
Which **two** characteristics of a transition metal ion are confirmed by this experiment?

Multistructural	
2	
1	
0	
NR	

1.6b Based on the observations, identify the transition metal ion present in the aqueous solution.

Unistructural	
1	
0	
NR	

1.7 Name the ion given below using IUPAC nomenclature:



Unistructural	
1	
0	
NR	

STRAND 2: ENERGY CHANGES IN CHEMICAL AND PHYSICAL PROCESSES

Assessor's use only

2.1 Which of the following is correct about energy and chemical bonds? Write the letter of your choice in the given box.

A. Stronger bonds involve less energy.

B. All bonds have the same bond energy.

C. Bond energy values are always positive.

D. Energy is absorbed during bond formation.

Unistructural	
1	
0	
NR	

2.2 Name the enthalpy change of the process given below:

$$Li_{(g)} \rightarrow Li^{+}_{(g)} + e^{-} \quad \Delta H° = 572.3 \text{ kJ/mol}$$

Unistructural	
1	
0	
NR	

Use the information below to answer questions 2.3a and 2.3b.

The reaction of methane (CH_4) with oxygen (O_2) forms carbon dioxide (CO_2) and water (H_2O), and releases 890 kJ of energy per mole of methane in the process.

2.3a Identify the enthalpy change for the given process.

Unistructural	
1	
0	
NR	

2.3b Write a thermochemical equation for the given process.

Multistructural	
2	
1	
0	
NR	

Assessor's use only

2.4 Ammonium sulphate, $(NH_4)_2SO_4$, is used as a fire retardant and wood preservative. It is prepared industrially by the reaction of ammonia (NH_3) with sulfuric acid (H_2SO_4):

$$2NH_{3\ (g)} + H_2SO_{4\ (aq)} \rightarrow (NH_4)_2SO_{4\ (s)}$$

The value of $\Delta H°_{rxn}$ is -179.4 kJ/mol.

Use the data from the table below to calculate the standard enthalpy of formation ($\Delta H°_f$) of $(NH_4)_2SO_{4\ (s)}$ in kJ/mol.

Substance	$\Delta H°_f$ (kJ/mol)
$NH_{3\ (g)}$	−45.9
$H_2SO_{4\ (aq)}$	−909.3

Your response should clearly show the method used and include relevant units.

Relational	
3	
2	
1	
0	
NR	

STRAND 3: AQUEOUS EQUILIBRIUM SYSTEMS

Assessor's use only

Use the information below to answer questions 3.1a and 3.1b.

Methanol, CH_3OH, is manufactured industrially by the reaction:

$$CO_{(g)} + 2H_{2\,(g)} \rightleftharpoons CH_3OH_{(g)}$$

At 500 K, the value of the equilibrium constant (K_c) for this reaction is 10.5.

3.1a Which of the following **best** describes the reaction above? Write the letter of your choice in the given box.

A. The reaction is yet to achieve equilibrium.
B. The reaction proceeds far towards completion.
C. The reaction is favoured towards the reactants.
D. The concentrations of reactants and product are equal.

Unistructural	
1	
0	
NR	

3.1b At 500 K, a two-litre reaction vessel contains a gaseous mixture of 0.20 moles of CO and 0.20 moles of H_2 at equilibrium.

Calculate the concentration of CH_3OH in the mixture.

Relational	
3	
2	
1	
0	
NR	

Assessor's use only

Use the information below to answer questions 3.2a and 3.2b.

HF, HCl, HBr and HI are called **binary acids**. HCl, HBr and HI are all strong acids, whereas HF is a weak acid ($K_a = 7.1 \times 10^{-4}$). HF ionises in aqueous solution as follows:

$$HF_{(aq)} + H_2O_{(l)} \rightleftharpoons F^-_{(aq)} + H_3O^+_{(aq)}$$

3.2a Name the acid, HF.

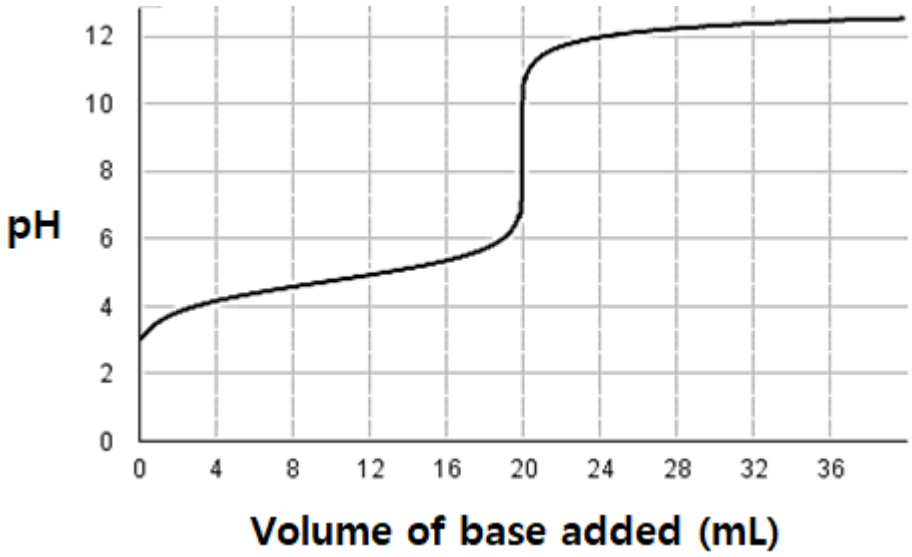
Unistructural	
1	
0	
NR	

3.2b Calculate the hydronium ion (H_3O^+) concentration of a 0.60 *M* aqueous solution of HF.

Relational	
3	
2	
1	
0	
NR	

Assessor's use only

3.3 During a weak acid–strong base titration, the pH of the solution was measured as the strong base was added to the weak acid. A titration curve was then plotted as shown below.



Label the **buffer region** on the curve above.

Unistructural	
1	
0	
NR	

3.4 The titration of NaOH using HCl is an example of a strong base–strong acid titration. The reaction equation is:

$$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$$

or

$$H^+_{(aq)} + OH^-_{(aq)} \longrightarrow H_2O_{(l)}$$

Calculate the pH of a solution when 15 mL of 0.10 *M* NaOH has been titrated with 25 mL of 0.10 *M* HCl. (Note: pH = −log [H^+])

Multistructural	
2	
1	
0	
NR	

Assessor's use only

	Use the information below to answer questions 3.5a and 3.5b. The solubility product of magnesium hydroxide, $Mg(OH)_2$, at 298 K is 2.0×10^{-11} mol/L.	
3.5a	Define **solubility product**. _____ _____ _____	**Unistructural** 1 0 NR
3.5b	Write the solubility product expression for magnesium hydroxide. _____ _____ _____ _____ _____ _____ _____	**Multistructural** 2 1 0 NR

STRAND 4: OXIDATION–REDUCTION REACTIONS

Assessor's use only

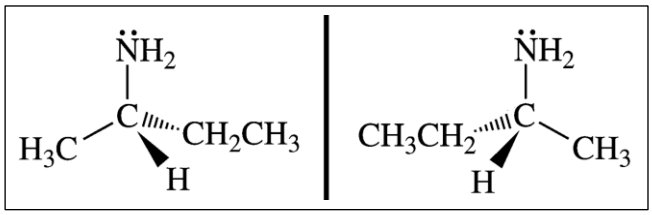
	Use the information below to answer questions 4.1a and 4.1b. A galvanic cell is constructed from the following half-cells linked by an external circuit and a K_2SO_4 salt bridge: • a Mg $_{(s)}$ electrode in $MgSO_4$ solution serving as the anode • a Ni $_{(s)}$ electrode in $NiSO_4$ solution serving as the cathode	
4.1a	Describe the process through which electrical energy would be produced by this galvanic cell.	**Multistructural** 2 | 1 | 0 | NR
4.1b	Use the IUPAC cell notation to represent this galvanic cell.	**Multistructural** 2 | 1 | 0 | NR

STRAND 5: ORGANIC CHEMISTRY

Assessor's use only

Use the information below to answer questions 5.1a and 5.1b.

The two isomers of a compound, $CH_3CH_2CH(NH_2)CH_3$, are shown below.



5.1a Identify the type of isomerism shown above.

Unistructural	
1	
0	
NR	

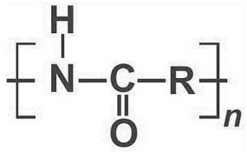
5.1b Name $CH_3CH_2CH(NH_2)CH_3$ using IUPAC nomenclature, while clearly outlining the steps used in the naming procress.

Relational	
3	
2	
1	
0	
NR	

Assessor's use only

Use the information below to answer questions 5.2a and 5.2b.

Proteins are examples of naturally occurring polymers that contain the repeating units shown below.



5.2a Idenitify the **functional group** in this unit.

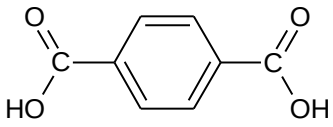
Unistructural	
1	
0	
NR	

5.2b The polypeptide chains of proteins form through a reaction known as condensation polymerisation.

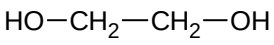
State **one** characteristic of this reaction.

Unistructural	
1	
0	
NR	

5.3 Write a balanced reaction equation for the formation of a polymer from the two compounds shown below.



benzene-1,4-dicarboxylic acid



ethane-1,2-diol

Multistructural	
2	
1	
0	
NR	

Assessor's use only

5.4 Alcohols are often referred to as the central functional group in organic chemistry because all other functional groups can be obtained from alcohols.

Discuss **one** reaction of alcohols that leads to functional group change and the relevance of this reaction in everyday life.

Your response should include the following:

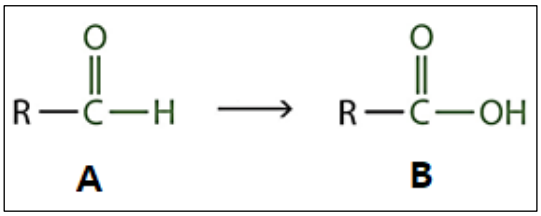
- the reaction conditions required;
- the type of reaction occuring;
- the structure of the main product formed; and
- real life application.

Extended Abstract	
4	
3	
2	
1	
0	
NR	

Assessor's use only

Use the information below to answer questions 5.5a–5.5c.

In the reaction shown below, where compound **A** converts to compound **B**, R represents any general alkyl group.



5.5a Identify the class of compounds that **A** belongs to.

Unistructural	
1	
0	
NR	

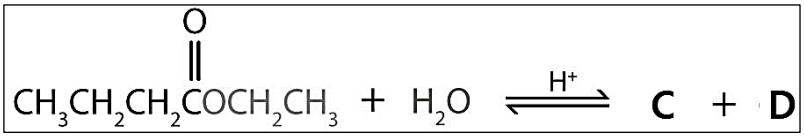
5.5b State a property of compound **B**.

Unistructural	
1	
0	
NR	

5.5c Describe the reaction conditions needed for the above reaction to occur.

Multistructural	
2	
1	
0	
NR	

5.6 For the acidic hydrolysis reaction given below, draw the structures of products **C** and **D**.



Product **C**

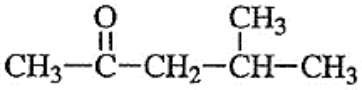
Product **D**

Multistructural	
2	
1	
0	
NR	

Assessor's use only

Use the information below to answer questions 5.7a and 5.7b.

The structure of a **ketone** is given below.



5.7a

Draw the structure of an isomer of the ketone and state the type of isomerism shown.

Structure of isomer:

Type of isomerism:

_____

_____

Multistructural	
2	
1	
0	
NR	

5.7b

Ketones can be reduced to alcohols under suitable conditions.

Complete the following equation for the reduction reaction of the given ketone, indicating the reagent and the main product.

Multistructural	
2	
1	
0	
NR	

Assessor's use only

5.8	Haloalkanes undergo elimination reactions to produce alkenes when heated under reflux with a concentrated solution of potassium hydroxide in ethanol. Write an equation for a reaction where a suitable haloalkane converts to $CH_3CH=CH_2$ in an elimination reaction.	

Multistructural	
2	
1	
0	
NR	

THE END