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TONGA NATIONAL FORM SEVEN CERTIFICATE

2021

CHEMISTRY

QUESTION AND ANSWER BOOKLET

Time allowed: 3 Hours

INSTRUCTIONS:

- 1. Write your Student Enrolment Number (SEN) on the top right-hand corner of this page.
- 2. This paper consists of **FIVE QUESTIONS** and is out of 70 Weighted scores.

QUESTION	STRANDS	TOTAL SKILL LEVEL
ONE	ATOMIC STRUCTURE, BONDING, SOLIDS AND RELATED PROPERTIES	16
TWO	KINETIC ENERGY AND NUCLEAR CHEMISTRY	11
THREE	INORGANIC AND REDOX CHEMISTRY	18
FOUR	QUANTITATIVE CHEMISTRY	17
FIVE	ORGANIC CHEMISTRY	8
	TOTAL	70

- 3. Answer ALL QUESTIONS. Write your answers in the spaces provided in this booklet.
- 4. Show all workings.
- 5. A **Periodic Table** is provided in page **23**
- 6. Use a **BLUE** or **BLACK** ball point pen only for writing. Use a pencil for drawing if required.
- 7. If you need more space for answers, ask the supervisor for extra paper. Write your **Student Enrolment Number (SEN)** on each additional sheet, number the questions clearly and insert them in the appropriate places in this booklet.
- 8. Check that this booklet contain pages 2 23 in the correct order and that page 22 has been deliberately left blank.

QUESTION ONE: ATOMIC STRUCTURE, BONDING, SOLIDS AND RELATED PROPERTIES

Part A: Atomic Structure and Bonding

Group 17 elements include fluorine F, chlorine Cl, bromine Br and Iodine I. They form compounds amongst themselves like iodine trifluoride, IF₃ and Cl₂.

a. Name the shape of an IF_3 molecule.

Name of the shape:	
	-

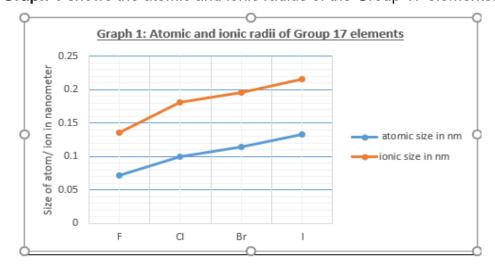
Skill level 1		
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b. IF₃ is a polar molecule. Describe the **factors** that contribute to IF₃ being polar.

Skill l	evel 2
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Use **Graph 1** below to answer **c**.

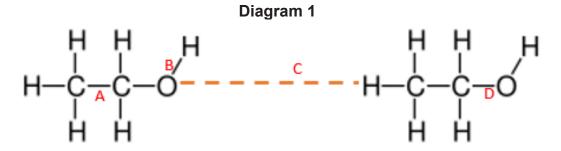
Graph 1 shows the atomic and ionic radius of the Group 17 elements.



	onic radius, Br ⁻ .		
			
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		Skill	le
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		0	+
Evoloin why colid bydrogon io	odide, HI will have a higher melting point than solid	NR	T
hydrogen bromide, HBr.	odide, Hi wili have a higher meiting point than solid		
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Part B: Solids, bonds and Related Properties

Diagram 1 below shows the structure of solid ethanol molecules with bonds labelled A, B, C, and D.



a. List the order of the bonds ${\bf A},\,{\bf B},\,{\bf C}$ and ${\bf D}$ in terms of their increasing relative strengths.

(weakest) (strongest)

Skill l	Skill level 2	
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b. Evaluate the physical properties of solid iron, Fe and solid carbon, C in the form of diamond as shown in **Table 1** below.

Table 1

Substance	Electrical conductivity	Melting point/°C	Boiling point/°C
Iron, Fe	Very high	1535	2750
Carbon (diamond), C	Non-existent	3550	4830

Note: Non-existent means "it does not happen"

(Consider in your answer the following:

- State the types of solids involved,
- Describe the structures of the two solids and types of bonds existing can draw diagrams to clarify the descriptions,
- Links between structures and their individual physical properties.

•	Links between structures and comparison of their physical properties)

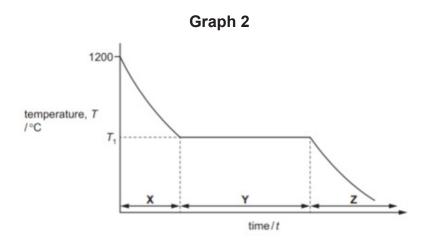
		
	Skill le	evel 4
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QUESTION TWO:

KINETIC ENERGY AND NUCLEAR CHEMISTRY

Part A: Kinetic Chemistry

Graph 2 below shows how the temperature of a sample of substance B (with **melting point at 620°C and boiling point at 1298°C**) changes over time, t, as it is slowly cooled.



a. Give the **states of matter** of substance B at stages **X** and **Y** of the processes shown in **Graph 2**.

Skill level 2		
2		
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NR		

b. What **type of thermochemical reaction** takes place at stage Z?

Skill	level 1
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Part B: Thermochemistry

If solid sodium hydrogen carbonate, $\mathsf{NaHCO}_{\mathsf{3(s)}}$ decomposes as follows:

$$2 \text{NaHCO}_{3(\text{s})} \ \ \, \overline{\hspace{1cm}} \ \ \, \text{Na}_{2} \text{CO}_{3(\text{s})} + \text{CO}_{2(\text{g})} + \text{H}_{2} \text{O}_{(\text{I})} \ \, \Delta \text{H}_{\text{decomp}^{\circ}} = +91.6 \text{ Jmol}^{-1}$$

Apply Hess's Law to calculate the standard enthalpy change of formation of solid sodium hydrogen carbonate, $\Delta_f H^{\circ}(NaHCO_{3(s)})$

$$Na_{(s)} + C(graphite) + H_{2(g)} + O_{2(g)} \longrightarrow NaHCO_{3(s)} \qquad \Delta_f H^{\circ} = ?$$

given the following standard enthalpies of formation:

$$\Delta_{\rm f} {\rm H}^{\circ} ({\rm Na_2CO_{3(s)}}) = -1130.7 \, {\rm kJmol^{-1}}$$

$$\Delta_{f}H^{\circ} (CO_{2(q)}) = -393.5 \text{ kJmo}^{I-1}$$

$$\Delta_{\rm f} H^{\circ} (H_2 O_{(1)}) = -285.8 \text{ kJmol}^{-1}$$

Skill l	evel 3
3	
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0	
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Part C: Nuclear Chemistry

Polonium-218 is radioactive. It decays to form lead, Pb and an alpha particle.	Skill le	evel 2
Write a balanced nuclear equation that shows this decay of Polonium-218.	2	
White a balancea nacional equation that shows this accay of 1 dichiam 216.	1	
	0	
	NR	
Substance D is also radioactive.		
If a sample of radioactive Substance D has an initial mass of 12 g and after 40,110 years the radioactive mass remaining is 0.09375 g, determine the half-life in years of Substance D.		

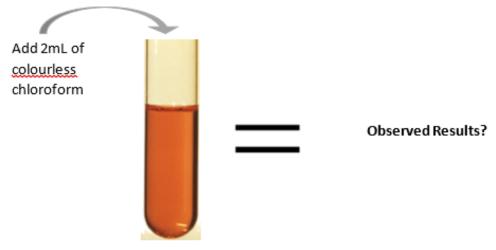
Skill le	evel 3
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0	
NR	

Part A: Inorganic Chemistry

1. Write the chemical formula of ammonium sulphide.

Skill le	evel 1
1	
0	
NR	

2. Chlorine water, $\text{Cl}_{2~\text{(aq)}}$, is mixed with a solution of potassium iodide, $\text{Kl}_{\text{(aq)}}$ in a test tube and 2mL of chloroform, $\text{CH}_3\text{Cl}_{\text{(l)}}$ is added to the mixture.



Chlorine water + Potassium iodide

Describe the observed results.

Skill I	evel 2
2	
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3. When solid iron(III) chloride, FeCl₃ dissolves in water, a large amount of **heat is released**.

$$\operatorname{FeCl}_{3(s)} + \operatorname{H}_2\operatorname{O}_{(l)} \longrightarrow \operatorname{Fe}^{3+}_{(aq)} + 3\operatorname{Cl}_{(aq)}^-$$

Explain how enthalpy and entropy changes drive this dissolving process.

	Skill l	evel 3
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	1	
	0	
	NR	

Part B: Transition Metals

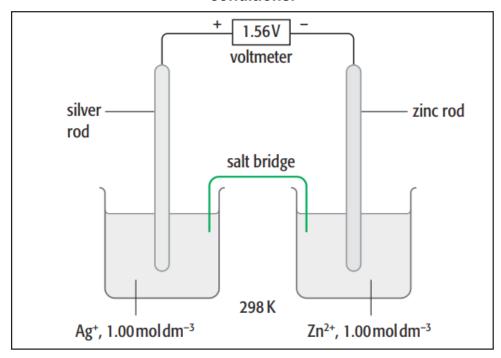
	Skill I	eve
Write a balanced equation for the formation of tetrachlorocopper(II) ion from chloride ons and copper ions.	2	
	1	L
	0	L
	NR	L
Chloride ion, Cl ⁻ is the ligand in the complex ion, tetrachlorocopper(II).		
Describe the nature of a ligand using the chloride ion as the example.		
	Skill I	eve
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	1	igdash
	0	1
-	110	一
Copper is a transition metal that has an oxidation number or oxidation state of +2.	NR	
Copper is a transition metal that has an oxidation number or oxidation state of +2. Explain why the transition metals, with the exception of Scandium, Sc, have an oxidation state of +2.	NR	
Explain why the transition metals, with the exception of Scandium, Sc, have an	NR	
Explain why the transition metals, with the exception of Scandium, Sc, have an	NR	
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Explain why the transition metals, with the exception of Scandium, Sc, have an	NR	

Skill I	evel 3
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Part C: Redox Chemistry

Study and use data from Figure 1 below and the given information to answer a. and b.

Figure 1: Electrochemical cell of two half cells, Ag/Ag⁺ and Zn/Zn²⁺ at standard conditions.



The standard electrode potential, E⁰value for the Ag/Ag⁺ half-cell, E⁰_(Ag/Ag+) is +0.80V.

Determine the standard electrode potential of the Zn/Zn ²⁺ half-cell, $E^0_{(Zn/Zn^2+)}$.		
Include in your answer the appropriate unit.		
	Skill I	eve
	2	L
	1	L
	0	
	NR	

Anode half-cell reaction: Observed changes:

Skill level 3

Reasons for observed changes: _	 	

QUESTION FOUR:

b.

QUANTITATIVE CHEMISTRY

Part A: Aqueous salt solutions

Barium hydroxide, $\mathrm{Ba(OH)}_{\!\scriptscriptstyle 2}$ is a sparingly soluble salt.

It dissolves in water to form a saturated solution containing ions **and** a small amount of solid barium hydroxide, Ba(OH)₂ settling at the bottom of the container.



$$Ba(OH)_{2(s)} + H_2O_{(l)} \implies Ba^{2+}_{(aq)} + 2OH^{-}_{(aq)}$$

a. Write the solubility product expression, K_s , for $Ba(OH)_2$.

Skill level 1			
1			
0			
NR			

NR

Calculate the solubility, \mathbf{s} , in gL ⁻¹ of barium hydroxide, Ba(OH) ₂ in pure water given its solubility product, K _s is 5.07 x 10 ⁻³ . The molecular formula M(Ba(OH) ₂) = 171gmol ⁻¹		
	Skill le	evel 3
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	0	

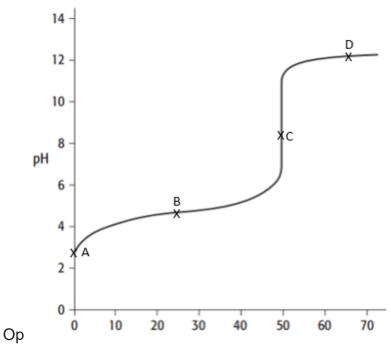
Explain the possible observations in the container if a small amount of concentrated hydrochloric acid, HCl is added to the saturated solution of Ba(Ol	H) _a .	
· ·	, 2	
		
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Part B: Acid-base Titration Curve

Use Graph 3 below to answer a. - d.

The titration curve below is a result of adding aqueous solution of sodium hydroxide, $NaOH_{(aq)}$ to 50mL of ethanoic acid solution, $CH_3COOH_{(aq)}$.

Graph 3: Titration curve for the addition of NaOH solution to CH₃COOH solution



a. From **Graph 3**, calculate the initial concentration of the 50mL of ethanoic acid solution given its acid dissociation constant at 25°C, K_a is 1.75x10⁻⁵molL⁻¹.

Skill level 2

SKIII I	Skill level Z		
2			
1			
0			
NR			

b. On the titration curve in **Graph 3**, draw a rectangle, _____ on the buffer region showing the pH limits. (i.e. maximum and minimum pH values)

Skill le	Skill level 2		
2			
1			
0			
NR			

c. Determine from the list of indicators below with their pKa values the most appropriate indicator for this titration

Indicator	pKa
Methyl orange	3.7
Bromophenol blue	4.0
Methyl red	5.0
Bromothymol blue	7.0
Phenol red	7.9
Phenolphthalein	9.3

Skill level 2		
2		
1		
0		
NR		

ъ.	- 41		 - 41			10: (

d. Discuss the changes in pH along the titration curve at points A, B, C and D in terms of the species present in the solution.

(Consider in your answer the following:

Balanced equation for the titration reaction at each point

Name of the most appropriate indicator:

- Species present & their relative concentration in solution at each point
- Link species present to pH value at each point
- Reasons for the pH value at each point)

Note:

- 1. pH value is already given in the graph. You do not have to calculate it.
- 2. You do not need to use exact concentrations at points A, B and C.

3.	Concentration MUST be exact at point D .

Skill le	evel 4
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 0	
NR	

QUESTION FIVE:

ORGANIC CHEMISTRY

Part A: Polymer

Nylon 6,6 is a widely used polymer. It has the following structure:

a.	Identify by circling ONE	(1) of the peptide link in the	structure of nylon 6,6 above.
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Skill l	evel 1
1	
0	
NR	

b. TWO monomers, Monomer 1 and Monomer 2, react to form nylon 6,6 above and a by-product, hydrogen chloride, HCl.

Deduce the **structural formula** of the two monomers, Monomer 1 and Monomer 2, that formed the nylon 6,6 above.

Draw the **structural formula** in the space provided below.

Monomer 1

Monomer 2	2
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Skill l	evel 2
2	
1	
0	
NR	

Part B: Organic reactions

Ammonia, hydroxide ions and water are examples of **nucleophiles**.

Describe the mechanism that leads to the attraction of the nucleophile (OH) in sodium hydroxide, NaOH) to the carbon-bromine bond, C-Br, in bromoethane, CH ₃ CH ₂ Br.		
(Use arrows to show the attraction forces.)		
	_	evel 2
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	1	-
	0	
	NR	

Part C: Isomers

Ex	plain v	vhy 2	2-chlorobutane	can	exhibit o	optical	isomerism	but	1-chlorobutane cannot.
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 $\mathsf{CH_2}\mathsf{CICH_2}\mathsf{CH_2}\mathsf{CH_3}$

CH₃CHCICH₂CH₃

1-chlorobutane

2-chlorobutane

(Consider in your answer the:

- Properties of an optical isomer,
- How each compound meet or does not meet the properties of an optical isomer
- Reason(s)

Conclusive statement.)		
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	Skill I	level 3
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PERIODIC TABLE

Series		odilgo	Lanthanide	
Ac 227	89	139	5	57
Th 232	90	140	Ce	58
Pg	91	141	Pr	59
∪ 238	92	144	Nd	60
Np	93	147	Pm	61
Pu 239		150	Sm	62
Am	95	152		63
Cm	96	157	Gd	64
BK	97	159	Ъ	65
251 Q		163	Dy	66
Es 252	99	165	ᆼ	67
Fm 257	100	167	щ	89
Md	101	169	Ī	69
No	102	173	YЬ	70

H 1.0 Molar mass / g mol-1 7 8 9 10 11 25 26 27 28 29 Mn Fe Co Ni Cu 54.9 55.9 58.9 58.7 63.5 107 Re Os Ir Pt Au 108 109 110 111 Bh Hs Mt Ds Rg	1 2	292	292	292		_	289		277	272	271	268	265	264	263	262	261	262	226	223
1 2 1.0 Molar mass / g mol 1.0	1 2 H	_	_	_	-	-			ე ე	Rg	Ds	≩	HS	Bh	Sg	B	굒	5	Ra	Ŧ
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H i 2 ii Be iv 9.0 iv Na Mg iv Na 23 iv Ca Sc 11 iv Ca 38 39 40 ii H i.0 Molar mass / g mol ⁻¹ ii No Molar mass / g mol ⁻¹ ii	H i Be i Na Mg 23.0 24.3 3 4 5 6 7 8 9 10 11 k Ca Sc Ii V Cr Mn Fe Co Ni Cu 39.1 40.1 45.0 47.9 50.9 52.0 54.9 55.9 58.9 58.7 63.5 Attachment of the column of the co	Cd In Sn Sb Te I Xe	In Sn Sb	In Sn Sb	In Sn	5		ဂ္ဂ		Ag	Pd	齐	R	ď	Mo	N D	Zr	4	δ	Вb
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