

HWA CHONG INSTITUTION C2 Preliminary Examinations Higher 2

CANDIDATE NAME	CT GROUP	20S
CENTRE NUMBER	INDEX NUMBER	
CHEMISTRY		9729/01

## Paper 1 Multiple Choice

17 September 2021

1 hour

Additional Materials: Multiple Choice Answer Sheet

Data Booklet

## READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Complete the information on the Answer Sheet as shown below.

1. Enter your <b>NAME</b> (as in NRIC).	Enter your NAME (as in NRIC).			US FC	USE PENCIL ONLY FOR ALL ENTRIES ON THIS SHEET					C		
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<ul> <li>5. Now SHADE the corresponding circles in the grid for EACH DIGIT or LETTER</li> </ul>		(5) (5) (6) (7)	0 (1) (2) (3)	0 (1) (2) (3)	0 (1) (2) (3)	0 (1) (2) (3)	0 (1 (2) (3)	0 (1 (2) (3)	0 1 2 3	(A) (B) (C) (D)	<ul><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li></ul>	<ul><li>(a)</li><li>(b)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><li>(c)</li><l< th=""></l<></ul>

There are **thirty** questions on this paper. Answer **all** questions. For each question, there are four possible answers **A**, **B**, **C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

## Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

The use of an approved scientific calculator is expected, where appropriate.

1 The successive ionisation energies of the gaseous **ion**, **G**<sup>+</sup>, are given in the table below:

1	2	3	4	5	6
1907	2914	4964	6274	21 267	25 431
	1 1907	1 2 1907 2914	1         2         3           1907         2914         4964	1         2         3         4           1907         2914         4964         6274	1         2         3         4         5           1907         2914         4964         6274         21 267

Which group in the periodic table does G belong to?

<b>A</b> 14 <b>B</b> 15 <b>C</b> 16 <b>D</b>	17
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- 2 In which of the following pairs of compounds would the second compound have a higher boiling point than the first compound?
  - 1 HCHO, CH<sub>3</sub>OH
  - 2 BF<sub>3</sub> , A/F<sub>3</sub>
  - **3** CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub>, C(CH<sub>3</sub>)<sub>4</sub>
  - **A** 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 1, 2 and 3
- 3 Information about the properties of some compounds are given below.

	density / g cm <sup>-3</sup>
ice	0.931
water	0.997
	boiling point / °C
HF	19.5
NH <sub>3</sub>	-33.3
2-nitrophenol	216
4-nitrophenol	279

Which statement about the hydrogen bonding in these compunds is incorrect?

- A HF has a higher boiling point than NH<sub>3</sub> because each HF molecule can form more hydrogen bonds on average compared to each NH<sub>3</sub> molecule.
- **B** Hydrogen bonds between molecules of H<sub>2</sub>O in ice causes the density of ice to be lower than that of water.
- **C** When  $CH_3CO_2H$  is dissolved in benzene, hydrogen bonding between two molecules of  $CH_3CO_2H$  causes the  $M_r$  to double from 60 to 120.
- **D** The boiling point of 2-nitrophenol is lower than 4-nitrophenol due to the presence of intramolecular hydrogen bonding in 2-nitrophenol.

- 4 Which graph will **not** have the same shape for a fixed mass of gas compared to the rest? (All values are measured in SI units.)
  - ApV against TCpV against V at constant T
  - B p against density at constant TD p against 1/V at constant T
- **5** When a liquid hydrocarbon was burnt in 100 cm<sup>3</sup> of excess oxygen gas, the gaseous mixture contracted by 15 cm<sup>3</sup>. On passing the resultant gaseous mixture through aqueous sodium hydroxide, there was a further contraction of 60 cm<sup>3</sup>. What could be the molecular formula of the hydrocarbon? All volumes were measured at room temperature and pressure.
  - **A**  $C_6H_8$  **B**  $C_6H_{12}$  **C**  $C_8H_8$  **D**  $C_8H_{12}$
- **6** The main isotopes of sulfur are summarised in the table below:

isotope	<sup>32</sup> S	<sup>33</sup> S	<sup>34</sup> S	<sup>36</sup> S
abundance	94.99	0.75	4.25	0.01

Which statements are correct?

- 1 The relative atomic mass of sulfur is 32.0929.
- **2** The relative isotopic mass of <sup>33</sup>S is the mass of 1 atom of <sup>33</sup>S relative to  $\frac{1}{12}$  of the mass of a <sup>12</sup>C atom.
- **3** When unipositively charged ions of the isotopes of sulfur are passed through an electric field, the angle of deflection for <sup>32</sup>S<sup>+</sup> ion is the largest.
- **A** 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 1, 2 and 3
- **7** When 13.1 g of zinc dust was added to 150 cm<sup>3</sup> of 1.0 mol dm<sup>-3</sup> aqueous copper(II) sulfate, the temperature of the solution rose by 15 °C.

What is the enthalpy change for the reaction:  $Cu^{2+}(aq) + Zn(s) \rightarrow Zn^{2+}(aq) + Cu(s)$ ?

Assume the specific heat capacity of the solution is 4.20 J  $g^{-1}$  K<sup>-1</sup> and the density of all solutions is 1.00 g cm<sup>-3</sup>.

Α	– 47.2 kJ mol <sup>–1</sup>	С	– 68.5 kJ mol <sup>-1</sup>

**B**  $-63.0 \text{ kJ mol}^{-1}$  **D**  $-1210 \text{ kJ mol}^{-1}$ 

8 Consider the following reactions:

 $\begin{array}{ll} 2\text{NaOH}(\text{aq}) + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(l) & \Delta H_1 \\ \text{NaOH}(\text{aq}) + \text{CH}_3\text{CO}_2\text{H}(\text{aq}) \rightarrow \text{CH}_3\text{CO}_2\text{Na}(\text{aq}) + \text{H}_2\text{O}(l) & \Delta H_2 \end{array}$ 

Which statements are correct?

- 1  $\Delta H_1$  represents the enthalpy change of neutralisation.
- 2 The pH of a solution of  $CH_3CO_2Na$  is greater than 7.
- **3** The magnitude of  $\Delta H_1$  is twice that of  $\Delta H_2$ .
- **A** 1 and 3 **B** 3 only **C** 2 only **D** 1, 2 and 3

**9** The equation for the reaction between bromate and bromide ions is shown below.

$$BrO_3^{-}(aq) + 5Br^{-}(aq) + 6H^{+}(aq) \rightarrow 3Br_2(aq) + H_2O(l)$$

From initial rates experiments, the following rate equation was derived.

rate = 
$$k[BrO_3^{-}][Br^{-}][H^{+}]^2$$

The results of the initial rate experiments are shown.

initial [BrO₃ <sup>–</sup> ] / mol dm <sup>–3</sup>	initial [Br⁻] / mol dm⁻³	initial [H⁺] / mol dm <sup>-3</sup>	initial rate, 1/t / s <sup>-1</sup>
0.004	0.04	0.40	0.10
0.004	0.04	0.80	х
0.004	0.08	0.40	У
0.008	Z	0.80	<mark>1.60</mark>

What are the missing values, x, y, and z?

	x	У	z
Α	0.20	0.10	0.08
В	0.20	0.10	0.16
С	0.40	0.20	0.16
D	0.40	0.20	0.08

10 The mechanism for a given gaseous phase reaction is shown below.

$2\mathbf{A} \rightarrow \mathbf{C}$	fast
$C + B \rightarrow D$	slow
$D + B \rightarrow E$	fast

Which statements are correct?

- 1 The overall equation is  $2\mathbf{A} + 2\mathbf{B} \rightarrow \mathbf{E}$ .
- 2 The units of the rate constant is  $atm^{-2} s^{-1}$ .
- **3** The initial rate of formation of **E** is directly proportional to the square of the initial partial pressure of **A**.
- **A** 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 1, 2 and 3
- **11** What is the effect on decreasing temperature on the rate constants,  $k_{\rm f}$  for the forward reaction and  $k_{\rm b}$  for the backward reaction, and on the equilibrium constant  $K_{\rm c}$ , for a reversible reaction where the forward reaction is exothermic?

	<i>K</i> f	<i>k</i> b	Kc
Α	decrease	decrease	increase
В	decrease	decrease	no effect
С	increase	decrease	increase
D	increase	increase	decrease

**12** When an acid is titrated with a strong base, the equivalence point is reached when the amount of base added is equal to the amount of H<sup>+</sup> dissociated.

Sulfurous acid,  $H_2SO_3$ , a dibasic acid, has  $pK_a$  values of 1.9 and 7.1.

The curve for the titration of 25.0 cm<sup>3</sup> of 0.10 mol dm<sup>-3</sup> sulfurous acid against a standard solution of sodium hydroxide, NaOH, is shown below.



The pH ranges of colour changes for thymol blue indicator are 1.2 - 2.8 and 8.0 - 9.6.

Which statement is correct?

- **A** The initial pH of 0.10 mol dm<sup>-3</sup> sulfurous acid is 1.20 if the effect of the second  $pK_a$  is ignored.
- **B** The concentration of sodium hydroxide is 0.05 mol dm<sup>-3</sup>.
- **C** Thymol blue is a suitable indicator to detect the first and second equivalence points.
- **D** HSO<sub>3</sub><sup>-</sup> has  $pK_a$  value of 7.1 and  $pK_b$  value of 12.1.
- **13** Phosphoric acid,  $H_3PO_4$ , a tribasic weak acid, has  $pK_a$  values of 2.1, 7.2 and 12.4.

What are the major species present in a solution of phosphoric acid buffered at pH 7?

- **A**  $H_3PO_4$  and  $HPO_4^{2-}$
- $\textbf{B} \quad H_3 PO_4 \text{ and } H_2 PO_4^-$
- **C**  $H_2PO_4^-$  and  $HPO_4^{2-}$
- $\textbf{D} \qquad \text{HPO}_4{}^{2-} \text{and PO}_4{}^{3-}$

14 A solution contains Cu<sup>2+</sup>(aq), Ni<sup>2+</sup>(aq), and Zn<sup>2+</sup>(aq), each of concentration 0.0010 mol dm<sup>-3</sup>. To selectively precipitate the cations present, H<sub>2</sub>S was bubbled into the solution until the concentration of S<sup>2-</sup>(aq) in the solution reaches 1 × 10<sup>-19</sup> mol dm<sup>-3</sup>.

The value of the solubility product of each of the sulfides is given below.

salt	$K_{\rm sp}$ / mol <sup>2</sup> dm <sup>-6</sup>
CuS	6.3 × 10 <sup>-36</sup>
ZnS	1.6 × 10 <sup>-24</sup>
NiS	4.0 × 10 <sup>-21</sup>

Which statement describes what happens in the solution?

- A CuS and ZnS only are precipitated
- **B** CuS only is precipitated
- C ZnS and NiS only are precipitated
- **D** NiS only is precipitated
- **15** Use of the Data Booklet is relevant to this question.

An electrochemical cell set-up is shown below:





Which combination will cause electrons to flow in the external circuit from X to Y?

	solution 1	solution 2	
Α	Cr <sup>3+</sup>	H <sub>2</sub> O <sub>2</sub> , H <sup>+</sup>	
В	H₂O₂, H⁺	Cl⁻	
С	Co <sup>3+</sup>	Fe <sup>2+</sup>	
D	Co <sup>2+</sup>	Fe <sup>3+</sup>	

**16** An electric current is passed through two cells connected in series. One cell contains gold(III) chloride and the other contains aqueous copper(II) sulfate. If 4.00 g of gold is formed in the cell containing gold(III) chloride, what is the mass of copper deposited in the other cell?



17 Which equation is correct?



**18** The compound below is reacted with an excess of hydrogen gas in the presence of a platinum catalyst.



How many **additional** chiral centres will each molecule of the product have after the reaction?

**A** 3 **B** 4 **C** 8 **D** 9

**19** Catalytic converters are used to convert the toxic gases emitted from exhausts of vehicles using internal combustion engines to less harmful compounds.

Which equations represent reactions that will take place in the catalytic converter?

- 1 Oxides of nitrogen + carbon monoxide  $\rightarrow$  nitrogen + carbon dioxide
- 2 Unburnt hydrocarbons + carbon monoxide  $\rightarrow$  carbon dioxide + water
- 3 Carbon monoxide + oxygen  $\rightarrow$  carbon dioxide
- **A** 3 only **B** 1 and 2 **C** 1 and 3 **D** 2 and 3

**20** Hydrogen bromide undergoes an addition reaction with propene forming 2-bromopropane. When propene is bubbled through bromine monochloride, BrC*l*, dissolved in a suitable solvent, a similar reaction occurs.

Which product would be present in the greatest yield?



- 21 Which statement about benzene and cyclohexene is correct?
  - **A** Benzene and cyclohexene have delocalised  $\pi$  electrons.
  - **B** Benzene and cyclohexene decolourises aqueous bromine in the presence of finely divided iron.
  - **C** Benzene and cyclohexene undergo complete combustion to give the same products.
  - **D** Benzene and cyclohexene are planar molecules.
- 22 The glucose molecule undergoes polymerisation to form carbohydrate chains of different lengths under suitable conditions. A short carbohydrate chain comprising 10 units of glucose molecules is shown below.



How many moles of  $H_2$  gas will form when 1 mole of the carbohydrate chain above is reacted with excess sodium metal?



**23** Which compound will give a yellow precipitate with alkaline aqueous iodine and also gives a brick red precipitate with Fehling's reagent?



24 How may the ester phenyl butanoate be made in the laboratory?

Α	$CH_3(CH_2)_2CO_2H + C_6H_5OH$	conc. H <sub>2</sub> SO <sub>4</sub> heat	ester + H <sub>2</sub> O
в	$C_6H_5CO_2H + CH_3(CH_2)_2CH_2OH$	conc. H <sub>2</sub> SO <sub>4</sub>	ester + H <sub>2</sub> O
С	$CH_3(CH_2)_2COCl + C_6H_5OH$	$\longrightarrow$	ester + HCl
D	C <sub>6</sub> H₅COCl + CH <sub>3</sub> (CH <sub>2</sub> ) <sub>2</sub> CH <sub>2</sub> OH	$\longrightarrow$	ester + HCl

- **25** Which statement about the relative basicity of methylamine, dimethylamine and trimethylamine in the gas phase is correct?
  - A The lone pair of electrons on the nitrogen atom of trimethylamine delocalises over three methyl groups, making trimethylamine most basic.
  - **B** The lone pair of electrons on the nitrogen atom of trimethylamine is most available for donation, making trimethylamine the strongest Lewis base.
  - **C** Three electron-withdrawing methyl groups increase the electron density of the nitrogen atom of trimethylamine, making trimethylamine most basic.
  - **D** Three methyl groups disperse the negative charge on the nitrogen atom of trimethylamine, making trimethylamine the strongest Bronsted base.
- 26 Which reagents can be used to distinguish between compounds Y and Z?



**27** The graphs below show the variation in two properties of the elements Na to P and their compounds.



Which properties are illustrated in Graphs I and II?

Graph I

- A electrical conductivity of the element
- **B** electrical conductivity of the element
- **c** melting point of the element
- **D** melting point of the element

Graph II pH of the chloride when added to water pH of the oxide when added to water pH of the chloride when added to water pH of the oxide when added to water

- **28** Which statement explains the variation in the type of bonding of oxides and chlorides across Period 3?
  - A The number of valence electrons available for bonding increases due to the ability of P, S and C*l* to expand their octets.
  - **B** Effective nuclear charge increases as the proton number increases but shielding effect remains relatively constant.
  - **C** The magnitude of the electron affinity of oxygen is greater than that of chlorine.
  - **D** Difference in electronegativity between each element and oxygen or between each element and chlorine decreases.
- **29** Use of the Data Booklet is relevant to this question.

Some properties of fluorine and its compounds are compared with those of chlorine and bromine.

Property **Q** for fluorine is lower than that for chlorine and bromine.

Which could be property **Q**?

- 1 The bond dissociation energy of the halogen–halogen bond.
- 2 The thermal stability of the hydrogen halide.
- **3** Reducing power of the halide ion.
- **A** 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 1 only

**30** Use of the Data Booklet is relevant to this question.

An excess of zinc powder, Zn, is added into a solution containing  $VO_3^-$  ions. What will be the final oxidation state of vanadium?

**A** 0 **B** +2 **C** +3 **D** +4

## **END OF PAPER**