

HWA CHONG INSTITUTION **C2** Preliminary Examinations Higher 2

CHEMISTRY		0700/04
CENTRE NUMBER	INDEX NUMBER	
CANDIDATE NAME	CT GROUP	17S

Paper 1 Multiple Choice

21 September 2018 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 NAME (as in NRIC).				US FO	E PEN	CIL ON ENTRI	LY ES ON	THIS S	HEET		C	
2. Enter the PAPER NUMBER.				(• • 0) C		2 ; D (3 4 D (4 ±	5 (6) (7)
3. Enter your CT GROUP.						N	RIC / F	IN				
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 FIN Number 5. Now SHADE the corresponding circles in the grid for EACH DIGIT or LETTER 	>	(8) (F) (G) (T)	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)	ABCD	(K) (L) (R) (R)	() () () () () () () () () () () () () (

There are 30 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 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, in kJ mol⁻¹, of an element **X** are given below.

870 1800 3000 3600 5800 7000 13200

What can be inferred from the data provided?

- **A X** has a half-filled p-subshell.
- **B X** has a giant covalent structure.
- **C X** is likely to form a compound with the formula BeX_2 when reacted with beryllium.
- **D X** has a lower first ionisation energy than the element preceding it in the Periodic Table.
- 2 In which pair does the first species have a larger bond angle than the second?
 - A CF₄ and BF₃
 - B SO₂ and CO₂
 - $C = ClO_3^- and H_2S$
 - \mathbf{D} PO₄³⁻ and NO₃⁻
- 3 Silicon has a giant covalent structure similar to that of diamond. At room temperature, it is a very poor conductor. However, when heated to higher temperatures, its electrical conductivity increases.

What is the best explanation for the increase in electrical conductivity at higher temperatures?

- **A** Heating ionises silicon to give Si⁴⁺ ions.
- **B** Heating increases the frequency of vibration of silicon atoms.
- **C** Heating breaks some of the Si–Si bonds, allowing silicon particles to move.
- **D** Heating excites some of the valence electrons to higher energy levels such that they can be delocalised.

4 Measured values of the pressure, volume and temperature of a known mass of a gaseous compound are to be substituted into the ideal gas equation to calculate the relative molecular mass, M_r , of the compound.

Which conditions of pressure and temperature would give the most accurate value of M_r ?

	pressure	temperature
Α	low	low
В	low	high
С	high	high
D	high	low

5 Which graph shows the behaviour of a fixed mass of an ideal gas at two constant temperatures, T_1 and T_2 , where $T_2 > T_1$?



6 When hydrogen chloride gas reacts with ammonia gas, ammonium chloride is produced which is seen as white fumes.

Which statement about this reaction is incorrect?

- A Ammonia is a Brønsted-Lowry base because it accepts a proton from hydrogen chloride.
- **B** Ammonia is a Lewis base because it donates its lone pair of electrons to a proton in hydrogen chloride.
- **C** Hydrogen chloride is an Arrhenius acid because it dissociates to give H⁺ ion.
- **D** Hydrogen chloride is a Lewis acid because it accepts a lone pair of electrons from ammonia.
- 7 Aqueous chlorine is added to aqueous sodium iodide and the mixture was shaken with an equal volume of trichloromethane.

Given that the density of trichloromethane is 1.48 g cm⁻³, which observation can be seen?



8 Use of the Data Booklet is relevant to this question.

 FeO_4^{2-} is a strong oxidising agent. It is produced by warming $Fe(OH)_3$ with ClO^- in alkaline medium.

$$2Fe(OH)_3 + 3ClO^- + 4OH^- \rightarrow 2FeO_4^{2-} + 5H_2O + 3Cl^-$$

The FeO₄^{2–} produced is typically precipitated out as BaFeO₄ (M_r = 257.1) and it is kept in dark bottles for future usage.

What can be deduced from the above information?

- 1 0.25 mol of $Fe(OH)_3$ and 0.40 mol of NaClO dissolved in excess NaOH solution can produce a maximum of 64.3 g of BaFeO₄.
- 2 $E^{\oplus}(\text{FeO}_4^{2-}/\text{Fe}(\text{OH})_3)$ is likely to be less than +0.81 V.
- 3 BaFeO₄ is likely to be sensitive to light.
- **A** 1, 2 and 3 **B** 1 and 3 only **C** 2 and 3 only **D** 1 only

- 5
- **9** When water freezes, 6.0 kJ mol⁻¹ of heat enthalpy is evolved.

What is the entropy change when 54 g of water freezes at 0 C?

- **A** –66 J K⁻¹ **B** –22 J K⁻¹ **C** 22 J K⁻¹ **D** 66 J K⁻¹
- **10** The initial rate of the slow reaction between peroxodisulfate(VI) and iodide ions can be studied by the "clock" method, using sodium thiosulfate.

$S_2O_8^{2-}$ + $2I^- \rightarrow 2SO_4^{2-}$ + I_2	reaction I
I_2 + 2Na ₂ S ₂ O ₃ \rightarrow 2NaI + Na ₂ S ₄ O ₆	reaction II

When sodium thiosulfate is added to the reaction mixture, the iodine produced by reaction I will immediately react in reaction II until all the sodium thiosulfate has been used up. At that point, there will be a sudden appearance of a deep blue colour if starch is present.

experiment	$\begin{array}{c} \text{volume} \\ \text{of } 0.200 \\ \text{mol } \text{dm}^{-3} \\ \text{S}_2 \text{O}_8^{2-} \\ \text{/cm}^3 \end{array}$	volume of 2.00 mol dm ⁻³ I ⁻ /cm ³	$\begin{array}{c} \text{volume} \\ \text{of } 0.050 \\ \text{mol } \text{dm}^{-3} \\ \text{Na}_2\text{S}_2\text{O}_3 \\ \text{/cm}^3 \end{array}$	volume of starch solution /cm ³	volume of water /cm ³	time <i>t</i> /s	Relative rate /s ⁻¹
1	10	20	2	4	14	56	0.0179
2	10	30	2	4	4	37	0.0270
3	10	10	1	2	2	28	0.0357

A series of experiments are carried out and the results are shown below.

Which statements about the above reaction are correct?

- 1 The rate equation for this reaction is rate = $k[S_2O_8^2-][I-]$.
- 2 The rate of formation of iodine in experiment 1 is $1.79 \times 10^{-5} \text{ mol dm}^{-3} \text{ s}^{-1}$.
- 3 Both Fe^{2+} and Fe^{3+} can be catalysts for this reaction.
- **A** 1 only **B** 1 and 2 only **C** 2 and 3 only **D** 1, 2 and 3

6

11 The numerical values of the equilibrium constant, K_{p} , for the reaction

 $Ag_2CO_3(s) = Ag_2O(s) + CO_2(g)$

are 3.20×10^{-3} and 1.50 at 298 K and 500 K respectively. Which statement is correct?

- A The backward reaction is endothermic.
- **B** The yield of carbon dioxide increases with temperature.
- **C** The value of K_p depends on the amount of Ag₂CO₃ used.
- **D** The yield of carbon dioxide will increase when Ag₂O is removed.
- **12** At 500 K, an equilibrium exists for the dissociation of Al_2Cl_6 .

$$Al_2Cl_6(g) = 2AlCl_3(g)$$

A sample of Al_2Cl_6 at a pressure of 0.72 atm was placed in an empty container and allowed to reach equilibrium at 500 K. The total pressure at equilibrium was 1.20 atm.

Which statements are correct?

- 1 The degree of dissociation, α , is 0.67.
- 2 When volume of the container is halved, the position of equilibrium will shift to the left.
- 3 Both the rate constant and equilibrium constant would increase with temperature.
- A 1 and 2 only B 1 and 3 only C 2 and 3 only D 1, 2 and 3
- **13** Human plasma is buffered mainly by dissolved CO₂ which has reacted to form carbonic acid, H₂CO₃.

$$H_2CO_3(aq) = H^+(aq) + HCO_3^-(aq)$$

Given that the pH of human plasma is 7.4 and the acid dissociation constant, K_a , of carbonic acid is 7.90 × 10⁻⁷ mol dm⁻³, which statement is correct?

- A The ratio of $[HCO_3^-]$ to $[H_2CO_3]$ in human plasma is 1 : 20.
- **B** The ratio of $[HCO_3^-]$ to $[H_2CO_3]$ in human plasma is 10 : 1.
- **C** This buffer system is more efficient in removing acid than base.
- **D** This buffer system can be prepared by mixing suitable amounts of sodium hydrogencarbonate and sodium hydroxide.

- **14** Which statement explains the observations that magnesium hydroxide dissolves in ammonium chloride, but not in aqueous sodium chloride?
 - A The ammonium ion acts as an acid.
 - **B** The ammonium ion changes the solubility product of Mg(OH)₂.
 - **C** Ammonium hydroxide is first formed, and then acts through a common ion effect.
 - **D** A complex is formed when magnesium hydroxide is added to ammonium chloride.



Which bonds are present in compounds X and Y above?

- 1 a σ bond formed by $2sp^2-2sp^2$ overlap between two N atoms in X
- 2 a σ bond formed by 2sp³-2sp² overlap between two C atoms in **Y**
- 3 a π bond formed by 2sp²-2sp² overlap between two C atoms in **Y**
- **A** 1 only **B** 1 and 2 only **C** 2 and 3 only **D** 1, 2 and 3
- **16** The structure of amoxicillin, an antibiotic useful for the treatment of a number of bacterial infections, is shown below.



What is the total number of chiral carbons in this molecule?

A 3 **B** 4 **C** 5 **D** 6

17 Deuterium (D or ²H) is a heavy isotope of hydrogen. A deuterated hydrocarbon has the formula shown below.

CDH=CH–CH=CHC₃H₇

What is the total number of isomers with the above formula?

- **A** 4 **B** 6 **C** 8 **D** 10
- **18** The equation for the complete combustion of an alkane, C_nH_{2n+2} , is given below.

$$C_nH_{2n+2} + \frac{3n+1}{2}O_2 \rightarrow nCO_2 + (n+1)H_2O_2$$

Which statement is **incorrect**?

- A The volume of oxygen required is directly proportional to the number of carbon atoms present in the alkane.
- **B** At 120 °C, the volume of steam produced per mole of alkane is more than the volume of carbon dioxide produced.
- **C** More oxygen is needed for the complete combustion of 1 mole of alkane as compared to 1 mole of an alkene with the same number of carbon atoms.
- **D** The volume of carbon dioxide produced at 25 °C is the same for the complete combustion of 1 mole of an alkane or 1 mole of an alkene with the same number of carbon atoms.
- **19** Hydroboration is a two-step reaction for the preparation of alcohols from alkenes, as shown in the scheme below for compound **X**.



compound X

Which statement is not true for this reaction?

- A H₂O₂ acts as a reducing agent in the second step.
- **B** The type of reaction involved in the first step is electrophilic addition.
- **C** In the first step, the boron atom of BH₃ adds to the less substituted carbon of the C=C group.

D $\stackrel{\text{OH}}{\longrightarrow}$ would be formed if BD₃ was used instead of BH₃ in the hydroboration above. (D = $^{2}_{1}$ H)

20 2-methylnitrobenzene is a pale yellow oil and it is often used to make dyes.



2-methylnitrobenzene

2-methylnitrobenzene is subjected to the following reactions:

- heat with tin in concentrated HC*l* followed by careful addition of cold NaOH(aq)
- dropwise addition of aqueous bromine

What is the product obtained after the above reactions?



21 Naphthalene-1,4-diol could be made from tetralin via the following synthetic scheme.



naphthalene-1,4-diol

What are the types of reactions involved in the above scheme?

- 1 free radical substitution
- 2 nucleophilic substitution
- 3 dehydration
- **A** 1 and 2 only **B** 1 and 3 only **C** 2 and 3 only **D** 1, 2 and 3

22 Which row is correct?



- **23** A contest for graduate students requires them to synthesise a molecule with the following features.
 - It is cyclic.
 - It contains two chiral centres.
 - It does not decolourise aqueous bromine.
 - It gives a silver mirror with Tollens' reagent.
 - It gives yellow precipitate when warmed with aqueous alkaline iodine.

What is the minimum number of carbon atoms the synthesised molecule could have in order to satisfy the above features?

A 5 **B** 6 **C** 7 **D** 8

24 5-hydroxyanthranillic acid (5-HAA) is a tryptophan metabolite that is suspected of generating oxidative stress and neuronal death.



When 5-HAA was subjected to ethanoyl chloride followed by lithium aluminium hydride in dry ether, the product was found to give a purple colouration with neutral $FeCl_3(aq)$.

Which is a likely product?



25 Part of the chain of a protein is shown.



What can be the products obtained when this protein is hydrolysed by 6 mol dm⁻³ NaOH?



26 In the diagram of the standard hydrogen electrode below, which labels are correct?



27 Which factors determine the amount of oxygen produced at the anode during the electrolysis of molten aluminium oxide?

	mass of Al ₂ O ₃ used	current	time
Α	\checkmark	\checkmark	×
в	\checkmark	×	×
С	X	\checkmark	\checkmark
D	×	×	\checkmark

28 Use of the Data Booklet is relevant to this question.

A contemporary direct methanol fuel cell is shown below.



In which direction do the electrons flow in the external circuit and which E^{e} value should be used for electrode Y?

	direction of electron flow	E ^e of electrode Y / V
Α	X to Y	+0.40
в	X to Y	+1.23
с	Y to X	+0.40
D	Y to X	+1.23

29 Ruthenium based organometallic catalysts are powerful tools for preparing organic compounds from previously unavailable routes. One of such complexes is shown.



The electronic configuration of ruthenium metal in the ground state is [Kr]4d⁷5s¹.

What is the electronic configuration of ruthenium in the complex above?

Α	[Kr]4d ⁷ 5s ¹	В	[Kr]4d ⁷	С	[Kr]4d ⁶	D	[Kr]4d⁵5s¹
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30 Which set of data correctly illustrates copper as a typical transition element and calcium as an *s*-block element?

	property	copper	calcium
1	density / g cm ⁻³	8.92	1.54
2	melting point/ °C	1085	842
3	electrical conductivity/ µSm ⁻¹	9.6	85

- A 1 only
- **B** 1 and 2 only
- C 2 and 3 only
- **D** 1, 2 and 3

END OF PAPER

1	2	3	4	5	6	7	8	9	10
D	С	D	В	D	С	D	Α	Α	D
11	12	13	14	15	16	17	18	19	20
В	D	С	Α	В	В	С	Α	Α	С
B 21	D 22	C 23	A 24	B 25	B 26	C 27	A 28	A 29	C 30