Class	Register Number	Name

南洋女子中学校

NANYANG GIRLS' HIGH SCHOOL

End-of-Year Examination 2020
Secondary Three
Mark Scheme

CHEMISTRY **45 minutes**
Paper 1 and 2 **1130 - 1215**
Wednesday **07 October 2020** **1 hour 45 minutes**
Additional materials: Writing papers **0845 - 1030**

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, register number and class in the spaces at the top of this page and on any separate writing paper used.

Section A (40 marks)
Answer **all** questions.
Write your answers in the spaces provided on the question paper.

Section B (30 marks)
Answer **all** questions including questions **B6**, **B7** and **B8 *Either*** or **B8 *Or***.
Write your answers on the separate writing paper provided.

At the end of the examination,
1. Fasten all your work securely together;
2. Tick **B8 *Either*** (for *Either*) or **B8 *Or*** (for *Or*) in the grid below to indicate which question you have answered;
3. **Hand in Section A and Section B separately.**

INFORMATION FOR CANDIDATES
The intended number of marks is given in the brackets [ ] at the end of each question or part question. You are advised to spend no longer than 1 hour on Section A and no longer than 45 minutes on Section B.

The use of approved scientific calculators is allowed.

Examiner's Use		
Section A		
Section B		
B6		
B7		
	B8 Either	
	B8 Or	
Total		

Paper 1

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

1	Substance exists as liquid at 10^0C, so melting point is lower than 10^OC; it exits as a gas at 60^0C, so its boiling point is lower than 60^0C, but higher than 10^0C.	C
2	"homogeneous blue colouration" would mean that the particles, copper(II) ions, sulfate ions and water molecules moved around to mix in order to achieve a homogeneous state.	D
3	To obtain water, we will need to carry out distillation so that water can be boiled, condensed over and collected at the distillate.	B
4	Iodine undergoes sublimation. Potassium chloride is a soluble salt. Barium sulfate is an insoluble salt. Sublimation must be carried out in the first step. Followed by addition of water to dissolve potassium, then filtering to remove barium sulfate before evaporating the potassium chloride solution.	A
5	Both NH_3 and HCl are gases, NH_3 (smaller Mr) will diffuse faster, reaching the moist red litmus paper first, and turning it blue before HCl reaches it to turn it red.	C
6	Expt 1 allows the **collection and measurement** of gases. Expt 2 allows for the change in mass. Expt 3 allows the **collection and measurement** of gases. Expt 4 does not have any useful measurement of either the change in mass of reactant/product nor collection and measurement of gas.	D
7	Potassium nitrate is neutral (pH 7) while potassium hydroxide is a strong alkaline with high pH.	C
8	Amphoteric oxides are insoluble in water. They are metallic oxides and can act as acid or bases when reacted with a base or acid respectively.	A
9	Options **A** and **B** will cause a coating of insoluble lead (II) sulfate, preventing further reaction, leading to very poor yield. Option **C**: By reacting lead(II) oxide with nitric acid, lead(II) nitrate is formed. Pb^{2+} (aq) can then form a precipitate with SO_4^{2-} (aq). Option **D** has not reaction between lead(II) chloride and nitric acid, so will not be able to form Pb^{2+}(aq) for precipitate with SO_4^{2-} (aq) from sodium sulfate.	C
10	When barium nitrate, was added to sample of polluted water, a white precipitate (of either $BaSO_4$ or $BaCO_3$) was observed. As it did not react with acid, we deduce that the anion is sulfate and not carbonate. When sample of polluted water was added with nitric acid followed by aqueous ammonia, a white precipitate that is soluble in excess	C

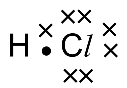
	aqueous ammonia was observed. We can deduce that the white precipitate is zinc hydroxide.	
11	I: NH_3 would be formed as well and present in the ionic equation. IV: $Ca^{2+}(aq) + SO_4^{2-}(aq) + 2H^+(aq) + 2OH^-(aq) \rightarrow 2H_2O\ (l) + CaSO_4\ (s)$ II and III: reagents and products except $CaSO_4$(s) are aqueous ions in solution, so spectator ions such as NO_3^-, H^+, and Na^+ will be cancelled out.	B
12	Green precipitate due to formation of $Fe(OH)_2$(s)and white precipitate due to $Ca(OH)_2$(s). Ammonia gas is evolved indicating that NH_4^+ was present in the solution.	C

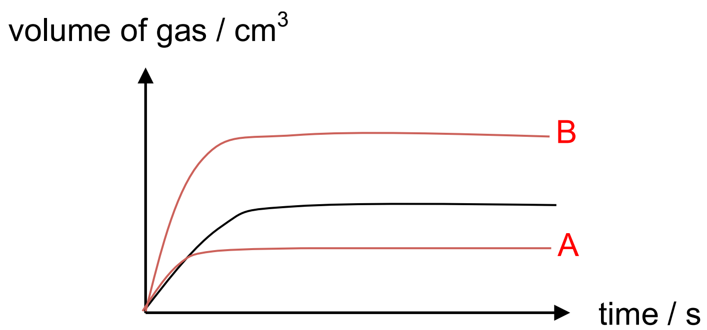
13	$Fe(NO)_3$: NaOH 1 : 3 no. of mol of $Fe(NO)_3$ given = 0.02 mol no. of mol of NaOH given = 0.03 mol NaOH is the limiting reagent, so at the end of reaction, there should be excess of $Fe(NO)_3$ (yellow solution) left apart from the formation of $Fe(OH)_3$ (reddish-brown precipitate).	C
14	X forms an ion of +2. So, X : H^+ 1: 2 no. of mole of HCl = 0.02 mol no. of mole of X = 0.01 mol Mr of X = 0.65/0.01 = 65	D
15	$P_4O_{10} + 6\ CaO \rightarrow 2\ Ca_3(PO_4)_2$ 0.5 mol : 3mol	A
16	I: $(NH_4)_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O + \mathbf{2NH_3}$ II: $\mathbf{2NH_3} + \underline{\mathbf{H_2SO_4}} \rightarrow (NH_4)_2SO_4$ III: $\underline{\mathbf{H_2SO_4}} + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$ No. of mole of NaOH in (III) =(25.80/1000)x0.100 =2.58 x 10^3 No. of mole of H_2SO_4 in (III) = 2.58 x 10^3 /2 =*1.29 x 10^{-3} mol* *(This is the excess of H_2SO_4 from II)* No. of mole of H_2SO_4 given in (II) = (50.0/1000)x0.0500 = 2.5 x 10^{-3} mol No. of mole of H_2SO_4 used in (II) = 2.5 x 10^{-3} - 1.29 x 10^{-3} = 1.21 x 10^{-3} mol No. of mole of NH_3 in 25 cm^3 of (II) = 2 x 1.21 x 10^{-3} = 2.42 x 10^{-3} mol No. of mole of NH_3 in 250 cm^3 of (II) = 10 x 2.42 x 10^{-3} = 0.0242 mol No. of mole of $(NH_4)_2SO_4$ (I) = 0.0242 /2 = 0.0121 mol Percentage mass = (0.0121 x 132.1)/5.00 x 100% = 32.0%	C
17	No. of mole of Cl_2 = [(0.00495/1000) x 500/1000]/71 = 3.4859 x 10^{-8} mol No. of Cl atoms = (2 x 3.4859 x 10^{-8}) x 6.02 x 10^{23} = 4.20 x 10^{16}	A

<table>
<tr><td>18</td><td><table><tr><td></td><td colspan="5">$CH_3SH(g) + 3O_2(g) \rightarrow CO_2(g) + SO_2(g) + 2H_2O(l)$</td></tr><tr><td>given</td><td>20</td><td>80 (excess)</td><td>0</td><td>0</td><td></td></tr><tr><td>reacted</td><td>-20</td><td>-60</td><td>+20</td><td>+20</td><td></td></tr><tr><td>left</td><td>0</td><td>20</td><td>20</td><td>20</td><td></td></tr></table>Total = 60 cm^3</td><td>B</td></tr>
<tr><td>19</td><td>$HClO_3$
(+1) + O.S. of Cl + 3(-2) = 0
O.S. of Cl = +5</td><td>C</td></tr>
<tr><td>20</td><td>ZnO lost an oxygen atom to C. ZnO undergoes reduction while C (gained an oxygen atom) undergoes oxidation.</td><td>A</td></tr>
<tr><td>21</td><td>No. of mole of Zn = 0.654/65.4 = 0.01 mol
No. of mole of e lost from Zn = 0.01 x 2 = 0.020 mol
No. of mole of VO_2^+ = (100/1000) x 0.10 = 0.010 mol
VO_2^+ : e
1 : 2
1 mole of VO_2^+ gained 2 mole of e
O.S. of V in product = +5 + 2e = +3</td><td>C</td></tr>
<tr><td>22</td><td>HSO_3^- reacts with H^+ to form water and SO_2.
There is no change in oxidation state, so it is not redox.</td><td>A</td></tr>
<tr><td>23</td><td>In an atom of Z, there would be 17 electrons:
$1s^2 2s^2 2p^6 \underline{3s^2 3p^5}$ Z is in group 17, will form a singly charged anion.
Mass number = 17 + 18 = 35</td><td>D</td></tr>
<tr><td>24</td><td>Electron will be attracted and pulled towards the negative plate due to electrostatic forces of attraction. The deflection will be greater as electron has a much lower relative mass compared to proton.</td><td>B</td></tr>
<tr><td>25</td><td>CO_2 dissolves in water to form a weak acid known as carbonic acid.
$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$
So it provides some electrical conductivity.</td><td>D</td></tr>
<tr><td>26</td><td>Compound exists as liquid at room temperature tells us that it has a low melting point, so it is a simple molecule. P and Q must be non-metals.</td><td>D</td></tr>
<tr><td>27</td><td>Sodium chloride is an ionic compound with strong electrostatic forces of attraction between oppositely charged ions while silicon tetrachloride is a simple molecule with weak intermolecular forces of attraction.</td><td>B</td></tr>
<tr><td>28</td><td>Q shows mass difference, therefore number of moles of HCl used must be the same, so cannot increase [HCl] as that will also increase its number of moles leading to more gases produced.
Only increase in temperature.
Pressure has no impact on rate for this reaction.</td><td>B</td></tr>
<tr><td>29</td><td>R shows a reaction that stops almost as it starts.
By adding sulfuric acid instead, a coating of insoluble $CaSO_4$ is formed, preventing further reactions.</td><td>D</td></tr>
<tr><td>30</td><td>Y and Z has same yield so number of moles of H_2O_2 must be the same.
Y has a steeper gradient, means that the rate is faster so the concentration of H_2O_2 used must be higher.
X has a higher yield. So the number of moles of H_2O_2 is higher than Y and Z.</td><td>D</td></tr>
</table>

Paper 2

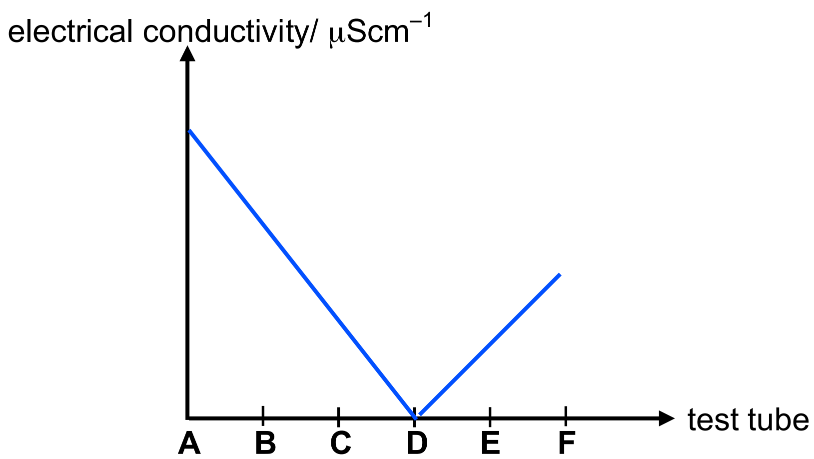
Section A
Answer **all** questions.
Write your answers in the spaces provided.

A1				
	(a)	Ammonium chloride sublimes/ sublimate/ changes from a solid to a gas on heating.		**[1]**
	(b)	**(i)**	covalent and ionic bonding	**[1]**
		(ii)	 1 mark for correct number of shared electrons 1 mark for correct number of atoms and valence electrons for chlorine 1 mark deducted if Lewis structure is drawn	**[2]**
	(c)	position **C**		**[1]**
			Total	**[5]**

A2				
	(a)	**(i)**	$2H^+(aq) + Ag_2CO_3(s) \rightarrow H_2O(l) + CO_2(g) + 2Ag^+(aq)$ –1 for wrong state symbols or if equation is not balanced. 0 if formula(e) is/are wrong.	**[2]**
		(ii)	No. of moles of $HNO_3 = \frac{150}{1000} \times 0.2 = 0.0300$ mol No. of moles of $Ag_2CO_3 = 8.00 \div 275.8 = 0.029007$ mol Limiting reactant is HNO_3. No. of moles of $CO_2 = 0.0300 \div 2 = 0.0150$ mol Volume of $CO_2 = 0.0150 \times 24 = 0.360\ dm^3$ (3 s.f.) ecf from a(i) and for each part	**[1]** **[1]** **[1]**
		(iii)	 Graph A: same gradient (accept gentler gradient), lower yield Graph B: steeper gradient, higher yield of 1.5 times	**[1]** **[1]**

	(b)	Surface area/particle size of silver carbonate Smaller particle size of silver carbonate has a larger surface area to volume ratio, there will be higher frequency of effective collisions, and therefore, higher rate of reaction. OR Add a catalyst Catalyst provide alternative pathway with lower activation energy, increasing the frequency of effective collision, leading to higher rate of reaction.	[1] [1] [1] [1] [1] [1]
		Total	**[10]**

A3						
	(a)	**A**	ammonium carbonate/ $(NH_4)_2CO_3$	**D**	sulfuric acid/ H_2SO_4	**[5]**
		B	carbon dioxide/ CO_2	**E**	iron(II) hydroxide/ $Fe(OH)_2$	
		C	aluminium/ Al			
	(b)	$CO_2(g) + Ca(OH)_2(aq) \rightarrow CaCO_3(s) + H_2O(l)$ correct chemical formulae & balanced equation – [1] state symbols – [1] [awarded only if the chemical formulae are correct]				**[2]**
					Total	**[6]**

A4					
	(a)	$Ba(OH)_2(aq) + H_2SO_4(aq) \rightarrow BaSO_4(s) + 2H_2O(l)$ Correct chemical formulae & balanced equation – [1] State symbols – [1] [awarded only if the chemical formulae are correct]			**[2]**
	(b)	**(i)**	test tube 2	blue/ violet / indigo / purple	**[1]**
		(ii)	test tube 5	red	**[1]**
	(c)	 1 mark for shape of the graph			[2]

		1 mark for showing the lowest electrical conductivity (0 μScm^{-1}) at test tube D Accept curve / bar chart		
			Total	**[6]**

A5				
	(a)	**(i)**	The acidified potassium manganate(VII) solution turns from purple to colourless.	**[1]**
		(ii)	$C_2O_4^{2-}(aq) \rightarrow 2CO_2(g) + 2e^-$ correct chemical formulae & balanced equation – [1] state symbols – [1] [awarded only if the chemical formulae are correct]	**[2]**
		(iii)	No. of moles of MnO_4^- added = 0.200 × 26.50/1000 = 0.00530 mol	**[1]**
		(iv)	No. of moles of $C_2O_4^{2-}$ reacted = 0.00530/2 × 5 = 0.0133 mol	**[1]**
	(b)	**(i)**	The reaction is not a redox reaction [1] as the <u>oxidation state of all elements remain unchanged</u> [1]. award marks for stating that reaction is not a redox reaction only if explanation shows correct concept	**[2]**
		(ii)	No. of moles of NaOH added = 0.100 × 10.45/1000 = 0.001045 = 0.00105 mol (3 s.f.)	**[1]**
		(iii)	No. of moles of $H_2C_2O_4$ reacted = 0.001045/2 = 0.0005225 = 0.000523 mol (3 s.f.)	**[1]**
		(iv)	No. of moles of $H_2C_2O_4$ in 250 cm^3 = 0.0005225 × 10 = 0.005225 mol [1] Mass of $H_2C_2O_4{\cdot}2H_2O$ = 0.005225 × (1.0 × 2 + 12.0 × 2 + 16.0 × 4 + 2 × 18.0) = 0.65835 g [1] Percentage by mass of $H_2C_2O_4{\cdot}2H_2O$ = 0.65835/4.21 = 15.6 % (3 s.f.) [1]	**[3]**
			Total	**[12]**

Section B

Answer all **three** questions from this section on the writing paper provided.
The last question is in the form of either/or and only **one** of the alternatives should be attempted.

B6				
	(a)	(i)	A covalent bond is the electrostatic forces of attraction between the shared/bonding (pair of) electrons and the (positive) nuclei (of the two atoms).	[1] [1]
		(ii)	HI is able to conduct electricity in the aqueous state, as it is able to ionise/dissociate in water to form mobile ions. $HI(aq) \rightarrow H^+(aq) + I^-(aq)$ Accept no state symbols given	[1] [1]
	(b)		In solid state, the oppositely charged ions are held in fixed positions/ there are no free-moving / mobile ions to conduct electricity. In liquid state, the electrostatic forces of attraction between ions are weakened, Hence, there are free-moving / mobile ions to conduct electricity.	[1] [1] [1]
	(c)		Strong covalent bonds between atoms require a lot of energy to break.	[1] [1]
	(d)		From the properties, aluminium chloride is covalently bonded, but it is expected to have ionic bonds (because the compound is formed between a metal and a non-metal). Accept any answers with similar idea e.g. - Aluminium chloride has covalent bonding although aluminium is metal and chlorine is non-metal - Aluminium chloride forms covalent bond between a metal and a non-metal but covalent bonding usually occurs between non-metals	[1]
			Total	**[10]**

B7				
	(a)	(i)	gas syringe Accept **inverted measuring cylinder/burette over water**. Reject 'measuring cylinder'	[1]
		(ii)	Initial no. of moles of H_2O_2 = 4.6 × 25/1000 = 0.115 mol No. of moles of H_2O_2 at 2000 s = 1.0 × 25/1000 = 0.0250 mol No. of moles of H_2O_2 decomposed = 0.115 – 0.0250 = 0.0900 mol No. of moles of O_2 = 0.0900/2 = 0.0450 mol Volume of O_2 = 0.0450 × 24 = 1.08 dm^3	 [1] [1] [1]
	(b)	(i)	Comparing experiments 1 and 3 [1] with the (initial concentration of hydrogen peroxide and hydrogen ions remaining constant at 0.0200 mol dm^{-3}), the doubling of the initial concentration of iodide ions resulted in about a doubling in the rate (8.00×10^{-6}/ 4.00×10^{-6} = 2) [1].	[2]

			Accept increase concentration→increase rate.	
		(ii)	Comparing experiments 3 and 4 [1] with the (initial concentration of iodide ions and hydrogen peroxide remaining constant at 0.0200 mol dm^{-3} and 0.0400 mol dm^{-3} respectively), the doubling of the initial concentration of hydrogen ions resulted in no change in the rate [1]. Accept varying concentration has no impact on the rate.	[2]
		(iii)	Monitor the change in electrical conductivity over time/as reaction proceeds/as reaction take place [1] as the number of mobile ions changes/ decreases [1]. Accept use of conductivity meter of instrument that is capable of measuring change in electrical conductivity over time. OR Monitor the change in pH over time/ as reaction takes place/ as reaction proceeds [1] as the concentration of H^+ ions decreases [1]. Accept data-logger/pH meter, these are instruments capable of measuring pH changes over time. Reject indicators, as they give a range and not able to give exact measurements to monitor rate over time. OR Monitor the change in colour intensity over time/ as reaction takes place/ as reaction proceeds [1] I^- is colourless and will oxidised to form I_2 which is brown [1]. Accept use of spectrometer/ colourimeter, instruments can measure colour intensity or amount of light passing through over time. Reject time taken for colour change of the solution from colourless to brown, this doesn't allow for monitoring of change during the progress of the reaction. It takes only the time form start till end.	[2]
			Total	**[10]**

B8	**EITHER**			
	(a)	**(i)**	KNO_3 is reduced as oxidation state of nitrogen decreases from +5 in KNO_3 to 0 in N_2. S is reduced as oxidation state of sulfur decreases from 0 in S to –2 in K_2S. C is oxidised as oxidation state of C increases from 0 in C to +4 in CO_2. penalise for phrasing error	**[1]** **[1]** **[1]**
		(ii)	The shock provides activation energy for the reaction to occur. accept any explanation with concept of activation energy	**[1]**

	(b)	**(i)**	No. of moles of KNO_3 = 75.0 ÷ 101.1 = 0.74184 = 0.742 mol (3 s.f.) No. of moles of S = = 12.5 ÷ 32.1 = 0.38941 = 0.389 mol (3 s.f.) No. of moles of C = 12.5 ÷ 12.0 = 1.0417 = 1.04 mol (3 s.f.)	**[2]**
		(ii)	1.04 mol of C requires 0.347 mol of S and 0.693 mol of KNO_3 for complete reaction, hence S and KNO_3 are in excess. Limiting reactant is C. mark for limiting reactant only if explanation is correct. accept alternative explanations.	**[1]** **[1]**
		(iii)	No. of moles of gases = $\frac{4}{3}$ x 1.0417 = 1.3889 mol Theoretical volume of gases = 1.3889 x 24 = 33.334 dm^3 % yield = $\frac{20}{33.334}$ x 100% = 60.0% (3 s.f.)	**[1]** **[1]**
			Total	**[10]**

B8	**OR**			
	(a)	**(i)**	Explain why the above reaction is a redox reaction in terms of oxidation states.	**[3]**
			P_4 is oxidised as oxidation state of phosphorus increases from 0 in P_4 to +5 in P_4O_{10}. $KClO_3$ is reduced as oxidation state of chlorine decreases from +5 in $KClO_3$ to –1 in KCl. Since both oxidation and reduction occurs at the same time, the reaction is a redox reaction.	**[1]** **[1]** **[1]**
		(ii)	Striking the match provides activation energy for the reaction to occur.	**[1]**
	(b)	**(i)**	$P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$	**[1]**
		(ii)	No. of moles of NaOH = $\frac{20}{1000}$ x 1 = 0.0200 mol No. of moles of H_3PO_4 = 0.02 ÷ 3 = 0.0066667 mol No. of moles of P_4O_{10} = 0.0066667 ÷ 4 = 0.00167 mol (3 s.f.)	**[1]** **[1]**
		(iii)	It is assumed that the impurity is not acidic/ does not react with NaOH. Reject: P_4O_{10} is limiting reactant (question mentioned that impurity is present so answer should take reference from that information)	**[1]**
		(iv)	No. of moles of $KClO_3$ = 0.0016667 x $\frac{10}{3}$ = 0.0055556 mol mass of $KClO_3$ = 0.0055556 x 122.6 = 0.681 g (3 s.f.)	**[1]** **[1]**
			Total	**[10]**