Class	Register Number	Name

南洋女子中學校

NANYANG GIRLS' HIGH SCHOOL

End-of-Year Examination 2019
Secondary Three

CHEMISTRY

Paper 2 Theory Paper **1 hour 45 minutes**

Monday **14 October 2019** **1000 - 1145**

Additional materials: Writing paper

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 answer 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 **B7**, **B8** and **B9** ***Either*** or **B9** ***Or***.
Write your answers on the separate writing paper provided.

At the end of the examination,

1. Fasten all your work securely together;
2. Circle **B9** ***Either*** (for Either) or **B9** ***Or*** (for Or) in the grid on the right to indicate the 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 60 minutes on Section A and no longer than 45 minutes on Section B.

The use of approved scientific calculators is allowed.

A copy of the periodic table is found on page 14.

Paper 1	**/ 30**
Paper 2	
Section A	**/ 40**
B7	**/ 9**
B8	**/ 11**
B9 *Either* / B9 *Or*	**/ 10**
Total	**/ 100**

Setters:
SCheong/ MI

This document consists of 14 printed pages.

Section A (40 marks)

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

A1 A barium meal, also known as upper gastrointestinal series is a procedure in which radiographs of the oesophagus, stomach and small intestine are taken after barium sulfate is ingested by 1 patient. Reacting barium hydroxide with sulfuric acid can produce barium sulfate.

(a) Suggest a reason why barium sulfate is safe to be ingested and used as part of the procedure. [1]

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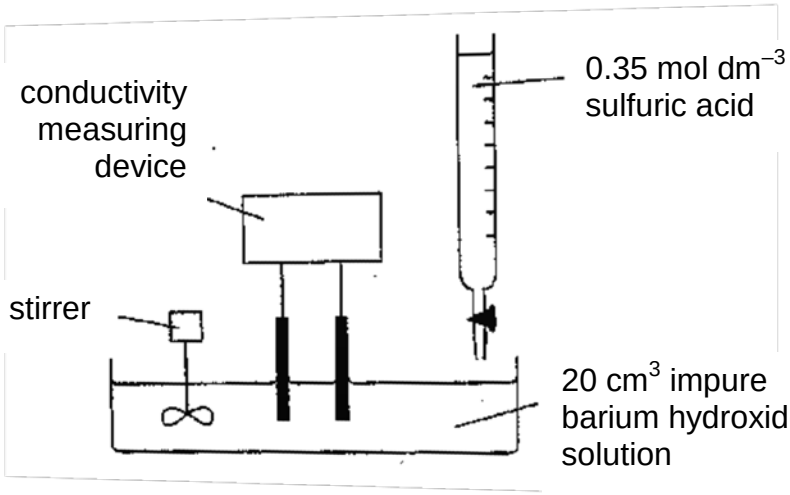
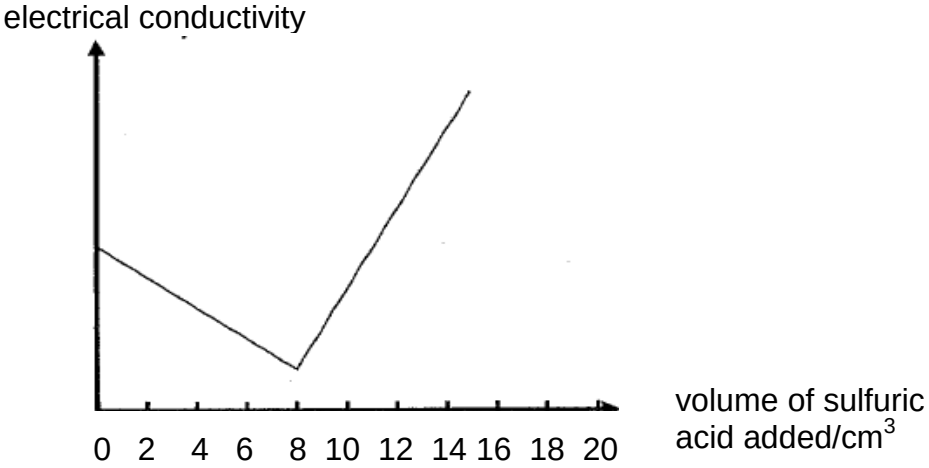
(b) The progress of the reaction between an impure solution of barium hydroxide and sulfuric acid can be followed by measuring the electrical conductivity of the barium hydroxide solution as shown in the setup below.



1cm^3 of sulfuric acid is added at a time and after each addition, the conductivity was measured. The results obtained are shown in the graph below.



(i) What volume of sulfuric acid is needed to neutralised 20cm^3 of impure barium hydroxide solution? [1]

.....

(ii) Barium hydroxide solution is formed by dissolving 25.0 g of impure sample of barium hydroxide in 1 dm^3 of distilled water.

Assuming that the impurities are not soluble in sulfuric acid, calculate the percentage purity of barium hydroxide sample. [3]

(iii) In another experiment, water was accidentally spilled into the sulfuric acid solution.

Would you expect a change in the volume of aqueous sulfuric acid required to neutralise the barium hydroxide solution? Explain your answer. [1]

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.....

(iv) Explain why barium hydroxide solution conducts electricity. [1]

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(v) Using your answer in **(b)(iv)**, explain the shape of the graph. [3]

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Total [10]

A2 Trichloromethane, $CHCl_3$, also known as chloroform, was used as an anaesthetic in surgery. It is not used today as it naturally reacts with oxygen in air to form a highly toxic gas phosgene, $COCl_2$ and hydrogen chloride gas.

(a) Write the balanced equation for the reaction of trichloromethane with oxygen. [1]

.....

(b) 10g of chloroform were reacted with excess oxygen and the gases formed were bubbled through aqueous ammonia and collected. Calculate the volume of gas collected. [2]

(c) In phosgene, the carbon atom is in the centre of the molecule and is attached to both chlorine atoms and to the oxygen atom.

(i) Draw a Lewis structure of the phosgene molecule. [1]

(ii) State the number of sigma (σ) bonds and the number of pi (π) bonds present in a single phosgene molecule. [1]

number of sigma bonds: .....

number of pi bonds: .....

(iii) Suggest the shape of the phosgene molecule and explain how you derive at your answer. [2]

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.....

.....

(iv) Explain why phosgene molecule is polar. [1]

.....

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Total [8]

A3 Reaction of an amine, $C_6H_5NH_2$, with bromine produces hydrogen bromide.

$$C_6H_5NH_2 + 3Br_2 \longrightarrow C_6H_2NH_2Br_3 + 3HBr$$

The table below shows the effect of concentration of each reactant on the rate of reaction measured by the concentration of hydrogen bromide formed per second.

experiment no.	concentration of $C_6H_5NH_2$ / mol dm^{-3}	concentration of Br_2 / mol dm^{-3}	initial rate of reaction / mol dm^{-3} s^{-1}
1	0.001	0.001	0.007
2	0.001	0.002	0.014
3	0.001	0.003	0.021
4	0.002	0.001	**(d)**
5	0.002	0.003	0.084

(a) Describe the general relationship between the concentrations of the reactants and the rate of reaction. [1]

.....

.....

(b) Using collision theory, explain your answer in **(a)**. [2]

.....

.....

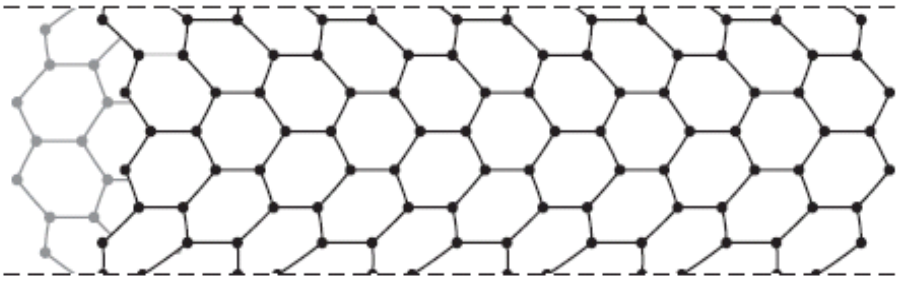
.....

(c) Does the increase in concentration of $C_6H_5NH_2$ and Br_2 have an equal effect on the rate of reaction? Explain your answer using results from the table, stating clearly which experimental data you are using. [4]

(d) Determine the initial rate in experiment 4 and explain how you derive your answer. [2]

Total [9]

A4 Carbon nanotubes (CNT) is an allotrope of carbon that consists of two-dimensional hexagonal lattice of carbon atoms, bent and joined so as to form a hollow cylinder. The diagram below shows the structure of CNT.



• carbon atom

CNT can exhibit 200 times the strength of steel and an electrical conductivity 5 times that of the current capacity of copper.

(a) With reference to the bonding and structure of CNT, determine why it is able to conduct electricity and has high strength. [3]

(b) State the electronic configuration of carbon, in spdf notation. [1]

.....

Total [4]

A5 100% gold is called '24 carat' gold. The percentage of gold present in a gold alloy depends upon the carat value.

carat value	alloy
22 carat	91.6% Au, 5.6% Ag, 2.8% Cu
18 carat	75.0% Au, 12.5% Ag, 12.5% Cu
14 carat	58.5% Au, 20.5%Ag, 21.0% Cu
9 carat	37.5% Au, 31.25% Ag, 31.25% Cu

An analyst was trying to determine the composition of a gold alloy comprising gold, silver and copper. He warmed 15 g of finely powdered alloy with excess concentrated nitric acid. This forms a suspension where copper and silver components are dissolved and the insoluble gold is collected by filtration.

The equations of the reactions are as shown below.

$$3Cu(s) + 8HNO_3\,(aq) \rightarrow 3Cu(NO_3)_2\,(aq) + 2NO(g) + 4H_2O(l)$$

$$3Ag(s) + 4HNO_3\,(aq) \rightarrow 3AgNO_3(aq) + NO(g) + 2H_2O(l)$$

(a) Warming of the alloy with excess concentrated nitric acid must be done in the fumehood as nitrogen monoxide is produced. Explain why. [1]

.....

(b) Describe a chemical test that could be carried out to confirm the presence of copper components in the gold alloy. [2]

.....

.....

(c) The pure gold obtained was weighed and its mass was found to be 8.77 g. Determine the carat value of the gold alloy. [1]

Total [4]

A6 Carrie is given three flasks labelled **Q**, **R** and **S**. Each flask contains one of the following solutions, $Pb(NO_3)_2$, KC*l* or Na_2CO_3.

Carrie is also given two other flasks containing solutions **X** and **Y**. One of these flasks contains $AgNO_3$ and the other contains BaCl_2.

She then carried out four tests to find out the identity of the solutions.

tests	reactants	observations
1	solution **Q** + solution **X**	precipitate seen
2	solution **Q** + solution **Y**	precipitate seen
3	solution **Q** + solution **S**	precipitate seen
4	solution **Q** + solution **R**	no precipitate seen

(a) Aqueous $Pb(NO_3)_2$ can be used to identify solution **X** and **Y**. Stating the observations clearly, explain how this can be carried out. [2]

.....

.....

.....

(b) Using the information given above, identify solutions **R** and **S**. [2]

R: .....

S: .....

(c) Identify the precipitate formed in test 3. [1]

.....

Total [5]

End of Section A

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.

B7 Bond length is the distance between the nuclei of two atoms that are covalently bonded to each other. The table below lists the bond length and bond energy of some covalently-bonded atoms.

bond	bond length / x 10^{-7} m	bond energy / kJ mol^{-1}
H–H	0.074	435
H–Cl	0.127	431
Cl–Cl	0.198	243
H–C	0.109	414
C–Cl	0.177	328
C–C	0.154	331
C=C	0.134	590
C≡C	0.120	812
C–O	0.143	326
C=O	0.120	803
C≡O	0.113	1075
N–N	0.145	159
N=N	0.125	473
N≡N	0.110	941

(a) (i) Deduce the relationship between the number of bonds between two atoms, and the bond energy. [1]

(ii) List **one set** of bonds, consisting of 2 or more bonds from the table, that you had used in order to make your deduction in **(a)(i)**. [1]

(b) (i) What is the relationship between bond length, and the number of bonds between the same type of atoms? [1]

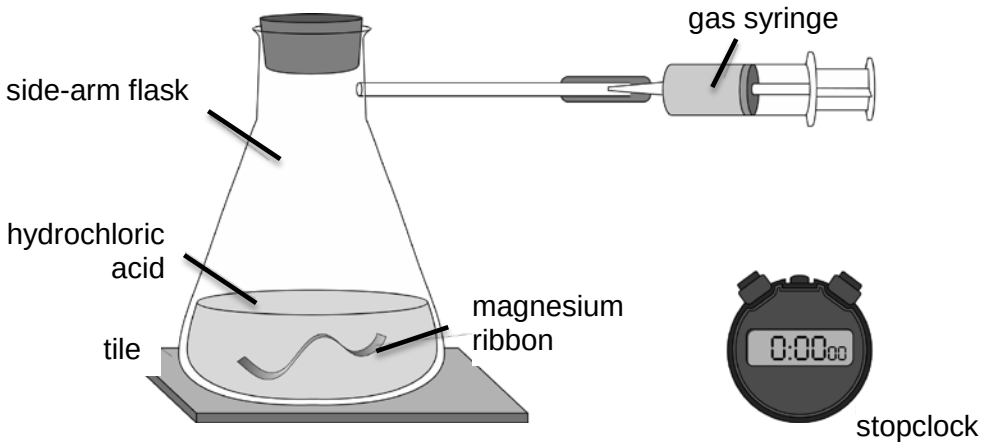
(ii) Suggest a reason for your answer to **(b)(ii)**. [2]

(c) Generally, the length of the bond between two atoms is approximately the sum of the covalent radii of the two atoms.

Hence, use effective nuclear charge to explain general trends for bond lengths across a period, for bonds between the same type of atoms. [3]

Total [8]

B8 **(a)** A reaction was carried out between magnesium ribbon and excess hydrochloric acid. The diagram below shows the setup of the experiment.



The following results were collected and recorded, by reading off the volume of gas in the syringe every 10 seconds for 90 seconds. All volumes were recorded at room temperature and pressure.

time/ seconds	0	10	20	30	40	50	60	70	80	90
volume of hydrogen gas collected in syringe / cm^3	0	18	30	40	48	53	57	58	58	58

Note: The gas syringe used had an instrumental precision of 1 cm^3 i.e. readings are taken to the nearest cm^3

(i) If the mole ratio of magnesium to hydrogen gas is 1:1, calculate the minimum mass of magnesium used in this experiment. [2]

(ii) Why is it important to record the volume of gas reading at zero seconds? [1]

(iii) The rate of a reaction over a period of time, measured in $cm^3\ s^{-1}$, can be calculated by dividing the change in a quantity by the change in time. Using the data in the table, calculate the rate of reaction, to one decimal place, for:

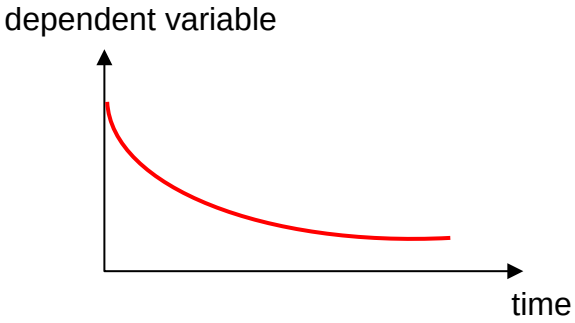
1. the first 10-second period of the reaction [1]

2. the second 10-second period of the reaction [1]

3. the average rate for the entire reaction [1]

(iv) Why is the average rate of a reaction less "useful" than the rate of the reaction at small intervals ? [1]

(v) A different dependent variable was measured to monitor the rate of the same reaction in a new setup, resulting in the following graph:



By considering the apparatus used for this new setup, suggest how this new method of measuring the rate of reaction might lead to results with a higher precision than in the original experiment. [1]

(b) The following tests were carried out on an unidentified colourless solution, and their observations recorded:

test	observations
1. Add aqueous sodium hydroxide to a portion of the solution.	White precipitate formed; precipitate soluble in excess NaOH(aq) to form a colourless solution.
2. Add aqueous ammonia to a portion of the solution.	White precipitate formed; precipitate soluble in excess NH_3(aq) to form a colourless solution.

(i) Write the ionic equation for the formation of the white precipitate in test 2. [1]

After carrying out tests 1 and 2, Student A carried out test 3 as shown below:

test	observations
3. Add aqueous barium chloride to a portion of the solution.	White precipitate formed.

She then correctly identified the anion in the solution.

(ii) Why was it **not** necessary for the student to acidify the solution when performing test 3, in order to make correct deductions? [1]

(iii) If the student had performed **only** Test 3 instead, (i.e. without tests 1 and 2), and obtained a similar observation of a white precipitate forming, suggest two possible identities of this white precipitate. [2]

Total [12]

B9 EITHER

(a) 20 cm^3 of 0.10 mol dm^{-3} of aqueous sodium hydroxide is added to 30 cm^3 of 0.20 mol dm^{-3} of sulfuric acid.

(i) Using calculations, deduce the identity of the excess reactant, and its concentration in the final solution. [4]

(ii) By consulting the tables below, deduce the pH of the final solution. [1]

concentration of H^+ / mol dm^{-3}	pH
0.05	1.3
0.10	1.0
0.20	0.7

concentration of OH^- / mol dm^{-3}	pH
0.05	12.7
0.10	13.0
0.20	13.3

(b) Five students each dissolved an indigestion tablet, containing sodium bicarbonate, in 100 cm^3 of water. They pipetted 25.0 cm^3 of their solutions into a conical flask, and reacted it with dilute hydrochloric acid in a burette using the same indicator. The results are shown in the table.

student	**1**	**2**	**3**	**4**	**5**
volume of dilute hydrochloric acid titrated / cm^3	19.40	19.55	19.45	19.60	21.00

For two **named** pieces of apparatus, suggest a rinsing error for each one that could explain the inconsistent result obtained by student **5**. [2]

(c) Compounds containing the chromate(VI) ion, CrO_4^{2-} , have the following solubility rules:

	soluble in water	insoluble in water
chromate(VI) ion, CrO_4^{2-}	salts of ammonium; Group 1 cations	all others

(i) Suggest two reagents that could be used to prepare a sample of zinc chromate(VI), $ZnCrO_4$. [2]

(ii) What is the name of the process used to prepare $ZnCrO_4$ in **(c)(i)** ? [1]

Total [10]

B9 OR

(a) A sample of 0.0200 mol of an oxochloride of sulfur, SO_2Cl_2, reacted completely with 250 cm^3 of water according to the following equation. Assume that the volume of the final solution is 250 cm^3.

$$SO_2Cl_2\ (l) + 2\ H_2O\ (l) \rightarrow H_2SO_4\ (aq) + 2\ HCl\ (aq)$$

(i) What are the number of moles of H_2SO_4 and HCl respectively, in 10.0 cm^3 of the above resulting solution? [2]

(ii) What would be the volume of 0.100 mol dm^{-3} aqueous sodium hydroxide required to neutralise 10.0 cm^3 of the above resulting solution? [3]

(b) You are tasked with determining the basicity of a strong acid **X**. You have the following chemicals and apparatus:

- 0.100 mol dm^{-3} acid **X**
- 0.100 mol dm^{-3} KOH
- Suitable titration apparatus i.e. burette, pipette, conical flask, indicators, retort stand etc

Describe and explain the type of results you would expect to obtain if acid **X** were dibasic. You do **not** have to show any specific volumes and calculations in your description. [2]

(c) Compounds of iodine have some physical properties similar to those of chlorine. This includes the colours of their Group 1 compounds and solubilities in water.

(i) Suggest two reagents that could be used to prepare a sample of sodium iodide, NaI. [2]

(ii) What is the name of the process used to prepare sodium iodide in **(c)(i)**? [1]

Total [10]

END OF PAPER

The Periodic Table of Elements

Group

1	2											13	14	15	16	17	18
							1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0	Key: atomic number / atomic symbol / name / relative atomic mass										5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.2	61 Pm promethium –	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
actinoids	89 Ac actinium –	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –