Class	Register Number	Name

南洋女子中學校

NANYANG GIRLS' HIGH SCHOOL

End-of-Year Examination 2017
Secondary Three

CHEMISTRY

Paper 2 Theory Paper **1 hour 45 minutes**
Wednesday **4 October 2017** **1045 - 1230**
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 **B8**, **B9** and **B10** ***Either*** or **B10** ***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 **B10** ***Either*** (for Either) or **B10** ***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 15.

Paper 1	**/ 30**
Paper 2	
Section A	**/ 40**
B8	**/ 10**
B9	**/ 10**
B10 *Either* / B10 *Or*	**/ 10**
Total	**/ 100**

Setters: **CDT / CWJ**

This document consists of 15 printed pages and 1 blank page.

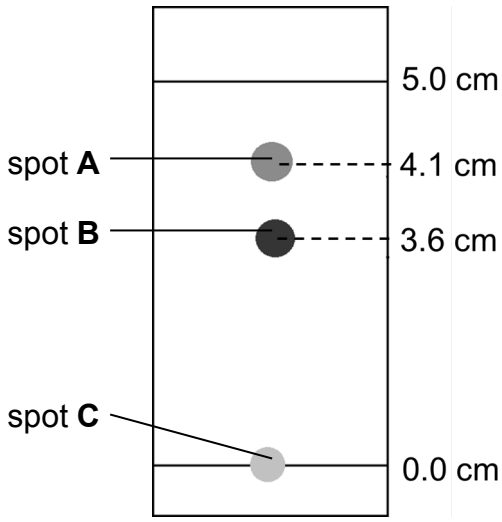
Section A (40 marks)

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

A1 A colourless liquid was left on a chemistry laboratory table.

Arthur collected the colourless liquid and conducted a few tests on it.

(a) He collected a drop of the colourless liquid and used paper chromatography with water as the solvent. He obtained the following chromatogram with 3 spots, with the help of a locating agent.



Suggest what can be deduced about the solubility of the three spots in water. [1]

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(b) Arthur then heated a sample of the colourless liquid until it completely boiled, while measuring its temperature. Suggest and explain what he would observe in the readings obtained. [2]

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Total [3]

A2 Calcium and sulfur are two elements in the Periodic Table.

(a) State the number of protons and valence electrons of a sulfur atom. [2]

number of protons .....

number of valence electrons .....

(b) The two elements react to form calcium sulfide.

(i) Draw a Lewis diagram to show the bonding in calcium sulfide. [1]

(ii) Explain if you would expect calcium sulfide to conduct electricity at room temperature, referring to its bonding and structure. [2]

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Total [5]

A3 Arsenic acid, H_3AsO_4, is a tribasic acid.

The table below shows the concentration of H^+ ions in solutions of different pH.

pH	concentration of H^+ / mol dm^{-3}
1	0.1
2	0.01
3	0.001
4	0.0001
5	0.00001
6	0.000001
7	0.0000001
8	0.00000001

0.0005 mol dm^{-3} of arsenic acid was found to have a pH of 3.

Using the information in the table, explain if arsenic acid is a weak or strong acid. Show all necessary working. [3]

Total [3]

A4 Sucrose is a carbohydrate that is found in cane sugar.

(a) Sucrose contains the elements carbon, hydrogen and oxygen.

In order to determine the ratio of the elements, 1 mole of sucrose was combusted with 12 moles of oxygen. It was found that 12 moles of carbon dioxide and 11 moles of water vapour were produced.

(i) Name a suitable apparatus for measuring the volumes of carbon dioxide and water vapour produced. [1]

(ii) Using the information above, state the molecular formula of sucrose. [1]

(iii) The empirical formula method could also be employed to find the ratio of the elements in sucrose. Given that a sample of sucrose has 41.5% of carbon, 6.40% of hydrogen and 52.1% of oxygen by mass, find its empirical formula. [2]

(iv) With reference to your answers in **(a)(ii)** and **(a)(iii)**, suggest a limitation of using the empirical formula method to find the ratio of the elements in sucrose. [1]

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(b) Raw sugar is a mixture of sucrose, inorganic ash and other organic matter that includes amino acids, gums and colour impurities obtained during extraction from sugar cane.

The flowchart below shows the main steps in the refining of raw sugar.

1		2		3
The raw sugar is mixed with saturated syrup. Impurities dissolve in the syrup and are removed, while sugar crystals are obtained.	→	Sugar crystals are redissolved. Amino acids, gums and colour impurities remain as a precipitate.	→	Solid activated charcoal is added to the mixture. The inorganic ash sticks to it.

Suggest method(s) of separating:

(i) amino acids, gums and colour impurities from dissolved sugar crystals in step 2; and [1]

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(ii) dissolved sugar from its solution after step 3 has been completed. [1]

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Total [7]

A5 Arsenic contamination of groundwater is a problem that affects millions of people across the world.

(a) Using spdf notation, state the electronic configuration of an arsenic atom. [1]

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(b) A sample of arsenic has 2 stable isotopes identified in it, ^{75}As and ^{73}As.

(i) Describe a difference between the two isotopes. [1]

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(ii) Using information from the Periodic Table, calculate the percentage of the ^{73}As isotope present. [2]

(c) Arsenic sublimes at 614 °C and at atmospheric pressure. Describe and explain the changes in arrangement and movement of arsenic molecules during the sublimation process. [3]

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(d) Arsenic is in group 15 of the periodic table, which contains non-metals like nitrogen and metals like bismuth.

Suggest why the metallic character of the elements increases down group 15. [1]

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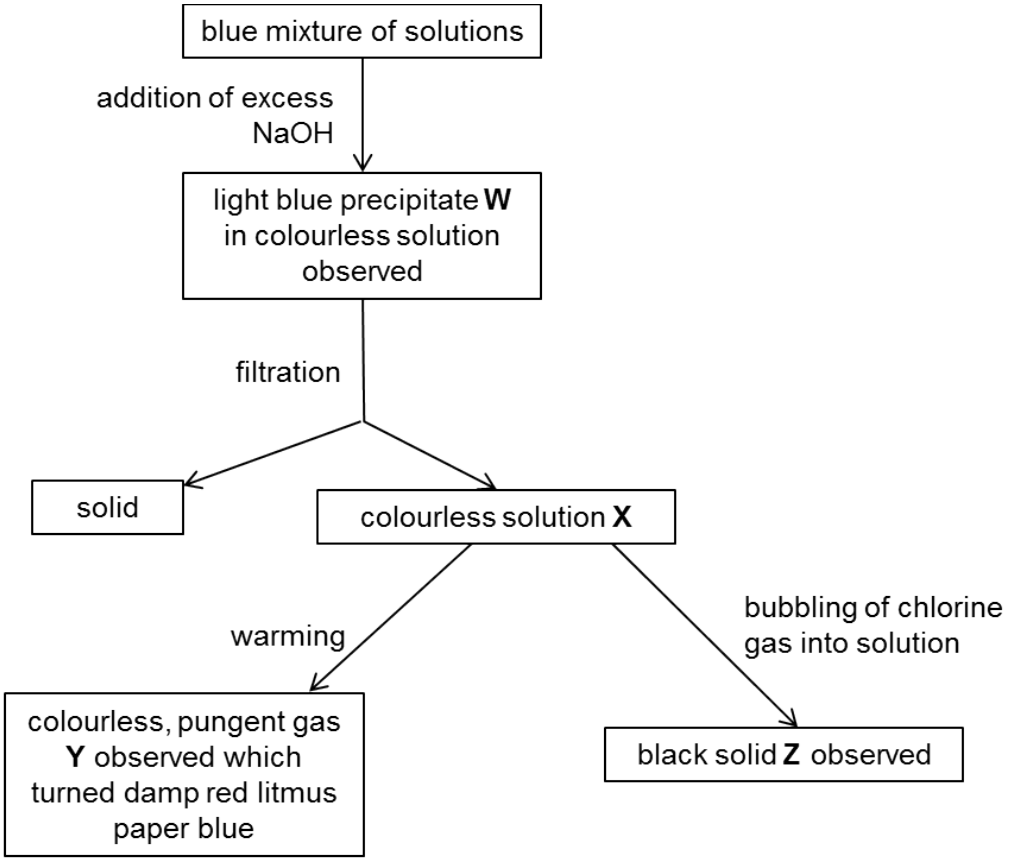
Total [8]

A6 Some tests were carried on a mixture of two solutions that contained 2 cations and 1 anion. The flowchart below shows the tests conducted on the mixture.



(a) Identify precipitate **W** and gas **Y**. [2]

precipitate **W** .....

gas **Y** .....

(b) State the formulae of the 2 ions in solution **X** that came from the original mixture. [2]

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(c) Identify solid **Z** and write a chemical equation, with state symbols, for its formation. [2]

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(d) State another reagent(s) that could have been added to solution **X** to identify the anion present and the expected observation(s). [1]

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(e) Acidified barium nitrate was added to another unknown solution and a white precipitate was observed. When acidified calcium nitrate was added to the same solution, there was no precipitate formed.

Suggest a possible reason for this observation. [1]

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Total [8]

A7 Transition metal compounds are commonly used in paints.

(a) State what is meant by the term "compound". [1]

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(b) Suggest why transition metal compounds are suitable used in paints. [1]

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(c) "Chrome yellow" contains the compound lead(II) chromate(IV), $PbCrO_4$. $PbCrO_4$ is an insoluble salt that can be prepared by reacting sodium chromate(IV) with lead(II) nitrate.

Write the ionic equation for the formation of lead(II) chromate(IV) via the reaction above. [1]

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(d) "Titanium white" is a white pigment made up of titanium dioxide, TiO_2, which is produced from titanium tetrachloride, $TiCl_4$.

The table below shows some properties of $TiCl_4$.

melting point / °C	−24.1
boiling point / °C	136.4
electrical conductivity	does not conduct in any state

Suggest the structure of $TiCl_4$, giving reasons for your answer. [3]

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Total [6]

End of Section A

Section B (30 marks)

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.

B8 Magnesium sulfate was discovered in water at Epsom, England in 1695. It is used to flush toxins from the body. The colourless crystalline heptahydrate, $MgSO_4.7H_2O$ is known as 'Epsom salt'.

It can be prepared in the laboratory by reacting magnesium carbonate with sulfuric acid, followed by filtration and crystallization. In a laboratory preparation, 4.03 g of magnesium carbonate was reacted with 250 cm^3 of 0.200 mol dm^{-3} sulfuric acid.

(a) **(i)** Identify the limiting reagent and calculate the mass of magnesium sulfate formed. [3]

(ii) Explain why the mixture is stirred after each addition of magnesium carbonate. [1]

(iii) Suggest why, if the evaporating dish is heated to dryness, crystals of Epsom salt are not obtained. [1]

(b) Calculate the percentage by mass of water of crystallization in hydrated magnesium sulfate, $MgSO_4.7H_2O$ (Epsom salt). [1]

(c) Name one other substance, that can be reacted with sulfuric acid to prepare hydrated magnesium sulfate. State the method used. [2]

(d) Explain why calcium sulfate cannot be prepared by reacting calcium carbonate with sulfuric acid. [2]

Total [10]

B9 Napoleon died in 1821 and analysis of his hair samples later showed high levels of arsenic. Arsenic exists in three common allotropes: metallic grey, yellow, and black arsenic. Arsenic is prepared by heating arsenic(III) oxide with carbon. The poisoning could have been deliberate or accidental.

If deliberate, arsenic(III) oxide was probably used. It could have been accidental if the poisonous gas arsine, AsH_3, was released from the blue copper(II) arsenate(III) used to decorate his prison cell.

(a) Arsenic is often classified as a metalloid. State the meaning of this term. [1]

(b) Identify the allotrope which is most likely to be an electrical conductor and suggest a reason for its high conductivity in its solid state. [2]

(c) (i) Draw a Lewis diagram, showing the arrangement of the valence electrons in a molecule of the covalent compound, arsine, AsH_3. It has a simple molecular structure. [1]

(ii) Explain, in terms of bonding and structure, why arsine is a gas at room temperature and is insoluble in water. [3]

(d) The formula of the arsenate(III) ion is AsO_3^{3-}. Write an ionic equation for the reaction:

copper(II) ions + arsenate(III) ions → copper(II) arsenate(III)

(State symbols are not required) [1]

(e) Arsenic(III) oxide reacts with carbon to form carbon dioxide and arsenic: $2As_2O_3 + 3C \rightarrow 3CO_2 + 4As$.

8.87 kg of arsenic(III) oxide is used in the reaction and 5.33 kg of arsenic is produced. Calculate the percentage yield. Show your working. [2]

Total [10]

EITHER

B10 In traditional non-digital photography, photographic film is coated with small lumps of light-sensitive silver bromide, AgBr. On exposure to light, colourless silver bromide is converted to silver atoms that appear as dark areas to form the negative.

The negative is placed in developer solution which reacts with the particles of silver bromide. The table below shows the effect temperature has on the time needed to develop the film.

temperature of developer /°C	time needed to develop the film /s
38	200
37	220
36	250
35	280

The developer solution is a mixture of chemicals including sodium hydroxide.

(a) Silver is a transition metal. State one property of its compounds that is **not** typical of transition metal compounds. [1]

(b) **(i)** Estimate the time needed to develop a film at 34 °C. [1]

(ii) Using collision theory, explain the effect of temperature on the rate of film development. [3]

(iii) Using collision theory, predict and explain the effect of using a more concentrated developer solution (at the same temperature) on the rate of film development. [2]

(iv) Predict and explain the effect of using powdered silver bromide, instead of lumps of silver bromide, on the rate of film development. [2]

(c) Suggest why some areas of the film are darker than others. [1]

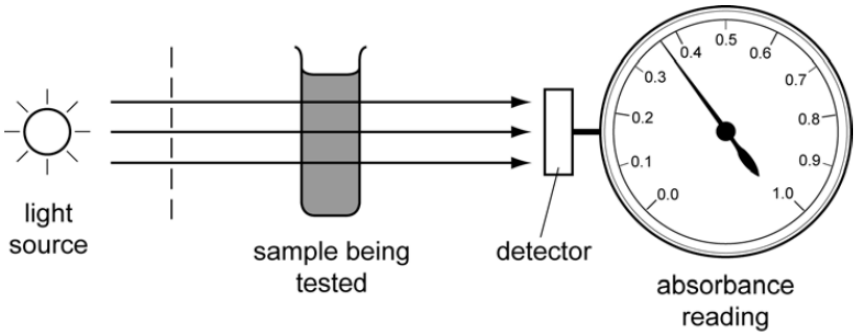
Total [10]

OR

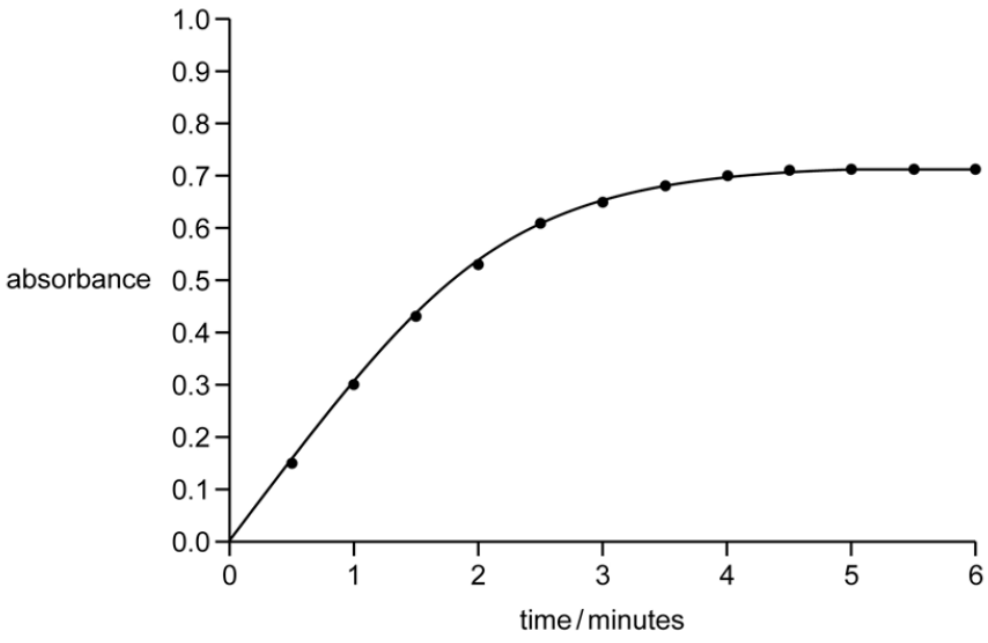
B10 A student carried out an experiment in a laboratory to investigate the displacement reaction between bromide ions (limiting reactant) and chlorine gas:

$$2Br^{-}(aq) + Cl_2(aq) \rightarrow Br_2(aq) + 2Cl^{-}(aq)$$

Chlorine gas was bubbled through dilute, aqueous sodium bromide for 6 minutes. Samples of the reaction were removed every 30 seconds and the colour intensity of each sample was measured using a colorimeter. The darker the colour of the solution, the more light is absorbed and the higher the absorbance reading on the colorimeter. There is a linear relationship between absorbance and concentration of a coloured chemical species.



The results of the experiment are shown in the graph below.



Four additional experiments were carried out to determine the effect temperature has on the time taken for the reaction to complete. The same volume but varying concentrations of sodium bromide solution was used.

The table below shows the results of the four experiments.

experiment	temperature /° C	absorbance reading at end of reaction	time taken for reaction to finish/ s
1	25	0.40	360
2	25	0.80	300
3	35	0.80	150
4	25	0.90	150

(a) Explain why aqueous bromine has a very high absorbance value but aqueous chlorine (at the same concentration) has a much lower absorbance value. [1]

(b) Describe and explain the changes, using collision theory, in the rate of the displacement reaction between chlorine gas and bromide ions as shown by the graph of absorbance against time. [4]

(c) **(i)** Using the information from the table, deduce which two experiments can be used to investigate the effect temperature has on the rate of displacement reaction between chorine gas and bromide ions. [1]

(ii) Using collision theory, explain the effect temperature has on the rate of displacement reaction. [3]

(d) Explain why there is no reaction when bromine gas is reacted with chloride ions. [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 –

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