Class	Register Number	Name

南洋女子中學校

NANYANG GIRLS' HIGH SCHOOL

End-of-Year Examination 2018
Secondary Three

CHEMISTRY

Paper 2 Theory Paper **1 hour 45 minutes**
Monday **8 October 2018** **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 **B5**, **B6** and **B7** ***Either*** or **B7** ***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 **B7** ***Either*** (for Either) or **B7** ***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.

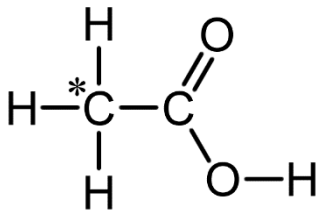
Paper 1	**/ 30**
Paper 2	
Section A	**/ 40**
B5	**/ 9**
B6	**/ 11**
B7 ***Either*** **/ B7** ***Or***	**/ 10**
Total	**/ 100**

Setters: This document consists of 15 printed pages and 1 blank page.
CJS / NHK

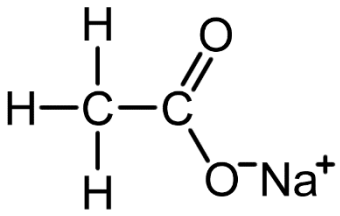
Section A (40 marks)

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

A1 The structures of ethanoic acid and sodium ethanoate are given below.



ethanoic acid



sodium ethanoate

(a) State the number of sigma bonds (σ bonds) and the number of pi bonds (π bonds) present in a single molecule of ethanoic acid.

number of sigma bonds …… [1]

number of pi bonds ……

(b) Study the structure of ethanoic acid.

(i) State the geometry of the bonds around the carbon atom that has been labelled with an asterisk (*). [1]

……

(ii) Explain your answer in **(bi)** with reference to the number of bonding pairs and non-bonding pairs (lone pairs) of electrons in the valence shell of the carbon atom. [1]

……

……

(c) Briefly explain why ethanoic acid and sodium ethanoate can both conduct electricity when dissolved in water. [1]

……...

……...

(d) The melting point of ethanoic acid is 16.6°C, while the melting point of sodium ethanoate is 324°C. Explain why the melting point of sodium ethanoate is significantly higher than the melting point of ethanoic acid. [2]

……...

……...

……...

(e) **(i)** Sodium ethanoate is a salt of ethanoic acid. Name the method that sodium ethanoate can be prepared from dilute ethanoic acid and aqueous sodium hydroxide. [1]

……

(ii) Another salt of ethanoic acid is calcium ethanoate $Ca(CH_3COO)_2$. Calcium ethanoate is a water soluble salt that is used in both medicine and the food industry.

Calcium ethanoate may be prepared in the laboratory by reacting calcium carbonate with dilute ethanoic acid.

Briefly describe how an aqueous solution of calcium ethanoate can be prepared from calcium carbonate and dilute ethanoic acid. [2]

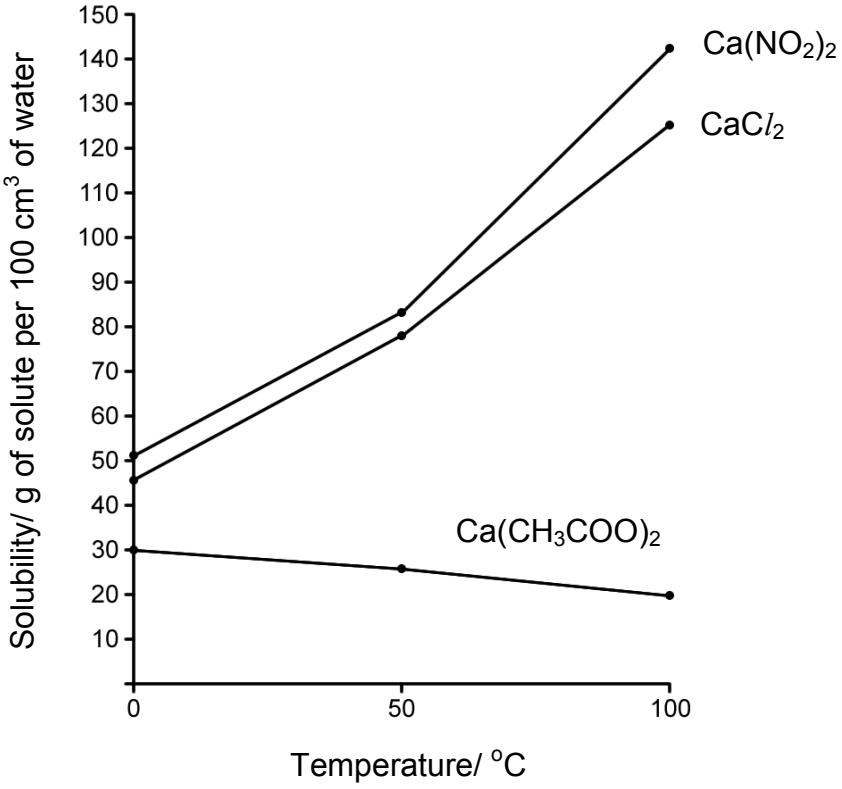
……

……

……

……

(iii) The graph below shows how the solubilities of calcium nitrite, $Ca(NO_2)_2$, calcium chloride, $CaCl_2$, and calcium ethanoate, $Ca(CH_3COO)_2$, change with temperature.



With reference to the graph, explain why it is **not** possible to crystallise calcium ethanoate from a hot saturated solution of the salt. Hence, state how solid calcium ethanoate should be obtained from aqueous solution. [3]

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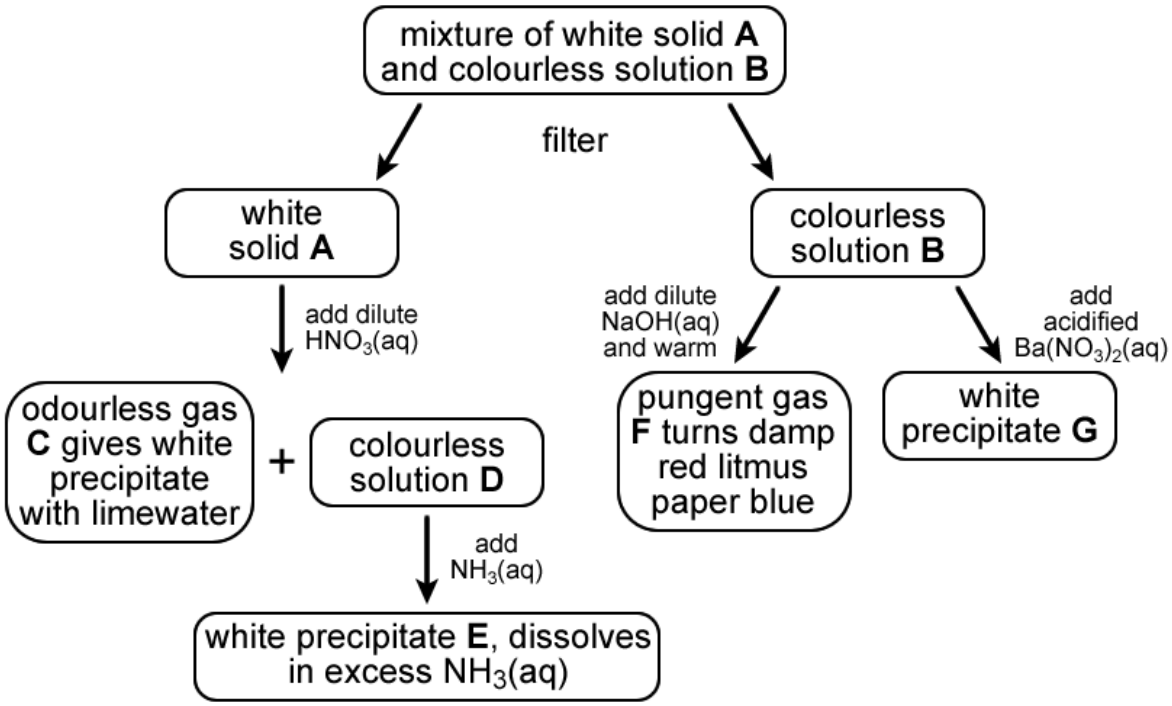
Total [12]

A2 Study the reaction scheme given below.



(a) Identify chemicals **A** to **G**, shown in the reaction scheme above. [7]

A …… **B** ……

C …… **D** ……

E …… **F** ……

G ……

(b) Explain why gas **F** turns damp red litmus paper blue. [1]

……...

(c) Write an ionic equation for the formation of white precipitate **G**. [1]

……...

Total [9]

A3 45.0 cm^3 of 1.60 mol dm^{-3} aqueous sodium carbonate reacted with 40.0 cm^3 of 2.00 mol dm^{-3} aqueous silver nitrate according to Equation 1.

Equation 1: $Na_2CO_3(aq) + 2AgNO_3(aq) \rightarrow Ag_2CO_3(s) + 2NaNO_3(aq)$

(a) By showing relevant calculations, identify the limiting reagent for the reaction. [3]

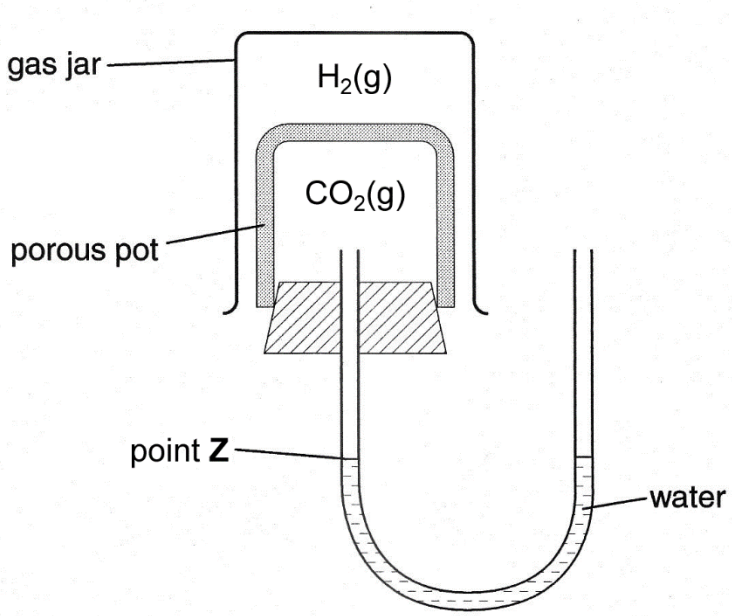
(b) Calculate the mass, in grams, of silver carbonate produced by the reaction. [2]

(c) The silver carbonate was filtered from the mixture, washed and dried. One quarter of the resulting solid was reacted with excess methanol, CH_2O, according to Equation 2.

Equation 2: $Ag_2CO_3(s) + CH_2O(aq) \rightarrow 2Ag(s) + 2CO_2(g) + H_2(g)$

Calculate the total volume, in cm^3, of gaseous products formed by the reaction at room temperature and pressure. [4]

(d) Yii Wenn set up the experiment shown below to investigate the rate of diffusion of the gaseous products, carbon dioxide and hydrogen.



Yii Wenn observed that the level of the water at point **Z** moved down. Briefly explain her observation. [3]

……...

……...

……...

……...

Total [12]

A4 Hydrogen peroxide decomposes to form oxygen gas and water according to the chemical equation below.

$$2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$$

The rate of this reaction can be increased by adding a suitable catalyst, such as aqueous potassium iodide. A student added three drops of aqueous potassium iodide to 50.0 cm^3 of 0.108 mol dm^{-3} hydrogen peroxide at room temperature and pressure. She measured the volume of oxygen gas produced against time.

Figure 4.1 shows a graph of her results.

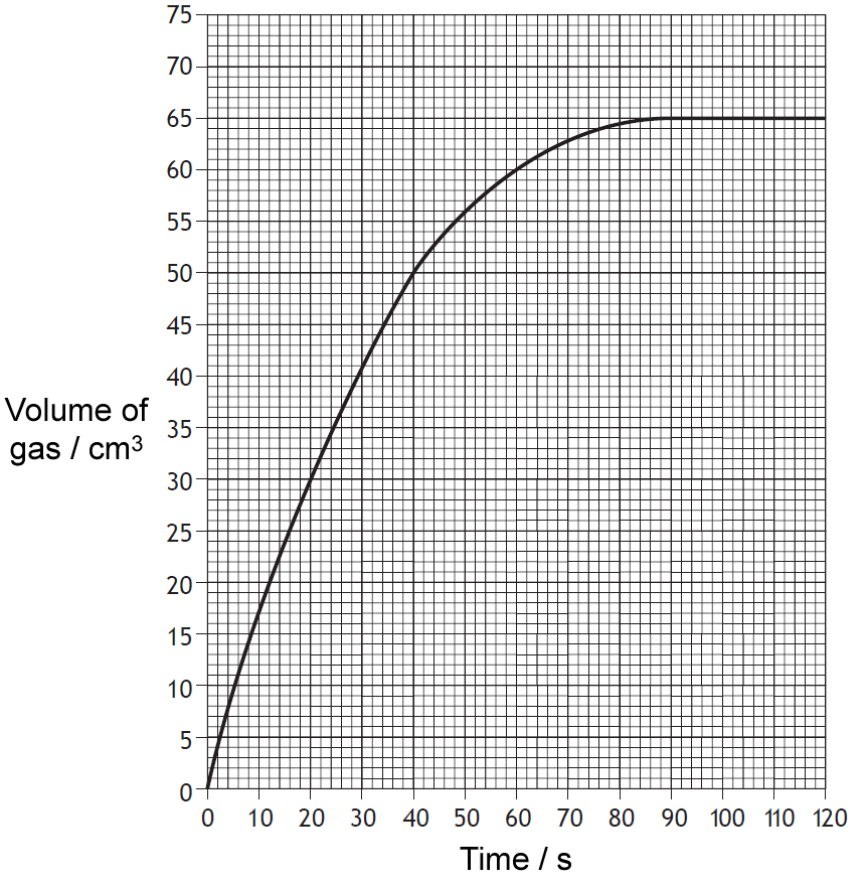


Figure 4.1

(a) Describe how a catalyst increases the rate of reaction. [1]

……

(b) Using collision theory, explain why the rate of the reaction decreases as the reaction progresses. [2]

……

……

……

……

(c) Sketch the graphs, on Figure 4.1, that would be obtained if the student repeated the same experiment, changing the following reaction conditions only.

(i) 25.0 cm^3 of 0.216 mol dm^{-3} hydrogen peroxide. Label this graph **X**. [1]

(ii) 50.0 cm^3 of 0.0540 mol dm^{-3} hydrogen peroxide. Label this graph **Y**. [1]

(d) Iodide ions from the aqueous potassium iodide catalyse the decomposition of hydrogen peroxide in two steps, shown below.

Step 1: $H_2O_2(aq) + I^-(aq) \rightarrow H_2O(l) + IO^-(aq)$
Step 2: $H_2O_2(aq) + IO^-(aq) \rightarrow H_2O(l) + O_2(g) + I^-(aq)$

(i) From the two reactions given above, what evidence is there that the iodide ions are functioning as a catalyst? [1]

……..

……..

(ii) Explain why adding aqueous silver nitrate to the reaction mixture will significantly slow down the rate at which hydrogen peroxide decomposes. [1]

……..

……..

Total [7]

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.

B5 Nitrogen monoxide is a gas that acts as a chemical messenger in the body and relays information from nerves to cells to control a range of bodily functions.

Nitrogen monoxide reacts with oxygen to produce nitrogen dioxide gas as follows:

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

A rate study of the reaction yielded the data in the table below.

experiment	initial concentration of NO/ mol dm^{-3}	initial concentration of O_2/ mol dm^{-3}	initial rate of formation of NO_2/ mol dm^{-3} s^{-1}
1	0.0200	0.0300	8.52×10^{-2}
2	0.0200	0.0900	2.56×10^{-1}
3	0.0600	0.0300	7.56×10^{-1}

(a) Using information from the table, describe the effect of varying the concentration of nitrogen monoxide only on the rate of reaction. [2]

(b) Using information from the table, describe the effect of varying the concentration of oxygen only on the rate of reaction. [2]

(c) Given that a reaction can be classified into zero, first or second order reactions based on the effect of concentrations of the reactants on the rate of the reaction.

For a zero-order reaction, the rate of reaction is independent of the concentration of a reactant.

For a first-order reaction, the rate of reaction is proportional to the concentration of one reactant and may be expressed as:

$$\text{rate} \propto [\mathbf{A}]$$

where [**A**] represents the concentration of a reactant **A**.

For a second-order reaction, the rate of the reaction is proportional to the square of the concentration of one reactant and may be expressed as:

$$\text{rate} \propto [\mathbf{A}]^2$$

Where [**A**] represents the concentration of a reactant **A**.

State the order of the reaction with respect to the change in concentration of:

(i) nitrogen monoxide; [1]

(ii) oxygen. [1]

(d) (i) When 25.0 cm^3 of nitrogen monoxide is reacted with 30.0 cm^3 of oxygen at room temperature and pressure, determine the limiting reactant by showing relevant calculations. [2]

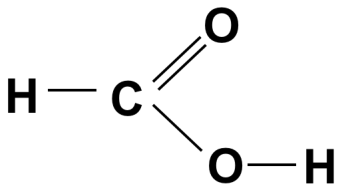
(ii) Calculate the volume of nitrogen dioxide formed. [1]

Total [9]

B6 Methanoic acid, HCO_2H, was formerly known as formic acid because it is present in the stings of ants and the Latin name for ant is *formica*. It was first extracted in 1671 by John Ray who collected a large number of dead ants.

At room temperature, pure methanoic acid is a liquid which is completely soluble in water.

Methanoic acid has the following structural formula.



(a) (i) When we are stung by a fire ant, a solution **R** of methanoic acid, is injected into our skin.

Solution **R** contains 60.0% by volume of pure methanoic acid and a fire ant contains 8.25×10^{-6} dm^3 of solution **R**.

Calculate how many fire ants are needed to extract 1.50 cm^3 of pure methanoic acid. Express your answer to the nearest integer.

[2]

(ii) When we are stung by a fire ant, the volume of solution **R** injected is 65% of the total volume of solution **R** present in one ant.

Calculate the volume of methanoic acid present in one ant sting. [2]

(b) Bees also sting us by using methanoic acid and a bee or an ant sting can be treated by using sodium hydrogen carbonate, $NaHCO_3$.

(i) Methanoic acid is a weak acid. Define a weak acid. [1]

(ii) Describe what would be observed when sodium hydrogen carbonate is added to methanoic acid. [2]

(iii) Write a balanced chemical equation for the reaction between methanoic acid and sodium hydrogen carbonate to form sodium methanoate, HCOONa as one of its products. [1]

(iv) In a bee sting, the mass of methanoic acid injected is 6.30×10^{-3} g. Calculate the volume of 0.100 mol dm^{-3} aqueous sodium hydrogen carbonate required to neutralise one bee sting. [3]

Total [11]

EITHER

B7 Tetrachloromethane, CCl_4 is an organic solvent for oils and fats and is also used as a refrigerant and as a dry-cleaning agent.

(a) (i) Draw the dot-and-cross diagram, showing only the valence electrons of a molecule of tetrachloromethane. [1]

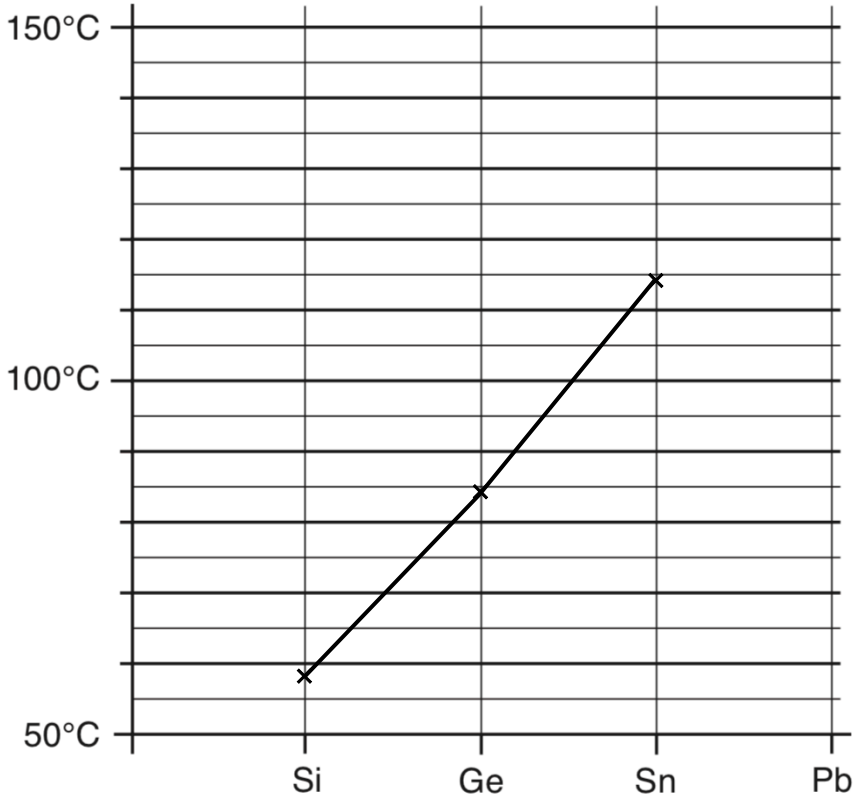
(ii) State the structure of tetrachloromethane. [1]

(iii) State the molecular shape of tetrachloromethane. [1]

(b) Group 14 elements form chlorides with the formula **M**Cl_4, with **M** as a symbol for Group 14 elements.

The boiling point of lead(IV) chloride cannot be measured directly because it decomposes on heating.

The graph below shows the boiling points of the group 14 chlorides.



(i) From the graph above, predict the boiling point of lead(IV) chloride if it did not decompose on heating. [1]

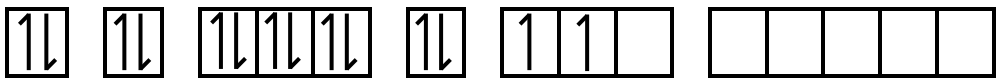
(ii) Given that the Group 14 chlorides do not conduct electricity in solid and liquid states, state and explain the general trend of the boiling points for the Group 14 chlorides. [3]

(c) Silicon tetrachloride, $SiCl_4$, reacts vigorously in water whereas tetrachloromethane is inert and does not react with water.

(i) Given that silicon tetrachloride reacts with water to form an acidic oxide and an acidic gas, write a chemical equation for the reaction of silicon tetrachloride with water. [1]

(ii) Silicon tetrachloride is able to react with water as silicon has empty d-orbitals available to accept a lone pair from water molecules.

The orbital diagram for silicon is as follows:



Suggest and explain whether tetrachloromethane will react with water. [2]

Total [10]

OR

B7 Carbon and nitrogen in Period 2 of the periodic table form compounds with hydrogen called hydrides.

Carbon and hydrogen form ethene, C_2H_4, while nitrogen and hydrogen form hydrazine, N_2H_4.

(a) **(i)** Draw the Lewis structures of ethene and hydrazine. [2]

(ii) Carbon forms another hydride called ethyne with the formula C_2H_2. The Lewis structure of ethyne is as follows:

With reference to the central carbon atom highlighted with an asterisk (*) and multiple bonds regarded as a single bond pair, ethyne has two bond pairs and thus has a linear molecular shape.

Ethene and hydrazine have a similar arrangement of atoms but differently shaped molecules. State the molecular shapes of ethene and hydrazine with reference to either one of the central carbon or nitrogen atoms. [2]

(b) The table below shows the melting and boiling points of ethene and hydrazine.

	ethene	hydrazine
melting point/ ^{o}C	−169	2
boiling point/ ^{o}C	−104	114

Given that the electronegativity values of N, C and H are 3.0, 2.5 and 2.1 respectively according to the Pauling scale, compare the melting and boiling points of ethene and hydrazine and explain the differences in the melting and boiling points. [3]

(c) Hydrazine is used as a rocket fuel propellant and burns to form ammonia, nitrogen and hydrogen. State the number of valence electron pairs in a molecule of ammonia. [1]

(d) Sulfur which is a non-metal as both carbon and hydrogen also forms a hydride.

The hydride formed by sulfur is a foul-smelling compound found in gases from volcanoes and burns with a blue flame in excess oxygen to form sulfur dioxide and water.

(i) Draw the Lewis structure for the hydride formed between one atom of sulfur and two atoms of hydrogen. [1]

(ii) State the molecular shape of the hydride formed. [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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