NATIONAL JUNIOR COLLEGE
SH2 TIMED PRACTICE
Higher 2

CANDIDATE NAME			
SUBJECT CLASS		REGISTRATION NUMBER	

CHEMISTRY **9729/A1**
Paper A1 Multiple Choice **30 May 2025**
30 min

Additional Materials: Optical Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, subject class and registration number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **fifteen** 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 separate 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.
A Data Booklet is provided.

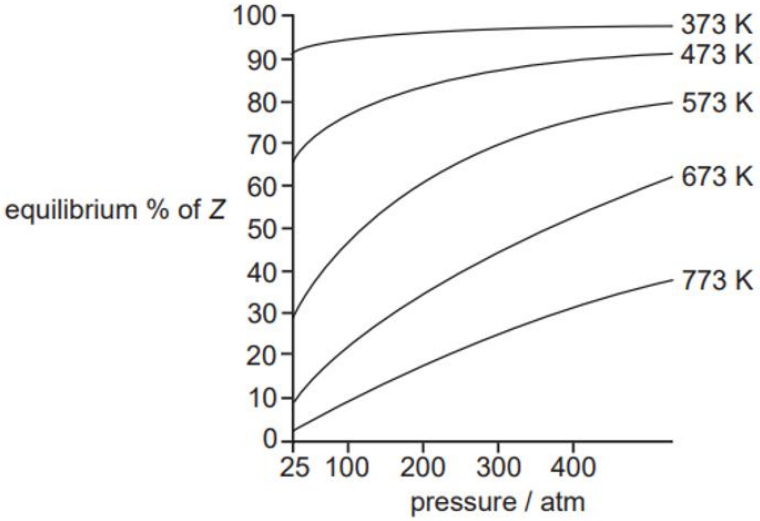
Instructions on how to fill in the Optical Mark Sheet
Shade the index number in a 5 digit format on the optical mark sheet:
2nd digit and the last 4 digits of the Registration Number.

Example:

Student	Examples of Registration No.	Shade:
	2405648	**45648**

This document consists of **8** printed pages.

1 The equilibrium percentage of **Z** varies according to varying pressures and temperatures as shown in the graph.



Which row in the table shows the correct information about the equilibrium?

	equilibrium reaction	sign of ΔH for the forward reaction
A	**Y**(g) + **X**(g) $\rightleftharpoons$ 3**Z**(g)	Positive
B	4**X**(g) + **Y**(g) $\rightleftharpoons$ 2**Z**(g)	Positive
C	**Y**(g) + **X**(g) $\rightleftharpoons$ 3**Z**(g)	Negative
D	4**X**(g) + **Y**(g) $\rightleftharpoons$ 2**Z**(g)	Negative

2 **X** decomposes on heating according to the following equation

$$2X(g) \rightleftharpoons 2Y(g) + B(g)$$

When 4 mol of **X** were put into a 2 dm^3 container and heated, the equilibrium mixture contained 0.8 mol of **B**.

What is the numerical value of the equilibrium constant, K_c?

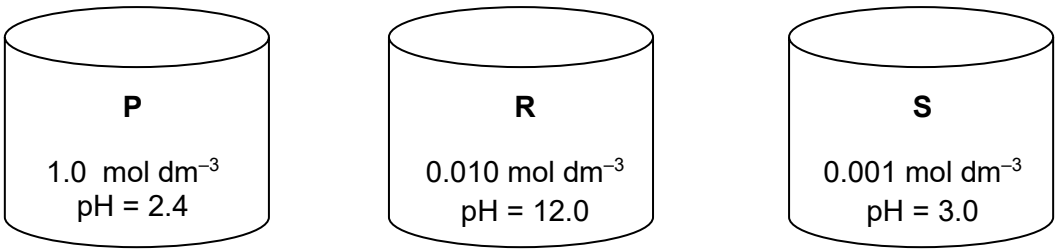
A $\dfrac{0.8 \times 0.8}{3.2}$

B $\dfrac{1.6 \times 1.6 \times 0.8}{2.4 \times 2.4}$

C $\dfrac{1.6 \times 1.6 \times 0.8}{2.4 \times 2.4 \times 2}$

D $\dfrac{0.4 \times 0.4 \times 0.8}{0.4 \times 0.4}$

3 The concentration and pH of each solution, **P**, **R** and **S** are shown below. Solutions **P**, **R** and **S** could be either a monobasic acid or a monoacidic base.



Which statements are correct?

1 **R** is a weak base.

2 **P** is a weak acid while **S** is a strong acid.

3 Mixing 100 cm^3 of **R** and 100 cm^3 of **S** produces a buffer solution.

4 Mixing 500 cm^3 of **P** and 500 cm^3 of **R** produces a buffer solution.

A 1 and 2 **B** 1 and 4 **C** 2 and 4 **D** 2 and 3

4 Equal volumes of 1.0×10^{-2} mol dm^{-3} aqueous $BaSiF_6$ and 2.5×10^{-1} mol dm^{-3} aqueous $CsBrO_3$ are mixed in a test-tube.

The numerical values of the solubility products are:
K_{sp} of $Ba(BrO_3)_2 = 2.43 \times 10^{-4}$
K_{sp} of $Cs_2SiF_6 = 1.3 \times 10^{-5}$

Which statement best describes what will be observed in the test tube?

A No precipitation is observed.

B Precipitation of Cs_2SiF_6 only.

C Precipitation of $Ba(BrO_3)_2$ only.

D Precipitation of both Cs_2SiF_6 and $Ba(BrO_3)_2$.

5 In the free radical substitution of 3-methylpentane with chlorine, a mixture of products was obtained.

How many constitutional isomers of mono-chlorinated products are theoretically possible?

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

6 Nitrobenzene is a precursor to many reagents. It can be prepared by reacting benzene with concentrated HNO_3 and concentrated H_2SO_4. What is the role of concentrated H_2SO_4?

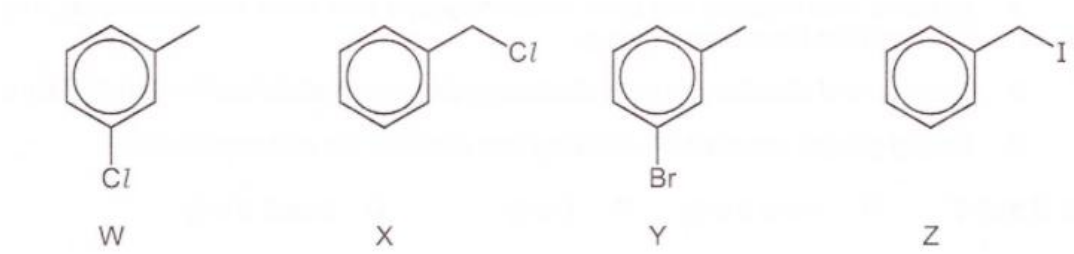
A To generate NO_2^- for the reaction

B To act as a dehydrating agent

C To direct the electrophile to a specific position on the benzene ring

D To act as a catalyst

7 Equal amounts of compounds **W**, **X**, **Y** and **Z** are added separately to four test tubes containing equal concentrations of ethanolic silver nitrate solution in a heated water bath. No precipitate forms in two of the tubes. In the two other tubes, precipitates form at different rates.

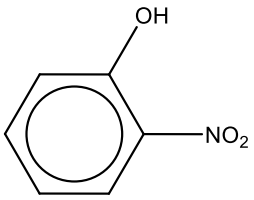


Which row is correct?

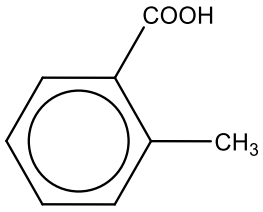
	Compounds which do **not** form a precipitate	Colour of the precipitate which forms the fastest
A	W	cream
B	W and X	yellow
C	X and Z	white
D	W and Y	yellow

8 Which compound is less acidic than phenol?

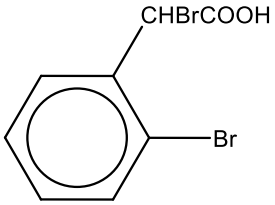
A



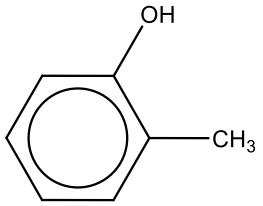
B



C



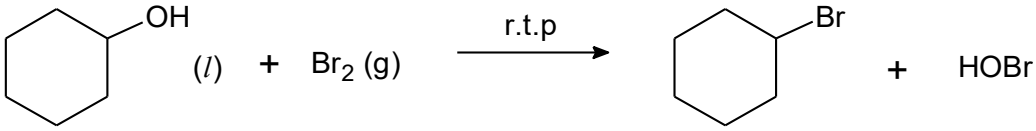
D



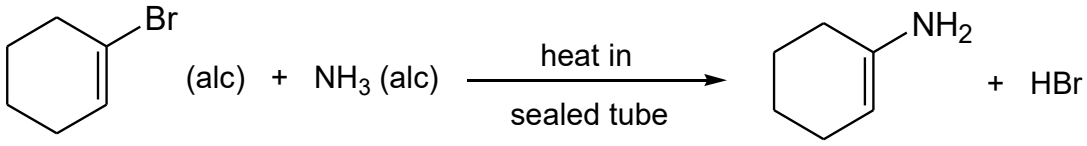
9 Which reaction gives the best yield of the organic products?

[(*alc*) indicates an alcoholic solution.]

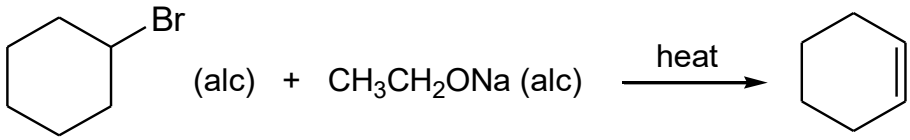
A



B



C



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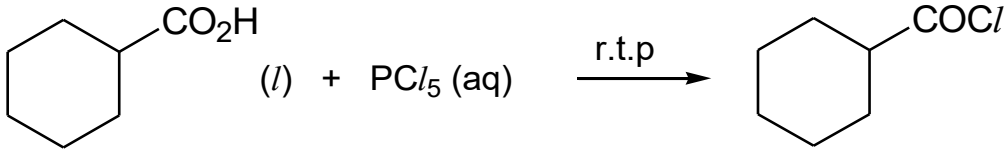
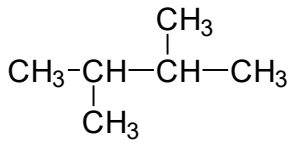
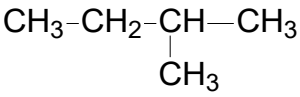


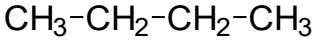
10 An iodoalkane and sodium, immersed in ether, react when heated under reflux to form an alkane according to the equation:

$$2RI + 2Na \rightarrow R-R + 2NaI$$

When iodoethane, CH_3CH_2I and 2-iodopropane, CH_3CHICH_3, are subjected to the reaction above, which alkane(s) will be formed?

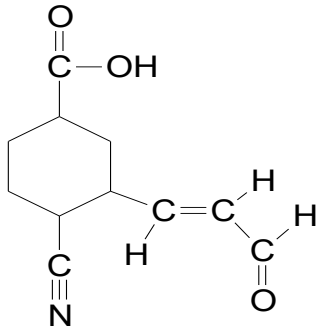
1 

2 

3 

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

11 How many moles of H_2 would react with one mole of the molecule below in the presence of Pt(s)?



A 2 **B** 3 **C** 4 **D** 6

12 A compound **Q** was heated with aqueous sulfuric acid and potassium manganate(VII), and the resulting mixture was cooled. One of the final products gave a yellow precipitate with alkaline aqueous iodine.

Which formula could **Q** represent?

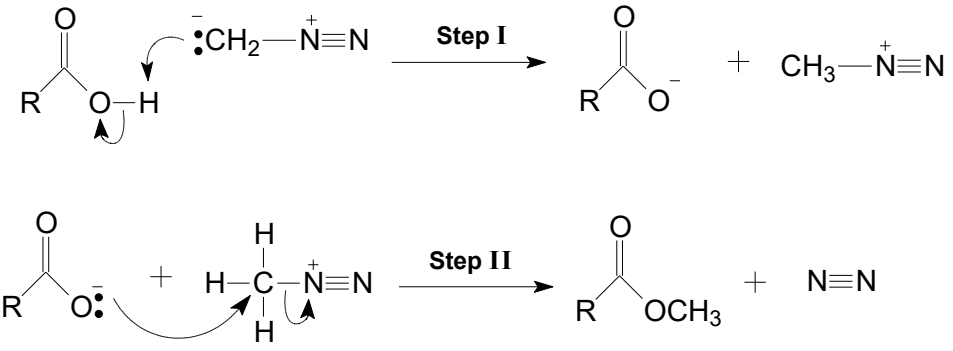
A $CH_3CO_2CH_3$

B $CH_3CO_2CH_2CH_3$

C $CH_3CO_2CH(CH_3)CH_3$

D $CH_3CO_2C(CH_3)_2CH_3$

13 Diazomethane (CH_2N_2) is a highly explosive yellow gas which is known to explode upon gentle impact or exposure to light. It is an efficient agent used in the preparation of methyl esters and the mechanism is shown below.



What types of reaction took place in Steps **I** and **II**?

	Step **I**	Step **II**
A	nucleophilic substitution	elimination
B	acid-base reaction	elimination
C	nucleophilic substitution	electrophilic addition
D	acid-base reaction	nucleophilic substitution

14 Methylamine was heated in a sealed tube with excess 1-bromoethane for a prolonged period.

Which is the major product?

A CH_5N

B C_3H_9N

C $C_5H_{13}N$

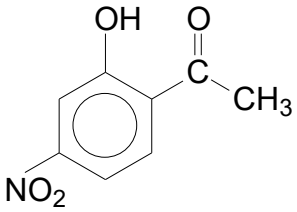
D $C_7H_{18}NBr$

15 Compound **R** undergoes the following reactions.

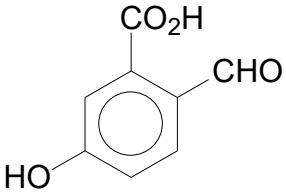
- It gives decolorises bromine water and gives white precipitate.
- It does not give any visible reaction with Fehling's solution.
- It gives a silver mirror with Tollen's reagent.
- It does not give any visible reaction with sodium carbonate.

What could compound **R** be?

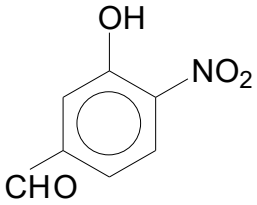
A



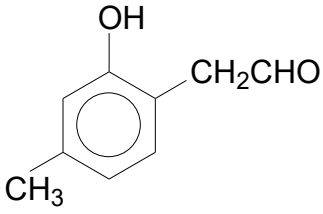
B



C



D



NATIONAL JUNIOR COLLEGE
SH2 MID YEAR TIMED PRACTICE
Higher 2

CANDIDATE NAME			
SUBJECT CLASS		REGISTRATION NUMBER	

CHEMISTRY **9729/A2**
Paper A2 Structured Questions **30 May 2025**
1 hour 30 min

Candidates answer on Question Paper.
Additional Materials: Data Booklet

READ THE INSTRUCTIONS FIRST

Write your subject class, registration number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.
The use of an approved scientific calculator is expected, where appropriate.

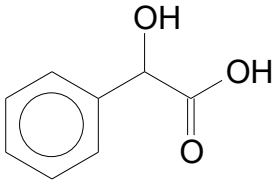
A Data Booklet is provided.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	**/17**
2	**/14**
3	**/7**
4	**/14**
5	**/8**
Paper 2 Total	**/60**

This document consists of **20** printed pages.

1 Mandelic acid is widely used in chemical peels, serums, and creams due to its gentle exfoliating and antibacterial properties. It is a weak acid with K_a value of 3.89×10^{-4}.



mandelic acid

(a) **(i)** Calculate the pH of 0.050 mol dm^{-3} mandelic acid.

[2]

(ii) Calculate the pH of 0.050 mol dm^{-3} NaOH.

[1]

A student adds small portions of 0.050 mol dm^{-3} NaOH (aq) to 25.0 cm^3 of 0.050 mol dm^{-3} mandelic acid. The student uses a pH meter to measure the pH of the mixture and the data are shown in Table 1.1.

Table 1.1

volume of 0.050 mol dm^{-3} NaOH(aq) added / cm^3	pH of mixture
25.0	7.5
50.0	12.4

(iii) Explain why the pH of the mixture is slightly greater than 7 when the student adds a total of 25.0 cm^3 of 0.050 mol dm^{-3} NaOH(aq) to the mandelic acid. Include relevant equations in your answer.

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[2]

(iv) State the volume of NaOH added to reach maximum buffer capacity and calculate the pH at that point.

[1]

(v) Sketch the shape of the pH curve on Fig 1.1 using all relevant information given or calculated.

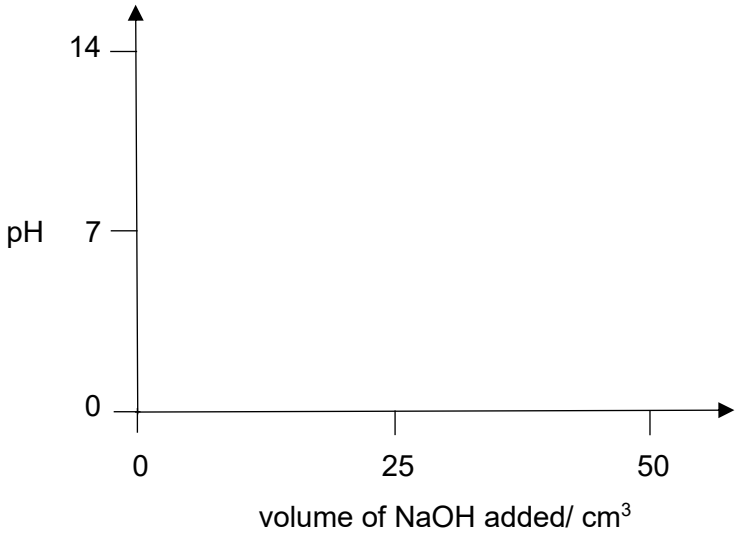

Fig 1.1

[1]

(b) The pH of the skin is usually 4.5 to 6.5. When aqueous mandelic acid is applied directly to skin, it may cause irritation and redness because the skin is sensitive to pH. To reduce skin sensitivity, skin creams often contain a pH buffer consisting of sodium mandelate and mandelic acid.

Calculate the volume of 0.050 mol dm^{-3} NaOH(aq) that needs to be added to 25.0 cm^3 of 0.050 mol dm^{-3} of mandelic acid so as to produce a buffer with pH 4.5.
[K_a of mandelic acid = 3.89×10^{-4}]

[2]

(c) Mandelic acid is made in a two-step process shown in Fig 1.2.

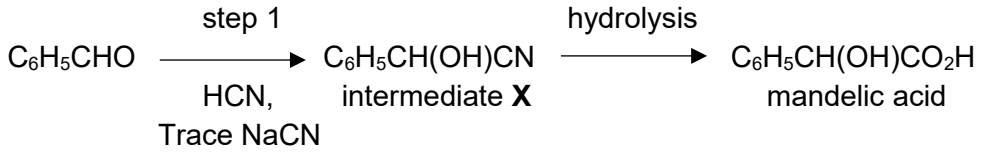

Fig 1.2

(i) Draw a reaction mechanism for step 1. Show relevant lone pairs of electrons, dipoles and curly arrows.

[3]

(ii) Deduce whether intermediate **X** formed from this reaction would be optically active.

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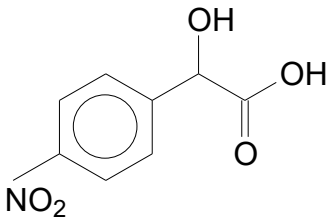
[2]

(d) Mandelic acid can be converted to other useful pharmaceutical intermediates such as 4-nitromandelic acid.



4-nitromandelic acid

Draw a reaction mechanism for the conversion of mandelic acid to 4-nitromandelic acid using concentrated H_2SO_4 and concentrated HNO_3. Show relevant lone pairs of electrons, dipoles and curly arrows.

[3]

[Total: 17]

2 Compounds **A** and **B** have the same molecular formula $C_5H_8O_3$.

(a) Compound **A** contains three functional groups. It is a straight chain compound that exhibits stereoisomerism.

Data about the reactions of **A** are given in Table 2.1.

Table 2.1

reaction	reagent	result
1	$K_2Cr_2O_7$ / H_2SO_4(aq), heat	solution turns from orange to green
2	2,4-dinitrophenylhydrazine	orange solution remains
3	I_2 / NaOH(aq), warm	yellow precipitate **D** produced
4	Br_2(aq)	orange solution decolourised. organic product formed with M_r = 212.9
5	Na_2CO_3 (aq)	effervescence observed

(i) Based on reactions **1** and **2**, name the functional group that could be present in **A**.

……..

[1]

(ii) State the name of the precipitate **D** formed in reaction **3**.

……..

[1]

(iii) What type of reaction takes place in reaction **4**?

Deduce the molecular formula of the organic product formed in reaction 4.

Type of reaction: ……..

Molecular formula: ……..

[2]

(iv) Name the functional group present in **A** that is confirmed by reactions **4** and **5**.

Reaction **4**: ……

Reaction **5**: ……

[2]

(v) You now have enough information to determine the structural formula of **A**.

Draw the displayed formula of compound **A**.

[2]

(vi) Using your structure of compound **A**, deduce the total number of stereoisomers that **A** can exhibit.

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……..

[1]

(b) Compound **B,** $C_5H_8O_3$, is an isomer of compound **A.** It can undergo several reactions as shown in Fig 2.1.

Draw the structures of organic compound **E**, **F** and **G** in the boxes in Fig 2.1.

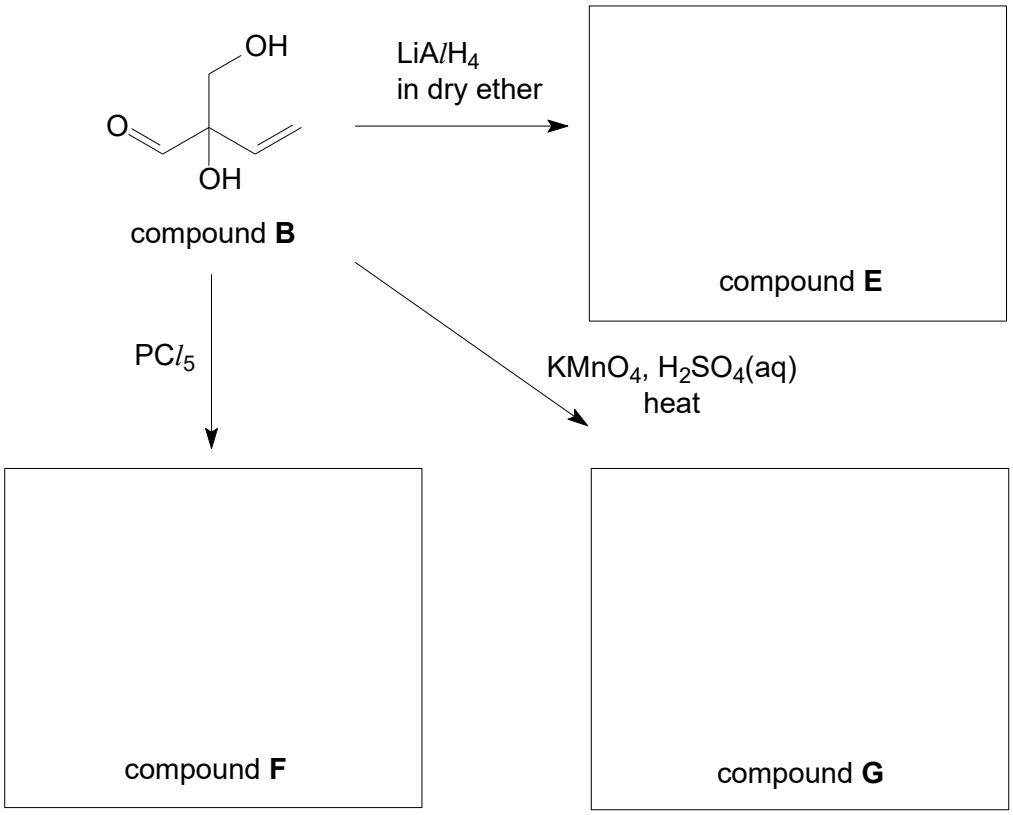


Fig 2.1

[3]

(c) Use a labelled diagram to show the orbitals that form the C=C bond in CH_2=CH_2.

[2]

[Total: 14 marks]

3 **(a)** In the presence of a base such as aqueous sodium carbonate, compound **X** can react with iodine to form compound **P** as shown in Fig 3.1.

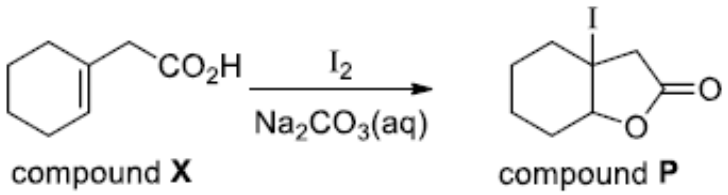
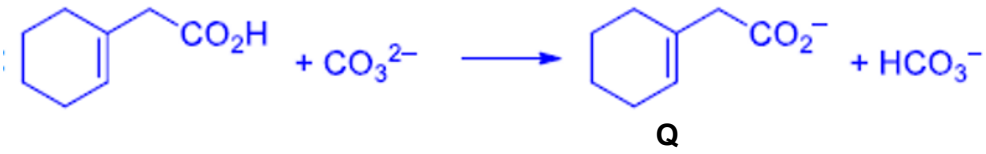


Fig 3.1

(i) This reaction follows a three-step mechanism.

The first step of the mechanism involves the acid-base reaction of **X** by Na_2CO_3 as shown below.



Q

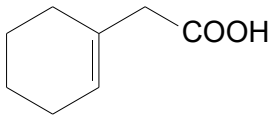
In the second step, **Q** reacts with I_2 to form a secondary carbocation **R**.

In the third step, the carbocation is attacked by O^- to form the product **P**.

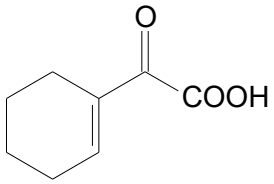
Describe the mechanism for steps 2 and 3. Show clearly any intermediates that may be formed, all charges and use curly arrows to indicate the movement of electron pairs and state the role of iodine in the reaction.

[3]

(ii) Describe a simple chemical test to distinguish between compounds **X** and **Y**. State the observations clearly.



compound **X**



compound **Y**

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[2]

(b) When the compounds shown below were reacted with aqueous sodium hydroxide at 55 °C, the rate of reaction decreases in the following order.

$$CH_3COBr > C_6H_5CH_2Br > C_6H_5Br$$

(i) Explain why C_6H_5Br has the slowest rate with aqueous sodium hydroxide at 55 °C.

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[1]

(ii) Explain why $C_6H_5CH_2Br$, a 1° halogenoalkane, undergoes S_N1 rather than S_N2 mechanism.

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[1]

[Total: 7]

4 **(a)** Depending on the conditions of the reaction, 4–ethylphenol can react with chlorine in two different ways, giving the two isomers **J** and **K** as shown in Fig. 4.1.

When ethanolic silver nitrate is added to both **J** and **K** and the resultant solutions are warmed, white precipitate is observed for **K** but no white precipitate is observed for **J.**

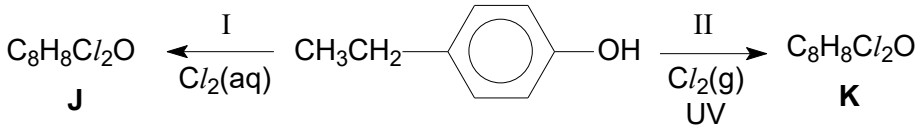

Fig. 4.1

(i) Deduce the structure of compound **J**.

[1]

(ii) Explain whether you would expect **J** to be more or less acidic than 4–ethylphenol.

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[2]

(iii) Suggest the type of reaction to convert 4–ethylphenol to **K.**

……..

[1]

(iv) **K** is observed to exhibit stereoisomerism.

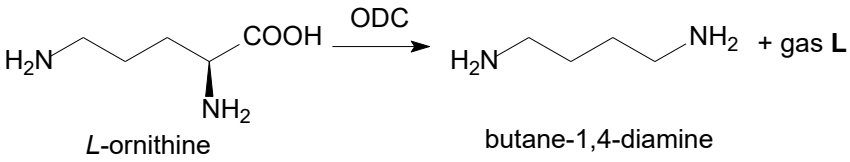
State the type of stereoisomerism that **K** exhibits and draw the pair of stereoisomers.

[2]

(b) Ornithine, an amino acid, has 2 stereoisomers, *L*-ornithine and *D*-ornithine.

When enzyme ODC is added to *L*-ornithine, reaction 4.1 occurs.

reaction 4.1



L-ornithine butane-1,4-diamine

When enzyme ODC is added to *D*-ornithine, no reaction occurs.

(i) Deduce the identity of the gaseous by-product of reaction 4.1.

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[1]

(ii) Explain why enzyme ODC reacts with *L*-ornithine but does not react with *D*-ornithine.

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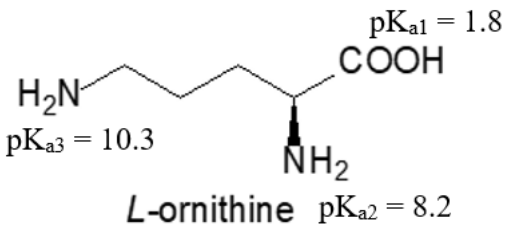
[1]

(iii) There are three pK_a values associated with *L*-ornithine: 1.8, 8.2, 10.3.



Make use of these pK_a values to suggest the major species present in solutions of L-ornithine with the following pH values.

pH 3	pH 9

[2]

(iv) In no more than 4 steps, suggest a reaction scheme to synthesise butane-1,4-diamine from ethanol.

State the reagents and conditions required and draw the structures of the intermediates formed for each step.

[4]

[Total : 14]

5 Fig. 5.1 shows the solubility of silver(I) chloride, AgC*l* in varying concentrations of C*l*$^-$ ions.

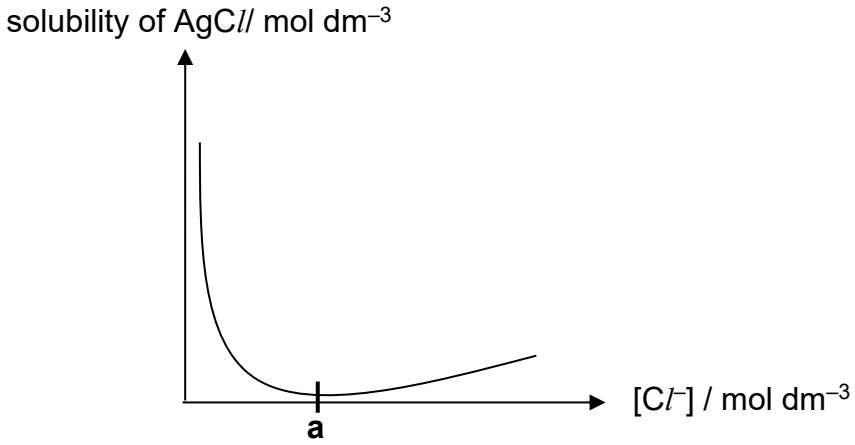


Fig. 5.1

The difference in solubility of AgC*l*, can be explained by the following two equilibria.

equation 5.1 $AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$ $K_1 = 1.8 \times 10^{-10}$ mol^2 dm^{-6}

equation 5.2 $Ag^+(aq) + 2Cl^-(aq) \rightleftharpoons [AgCl_2]^-(aq)$ $K_2 = 1.8 \times 10^5$ mol^{-2} dm^6

(a) Use the information provided to explain the shape of the graph in Fig. 5.1.

(i) Before point **a**

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[1]

(ii) After point **a**

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[2]

(b) **(i)** Write an expression for the equilibrium constant, K_2.

[1]

(ii) Hence, use equations 1 and 2 to show that the concentration of $[AgCl_2]^-$ is expressed as $[AgCl_2]^- = 3.24 \times 10^{-5} \times [Cl^-]$.

[1]

(c) The solubility of AgC*l* is expressed as the sum of the concentrations of Ag^+ and $[AgCl_2]^-$.

Solubility of AgC*l* is lowest when $[Ag^+] = [AgCl_2]^-$.

(i) Use your answer in **(b)(i)** to calculate the concentration of Cl^- when $[Ag^+] = [AgCl_2]^-$.

[1]

(ii) Hence, calculate the lowest solubility of AgC*l*.

[2]

[Total: 8]

NATIONAL JUNIOR COLLEGE
SH2 TIMED PRACTICE
Higher 2

CANDIDATE NAME			
SUBJECT CLASS		REGISTRATION NUMBER	

CHEMISTRY **9729/B1**
Paper B1 Multiple Choice **3 July 2025**
30 min

Additional Materials: Optical Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, subject class and registration number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **fifteen** 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 separate 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.
A Data Booklet is provided.

Instructions on how to fill in the Optical Mark Sheet
Shade the index number in a 5 digit format on the optical mark sheet:
2nd digit and the last 4 digits of the Registration Number.

Example:

Student	Examples of Registration No.	Shade:
	2405648	**45648**

This document consists of **7** printed pages.

1 Which statement about one mole of a metal is always correct?

A It contains the same number of atoms as 0.5 mol of hydrogen gas.

B It contains the same number of atoms as $\frac{1}{12}$ mol of ^{12}C.

C It has the same mass as 1 mol of hydrogen atoms.

D It produces one mole of hydrogen gas when reacted with excess acid.

2 10 cm^3 of a gaseous hydrocarbon was reacted with an excess of oxygen. A contraction of 30 cm^3 occurred. On treating the cooled resulting mixture with excess barium hydroxide, a further contraction of 40 cm^3 occurred. All volumes were measured at room temperature and pressure.

What is the formula of the hydrocarbon?

A C_2H_4 **B** C_2H_6 **C** C_4H_8 **D** C_4H_{10}

3 In an experiment, 40 cm^3 of 0.020 mol dm^{-3} acidified iron(II) sulfate was used to react with 20 cm^3 of 0.010 mol dm^{-3} of XO_3^-.

What is the final oxidation state of X?

A +1 **B** +2 **C** −1 **D** −2

4 The information on two particles, $\mathbf{Q}^+$ and $\mathbf{R}^+$, are given in the table below.

particles	number of electrons	number of neutrons	angle of deflection in an electric field
$\mathbf{Q}^+$	20	25	2.0°
$\mathbf{R}^+$		20	2.3°

Which of the following pairs of particles are isoelectronic?

A **Q** and **R**

B **Q** and $\mathbf{R}^+$

C $\mathbf{Q}^+$ and **R**

D $\mathbf{Q}^+$ and $\mathbf{R}^+$

5 The successive ionisation energies (in kJ mol^{-1}) of an element are shown below:

1762, 2540, 4320, 5590, 9100, 10800

Which group does this element belong to?

A 2 **B** 13 **C** 14 **D** 15

6 For which pairs does the first species have a smaller bond angle?

1 NCl_3, CO_2

2 BF_4^-, SCl_2

3 PCl_6^-, ClO_2^-

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

7 Which statements about the properties associated with ionic and covalent bonds are **incorrect**?

1 A covalent compound cannot be an electrolyte.

2 Any covalent compound that contains both oxygen and hydrogen forms hydrogen bonds.

3 Ionic bonds and covalent bonds can both occur in the same compound.

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

8 In which of the following pairs of compounds would the first compound have a higher melting point than the second compound?

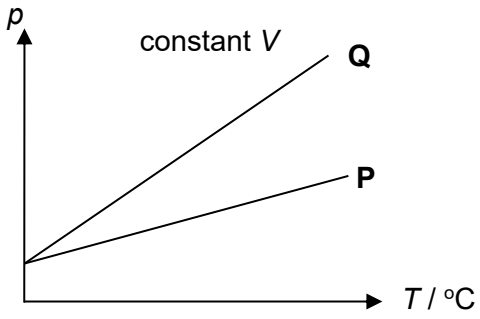
	first compound	second compound
1	$SiCl_4$	SiO_2
2	$NaCl$	KCl
3	AlF_3	$AlBr_3$

A 1, 2 and 3 **B** 2 only

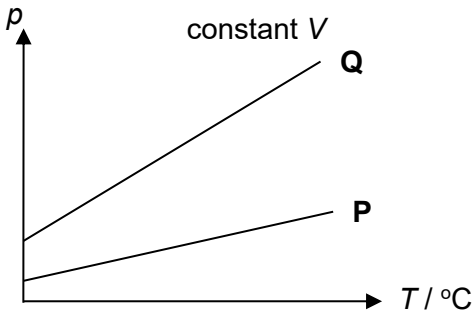
C 3 only **D** 2 and 3 only

9 Which graph correctly describes the behaviour of two ideal gases **P** and **Q**, both having the same mass, where **P** has a larger M_r than **Q**?

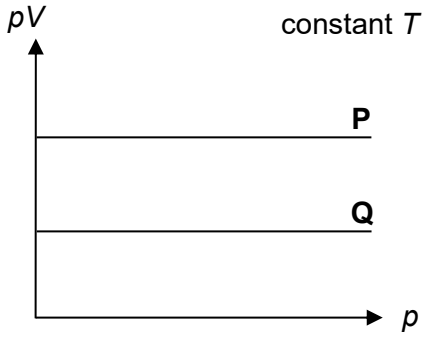
A



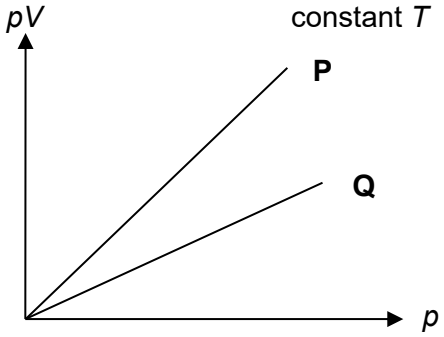
B



C



D



10 During the operation of a refrigerator, the coolant is constantly being liquefied under pressure, and vaporised once the pressure is released. Under these conditions, the gas does not behave as an ideal gas.

Which statement best describes why the gas liquefies under pressure?

A Increasing the pressure pushes the molecules closer together, and so the short-range intermolecular forces of attraction are more effective.

B Increasing the pressure decreases the kinetic energy of the molecules, creating the ordered liquid state.

C Increasing the pressure decreases the size of the molecules, and so increases the intermolecular attraction.

D Increasing the pressure causes the temperature of the gas to decrease to below its boiling point.

11 When bromine vaporises at 58.8 °C, 30.9 kJ mol^{-1} of heat was required.

What is the entropy change of vaporisation?

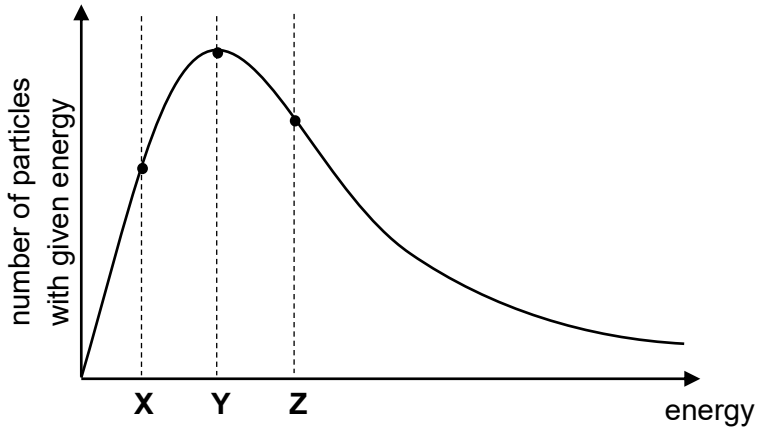
A − 525.5 J mol^{-1} K^{-1}

B + 525.5 J mol^{-1} K^{-1}

C − 93.1 J mol^{-1} K^{-1}

D + 93.1 J mol^{-1} K^{-1}

12 The Maxwell–Boltzmann distribution for a gas at constant temperature is shown below.



How would the number of particles change at the kinetic energies **X**, **Y** and **Z** when temperature is lowered by 5 °C?

	X	**Y**	**Z**
A	lower	lower	higher
B	lower	higher	higher
C	higher	lower	lower
D	higher	higher	lower

13 The table below shows the results of three experiments conducted for the reaction

$$P + Q \rightarrow \text{products}$$

[P] / mol dm^{-3}	**[Q] / mol dm^{-3}**	**rate / mol dm^{-3} s^{-1}**
0.012	0.005	1.0×10^{-4}
0.024	0.010	2.0×10^{-4}
0.048	0.010	4.0×10^{-4}

If the rate constant doubles for each 10 °C rise in temperature, which pairs of experimental conditions will result in the same rate?

	[P] / mol dm^{-3}	**[Q] / mol dm^{-3}**	**temperature / °C**
condition 1	0.10	0.20	40
condition 2	0.20	0.20	30
condition 3	0.30	0.30	20

1 conditions 1 and 2

2 conditions 1 and 3

3 conditions 2 and 3

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

14 Element **G** is found in Period 3 of the Periodic Table.

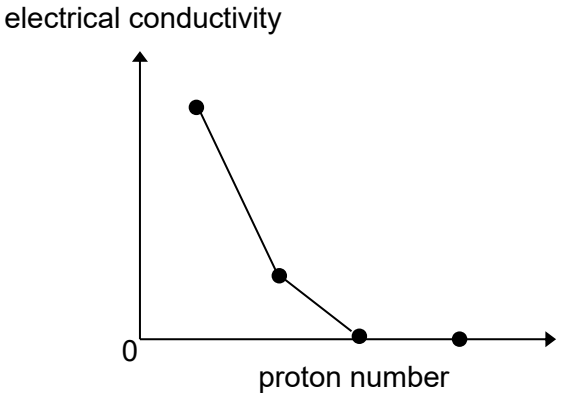
The oxide and chloride of element **G** are separately mixed with water. The two resulting solutions have the same effect on purple litmus solution.

What is the identity of element **G**?

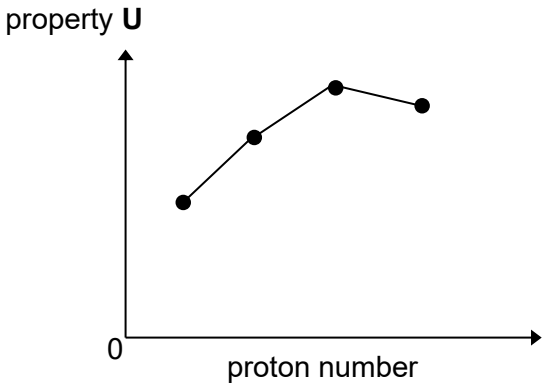
A phosphorus **B** magnesium

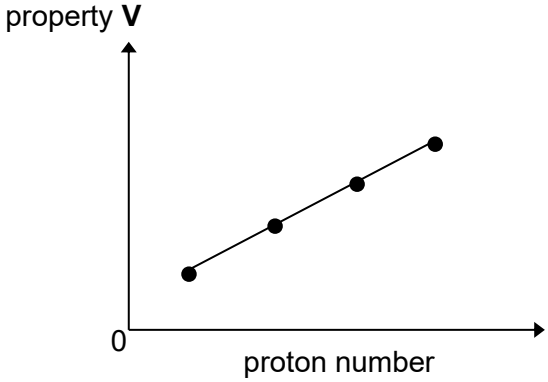
C silicon **D** sodium

15 The diagram represents the electrical conductivity of four consecutive elements in Period 3 of the Periodic Table.



The sketches below represent another two properties of the four consecutive elements.





What are properties **U** and **V**?

	property **U**	property **V**
A	ionic radius	nuclear charge
B	boiling point	melting point
C	first ionisation energy	electronegativity
D	number of valence electrons	atomic radius

NATIONAL JUNIOR COLLEGE
SH2 MID YEAR TIMED PRACTICE
Higher 2

CANDIDATE NAME			
SUBJECT CLASS		REGISTRATION NUMBER	

CHEMISTRY

9729/B2

Paper B2 Structured Questions

3 Jul 2025
1 hour 30 min

Candidates answer on Question Paper.
Additional Materials: Data Booklet

READ THE INSTRUCTIONS FIRST

Write your subject class, registration number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.
The use of an approved scientific calculator is expected, where appropriate.

A Data Booklet is provided.

For Examiner's Use	
1	**/ 9**
2	**/ 20**
3	**/ 16**
4	**/ 15**
Paper 2 Total	**/ 60**

The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **16** printed pages.

1 **(a)** The elements in Group 13 of the Periodic Table form compounds which display a range of chemical and physical properties.

The table below shows the properties of $AlCl_3$ and Al_2O_3.

compound	melting point/ °C	pH of aqueous solution
$AlCl_3$	192 (sublimes)	3
Al_2O_3	2072	−

(i) Explain the difference in melting points between $AlCl_3$ and Al_2O_3.

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[2]

(ii) $AlCl_3$ dissolves in water to form a solution with pH 3. Write balanced equations and account for the pH of $AlCl_3$ solution.

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[2]

1 **(b)** **(i)** $AlCl_3$ can react with NH_3 to form an addition product $AlCl_3NH_3$.

Draw the structure of the addition product formed.

[1]

(b) **(ii)** Explain why aluminium can form four bonds even though it has only three valence electrons. Describe the type of bond formed during this reaction.

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[2]

(c) Explain why the first ionisation energy of the elements decreases down Group 13.

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[2]

[Total: 9]

2 A metal nitrate, $M(NO_3)_2$, decomposes upon heating to form the metal oxide, MO, nitrogen dioxide gas (NO_2), and oxygen gas (O_2). The enthalpy change of decomposition, ΔH_{decomp}, can be determined using Hess' Law.

(a) (i) The following thermochemical equations are given.

equation	reaction	ΔH / kJ mol^{-1}
1	$M(NO_3)_2(s) \rightarrow MO(s) + 2NO_2(g) + ½O_2(g)$	$\Delta H_1 = y$
2	$M(s) + ½\ O_2(g) \rightarrow MO(s)$	$\Delta H_2 = -400$
3	$N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$	$\Delta H_3 = +66$
4	$M(s) + N_2(g) + 3O_2(g) \rightarrow M(NO_3)_2(s)$	$\Delta H_4 = -450$

Construct an energy cycle to determine the value of y, the enthalpy change of decomposition, ΔH_{decomp}, for $M(NO_3)_2$.

[3]

(ii) Explain how entropy changes during the decomposition of $M(NO_3)_2$.

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[2]

2 **(a)** **(iii)** Hence, explain the effects of increasing temperature on the spontaneity of the decomposition of $M(NO_3)_2$.

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[1]

(iv) Given that the minimum temperature for the decomposition of $M(NO_3)_2$ is 872 K, where $\Delta G = 0$. With reference to your answer in **(a)(i)**, calculate ΔS for the decomposition of $M(NO_3)_2$, stating its unit.

[2]

(b) Explain with the aid of the Boltzmann distribution curve, how an increase in temperature affects the rate of decomposition of $M(NO_3)_2$.

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[4]

2 **(c)** Nitrogen monoxide, NO, reacts with oxygen to form nitrogen dioxide, NO_2.

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

The rate equation for the reaction is rate = $k[NO]^2[O_2]$.

Two separate experiments are carried out at 30 °C to determine the rate of the reaction.

experiment	[NO] / mol dm^{-3}	$[O_2]$ / mol dm^{-3}	rate / mol dm^{-3} s^{-1}
1	0.00300	0.00200	1.51×10^{-4}
2		0.00500	6.05×10^{-5}

(i) Use the data for experiment 1 to calculate the value of the rate constant, *k*. State the units of *k*.

[2]

(ii) Calculate the value of [NO] in experiment 2.

[1]

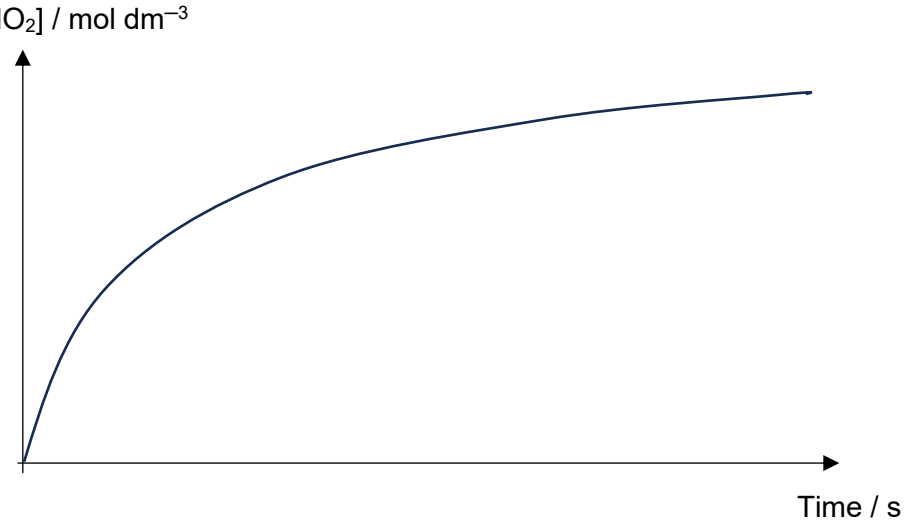
2 **(c)** **(iii)** In another experiment, a large excess of NO is mixed with 0.00975 mol dm^{-3} O_2. Under the conditions used, the half-life of $[O_2]$ is 48 s.

Calculate $[O_2]$ at t = 192 s.

[2]

(iv) The graph below shows how $[NO_2]$ changes with time.

Using the information given in **(iii)** and the given equation for the reaction in **(a)**, complete the graph by labelling the appropriate concentration values and time values to show that the reaction is first order with respect to O_2.



[2]

(v) Another similar experiment is carried out at a higher temperature. State how the half-life of the reaction will be affected.

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[1]

[Total: 20]

3 **(a)** An experiment was conducted to investigate the thermal decomposition of Group 2 carbonates.

$MgCO_3$ decomposes at 350 °C whereas $SrCO_3$ decomposes at 1200 °C.

A 20.0 g sample containing a mixture of magnesium carbonate and strontium carbonate was heated at 500 °C. The remaining white solid weighed 11.3 g.

(i) Draw the dot-and-cross diagram for magnesium carbonate.

[1]

(ii) Using relevant data from the *Data Booklet*, explain the difference in decomposition temperature of magnesium carbonate and strontium carbonate.

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[3]

(iii) Write an equation for the reaction that occurred when the sample is heated at 500 °C.

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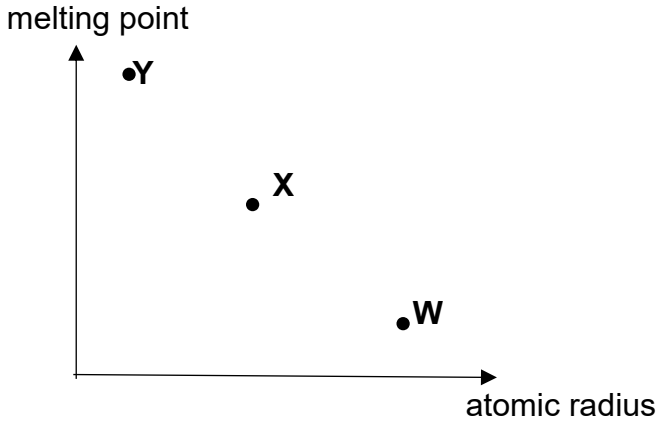
[1]

3 **(a)** **(iv)** Calculate the percentage composition by mass of magnesium carbonate in the 20.0 g sample.

[2]

(b) **W**, **X** and **Y** represent consecutive elements in Period 3. The following shows a graph of their melting points plotted against the atomic radius (not drawn to scale).



The oxide of **Y** is insoluble in water but dissolves when the oxide of **W** is subsequently added.

(i) Suggest the identities of **Y** and **W**.

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[1]

(ii) Explain the above observations and write equations for all the reactions that have occurred.

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[3]

3 **(c)** The lattice energies of three ionic compounds are given.

compound	lattice energy / kJ mol^{-1}
LiF(s)	−1022
CaO(s)	−3513
SrO(s)	−3310

(i) Define the term *lattice energy*.

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[1]

(ii) With the aid of the *Data Booklet*, explain why the lattice energy of CaO is more exothermic than the lattice energy of LiF.

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[3]

(iii) Use the data in the table to estimate approximate values for the lattice energies of magnesium oxide and barium oxide.

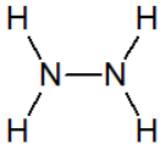
Lattice energy of MgO(s) = ... kJ mol^{-1}

Lattice energy of BaO(s) = ... kJ mol^{-1}

[1]

[Total : 16]

4 Hydrazine, N_2H_4, was used as a propellant for the rocket to fly a probe to explore Mars in 2012.



hydrazine

(a) **(i)** State and explain, with reference to the Valence Shell Electron Pair Repulsion Theory, the shape and bond angle about the N atom in N_2H_4.

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[2]

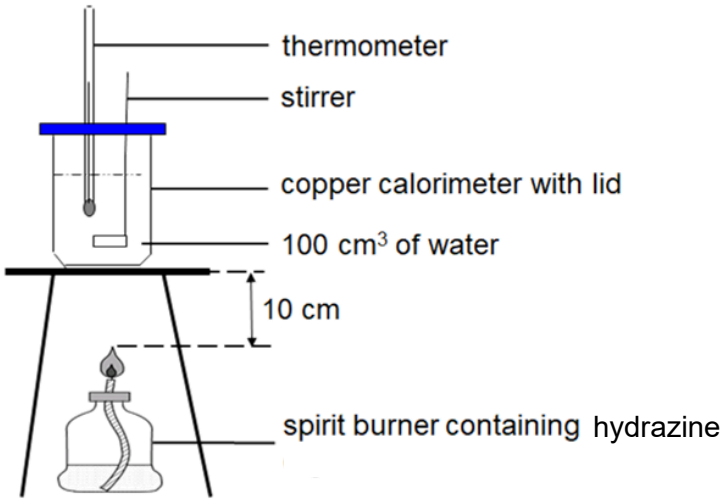
(ii) Hydrazine is soluble in water. Use a suitable diagram to illustrate the interactions between a hydrazine molecule and a water molecule.

[1]

4 **(b)** Liquid hydrazine undergoes combustion in oxygen to form nitrogen gas and water.

$$N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2H_2O(l)$$

An experiment is carried out to determine the enthalpy change of combustion of liquid hydrazine. Some hydrazine was burnt in a spirit burner to heat 100 cm^3 of water in a copper calorimeter as shown in the diagram below. The experimental data collected are shown in the table below.



initial temperature of water/ °C	25.0
highest temperature of water/ °C	78.8
mass of spirit burner containing hydrazine before combustion/ g	85.8
mass of spirit burner containing hydrazine after combustion/ g	84.2

You may assume the following:

1. The heat released from the burning of the wick is negligible,

2. There is negligible loss of hydrazine through evaporation during the experiment.

(i) Using relevant data in **(b)** and from the *Data Booklet*, calculate the enthalpy change of combustion of liquid hydrazine.

[2]

4 **(b)** **(ii)** Using the bond energies in the *Data Booklet*, calculate the enthalpy change of combustion of liquid hydrazine.

[2]

(iii) The actual enthalpy change of combustion of hydrazine of liquid hydrazine is −622 kJ mol^{-1}.

Suggest **two** reasons for the deviation of the enthalpy change of combustion of liquid hydrazine calculated in **(b)(ii)** from the actual value.

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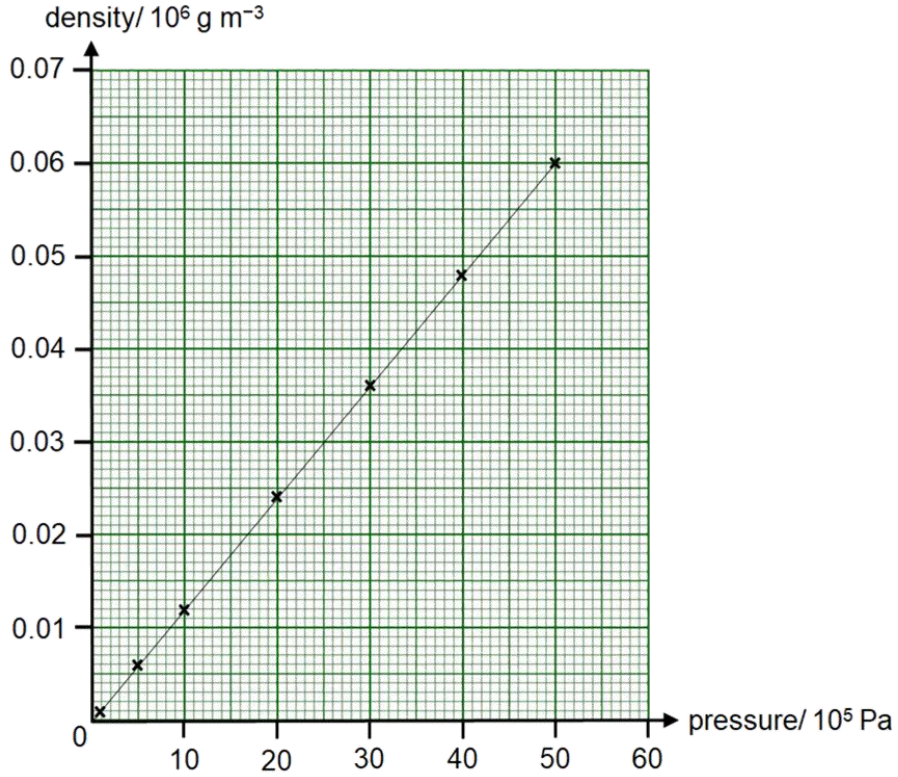
[2]

4 **(c)** A gas sample of Mars' atmosphere collected during an exploration was taken back to Earth and studied.

It was found that most of the gas mixture is made up of a single type of gas **X**, whose identity is either nitrogen, oxygen, carbon dioxide or argon gas.

The relationship between density and pressure for the gas sample from Mars is plotted in the graph below. The experiment was conducted at 180 ºC.



(i) Determine the value for the gradient of the graph.

[1]

4 **(c)** **(ii)** Using information in **(c)** and your answer in **(c)(i)**, calculate the average M_r of the gas sample from Mars and determine the identity of gas **X**.

[2]

(d) On Mars, the average temperature is about −70 ºC.

Explain why a gas is more likely to show more deviation from the ideal gas behaviour on Mars than on Earth.

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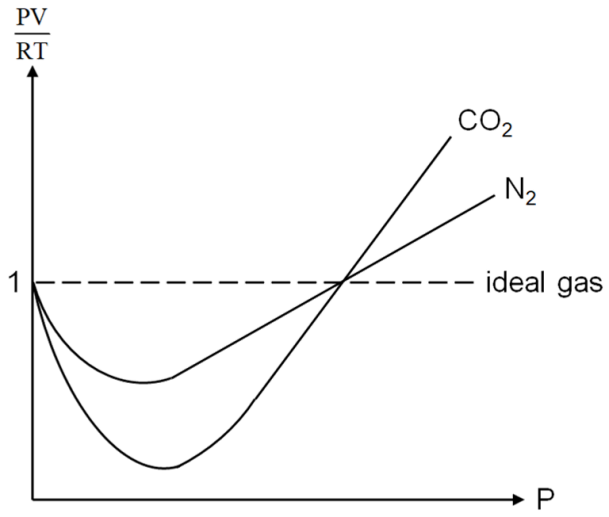
[1]

4 **(e)** The graph below shows the behaviour of 1 mole each of N_2 and CO_2 gas at 293 K.



Give a reason to account for the difference in the graphs of CO_2 and N_2.

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[2]

[Total: 15]