**RAFFLES INSTITUTION**
**2017 YEAR 6 PRELIMINARY EXAMINATION**

**Higher 1**

# CHEMISTRY
# 8872/01

Paper 1 Multiple Choice **25 September 2017**

**50 minutes**

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

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**READ THESE INSTRUCTIONS FIRST**

**Do not open this booklet until you are told to do so.**

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, index number and civics tutorial group in the spaces provided on the Answer Sheet.

There are **thirty** questions in 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 shade 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.

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This document consists of **13** printed pages.

## Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

**1** *Use of the Data Booklet is relevant to this question.*

How many atoms of carbon are present in 72 g of Buckministerfullerene, $C_{60}$?

**A** $6.02 \times 10^{22}$ **B** $7.22 \times 10^{22}$

**C** $1.20 \times 10^{23}$ **D** $3.61 \times 10^{24}$

**2** *Use of the Data Booklet is relevant to this question.*

Ethyl butyrate is an organic liquid with a pineapple-like odour.
The percentage by mass of ethyl butyrate is: C, 62.1%; H, 10.3%; O, 27.6%.

Which empirical formula could be that of ethyl butyrate?

**A** $CH_2O$ **B** $CHO_2$

**C** $C_3H_6O$ **D** $C_5H_{10}O$

**3** *Use of the Data Booklet is relevant to this question.*

A 1.881 g sample of an unknown metallic carbonate is decomposed by heating to form the metallic oxide and 0.66 g of carbon dioxide according to the equation:

$$\mathbf{M}CO_3(s) \rightarrow \mathbf{M}O(s) + CO_2(g)$$

What is metal **M**?

**A** Ca **B** Mn

**C** Ni **D** Zn

**4** Which compound contains two different elements with identical oxidation states?

**A** HC*l*O **B** $Mg(OH)_2$ **C** $Na_2SO_4$ **D** $NH_4Cl$

**5** Which of the following is **incorrect** for $^{32}S^{2-}$?

**A** It is isoelectronic with argon.

**B** Its p-orbitals are completely filled.

**C** It is smaller than a sulfur atom.

**D** It has an equal number of protons and neutrons.

**6** *Use of the Data Booklet is relevant to this question.*

The table below gives the successive ionisation energies for an element **X**.

What could be the formula of the chloride of **X**?

| | 1st | 2nd | 3rd | 4th | 5th | 6th |
|---|---|---|---|---|---|---|
| ionisation energy / kJ $mol^{-1}$ | 1010 | 1910 | 2910 | 4960 | 6270 | 21270 |

**A** **X**C*l*

**B** **X**C$l_2$

**C** **X**C$l_3$

**D** **X**C$l_4$

**7** Which of the following will **not** form a hydrogen bond with another of its own molecule?

**A** $CH_3OH$

**B** $CH_3CHO$

**C** $CH_3NH_2$

**D** $CH_3COOH$

**8** Which of the following statements is correct?

**A** The C*l*−P−C*l* bond angle in PC$l_3$ is 120º.

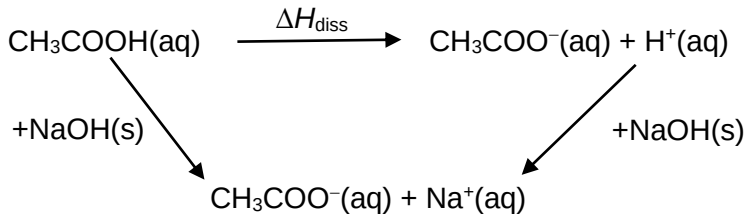
**B** Both $CO_2$ and $SiO_2$ have simple molecular structures.

**C** The C−O bond has a larger dipole moment than the C−N bond.

**D** The triple bond in nitrogen is three times as strong as an N−N single bond.

**9** *Use of the Data Booklet is relevant to this question.*

The energy cycle below can be used to calculate the enthalpy of dissociation of ethanoic acid, $\Delta H_{diss}$.




Two experiments were conducted to determine $\Delta H_{diss}$.

In experiment 1, 1.0 g of sodium hydroxide pellets was added to 50 $cm^3$ ethanoic acid (in excess) and the temperature rise was found to be 11.8 $^oC$.

In experiment 2, solid sodium hydroxide was reacted with aqueous nitric acid and the enthalpy change of neutralisation was found to be $-101.3$ kJ $mol^{-1}$.

Using the energy cycle and the results of experiments 1 and 2, calculate a value for $\Delta H_{diss}$.

**A** $-2.7$ kJ $mol^{-1}$ **B** $-0.7$ kJ $mol^{-1}$

**C** $+0.7$ kJ $mol^{-1}$ **D** $+2.7$ kJ $mol^{-1}$

**10** One of the processes in the production of iron from its ore involves the reduction of iron(III) oxide by carbon monoxide as shown below.

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g) \qquad \Delta H = -28.0 \text{ kJ mol}^{-1}$$

Additional data:
Enthalpy change of formation of iron(III) oxide = $-824$ kJ $mol^{-1}$
Enthalpy change of formation of carbon dioxide = $-394$ kJ $mol^{-1}$

Calculate a value for the enthalpy change of formation of carbon monoxide.

**A** $-330$ kJ $mol^{-1}$ **B** $-110$ kJ $mol^{-1}$

**C** $+110$ kJ $mol^{-1}$ **D** $+330$ kJ $mol^{-1}$

**11** For the following system at equilibrium, which change would increase the amount of $C_6H_{12}O_6(s)$?

$$6CO_2(g) + 6H_2O(l) \rightleftharpoons C_6H_{12}O_6(s) + 6O_2(g) \quad \Delta H > 0$$

**A** Increasing the concentration of oxygen

**B** Decreasing the total pressure

**C** Heating the reaction mixture

**D** Removing $CO_2$

**12** Which of the following pairs would give a buffer solution when equal volumes of the two solutions are mixed?

**A** 0.1 mol $dm^{-3}$ NaOH and 0.1 mol $dm^{-3}$ $CH_3COOH$

**B** 0.2 mol $dm^{-3}$ $Ba(OH)_2$ and 0.1 mol $dm^{-3}$ $H_2C_2O_4$

**C** 0.05 mol $dm^{-3}$ $Ba(OH)_2$ and 0.2 mol $dm^{-3}$ $CH_3COOH$

**D** 0.2 mol $dm^{-3}$ NaOH and 0.1 mol $dm^{-3}$ $H_2C_2O_4$

**13** Some data on two acid-base indicators are shown in the table below.

| Indicator | Approximate working range | Colour in | |
|---|---|---|---|
| | | Acid | Alkali |
| methyl orange | 3.2 – 4.4 | red | yellow |
| bromothymol blue | 6.0 – 7.6 | yellow | blue |

Which of the following conclusions can be drawn about a solution in which methyl orange is yellow and bromothymol blue is yellow?

**A** It is weakly basic.

**B** It is weakly acidic.

**C** It could be a solution of sodium chloride.

**D** It could be a solution of sodium ethanoate.

**14** Values of the ionic product of water, $K_w$, at various temperatures are tabulated below.

| Temperature / ºC | $K_w$ / mol$^2$ dm$^{-6}$ |
|---|---|
| 10 | $2.88 \times 10^{-15}$ |
| 20 | $6.92 \times 10^{-15}$ |
| 30 | $14.5 \times 10^{-15}$ |
| 40 | $28.8 \times 10^{-15}$ |

Which of the following statements is **not** correct?

**A** When pure water is heated, the pH of the water decreases.

**B** Water is acidic at 40 ºC.

**C** The dissociation of pure water is an endothermic process.

**D** When pure water is heated, the concentration of $OH^-(aq)$ increases.

**15** Which of the following sets contains a basic, an acidic and an amphoteric oxide?

| | | | |
|---|---|---|---|
| **A** | $Al_2O_3$ | $SiO_2$ | $P_4O_{10}$ |
| **B** | $SiO_2$ | $SO_3$ | $P_4O_{10}$ |
| **C** | MgO | $P_4O_{10}$ | $SO_3$ |
| **D** | $Na_2O$ | $Al_2O_3$ | $SO_3$ |

**16** Which statement regarding the chlorides $MgCl_2$, $SiCl_4$ and $PCl_3$ is correct?

**A** All three chlorides hydrolyse completely in water to give acidic solutions.

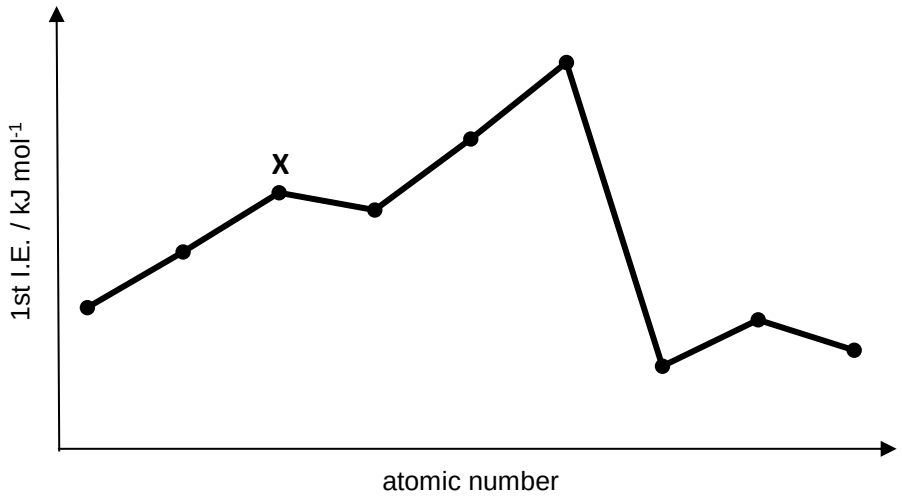
**B** The oxidation states of chlorine in the three chlorides are –2, –4 and –3 respectively.

**C** All three chlorides are able to conduct electricity in the liquid state.

**D** $SiCl_4$ and $PCl_3$ are the only chlorides which exist as discrete molecules.

**17** The first ionisation energies of nine consecutive elements which have atomic numbers less than 20 are shown in the graph below.
What is the valence electronic configuration of element **X**?

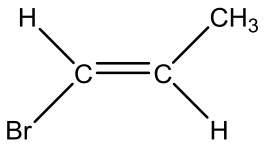


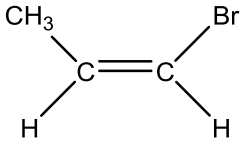

**A** $ns^2\ np^2$ **B** $ns^2\ np^3$

**C** $ns^2\ np^4$ **D** $ns^2\ np^5$

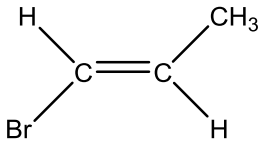
**18** Which of the following pairs of compounds are cis-trans isomers?

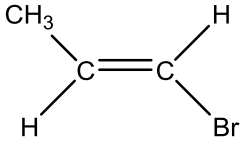
**A**



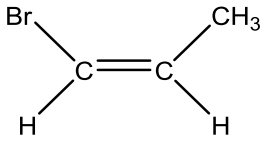



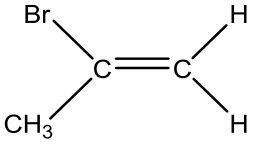

**B**



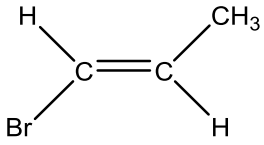



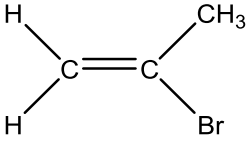

**C**



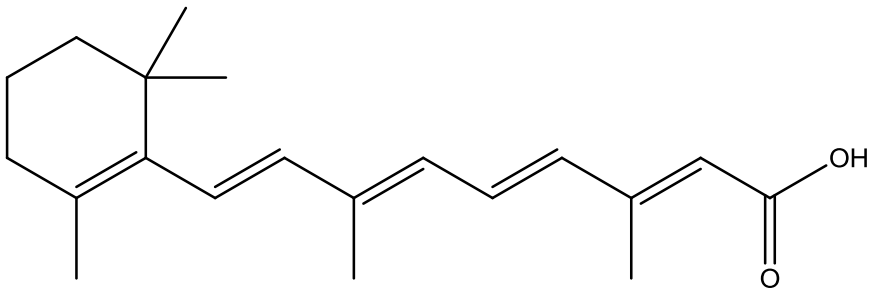




**D**



**19** Retinoic acid is an active ingredient found in anti-aging creams and has the following structure.



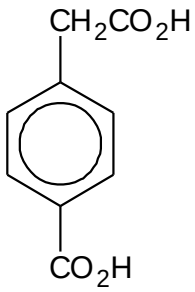

What is the maximum number of Br atoms that could be incorporated in one molecule of retinoic acid when it is reacted with aqueous bromine?

**A** 5 **B** 6

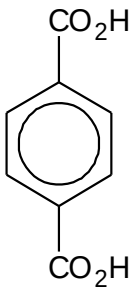
**C** 10 **D** 12

**20** What is the product formed when 1-ethyl-4-methylbenzene reacts with hot alkaline potassium manganate(VII)?

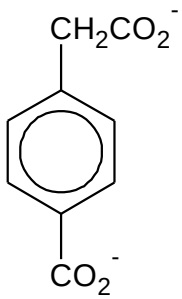
**A**



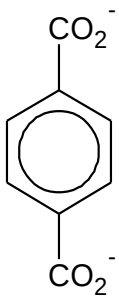

**B**




**C**




**D**




**21** Which statement best explains why fluoroalkanes are the least reactive halogenoalkanes?

**A** Fluorine is much more electronegative than carbon.

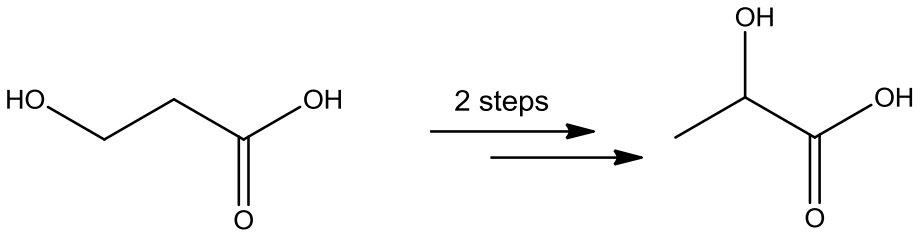
**B** The $F^-$ ion is the most stable halide ion.

**C** The C–F bond is the most polar carbon–halogen bond.

**D** The C–F bond is the strongest carbon–halogen bond.

**22** Lactic acid is often used as a chemical exfoliant for acne-prone skin.
It can be produced from 3–hydroxypropanoic acid in two steps.

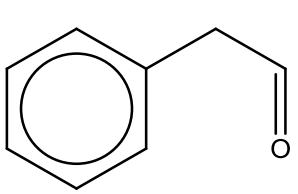


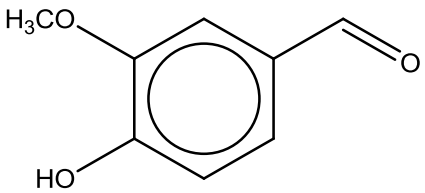

3-hydroxypropanoic acid  Lactic acid

Which of the following is the correct set of reagents and conditions for the two steps?

| | Step 1 | Step 2 |
|---|---|---|
| **A** | excess concentrated sulfuric acid, 170 $^{o}$C | cold, concentrated sulfuric acid, followed by water, heat |
| **B** | cold, concentrated sulfuric acid | excess concentrated sulfuric acid, 170 $^{o}$C, followed by water |
| **C** | hot, ethanolic NaOH | aqueous NaOH, heat |
| **D** | aqueous NaOH, heat | hot, ethanolic NaOH |

**23** Phenylacetaldehyde and vanillin are organic compounds found in chocolates and vanilla respectively.
[You may assume $CH_3O$– and –OH groups to be inert.]




phenylacetaldehyde  vanillin

Which of the following could distinguish phenylacetaldehyde from vanillin?

**A** hot, acidified potassium dichromate(VI)

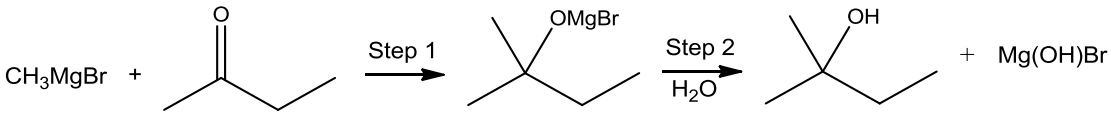
**B** alkaline copper(II) tartrate

**C** hot, alkaline potassium manganate(VII)

**D** diammine silver(I) ions

**24** Magnesium forms an important group of covalent compounds which are known as Grignard reagents. One example of a Grignard reagent is $CH_3MgBr$.

A typical example of the use of a Grignard reagent is the two-step reaction of $CH_3MgBr$ with butan-2-one as shown below.




Which type of reaction occurs in Step 2?

**A** Acid-base **B** Nucleophilic addition

**C** Hydrolysis **D** Nucleophilic substitution

**25** How many esters are possible with the molecular formula $C_5H_{10}O_2$, excluding stereoisomers?

**A** 7 **B** 8 **C** 9 **D** 10

## Section B

For each of the following questions, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

| A | B | C | D |
|---|---|---|---|
| **1, 2** and **3** are correct | **1** and **2** only are correct | **2** and **3** only are correct | **1** only is correct |

No other combination of statements is used as a correct response.

**26** *Use of the Data Booklet is relevant to this question.*

Consider the following reaction.

$$SF_4(g) + F_2(g) \rightarrow SF_6(g) \quad \Delta H = -434 \text{ kJ mol}^{-1}$$

Which of the following statements are correct?

**1** $F_2(g)$ acts as an oxidising agent.

**2** The average value of the S–F bond energy is 296 kJ $mol^{-1}$.

**3** $SF_4$ has a see-saw shape.

**27** The conversion of graphite into diamond is an endothermic reaction ($\Delta H$ = +3.0 kJ $mol^{-1}$).

Which of the following statements are correct?

**1** Diamond has a more exothermic enthalpy of combustion than graphite.

**2** Graphite takes in more energy to form one mole of gaseous atoms than diamond.

**3** The enthalpy change of formation of graphite is –3.0 kJ $mol^{-1}$.

The responses **A** to **D** should be selected on the basis of

| A | B | C | D |
|---|---|---|---|
| **1, 2** and **3** are correct | **1** and **2** only are correct | **2** and **3** only are correct | **1** only is correct |

No other combination of statements is used as a correct response.

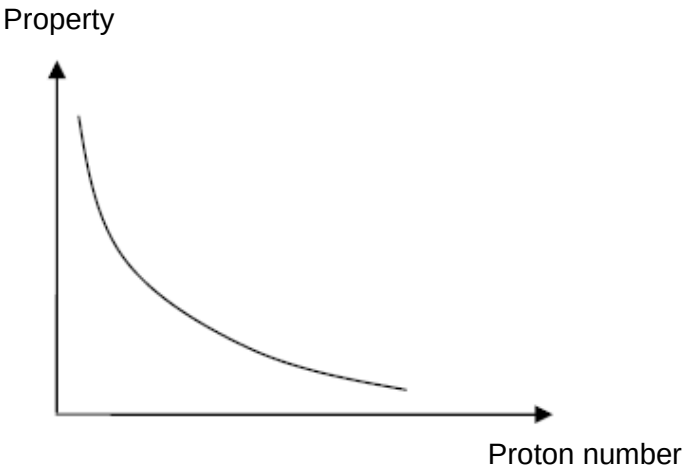
**28** Which statements about a catalysed reversible reaction are correct?

**1** The catalyst increases the rate constants for both the forward and reverse reactions.

**2** The catalyst decreases the activation energies for both the forward and reverse reactions.

**3** The catalyst alters the composition of the equilibrium mixture.

**29** The graph shows how a property of some elements varies with proton number.




Which of the following can be the property that shows the above trend?

**1** boiling point of the Group VII elements

**2** melting point of Group I elements

**3** atomic radius of the Period 2 elements

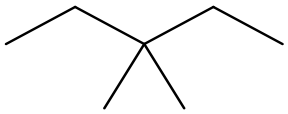
The responses **A** to **D** should be selected on the basis of

| A | B | C | D |
|---|---|---|---|
| **1, 2** and **3** are correct | **1** and **2** only are correct | **2** and **3** only are correct | **1** only is correct |

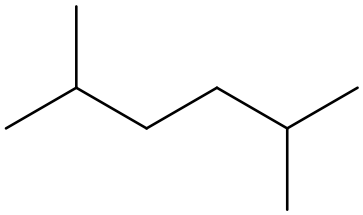
No other combination of statements is used as a correct response.

**30** Which of the following alkanes react with bromine to form three types of mono-brominated products, excluding stereoisomers?

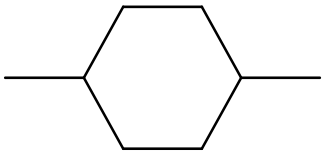
**1**



**2**



**3**



**RAFFLES INSTITUTION**
**2017 YEAR 6 PRELIMINARY EXAMINATION**

**Higher 1**

| | | | |
|---|---|---|---|
| CANDIDATE NAME | | | |
| CLASS | | INDEX NUMBER | |

# CHEMISTRY 8872/02

Paper 2 **11 September 2017**
**2 hours**

Candidates answer Section A on the Question Paper.

Additional Materials: Answer paper
Data Booklet

**READ THESE INSTRUCTIONS FIRST**

Write your name, class and index number in the spaces provided at the top of this page.
Write in dark blue or black pen in the spaces provided.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
The use of an approved scientific calculator is expected, where appropriate.
A Data Booklet is provided. Do not write anything on it.
You are reminded of the need for good English and clear presentation in your answers.

**Section A**
Answer **all** the questions on the question paper.

**Section B**
Answer any **two** questions on separate answer paper.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | | |
|---|---|---|
| **Paper 1** | | / 30 |
| **Paper 2** | **A1** | / 10 |
| | **A2** | / 7 |
| | **A3** | / 10 |
| | **A4** | / 13 |
| | **B5** | / 20 |
| **(circle the questions you have answered in Section B)** | **B6** | / 20 |
| | **B7** | / 20 |
| **Sub-total** | | / 80 |
| **Total** | | **/ 110** |

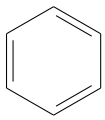
This document consists of **18** printed pages.

## Section A (40 marks)

Answer **all** the questions in this section in the spaces provided.

**1** Benzene is an important industrial chemical and is used in a wide range of manufacturing processes. Over time our understanding of the structure and bonding of benzene has changed and various models have been proposed.

In 1865, Kekulé proposed that the structure of benzene was a ring of alternating double and single bonds, but there was considerable evidence to suggest that Kekulé's model may not be correct.



Kekulé structure of Benzene

**(a)** State two evidence that led scientists to doubt the model proposed by Kekulé.

……..……..……..

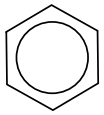
……..……..……..

……..……..……..

……..……..……..

……..…….. [2]

**(b)** Alternative models of benzene were proposed after Kekulé's structure. The current accepted structure is shown below.



Describe the bonding in the structure of benzene as understood today in terms of orbital overlap. You may draw a diagram to illustrate your answer.

……..……..

……..……..

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……..……..

……..…… [3]

**(c)** Benzene is an additive in non-leaded petrol. Calculate the minimum volume of oxygen gas required for the complete combustion of 24.0 g of benzene.

[All volumes are measured at s.t.p. conditions.]

[3]

**(d)** Benzene can react to form bromobenzene. Write an equation for this reaction and state the reagents and conditions necessary for the reaction to occur.

equation: ……

reagents and conditions: ……

[2]

[Total: 10]

**2** The following data was obtained in a series of experiments investigating the rate of the reaction between compounds **A** and **B** at a constant temperature.

| experiment | initial concentration of **A** / mol $dm^{-3}$ | initial concentration of **B** / mol $dm^{-3}$ | initial rate/ mol $dm^{-3}$ $s^{-1}$ |
|---|---|---|---|
| 1 | 0.12 | 0.26 | $2.10 \times 10^{-4}$ |
| 2 | 0.36 | 0.26 | $1.89 \times 10^{-3}$ |
| 3 | 0.72 | 0.13 | $3.78 \times 10^{-3}$ |

**(a)** Show how this data can be used to deduce the rate equation for the reaction between **A** and **B**.

rate equation: ……

[5]

**(b)** With the aid of a sketch of the Boltzmann distribution curve, explain how an increase in temperature increases the rate of reaction between compounds **A** and **B**.

……..……..

……..……..

……..……..

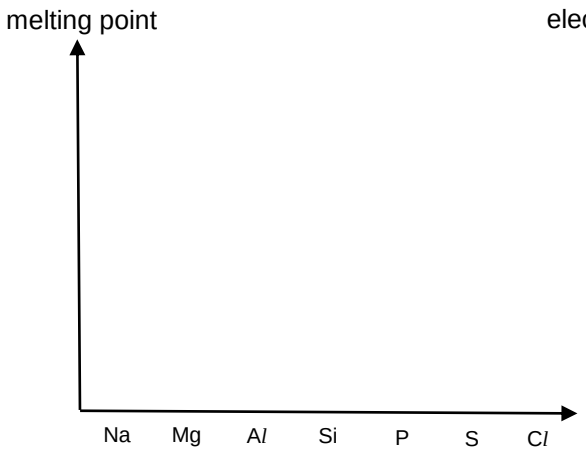
……..……..

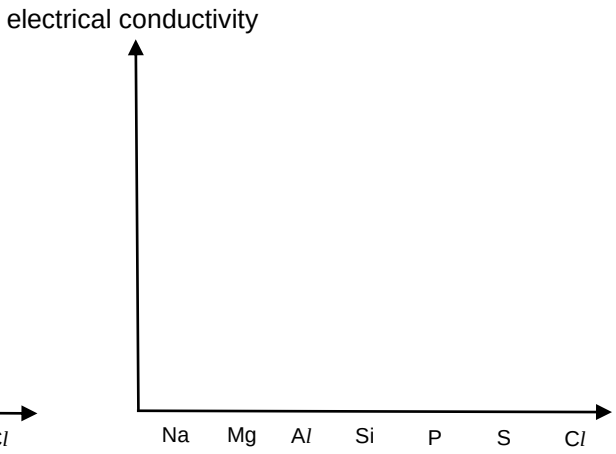
……..……..

……..…… [2]

[Total: 7]

**3** **(a)** On each of the grids below, sketch the general trends of the properties of the elements across the third period of the Periodic Table. No scale is specified on the vertical axis.




[2]

**(b)** With reference to structure and bonding, identify and explain which element in the third period has the

**(i)** highest melting point

……..……..……..

……..……..……..

..……..……..……[1]

**(ii)** greatest electrical conductivity

……..……..……..

……..……..……..

..……..……..……[1]

**(c)** Aluminium can react with chlorine to form aluminium chloride.

**(i)** Write an equation to show the reaction of aluminium with chlorine.

……[1]

**(ii)** Melting points of $AlF_3$ and $AlCl_3$ are given below.

| compound | melting point / $^oC$ |
|---|---|
| $AlF_3$ | 1290 |
| $AlCl_3$ | 192 |

By considering the type of structure and bonding present, explain why the two aluminium halides have different melting points.

……

……

……

……

……

……[3]

**(d)** In the liquid and gas phases, aluminium chloride dimerises to form $Al_2Cl_6$ via the formation of a dative covalent bond.

**(i)** Explain why aluminium chloride is able to form dative covalent bonds.

……

……

……

……[1]

**(ii)** Draw a dot-and-cross diagram to show the bonding within a molecule of $Al_2Cl_6$.

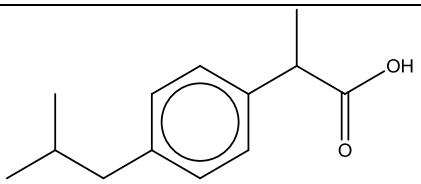
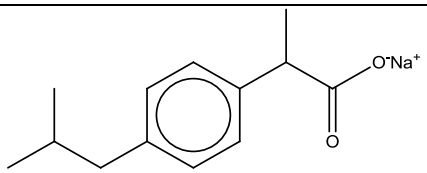
[1]

[Total: 10]

**4** Ibuprofen is a drug used for the treatment of pain and fever.

Ibuprofen is often taken orally where they will be absorbed and metabolised in the gut. Alternatively, ibuprofen can also be taken as its sodium salt which shows an increased rate of absorption as compared to ibuprofen.

Some data for ibuprofen and sodium ibuprofen are shown below.

| | ibuprofen | sodium ibuprofen |
|---|---|---|
| chemical structure |  |  |
| molar mass / g $mol^{-1}$ | 206.0 | 228.0 |
| solubility in water / g $dm^{-3}$ | 0.021 | 100 |

**(a)** Explain why ibuprofen has a lower solubility in water as compared to sodium ibuprofen.

……

……

……

……

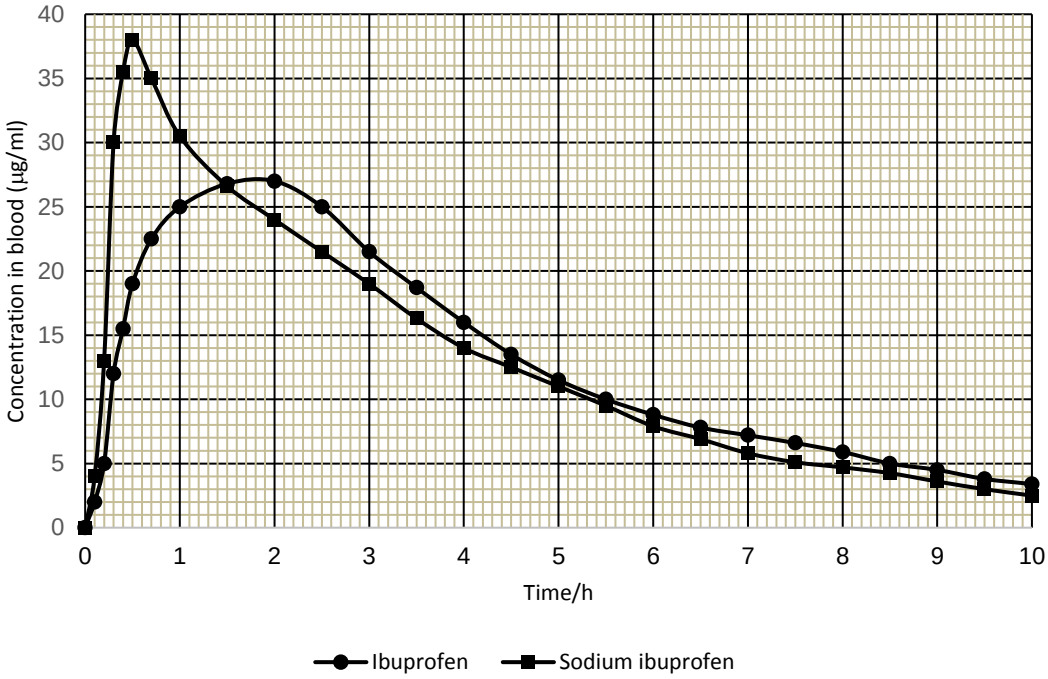
……

……

……[3]

**(b)** When a drug is consumed, it will enter the bloodstream. The concentration of a drug in blood is measured in μg/ml.

The graphs below show the mean concentrations (in μg/ml) of ibuprofen and sodium ibuprofen after equivalent doses were consumed separately at $t$=0.




**(i)** From the graphs above, state how long it takes for ibuprofen and sodium ibuprofen to reach their highest concentrations.

ibuprofen: ……h sodium ibuprofen: ……h

[1]

**(ii)** Calculate the highest concentration of ibuprofen reached in the blood sample, in mol $dm^{-3}$.
[1 g = $10^6$ μg; 1 $dm^3$ = 1000 ml]

highest concentration: …… mol $dm^{-3}$

[2]

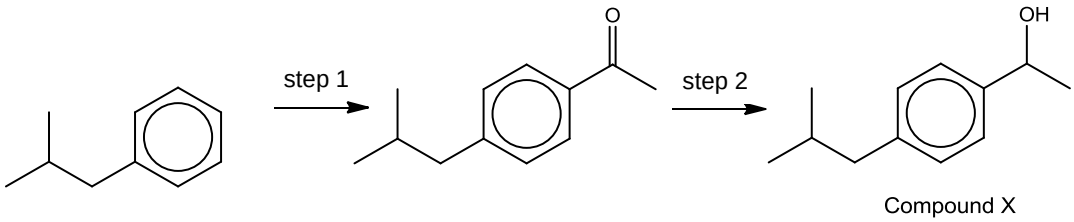
**(iii)** ***After*** reaching its highest concentration, the concentration of sodium ibuprofen starts to decrease due to metabolism.

Using the graph, show that the metabolism of sodium ibuprofen follows first order kinetics and calculate the rate constant for the metabolism process.

rate constant: …….

[2]

**(c)** The following shows a possible reaction pathway for the synthesis of compound **X**, a precursor of ibuprofen.



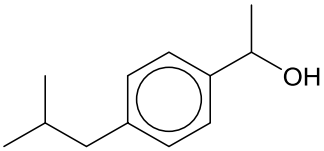

Compound X

**(i)** Suggest the type of reaction which occurs in step 1 and 2 of the synthesis.

| | reaction type |
|---|---|
| step 1 | |
| step 2 | |

[2]

**(ii)** Suggest a three–step route for the synthesis of ibuprofen from compound **X**, stating the reagents and conditions for each step, and giving the structures of the intermediate compounds.

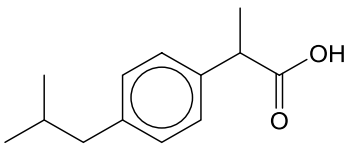



compound **X**

step 1

step 2

step 3




ibuprofen

| | reagents and conditions |
|---|---|
| step 1 | |
| step 2 | |
| step 3 | |

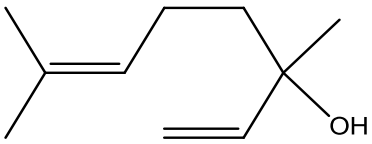
[3]

[Total: 13]

## Section B (40 marks)

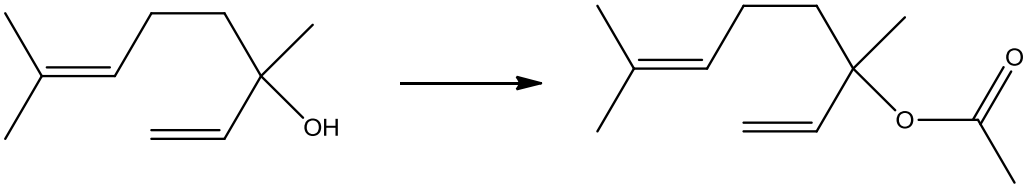
Answer **two** questions from this section on separate answer paper.

**5** Linalool, $C_{10}H_{18}O$, commonly found in coriander oil, has the following structure.




linalool

**(a)** Linalool can be converted to lavender oil as shown below.




lavender oil

State the reagents and conditions for the conversion of linalool to lavender oil. [1]

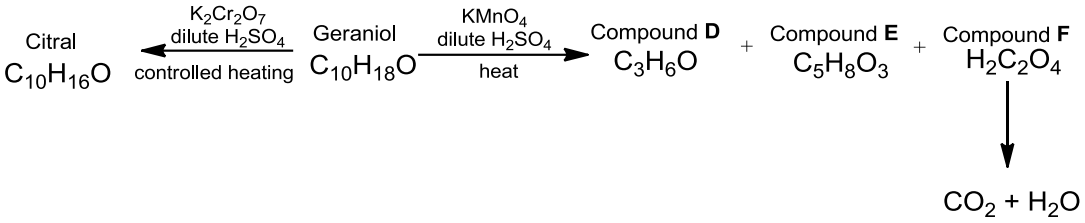
**(b)** Linalool reacts with excess hydrogen and nickel catalyst to produce compound **C** which has a lily–like aroma.

Draw the structure and give the IUPAC name of compound **C**. [2]

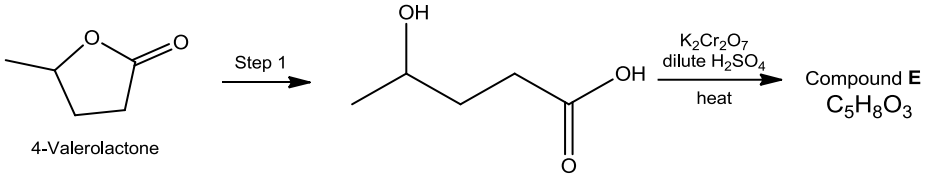
**(c)** Draw the structural formula of the **major** product formed when linalool is reacted with an excess of gaseous hydrogen bromide. [2]

**(d)** A structural isomer of linalool is geraniol which is found in rose oil. Geraniol can exist as a pair of cis-trans isomers.

Geraniol undergoes oxidation under different conditions as shown below.




Compound **E** can be obtained from 4-Valerolactone as shown below.




**(i)** Draw the structure of compound **E**. [1]

**(ii)** State the reagents and conditions in step 1. [1]

**(iii)** Given the following information,

- both citral and compound **D** give a positive test with 2,4-dinitrophenylhydrazine.
- compound **D** gives yellow precipitate with aqueous alkaline iodine.
- only citral gives a positive test with Tollens' reagent.
- compound **F** gives effervescence with aqueous sodium carbonate.

deduce the structures of geraniol, citral, compounds **D** and **F**, with reasoning. [8]

**(iv)** Write an equation for the reaction between compound **D** and 2,4-dinitrophenylhydrazine. [1]

**(e)** **(i)** Write an equation for the hydrogenation of ethanal and use relevant data from the *Data Booklet* to calculate a value for the enthalpy of hydrogenation for ethanal. [3]

**(ii)** By using enthalpy changes of formation data, the theoretical value of the hydrogenation of ethanal was calculated to be $-161.5$ kJ mol$^{-1}$.
Suggest a reason for the discrepancy in the theoretical value and the value calculated in **(e)(i)**. [1]

[Total: 20]

**6** Fluorite is a mineral composed of calcium fluoride, $CaF_2$. It is commonly used for making aerosol propellants and fire retardants.

**(a)** The calcium in calcium fluoride exists as the $Ca^{2+}$ ion.

**(i)** State the full electronic configurations of a calcium atom, Ca, and a calcium ion, $Ca^{2+}$. [2]

**(ii)** Using data from the *Data Booklet*, state and compare the values of the atomic and ionic radii of calcium. Explain why they differ. [2]

**(b)** Describe, by means of a diagram, how the paths of the separate beams of

**(i)** $Ca^{2+}$ and

**(ii)** $F^-$,

are affected on passing through an electric field which is at right angles to their direction of travel. You should relate clearly the magnitude and the direction of deflection of each beam to the others. [2]

**(c)** $^{19}F$ is the only stable, naturally occurring *isotope* of the element. There are other radioactive isotopes, with $^{18}F$ having the longest half-life. It undergoes positron decay to give element **Z**, according to the equation as shown:

$$^{18}_{9}F \rightarrow {}^{x}_{y}Z + {}^{0}_{1}e$$

**(i)** What do you understand by the term *isotope*? [1]

**(ii)** Give the values of *x* and *y*, and hence identify element **Z**. [2]

**(d)** **(i)** Write a chemical equation to represent the lattice energy of $CaF_2$. [1]

**(ii)** The lattice energy of calcium fluoride is $-2630$ kJ $mol^{-1}$. Suggest, with reasons, how the magnitude of the lattice energy of calcium fluoride might compare to that of calcium oxide. [2]

**(e)** **(i)** The characteristic reactions of halogenoalkanes may be described as *nucleophilic substitution*. Explain why halogenoalkanes are susceptible to this type of reaction. [2]

**(ii)** Write an equation to show the reaction of chloroethane with excess alcoholic ammonia. Draw the displayed formula of the organic product obtained. [2]

**(iii)** State and explain how the rate of reaction in **(e)(ii)** changes when chloroethane is replaced by iodoethane. [2]

**(iv)** Suggest a simple chemical test to distinguish between chloroethane and iodoethane. [2]

[Total: 20]

**7** Chemicals are commonly used for more effective cleaning of surfaces.

**(a)** Acid cleaners are classified by their pH level and are mainly used for the removal of inorganic deposits.

Glycolic acid, $HOCH_2COOH$, is preferred over hydrochloric acid, HC*l*, for use on many metals and surfaces.

**(i)** Explain in terms of its structure why glycolic acid is acidic. [2]

Solutions containing same concentrations of glycolic acid and HC*l* were tested for corrosion on carbon steel and stainless steel. The results are shown below.

| | % mass loss | |
|---|---|---|
| test metal | glycolic | HC*l* |
| carbon steel | 0.17 | 2.03 |
| stainless steel | 0.008 | 0.53 |

**(ii)** Based on the above data, explain the differences in behaviour between glycolic acid and hydrochloric acid. [2]

**(iii)** The pH of a given solution of glycolic acid is 0.1. Calculate the the hydrogen ion concentration, $[H^+]$, of this solution. [2]

**(b)** Potassium hydroxide and ammonia are common alkaline cleaning agents. Alkaline cleaners can dissolve fats, oils, and protein-based substances.

**(i)** Calculate the pH of a 0.125 mol $dm^{-3}$ solution of potassium hydroxide. [2]

Ammonia is manufactured industrially from the Haber Process, where nitrogen and hydrogen react as follows.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

**(ii)** Describe this process including the catalyst involved, the conditions used, and the reasons why these particular conditions are chosen. [5]

A mixture of 0.105 mol of nitrogen and 0.150 mol of hydrogen was mixed in a 1.5 $dm^3$ container and allowed to reach equilibrium at a particular temperature.

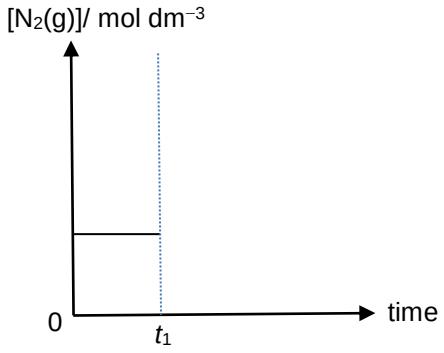
At equilibrium there was 0.09 mol of nitrogen present.

**(iii)** Explain, in terms of reaction rates, what is meant by a reaction which has reached equilibrium. [1]

**(iv)** Calculate the equilibrium constant, $K_c$, including units, if any, for this equilibrium. [5]

**(v)** The concentration of nitrogen in the equilibrium mixture determined in **(iv)** was increased at time, $t_1$, and the mixture was then allowed to re-establish equilibrium, at the same temperature.

Copy the diagram below and complete the graph to illustrate how the concentration of nitrogen changes with time when the stated change was made to the equilibrium system at time $t_1$.




[1]

[Total: 20]

**END OF PAPER**