

ST ANDREW'S JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATIONS

HIGHER 2

| CANDIDATE<br>NAME | STUDI | ENT WO | ORKED | SOLUT | IONS | <br> |  |  |  |  |
|-------------------|-------|--------|-------|-------|------|------|--|--|--|--|
| CLASS             | 2     | 1      | S     |       |      |      |  |  |  |  |

## CHEMISTRY

Paper 1 Multiple Choice

15 September 2022

9729/01

1 hour

Additional Materials: Multiple Choice 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 and class on the Answer Sheet in the spaces provided.

There are **thirty** 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.

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.

This document consists of **19** printed pages (including this cover page) and **1** blank page.

| 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 |
|----|----|----|----|----|----|----|----|----|----|
| С  | D  | С  | A  | В  | A  | A  | С  | В  | С  |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| С  | В  | D  | С  | С  | D  | D  | A  | D  | С  |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| С  | В  | D  | В  | А  | В  | В  | С  | В  | D  |

| 1 | Use of the Data Booklet is relevant to this question.          |  |  |  |  |  |  |
|---|--|--|--|--|--|--|--|
|   | Which statements about chromium and its compounds are correct? |  |  |  |  |  |  |
|   | 1  | The valence electronic configuration of Cr contains both an unpaired s electron and an                                 |  |  |  |  |  |
|   |  | unpaired p electron.   |  |  |  |  |  |
|   | 2  | One of the 3d orbitals in chromium atom has only 2 lobes.  |  |  |  |  |  |
|   | 3  | There are 58 electrons and 60 neutrons in the ${}^{52}Cr^{16}O_4{}^{2-}$ ion.  |  |  |  |  |  |
|   |  |  |  |  |  |  |  |
|   | Α  | 1, 2, and 3  |  |  |  |  |  |
|   | В  | 1 and 2  |  |  |  |  |  |
|   | C  | 2 and 3  |  |  |  |  |  |
|   | D  | 1 only   |  |  |  |  |  |
|   |  | 1. The electronic configuration of Cr is [Ar]3d <sup>5</sup> 4s <sup>1</sup> . Cr contains both an unpaired s electron |  |  |  |  |  |
|   |  | and an unpaired d electron (not p electron).   |  |  |  |  |  |
|   |  | 2. Only the $3d_z^2 d$ orbital has 2 lobes.  |  |  |  |  |  |
|   |  | 3. No of electrons = $24 + (4 \times 8) + 2 = 58$  |  |  |  |  |  |
|   |  | No of neutrons = $(52 - 24) + 4(16 - 8) = 60$  |  |  |  |  |  |
|   | Ans  | wer: C   |  |  |  |  |  |
|   |  |  |  |  |  |  |  |
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| 5 | Which description of Dalton's law is correct? |   |  |  |  |  |  |  |
|---|---|---|--|--|--|--|--|--|
|   | Α   | Equal volumes of gases at the same temperature and pressure contain equal numbers of                    |  |  |  |  |  |  |
|   |   | molecules.  |  |  |  |  |  |  |
|   | B   | The total pressure of a mixture of gases is equal to the sum of the partial pressures of                |  |  |  |  |  |  |
|   |   | those gases.  |  |  |  |  |  |  |
|   | С   | The partial pressure of a gas in mixture is given by the product of its mole fraction and the           |  |  |  |  |  |  |
|   |   | total pressure.   |  |  |  |  |  |  |
|   | D   | The partial pressure of a gas in a mixture is given by the product of its percent by mass               |  |  |  |  |  |  |
|   |   | and the total pressure.   |  |  |  |  |  |  |
|   | Ans   | wer: B  |  |  |  |  |  |  |
|   | Dal   | ton's Law of Partial Pressure:  |  |  |  |  |  |  |
|   | At o  | constant temperature, for gases which do not react chemically, the total pressure of a                  |  |  |  |  |  |  |
|   | mix   | cture of gases in a given volume is equal to the <b>sum</b> of the partial pressures of the constituent |  |  |  |  |  |  |
|   | gas   | es.   |  |  |  |  |  |  |
|   |   |   |  |  |  |  |  |  |
|   |   | $p_{T} = p_{A} + p_{B} + p_{C} + \dots$   |  |  |  |  |  |  |
|   |   |   |  |  |  |  |  |  |
|   |   |   |  |  |  |  |  |  |
|   |   |   |  |  |  |  |  |  |



| 7 | Wh   | ich property describes the trend for the hydrogen halides as stated below?  |  |  |  |  |
|---|--|---|--|--|--|--|
|   |  | HCI > HBr > HI  |  |  |  |  |
|   |  |   |  |  |  |  |
|   | A  | thermal stability   |  |  |  |  |
|   | В  | boiling point   |  |  |  |  |
|   | С  | ease of oxidation   |  |  |  |  |
|   | D  | acidity   |  |  |  |  |
|   | Opt  | ion A is correct as down the group, the bond length of H-X increases, bond strength   |  |  |  |  |
|   | dec  | reases and bond energy decreases. Hence thermal stability decreases down the group.   |  |  |  |  |
|   | Opt  | ion B is wrong as down the group, the size of electron cloud of H-X compound increases,   |  |  |  |  |
|   | it is  | more easily polarised, hence the strength of instantaneous dipole-induced dipole (id-id)  |  |  |  |  |
|   | inte   | ractions between molecules increases, more energy is needed to overcome the id-id   |  |  |  |  |
|   | inte   | ractions, resulting in higher boiling point.  |  |  |  |  |
|   |  |   |  |  |  |  |
|   | Opt  | tion C is wrong as the ease of oxidation of the compounds, $X^-$ increase down the group.   |  |  |  |  |
|   | Dov  | where the group, $E^{\bullet}(X_2/X^-)$ becomes less positive, X <sup>-</sup> is more readily oxidized to X <sub>2</sub> . Reducing |  |  |  |  |
|   | pov  | ver of X <sup>-</sup> increases down the group.   |  |  |  |  |
|   | Option D is wrong as acid strength increases down the group, i.e. HC/< HBr < HL Down the |   |  |  |  |  |
|   | gro  | up, size of halogen atom increases, -X bond length increases, H-X bond strength   |  |  |  |  |
|   | dec  | reases less energy required to break H-X bond. H-X dissociates to give H <sup>+</sup> more easily.                                  |  |  |  |  |
|   | Ans  | swer A  |  |  |  |  |
|   |  |   |  |  |  |  |
| 8 | Use  | e of the Data Booklet is relevant to this question.   |  |  |  |  |
|   | Wh   | ich contains the largest number of molecules?   |  |  |  |  |
|   | Α  | 810 cm <sup>3</sup> of sulfur dioxide gas (measured at r.t.p.)  |  |  |  |  |
|   | В  | 1.56 g of methyl methanoate   |  |  |  |  |
|   | C  | 5.25 cm <sup>3</sup> of ethanol where the density of ethanol is 0.755 g cm <sup>-3</sup>  |  |  |  |  |
|   | D  | 1./U x 10 <sup></sup> molecules of hydrogen peroxide.   |  |  |  |  |
|   | Am   | ount of $SO_2 = 810 / 24000 = 0.03375$ mol  |  |  |  |  |
|   | Am   | ount of methyl methanoate = $1.56 / 60 = 0.0260$ mol  |  |  |  |  |
|   | Ma   | ss of ethanol = $5.25 \times 0.755 = 3.964 \text{ g}$   |  |  |  |  |
|   | Am   | ount of ethanol = $3.964 / 46 = 0.0862$ mol   |  |  |  |  |





| Α                | 0.304 mol                               |                 |          | C | <mark>0.412 mol</mark> |                 |  |
|------------------|---|-----------------|----------|---|------------------------|-----------------|--|
| В                | 0.112 mol                               |                 |          | D | 0.346 mol              |                 |  |
|                  |   |                 |          |   |                        |                 |  |
| Мо               | I                                       | CH <sub>4</sub> | $H_2O =$ |   | СО                     | 3H <sub>2</sub> |  |
| Init             | ial                                     | 0.60            | x        |   | 0                      | 0               |  |
| Ch               | ange                                    | -у              | -у       |   | +y                     | +3y             |  |
| Eq               | m                                       | 0.60 – y x - y  |          |   | у                      | Зу              |  |
|                  |   | =0.30           | x-0.30   |   | 0.30                   | 0.90            |  |
| 3y =             | : 0.90                                  | 1               |          |   |                        |                 |  |
| y = 0            | 0.30                                    |                 |          |   |                        |                 |  |
| K <sub>c</sub> = | $\frac{(0.30)(0.90)^3}{(0.30)(x-0.30)}$ | = 6.5           |          |   |                        |                 |  |
| 0.03             | 336 = 0.3x - 0                          | 0.09            |          |   |                        |                 |  |
| 0.12             | 236 = 0.3x                              |                 |          |   |                        |                 |  |
| x =              | 0.412                                   |                 |          |   |                        |                 |  |
| Answer: C        |   |                 |          |   |                        |                 |  |
| _                |   |                 |          |   |                        |                 |  |



|    | Opt             | ion D: O-D is stronger than O-H bond since the ionisation of $D_2O$ is weaker than $H_2O$ .                  |  |  |  |  |  |
|----|-----------------|--|--|--|--|--|--|
|    | 000             |  |  |  |  |  |  |
|    | Ans             | Answer: B  |  |  |  |  |  |
|    |                 |  |  |  |  |  |  |
| 13 | The             | numerical values of the solubility product of calcium bydroxide and calcium carbonate are                    |  |  |  |  |  |
| 10 | 6.5             | $x 10^{-6}$ and $8.0 \times 10^{-7}$ respectively at 25 °C   |  |  |  |  |  |
|    | 0.5             | x to and 6.0 x to respectively at 25 °C.   |  |  |  |  |  |
|    | Wh              | ich statements are correct?  |  |  |  |  |  |
|    | 1               | A precipitate is formed when equal volumes of 0.001 mol dm <sup>-3</sup> calcium nitrate and a               |  |  |  |  |  |
|    |                 | solution of pH 12.5 are mixed.   |  |  |  |  |  |
|    | 2               | The solubility of calcium hydroxide in a solution of pH 12.5 is higher than the solubility of                |  |  |  |  |  |
|    |                 | calcium carbonate in water.  |  |  |  |  |  |
|    | 3               | The solubility product of calcium carbonate and calcium hydroxide decrease in a solution                     |  |  |  |  |  |
|    | -               | containing calcium nitrate   |  |  |  |  |  |
|    |                 |  |  |  |  |  |  |
|    | Δ               | 1.2 and 3  |  |  |  |  |  |
|    |                 | 1, 2, and 3  |  |  |  |  |  |
|    | D<br>C          |  |  |  |  |  |  |
|    |                 |  |  |  |  |  |  |
|    | U               |  |  |  |  |  |  |
|    | [OF             | f']=0.0316 mol dm <sup>-3</sup>  |  |  |  |  |  |
|    | IP =            | = (0.0316 / 2) <sup>2</sup> x (0.001/2) = <mark>1.25 x 10<sup>-/</sup> mol<sup>3</sup>dm<sup>-9</sup></mark> |  |  |  |  |  |
|    | Sin             | ce IP < Ksp, ppt is not formed.  |  |  |  |  |  |
|    | Op              | tion 1 is incorrect.   |  |  |  |  |  |
|    |                 |  |  |  |  |  |  |
|    | Ca              | $CO_3$ (s) $\rightleftharpoons$ $Ca^{2+}(aq) + CO_3^{2-}(aq)$  |  |  |  |  |  |
|    | S               | S S  |  |  |  |  |  |
|    | K <sub>sp</sub> | = [Ca <sup>2+</sup> ][CO <sub>3</sub> <sup>2-</sup> ]  |  |  |  |  |  |
|    | 8.0             | $x 10^{-7} = (s)(s)$   |  |  |  |  |  |
|    | s =             | $8.94 \times 10^{-4}$ mol dm <sup>-3</sup>   |  |  |  |  |  |
|    | Cal             | $(OH)_2(s) \rightleftharpoons Ca^{2+}(aq) + 2OH^{-}(aq)$   |  |  |  |  |  |
|    |                 |  |  |  |  |  |  |
|    | K               | - [Ca <sup>2+</sup> ][OH <sup>-</sup> ] <sup>2</sup>   |  |  |  |  |  |
|    | 6 F             | = [00 ] [00 ]  |  |  |  |  |  |
|    | 0.0             | 10 - (3)(23)   |  |  |  |  |  |
|    | s =             |  |  |  |  |  |  |
|    | The             | e solubility of calcium hydroxide in $pH = 12.5$ is calculated as follows.                                   |  |  |  |  |  |
|    | [OF             | +]=0.0316 mol dm <sup>-3</sup>   |  |  |  |  |  |



| 15 | Ros   | marinic acid can be found in herbs such as rosemary, sage and thyme. It has the          |
|----|-------|--|
|    | follo | wing structure.  |
|    |       |  |
|    |       | ОН   |
|    |       | O OH OH  |
|    |       |  |
|    |       |  |
|    |       |  |
|    |       | НО   |
|    |       | он<br>Он   |
|    |       |  |
|    | Whi   | ch functional groups will remain in the product after rosmarinic acid reacts with excess |
|    | hydi  | ogen gas in the presence of platinum?  |
|    |       |  |
|    | 1     | Alkene   |
|    | 2     | Carboxylic acid  |
|    | 3     | Ester  |
|    | 4     | Phenol   |
|    |       |  |
|    | Α     | 1 and 2  |
|    | В     | 3 and 4  |
|    | С     | 2, 3 and 4   |
|    | D     | 4 only   |
|    | Of t  | ne 4 functional groups present, hydrogen gas in the presence of a platinum catalyst will |
|    | only  | react with alkene, which will not be present in the product. The other 3 will remain.    |
|    | Ans   | C C  |
|    |       |  |
| 16 | Met   | hylbenzene can undergo the following reaction.   |
|    |       |  |
|    |       | CH3 CH3  |
|    |       | SO <sub>2</sub> C <i>l</i>   |
|    |       | $C/SO_3H$ + H <sub>2</sub> O   |
|    |       |  |
|    |       |  |
|    | Whi   | ch statement about the mechanism of this reaction is correct?                            |

|    | Α         | The hybridisation states of the carbon atoms in benzene do not change during the  |  |  |  |  |  |  |
|----|-----------|---|--|--|--|--|--|--|
|    |           | reaction.   |  |  |  |  |  |  |
|    | В         | The $\pi$ electron cloud of benzene will attack the O atom in C/SO <sub>3</sub> H.                                      |  |  |  |  |  |  |
|    | С         | C The mechanism of this reaction is electrophilic addition.   |  |  |  |  |  |  |
|    | D         | The bond broken in C/SO <sub>3</sub> H is the S-O bond.   |  |  |  |  |  |  |
|    | This      | type of reaction undergone is electrophilic substitution as the $\pi$ electrons in benzene is                           |  |  |  |  |  |  |
|    | rest      | ored. Hence Option C is wrong.  |  |  |  |  |  |  |
|    | As s      | een in the reaction, the bond formed between the benzene ring and $C/SO_3H$ is S. Hence                                 |  |  |  |  |  |  |
|    | the       | π electron attacks the S atom in C/SO <sub>3</sub> H and not the O atom. Hence, option B is wrong.                      |  |  |  |  |  |  |
|    | The       | intermediate formed during this reaction involves one of the carbon having 4 bonds.                                     |  |  |  |  |  |  |
|    | Hen       | ce, the hybridisation of this carbon changed from $sp^2$ to $sp^3$ and back to $sp^2$ when the $\pi$                    |  |  |  |  |  |  |
|    | elec      | trons in benzene are restored. Hence Option A is wrong.   |  |  |  |  |  |  |
|    | CIS       | $D_3H$ will lose the OH as seen from the product formed. Hence the bond broken has to                                   |  |  |  |  |  |  |
|    | invo      | lve S and O. Option D is correct.   |  |  |  |  |  |  |
|    | Ans       | D   |  |  |  |  |  |  |
|    |           |   |  |  |  |  |  |  |
| 17 | 1-br      | omo-2,2-dimethylpropane, (CH <sub>3</sub> ) <sub>3</sub> CCH <sub>2</sub> Br, can be obtained from 2,2-dimethylpropane, |  |  |  |  |  |  |
|    | (CH       | <sub>3</sub> ) <sub>4</sub> C, via free radical substitution with excess bromine. The yield however is low.             |  |  |  |  |  |  |
|    | vvna<br>A | Different mone substituted products are formed  |  |  |  |  |  |  |
|    | A         | The Pr Pr band requires a lot of energy to break  |  |  |  |  |  |  |
|    |           |   |  |  |  |  |  |  |
|    |           | The bromine radical is regenerated during the formation of (CH <sub>2</sub> ) <sub>2</sub> CCH <sub>2</sub> Br          |  |  |  |  |  |  |
|    |           | he H in 2.2-dimethylpropane are equivalent. Hence there is only 1 mono-brominated                                       |  |  |  |  |  |  |
|    | proc      | luct formed and no other isomers, making statement A wrong.   |  |  |  |  |  |  |
|    | Sinc      | e the reaction is carried out with excess bromine and bromine radical is regenerated                                    |  |  |  |  |  |  |
|    | durii     | ng the mechanism, this will result in a lot of bromine radicals, leading to a mixture of                                |  |  |  |  |  |  |
|    | proc      | lucts being formed.   |  |  |  |  |  |  |
|    | Ans       | D   |  |  |  |  |  |  |
|    |           |   |  |  |  |  |  |  |
| 18 | Mole      | ecule ${f M}$ is a halogenoalkane. It is reacted with various reagents to give the following                            |  |  |  |  |  |  |
|    | resu      | lts.  |  |  |  |  |  |  |
|    |           |   |  |  |  |  |  |  |
|    | •         | • <b>M</b> is first heated with NaOH(aq). After it has cooled, HNO <sub>3</sub> is added followed by                    |  |  |  |  |  |  |
|    |           | AgNO <sub>3</sub> . A precipitate appears and is only soluble in concentrated $NH_3$ .                                  |  |  |  |  |  |  |

|    | •  | • M reacts with ethanolic KCN when heated. The product reacted with $LiA/H_4$ in dry            |  |  |  |  |  |
|----|--|---|--|--|--|--|--|
|    |  | ether to yield a product that has the molecular formula $C_5H_{13}N$ .                          |  |  |  |  |  |
|    |  |   |  |  |  |  |  |
|    | Which conclusion can be drawn from these results?  |   |  |  |  |  |  |
|    | A  | There are 4 possible constitutional isomers for molecule <b>M</b> .                             |  |  |  |  |  |
|    | В  | When treated with ethanolic AgNO $_3$ , the precipitate for molecule ${f M}$ will appear slower |  |  |  |  |  |
|    |  | than 1-chlorobutane.  |  |  |  |  |  |
|    | С  | Molecule <b>M</b> contains 5 carbon atoms.  |  |  |  |  |  |
|    | D  | Molecule <b>M</b> is a tertiary halogenoalkane.   |  |  |  |  |  |
|    | Fron   | n the first reaction, molecule ${f M}$ is a bromoalkane. Hence, when reacted with ethanolic     |  |  |  |  |  |
|    | AgN  | $O_3$ , its ppt will appear faster than 1-chlorbutane. Hence option B is wrong.                 |  |  |  |  |  |
|    | Fron   | n the second reaction, it's a carbon extension reaction. Since the product after extension      |  |  |  |  |  |
|    | has  | 5 carbon atoms, molecule $\mathbf{M}$ can only contain 4 carbon atoms. Hence option C is wrong. |  |  |  |  |  |
|    | Mole   | ecule M would have a molecular formula of $C_4H_9X$ (where X = halogen). It can be a            |  |  |  |  |  |
|    | prim   | ary, secondary or tertiary halogenoalkane and there is not enough information about             |  |  |  |  |  |
|    | mole   | ecule <b>M</b> to conclude. Option D is wrong.  |  |  |  |  |  |
|    | The  | possible isomers for molecule <b>M</b> are  |  |  |  |  |  |
|    | CH <sub>2</sub>  | $XCH_2CH_2CH_3$ , $CH_3CH(X)CH_2CH_3$ , $CH_2XCH(CH_3)CH_3$ and $(CH_3)_3CX$                    |  |  |  |  |  |
|    | Ans:   | A   |  |  |  |  |  |
|    |  |   |  |  |  |  |  |
| 19 | Whie   | ch statement about $S_N1$ nucleophilic substitution mechanism is correct?                       |  |  |  |  |  |
|    | Α  | The rate of the reaction is dependent on the concentration of the nucleophile.                  |  |  |  |  |  |
|    | В  | If the product formed is chiral, it will be able to rotate the plane of polarised light.        |  |  |  |  |  |
|    | С  | Transition states are formed but not intermediates.   |  |  |  |  |  |
|    | D  | This usually takes place for tertiary halogenoalkanes.  |  |  |  |  |  |
|    | $S_N1$ nucleophilic substitution reactions takes places in 2 steps. The first step is the rate               |   |  |  |  |  |  |
|    | dete   | rmining step which involved the halogen leaving to produce a carbocation intermediate.          |  |  |  |  |  |
|    | Thus, the rate equation for such reaction is only k[RX] as the nucleophile is only involved in               |   |  |  |  |  |  |
|    | the 2 <sup>nd</sup> step which is fast. Rate of such reactions is thus independent of the nucleophile. Hence |   |  |  |  |  |  |
|    | state  | ement A and C is wrong.   |  |  |  |  |  |
|    | The  | intermediate formed from the first step is planar. This allows the nucleophile to attack        |  |  |  |  |  |
|    | from   | both the top and the bottom of the plane in equal proportion, giving rise to a racemic          |  |  |  |  |  |
|    | mixt   | ure. Hence, even if the product is chiral, it would not rotate the plane of polarised light.    |  |  |  |  |  |
|    | State  | ement B is thus wrong.  |  |  |  |  |  |

| As mentioned earlier, the first step involved the halogen leaving first to make space for the |
|---|
| nucleophile to attack. This would mean that this reaction favors tertiary halogenoalkanes as  |
| there are many bulky groups around the halogen, blocking the attack of the nucleophile.       |
| Ans: D  |
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| 20 | Con               | pound <b>E</b> has the following structure.   |
|----|-------------------|---|
|    |                   | OH  |
|    | Whi               | ch statements are correct about the organic product formed after compound E has   |
|    | read              | ted with hot acidified KMnO₄?   |
|    | 1                 | It contains 6 carbon atoms.   |
|    | 2                 | It can react with 3 moles of $PCl_5$ .  |
|    | 3                 | It gives a yellow ppt with alkaline aqueous iodine.   |
|    | 4                 | It can react with 2 moles of aqueous NaOH.  |
|    |                   |   |
|    | Α                 | 1 and 2   |
|    | B                 | 1 and 3   |
|    | C                 | 2 and 4   |
|    | D                 | 3 and 4   |
|    | Atte              | r compound <b>E</b> undergoes a reaction with not acidified KiVinO <sub>4</sub> , the 2 C=C are broken. This result in  |
|    | The<br>the<br>The | <ul> <li>In the second second</li></ul> |
|    | Ans               | <ul> <li>does not give a positive test with iodoform due to the lack of methyl alcohol and methyl ketone (statement 3 is incorrect)</li> <li>reacts with 2 moles of NaOH(aq) due to 2 COOH groups (statement 4 is correct)</li> </ul>   |
|    | 7115              | . •   |



| 22 | Compound L has the following structure.  |  |  |
|----|--|--|--|
|    | O<br>II  |  |  |
|    |  |  |  |
|    |  |  |  |
|    | Whic   | ch statement about compound L is <b>incorrect</b> ?  |  |
|    | Α  | It can undergo a condensation reaction.  |  |
|    | B  | It can undergo a hydrolysis reaction   |  |
|    | С  | It can undergo reduction reaction.   |  |
|    | D  | It can be attacked by a nucleophile.   |  |
|    | The  | ketone group present in the molecule can undergo a condensation reaction with              |  |
|    | 2,4-[  | DNPH and hence Option A is true.   |  |
|    | The ketone group can also undergo a reduction reaction to form a secondary alcohol and |  |  |
|    | hend   | ce Option C is true  |  |
|    | The  | C of ketone can also be attacked a nucleophile due to it being electron deficient as it is |  |
|    | attached to an electronegative O. Hence, Option D is also true.                        |  |  |
|    | Ketones cannot undergo hydrolysis.   |  |  |
|    | Ans: B   |  |  |
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| 23  | Man   | delic acid and 4-hydroxypher             | nylacetic acid are isomers. They have the following      |  |  |  |
|---|---|--|--|--|--|--|
|   | structures.   |  |  |  |  |  |
|   |   | но он                                    | HO   |  |  |  |
|   |   | Mandelic acid 4-hydroxyphenylacetic acid |  |  |  |  |
| Given that the p $K_a$ value of the carboxylic acid in mandelic acid is 3.75, which option 4-hydroxyphenylacetic acid is correct? |   |  | boxylic acid in mandelic acid is 3.75, which option abou |  |  |  |
|   |   | $pK_a$ of the carboxylic acid in         | Reason   |  |  |  |
|   |   | 4-hydroxyphenylacetic acid               |  |  |  |  |
|   | Α   | 3.25                                     | Lone pair of electrons on O of the phenol in             |  |  |  |
|   |   |  | 4-hydroxyphenylacetic acid can delocalise into the       |  |  |  |
|   |   |  | benzene ring   |  |  |  |
|   | В   | 3.25                                     | The alcohol group of mandelic acid is an electron        |  |  |  |
|   |   |  | withdrawing group  |  |  |  |
|   | С   | 4.05                                     | Lone pair of electrons on O of the phenol in             |  |  |  |
|   |   |  | 4-hydroxyphenylacetic acid can delocalise into the       |  |  |  |
|   |   |  | benzene ring   |  |  |  |
|   | D   | <mark>4.05</mark>                        | The alcohol group of mandelic acid is an electron        |  |  |  |
|   |   |  | withdrawing group  |  |  |  |
|   | The alcohol OH group in mandelic acid is nearer the carboxylic acid group. Hence, due electronegativity of O, it is an electron withdrawing group and hence able to better st the carboxylate ion of the conjugate base of mandelic acid, making mandelic acid a st acid than 4-hydroxyphenylacetic acid. Hence, 4-hydroxyphenylacetic acid is less acidi mandelic acid, resulting in it having a lower Ka but higher pKa value when compa mandelic acid. |  |  |  |  |  |
|   |   |  |  |  |  |  |
|   |   |  |  |  |  |  |

| 24 | Compounds <b>X</b> and <b>Y</b> have the following structures.   |  |  |
|----|--|--|--|
|    |  | $ \begin{array}{c} & & & \\ & & \\ \hline \\ & & \\ \hline \\ \\ & \\ \hline \\ \\ \hline \\ & \\ \hline \\ \\ \hline \\ \hline \\ \\ \hline \hline \\ \hline \hline \\ \hline \\ \hline \hline \\ \hline \\ \hline \\ \hline \hline \\ \hline \\ \hline \hline \\ \hline \\ \hline $ |  |
|    | Whie   | ch reagents can be used to distinguish them?   |  |
|    | 1  | Br <sub>2</sub> (aq)   |  |
|    | 2  | Fehling's solution and warm  |  |
|    | 3  | Tollens' reagent and warm  |  |
|    |  |  |  |
|    | A  | 1 only   |  |
|    | B  | 1 and 2  |  |
|    |  | 2 and 3  |  |
|    | $\mathbf{V}$ [1, 2 and 3]<br>Bro (ad) can be used as Compound $\mathbf{X}$ has the C-C but Compound $\mathbf{V}$ does not have any |  |  |
|    | functional group that will reaction with $Br_2$ (ag). Option 1 is possible.  |  |  |
|    | Fehling's solution can also be used as Compound <b>X</b> has an aliphatic aldehyde but Compound                                    |  |  |
|    | Y has a benzaldehyde which does not reaction with Fehling's solution. Option 2 is possible   |  |  |
|    | Tollens' reagent will react with the aldehyde groups in both the compounds and hence it  |  |  |
|    | cannot be used. Option 3 is not possible.  |  |  |
|    | Ans:   | В  |  |
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|    | Ans   | : A  |                         |  |
|----|---|--|-------------------------|--|
| 26 | Which option correctly shows the product and observation of the resultant solution when aqueous propanoic acid is added dropwise to aqueous propylamine until the reaction is |  |                         |  |
|    | complete?   |  |                         |  |
|    |   | Product formed   | Observations            |  |
|    | A   | CH <sub>3</sub> CH <sub>2</sub> CONHCH <sub>2</sub> CH <sub>2</sub> CH <sub>3</sub>  | One homogenous solution |  |
|    | B   | (CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> NH <sub>3</sub> ) <sup>+</sup> (CH <sub>3</sub> CH <sub>2</sub> COO)  | One homogenous solution |  |
|    | С   | CH <sub>3</sub> CH <sub>2</sub> CONHCH <sub>2</sub> CH <sub>2</sub> CH <sub>3</sub>  | Two distinct layers     |  |
|    | D   | $(CH_3CH_2CH_2NH_3)^+(CH_3CH_2COO)^-$  | Two distinct layers     |  |
| 27 | in a<br>Sinc<br>inter<br>Ans:<br>Aspa   | reaction between propanoic acid and propylamine is an acid-base reaction that will result<br>salt form and not an amide. Hence Option A and C are wrong.<br>De a salt is form, the salt will readily dissolve in water as it is able to form ion-dipole<br>raction with water, allowing it to dissolve readily to give a homogenous solution.<br>The B<br>martic acid is used in the biosynthesis of proteins and has the following structure.<br>$\begin{array}{c} O \\ HO \\ HO \\ HO \\ HO \\ HH_2 \end{array}$ |                         |  |
|    | Aspartic acid has $pK_a$ values of 2.0, 3.7 and 9.7.  |  |                         |  |
|    | At w  | At what pH will the major species in the solution be the zwitterion of aspartic acid?  |                         |  |
|    | Α   | 1.5  |                         |  |
|    | B   | <mark>3.4</mark>   |                         |  |
|    | С   | 7.0  |                         |  |
|    | D   | 10.3   |                         |  |
|    | The   | The pK <sub>a</sub> values assigned to aspartic acid are as follows.   |                         |  |

|    | •  | The $\alpha$ carboxylic group is 2.0 as it's the most acidic due to it being nearer the N of the   |  |  |
|----|--|--|--|--|
|    | $\alpha$ amino group which is electronegative and helps to stabilise the conjugate base ion                          |  |  |  |
|    |  | more than the side chain carboxylic group.   |  |  |
|    | •  | The side chain carboxylic group is hence assigned the pKa of 3.7   |  |  |
|    | •  | The $\alpha$ amino group is thus assigned the pK <sub>a</sub> of 9.7   |  |  |
|    | The  | zwitterion of aspartic acid is when one of the carboxylic groups and the $\boldsymbol{\alpha}$ amino group   |  |  |
|    | are protonated to produce a species that is electrically neutral. This would mean the $\alpha$                       |  |  |  |
|    | carboxylic group would be in the basic form and pH has to be above its $pK_a$ which is 2.1                           |  |  |  |
|    | This also means the $\alpha$ amino group would be in the acidic form and pH has to be below its                      |  |  |  |
|    | $pK_a$ which is 9.7. This would mean Options A and D are incorrect.  |  |  |  |
|    | As for option C, at pH 7.0, the side chain carboxylic group will be protonated (i.e. COO) as                         |  |  |  |
|    | the p  | bH is above its $pK_a$ which is 3.7. This would not result in the formation of the zwitterion.   |  |  |
|    | Ans:   | B  |  |  |
|    |  |  |  |  |
| 28 | A pe   | entapeptide has the following structure.   |  |  |
|    |  |  |  |  |
|    |  |  |  |  |
|    |  | H <sub>2</sub> N OH  |  |  |
|    |  | $\gamma$ NH $0$ 0  |  |  |
|    |  |  |  |  |
|    |  |  |  |  |
|    | Whie   | ch statement about this pentapeptide is <b>incorrect</b> ?   |  |  |
|    | Α  | When this pentapeptide reacts with aqueous $H_2SO_4$ the product will have an overall  |  |  |
|    |  | charge of 1+   |  |  |
|    | B  | This pentapentide contains 4 pentide bonds   |  |  |
|    |  | This pentapeptide is made up of 4 different types of gramine acids   |  |  |
|    |  | This periapeptide is made up of 4 different types of d-anino acids.<br>$M$ of this pertapeptide = (Sum of $M$ of all the $\alpha$ amine acids residues) = 72     |  |  |
|    | <b>D</b> <i>M</i> <sub>r</sub> or this pentapeptide = (Sum of M <sub>r</sub> of all the α-amino acids residues) – 72 |  |  |  |
|    |  | t and bases correct on sucrall charge of $(1, Option 1)$ is correct  |  |  |
|    | NH <sub>3</sub> <sup>+</sup> and hence carry an overall charge of +1. Option 1 is correct.                           |  |  |  |
|    | Sinc   | e this is a pentapeptide, it is made up of 5 $\alpha$ -amino acid residues and the number of   |  |  |
|    | pept   | ide bonds it will form is 4 (5 – 1). The bond in the side chain of the $3^{10} \alpha$ -amino acid is a  |  |  |
|    | amic   | de bond and not a peptide bond as it was not formed by $\alpha$ -amino acids. Option 2 is correct.   |  |  |
|    | Polypeptides are made of up $\alpha$ -amino acids, which all have the general formula,                               |  |  |  |
| 1  | $H_2NCH(R)COOH$ . They only differ by the R. For this pentapeptide, the R groups are (from left                      |  |  |  |
|    | 1 121 1  |  |  |  |
|    | to riç   | ght) -CH <sub>3</sub> , -H, -CH <sub>2</sub> CH <sub>2</sub> CONH <sub>2</sub> , -CH <sub>3</sub> and -H. Since the -CH <sub>3</sub> and -H groups are repeated, |  |  |

Polypeptides are formed from various  $\alpha$ -amino acid residues, When the  $\alpha$ -amino acids react to form the peptide bonds, water is lost. Since there are 4 peptide bonds formed in this pentapeptide, 4 water molecules are lost. The Mr of this pentapeptide is hence the sum of the Mr of all the α-amino acid residues minus away 4 water molecules which has a collective Mr of 72. Hence Option D is correct. Ans: C 29 Use of the Data Booklet is relevant to this question. Given the following information on the colours of the aqueous vanadium-containing ions, what is likely to be the colour change when excess nickel is added to a solution containing VO<sup>2+</sup>? Aqueous vanadium-Colour containing ions  $VO_2^+$ Yellow VO<sup>2+</sup> Blue V<sup>3+</sup> Green V<sup>2+</sup> Purple Α Blue to yellow B Blue to green С Blue to purple D Yellow to green Ni<sup>2+</sup> + 2e — Ni  $E^{0} = -0.25 \text{ V}$  $VO_2^+$  + 2H<sup>+</sup> + e = H<sub>2</sub>O + VO<sup>2+</sup>  $E^{0} = +1.00 \text{ V}$ yellow blue  $VO^{2+}$  + 2H<sup>+</sup> + e = H<sub>2</sub>O + V<sup>3+</sup>  $E^{\theta} = +0.34 \text{ V}$ blue green V<sup>3+</sup> + e - V<sup>2+</sup>  $E^{0} = -0.26 \text{ V}$ green purple



| В   | The overall charge of the complex ion is 4–.  |
|---|---|
| С   | The co-ordination number of the complex ion is 3.   |
| D   | The geometry of the complex ion is octahedral about Fe <sup>2+</sup> .                        |
| Opt   | ion A: Since the colour of the complex is red, the complex ion reflects red light and not     |
| absorb it.  |   |
|   |   |
| Option B – D:   |   |
| Fe <sup>2+</sup> : <i>ortho</i> -phenanthroline   |   |
| $= 1 \times 10^{-5} : 3 \times 10^{-5}$   |   |
| = 1 : 3   |   |
| Since ortho-phenanthroline is a bidentate ligand, there are 6 dative bonds formed             |   |
| (coordination number = 6) around $Fe^{2+}$ , resulting in an octahedral geometry. The overall |   |
| cha   | rge of the complex is +2 i.e. [Fe( <i>ortho</i> -phenanthroline) <sub>3</sub> ] <sup>2+</sup> |
|   |   |
| Ansv  | ver: D  |

## **END OF PAPER**