

ST ANDREW'S JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATIONS

HIGHER 2

CANDIDATE								
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9729/01

1 hour

15 September 2022

CHEMISTRY

Paper 1 Multiple Choice

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 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.
- **A** 1, 2, and 3
- **B** 1 and 2
- **C** 2 and 3
- D 1 only
- 2 The following graph shows the second ionisation energy of eight consecutive elements in Period 2 and 3.



Which of the options **A**, **B**, **C** or **D** is silicon?

3 Which option is correct?

	Molecule	Planar	Polarity
Α	Xenon difluoride	Yes	Polar
В	Chlorine(I) oxide	No	Non-polar
С	Methanal	Yes	Polar
D	Dichloromethane	No	Non-polar

[TURN OVER

- 4 Which statements about ethanoic acid are correct?
 - 1 1 molecule of ethanoic acid has 4 lone pairs of electrons.
 - 2 Gaseous ethanoic acid forms a dimer comprising of two hydrogen bonds within a ring of 8 atoms.
 - 3 The C–C bond in ethanoic acid is formed from a sp^3-sp^2 orbital overlap.
 - **A** 1, 2 and 3
 - **B** 1 and 2
 - **C** 2 and 3
 - D 1 only
- 5 Which description of Dalton's law is correct?
 - A 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.
 - **C** 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.

6 Which graph shows the correct trends when the physical property of each of the elements Na, A*l*, Si and S is plotted against its atomic radius?



7 Which property describes the trend for the hydrogen halides as stated below?

- A thermal stability
- **B** boiling point
- **C** ease of oxidation
- D acidity

8 Use of the Data Booklet is relevant to this question.

Which contains the largest number of molecules?

- A 810 cm³ of sulfur dioxide gas (measured at r.t.p.)
- B 1.56 g of methyl methanoate
- C 5.25 cm³ of ethanol where the density of ethanol is 0.755 g cm⁻³
- **D** 1.70×10^{22} molecules of hydrogen peroxide.
- **9** Silane, SiH₄, exists as a gas at standard temperature and pressure. Hess' Law can be used to calculate the average Si–H bond energy in gaseous SiH₄. Which information is needed to perform the calculation?
 - **A** $\Delta H^{\theta}_{\text{formation}}(\text{SiH}_4)$ only
 - **B** ΔH^{θ} atomisation(Si), ΔH^{θ} atomisation(H), ΔH^{θ} formation(SiH₄)
 - **C** ΔH^{θ} combustion(Si), ΔH^{θ} combustion(H₂), ΔH^{θ} combustion(SiH₄)
 - **D** $\Delta H^{\theta}_{\text{combustion}}(\text{Si}), \Delta H^{\theta}_{\text{combustion}}(\text{H}_2), \Delta H^{\theta}_{\text{formation}}(\text{SiH}_4)$

10 The decomposition of Arsine, AsH₃, is catalysed by Arsenic, As, and can be represented by the following equation.

$$AsH_3 \rightarrow As + \frac{3}{2}H_2$$

Which graph does not describe the above reaction?



11 Steam reforming process is the most common method used for the industrial production of hydrogen.

$$CH_4(g) + H_2O(g) = CO(g) + 3H_2(g)$$
 $K_c = 6.50 \text{ mol}^2 \text{ dm}^{-6}$

What is the number of moles of steam used to react with 0.60 mol of methane, to form 0.90 mol of hydrogen in a 1 dm³ vessel?

 A
 0.304 mol
 C
 0.412 mol

 B
 0.112 mol
 D
 0.346 mol

12 Deuterium oxide, otherwise known as 'heavy water', consists of an oxygen atom bonded to two atoms of the hydrogen isotope, deuterium $\binom{2}{1}D$.

Like water, deuterium oxide can undergo autoionisation. For D₂O, we can use the term K_D instead of K_W .

$$2D_2O \Longrightarrow D_3O^+ + OD^-$$

The following graph show how the values of K_W of H₂O and K_D of D₂O vary with temperature.



Which deduction is correct?

- **A** The enthalpy changes of autoionisation for both H_2O and D_2O are negative.
- **B** The extent of ionisation is smaller for D_2O .
- **C** [OH⁻] and [OD⁻] decrease with increasing temperature.
- **D** O–D bond is weaker than O–H bond.

13 The numerical values of the solubility product of calcium hydroxide and calcium carbonate are 6.5×10^{-6} and 8.0×10^{-7} respectively at 25 °C.

Which statements are correct?

- 1 A precipitate is formed when equal volumes of 0.001 mol dm⁻³ 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.
- A 1, 2, and 3
- **B** 1 and 2
- C 2 and 3
- D 2 only
- 14 How many stereoisomers does the following molecule have?



- **A** 16
- **B** 64
- **C** 128
- **D** 256

15 Rosmarinic acid can be found in herbs such as rosemary, sage and thyme. It has the following structure.



Which functional groups will remain in the product after rosmarinic acid reacts with excess hydrogen gas in the presence of platinum?

- 1 Alkene
- 2 Carboxylic acid
- 3 Ester
- 4 Phenol
- **A** 1 and 2
- **B** 3 and 4
- **C** 2, 3 and 4
- **D** 4 only

16 Methylbenzene can undergo the following reaction.



Which statement about the mechanism of this reaction is correct?

- A The hybridisation states of the carbon atoms in benzene do not change during the reaction.
- **B** The π electron cloud of benzene will attack the O atom in ClSO₃H.
- **C** The mechanism of this reaction is electrophilic addition.
- **D** The bond broken in $ClSO_3H$ is the S-O bond.
- 17 1-bromo-2,2-dimethylpropane, (CH₃)₃CCH₂Br, can be obtained from 2,2-dimethylpropane, (CH₃)₄C, via free radical substitution with excess bromine. The yield however is low.
 What is the main reason for this?
 - A Different mono-substituted products are formed.
 - **B** The Br-Br bond requires a lot of energy to break.
 - **C** $(CH_3)_3CCH_2Br$ is very unstable.
 - **D** The bromine radical is regenerated during the formation of (CH₃)₃CCH₂Br.

- **18** Molecule **M** is a halogenoalkane. It is reacted with various reagents to give the following results.
 - **M** is first heated with NaOH(aq). After it has cooled, HNO₃ is added followed by AgNO₃. A precipitate appears and is only soluble in concentrated NH₃.
 - **M** reacts with ethanolic KCN when heated. The product reacted with LiA*l*H₄ in dry ether to yield a product that has the molecular formula C₅H₁₃N.

Which conclusion can be drawn from these results?

- **A** There are 4 possible constitutional isomers for molecule **M**.
- **B** When treated with ethanolic AgNO₃, the precipitate for molecule **M** will appear slower than 1-chlorobutane.
- **C** Molecule **M** contains 5 carbon atoms.
- **D** Molecule **M** is a tertiary halogenoalkane.
- **19** Which statement about S_N1 nucleophilic substitution mechanism is correct?
 - **A** The rate of the reaction is dependent on the concentration of the nucleophile.
 - **B** If the product formed is chiral, it will be able to rotate the plane of polarised light.
 - **C** Transition states are formed but not intermediates.
 - **D** This usually takes place for tertiary halogenoalkanes.

20 Compound **E** has the following structure.



Which statements are correct about the organic product formed after compound E has reacted 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.
- A 1 and 2
- **B** 1 and 3
- **C** 2 and 4
- **D** 3 and 4

- 21 Alcohol **Q** undergoes the following reactions.
 - With concentrated H₂SO₄ at 170°C, only one product is formed.
 - With hot acidified K₂Cr₂O₇, a green solution is formed that does not produce effervescence with Na₂CO₃.

What could be the identity of Q?



22 Compound L has the following structure.



Which statement about compound L is incorrect?

- A It can undergo a condensation reaction.
- **B** It can undergo a hydrolysis reaction
- **C** It can undergo reduction reaction.
- **D** It can be attacked by a nucleophile.

23 Mandelic acid and 4-hydroxyphenylacetic acid are isomers. They have the following structures.



Mandelic acid

4-hydroxyphenylacetic acid

Given that the pK_a value of the carboxylic acid in mandelic acid is 3.75, which option about 4-hydroxyphenylacetic acid is correct?

	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	4.05	The alcohol group of mandelic acid is an electron		
		withdrawing group		

24 Compounds X and Y have the following structures.



Compound X

Compound Y

Which reagents can be used to distinguish them?

- 1 Br₂(aq)
- 2 Fehling's solution and warm
- 3 Tollens' reagent and warm
- A 1 only
- **B** 1 and 2
- **C** 2 and 3
- **D** 1, 2 and 3

25 Phthalate esters are mainly used in plasticisers to increase their flexibility, transparency and durability. They have the following structure.



Which pair of compounds can react to form a phthalate ester?



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?

- $A \qquad CH_3CH_2CONHCH_2CH_2CH_3$
- $\mathbf{B} \quad (CH_3CH_2CH_2NH_3)^+(CH_3CH_2COO)^-$
- C CH₃CH₂CONHCH₂CH₂CH₃
- $\mathbf{D} \quad (CH_3CH_2CH_2NH_3)^+(CH_3CH_2COO)^-$

Observations One homogenous solution One homogenous solution Two distinct layers Two distinct layers 27 Aspartic acid is used in the biosynthesis of proteins and has the following structure.



Aspartic acid has pK_a values of 2.0, 3.7 and 9.7.

At what pH will the major species in the solution be the zwitterion of aspartic acid?

- **A** 1.5
- **B** 3.4
- **C** 7.0
- **D** 10.3
- 28 A pentapeptide has the following structure.



Which statement about this pentapeptide is incorrect?

- A When this pentapeptide reacts with aqueous H₂SO₄, the product will have an overall charge of 1+.
- **B** This pentapeptide contains 4 peptide bonds.
- **C** This pentapeptide is made up of 4 different types of α -amino acids.
- **D** M_r of this pentapeptide = (Sum of M_r of all the α -amino acids residues) 72

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^{2+} ?

Aqueous vanadium-	Colour		
containing ions			
VO ₂ +	Yellow		
VO ²⁺	Blue		
V ³⁺	Green		
V ²⁺	Purple		

- A Blue to yellow
- **B** Blue to green
- **C** Blue to purple
- **D** Yellow to green

30 Fe²⁺ forms a red complex with *ortho*-phenanthroline. Various samples containing different volumes of 1×10^{-5} mol dm⁻³ Fe²⁺ and 3×10^{-5} mol dm⁻³ *ortho*-phenanthroline were prepared. The structure of *ortho*-phenanthroline is shown below. Each *ortho*-phenanthroline molecule is a bidendate ligand.



ortho-phenanthroline

The following graph was obtained when the colour intensity of the samples was measured using a colorimeter.



Which statement about the complex ion is correct?

- A The complex ion absorbs red light.
- **B** The overall charge of the complex ion is 4–.
- **C** The co-ordination number of the complex ion is 3.
- **D** The geometry of the complex ion is octahedral about Fe²⁺.

END OF PAPER

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