# Catholic Junior College

## JC 2 Preliminary Examinations

## Higher 2

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|---|---|
| **CANDIDATE NAME** | |
| **CLASS** | **2T** |

# CHEMISTRY 9729/01

**Paper 1 Multiple Choice** **September 2021**

**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, class and NRIC/FIN number 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.

**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.

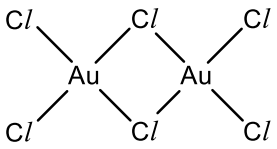
This document consists of **12** printed pages.

**1** Nitrogen exists as a diatomic molecule, $N_2$. Hydrazine, $N_2H_4$, and dinitrogen difluoride, $N_2F_2$, are compounds of nitrogen.

Which of the following gives the correct number of $\pi$ bonds in $N_2$, $N_2H_4$ and $N_2F_2$?

| | number of $\pi$ bonds in $N_2$ | number of $\pi$ bonds in $N_2H_4$ | number of $\pi$ bonds in $N_2F_2$ |
|---|---|---|---|
| **A** | 2 | 0 | 1 |
| **B** | 2 | 1 | 1 |
| **C** | 1 | 1 | 2 |
| **D** | 3 | 0 | 2 |

**2** Aluminium chloride is a covalent compound that forms a dimer with the formula $Al_2Cl_6$. A compound of gold and chlorine has a similar molecular formula of $Au_2Cl_6$ and has the following structure:




The three statements below are properties of the gold compound, $Au_2Cl_6$.

1 The oxidation state of the metal is +3.
2 The dimer exists in the vapour phase.
3 The Cl-Au-Cl bond angle is 90°.

Which property described is **different** from that of the aluminium compound, $Al_2Cl_6$?

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

**3** The table below lists three compounds:

| compound | boiling point / $^{o}$C |
|---|---|
| $CH_3CH_2$–S–H | 35 |
| $CH_3$–S–$CH_3$ | 37 |
| $CH_3CH_2$–O–H | 78 |

Which of the following statements about the compounds is true?

**A** The C–S–H bond angle is larger than the C–O–H bond angle because S is larger than O.
**B** $CH_3CH_2$–S–H has weaker intermolecular hydrogen bonding than $CH_3CH_2$–O–H.
**C** $CH_3CH_2$–S–H and $CH_3$–S–$CH_3$ have similar boiling points because they have intermolecular permanent dipole – permanent dipole forces of attraction of similar strengths.
**D** $CH_3CH_2$–O–H has the highest boiling point because the O–H bond energy is higher than the S–H bond energy.

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

An isotope of a metal, **Z**, undergoes radioactive decay to form helium and an element hafnium, Hf, according to the following equation.

$$\mathbf{Z} \longrightarrow {}^{4}_{2}\mathrm{He} + \mathrm{Hf}$$

Given that Hf has a nucleon number of 176, which row correctly shows the identity and composition of **Z**?

| | identity of **Z** | number of nucleons in **Z** |
|---|---|---|
| **A** | tungsten | 180 |
| **B** | tungsten | 178 |
| **C** | osmium | 180 |
| **D** | osmium | 178 |

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

The first six ionisation energies of an element, **Y**, in kJ $mol^{-1}$ are shown.

738; 1451; 7733; 10543; 13630; 18020

**Y** forms an oxide by heating **Y** with oxygen gas.
What is the *spdf* electronic configuration of **Y** in its oxide form?

**A** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$
**B** $1s^2\ 2s^2\ 2p^6$
**C** $1s^2\ 2s^2\ 2p^6\ 3s^2$
**D** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$

**6** What is the element that has a **second** ionisation energy lower than that of each of the elements either side of it in the Periodic Table?

**A** boron **B** nitrogen **C** oxygen **D** fluorine

**7** Analysis of a mixture of two sulfur-containing gases show that hydrogen sulfide, $H_2S$, and carbon sulfide, $CS_2$, are present in a 3 : 1 mole ratio.

This mixture is burned in excess oxygen.
What will be the $CO_2$ : $SO_2$ mole ratio in the mixture obtained after complete combustion?

**A** 1 : 2 **B** 1 : 3 **C** 1 : 4 **D** 1 : 5

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

A mordant is a soluble salt which forms an acidic aqueous solution and improves the binding of the molecules of a dyestuff to a material.

Which solution is least likely to be used as a mordant in the dyeing process?

**A** sodium sulfate
**B** magnesium sulfate
**C** aluminium sulfate
**D** iron(II) sulfate

**9** Element **X** is in Period 3 of the Periodic Table. The following four statements describe the properties of element **X** or its compounds.

Three statements are correct descriptions. One of the statements is not correct because it does not fit with the other three.

Which statement is **not** correct?

**A** Element **X** is a solid at room temperature which conducts electricity.

**B** The chloride of element **X** reacts with water to give an acidic solution.

**C** The oxide of element **X** reacts in water to give an acidic solution.

**D** Adding NaOH(aq) to the solution resulting from the reaction of **X**C$l_3$ with water produces a white precipitate which is soluble in an excess of NaOH(aq).

**10** Which property generally increases down Group 2?

**A** charge density of $M^{2+}$ ion
**B** electronegativity
**C** melting point
**D** thermal stability of the carbonate

**11** A comproportionation reaction is a chemical reaction where two reactants, each containing the same element but with a different oxidation number, form a product in which the elements involved reach the same oxidation number.

2 mol of hydrogen sulfide, $H_2S$, react with 1 mol of another sulfur-containing compound to form 3 mol of elemental sulfur, S, in a comproportionation reaction.

What is a possible identity of the sulfur-containing compound?

**A** $SO_2$ **B** $SO_3$ **C** $H_2SO_4$ **D** S$Cl_2$

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

Dinitrogen oxide, N=N=O, burns in ethyne, $C_2H_2$, to produce water vapour, carbon dioxide and nitrogen gas according to the following equation.

$$5N_2O(g) + C_2H_2(g) \rightarrow H_2O(g) + 2CO_2(g) + 5N_2(g)$$

The enthalpy change for this reaction is –1668 kJ $mol^{-1}$ and in dinitrogen oxide, the N=N bond energy has a value of +418 kJ $mol^{-1}$. With reference to other appropriate bond energy data from the *Data Booklet*, what is the N=O bond energy in dinitrogen oxide?

**A** 344 kJ $mol^{-1}$
**B** 688 kJ $mol^{-1}$
**C** 1354 kJ $mol^{-1}$
**D** 3442 kJ $mol^{-1}$

**13** Which of the following is an endothermic process?

1 The combustion of methane
2 The condensation of steam
3 The electrolysis of water
4 The sublimation of iodine

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

**14** At 1200 K, in the presence of gold catalyst, dinitrogen oxide, $N_2O$, decomposes according to the equation below.

$$2N_2O(g) \rightarrow 2N_2(g) + O_2(g)$$

The following data is obtained in an experiment.

| time, *t* / s | 0 | 1030 | 2360 | 4230 | 7430 |
|---|---|---|---|---|---|
| partial pressure of $N_2O$ / kPa | 25.0 | 20.0 | 15.0 | 10.0 | 5.0 |

Which of the following statements is correct?

1 The partial pressure of $N_2O$ at any given time is not affected by temperature.
2 The reaction is first order with respect to $N_2O$.
3 The value of the rate constant remains unchanged in the absence of gold.
4 The total pressure at the completion of the reaction can be determined from the above data.

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

**15** The reaction shown below takes place via a one-step mechanism.

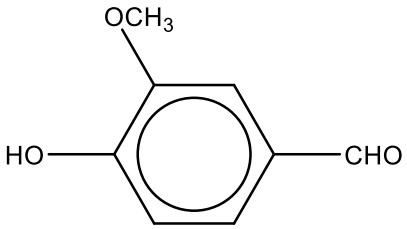
$$A(g) + 2B(g) \rightleftharpoons C(g)$$

Which of the following statements is most likely to be correct?

1 The yield of C increases at lower pressure.
2 The yield of C decreases when the volume of the reaction vessel is halved.
3 The equilibrium concentration of C is given by the expression: $[C] = K_C[A][B]^2$
4 The rate of the forward reaction is given by the expression: rate = $k[A][B]^2$

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

**16** Vanillin is the key flavour compound in vanilla, and its structure is shown.




vanillin

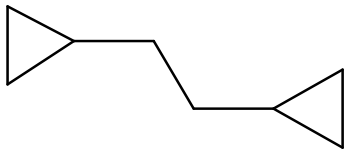
How many $sp^2$ hybridised carbons are there in a molecule of vanillin?

**A** 5 **B** 6 **C** 7 **D** 8

**17** A non-cyclic organic compound has the molecular formula $C_3H_4O_2$.
Which combination of functional groups **cannot** be present in this molecule?

**A** one alkene and one carboxylic acid group
**B** one alkene and one ester group
**C** one alkene and two alcohol groups
**D** one aldehyde and one ketone group

**18** Compound **W**, $C_8H_{14}$, reacts with chlorine gas in the presence of *uv* light.



**W**

Which of the following statements about this reaction is correct?

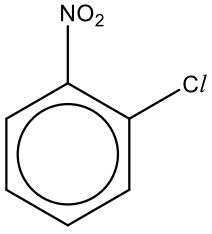
1 The maximum number of mono-chlorinated constitutional isomers with formula $C_8H_{13}Cl$ is 3.
2 $C_{16}H_{28}$ is present in small quantities in the product.
3 Homolytic fission only occurs in the initiation step.

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

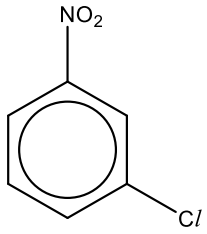
**19** When nitrobenzene is heated with $BrCl$ and $AlBr_3$, a mono-halogenated product is formed.

Which product is most likely to be formed?

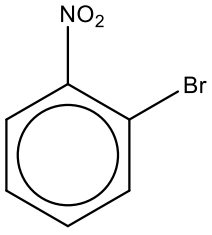
**A**



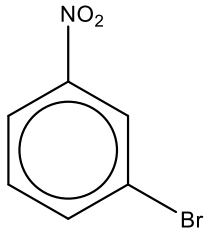

**B**




**C**

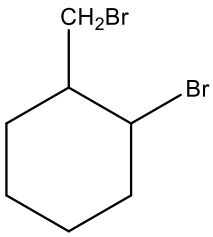



**D**

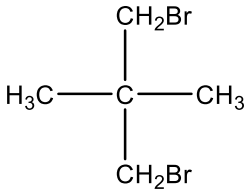


**20** 1 mol of organic compound **V** reacts with ethanolic sodium hydroxide to form 2 mol of HBr. What could **V** be?

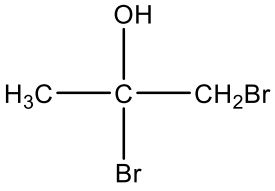
**A**



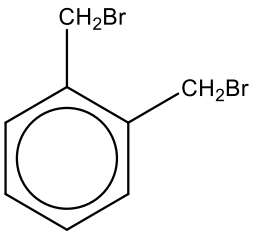

**B**



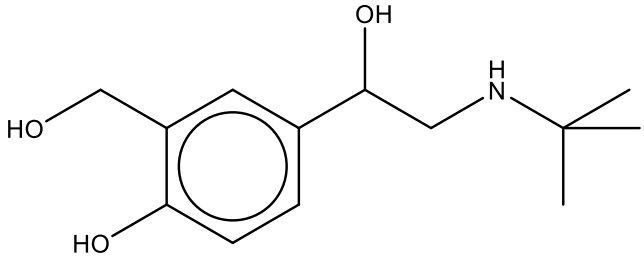

**C**




**D**




**21** Salbutamol is a common medicine used to alleviate asthma attacks.




salbutamol

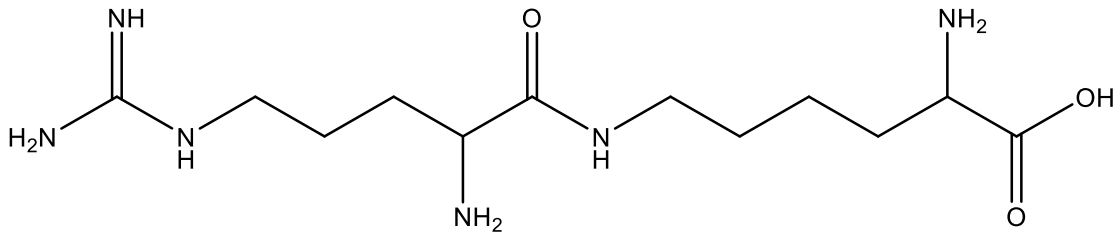
Which statement about 1 mol of salbutamol is **incorrect**?

**A** It reacts with 4 mol of ethanoyl chloride, $CH_3COCl$, to form 3 ester and 1 amide group.
**B** It reacts with excess acidified $K_2Cr_2O_7$(aq) to form 1 carboxylic acid and 1 ketone group.
**C** It reacts with 3 mol of sodium metal.
**D** It reacts with 2 mol of NaOH(aq).

**22** Which of the following shows the correct order of decreasing p$K_a$?

**A** $C_6H_5OH$ > $CH_3CH_2OCOH$ > $CH_3CH_2CO_2H$ > $CH_3CHFCO_2H$
**B** $CH_3CH_2OCOH$ > $C_6H_5OH$ > $CH_3CH_2CO_2H$ > $CH_3CHFCO_2H$
**C** $CH_3CHFCO_2H$ > $CH_3CH_2CO_2H$ > $C_6H_5OH$ > $CH_3CH_2OCOH$
**D** $CH_3CH_2OCOH$ > $CH_3CHFCO_2H$ > $CH_3CH_2CO_2H$ > $C_6H_5OH$

**23** Compound **U** is a by-product formed in the body to counteract the effect of the drug administered to treat herpes.




compound **U**

Which one of the following statements about compound **U** is correct?

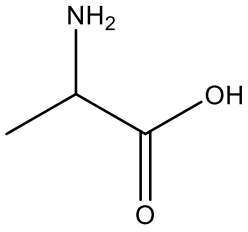
**A** **U** undergoes nucleophilic addition with chloroethane.
**B** 1 mol of **U** can be hydrolysed to produce 2 mol of amino acids.
**C** 1 mol of **U** can react with 6 mol of hydrochloric acid at room temperature.
**D** When an aqueous solution of **U** at pH 3 is analysed by electrophoresis, it is found near the anode.

**24** A compound **T** is boiled with aqueous sodium hydroxide and the resulting mixture cooled and acidified. The final product includes a compound $C_3H_6O_2$ and an alcohol that gives a positive iodoform test.

Which formula could represent compound **T**?

**A** $CH_3CH_2CO_2CH_2CH_2Cl$
**B** $CH_3CH_2OCOCH_3$
**C** $CH_3OCOCH_2COCH_3$
**D** $CH_3CH_2CO_2CH_2CHClCH_3$

**25** Which of the following is **not** a correct statement about *alanine* extracted from silkworm?




alanine

**A** *Alanine* is able to rotate plane-polarised light.
**B** *Alanine* has a higher solubility in water than in ether.
**C** *Alanine* can react with ethanoic acid to give an amide.
**D** An aqueous solution of *alanine* has a buffering capacity.

**26** The equation below shows a ligand exchange reaction.

$$[Cu(H_2O)_6]^{2+}(aq) + 4NH_3(aq) \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+}(aq) + 4H_2O(l)$$

Which is a possible reason to explain why $NH_3$ ligands displace $H_2O$ ligands?

**A** $\Delta S$ is positive for the displacement reaction.
**B** $NH_3$ is more tightly bound to $Cu^{2+}$ ions than $H_2O$.
**C** The energy difference for d→d transition in $[Cu(NH_3)_4(H_2O)_2]^{2+}(aq)$ is greater than that in $[Cu(H_2O)_6]^{2+}(aq)$.
**D** The pH of $NH_3$ is higher than the pH of $H_2O(l)$

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

The table below gives data about some physical properties of the elements calcium and copper.
Which row gives the correct properties under the correct element?

| | | calcium | copper |
|---|---|---|---|
| **A** | melting point / K | 1358 | 1112 |
| **B** | density / g $cm^{-3}$ | 1.54 | 8.92 |
| **C** | first ionisation energy / kJ $mol^{-1}$ | 745 | 590 |
| **D** | atomic radius (metallic) / nm | 0.128 | 0.197 |

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

The silver chloride electrode is a type of reference electrode commonly used in electrochemical measurements. It can be represented as below.

$$AgCl(s) + e^- \rightleftharpoons Ag(s) + Cl^-$$

The reduction potential of $Cr^{3+}/Cr^{2+}$ half-cell is −0.61 V when it is measured using the AgCl /Ag reference electrode at standard conditions.

What is the reduction potential of AgCl /Ag electrode when it is measured against the standard hydrogen electrode as reference?

**A** +0.80 V **B** +0.41 V **C** +0.20 V **D** –0.41V

**29** A voltaic cell is set up using the $Mg^{2+}/Mg$ and $Fe^{3+}/Fe^{2+}$ half-cells.

$Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s)$ $\quad E^{\ominus}_{Mg^{2+}/Mg} = -2.38$ V

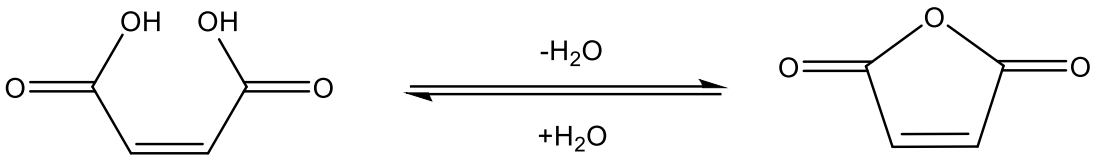
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$ $\quad E^{\ominus}_{Fe^{3+}/Fe^{2+}} = +0.77$ V

Under standard conditions, the cell e.m.f. would be 3.15 V. However, the voltmeter recorded a reading of 3.05 V.

What is the best explanation for this lower e.m.f.?

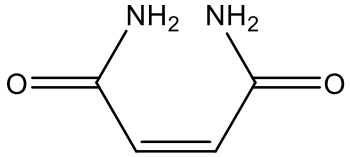
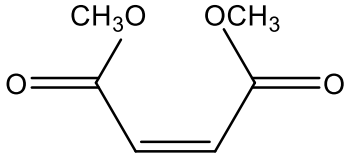
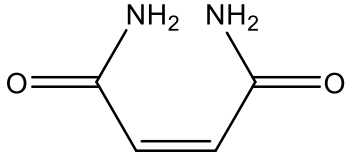
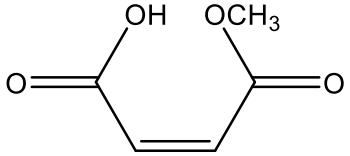
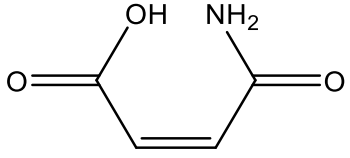
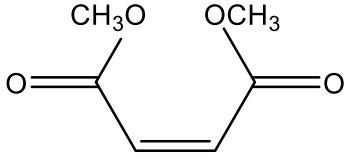
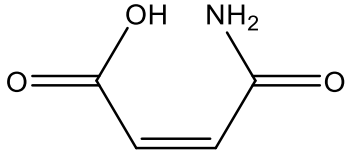
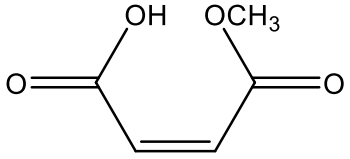
**A** a smaller magnesium electrode was used
**B** a higher concentration of $Fe^{3+}$ was used
**C** a higher concentration of $Mg^{2+}$ was used
**D** water evaporated from the $Fe^{3+}/Fe^{2+}$ half-cell

**30** Maleic acid loses water on strong heating to form compound **S**. On addition of water to compound **S**, it reforms maleic acid.




maleic acid $\qquad$ compound **S**

Which of the following shows the correct compounds formed when ammonia and methanol are added to compound **S** separately?

| | Addition of $NH_3$ | Addition of $CH_3OH$ |
|---|---|---|
| **A** |  |  |
| **B** |  |  |
| **C** |  |  |
| **D** |  |  |