**RAFFLES INSTITUTION**
**2023 YEAR 6 PRELIMINARY EXAMINATION**

Higher 2

# CHEMISTRY 9729/01

**Paper 1 Multiple Choice**

**22 September 2023**

**1 hour**

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

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**READ THESE INSTRUCTIONS FIRST**

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

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, class and index number 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 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.
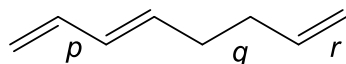Any rough working should be done in the question booklet.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **13** printed pages and **1** blank page.

1   Which simple covalent molecule is non-polar?

**A**   $CH_2F_2$   **B**   $SF_4$   **C**   $NF_3$   **D**   $BeF_2$

2   In octa-1,3,7-triene, three of the carbon-carbon bonds are labelled *p*, *q* and *r*.



octa-1,3,7-triene

What is the correct order of **decreasing** bond strength?

**A**   $p \rightarrow r \rightarrow q$
**B**   $p \rightarrow q \rightarrow r$
**C**   $r \rightarrow q \rightarrow p$
**D**   $r \rightarrow p \rightarrow q$

3   Which bonding type does **not** correspond to its description of physical properties?

| | bonding type | physical properties |
|---|---|---|
| **A** | giant covalent | high melting point, conducts electricity when in solution but not when solid |
| **B** | simple covalent | low melting point, does not conduct electricity in any state |
| **C** | metallic | variety of melting points, conducts electricity when solid and when molten |
| **D** | ionic | high melting point, conducts electricity when molten but not when solid |

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

The table shows the seventh, eighth, ninth and tenth ionisation energies of an element in the third period.

| | 7th | 8th | 9th | 10th |
|---|---|---|---|---|
| ionisation energy / kJ mol$^{-1}$ | 20 117 | 25 496 | 28 932 | 141 362 |

Which element has these ionisation energy values?

**A**   Na   **B**   Mg   **C**   A*l*   **D**   Si

**5** Down the group, the atomic radius of the elements increases.

Which statements explain this?

1 The number of protons increases.

2 The number of electronic shells increases.

3 The electrostatic forces of attraction between the nucleus and valence electrons increases.

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

**6** X and Y are two different samples of the same ideal gas.

Given that X contains a higher mass than Y, which graph shows the correct ideal gas relationship for the two samples of gas?
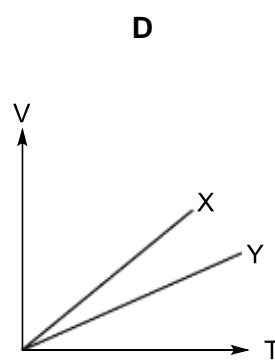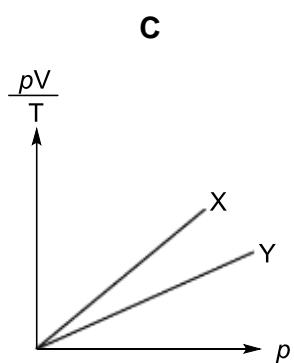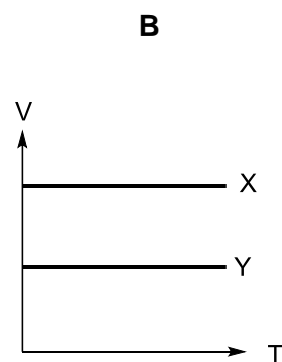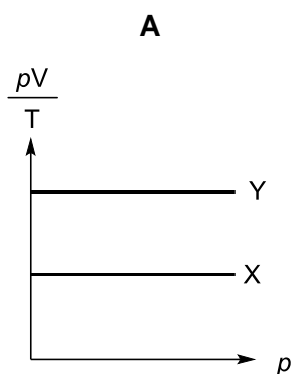
**7** *Use of the Data Booklet is relevant to this question.*

Compound W is a Period 3 chloride. It dissolves in water to form a solution of pH 3.

Which statement best describes the observation when aqueous ammonia was added to the solution?

**A** No precipitate was formed.

**B** A vigorous reaction occurred, producing white fumes.

**C** A white precipitate was formed which was insoluble in excess aqueous ammonia.

**D** A white precipitate was formed which was soluble in excess aqueous ammonia to form a colourless solution.

**8** What are the trends in the stated properties down Group 17 from chlorine to iodine?

|  | thermal stability of the hydrogen halides | oxidising power of the element |
|---|---|---|
| **A** | increases | increases |
| **B** | increases | decreases |
| **C** | decreases | increases |
| **D** | decreases | decreases |

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

Which contains the greatest number of molecules?

**A** 9.60 g of ozone, $O_3$

**B** 14.2 g of chlorine gas

**C** $2.41 \times 10^{23}$ molecules of methyl ethanoate

**D** 2.4 $dm^3$ of carbon dioxide (measured at r.t.p.)

**10** Acidified cerium(IV) sulfate is a strong oxidising agent which reacts with hydrogen peroxide in a 2:1 mole ratio.

In a titration, a solution of hydrogen peroxide required 25.00 cm$^3$ of cerium(IV) sulfate to reach the end-point.

Which statements about the titration are correct?

    1    A gas is given off during the reaction.

    2    The reduced cerium has an oxidation state of +3.

    3    If the titration was carried out using acidified $KMnO_4$ of the same concentration as the titrant, the titre volume will be greater than 25.00 cm$^3$.

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

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

A student mixes 20.0 cm$^3$ of 1.00 mol dm$^{-3}$ barium hydroxide with an equal volume of 2.50 mol dm$^{-3}$ ethanoic acid. The initial temperature of both solutions is 25.0 °C.

The maximum temperature reached after the reaction is 37.5 °C. Assume the density of both solutions is 1 g cm$^{-3}$.

What is the value for the enthalpy change of neutralisation calculated using these values?

**A**    −5.23 kJ mol$^{-1}$

**B**    −26.2 kJ mol$^{-1}$

**C**    −52.3 kJ mol$^{-1}$

**D**    −105 kJ mol$^{-1}$

**12**   Which class of reaction always has an endothermic enthalpy change?

**A**   hydration

**B**   atomisation

**C**   formation

**D**   solution

**13**   The Haber Process is an example of an important industrial reaction.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H^{\ominus} = -92 \text{ kJ mol}^{-1}$$
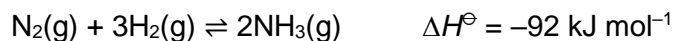
Which statements are correct?

1   When temperature is increased, the yield of $NH_3$ decreases.

2   When the total volume is increased, the yield of $NH_3$ decreases.

3   When more catalyst is added, the yield of $NH_3$ increases.

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

**14**   The mechanism for the reaction of NO and $O_2$ to form $NO_2$ is given below.

$$\text{step 1:} \quad NO + NO \rightleftharpoons N_2O_2$$
$$\text{step 2:} \quad N_2O_2 + O_2 \longrightarrow 2NO_2 \text{ (slow)}$$
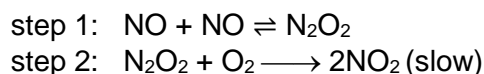
Which statements are correct?

1   The overall order of the reaction is 3.

2   The rate equation contains NO only.

3   If the reaction occurred via a single-step mechanism, the same rate equation would be obtained.

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

**15** Values for the ionic product of water, $K_w$, at two different temperatures are given below.

| temperature/ °C | $K_w$ / mol$^2$ dm$^{-6}$ |
|---|---|
| 25 | $1.00 \times 10^{-14}$ |
| 30 | $1.44 \times 10^{-14}$ |

What is correct for pure water at 30 °C?

**A** $[H^+] > [OH^-]$

**B** $[H^+] = 1.44 \times 10^{-7}$ mol dm$^{-3}$

**C** pH < 7

**D** pH = 7

**16** When 0.10 mol dm$^{-3}$ ethanoic acid is titrated against 0.10 mol dm$^{-3}$ sodium hydroxide, the equivalence point has a pH of 8.72.

Which is the best indicator for this titration?

| | indicator | approximate pH range |
|---|---|---|
| **A** | methyl orange | 3.2 – 4.4 |
| **B** | phenol red | 6.8 – 8.2 |
| **C** | thymol blue | 8.0 – 9.6 |
| **D** | indigo carmine | 11.6 – 14.0 |

**17** Under suitable conditions, butane reacts with bromine to produce bromoalkanes.

Which statement about this reaction is correct?

**A** HBr is formed during the termination step.

**B** Hexane is a suitable solvent for the reaction.

**C** The reaction does not involve heterolytic bond breaking.

**D** Small amounts of $CH_3CH_2C(CH_3)_2CH_2CH_3$ is produced from the reaction.

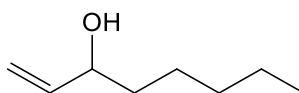**18** When one mole of cyclohex-3-en-1-one reacts with one mole of HBr, isomers of $C_6H_9OBr$ are formed.
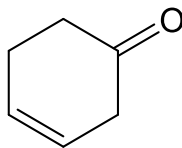


cyclohex-3-en-1-one

How many possible isomers, including stereoisomers, of $C_6H_9OBr$ can be formed from the reaction?

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

**19** Octenol is known to attract mosquitoes.



octenol

When octenol is heated with acidified $KMnO_4$, organic product Z is formed.

Which statement is correct?

**A** Octenol has a higher molecular mass than Z.

**B** Octenol and Z can be distinguished by the addition of $PCl_5$.

**C** Z can also be formed by heating octenol with acidified $K_2Cr_2O_7$.

**D** Octenol and Z have the same number of $sp^2$ hybridised carbons.

**20** Compound Q undergoes nucleophilic substitution through an $S_N1$ mechanism when it is heated with aqueous sodium hydroxide.
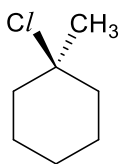


compound Q

Which statements about this reaction are correct?

1    A racemic mixture is formed.

2    The reaction proceeds via two transition states.

3    Increasing the concentration of sodium hydroxide increases the rate of reaction.

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

**21** A student carried out an investigation on a mixture containing two compounds and recorded the following observations.

| test | observations |
|---|---|
| To a boiling tube containing 2 cm depth of the mixture, add a few drops of aqueous ethanolic silver nitrate. | White fumes was evolved. A precipitate was formed. |
| Heat the resultant mixture. | No further precipitate was formed. |
| Allow the resultant mixture to cool. Then add aqueous ammonia until no further change is seen. | All the precipitate dissolved. |

Which pairs of compounds could be present in the mixture?

1    bromoethane and chloroethane

2    chloroethane and benzoyl iodide ($C_6H_5COI$)

3    iodobenzene and benzoyl chloride ($C_6H_5COCl$)

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

**22** Which reagents and conditions are appropriate for the following conversion?
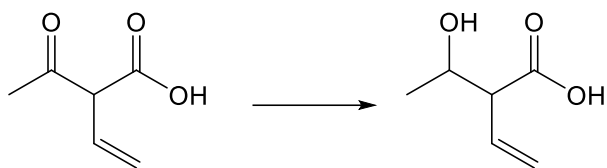


   **A**      LiA$l$H$_4$ in dry ether

   **B**      H$_2$, Ni, heat

   **C**      NaBH$_4$

   **D**      Sn, conc. HC$l$, heat

**23** Which reagents and conditions can be used to distinguish the two compounds below?
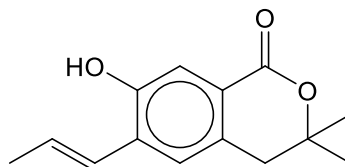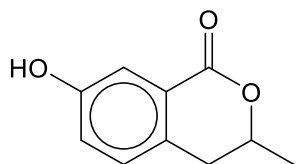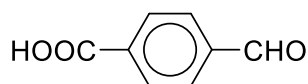


   1    hot acidified K$_2$Cr$_2$O$_7$

   2    hot acidified KMnO$_4$

   3    Br$_2$(aq)

   4    I$_2$, NaOH(aq), heat

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

**24** Which row correctly describes the relative acid strength of the following compounds?

**A** $C_6H_5OH > CH_3COOH > CH_3CH_2OH$

**B** $CH_3CH_2OH > CH_3COOH > C_6H_5OH$

**C** $CH_3CH_2OH > C_6H_5OH > CH_3COOH$

**D** $CH_3COOH > C_6H_5OH > CH_3CH_2OH$

**25** A student made the following claims about compound X.

$$HOOC-\bigcirc-CHO$$
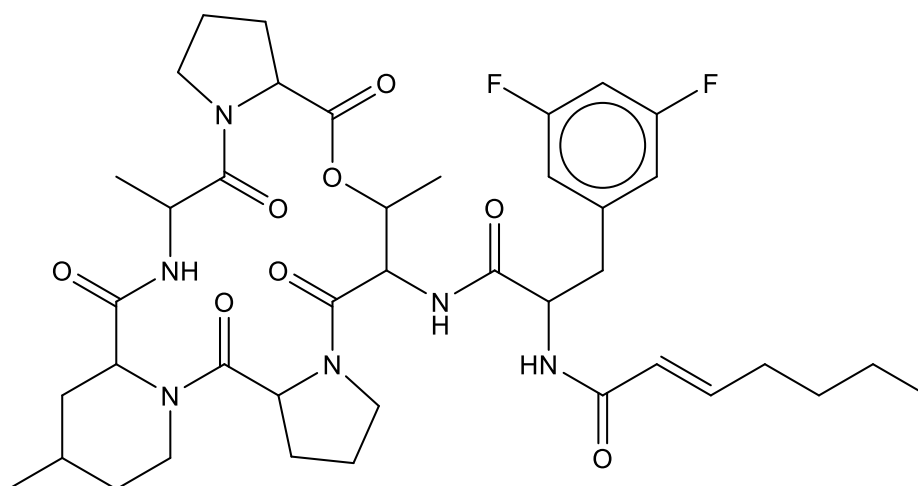
compound X

Which statements are correct?

    1    X gives a precipitate with Fehling's solution.

    2    1 mol of X reacts with 1 mol of HCN.

    3    1 mol of X reacts with excess sodium metal to give 1 mol of hydrogen gas.
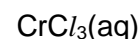
**A** 1 only    **B** 2 only    **C** 1 and 3    **D** 2 and 3

**26** How many fragments will be obtained upon treating the following molecule with an enzyme which hydrolyses only amide bonds?

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

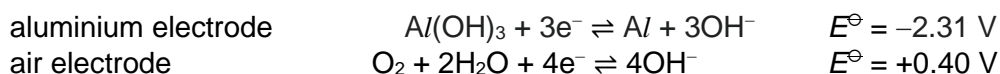**27** The following electrochemical cell was set up under standard conditions.

CrC$l_3$(aq)

Which change to the half-cells could result in an $E_{cell}$ value of +0.77 V?

**A** 0.5 mol dm$^{-3}$ Cr$^{3+}$(aq) was used.

**B** The pressure of H$_2$(g) was 2 bar.

**C** 1.0 mol dm$^{-3}$ ethanoic acid was used.

**D** The surface area of the Cr electrode was smaller.

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

Aluminium-air batteries are studied for their potential to power electric vehicles. The half–equations for an aluminium-air battery are given below.

aluminium electrode        A$l$(OH)$_3$ + 3e$^-$ ⇌ A$l$ + 3OH$^-$      $E^\ominus$ = −2.31 V
air electrode                O$_2$ + 2H$_2$O + 4e$^-$ ⇌ 4OH$^-$       $E^\ominus$ = +0.40 V

The overall cell reaction is 4A$l$ + 3O$_2$ + 6H$_2$O → 4A$l$ (OH)$_3$.

In which direction do the electrons flow in the external circuit and what is the $\Delta G^\ominus$ for the cell reaction?

| | direction of electron flow | $\Delta G^\ominus$ / kJ mol$^{-1}$ |
|---|---|---|
| **A** | air to aluminium | −553 |
| **B** | air to aluminium | −3140 |
| **C** | aluminium to air | −553 |
| **D** | aluminium to air | −3140 |

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

A current of 1.22 A was passed through dilute sulfuric acid for 30 minutes. 302 $cm^3$ of hydrogen gas was collected at the cathode at room temperature and pressure.

Which value of the charge on the electron, in Coulombs, do **these figures** give?

| | | | |
|---|---|---|---|
| **A** | $1.37 \times 10^{-19}$ | **B** | $1.45 \times 10^{-19}$ |
| **C** | $1.55 \times 10^{-19}$ | **D** | $1.61 \times 10^{-19}$ |

**30** The following data refer to calcium as an s-block element and vanadium as a typical transition element.

For which rows are the data correctly assigned?

| | property | calcium | vanadium |
|---|---|---|---|
| 1 | atomic radius / nm | 0.135 | 0.197 |
| 2 | melting point / °C | 1910 | 843 |
| 3 | oxidation states in aqueous solution | +2 | +2, +3, +4, +5 |

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

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