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Paper 1 Multiple Choice

16 September 2024

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.

Complete the information on the Answer Sheet as shown below.

1. Enter your NAME (as in NRIC).				U: FC		CIL ON	LY ES ON	THIS S	HEET		Ø	9
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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.

	electrons	neutrons
Α	10	11
В	11	11
С	10	8
D	11	8

What are the numbers of electrons and neutrons in D_3O^+ ?

2 Which species has two unpaired electrons?

Α	Li+	В	Ti⁺	С	Mg	D	S
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3 The Valence Shell Electron Pair Repulsion theory (VSEPR) is used to predict the bond angles of molecules.

Which bond angle is correctly predicted by VSEPR?

	number of bonded electron pairs around central atom	number of lone pairs around central atom	bond angle
Α	2	1	105°
В	2	2	118°
С	3	1	107°
D	3	2	90°

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

Some information about the carbonate ion, CO_3^{2-} , is given.

- all carbon-oxygen bonds are of the same length
- π electrons are delocalised throughout the structure

What is the likely carbon-oxygen bond energy, in kJ mol⁻¹, in the carbonate ion?

- **A** 360 **B** 485
- **C** 740 **D** 805

5 Which bonding type corresponds to its description of physical properties?

	bonding type	physical properties				
1	giant covalent	high melting point, conducts electricity when in solution but not when solid				
2	simple covalent	low melting point, does not conduct electricity in any state				
3	metallic	variety of melting points, conducts electricity when solid and when molten				
4	ionic	low melting point, conducts electricity in any state				
Α	1 and 2 only B 3 and 4 only C	2 and 3 only D 1 and 4 only				

6 The volumes and pressures of equal masses of four gases, nitrogen, methane, chlorine and helium, are separately investigated, at constant temperature.

The results are plotted on a graph of pV against V. All four gases behave as ideal gases under the conditions chosen.

Which plot shows the results for methane?



7 When a sample of a gas is compressed at constant temperature from 15 atm to 60 atm, its volume changes from 76 cm³ to 20.5 cm³.

Which statements are possible explanations for this observation?

- 1 The gas behaves non-ideally.
- 2 Some of the gas dimerises.
- 3 There are significant intermolecular forces of attraction between the gas molecules.
- A 1 only B 1 and 2 only C 1 and 3 only D 2 only

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

Which diagram shows the correct trends when the melting points of the elements Mg, A*l*, Si and P are plotted against their first ionisation energies?



9 Consider the following half equations:

$$\begin{array}{rcl} \mathsf{F}e^{2+} & \to & \mathsf{F}e^{3+} + e^{-} \\ \mathsf{C}_2\mathsf{O}_4^{2-} & \to 2\mathsf{C}\mathsf{O}_2 + 2e^{-} \end{array}$$

In an experiment, 20 cm³ of an acidified solution of 0.020 mol dm⁻³ of FeC₂O₄ is oxidised by 15 cm³ of 0.020 mol dm⁻³ KMnO₄.

What is the final oxidation state of manganese, given that both Fe^{2+} and $C_2O_4^{2-}$ can be oxidised by KMnO₄?

A +1 B +2 C +3 D +4

- **10** Given 1.0 g samples of the same mixture of magnesium carbonate and barium carbonate, which method allows one to determine the mole fraction of magnesium carbonate in the mixture?
 - 1 Add a known volume of 0.1 mol dm^{-3} HC*l*(aq), in excess, and back titrate the excess of acid.
 - 2 Add an excess of HC*l*(aq) and measure, at known temperature and pressure, the volume of CO₂ liberated.
 - 3 Add an excess of HC*l*(aq) followed by an excess of H₂SO₄(aq); filter, dry and weigh the precipitate.
 - A
 3 only
 B
 1 and 2 only

 C
 2 and 3 only
 D
 1, 2 and 3
- **11** Which enthalpy change is always exothermic?
 - A lattice energy
 - **B** bond breaking
 - **C** ionisation energy
 - **D** electron affinity
- **12** The hydrolysis of sucrose in aqueous solution is catalysed by H⁺(aq) ions, for example, from hydrochloric acid.

sucrose $\xrightarrow{H^+(aq)}$ glucose + fructose

Which procedure can be used to determine the order of reaction with respect to H⁺(aq) ions?

- **A** Measure the change in pH during the reaction.
- **B** Remove samples at various time intervals, quench using excess water, then titrate against a standard solution of sodium hydroxide.
- **C** Add a suitable acid-base indicator and watch for the time when the colour changes.
- **D** Measure the time taken for a fixed amount of sucrose to be consumed in the presence of different concentrations of hydrochloric acid each time.

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

Hydrogen peroxide solution decomposes. The equation for this reaction is shown.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

A 280 cm³ sample of 2.38 mol dm⁻³ hydrogen peroxide solution is warmed. The volume of oxygen gas collected over time, measured at r.t.p., is recorded in the graph below.



Which statements are correct?

- 1 The total volume of oxygen gas collected at the end of the reaction is 8.0 dm³.
- 2 The rate constant for this reaction is 0.017 min^{-1} .
- 3 The half-life for the reaction will be about 20 min if initial concentration is 1.19 mol dm⁻³.

Α	1 only	В	1 and 2 only	С	2 and 3 only	D	1, 2 and 3
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- 14 Which statement about the Haber process for the manufacture of ammonia is correct?
 - A At higher temperatures, the yield goes up and the rate of production of ammonia is faster.
 - **B** At higher pressure, the yield goes up and the rate of production of ammonia is faster.
 - **C** In the presence of a catalyst, the yield goes down but the rate of production of ammonia is faster.
 - **D** When more nitrogen is added, the yield goes down but the rate of production of ammonia is faster.
- **15** The graph shows how ΔG° changes with temperature for the reaction shown.



 $H_2O(g) + CO(g) \rightleftharpoons H_2(g) + CO_2(g)$

Equimolar amounts of H_2O and CO were introduced into a sealed container and allowed to reach equilibrium.

Which statement about this equilibrium is true?

- A The concentration of CO_2 is greater than the concentration of H_2O at point 1.
- **B** The concentration of CO_2 is greater than the concentration of H_2O at point 2.
- **C** The concentration of H_2 is greater than the concentration of CO_2 at point 3.
- **D** The concentration of H_2 is greater than the concentration of CO at point 4.

16 When a solution of potassium iodide, KI, was added to a solution of lead(II) nitrate, a bright yellow precipitate, PbI₂, was formed.

A sketch of the mass of precipitate formed against the volume of the KI solution added is shown below.



Which statements can be used to explain the shape of the graph beyond V cm³?

- 1 Lead(II) nitrate is the limiting reagent.
- 2 The position of equilibrium of $PbI_2(s) \square Pb^{2+}(aq) + 2I^{-}(aq)$ shifts right.
- 3 PbI₂ reacts with excess KI to form a complex, PbI₄^{2–}.
- **A** 3 only **B** 1 and 2 only **C** 2 and 3 only **D** 1, 2 and 3
- 17 How many constitutional isomers are possible for $C_4H_{10}O$?

Α	5	В	6	C 7	D	8

18 The pinacol rearrangement is a method for converting a 1,2-diol to an aldehyde or ketone. An example is shown below using 2-methylbutane-2,3-diol.



Stage 1 favours the production of a more stable carbocation. This is followed by the migration of an alkyl group in stage 2.

What is the major product when Q undergoes the pinacol rearrangement?



19 Which statement regarding the free radical substitution of methylcyclohexane is correct?

A Hydrogen gas is a product.

+

- B Ignoring stereoisomers, there are seven possible monosubstituted products.
- **C** Two of its monosubstituted products are chiral.
- **D** Z can be formed as one of its termination products.



20 What is the intermediate that leads to the major product in the reaction between propene and aqueous bromine?

- A CH₂(Br)-CHCH₃
- B CH₂-CH(Br)CH₃
- $\mathbf{C} \quad \stackrel{+}{\mathrm{CH}_2}-\mathrm{CH}(\mathrm{OH})\mathrm{CH}_3$
- D CH₂(Br)-CHCH₃
- 21 Citral is present in the volatile oils of several plants.





Which statements about citral are correct?

- 1 It gives a positive test with ammoniacal silver nitrate.
- 2 Carbon dioxide is produced when citral is heated with acidified potassium manganate(VII).
- 3 The number of sp³-hybridised carbon atoms is equal to the number of sp²-hybridised carbon atoms in the citral molecule.
- **A** 1 only **B** 3 only **C** 2 and 3 only **D** 1, 2 and 3
- 22 Which statement about benzene reacting with concentrated HNO₃ is correct?
 - **A** Electrons in the π electron cloud are donated to a nucleophile.
 - **B** Electrons in the carbon-carbon σ bond are donated to an electrophile.
 - **C** The hybridisation state of all the carbon atoms of benzene remains unchanged at every step of the reaction.
 - **D** Benzene undergoes a substitution reaction so that the delocalised π electron system remains undisrupted at the end of the reaction.

23 Which reaction will give the product indicated?



- 24 Which compound gives a yellow solid with warm alkaline aqueous iodine?
 - A CH₃CHO
 - **B** (CH₃)₃COH
 - C CH₃CO₂CH₃
 - D CH₃CH₂CH₂CHO

25 The following three compounds are present in a sample in the ratio X : Y : Z = 1 : 1 : 2.

- $X HO_2CCH_2CH_2CH=CHCO_2H$
- Y CH₃CH₂CH₂CH₂CH=CHCOCH₃
- Z CH₃CH₂CH₂CH₂CH=CHCH=CHCHO

How many hydrogen atoms would be incorporated on average per molecule when the sample is reacted with excess LiA/H_4 ?

A 1.50 **B** 2.50 **C** 2.67 **D** 5.50

26 Four compounds are shown below.

$C/CH_2CH_2CO_2H$	CICH(CH ₃)CO ₂ H	H ₂ NCH(CH ₃)CO ₂ H	$CH_3CH_2CO_2H$
I	II	III	IV

What is the correct order in terms of increasing acid strength of the carboxylic acid group?

- $\textbf{C} \quad III < IV < II < I \qquad \qquad \textbf{D} \quad IV < II < I < III$

27 The same carboxylic acid is obtained either by the hydrolysis of a nitrile **P** or by the oxidation of an alcohol **Q**.

What could be **P** and **Q**?

	Р	Q
Α	CH ₃ CH ₂ CN	CH ₃ CH ₂ OH
В	CH ₃ CH ₂ CN	CH ₃ CH ₂ CH(OH)CH ₃
С	(CH ₃) ₂ CHCN	(CH ₃) ₃ COH
D	C_6H_5CN	C ₆ H₅OH

- 28 Which statements are correct about the reaction between ethylamine and ethanoyl chloride?
 - 1 During the reaction, a carbon-chlorine bond is broken and a carbonnitrogen bond is formed.
 - 2 The same reaction will take place if ethanoyl chloride is replaced by ethanoic acid.
 - 3 The organic product formed, when dissolved in water will give a solution that has a pH greater than 7.
 - **A** 1 only **B** 1 and 2 only **C** 2 and 3 only **D** 1, 2 and 3
- **29** Use of the Data Booklet is relevant to this question.

When the Fe³⁺/Fe²⁺ half cell in standard conditions is joined to a standard hydrogen electrode, the E^{e}_{cell} = +0.77V.

Which changes to the cell conditions would lead to a lower cell potential?

- 1 Adding water into the Fe^{3+}/Fe^{2+} half cell.
- 2 Increasing the pressure of $H_2(g)$.
- 3 Adding an excess of $CN^{-}(aq)$ into the Fe^{3+}/Fe^{2+} half cell.
- **A** 1 only **B** 3 only **C** 1 and 3 only **D** 2 and 3 only

30 Transition metal ions can react in a number of different ways. Listed are four different reactions of transition metal ions with relevant observations.

Which observation does not involve ligand exchange?

- A When a purple solution of chromium(III) sulfate is warmed, a green solution containing $[Cr(H_2O)_5SO_4]^+$ is formed.
- **B** When an excess of aqueous ammonia is added to a solution of cobalt(II) chloride, a brown solution of $[Co(NH_3)_6]^{3+}$ ions is made.
- **C** When an excess of aqueous sodium hydroxide is added to a solution of iron(III) chloride, a reddish-brown precipitate of Fe(OH)₃ is formed.
- **D** When concentrated hydrochloric acid is added to a blue-green solution of aqueous copper(II) chloride, a yellow solution of aqueous [CuC*l*₄]²⁻ is formed.