Oxford Cambridge and RSA

Tuesday 14 May 2024 – Morning

AS Level Chemistry A

H032/01 Breadth in chemistry

Time allowed: 1 hour 30 minutes

You must have:
- the Data Sheet for Chemistry A

You can use:
- a scientific or graphical calculator
- an HB pencil

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **24** pages.

ADVICE
- Read each question carefully before you start your answer.

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SECTION A

You should spend a **maximum** of **25 minutes** on this section.

Write your answer to each question in the box provided.

1 Which diagram shows a p-orbital?

A	
B	
C	
D	

Your answer ☐ **[1]**

2 Which row shows the atomic structure of $^{25}Mg^{2+}$?

	Protons	**Neutrons**	**Electrons**
A	10	12	13
B	10	15	12
C	12	13	10
D	12	13	14

Your answer ☐ **[1]**

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3 A nitrogen oxide contains 36.84% of nitrogen by mass.

What is the empirical formula of the nitrogen oxide?

A NO

B NO_2

C N_2O

D N_2O_3

Your answer ☐ **[1]**

4 Carbon monoxide reacts with oxygen to form carbon dioxide:

$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$

Which volumes of CO(g) and $O_2(g)$ produce the largest volume of $CO_2(g)$?

All gas volumes are measured at RTP.

A 1.00 dm^3 CO and 4.00 dm^3 O_2

B 2.00 dm^3 CO and 3.00 dm^3 O_2

C 3.00 dm^3 CO and 2.00 dm^3 O_2

D 4.00 dm^3 CO and 1.00 dm^3 O_2

Your answer ☐ **[1]**

5 Which reaction produces a product with linear molecules?

A $2B + 3F_2 \rightarrow$

B $C + O_2 \rightarrow$

C $2H_2 + O_2 \rightarrow$

D $N_2 + 3H_2 \rightarrow$

Your answer ☐ **[1]**

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6 Which statement about the periodic table is **not** correct?

A Elements in the same group have similar **chemical** properties.

B The elements are ordered by increasing atomic mass.

C The elements are ordered by increasing atomic number.

D There is a repeating trend of **physical** and **chemical** properties across the periods.

Your answer ☐ **[1]**

7 Group 2 compounds can be used in agriculture to neutralise acid soils and in medicine to treat indigestion.

Which Group 2 compound is **not** suitable for either use?

A $Mg(OH)_2$

B $MgSO_4$

C $CaCO_3$

D CaO

Your answer ☐ **[1]**

8 In the UK, water companies typically treat drinking water with chlorine gas at a concentration of $0.500\,mg\,dm^{-3}$ or less.

Which statement about UK drinking water is correct?

A Chlorine in drinking water can catalyse the breakdown of ozone.

B Chlorine may form toxic chlorinated hydrocarbons.

C Drinking water with a chlorine gas concentration of $0.500\,mg\,dm^{-3}$ contains 2.12×10^{18} chlorine molecules in each dm^3.

D In hot weather, chlorine can vaporise from drinking water to cause global warming.

Your answer ☐ **[1]**

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9 Which reaction does **not** show disproportionation of chlorine?

A $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$

B $Cl_2 + H_2O \rightarrow HCl + HClO$

C $2ClO_2 + 2NaOH \rightarrow NaClO_2 + NaClO_3 + H_2O$

D $2NaOH + Cl_2 \rightarrow NaCl + NaClO + H_2O$

Your answer ☐ **[1]**

10 An unknown compound is tested to identify whether it contains sulfate, carbonate or halide ions.

What is the correct sequence of tests required?

A carbonate, halide, sulfate

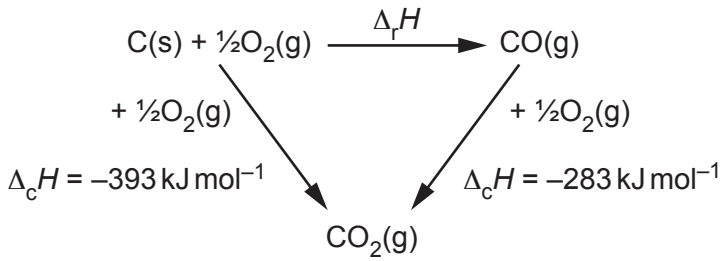
B carbonate, sulfate, halide

C halide, carbonate, sulfate

D sulfate, carbonate, halide

Your answer ☐ **[1]**

11 An enthalpy cycle is shown below.



What is $\Delta_r H$, in kJ mol^{-1}, shown in the enthalpy cycle?

A +676

B +110

C –110

D –676

Your answer ☐ **[1]**

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12 A mixture of gases is heated in a closed container. The reaction rate increases.

Which statement explains why the rate increases?

A More molecules have an energy greater than the activation energy.

B The activation energy decreases.

C The activation energy increases.

D The concentration of the gases increases.

Your answer ☐ **[1]**

13 The reversible reaction below is at equilibrium.

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

What is the expression for K_c?

A $\dfrac{[SO_2(g)]^2\,[O_2(g)]}{[SO_3(g)]^2}$

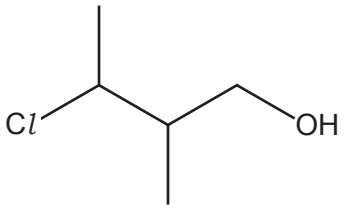
B $\dfrac{[SO_3(g)]^2}{[SO_2(g)]^2\,[O_2(g)]}$

C $\dfrac{2[SO_2(g)] + [O_2(g)]}{2[SO_3(g)]}$

D $\dfrac{2[SO_3(g)]}{2[SO_2(g)] + [O_2(g)]}$

Your answer ☐ **[1]**

14 What is the name of the compound below?



A 1-chloro-1,2-dimethylpropan-3-ol

B 2-chloro-3-methylbutan-4-ol

C 3-chloro-2-methylbutan-1-ol

D 3-chloro-2,3-dimethylpropan-1-ol

Your answer ☐ **[1]**

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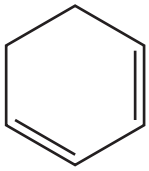
15 The structure of a hydrocarbon is shown below.



Which terms describe this hydrocarbon?

A Alicyclic and saturated

B Aliphatic and alicyclic

C Aliphatic and aromatic

D Aromatic and unsaturated

Your answer ☐ **[1]**

16 Which property explains the low reactivity of alkanes?

A Low C–C bond enthalpy.

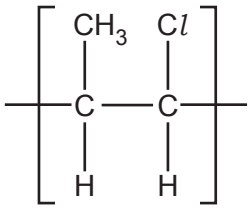
B Low bond enthalpy of π-bonds.

C Low polarity of σ-bonds.

D Low reactivity of carbon and hydrogen.

Your answer ☐ **[1]**

17 The repeat unit of an addition polymer is shown below.



Which statement about this addition polymer is correct?

A Combustion produces toxic alkaline fumes.

B The addition polymer is biodegradable.

C The monomer is $H_3CCH{=}CHCl$.

D The repeat unit above is shown as a displayed formula.

Your answer ☐ **[1]**

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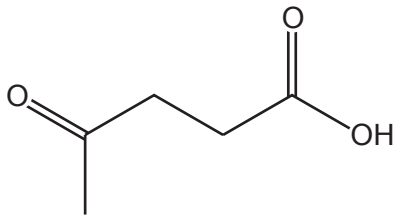
18 Which functional groups are present in the compound below?



A Alcohol and aldehyde.

B Alcohol and ketone.

C Carboxylic acid and aldehyde.

D Carboxylic acid and ketone.

Your answer ☐ **[1]**

19 Which statement about infrared radiation (IR) is **not** correct?

A Absorption of IR by molecules such as CO_2, H_2O and CH_4 has been linked to global warming.

B IR causes CFC molecules to produce chlorine radicals that initiate ozone breakdown in the upper atmosphere.

C IR causes some covalent bonds to vibrate more and absorb energy.

D IR is used in modern breathalysers to detect ethanol.

Your answer ☐ **[1]**

20 An alcohol $CH_3CH_2CH(CH_3)OH$ produces a mass spectrum.

The mass spectrum contains a large fragment ion at m/z = 45.

What is the possible identity of this fragment ion?

A CH_2CHOH^+

B $CH_2CH_2OH^+$

C CH_3CHOH^+

D $CH_3CH_2CH^+$

Your answer ☐ **[1]**

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Turn over for Section B

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SECTION B

21 This question is about iron.

(a) A sample of iron is isolated from a meteorite and analysed by mass spectrometry.

The mass spectrum shows peaks with the relative abundances below.

Isotope	^{54}Fe	^{56}Fe	^{57}Fe	^{58}Fe
Relative abundance	78.54%	8.88%	5.10%	7.48%

Calculate the relative atomic mass of the iron in the sample.

Give your answer to **2** decimal places.

relative atomic mass = ... **[2]**

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(b) Iron can be extracted from iron ores containing the oxide Fe_2O_3.

(i) What is the systematic name for Fe_2O_3?

..... **[1]**

(ii) Balance the equation for the reduction of Fe_2O_3 with carbon monoxide.

..... Fe_2O_3 + ... CO → ..... Fe + ... CO_2 **[1]**

(c) The iron compound, $Fe(NO_3)_3$, decomposes when heated.
The equation for the decomposition of $Fe(NO_3)_3$ is shown below.

$4Fe(NO_3)_3(s) \rightarrow 2Fe_2O_3(s) + 12NO_2(g) + 3O_2(g)$

Molar mass of $Fe(NO_3)_3$ = 241.8 g mol^{-1}

4.836 g of $Fe(NO_3)_3$ is heated until it has completely decomposed.

Calculate the **total** volume of gas, in dm^3, produced at RTP.

total volume of gas = ... dm^3 **[3]**

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22 This question is about the reactions of acids.

(a) What is the difference between a **strong** acid and a **weak** acid?

.....

..... **[1]**

(b) Ethanoic acid, CH_3COOH, is found in some descalers to soften hard water.

A student carries out a titration with a standard solution of sodium carbonate, Na_2CO_3, to determine the percentage composition by mass of CH_3COOH in a descaler.

The equation is shown below.

$$2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COONa + CO_2 + H_2O$$

(i) The method is outlined below:

- Dissolve 6.50 g of the descaler in distilled water.
- Transfer the solution into a 250.0 cm^3 volumetric flask.
- Make up to the mark with distilled water and invert several times.
- Pipette 25.0 cm^3 of this solution into a conical flask and add a few drops of indicator.
- Titrate this solution with 0.200 mol dm^{-3} Na_2CO_3(aq), in the burette.

The student carries out a trial titration, followed by further titrations.

The results are shown in the table below.

The trial titration has been omitted.

Titration	**1**	**2**	**3**
Final reading / cm^3	48.95	24.15	48.35
Initial reading / cm^3	24.55	0.00	24.10
Titre / cm^3			

Complete the table by adding the titres.

[1]

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(ii) Calculate the mean titre, to the nearest 0.05 cm^3, that the student should use for analysing these results.

mean titre = ... cm^3 **[1]**

(iii) Calculate the percentage composition by mass of CH_3COOH in the descaler.

Assume that CH_3COOH is the only acid in the descaler.

Give your answer to **3** significant figures.

percentage composition by mass = ... % **[5]**

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23 This question is about covalent compounds of nitrogen.

(a) Ammonia, NH_3, is manufactured by reacting nitrogen and hydrogen gases.

This is a reversible reaction and the equilibrium is shown below.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92\,kJ\,mol^{-1}$

(i) This is an example of a dynamic equilibrium.

State **2** features of a dynamic equilibrium.

1 .....

.....

2 .....

.....

[2]

(ii) State and explain the conditions of temperature and pressure that would produce a large equilibrium yield of NH_3.

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..... **[3]**

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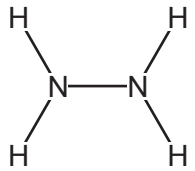
(b) Hydrazine, N_2H_4, shown below, can be used as a rocket fuel.



As a fuel, N_2H_4 reacts with oxygen as shown below.

$N_2H_4(g) + O_2(g) \rightarrow N_2(g) + 2H_2O(g) \qquad \Delta H = -581\,kJ\,mol^{-1}$

Average bond enthalpies are shown in the table.

Bond	N–N	O=O	N≡N	O–H
Average bond enthalpy / kJ mol^{-1}	+158	+498	+945	+464

Calculate the average bond enthalpy of the N–H bond.

average bond enthalpy of N–H = ... kJ mol^{-1} **[3]**

(c) Hydrogen cyanide, HCN, is bonded by a single bond between the H and C atoms and a triple bond between the C and N atoms.

Draw a ‘dot-and-cross’ diagram for a molecule of HCN.

Use different symbols for electrons from H, C and N.

Show outer electrons only.

[2]

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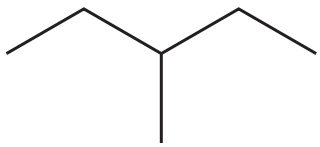
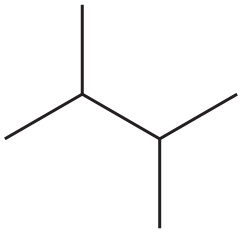
24 This question is about hydrocarbons.

(a) The skeletal formulae and boiling points of three isomers of C_6H_{14} are shown in the table below.

Isomer	Molecular formula	Skeletal formula	Boiling point / °C
A	C_6H_{14}		69
B	C_6H_{14}		63
C	C_6H_{14}		58

State and explain the trend in the boiling points shown in the table.

Refer to the isomers **A**, **B** and **C** in your answer.

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..... **[4]**

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(b) The hydrocarbon C_2H_6 reacts with bromine, Br_2, to form C_2H_5Br under suitable conditions.

Complete the table below to show the mechanism for the three stages of the reaction of C_2H_6 with Br_2 to form C_2H_5Br.

The equation for one of the possible reactions for termination has been completed.

In your equations, use molecular formulae and 'dots' (•) with any radicals.

Initiation	Conditions ..... Equation ..... → .....
Propagation	**1** ..... → ..... **2** ..... → .....
Termination	**1** $Br\bullet + Br\bullet \rightarrow Br_2$ **2** ..... → ..... **3** ..... → .....

[5]

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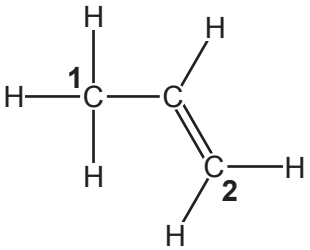
(c) Propene, C_3H_6, has different bond angles and shapes around the carbon atoms.
The displayed formula of a propene molecule is shown below.



Predict the bond angles and the names of the shapes around the C atoms **1** and **2** above, and explain why the bond angles and shapes are different.

Carbon atom	Bond angle	Name of shape
1		
2		

Explanation: .....

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..... **[5]**

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Turn over for the next question

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25 Three alcohols, **A**, **B** and **C**, are structural isomers with the molecular formula $C_5H_{12}O$.

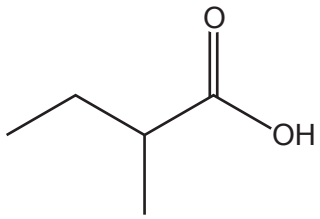
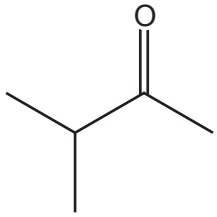
(a) **A**, **B** and **C** take part in combustion reactions.

Complete the equation for the complete combustion of $C_5H_{12}O$.

$C_5H_{12}O$ + ... **[2]**

(b) Alcohols **A**, **B** and **C** are each refluxed with acidified dichromate(VI), $H^+/Cr_2O_7^{2-}$.
The organic products are shown in the table below.

Complete the table to show the structures of alcohols **A**, **B** and **C**.

Alcohol	**Structure of alcohol**	**Organic product after refluxing with $H^+/Cr_2O_7^{2-}$**
A		
B		
C		No reaction

[3]

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(c) Primary alcohols can be oxidised under distillation to make aldehydes.

Draw a labelled diagram to show how you would set up apparatus for distillation.

[2]

(d) Alcohols can be prepared by the hydrolysis of haloalkanes with aqueous alkali.

(i) Write an equation for the hydrolysis of 2-bromo-2-methylpropane.

Show organic compounds as structures.

[2]

(ii) A student hydrolyses a chloroalkane, RC*l*, a bromoalkane, RBr, and an iodoalkane, RI.

For a fair comparison, the student has chosen the same R group for each haloalkane.

Predict, with a reason, the relative rates of hydrolysis of these three haloalkanes.

.....

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..... **[2]**

END OF QUESTION PAPER

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EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.

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