Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/13**

Paper 1 Multiple Choice **May/June 2020**

1 hour

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data booklet

INSTRUCTIONS

- There are **forty** 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 multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
- Any rough working should be done on this question paper.

This document has **16** pages. Blank pages are indicated.

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Section A

For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

Use of the Data Booklet may be appropriate for some questions.

1 Which particle has equal numbers of protons and neutrons and an electronic structure of $1s^2 2s^2 2p^6 3s^2 3p^6$?

A $^{39}_{18}Ar$ **B** $^{40}_{20}Ca^{2+}$ **C** $^{16}_{8}O^{2-}$ **D** $^{32}_{16}S$

2 Which molecule contains six bonding electrons?

A NCl_3 **B** H_2S **C** C_2H_4 **D** SF_6

3 Solid carbon dioxide, CO_2, is similar to solid iodine, I_2, in its structure.

Which statement about solid CO_2 and solid SiO_2 is correct?

A Both solid CO_2 and solid SiO_2 exist in a lattice structure.

B Both solid CO_2 and solid SiO_2 have a simple molecular structure.

C Both solid CO_2 and solid SiO_2 have atoms joined by single covalent bonds.

D Both solid CO_2 and solid SiO_2 change spontaneously to gas at s.t.p..

4 The enthalpy changes of two reactions are shown.

$$K_2CO_3(s) + 2HCl(aq) \rightarrow 2KCl(aq) + H_2O(l) + CO_2(g) \quad \Delta H = -34.0\,kJ\,mol^{-1}$$

$$KHCO_3(s) + HCl(aq) \rightarrow KCl(aq) + H_2O(l) + CO_2(g) \quad \Delta H = +32.8\,kJ\,mol^{-1}$$

What is the enthalpy change for the reaction shown?

$$2KHCO_3(s) \rightarrow K_2CO_3(s) + H_2O(l) + CO_2(g)$$

A $-31.6\,kJ\,mol^{-1}$

B $1.2\,kJ\,mol^{-1}$

C $66.8\,kJ\,mol^{-1}$

D $99.6\,kJ\,mol^{-1}$

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5 Nitrogen reacts with oxygen to form nitrogen monoxide, NO, and nitrogen dioxide, NO_2. Nitrogen dioxide reacts with water and with hydroxide ions.

$$N_2(g) + O_2(g) \rightarrow 2NO(g)$$

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

$$2NO_2(g) + H_2O(l) \rightarrow HNO_2(aq) + H^+(aq) + NO_3^-(aq)$$

$$2NO_2(g) + 2OH^-(aq) \rightarrow NO_2^-(aq) + NO_3^-(aq) + H_2O(l)$$

What can be deduced using **only** the information from these equations?

A HNO_2 is a strong acid.

B HNO_3 is a weak acid.

C NO_2 is a neutral gas.

D NO is a reducing agent.

6 Which solution has the lowest pH value?

A 0.01 mol dm^{-3} butanoic acid

B 0.01 mol dm^{-3} ethanoic acid

C 0.01 mol dm^{-3} hydrochloric acid

D 0.01 mol dm^{-3} sulfuric acid

7 The element sulfur produces a mass spectrum with the following peaks.

m / *e* value of peak	relative abundance
32	95.02
33	0.76
34	4.20
36	0.02

Which relative atomic mass of sulfur can be calculated from these data, given to four significant figures?

A 32.07 **B** 32.08 **C** 32.09 **D** 32.10

8 What is the electronic configuration of an isolated Ni^{2+} ion?

A $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$

B $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^1$

C $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$

D $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8$

9 At 200 °C aluminium chloride is a gas with M_r = 267.

What is the number of covalent bonds, dative covalent bonds and lone pairs of electrons in one molecule of aluminium chloride at 200 °C?

	covalent bonds	dative covalent bonds	lone pairs
A	6	2	0
B	6	2	16
C	6	2	18
D	3	0	9

10 When solid $KClO_3$ is heated in the absence of air, a mixture of two chlorine compounds in the mole ratio of 3 : 1 is formed. Chlorine is the only element whose oxidation number changes in this reaction.

What could be the oxidation numbers of chlorine in the two compounds that are formed?

A +3 and –1 **B** +6 and +4 **C** +7 and –1 **D** +7 and +1

11 Two reactions are shown.

reaction 1 $X_2(g) + Y_2(g) \rightleftharpoons 2XY(g)$

reaction 2 $XY(g) \rightleftharpoons \frac{1}{2}X_2(g) + \frac{1}{2}Y_2(g)$

The equilibrium constant, K_p, for reaction 1 is 0.0052.

What is K_p for reaction 2?

A 2.6×10^{-3} **B** 13.9 **C** 192.3 **D** 384.6

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12 Compound T is a white crystalline solid.

When a sample of compound T is mixed with aqueous sodium hydroxide and heated, a gas is produced which turns damp red litmus paper blue.

Further testing of a solution of compound T with aqueous barium chloride produces a dense white precipitate which does not dissolve when dilute hydrochloric acid is added to the mixture.

What is the identity of compound T?

A ammonium carbonate

B ammonium sulfate

C sodium carbonate

D sodium sulfate

13 Which property explains the trend in volatility of the elements going down Group 17?

A decreasing covalent bond strength

B decreasing van der Waals' forces

C increasing covalent bond strength

D increasing van der Waals' forces

14 The statements apply to the elements in Group 2.

Which statement is correct?

A As atomic number increases, ionic radius increases.

B As atomic number increases, reducing ability decreases.

C As atomic number increases, first ionisation energy increases.

D As atomic radius increases, first ionisation energy increases.

15 Which element, when burned in oxygen, can form an oxide that is a reducing agent?

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

16 Nitrogen oxides are removed from the exhaust gases of internal combustion engines by the action of a catalyst in a catalytic converter.

Which row is correct?

	change in oxidation number of nitrogen	type of catalyst
A	decrease	heterogeneous
B	decrease	homogeneous
C	increase	heterogeneous
D	increase	homogeneous

17 The addition of aqueous silver nitrate to aqueous barium chloride produces a white precipitate which dissolves in an excess of dilute aqueous ammonia to form a colourless solution.

The addition of an excess of dilute nitric acid to the colourless solution produces a white precipitate, Z.

What is Z?

A $AgCl$ **B** $BaCl_2$ **C** $Ba(NO_3)_2$ **D** NH_4NO_3

18 Which property shows an **increase** from calcium to barium going down Group 2?

A the ease of decomposition of the carbonates

B the solubility of the hydroxides

C the solubility of the sulfates

D the volume of hydrogen given off when 1 g of the metal reacts with water

19 Element X is in Period 3. It reacts rapidly with water to form an alkaline solution.

Which statement about the **chloride** of element X is correct?

A It conducts electricity when molten.

B It has a melting point of less than 100 °C.

C It has covalent bonding.

D It reacts rapidly with cold water.

20 Structural and stereoisomerism should be considered when answering this question.

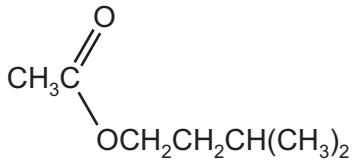
When *trans*-pent-2-ene reacts with HBr, how many different products can form?

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

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21 Ester P has the following structural formula.

ester P



Which compounds are produced when P is hydrolysed using dilute hydrochloric acid?

A CH_3COCl and $(CH_3)_2CHCH_2CH_2OH$

B CH_3CH_2OH and $(CH_3)_2CHCH_2CO_2H$

C CH_3CO_2H and $(CH_3)_2CHCH_2CO_2H$

D CH_3CO_2H and $(CH_3)_2CHCH_2CH_2OH$

22 There are many non-cyclic alcohols that cannot be oxidised by warm acidified MnO_4^- ions. Alcohol X is the member of this set of alcohols with the **lowest** molecular mass.

How many moles of oxygen are required for the complete combustion of 1.0 mol of alcohol X?

A 3.5 mol **B** 4.5 mol **C** 6.0 mol **D** 6.5 mol

23 Butanoic acid can be produced from 1-bromopropane in two steps using reagents V and W as shown.

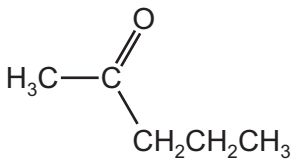


What could be reagents V and W?

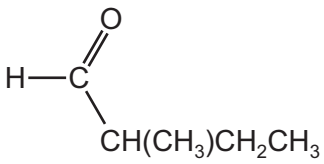
	V	W
A	KCN in ethanol	HCl(aq)
B	KCN in ethanol	NaOH(aq)
C	NH_3 in ethanol	HCl(aq)
D	NaOH(aq)	$H^+ / Cr_2O_7^{2-}$(aq)

24 Which statement about compound T and compound U is correct?

compound T



compound U



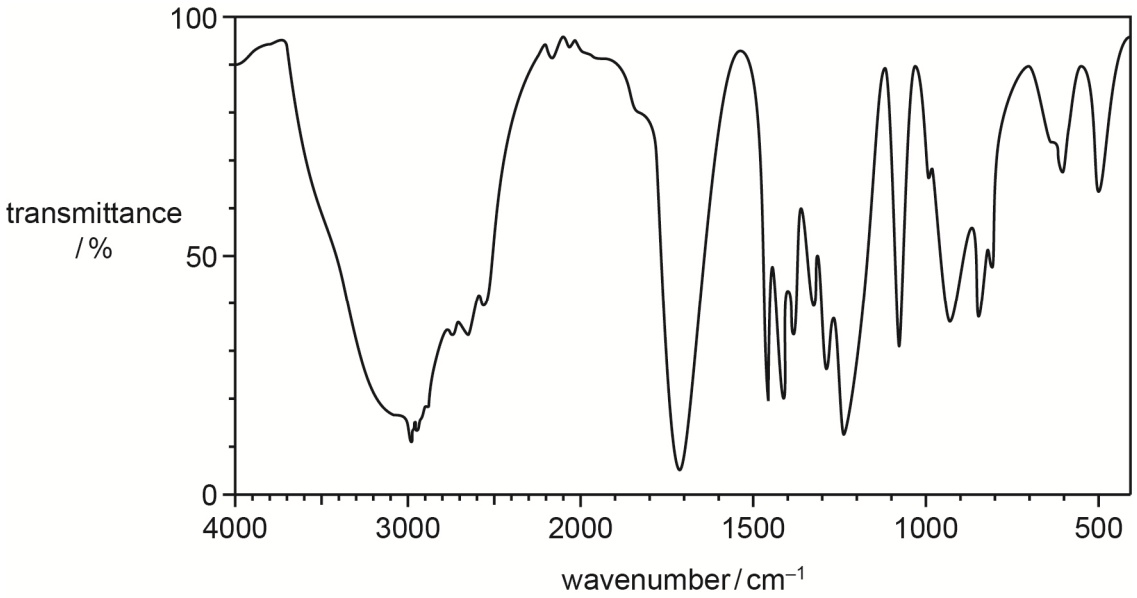
A T and U are stereoisomers.

B T can be distinguished from U by the use of alkaline aqueous iodine.

C T can be reduced by $LiAlH_4$ but not by $NaBH_4$.

D U can be formed by the oxidation of 3-methylbutan-1-ol.

25 The diagram shows the infrared spectrum of an organic compound.



What could be the identity of this compound?

A propan-1-ol

B propanal

C propanoic acid

D propanone

26 Which reagent reacts with **both** of the –OH groups in lactic acid, $CH_3CH(OH)CO_2H$?

A acidified potassium dichromate(VI)

B ethanol

C sodium

D sodium hydroxide

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27 1,2-dibromopropane can be made from 1-bromopropane in two steps.

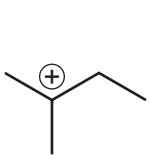
Which row is correct?

	step 1	step 2
A	addition	substitution
B	elimination	addition
C	hydrolysis	elimination
D	substitution	hydrolysis

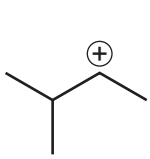
28 2-methylbut-2-ene reacts with HBr(g) to form two isomeric products. During the reaction two positively charged intermediates can be made.

Which diagram shows the more stable of the two positively charged intermediates?

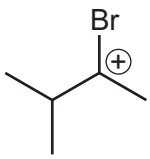
A



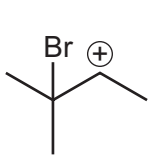
B



C



D



29 The ester ethyl methanoate is prepared in a school laboratory by reacting a carboxylic acid with an alcohol.

During the reaction, only 50.0% of the alcohol is converted into the ester.

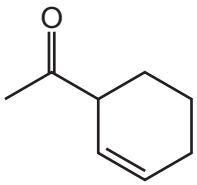
Which mass of alcohol is needed to prepare 10.0 g of the ester?

A 3.11 g **B** 8.65 g **C** 12.4 g **D** 32.2 g

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30 Compound X has the structure shown.

compound X



Which type of carbonyl group is present and how many chiral centres are there in one molecule of X?

	carbonyl group	chiral centres
A	aldehyde	0
B	aldehyde	1
C	ketone	0
D	ketone	1

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Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

Use of the *Data Booklet* may be appropriate for some questions.

31 Which contain one mole of the underlined substance under room conditions?

1 a balloon containing 24.0 dm^3 of <u>helium</u>

2 a block of <u>calcium carbonate</u> weighing 100.1 g

3 4000 cm^3 of a 0.250 mol dm^{-3} solution of <u>sulfuric acid</u>

32 Buckminsterfullerene is a fullerene allotrope of carbon.

Which statements about buckminsterfullerene are correct?

1 Buckminsterfullerene is a giant covalent molecule.

2 Buckminsterfullerene has delocalised electrons.

3 Buckminsterfullerene has strong intramolecular bonds.

33 Gaseous sodium ions can be formed from sodium atoms.

$$Na(s) \rightarrow Na^+(g)$$

Which quantities are required to calculate the enthalpy change of formation of $Na^+(g)$?

1 first ionisation energy of sodium

2 enthalpy change of atomisation of sodium

3 enthalpy change of formation of sodium

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The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

34 The Haber process is used in industry to form ammonia from hydrogen and nitrogen.

$$3H_2 + N_2 \rightleftharpoons 2NH_3$$

Which statements about the activation energy for this process are correct?

1 The activation energy for the forward reaction is the same as the activation energy for the reverse reaction.

2 The activation energy for the reverse reaction is decreased by the addition of iron.

3 The activation energy is the minimum energy that colliding particles must possess in order to react.

35 Strontium nitrate is heated strongly for several minutes.

Which statements are correct?

1 A brown gas is produced.

2 A gas is produced that relights a glowing splint.

3 A white powder remains after heating.

36 When added to water, which oxides will **not** cause a change in pH?

1 Al_2O_3

2 SiO_2

3 P_4O_{10}

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37 Propanal reacts with hydrogen cyanide to form 2-hydroxybutanenitrile. A suitable catalyst for this reaction is sodium cyanide.

$$CH_3CH_2CHO + HCN \xrightarrow{NaCN} CH_3CH_2CH(OH)CN$$

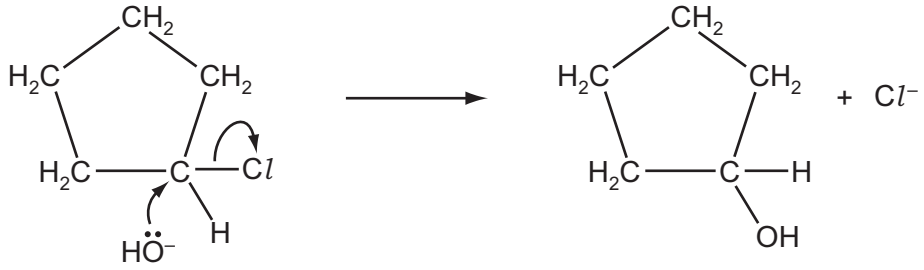
Which statements about this catalysed reaction of propanal with hydrogen cyanide are correct?

1 The sodium cyanide provides a stronger nucleophile than HCN.

2 The reaction can be classified as nucleophilic substitution.

3 The hydrogen cyanide molecule attacks the propanal molecule to form an intermediate ion.

38 A reaction mechanism is shown.



Which statements about this reaction are correct?

1 It is a substitution reaction.

2 OH^- behaves as a nucleophile.

3 Heterolytic bond fission is involved.

39 On complete combustion, a sample of X produces 44 g of carbon dioxide and 27 g of water.

On complete combustion, a sample of Y produces 44 g of carbon dioxide and 18 g of water.

On complete combustion, a sample of Z produces 22 g of carbon dioxide and 9 g of water.

Which substances could be straight chain alkanes?

1 X

2 Y

3 Z

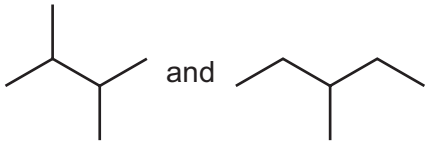
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

40 Which pairs are structural isomers of each other?

1 $CH_3CH_2CH_2CH_2CH_2CO_2H$ and $CH_3CH_2CH_2CO_2CH_2CH_3$

2  and

3 $CH_3CH_2CH_2CH(OH)CH_2CH_3$ and $CH_3CH_2CH(OH)CH_2CH_2CH_3$

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