Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/11**

Paper 1 Multiple Choice **May/June 2023**

1 hour 15 minutes

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)

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.
- Any rough working should be done on this question paper.
- The Periodic Table is printed in the question paper.
- Important values, constants and standards are printed in the question paper.

IB23 06_9701_11/7RP
© UCLES 2023

[Turn over

1 Element X has six more protons than element Y.

Which statement **must** be correct?

A Atoms of element Y are smaller than atoms of element X.

B Element X has a full shell of electrons.

C Element X and element Y are in the same group.

D Element X and element Y are in the same period.

2 Which statement explains why calcium has a higher melting point than barium?

A Calcium cations are smaller than barium cations and have a stronger attraction to the delocalised electrons.

B The structure of calcium is partly giant molecular.

C There are more delocalised electrons in calcium than in barium as it has a lower ionisation energy.

D There is greater repulsion between barium atoms as they have more complete electron shells than calcium atoms.

3 Three statements about potassium and chlorine and their ions are listed.

1 The atomic radius of a potassium atom is greater than the atomic radius of a chlorine atom.

2 The first ionisation energy of potassium is greater than the first ionisation energy of chlorine.

3 The ionic radius of a potassium ion is greater than the ionic radius of a chloride ion.

Which statements are correct?

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

4 For which equilibrium do both of the equilibrium constants K_c and K_p have no units?

A $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

B $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

C $N_2O_4(g) \rightleftharpoons 2NO_2(g)$

D $SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g)$

© UCLES 2023

5 Calcium carbide, CaC_2, reacts with water, as shown. The data below the equation show, in $kJ\,mol^{-1}$, the standard enthalpies of formation of the compounds involved.

$CaC_2(s)$	+	$H_2O(l)$	→	$CaO(s)$	+	$C_2H_2(g)$
–60		–286		–635		+228

What is the standard enthalpy change of the reaction shown?

A $-753\,kJ\,mol^{-1}$

B $-61\,kJ\,mol^{-1}$

C $+61\,kJ\,mol^{-1}$

D $+753\,kJ\,mol^{-1}$

6 In the sodium chloride lattice the number of chloride ions that surround each sodium ion is called the coordination number of the sodium ions.

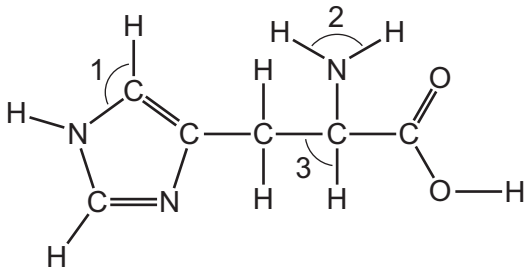
What are the coordination numbers of the sodium ions and the chloride ions in the sodium chloride lattice?

	coordination number of sodium ions	coordination number of chloride ions
A	4	6
B	6	4
C	6	6
D	8	6

© UCLES 2023

7 Histidine is an amino acid.

histidine



What are the approximate bond angles 1, 2, and 3?

	1	2	3
A	109.5°	107°	90°
B	120°	107°	109.5°
C	120°	120°	90°
D	120°	120°	109.5°

8 The Contact process takes place at a pressure between 100 000 Pa and 200 000 Pa. A catalyst is used.

Which statement is correct?

A A V_2O_5 catalyst is added to increase the equilibrium yield of the reaction.

B Changes in pressure have no effect on the position of equilibrium.

C The equilibrium yield of the reaction is very high under the conditions used.

D An iron catalyst is added to increase the rate of reaction.

© UCLES 2023

9 Bromine reacts with aqueous sodium hydroxide at 25 °C.

reaction 1 $Br_2(aq) + 2NaOH(aq) \rightarrow NaBr(aq) + NaOBr(aq) + H_2O(l)$

The NaOBr formed is unstable at 25 °C and reacts further.

reaction 2 $3NaOBr(aq) \rightarrow 2NaBr(aq) + NaBrO_3(aq)$

Which reactions are disproportionations?

A both reaction 1 and reaction 2

B neither reaction 1 nor reaction 2

C reaction 1 only

D reaction 2 only

10 Which statement is correct?

A The relative atomic mass of a ^{35}Cl atom is 35.5.

B The relative formula mass of $CaCO_3$ is 100.1.

C The relative isotopic mass of a ^{24}Mg atom is 24.3.

D The relative molecular mass of O_2 is 16.0.

11 Iodine and propanone react according to the following equation.

$$I_2(aq) + CH_3COCH_3(aq) \rightarrow CH_3COCH_2I(aq) + HI(aq)$$

If the concentration of propanone is increased, keeping the total reaction volume constant, the initial rate of the reaction also increases.

What could be the reason for this?

A A greater proportion of collisions are successful at the higher concentration.

B The particles are further apart at the higher concentration.

C The particles have more energy at the higher concentration.

D There are more collisions per second between particles at the higher concentration.

© UCLES 2023

12 Four successive ionisation energies (IE) of element E are shown.

Element E is in Period 3 of the Periodic Table.

fifth IE / kJ mol^{-1}	sixth IE / kJ mol^{-1}	seventh IE / kJ mol^{-1}	eighth IE / kJ mol^{-1}
16 000	20 000	24 000	29 000

In which group of the Periodic Table is E?

A 14 **B** 15 **C** 16 **D** 17

13 In this question you should assume that the gas formed behaves as an ideal gas.

A 1.7 g sample of Mg reacts with 50.0 cm^3 of 2.2 mol dm^{-3} HC*l* at 303 K and 110 400 Pa.

Which volume of gas is produced, measured under these conditions?

A 1.3 dm^3 **B** 1.6 dm^3 **C** 2.5 dm^3 **D** 5.0 dm^3

14 Chlorine dioxide, C*l*O$_2$, reacts with aqueous sodium hydroxide to produce water and a mixture of two sodium salts, NaC*l*O$_2$ and NaC*l*O$_3$.

What is the mole ratio of NaC*l*O$_2$ to NaC*l*O$_3$ in the product mixture?

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

15 The temperature of a sample of an inert gas is increased.

What effect does this have on the number of molecules with the most probable energy and on the number of molecules with higher energy?

	number of molecules with the most probable energy	number of molecules with higher energy
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

© UCLES 2023

16 For which compound is there the greatest percentage loss of mass on strong heating?

A anhydrous calcium carbonate

B anhydrous calcium nitrate

C anhydrous magnesium carbonate

D anhydrous magnesium nitrate

17 The solids sodium chloride and sodium iodide both react with concentrated sulfuric acid at room temperature.

With NaCl, the products are $NaHSO_4$ and HCl.

With NaI, the products are $NaHSO_4$, HI, I_2, SO_2, H_2O, S and H_2S.

What is the explanation for this difference in products?

A Chloride ions will displace iodine from the solution.

B Hydrogen chloride is more volatile than hydrogen iodide.

C Iodide ions are better reducing agents than chloride ions.

D Sulfuric acid is able to act as a dehydrating agent with NaI.

18 SiO_2 has a melting point of 1713 °C. It reacts with hot NaOH(aq) to form sodium silicate, Na_2SiO_3, and water.

No reaction occurs when SiO_2 is added to hot H_2SO_4(aq).

What can be deduced from this information?

	chemical behaviour of SiO_2	structure of SiO_2
A	amphoteric	giant
B	amphoteric	simple
C	acidic	giant
D	acidic	simple

© UCLES 2023

19 Element X has the second largest atomic radius in its period. An atom of X has three occupied electron shells only.

The oxide of X is shaken with water.

What could be the pH of the resulting solution?

A 5 **B** 7 **C** 9 **D** 14

20 Which emission from an internal combustion engine contributes to the erosion of marble statues?

A carbon monoxide

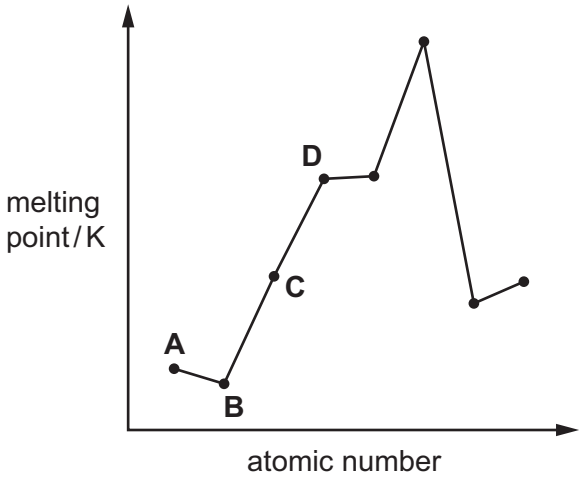
B nitrogen

C nitrogen dioxide

D unburnt hydrocarbons

21 The diagram shows the melting points of eight elements with consecutive atomic numbers.

Which element could be sodium?



22 The boiling points of Br_2, IC*l* and IBr are given in the table.

	Br_2	IC*l*	IBr
boiling point / °C	59	97	116

Which row explains:

- why the boiling point of IC*l* is greater than Br_2
- why the boiling point of IBr is greater than IC*l*?

	boiling point of IC*l* is greater than Br_2	boiling point of IBr is greater than IC*l*
A	IC*l* has stronger instantaneous dipole-induced dipoles	IBr has stronger instantaneous dipole-induced dipoles
B	IC*l* has permanent dipoles	IBr has stronger instantaneous dipole-induced dipoles
C	IC*l* has stronger instantaneous dipole-induced dipoles	IBr has stronger permanent dipoles
D	IC*l* has permanent dipoles	IBr has stronger permanent dipoles

23 A solution contains both $Mg^{2+}(aq)$ and $Sr^{2+}(aq)$ at the same concentration.

The solution is divided into two equal portions. Aqueous sodium hydroxide is added dropwise to one portion. Dilute sulfuric acid is added dropwise to the other portion.

Which row is correct?

	precipitate seen first when NaOH(aq) is added	precipitate seen first when $H_2SO_4(aq)$ is added
A	magnesium hydroxide	magnesium sulfate
B	magnesium hydroxide	strontium sulfate
C	strontium hydroxide	magnesium sulfate
D	strontium hydroxide	strontium sulfate

© UCLES 2023

24 Structural isomerism and stereoisomerism should be considered when answering this question.

If a molecule contains two non-identical chiral carbon atoms, four optical isomers exist.

How many isomers are there with:

- molecular formula $C_7H_{14}O$ **and**
- a five-membered ring **and**
- a tertiary alcohol group?

A 4 **B** 5 **C** 9 **D** 13

25 Which reagent will react with pentan-3-ol to give a mixture of stereoisomers?

A acidified potassium dichromate

B concentrated sulfuric acid

C ethanoic acid in the presence of a little concentrated H_2SO_4

D hydrogen chloride

26 An organic molecule W contains 3 carbon atoms. It requires 4.5 molecules of oxygen for complete combustion.

What could W be?

A propane

B propanoic acid

C propanone

D propan-1-ol

27 Which equation represents a reaction that proceeds through initiation, propagation and termination steps?

A $C_4H_{10} + Cl_2 \rightarrow C_4H_9Cl + HCl$

B $C_5H_{11}Br + NaOH \rightarrow C_5H_{11}OH + NaBr$

C $C_6H_{12} + H_2O \rightarrow C_6H_{13}OH$

D $C_6H_{13}CHO + HCN \rightarrow C_6H_{13}CH(OH)CN$

© UCLES 2023

28 Structural isomerism and stereoisomerism should be considered when answering this question.

A set of isomeric hydrocarbons:

- all contain 14.3% by mass of hydrogen
- all react with bromine by addition, 0.280 g of each hydrocarbon reacting with 0.799 g of bromine.

What is the maximum number of isomeric compounds in the set?

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

29 Which row describes the solvent used and type of reaction occurring when bromoethane reacts with NaOH to form ethene?

	solvent	type of reaction
A	ethanol	elimination
B	ethanol	substitution
C	water	elimination
D	water	substitution

30 Which row describes the type of reaction that occurs when propan-1-ol reacts to form the named carbon-containing product?

	carbon-containing product	type of reaction
A	1-chloropropane	addition to propan-1-ol
B	carbon monoxide	complete combustion of propan-1-ol
C	propene	dehydration of propan-1-ol
D	propanal	reduction of propan-1-ol

31 Which statement describes what happens when 2-chloro-2-methylpropane is warmed with NaOH(aq)?

A This secondary halogenoalkane reacts by a mixture of an S_N1 and an S_N2 mechanism.

B This secondary halogenoalkane reacts only by an S_N2 mechanism.

C This tertiary halogenoalkane reacts mostly by an S_N1 mechanism.

D This tertiary halogenoalkane does **not** react with hydroxide ions under these conditions.

© UCLES 2023

32 How many structurally isomeric secondary alcohols are there with the molecular formula $C_5H_{12}O$?

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

33 Which reagent:

- can confirm the presence of a carbonyl group in an organic compound
- does **not** distinguish between aldehydes and ketones?

A acidified $K_2Cr_2O_7$

B 2,4-DNPH reagent

C Fehling's reagent

D $LiAlH_4$

34 Which compound gives a positive test with alkaline aqueous iodine and does **not** show optical isomerism?

A $CH_3COCH_2CH_2OH$

B $CH_3CH_2CH(OH)CHO$

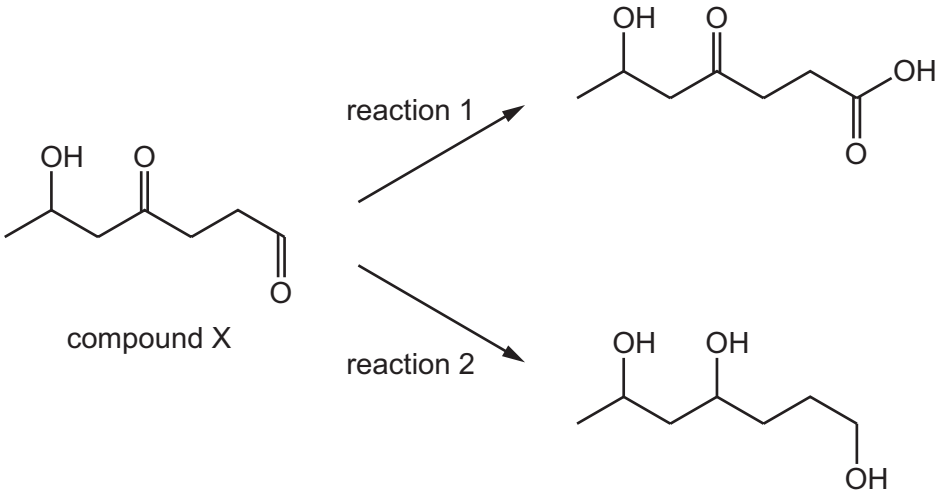
C $CH_3COCH(OH)CH_3$

D $(CH_3)_2C(OH)CHO$

© UCLES 2023

35 Two samples of compound X were treated separately with different reagents which were added in excess.

The products of these two reactions are shown.



Which reagents could be used for reaction 1 and reaction 2?

	reaction 1	reaction 2
A	hot acidified sodium dichromate(VI)	Na
B	hot acidified sodium dichromate(VI)	$NaBH_4$
C	Tollens' reagent followed by HC*l*(aq)	Na
D	Tollens' reagent followed by HC*l*(aq)	$NaBH_4$

36 Which method could produce butanoic acid?

A an acid–base reaction involving $CH_3CH_2CH_2CO_2Na$

B the hydrolysis of $CH_3CH_2CH_2CH_2CN$

C the acidic hydrolysis of $CH_3CH_2COOCH_2CH_2CH_3$

D the oxidation of $CH_3CH_2CH_2OH$

© UCLES 2023

[Turn over

37 Which ester may be hydrolysed to produce two products, one of which may be reduced to the other?

A $CH_3CH_2CO_2CH_3$

B $CH_3CH(CH_3)CO_2CH_2CH(CH_3)_2$

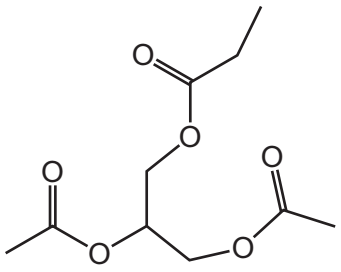
C $CH_3CH_2CO_2CH(CH_3)_2$

D $(CH_3)_2CHCO_2CH(CH_3)_2$

38 Two compounds, X and Y, are mixed and a little concentrated H_2SO_4 is added.

Ester Z is found in the resulting mixture of products.

ester Z



Which two compounds could be X and Y?

	X	Y
A	CH_3CH_2OH	$CH(CO_2H)_3$
B	CH_3CH_2OH	$CH_3CO_2CH_2CH(OH)CH_2OCOCH_2CH_3$
C	CH_3CO_2H	$CH_3CH_2CO_2CH_2CH(OH)CH_2OH$
D	CH_3CO_2H	$CH_2(OH)CH(OH)CH_2(OH)$

39 The diagram shows a section of a polymer molecule.

$$–CH_2–CH=CH–CH_2–CH_2–CH=CH–CH_2–$$

Which monomer will produce this polymer?

A $CH_2=CH_2$

B $CH_3CH=CH_2$

C $CH_3CH=CHCH_3$

D $CH_2=CH–CH=CH_2$

© UCLES 2023

40 There are two naturally occuring isotopes of bromine. One isotope has 44 neutrons. The other isotope has 46 neutrons.

Ignoring fragments, how many peaks are there in the mass spectrum of tribromomethane, $^{12}C^{1}HBr_3$?

A 2 **B** 3 **C** 4 **D** 6

© UCLES 2023

BLANK PAGE

BLANK PAGE

© UCLES 2023

BLANK PAGE

© UCLES 2023

Important values, constants and standards

molar gas constant	$R = 8.31\,\text{J K}^{-1}\,\text{mol}^{-1}$
Faraday constant	$F = 9.65 \times 10^{4}\,\text{C mol}^{-1}$
Avogadro constant	$L = 6.02 \times 10^{23}\,\text{mol}^{-1}$
electronic charge	$e = -1.60 \times 10^{-19}\,\text{C}$
molar volume of gas	$V_m = 22.4\,\text{dm}^3\,\text{mol}^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0\,\text{dm}^3\,\text{mol}^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14}\,\text{mol}^2\,\text{dm}^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18\,\text{kJ kg}^{-1}\,\text{K}^{-1}$ ($4.18\,\text{J g}^{-1}\,\text{K}^{-1}$)

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge Assessment International Education Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cambridgeinternational.org after the live examination series.

Cambridge Assessment International Education is part of Cambridge Assessment. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which is a department of the University of Cambridge.

© UCLES 2023

© UCLES 2023

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0											5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.4	61 Pm promethium –	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
actinoids	89 Ac actinium –	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –