Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **October/November 2023**

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

* 8 5 9 9 7 8 9 8 2 3 *

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.

This document has **16** pages.

1 Which particle contains 8 protons, 9 neutrons and 10 electrons?

A $^{16}_{8}O^{-}$ **B** $^{16}_{8}O^{2-}$ **C** $^{17}_{8}O^{-}$ **D** $^{17}_{8}O^{2-}$

2 The second ionisation energy of oxygen is greater than the second ionisation energy of fluorine.

Which factor explains this difference?

A The atomic radius of an oxygen atom is smaller than that of fluorine.

B The covalent bond in a fluorine molecule is weaker than the bond in an oxygen molecule.

C A spin-paired electron is removed from fluorine but **not** from oxygen.

D Fluorine has more electrons in total than oxygen. This causes a greater shielding of the nuclear attraction in fluorine.

3 Zinc reacts with concentrated nitric acid giving three products only: zinc nitrate, an oxide of nitrogen and water.

3.0 moles of zinc react with 8.0 moles of nitric acid. Zinc nitrate contains Zn^{2+} ions.

What could be the formula of the oxide of nitrogen?

A N_2O **B** NO **C** N_2O_3 **D** NO_2

4 A 3.7 g sample of copper(II) carbonate is added to $25\,cm^3$ of $2.0\,mol\,dm^{-3}$ hydrochloric acid.

Which volume of gas is produced at room conditions?

A $0.60\,dm^3$ **B** $0.72\,dm^3$ **C** $1.20\,dm^3$ **D** $2.40\,dm^3$

5 Ammonium ions, NH_4^{+}, are formed when ammonia gas reacts with hydrogen chloride gas.

Which statement about the changes that occur in this reaction is correct?

A The dipole moment of an ammonium ion is greater than the dipole moment of an ammonia molecule.

B The H–N–H bond angle decreases when an ammonium ion is formed.

C The hybridisation of nitrogen does **not** change.

D There is electron transfer from nitrogen to chlorine.

6 Which feature is present in both ethene and poly(ethene)?

A bond angles of 109.5°

B π covalent bonds

C σ covalent bonds

D sp^3 orbitals

7 Two compounds of boron are sodium borohydride, $NaBH_4$, and boron trifluoride, BF_3.

What are the shapes of the borohydride ion and the boron trifluoride molecule?

	borohydride ion	boron trifluoride
A	square planar	pyramidal
B	square planar	trigonal planar
C	tetrahedral	pyramidal
D	tetrahedral	trigonal planar

8 In an experiment, 0.100 mol of propan-1-ol is burnt completely in 12.0 dm^3 of oxygen, measured at room conditions.

What is the final volume of gas, measured at room conditions?

A 7.20 dm^3 **B** 8.40 dm^3 **C** 16.80 dm^3 **D** 18.00 dm^3

9 At a temperature of 2500 K and a pressure of 1.00×10^{-4} Pa, a sample of 0.321 g of sulfur vapour has a volume of $2.08 \times 10^6\ m^3$.

What is the molecular formula of sulfur under these conditions?

A S **B** S_2 **C** S_4 **D** S_8

10 In the structure of solid SiO_2

each silicon atom is bonded to x oxygen atoms

each oxygen atom is bonded to y silicon atoms

each bond is a z type bond.

What is the correct combination of x, y and z in these statements?

	x	y	z
A	2	1	covalent
B	2	1	ionic
C	4	2	covalent
D	4	2	ionic

11 Nitric acid is made industrially by the oxidation of ammonia. The overall equation for the process is shown.

equation 1 $NH_3 + 2O_2 \rightarrow HNO_3 + H_2O$

The process happens in three stages. The equations and enthalpy changes for these stages are given.

stage 1 $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$ $\Delta H = -904\,kJ\,mol^{-1}$

stage 2 $2NO + O_2 \rightarrow 2NO_2$ $\Delta H = -114\,kJ\,mol^{-1}$

stage 3 $4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$ $\Delta H = -348\,kJ\,mol^{-1}$

What is the enthalpy change of the process shown in equation 1?

A $-1480\,kJ\,mol^{-1}$

B $-370\,kJ\,mol^{-1}$

C $-341.5\,kJ\,mol^{-1}$

D $+82\,kJ\,mol^{-1}$

12 Chlorine reacts with sodium bromide.

$$\tfrac{1}{2}Cl_2 + NaBr \rightarrow NaCl + \tfrac{1}{2}Br_2$$

Which words correctly describe this reaction?

1 redox

2 displacement

3 disproportionation

A 1, 2 and 3

B 1 and 2 only

C 1 only

D 2 only

13 The equation for the reaction between aqueous copper ions and aqueous iodide ions is as follows.

$$2Cu^{2+}(aq) + 4I^{-}(aq) \rightarrow 2CuI(s) + I_2(aq)$$

What is the change in oxidation state of copper?

A +2 to –1 **B** +2 to 0 **C** +2 to +1 **D** +4 to +2

14 A mixture of the three gases, oxygen, nitrogen and argon, is at a total pressure of 500 kPa. There is a total of 1.2 moles of gas in the mixture.

If the oxygen gas alone occupied the entire volume of the mixture, it would exert a pressure of 150 kPa.

At room conditions the amount of nitrogen gas in the mixture would occupy a volume of 5.76 dm^3.

What is the partial pressure of the argon gas in the mixture?

A 150 kPa

B 200 kPa

C 250 kPa

D 300 kPa

15 0.200 mol of sulfur dioxide and 0.200 mol of oxygen are placed in a 1.00 dm^3 sealed container. The gases are allowed to react until equilibrium is reached.

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

At equilibrium there is 0.100 mol of SO_3 in the container.

What is the value of K_c?

A 0.150 mol dm^{-3}

B 0.800 mol dm^{-3}

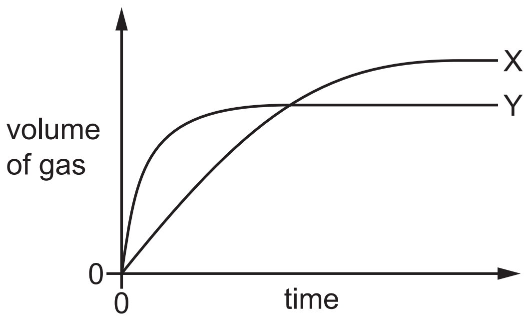
C 1.25 mol^{-1} dm^3

D 6.67 mol^{-1} dm^3

16 The decomposition of hydrogen peroxide in the presence of MnO_2 produces water and oxygen gas.

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

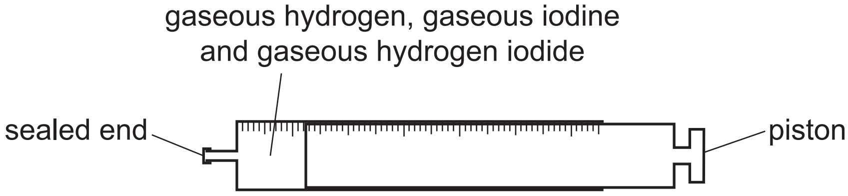
The volume of gas collected when 0.2 g of MnO_2 is added to two different hydrogen peroxide solutions at 20 °C is shown on the graph as curves X and Y.



Which row shows the conditions that will result in curves X and Y?

	curve X			curve Y		
	volume of H_2O_2 / cm^3	concentration of H_2O_2 / mol dm^{-3}	form of MnO_2	volume of H_2O_2 / cm^3	concentration of H_2O_2 / mol dm^{-3}	form of MnO_2
A	50	0.1	lumps	50	0.2	powder
B	25	0.2	powder	25	0.1	lumps
C	50	0.1	lumps	20	0.2	powder
D	20	0.2	powder	40	0.1	lumps

17 The diagram shows a gas syringe with a free-moving piston. The syringe contains gaseous hydrogen, gaseous iodine and gaseous hydrogen iodide at equilibrium.



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

Three changes are listed.

1 increasing the total pressure by adding an inert gas and keeping the volume constant

2 increasing the pressure by adding more gaseous hydrogen iodide and keeping the volume constant

3 decreasing the volume by pushing the piston to the left

Which changes will result in an equilibrium position at which the rate of the forward reaction has increased?

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

18 Which row gives the best description of the variations in the melting points and the first ionisation energies of the elements in Period 3 from sodium to argon?

	melting points	first ionisation energies
A	increase up to a peak at aluminium then decrease	generally decrease
B	increase up to a peak at aluminium then decrease	generally increase
C	increase up to a peak at silicon then decrease	generally decrease
D	increase up to a peak at silicon then decrease	generally increase

19 X and Y are atoms of different elements in Period 3 of the Periodic Table. Neither X nor Y is argon.

X is a non-metal.

X has a greater atomic radius than Y.

Which statement is correct?

A X has more occupied electron shells than Y.

B X has more protons in each atom than Y.

C X has the same number of outer electrons in each atom as Y.

D Y is a non-metal.

20 Four mixtures are added to four separate $50\,cm^3$ samples of water and stirred.

Which mixture results in a solution with the highest pH?

A 1.0 g of aluminium oxide and 1.0 g of aluminium chloride

B 1.0 g of magnesium oxide and 1.0 g of magnesium chloride

C 1.0 g of phosphorus oxide and 1.0 g of phosphorus chloride

D 1.0 g of silicon dioxide and 1.0 g of silicon chloride

21 What happens when a piece of magnesium ribbon is placed in cold water?

A A vigorous effervescence occurs.

B Bubbles of gas form slowly on the magnesium.

C The magnesium floats on the surface of the water and reacts quickly.

D The magnesium glows and a white solid is produced.

22 The table gives some data for compounds of two elements from Group 2 of the Periodic Table.

element	decomposition temperature of carbonate / °C	solubility of sulfate in mol / 100 g of water	solubility of hydroxide in mol / 100 g of water
calcium	840	4.66×10^{-3}	1.53×10^{-3}
Z	?	?	2.00×10^{-5}

What is the missing data for element Z?

	decomposition temperature of carbonate / °C	solubility of sulfate in mol / 100 g of water
A	350	1.83×10^{-1}
B	350	7.11×10^{-5}
C	1100	1.83×10^{-1}
D	1100	7.11×10^{-5}

23 Q is a mixture of two compounds of Group 2 elements.

Q undergoes thermal decomposition to produce a white solid and only two gaseous products. One of the gaseous products relights a glowing splint.

What could be the components of mixture Q?

A $MgCl_2$ and $CaCO_3$

B $MgCO_3$ and $Ca(NO_3)_2$

C $Mg(NO_3)_2$ and $Ca(NO_3)_2$

D MgO and CaO

24 Iodine has a higher melting point than chlorine.

What is the reason for this?

A Iodine has stronger covalent bonds than chlorine.

B Iodine molecules have stronger permanent dipoles than chlorine molecules.

C Iodine is more volatile than chlorine.

D Iodine has stronger instantaneous dipole–induced dipole forces than chlorine.

25 When concentrated sulfuric acid is added to solid sodium chloride, HCl is formed but **not** Cl_2.

When concentrated sulfuric acid is added to solid sodium iodide, I_2 is formed.

Which statement explains these observations?

A Sulfuric acid is an oxidising agent and chloride ions are more easily oxidised than iodide ions.

B Sulfuric acid is an oxidising agent and iodide ions are more easily oxidised than chloride ions.

C Sulfuric acid is a reducing agent and chloride ions are more easily reduced than iodide ions.

D Sulfuric acid is a reducing agent and iodide ions are more easily reduced than chloride ions.

26 $NaOH(aq)$ is added to $NH_4Cl(aq)$. The mixture is warmed.

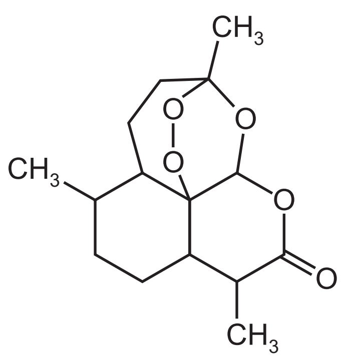
The gas that is produced turns damp red litmus paper blue.

Which row is correct?

	behaviour of the ammonium ion in NH_4Cl	behaviour of the water present on the litmus paper
A	Brønsted–Lowry acid	Brønsted–Lowry base
B	Brønsted–Lowry acid	Brønsted–Lowry acid
C	Brønsted–Lowry base	Brønsted–Lowry acid
D	Brønsted–Lowry base	Brønsted–Lowry base

27 Artemisinin is a powerful anti-malarial drug.

artemisinin



How many chiral centres are there in each molecule of artemisinin?

A 4 **B** 6 **C** 7 **D** 8

28 Which row shows the correct name and classification of the halogenoalkane shown?

$CH_3(CH_2)_2CBr(CH_3)CH_2CH_3$

	name	classification of halogenoalkane
A	3-bromo-3-methylhexane	secondary
B	3-bromo-3-methylhexane	tertiary
C	3-bromo-4-methylhexane	tertiary
D	4-bromo-5-methylhexane	secondary

29 How many geometrical (cis/trans) isomers are there of hex-2,4-diene, $CH_3CH{=}CHCH{=}CHCH_3$?

A none; hex-2,4-diene does **not** show geometric isomerism

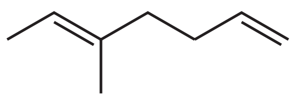
B 2

C 3

D 4

30 The structure of compound X is shown.

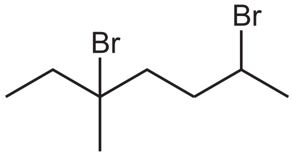
compound X



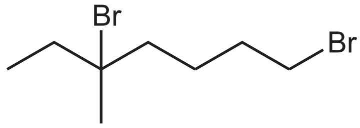
One mole of compound X reacts completely with two moles of hydrogen bromide.

What is the structure of the major product of this reaction?

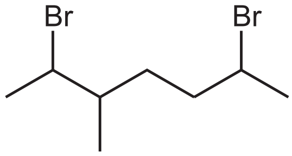
A



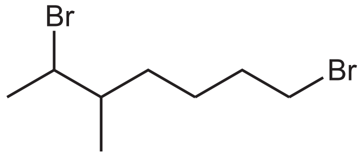
B



C



D



31 The formulae of three compounds are shown.

C_3H_7CHO $C_2H_5COCH_3$ $CH_2CHCH_2CH_2OH$

Only one of these compounds will decolourise bromine water. Only one of these compounds will produce a silver mirror with Tollens' reagent.

Which row shows the correct results?

	decolourises bromine water	forms a silver mirror with Tollens' reagent
A	C_3H_7CHO	$C_2H_5COCH_3$
B	$C_2H_5COCH_3$	C_3H_7CHO
C	$CH_2CHCH_2CH_2OH$	$C_2H_5COCH_3$
D	$CH_2CHCH_2CH_2OH$	C_3H_7CHO

32 Which list contains a compound that is **not** made during the free radical substitution of methane with chlorine?

A CH_3Cl, CCl_4, C_2H_6

B Cl_2, CH_2Cl_2, CCl_4

C CH_3Cl, CH_2Cl_2, $CHCl_3$

D CH_3Cl, $CHCl_3$, $C_2H_2Cl_2$

33 Propanoic acid can be used to make propene by a two-stage synthesis.

Which row shows suitable reagents for this synthesis?

	reagent for first stage	reagent for second stage
A	$LiAlH_4$	conc. H_2SO_4
B	$LiAlH_4$	NaOH in ethanol
C	$NaBH_4$	conc. H_2SO_4
D	$NaBH_4$	NaOH in ethanol

34 Which alcohol reacts with alkaline $I_2(aq)$ to produce ethanoate ions?

A ethanol

B methylpropan-2-ol

C propan-2-ol

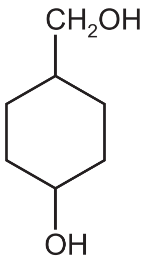
D butan-2-ol

35 Heating compound X, $C_7H_{14}O_2$, under reflux with an excess of acidified potassium dichromate(VI) produces compound Y.

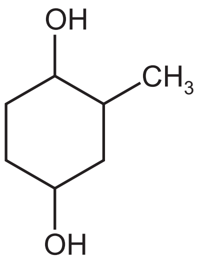
Compound Y produces hydrogen gas with sodium metal and forms orange crystals with 2,4-DNPH reagent.

What could X be?

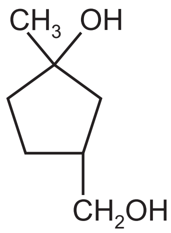
A



B



C



D

$(CH_3)_2C(OH)CH_2CH_2CH_2CHO$

36 Which reaction takes place by a nucleophilic addition mechanism?

A propene reacting with hydrogen bromide

B 2-bromopropane reacting with sodium hydroxide in ethanol

C propanone reacting with hydrogen cyanide

D methane reacting with chlorine

37 Three equations are shown.

1 $CH_3COOH + MgCO_3 \rightarrow CH_3COOMg + CO_2 + H_2O$

2 $CH_3CH_2COOH + Na \rightarrow CH_3CH_2COONa + \frac{1}{2}H_2$

3 $CH_3CH_2COOH + 2Ba(OH)_2 \rightarrow CH_3CH_2COOBa_2 + 2H_2O$

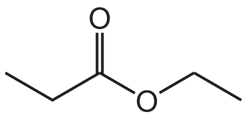
Which of the equations are correct?

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

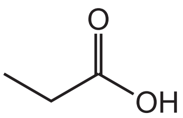
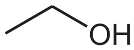
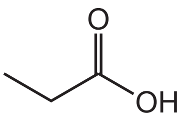
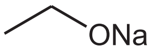
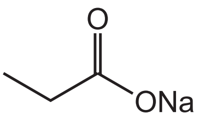
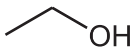
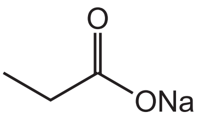
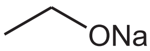
38 How many esters with the molecular formula $C_5H_{10}O_2$ can be made by reacting a primary alcohol with a carboxylic acid?

A 4 **B** 5 **C** 6 **D** 8

39 The diagram shows an ester. It is heated under reflux with an excess of NaOH(aq).



Which row shows the 2 products of the reaction?

	product 1	product 2
A		
B		
C		
D		

40 Oxygen has three stable isotopes, ^{16}O, ^{17}O and ^{18}O. All three isotopes are present in a sample of oxygen gas, O_2, which was analysed using a mass spectrometer.

How many peaks associated with the O_2^+ ion would be expected?

A 3 **B** 5 **C** 6 **D** 9

Important values, constants and standards

molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
Faraday constant	$F = 9.65 \times 10^{4}\,\mathrm{C\,mol^{-1}}$
Avogadro constant	$L = 6.022 \times 10^{23}\,\mathrm{mol^{-1}}$
electronic charge	$e = -1.60 \times 10^{-19}\,\mathrm{C}$
molar volume of gas	$V_m = 22.4\,\mathrm{dm^3\,mol^{-1}}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0\,\mathrm{dm^3\,mol^{-1}}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14}\,\mathrm{mol^2\,dm^{-6}}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18\,\mathrm{kJ\,kg^{-1}\,K^{-1}}$ ($4.18\,\mathrm{J\,g^{-1}\,K^{-1}}$)

The Periodic Table of Elements

Key

atomic number atomic symbol name relative atomic mass

Group 1	2	3	4	5	6	7	8	9	10	11	12	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											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 –

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 –