



Cambridge International AS & A Level

CHEMISTRY**9701/11**

Paper 1 Multiple Choice

May/June 2022**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

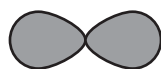
- The total mark for this paper is 40.
- Each correct answer will score one mark.
- Any rough working should be done on this question paper.
- The Periodic Table is printed in the question paper.
- Important values, constants and standards are printed in the question paper.

This document has **16** pages.



2

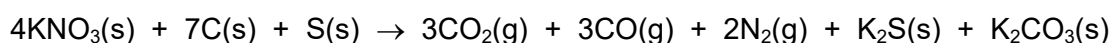
- 1 Which atom has its outermost electron in an orbital of the shape shown, with principal quantum number 3?



- A sodium
B chlorine
C calcium
D bromine
- 2 Which atom has the same number of electrons as the hydroxide ion, OH^- ?
- A F B Ne C Na D Mg
- 3 In separate experiments, 5.0 g samples of each of four s-block metals are added to an excess of water. The gas evolved is collected and its volume measured under the same conditions of temperature and pressure for each sample.
- Which metal produces the largest volume of gas?
- A calcium
B potassium
C rubidium
D strontium
- 4 A student reacts 1 mol of copper with concentrated nitric acid to produce 1 mol of copper(II) nitrate, 2 mol of water and substance X. No other product is formed.
- Substance X does not contain copper or hydrogen.
- What could be substance X?
- A N_2 B N_2O C NO D NO_2
- 5 In which structure are three atoms bonded together in a straight line?
- A poly(ethene), $-(\text{CH}_2\text{CH}_2)_n-$
B propane, C_3H_8
C silicon tetrachloride, SiCl_4
D sulfur hexafluoride, SF_6

- 6 Which statement about aluminium chloride is correct?
- A** Aluminium chloride has a much higher melting point than magnesium chloride due to the small size of the aluminium ion.
- B** Anhydrous aluminium chloride reacts vigorously with water to form a solution with a pH greater than 7.
- C** Each Al_2Cl_6 molecule found in aluminium chloride vapour contains two coordinate bonds.
- D** The bonding between aluminium and chlorine is strongly ionic due to the large difference in electronegativity.

- 7 'Black powder' is a mixture of potassium nitrate, carbon and sulfur. The mixture reacts as shown.



A sealed tube containing black powder has a volume of 10.0 cm^3 . When all of the black powder reacts, the reaction causes a pressure of $2 \times 10^6 \text{ Pa}$ and a temperature of 2500 K .

The volume of the K_2CO_3 and K_2S produced can be ignored.

How many moles of KNO_3 are contained in the sealed tube?

- A** 4.81×10^{-4} **B** 9.63×10^{-4} **C** 1.93×10^{-3} **D** 9.63×10^{-1}
- 8 For which pair is the boiling point of the first compound **higher** than the boiling point of the second compound?
- A** CH_3CH_2OH and CH_3CH_2SH
- B** $CH_3CO_2CH_3$ and $CH_3CH_2CO_2H$
- C** CH_3OCH_3 and CH_3CH_2OH
- D** CH_3CH_2CHO and $CH_3CH_2CO_2H$

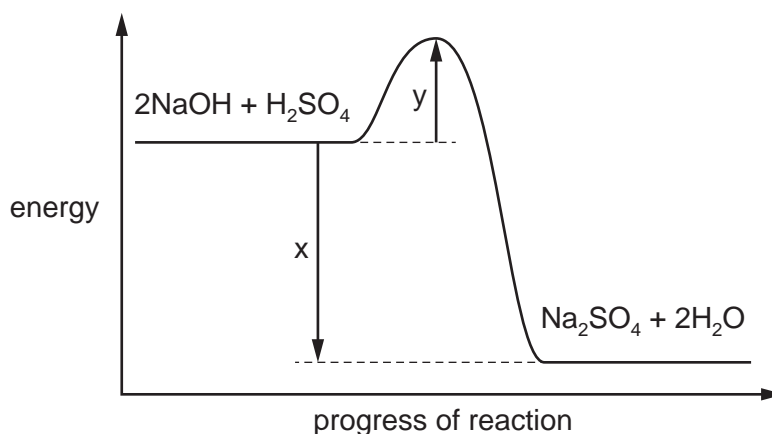
- 9 The equation for an enthalpy change is shown. The enthalpy change is Q.



What is the correct expression to calculate Q?

- A** $2 \times \Delta H_c^\ominus [CO_2(g)] - 3 \times \Delta H_f^\ominus [H_2(g)]$
- B** $3 \times \Delta H_f^\ominus [H_2O(g)] + 2 \times \Delta H_c^\ominus [CO_2(g)]$
- C** $2 \times \Delta H_f^\ominus [CO_2(g)] - 3 \times \Delta H_f^\ominus [H_2(g)]$
- D** $3 \times \Delta H_f^\ominus [H_2O(l)] + 2 \times \Delta H_f^\ominus [CO_2(g)]$

- 10 A reaction pathway diagram for the reaction of aqueous sodium hydroxide and dilute sulfuric acid is shown.



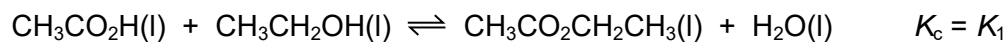
What is the value of the enthalpy change of neutralisation, ΔH_{neut} ?

- A** x **B** $x - y$ **C** $\frac{x}{2}$ **D** $\frac{(x - y)}{2}$
- 11 A student reacts 4 mol of ammonia with oxygen to produce an oxide of nitrogen and water only. Each nitrogen atom increases its oxidation state by 5 in the reaction.
- How many moles of oxygen gas react with 4 mol of ammonia in this reaction?
- A** 4 mol **B** 5 mol **C** 7 mol **D** 10 mol
- 12 In the treatment of domestic water supplies, chlorine is added to water to kill bacteria. Some ClO^- ions are formed.
- What is the change in oxidation number of chlorine when forming the ClO^- ion from aqueous chlorine?
- A** -1 **B** 0 **C** $+1$ **D** $+2$

13 Ethanoic acid is mixed with ethanol.

The ethanol is contaminated with a small amount of methanol.

The following equilibria are established.



Which statement about the equilibrium mixture is correct?

- A** Only ethyl ethanoate will be formed because there is much more ethanol present than methanol.
- B** In this mixture $\frac{[\text{CH}_3\text{CO}_2\text{CH}_2\text{CH}_3]}{[\text{CH}_3\text{CO}_2\text{CH}_3]} = \frac{K_1}{K_2}$.
- C** Adding water to the mixture will alter the mole ratio of the two esters.
- D** Adding methyl ethanoate to the mixture will increase the number of moles of ethyl ethanoate.

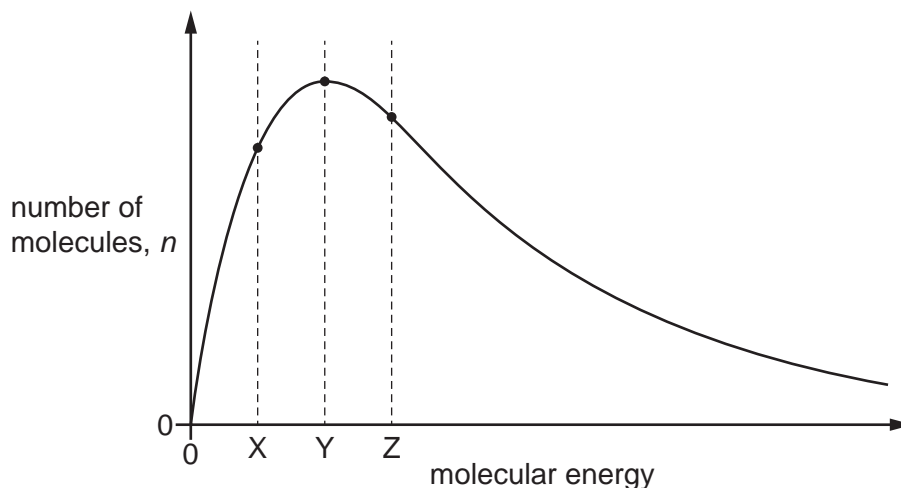
14 SO_3 is manufactured from SO_2 and O_2 in the Contact process.

The reaction is exothermic.

Which row shows the effect on the equilibrium yield obtained in the Contact process of increasing the temperature and of adding a vanadium(V) oxide catalyst?

	increasing the temperature	adding vanadium(V) oxide as catalyst
A	equilibrium yield decreases	equilibrium yield increases
B	equilibrium yield decreases	equilibrium yield unchanged
C	equilibrium yield increases	equilibrium yield unchanged
D	equilibrium yield increases	equilibrium yield increases

- 15 The Boltzmann distribution for a gas at a constant temperature of 50 °C is shown.

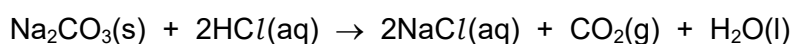


If the temperature of the gas is **reduced** by 10 °C, the graph changes shape.

What happens to the values of n for the molecular energies X, Y and Z?

	X	Y	Z
A	higher	lower	higher
B	higher	lower	lower
C	lower	higher	lower
D	lower	lower	lower

- 16 A 3.0 g sample of Na_2CO_3 powder is stirred into 50 cm³ of 1.0 mol dm⁻³ HCl. The volume of CO_2 produced is 600 cm³.



[M_r : Na_2CO_3 , 106.0]

Which volume of CO_2 is produced if 1.0 g of Na_2CO_3 powder is stirred into 50 cm³ of 1.0 mol dm⁻³ HCl under the same conditions?

- A 600 cm³ B 452 cm³ C 226 cm³ D 200 cm³
- 17 Solid sodium iodide reacts with concentrated sulfuric acid to form more than one product that contains sulfur.

What is the lowest oxidation number of sulfur in these products?

- A -2 B 0 C +4 D +6

18 Which statement for the element in Period 3 and Group 13 of the Periodic Table is correct?

- A It has the highest melting point of the elements in its period.
- B It has exactly one electron in its shell with principal quantum number 3.
- C It forms an oxide that reacts with aqueous sodium hydroxide.
- D It forms a chloride that dissolves in water to give a neutral solution.

19 A student reacts 0.100 mol of each of sodium, magnesium and phosphorus atoms separately with an excess of oxygen.

Which rows are correct?

	oxide	mass of oxide formed / g
1	sodium	3.10
2	magnesium	4.03
3	phosphorus	7.10

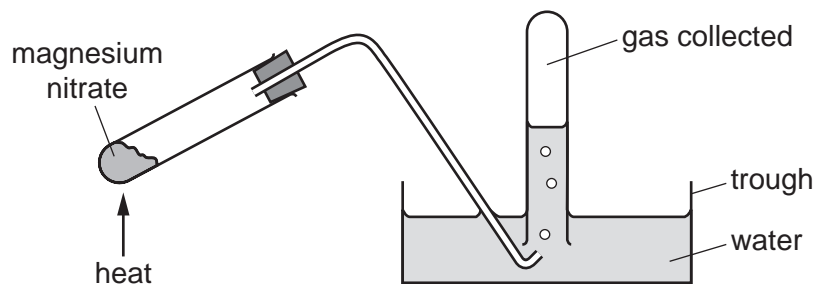
- A 1, 2 and 3 B 1 and 2 only C 1 and 3 only D 2 and 3 only

20 A mixture contains magnesium carbonate and barium carbonate only. A sample of the mixture is dissolved in nitric acid to produce a solution.

How could this solution be processed into a magnesium compound and a separate barium compound?

- A Add $\text{HCl}(\text{aq})$, filter off the solid barium chloride.
- B Add $\text{HCl}(\text{aq})$, filter off the solid magnesium chloride.
- C Add $\text{H}_2\text{SO}_4(\text{aq})$, filter off the solid barium sulfate.
- D Add $\text{H}_2\text{SO}_4(\text{aq})$, filter off the solid magnesium sulfate.

21 A sample of magnesium nitrate is heated in the apparatus shown.



The pH of the solution in the trough is measured.

The gas collected is tested with a glowing splint.

What are the results?

	pH of solution in trough	splint test
A	8	relights
B	2	relights
C	8	extinguished
D	2	extinguished

22 The results of tests performed on a white crystalline solid, X, are given in the table.

reagent and conditions	observation
X is gently heated	X sublimes
X is shaken with H ₂ O	a colourless solution, Y, forms
Y is warmed with NaOH(aq)	a gas is given off
AgNO ₃ (aq) is added to Y	a white precipitate, Z, forms
Z is shaken with NH ₃ (aq)	a colourless solution forms

What is the identity of X?

- A** aluminium bromide
- B** aluminium chloride
- C** ammonium bromide
- D** ammonium chloride

23 Silicon is heated in an excess of chlorine, producing compound J.

An excess of water is added to the sample of J produced.

Which row is correct?

	structure of J	Is HCl produced when water is added to J?
A	giant molecular	no
B	giant molecular	yes
C	simple molecular	no
D	simple molecular	yes

24 In a catalytic converter, 5.6 g of carbon monoxide react with an excess of nitrogen monoxide.

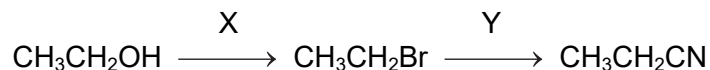
What is produced in this reaction?

- A** 2.4 g of C and 6.0 g of NO₂
- B** 2.4 g of C and 9.2 g of NO₂
- C** 8.8 g of CO₂ and 1.4 g of N₂
- D** 8.8 g of CO₂ and 2.8 g of N₂

25 Which reaction mixture produces an acidic gas?

- A** aqueous ammonium nitrate and solid calcium oxide
- B** calcium and aqueous hydrochloric acid
- C** potassium chloride and concentrated sulfuric acid
- D** sodium oxide and water

26 Ethanol can be used to make propanenitrile in two steps.



What types of reaction are X and Y?

	X	Y
A	free-radical substitution	electrophilic substitution
B	free-radical substitution	nucleophilic substitution
C	nucleophilic substitution	nucleophilic substitution
D	nucleophilic substitution	electrophilic substitution

27 Which compound will react with LiAlH_4 to form two optical isomers?

- A** $\text{CH}_3\text{CH}_2\text{COCH}_3$
- B** $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$
- C** $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$
- D** $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CO}_2\text{H}$

28 How many esters have the molecular formula $\text{C}_4\text{H}_8\text{O}_2$?

- A** 2 **B** 3 **C** 4 **D** 5

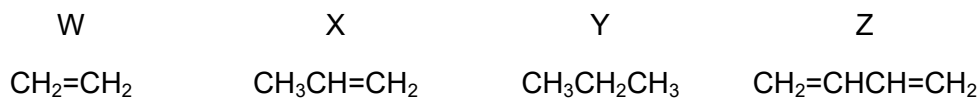
29 Carbon monoxide, CO , nitrogen dioxide, NO_2 , and sulfur dioxide, SO_2 , are all atmospheric pollutants.

Which reaction occurs in the atmosphere?

- A** CO is spontaneously oxidised to CO_2 .
- B** NO_2 is reduced to NO by SO_2 .
- C** NO_2 is reduced to NO by CO .
- D** SO_2 is oxidised to SO_3 by CO_2 .

30 Oct-1-ene, $\text{CH}_3(\text{CH}_2)_5\text{CH}=\text{CH}_2$, can be thermally cracked.

Which of the compounds W, X, Y and Z can be obtained by thermally cracking oct-1-ene?



- A** W, X, Y and Z
B W, X and Y only
C W, X and Z only
D W and X only

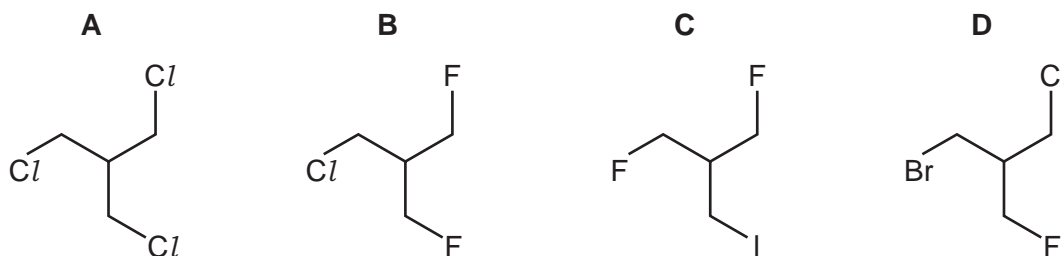
31 Structural isomerism and stereoisomerism should be taken into account when answering this question.

How many isomeric alkenes with formula C_5H_8 are present in the mixture produced when 1,4-dibromopentane is reacted with NaOH in ethanol?

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

32 The presence of a halogen in an organic compound may be detected by warming the organic compound with aqueous silver nitrate.

Which compound would be the quickest to produce a precipitate?



33 17.6 g of pentan-1-ol is completely combusted.

Which volume of gaseous products is formed when measured at s.t.p.?

- A** 22.4 dm³ **B** 24.0 dm³ **C** 49.3 dm³ **D** 52.8 dm³

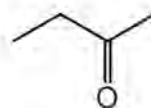
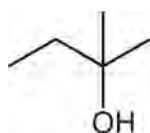
34 Crotyl alcohol, $\text{CH}_3\text{CH}=\text{CHCH}_2\text{OH}$, is a colourless liquid which is used as a solvent.

Crotyl alcohol will react separately with Br_2 , $\text{K}_2\text{Cr}_2\text{O}_7/\text{H}^+$, conc. KMnO_4/H^+ and PCl_5 under suitable conditions.

Which row is correct?

	reactant	conditions	main product
A	Br_2	room temperature	$\text{CH}_3\text{CH}=\text{CHCH}_2\text{Br}$
B	$\text{K}_2\text{Cr}_2\text{O}_7/\text{H}^+$	heat under reflux	$\text{CH}_3\text{CH}=\text{CHCHO}$
C	conc. KMnO_4/H^+	heat under reflux	$\text{CH}_3\text{CH}=\text{CHCO}_2\text{H}$
D	PCl_5	room temperature	$\text{CH}_3\text{CH}=\text{CHCH}_2\text{Cl}$

35 The skeletal formulae of two organic compounds are shown.



Which reagents can be used to distinguish these two compounds?

- 1 alkaline $\text{I}_2(\text{aq})$
- 2 acidified $\text{K}_2\text{Cr}_2\text{O}_7$
- 3 2,4-dinitrophenylhydrazine (2,4-DNPH reagent)

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

36 A carbonyl compound, X, reacts with HCN in the presence of NaCN to make a compound with M_r 85. Compound X does **not** react with Fehling's reagent.

What is compound X?

- A** butanal
- B** butanone
- C** propanal
- D** propanone

37 Which compound produces butan-2-ol and ethanoic acid on hydrolysis?

- A $\text{CH}_3\text{CO}_2\text{CH}(\text{CH}_3)_2$
- B $\text{CH}_3\text{CO}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$
- C $\text{CH}_3\text{CH}(\text{CH}_3)\text{CO}_2\text{CH}_2\text{CH}_3$
- D $\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$

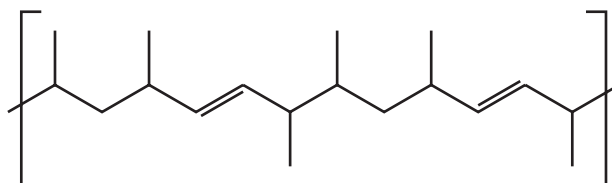
38 Two 1 g samples of Y are reacted separately and completely with sodium and with sodium carbonate. The volumes of the gases produced are collected and measured.

	relative volumes of gases	
	with Na	with Na_2CO_3
Y	2	1

What could Y be?

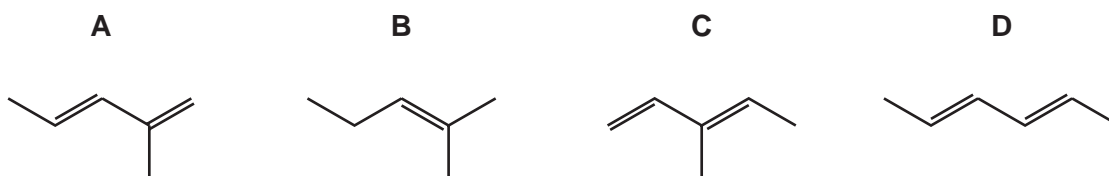
- A $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{OH}$
- B $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H}$
- C $\text{CH}_3\text{COCH}_2\text{OH}$
- D $\text{CH}_3\text{COCO}_2\text{H}$

39 The diagram shows a section of an addition polymer formed from two different monomers.



One of the monomers is propene.

What is the other monomer?



- 40 A scientist chooses either infrared spectroscopy or mass spectrometry to find a particular piece of information.

In which row has the **best** choice been made?

	target information	analytic method used
A	identities of functional groups in an organic compound	infrared spectroscopy
B	identities of functional groups in an organic compound	mass spectrometry
C	values of successive ionisation energies of Na	infrared spectroscopy
D	values of successive ionisation energies of Na	mass spectrometry

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 $\text{J g}^{-1} \text{ K}^{-1}$)

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