Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/11**

Paper 1 Multiple Choice **May/June 2021**

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.
- Any rough working should be done on this question paper.

This document has **16** pages. Any blank pages are indicated.

© UCLES 2021

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 contains the largest number of hydrogen atoms?

A 0.10 mol of pentane

B 0.20 mol of but-2-ene

C 1.00 mol of hydrogen molecules

D 6.02×10^{23} hydrogen atoms

2 In which pair of species do both species have only one unpaired p electron?

A Ar^+ and C^- **B** B and Ti^+ **C** F and Ga **D** Se^- and Si^-

3 Phosphorus forms two chlorides. Phosphorus(III) chloride, PCl_3, is a covalent liquid.

Phosphorus(V) chloride is an ionic solid. One of the ions present is $[PCl_4]^+$.

What is the shape of the PCl_3 molecule and the $[PCl_4]^+$ ion?

	PCl_3	$[PCl_4]^+$
A	pyramidal	square planar
B	pyramidal	tetrahedral
C	tetrahedral	square planar
D	trigonal planar	tetrahedral

© UCLES 2021

4 $\Delta H_1^\ominus$ is the standard enthalpy of formation of methane.

$\Delta H_2^\ominus$ is the standard enthalpy of combustion of carbon.

$\Delta H_3^\ominus$ is the standard enthalpy of combustion of hydrogen.

$$CH_4(g) + 2O_2(g) \xrightarrow{\Delta H_c^\ominus} CO_2(g) + 2H_2O(l)$$

Which expression is equivalent to $\Delta H_c^\ominus$?

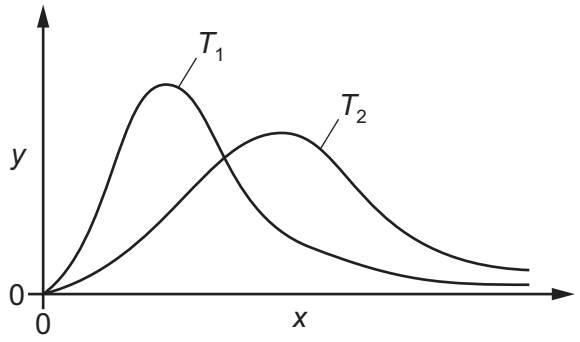
A $\Delta H_1^\ominus - \Delta H_2^\ominus + \Delta H_3^\ominus$

B $\Delta H_1^\ominus - 2\Delta H_3^\ominus - \Delta H_2^\ominus$

C $\Delta H_2^\ominus - \Delta H_3^\ominus + \Delta H_1^\ominus$

D $\Delta H_2^\ominus + 2\Delta H_3^\ominus - \Delta H_1^\ominus$

5 The diagram shows the Boltzmann distribution for the same gas at two different temperatures, T_1 and T_2.



What is plotted on the *y*-axis and which line represents the higher temperature?

	plotted on *y*-axis	higher temperature
A	number of molecules	T_1
B	number of molecules	T_2
C	molecular energy	T_1
D	molecular energy	T_2

6 What is the minimum mass of oxygen required to ensure the complete combustion of 12 dm^3 of propane measured under room conditions?

A 60 g **B** 80 g **C** 120 g **D** 160 g

© UCLES 2021

7 Why is the first ionisation energy of oxygen less than that of nitrogen?

A The nitrogen atom has its outer electron in a different subshell.

B The nuclear charge on the oxygen atom is greater than that on the nitrogen atom.

C The oxygen atom has a pair of electrons in one p orbital that repel one another.

D There is more shielding in an oxygen atom.

8 Which gas would behave most like an ideal gas under room conditions?

A helium

B nitrogen

C ammonia

D krypton

9 When hydrogen iodide is reacted with concentrated sulfuric acid, several reactions occur, including:

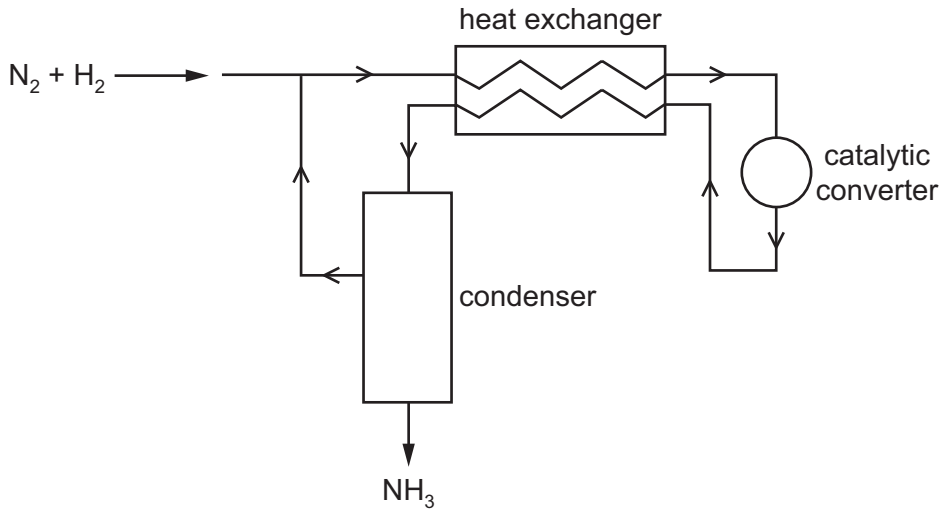
$$8HI + H_2SO_4 \rightarrow H_2S + 4H_2O + 4I_2$$

Which row gives the change in oxidation number of iodine and of sulfur in this reaction?

	change in oxidation number of iodine	change in oxidation number of sulfur
A	–1	+6
B	–1	+8
C	+1	–6
D	+1	–8

© UCLES 2021

10 The diagram represents the Haber process for the manufacture of ammonia from nitrogen and hydrogen.



What is the purpose of the heat exchanger?

A to cool the incoming gas mixture to avoid overheating the catalyst

B to cool the reaction products and separate the NH_3 from unused N_2 and H_2

C to warm the incoming gas mixture and shift the equilibrium to give more NH_3

D to warm the incoming gas mixture and speed up the reaction

11 Which statement about catalysts is correct?

A They change the reaction pathway by increasing the activation energy.

B They increase the rate of reaction by lowering the enthalpy change of the reaction.

C They increase the number of particles that have sufficient energy to react.

D Heterogeneous catalysts are in the same state as the reactant.

12 Element X is in Period 3. Element X forms a solid oxide Y.

Y reacts with hot concentrated hydrochloric acid. Y reacts with hot aqueous sodium hydroxide to form a compound in which X is part of an anion.

How many p electrons does one atom of X have in its outer shell?

A 0 **B** 1 **C** 2 **D** 3

© UCLES 2021

13 The gaseous products of heating a mixture of $Ca(OH)_2$ and NH_4Cl are passed through solid CaO. A single gaseous product, W, is collected.

A sample of W reacts with Cl_2(g) to produce two gases, X and Y.

X is an element. Y is acidic.

Y reacts with W to produce Z.

What are X and Z?

	X	Z
A	N_2	$CaCl_2$
B	N_2	NH_4Cl
C	O_2	$CaCl_2$
D	O_2	NH_4Cl

14 Q is a mixture of a Group 2 oxide and a Group 2 sulfate. Q contains equal amounts of the two compounds.

Q is shaken with water and the resulting mixture filtered; a solid residue is obtained. There is no reaction when the solid residue is shaken with HCl(aq). Shaking the filtrate with H_2SO_4(aq) produces a white precipitate.

What could be Q?

A $BaO + BaSO_4$

B $BaO + MgSO_4$

C $MgO + BaSO_4$

D $MgO + MgSO_4$

15 Which substance will **not** be a product of the thermal decomposition of hydrated magnesium nitrate?

A dinitrogen monoxide

B magnesium oxide

C oxygen

D steam

© UCLES 2021

16 A 5 cm^3 sample of 0.05 mol dm^{-3} sodium chloride is mixed with a 5 cm^3 sample of 0.05 mol dm^{-3} potassium iodide. 10 cm^3 of acidified 0.05 mol dm^{-3} silver nitrate is then added, followed by concentrated ammonia solution.

What is seen after the addition of an excess of concentrated ammonia solution?

A a cream precipitate

B a white precipitate

C a yellow precipitate

D no precipitate

17 The volatility of the Group 17 elements, chlorine, bromine and iodine, decreases down the group.

What is responsible for this trend?

A bond length in the halogen molecule

B bond strength in the halogen molecule

C electronegativity of the halogen atom

D number of electrons in the halogen atom

18 Acid rain is a dilute solution of sulfuric acid.

Which pollutant also contributes to the formation of acid rain?

A carbon monoxide

B carbon dioxide

C nitrogen dioxide

D hydrocarbons

19 R is an oxide of Period 3 element T. 5.00 g of R contains 2.50 g of T.

What is T?

A magnesium

B aluminium

C silicon

D sulfur

© UCLES 2021

[Turn over

20 Bromoethane reacts with cyanide ions, producing propanenitrile.

Which statement about the S_N2 mechanism of this reaction is correct?

A The lone pair of electrons on C of CN^- attacks the carbon atom of the C–Br bond.

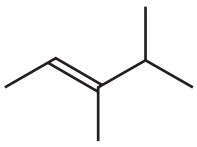
B The lone pair of electrons on C of CN^- attacks the carbocation formed when the C–Br bond breaks.

C The lone pair of electrons on N of CN^- attacks the carbon atom of the C–Br bond.

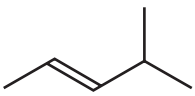
D The lone pair of electrons on N of CN^- attacks the carbocation formed when the C–Br bond breaks.

21 Which compound would produce two different carboxylic acids when treated with hot, concentrated, acidified manganate(VII) ions?

A



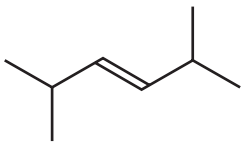
B



C

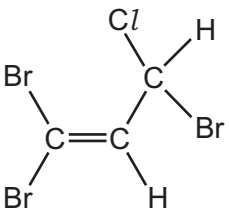


D

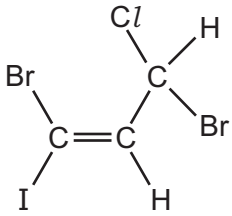


22 Which compound could show **both** *cis-trans* isomerism and optical isomerism?

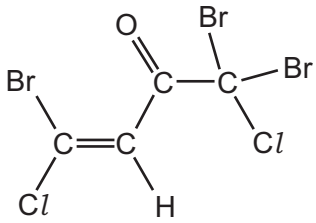
A



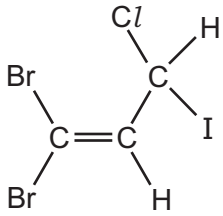
B



C

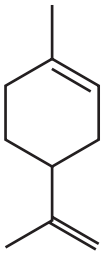


D



23 Limonene is a hydrocarbon found in the rind of citrus fruits.

limonene



What is the molecular formula of limonene?

A $C_{10}H_{12}$ **B** $C_{10}H_{14}$ **C** $C_{10}H_{16}$ **D** $C_{10}H_{18}$

© UCLES 2021

24 The compound cetyl palmitate, $C_{15}H_{31}CO_2C_{16}H_{33}$, is a waxy solid.

Cetyl palmitate is heated under reflux with an excess of aqueous sodium hydroxide.

Which products will be formed?

A $C_{15}H_{31}ONa$ and $C_{16}H_{33}CO_2Na$

B $C_{15}H_{31}CO_2Na$ and $C_{16}H_{33}ONa$

C $C_{15}H_{31}OH$ and $C_{16}H_{33}CO_2Na$

D $C_{15}H_{31}CO_2Na$ and $C_{16}H_{33}OH$

25 When an organic compound is oxidised, any oxygen atom gained by the organic molecule is considered to be from a water molecule also producing $2H^+ + 2e^-$. Any hydrogen atom lost may be considered to be lost as $H^+ + e^-$.

These changes can be represented by the following two equations.

$$H_2O \rightarrow [O] + 2H^+ + 2e^-$$

$$[H] \rightarrow H^+ + e^-$$

Compound X is oxidised by heating under reflux with hot, acidified potassium dichromate(VI) for one hour. The half-equation for the reduction reaction is shown.

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$$

Under these conditions, one mole of potassium dichromate(VI) oxidises three moles of X.

What could X be?

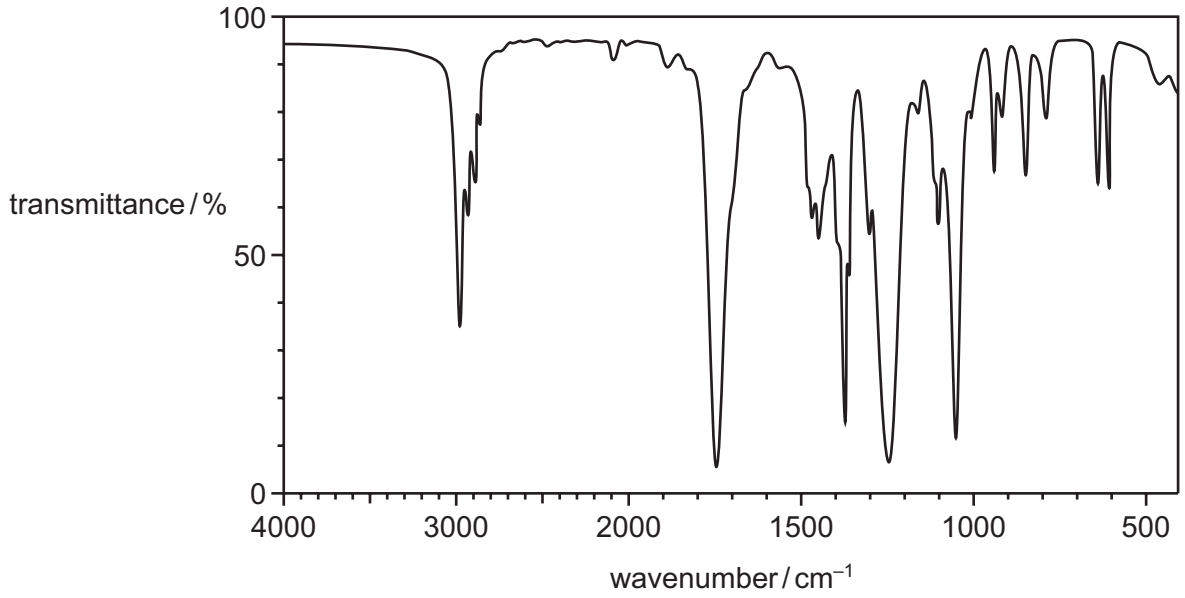
A propanal

B propan-1-ol

C propan-1,2-diol

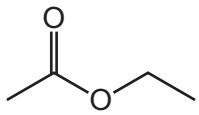
D propan-1,3-diol

26 Compound X has the empirical formula C_2H_4O. Its infra-red spectrum is shown.

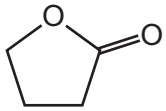


What could be the skeletal formula of compound X?

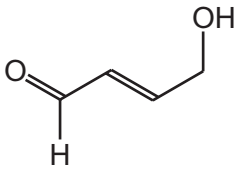
A



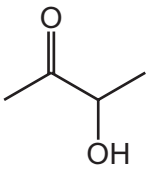
B



C

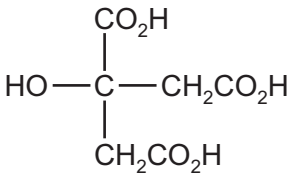


D



27 How many moles of hydrogen, H_2, are evolved when an excess of sodium metal is added to one mole of citric acid?

citric acid



A 0.5 **B** 1.5 **C** 2 **D** 4

28 Which statement is correct for the reaction of carbonyl compounds with HCN?

A The reaction is catalysed by concentrated H_2SO_4.

B Pentan-2-one and HCN react to give a chiral product.

C The reaction is a condensation reaction.

D The reaction is nucleophilic substitution.

© UCLES 2021

29 The table describes four reactions of propene.

Which row is correct?

	reagent used	name of main organic product
A	aqueous bromine	2-bromopropane
B	cold acidified aqueous potassium manganate(VII)	propane-1,3-diol
C	hydrogen chloride	2-chloropropane
D	steam	propan-1-ol

30 Butanoic acid is prepared from 1-bromopropane.

This synthesis requires a sequence of two reactions.

Which compound is prepared in the first stage of the synthesis?

A 1-aminopropane

B propan-1-ol

C butanal

D butanenitrile

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 Ethanol combines with ethanoic acid to form ethyl ethanoate according to the following reaction.

$$C_2H_5OH(l) + CH_3CO_2H(l) \rightleftharpoons CH_3CO_2C_2H_5(l) + H_2O(l) \qquad \Delta H^{\ominus} = -6\,kJ\,mol^{-1}$$

9.2 g ethanol, 12 g ethanoic acid and 8.8 g ethyl ethanoate are mixed and allowed to stand at 298 K, until equilibrium is reached.
(M_r: C_2H_5OH, 46; CH_3CO_2H, 60; $CH_3CO_2C_2H_5$, 88)

The resulting equilibrium mixture is found to contain 4.8 g ethanoic acid.

The experiment is repeated at 323 K.

Which statements are correct?

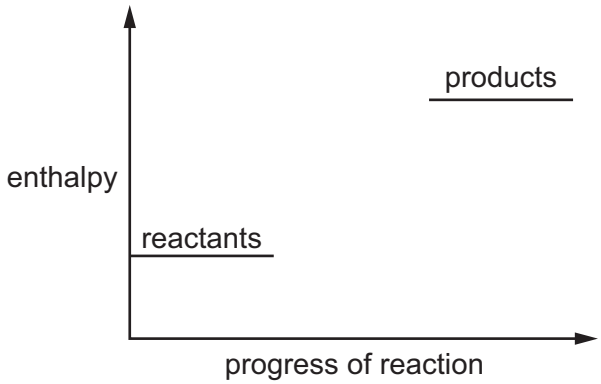
1 There are 0.22 moles of ethyl ethanoate in the mixture at equilibrium at 298 K.

2 The equilibrium mixture at 323 K will contain more than 4.8 g of ethanoic acid.

3 If a small amount of water is added at the start of either experiment the value of K_c would not be affected.

© UCLES 2021

32 The diagram shows an incomplete energy profile diagram for a reaction.



Which reactions could this diagram refer to?

1 $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

2 $H_2(g) \rightarrow 2H(g)$

3 $Cl^-(aq) \rightarrow Cl^-(g) + aq$

33 A gaseous hydrocarbon has a density of $2.42\,g\,dm^{-3}$ under room conditions.

What could be the skeletal formula of this hydrocarbon?

1 

2 

3 

34 Which molecules contain at least one bond angle of 120°?

1 C_2H_4

2 PF_5

3 NCl_3

35 Which statements are correct going across Period 3 from sodium to chlorine?

1 The charge on the nucleus increases, pulling the electrons closer to it.

2 The radius of the most common ion of each element decreases.

3 The shielding caused by inner electrons decreases, so the outer electrons are pulled closer to the nucleus.

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.

36 Which statements are correct?

1 Magnesium carbonate decomposes at a lower temperature than calcium carbonate.

2 Calcium hydroxide is more soluble in water than magnesium hydroxide.

3 Calcium is a stronger reducing agent than magnesium.

37 Which statements are correct?

1 1,1-difluoroethane is less reactive than 1,1-dichloroethane.

2 1,1-difluoroethane is polar.

3 The C–F bond is stronger than the C–C*l* bond.

38 Which pairs of compounds may be distinguished by testing with alkaline aqueous iodine?

1 butanal and butanone

2 pentan-2-one and pentan-3-ol

3 propanone and propan-2-ol

39 Which reactions have a coloured organic product?

1 ethanal + 2,4-dinitrophenylhydrazine reagent

2 ethanol + acidified potassium dichromate(VI)

3 ethene + cold dilute acidified potassium manganate(VII)

40 Propanoic acid is reacted with an excess of lithium aluminium hydride. The organic product of this reaction is reacted with ethanoic acid in the presence of concentrated sulfuric acid, forming product X.

What are major commercial uses of X?

1 fuel

2 solvent

3 flavouring

© UCLES 2021

BLANK PAGE

BLANK PAGE

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 the Cambridge Assessment Group. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which itself is a department of the University of Cambridge.

© UCLES 2021