Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/13**

Paper 1 Multiple Choice **October/November 2015**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

8050022522

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

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 separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Electronic calculators may be used.

This document consists of **13** printed pages and **3** blank pages.

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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.

1 The table gives the successive ionisation energies for an element X.

	1st	2nd	3rd	4th	5th	6th
ionisation energy / kJ mol^{-1}	950	1800	2700	4800	6000	12 300

What could be the formula of a chloride of X?

A XCl **B** XCl_2 **C** XCl_3 **D** XCl_4

2 Which set of conditions gives the highest yield of ammonia at equilibrium?

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H^{\ominus} = -92\,kJ\,mol^{-1}$$

	catalyst	pressure	temperature
A	absent	high	low
B	absent	low	high
C	present	high	high
D	present	low	low

3 *Use of the Data Booklet is relevant to this question.*

The compound S_2O_7 is hydrolysed by water to produce sulfuric acid and oxygen only.

Which volume of oxygen, measured at room temperature and pressure, is evolved when 0.352 g of S_2O_7 is hydrolysed?

A 12 cm^3 **B** 24 cm^3 **C** 48 cm^3 **D** 96 cm^3

4 Nitrogen, N_2, and carbon monoxide, CO, both have $M_r = 28$.

The boiling point of N_2 is 77 K.

The boiling point of CO is 82 K.

What could be responsible for this difference in boiling points?

A CO molecules have a permanent dipole, the N_2 molecules are not polar.

B N_2 has σ and π bonding, CO has σ bonding only.

C N_2 has a strong N≡N bond, CO has a C=O bond.

D The CO molecule has more electrons than the N_2 molecule.

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5 Some car paints contain small flakes of silica, SiO_2.

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

6 Solid sulfur consists of molecules made up of eight atoms covalently bonded together.

The bonding in sulfur dioxide is O=S=O.

enthalpy change of combustion of S_8, $\Delta H_c^{\ominus} S_8(s) = -2376\,kJ\,mol^{-1}$

energy required to break 1 mole $S_8(s)$ into gaseous atoms = $2232\,kJ\,mol^{-1}$

O=O bond enthalpy = $496\,kJ\,mol^{-1}$

Using these data, what is the value of the S=O bond enthalpy?

A $239\,kJ\,mol^{-1}$ **B** $257\,kJ\,mol^{-1}$ **C** $319\,kJ\,mol^{-1}$ **D** $536\,kJ\,mol^{-1}$

7 *Use of the Data Booklet is relevant for this question.*

In an experiment, the burning of 1.45 g (0.025 mol) of propanone was used to heat 100 g of water. The initial temperature of the water was 20.0 °C and the final temperature of the water was 78.0 °C.

Which experimental value for the enthalpy change of combustion for propanone can be calculated from these results?

A $-1304\,kJ\,mol^{-1}$

B $-970\,kJ\,mol^{-1}$

C $-352\,kJ\,mol^{-1}$

D $-24.2\,kJ\,mol^{-1}$

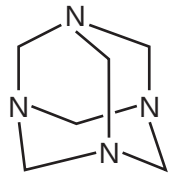
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8 Which row correctly describes the electrodes that can be used in a diaphragm cell for the production of chlorine, hydrogen and sodium hydroxide?

	anode	cathode
A	steel	graphite
B	steel	titanium
C	titanium	graphite
D	titanium	steel

9 Hexamine is a crystalline solid used as a fuel in portable stoves.

The diagram shows its skeletal structure.



What is the empirical formula of hexamine?

A CH_2N **B** $C_3H_6N_2$ **C** $C_4H_8N_4$ **D** $C_6H_{12}N_4$

10 A mixture of nitrogen and hydrogen gases, at a temperature of 500 K, was put into an evacuated vessel of volume 6.0 dm^3. The vessel was then sealed.

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

The mixture was allowed to reach equilibrium. It was found that 7.2 mol of N_2 and 12.0 mol of H_2 were present in the equilibrium mixture. The value of the equilibrium constant, K_c, for this equilibrium is 6.0×10^{-2} at 500 K.

What is the concentration of ammonia present in the equilibrium mixture at 500 K?

A 0.58 mol dm^{-3}

B 0.76 mol dm^{-3}

C 3.5 mol dm^{-3}

D 27 mol dm^{-3}

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11 Ammonia is made by the Haber process. The reactants are nitrogen and hydrogen.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H \text{ –ve}$$

What will increase the rate of the forward reaction?

A adding argon to the mixture but keeping the total volume constant

B decreasing the temperature

C increasing the total pressure by reducing the total volume at constant temperature

D removing ammonia as it is made but keeping the total volume of the mixture the same

12 **X** is a Group II metal. The carbonate of **X** decomposes when heated in a Bunsen flame to give carbon dioxide and a white solid residue as the only products. This white solid residue is sparingly soluble in water. Even when large amounts of the solid residue are added to water the pH of the saturated solution is less than that of limewater.

What could be the identity of **X**?

A magnesium

B calcium

C strontium

D barium

13 Rat poison needs to be insoluble in rain water but soluble at the low pH of stomach contents.

What is a suitable barium compound to use for rat poison?

A barium carbonate

B barium chloride

C barium hydroxide

D barium sulfate

14 *Use of the Data Booklet is relevant to this question.*

Which of the elements sodium, magnesium, aluminium, silicon, phosphorus, sulfur and chlorine

- has a lower first ionisation energy than the preceding element in the Periodic Table,
- conducts electricity and
- has a lower atomic radius than the preceding element in the Periodic Table?

A aluminium

B magnesium

C phosphorus

D sulfur

15 The melting points of the Period 3 elements sodium to aluminium are shown in the table.

element	Na	Mg	Al
mp / K	371	923	932

Which factor explains the **increase** in melting points from sodium to aluminium?

A the changes in first ionisation energy from sodium to aluminium

B the increase in electronegativity from sodium to aluminium

C the increase in the A_r of the elements from sodium to aluminium

D the increase in the number of outer electrons in each atom from sodium to aluminium

16 **X** is the oxide of a Period 3 element. **X** reacts with water to give an acidic solution.

A solution is prepared by reacting 0.100 g of **X** with excess water. This solution was neutralised by exactly 25.0 cm^3 of 0.100 mol dm^{-3} sodium hydroxide solution.

What could be the identity of **X**?

A Al_2O_3 **B** MgO **C** P_4O_{10} **D** SO_3

17 Which statement about bromine is correct?

A Bromine is insoluble in non-polar solvents.

B Bromine vapour is more dense than air.

C Bromine will not vaporise significantly under normal conditions.

D Gaseous bromine is purple.

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

The addition of excess 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

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19 Element X forms a pollutant oxide Y. Y can be further oxidised to Z. Two students made the following statements.

Student P 'The molecule of Y contains lone pairs of electrons.'

Student Q 'The oxidation number of X increases by 1 from Y to Z.'

X could be carbon or nitrogen or sulfur.

Which student(s) made a correct statement?

A P only

B Q only

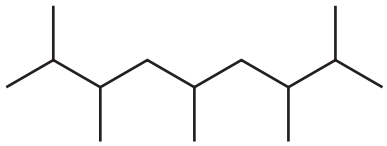
C both P and Q

D neither P nor Q

20 How many isomeric esters have the molecular formula $C_4H_8O_2$?

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

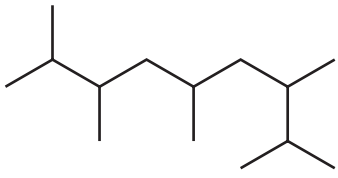
21 A new jet fuel has been produced that is a mixture of different structural isomers of compound Q.



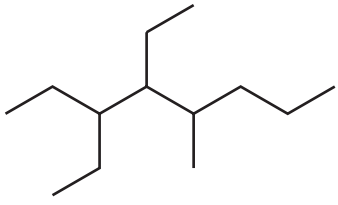
Q

Which skeletal formula represents a **structural isomer** of Q?

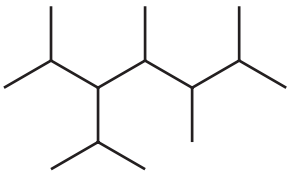
A



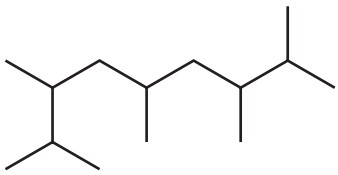
B



C



D



22 Crude oil is a mixture of many hydrocarbons ranging in size from 1 to 40 carbon atoms per molecule. The alkanes in crude oil can be separated because they have different boiling points.

The table below shows the boiling points of some alkanes.

alkane	boiling point / °C	M_r
butane	0	58
pentane	36	72
hexane	69	86
2-methylbutane	28	72
dimethylpropane	10	72
2,3-dimethylbutane	58	86

What is the correct explanation for the difference in the boiling points of the three isomers with M_r = 72?

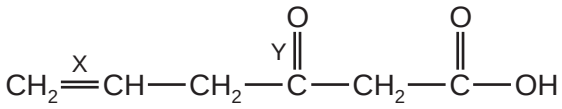
A Boiling point is dependent upon the length of the carbon chain **only**.

B Increased branching on a carbon chain increases the boiling point.

C Increased branching reduces the strength of the intermolecular hydrogen bonding.

D Increased branching reduces the strength of the intermolecular van der Waals' forces.

23 Compound Q contains three double bonds per molecule.



Q

Which bond, X or Y, will be ruptured by hot, concentrated acidified $KMnO_4$ and how many lone pairs of electrons are present in one molecule of Q?

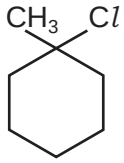
	bond ruptured by hot, concentrated acidified $KMnO_4$	number of lone pairs
A	X	5
B	X	6
C	Y	5
D	Y	6

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24 Which compound undergoes an S_N1 substitution reaction with NaOH(aq)?

A $CH_3CH_2CH_2Br$

B $(CH_3)_3CCH_2I$

C 

D $CH_2{=}CHCl$

25 If the starting material is iodoethane, which sequence of reactions will produce propanoic acid as the main final product in good yield?

A add NaOH(aq), isolate the organic product, add acidified $K_2Cr_2O_7$ and boil under reflux

B add NaOH(aq), isolate the organic product, add H_2SO_4(aq) and boil under reflux

C heat with HCN in ethanol, isolate the organic product, add H_2SO_4(aq) and boil under reflux

D heat with KCN in ethanol, isolate the organic product, add H_2SO_4(aq) and boil under reflux

26 Which compound **cannot** be oxidised by acidified potassium dichromate(VI) solution but **does** react with sodium metal?

A $(CH_3)_3COH$

B $CH_3COCH_2CH_3$

C $CH_3CH_2CH_2CH_2OH$

D $CH_3CH_2CH(OH)CH_3$

27 Butan-2-ol can be made by reducing X with H_2 / Ni.

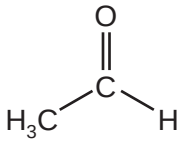
Butan-2-ol can be dehydrated to form Y and Z which are structural isomers of each other.

Which row is correct?

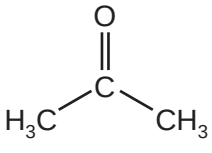
	X is	*cis-trans* isomerism is shown by
A	an aldehyde	both Y and Z
B	an aldehyde	only one of Y and Z
C	a ketone	both Y and Z
D	a ketone	only one of Y and Z

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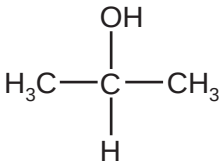
28 Tollens' reagent can be used to help identify compounds P, Q and R.



P



Q

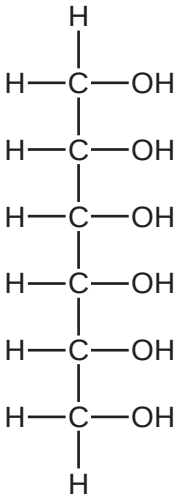


R

Which compound(s) form a silver precipitate on warming with Tollens' reagent?

A P and Q **B** P only **C** Q only **D** R only

29 Sorbitol is a naturally-occurring compound with a sweet taste. It is often used as a substitute for sucrose by the food industry.



sorbitol

How many chiral centres are present in sorbitol?

A 3 **B** 4 **C** 5 **D** 6

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

A $CH_3CO_2CH(CH_3)_2$

B $CH_3CO_2CH(CH_3)CH_2CH_3$

C $CH_3CH(CH_3)CO_2CH_2CH_3$

D $CH_3CH_2CO_2CH(CH_3)CH_2CH_3$

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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.

31 Which statements about orbitals in a krypton atom are correct?

1 The 1s and 2s orbitals have the same energy as each other but different sizes.

2 The third energy level (n=3) has three subshells and nine orbitals.

3 The 3d subshell has five orbitals that have the same energy as each other in an isolated atom.

32 The Group IV elements carbon, silicon and germanium can all exist in the giant molecular structure which is also found in diamond. The bond lengths in these structures are given below.

element X	C	Si	Ge
bond length X–X / nm	0.154	0.234	0.244

Why does the bond length increase down the group?

1 Orbital overlap decreases down the group.

2 Atomic radius increases down the group.

3 Nuclear charge increases down the group.

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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.

33 The salt $NaClO_3$ is used as a non-selective weedkiller.

On careful heating, this reaction occurs: $4NaClO_3 \rightarrow NaCl + 3NaClO_4$.

On strong heating this reaction occurs: $NaClO_4 \rightarrow NaCl + 2O_2$.

The overall reaction is $2NaClO_3 \rightarrow 2NaCl + 3O_2$.

What do these equations show?

1 $NaClO_3$ can behave as an oxidising agent.

2 $NaClO_3$ can behave as a reducing agent.

3 The oxidation numbers of chlorine in the three compounds shown are +6, +8 and –1.

34 Which statements correctly describe an effect of a rise in temperature on a gas-phase reaction?

1 More particles now have energies greater than the activation energy.

2 The energy distribution profile changes with more particles having the most probable energy.

3 The activation energy of the reaction is decreased.

35 Which statements concerning the Group II elements magnesium, calcium and barium are correct?

1 Their reactivity increases with increasing relative atomic mass.

2 The oxidation number exhibited in their stable compounds is +2.

3 On strong heating, their nitrates give off oxygen only.

36 Sulfur dioxide is used as a food preservative.

Which statements about sulfur dioxide, SO_2, are correct?

1 SO_2 behaves as an antioxidant.

2 Aqueous SO_2 contains SO_3^{2-} ions.

3 SO_2 inhibits the growth of mould and yeasts.

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37 An oxidising agent that can oxidise ethanal to ethanoic acid, or to ethanoate ions, will also oxidise methanoic acid, HCO_2H, to carbon dioxide and water.

Which reagents, on heating, will react differently with HCO_2H and CH_3CO_2H?

1 $Na_2CO_3(aq)$

2 Fehling's reagent

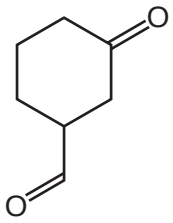
3 dilute acidified $KMnO_4$

38 Each of the compounds below is treated separately with excess $NaBH_4$. The product of each reaction is then heated with excess concentrated H_2SO_4.

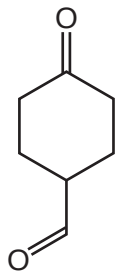
In each case, one or more products are formed with molecular formula C_7H_{10}.

Which compounds give **only one** final product with the molecular formula C_7H_{10}?

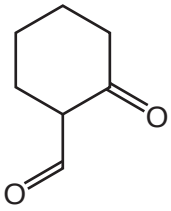
1



2



3



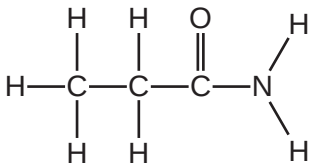
39 Which reactions result in the formation of propanoic acid?

1 $CH_3CH_2CO_2Na$ with dilute $H_2SO_4(aq)$

2 $CH_3CH{=}CHCH_3$ with hot, concentrated $H^+ / MnO_4^-(aq)$

3 CH_3CH_2OH with $H^+ / Cr_2O_7^{2-}(aq)$

40 The diagram shows the structure of propanamide.



propanamide

Which statements about the hydrolysis of propanamide are correct?

1 Propanamide can be hydrolysed by heating under reflux with $H_2SO_4(aq)$.

2 Propanamide can be hydrolysed by heating under reflux with $NaOH(aq)$.

3 Propanamide can be hydrolysed by cold water.

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