Cambridge International AS & A Level

**Cambridge International Examinations**
Cambridge International Advanced Subsidiary and Advanced Level

**CHEMISTRY** **9701/12**

Paper 1 Multiple Choice **May/June 2018**

**1 hour**

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

* 2 7 2 0 9 6 9 7 8 2 *

**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.



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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.

Use of the Data Booklet may be appropriate for some questions.

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

**A** bond angles of 109°

**B** $\pi$ covalent bonds

**C** $\sigma$ covalent bonds

**D** $sp^3$ orbitals

**2** The electronic configuration of an atom of sulfur is $1s^2 2s^2 2p^6 3s^2 3p^4$.

How many valence shell and unpaired electrons are present in one sulfur atom?

| | valence shell electrons | unpaired electrons |
|---|---|---|
| **A** | 2 | 1 |
| **B** | 4 | 2 |
| **C** | 6 | 0 |
| **D** | 6 | 2 |

**3** In which pair does the second substance have a **lower** boiling point than the first substance?

**A** $C_2H_6$ and $C_2H_5Cl$

**B** $CH_3OCH_3$ and $C_2H_5OH$

**C** Ne and Ar

**D** $CH_3NH_2$ and $C_2H_6$

**4** Compound J burns in excess oxygen to give carbon dioxide and water only. When a 3.00 g sample of compound J is burnt in excess oxygen, 4.40 g of carbon dioxide and 1.80 g of water are formed.

What is the empirical formula of J?

**A** CH **B** CHO **C** $CH_2$ **D** $CH_2O$

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**5** The gases X and Y react to form Z.

$$X(g) + Y(g) \rightleftharpoons Z(g)$$

An equilibrium mixture of these three gases is compressed at constant temperature.

What will be the changes in the mole fraction of Z and in $K_p$?

| | mole fraction of Z | $K_p$ |
|---|---|---|
| **A** | increase | increase |
| **B** | increase | no change |
| **C** | no change | increase |
| **D** | no change | no change |

**6** Which gas is likely to deviate most from ideal gas behaviour?

**A** HC*l* **B** He **C** $CH_4$ **D** $N_2$

**7** The enthalpy change of reaction 1 is $-114\,kJ\,mol^{-1}$.

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l) \qquad \text{reaction 1}$$

By using this information, what is the most likely value for the enthalpy change of reaction 2?

$$Ba(OH)_2(aq) + 2HCl(aq) \rightarrow BaCl_2(aq) + 2H_2O(l) \qquad \text{reaction 2}$$

**A** $-57\,kJ\,mol^{-1}$ **B** $-76\,kJ\,mol^{-1}$ **C** $-114\,kJ\,mol^{-1}$ **D** $-228\,kJ\,mol^{-1}$

**8** Sulfur reacts with concentrated nitric acid in a redox reaction.

$$S + 4HNO_3 \rightarrow SO_2 + 4NO_2 + 2H_2O$$

What are the changes in oxidation number of sulfur and of nitrogen in this reaction?

| | sulfur | nitrogen |
|---|---|---|
| **A** | +2 | –3 |
| **B** | +2 | –1 |
| **C** | +4 | –3 |
| **D** | +4 | –1 |

**9** Materials can be classified by their chemical structures. Four common types of structure are metallic, ionic, simple molecular and giant molecular.

Some physical properties of four substances are shown in the table.

Which substance has a simple molecular structure?

| | melting point / °C | effect of adding water | electrical conductivity |
|---|---|---|---|
| **A** | 64 | reacts | good when solid |
| **B** | 113 | insoluble | always poor |
| **C** | 767 | soluble | good when solid |
| **D** | 1600 | insoluble | always poor |

**10** In a particular reversible reaction the yield of product is increased

- if the temperature is increased;
- if the pressure is decreased.

Which equation could describe this reversible reaction?

**A** $CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g)$ $\Delta H = +206\,kJ\,mol^{-1}$

**B** $4NH_3(g) + 3O_2(g) \rightleftharpoons 2N_2(g) + 6H_2O(g)$ $\Delta H = -227\,kJ\,mol^{-1}$

**C** $2NO_2(g) \rightleftharpoons N_2O_4(g)$ $\Delta H = -58\,kJ\,mol^{-1}$

**D** $3O_2(g) \rightleftharpoons 2O_3(g)$ $\Delta H = +143\,kJ\,mol^{-1}$

**11** A chemical company used a catalyst in a chemical process. The company has now decided not to use the catalyst but to increase the temperature so that the rate of the reaction is the same as it was when the catalyst was used.

Which statement about the new conditions compared to the original conditions is correct?

**A** The activation energy has been decreased.

**B** The activation energy has been increased.

**C** There are fewer successful collisions per unit time.

**D** There are more successful collisions per unit time.

**12** Which oxide does **not** react with cold, dilute sodium hydroxide to produce a salt?

**A** $Al_2O_3$ **B** $P_4O_{10}$ **C** $SO_2$ **D** $SiO_2$

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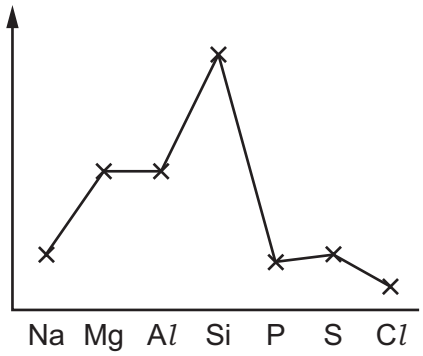
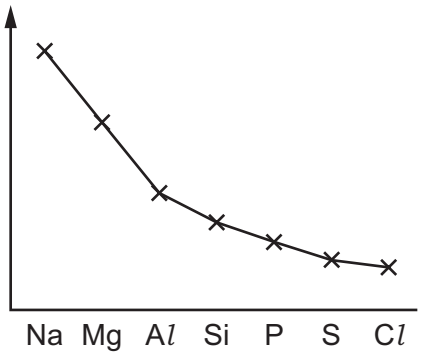
**13** The graphs show trends in four physical properties of elements in Period 3, excluding argon.

Which graph has electronegativity on the *y*-axis?

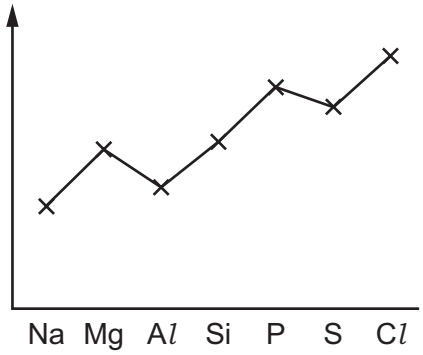
**A**



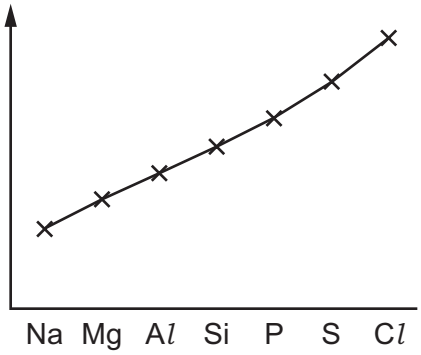

**B**




**C**




**D**




**14** In this question, X represents an atom of chlorine, bromine or iodine.

Which explanation for the variation in volatility down Group 17 is correct?

**A** Instantaneous dipole-induced dipole forces between molecules become stronger.

**B** Permanent dipole-permanent dipole forces between molecules become stronger.

**C** The bond energy of the $X_2$ molecules decreases.

**D** The first ionisation energy $X(g) \rightarrow X^+(g) + e^-$ decreases.

**15** To manufacture cement, 1000 million tonnes of limestone are decomposed each year. To manufacture lime for agriculture, 200 million tonnes of limestone are decomposed each year.

What is the total mass of carbon dioxide in million tonnes produced from these two processes in a year?

**A** 440 **B** 528 **C** 660 **D** 880

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**16** In Group 2 of the Periodic Table, the properties of the elements and their compounds show regular change down the group.

Which property shows a **decrease** from magnesium to barium?

**A** the decomposition temperature of the carbonates

**B** the decomposition temperature of the nitrates

**C** the solubility of the hydroxides

**D** the solubility of the sulfates

**17** When concentrated sulfuric acid is added to solid sodium bromide, bromine gas is produced, along with a number of other products. However when concentrated sulfuric acid is added to solid sodium chloride **only** hydrogen chloride and sodium hydrogensulfate are produced.

What is the reason for this difference?

**A** Bromine is less volatile than chlorine.

**B** Hydrochloric acid is a weak acid.

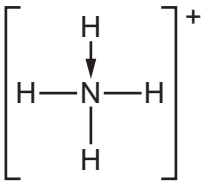
**C** Sulfuric acid is not an oxidising agent.

**D** The bromide ion is a stronger reducing agent than the chloride ion.

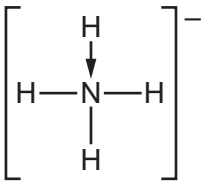
**18** The dative covalent bond can be represented by an arrow, →. The arrow points towards the atom receiving the lone pair.

Which diagram of an ammonium ion is correct?

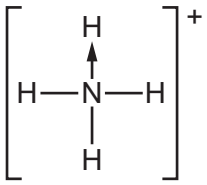
**A**



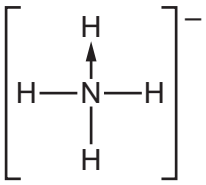
**B**



**C**



**D**



**19** Sulfur dioxide can be catalytically oxidised by an oxide of nitrogen in the atmosphere.

Which reaction shows the regeneration of the catalyst?

**A** $N_2 + 2O_2 \rightleftharpoons 2NO_2$

**B** $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

**C** $N_2 + O_2 \rightarrow 2NO$

**D** $NO + \frac{1}{2}O_2 \rightarrow NO_2$

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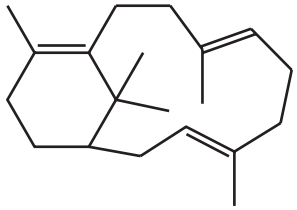
**20** Compound Y is treated with an excess of hydrogen gas in the presence of a nickel catalyst. The product is fully saturated.



compound Y

What is the number of chiral carbon atoms in the product?

**A** 5 **B** 6 **C** 7 **D** 8

**21** Which equation represents a valid propagation step in the chlorination of ethane?

**A** $C_2H_6 + Cl\bullet \rightarrow C_2H_5Cl + H\bullet$

**B** $C_2H_5Cl + Cl\bullet \rightarrow C_2H_4Cl\bullet + HCl$

**C** $C_2H_5Cl + H\bullet \rightarrow C_2H_5\bullet + HCl$

**D** $C_2H_5\bullet + Cl\bullet \rightarrow C_2H_5Cl$

**22** Maleic acid is used in the food industry and for stabilising drugs. It is the cis-isomer of butenedioic acid and has the structural formula $HO_2CCH{=}CHCO_2H$.

What is the product formed from the reaction of maleic acid with cold, dilute, acidified manganate(VII) ions?

**A** $HO_2CCH(OH)CH(OH)CO_2H$

**B** $HO_2CCO_2H$

**C** $HO_2CCH_2CH(OH)CO_2H$

**D** $HO_2CCOCOCO_2H$

**23** Primary halogenoalkanes undergo hydrolysis reactions.

Which reaction would occur most rapidly if they are all warmed to the same temperature?

**A** $C_2H_5Br$ with $H_2O$

**B** $C_2H_5Br$ with NaOH(aq)

**C** $C_2H_5Cl$ with $H_2O$

**D** $C_2H_5Cl$ with NaOH(aq)

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

A colourless liquid, $C_5H_{11}Cl$, exists as a mixture of two optical isomers.

When heated with sodium hydroxide in ethanol, a mixture of **only** two alkenes is formed.

What could the colourless liquid be?

**A** $(CH_3CH_2)_2CHCl$

**B** $CH_3CH_2CH_2CHClCH_3$

**C** $(CH_3)_2CHCHClCH_3$

**D** $CH_3CH_2CCl(CH_3)_2$

**25** When warm water is added to halogenoalkane X, an $S_N1$ reaction occurs.

$AgNO_3(aq)$ is then added; a yellow precipitate is formed.

What could be X?

**A** 1-chlorobutane

**B** 1-iodobutane

**C** 2-chloro-2-methylpropane

**D** 2-iodo-2-methylpropane

**26** Which alcohol will react with an acidified solution of potassium dichromate(VI) to produce a ketone containing six carbon atoms?

**A** 2,2-dimethylbutan-1-ol

**B** 2-methylpentan-3-ol

**C** 3,3-dimethylpentan-2-ol

**D** 3-methylpentan-3-ol

**27** Which statement about butanone is correct?

**A** Butanone can be dehydrated by concentrated sulfuric acid to give $CH_2{=}CHCH{=}CH_2$.

**B** Butanone gives a positive result with Tollens' reagent.

**C** Butanone reacts with HCN by an electrophilic addition mechanism.

**D** Butanone reacts with $NaBH_4$ to give a chiral product.

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**28** Ethanal, $CH_3CHO$, is used to make product R in a three-stage synthesis.

$$CH_3CHO \xrightarrow[/\,NaCN]{HCN} \text{product P} \xrightarrow[\text{reflux}]{H_2SO_4(aq),} \text{product Q} \xrightarrow[\text{(a few drops)}]{\text{conc. } H_2SO_4} \text{product R}$$

Two molecules of Q react to give one molecule of R plus two molecules of water.

R has two ester functional groups in each molecule. R does not react with sodium.

What is the empirical formula of R?

**A** CHO **B** $C_3H_4O_2$ **C** $C_3H_5O_2$ **D** $C_6H_{10}O_5$

**29** The ester ethyl butanoate can be hydrolysed using an excess of dilute sodium hydroxide solution.

Which substance is a product of this reaction?

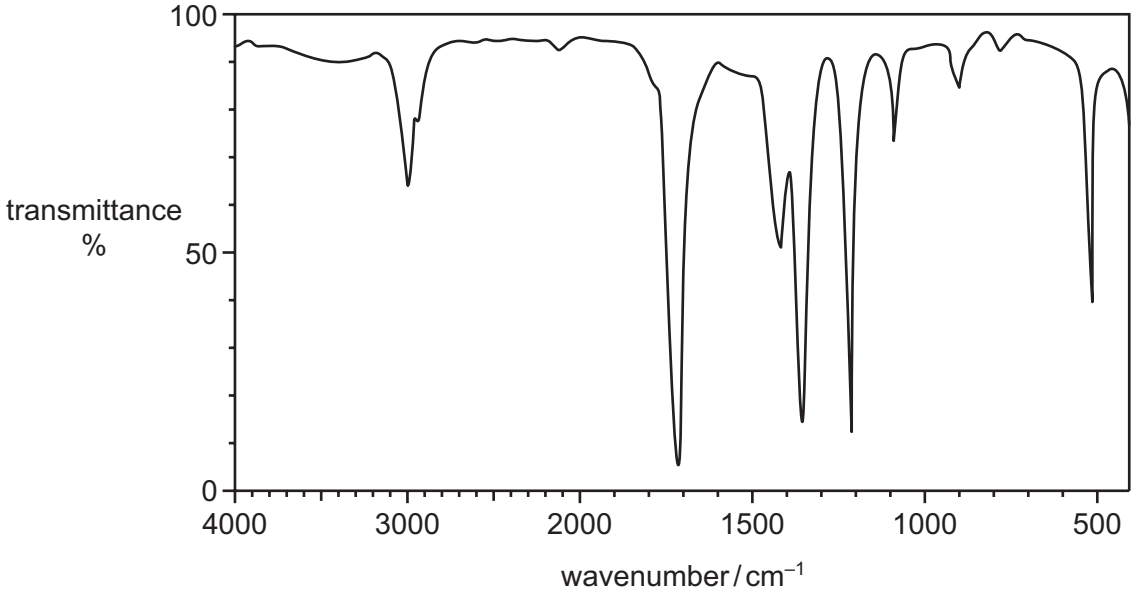
**A** $CH_3CH_2CH_2CO_2Na$

**B** $CH_3CO_2Na$

**C** $CH_3CH_2ONa$

**D** $H_2O$

**30** The infra-red spectrum of an organic compound is shown.




Which compound could give this spectrum?

**A** $CH_3CH_2CO_2H$

**B** $CH_3CH(OH)CH_3$

**C** $CH_3COCH_3$

**D** $CH_3COCH_2OH$

## 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** For complete combustion, 1 mol of an organic compound X requires 2.5 mol of $O_2$.

Which compounds could be X?

**1** $C_2H_5OH$

**2** $C_2H_2$

**3** $CH_3CHO$

**32** In which pairs do both species have the same number of electrons?

**1** $^{35}Cl$ and $^{37}Cl$

**2** $^{35}Cl^-$ and $^{40}Ar$

**3** $^{40}Ar$ and $^{40}K^+$

**33** For which reactions does the value of $\Delta H^\ominus$ represent **both** a standard enthalpy change of combustion **and** a standard enthalpy change of formation?

**1** $C(s) + O_2(g) \rightarrow CO_2(g)$

**2** $2C(s) + O_2(g) \rightarrow 2CO(g)$

**3** $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$

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**34** The temperature of a reversible gas phase reaction is increased.

Which statements are **always** correct?

**1** More product is present at equilibrium.

**2** The average speed of the particles increases.

**3** There are more successful collisions per unit time.

**35** Three samples of chlorine gas each contain 0.710 g of chlorine. Each sample is reacted with a reagent.

- In the first reaction a sample is reacted completely with hydrogen gas.
- In the second reaction a sample is reacted completely with cold NaOH(aq).
- In the third reaction a sample is reacted completely with hot NaOH(aq).

Which masses of the named products would be formed?

**1** Exactly 0.730 g of HC*l* form in the first reaction.

**2** Exactly 0.585 g of NaC*l* form in the second reaction.

**3** Exactly 0.975 g of NaC*l* form in the third reaction.

**36** Solid barium oxide is added to some ammonium sulfate solution in a test-tube and the mixture is warmed. A piece of damp red litmus paper is held over the mouth of the test-tube.

Which observations would be made?

**1** The damp litmus paper initially turns from red to blue.

**2** A white precipitate forms in the test-tube.

**3** A brown gas is evolved with strong heating.

**37** Which compounds show geometrical (cis-trans) isomerism?

**1** $CH_3CH{=}C(CH_3)C_2H_5$

**2** $CH_3CH{=}CHCH_2CH_2CH_3$

**3** $C_2H_5CH{=}CHC_2H_5$

**38** Which pairs of compounds may be distinguished from each other by testing with alkaline aqueous iodine?

**1** ethane-1,2-diol and ethanol

**2** propan-2-ol and methylpropan-2-ol

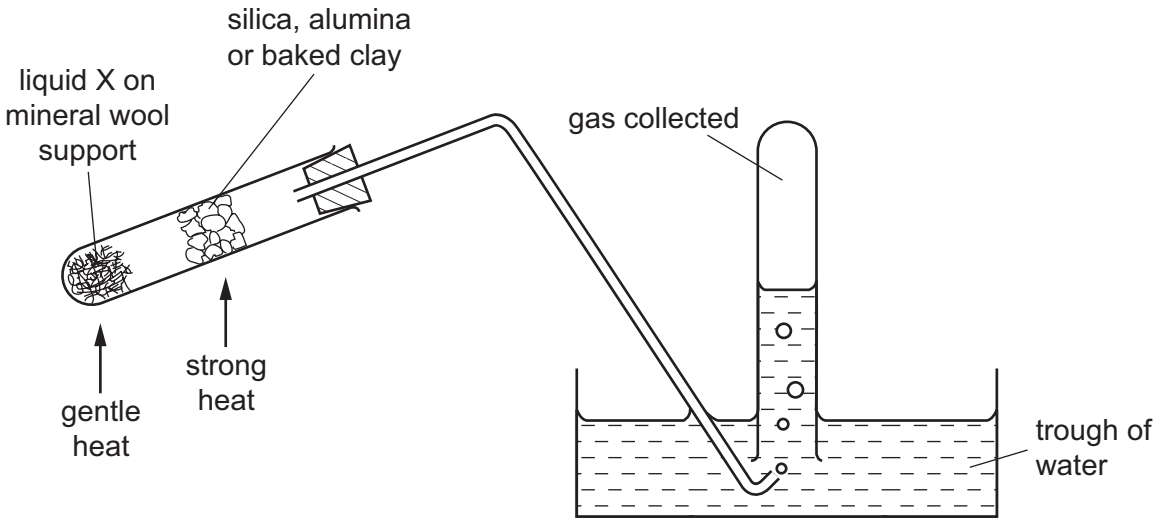
**3** ethanol and butan-2-ol

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.

**39** The diagram shows an experimental set-up which can be used in several different experiments.




Which processes could be demonstrated by using the above apparatus?

**1** oxidation of ethanol (liquid X)

**2** dehydration of ethanol (liquid X)

**3** cracking of paraffin (liquid X)

**40** The ester $C_2H_5CO_2CH_2CH_2CH_3$ can be made in a school or college laboratory by a sequence of four reactions or fewer using compound Z as the **only** organic material.

What might be the identity of compound Z?

**1** $CH_3CH_2CH_2OH$

**2** $CH_3CH_2CHO$

**3** $CH_3COCH_3$

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