UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

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

Paper 1 Multiple Choice **May/June 2013**

**1 hour**

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

* 9 6 4 0 2 4 2 9 3 0 7 *

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, highlighters, 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 **14** printed pages and **2** 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** During the electrolysis of molten aluminium oxide to produce aluminium, using carbon electrodes, two consecutive reactions occur at the anode, each producing a different gas.

How does the oxidation number of oxygen change in these reactions?

**A** decreases by 2, then increases by 2

**B** increases by 2, then decreases by 2

**C** increases by 2, then decreases by 4

**D** no change, then decreases by 2

**2** Equations involving four enthalpy changes are shown.

$$Na(g) \rightarrow Na^{+}(g) + e^{-} \qquad \Delta H = W$$

$$Na(g) \rightarrow Na^{2+}(g) + 2e^{-} \qquad \Delta H = X$$

$$Na(s) \rightarrow Na(g) \qquad \Delta H = Y$$

$$Na(s) \rightarrow Na^{2+}(g) + 2e^{-} \qquad \Delta H = Z$$

What is the second ionisation energy of sodium?

**A** X **B** X – W **C** Y – W **D** Z – Y

**3** Which ion has more electrons than protons and more protons than neutrons?
[H = $^{1}_{1}H$ ; D = $^{2}_{1}H$ ; O = $^{16}_{8}O$]

**A** $D^{-}$ **B** $H_3O^{+}$ **C** $OD^{-}$ **D** $OH^{-}$

**4** Which factor can affect the value of the activation energy of a reaction?

**A** changes in concentration of the reactants

**B** decrease in temperature

**C** increase in temperature

**D** the presence of a catalyst

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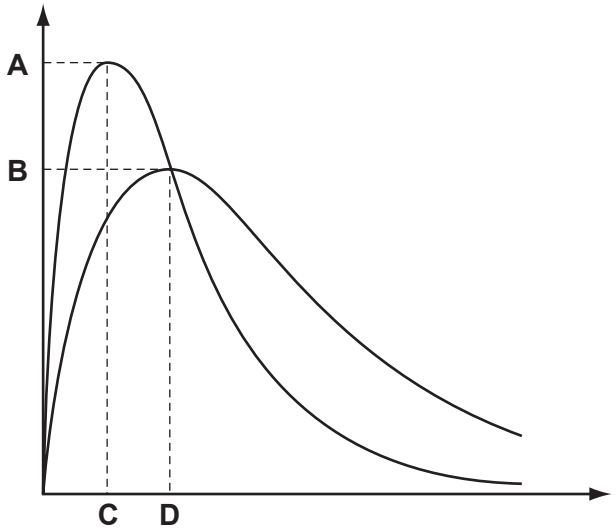
**5** The diagram shows the Maxwell-Boltzmann energy distribution curves for molecules of a sample of a gas at two different temperatures.

Which letter on the axes represents the most probable energy of the molecules at the **lower** temperature?




**6** Which pair of elements has chemical bonds of the same type between their atoms in the solid state?

**A** aluminium and phosphorus

**B** chlorine and argon

**C** magnesium and silicon

**D** sulfur and chlorine

**7** Ethanol has a boiling point of 78 °C. At 101 kPa and 79 °C ethanol vapour does not perfectly obey the gas equation $pV = nRT$.

What is the reason for this?

**A** Ethanol vapour is in equilibrium with ethanol liquid at 79 °C.

**B** There are intermolecular forces between the molecules of ethanol vapour.

**C** The vapourisation of ethanol liquid is an endothermic process.

**D** Vapours will not obey the gas equation perfectly at such a low pressure.

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**8** The reaction between sulfur dioxide and oxygen is a dynamic equilibrium.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

What happens when the pressure of the system is increased?

**A** The rate of reaction will decrease and the position of the equilibrium will move to the left.

**B** The rate of reaction will decrease and the position of the equilibrium will move to the right.

**C** The rate of reaction will increase and the position of the equilibrium will move to the left.

**D** The rate of reaction will increase and the position of the equilibrium will move to the right.

**9** Dicarbon monoxide, $C_2O$, is found in dust clouds in space. Analysis of it shows that the sequence of atoms in this molecule is C – C – O. All bonds are double bonds and there are no unpaired electrons.

How many lone pairs of electrons are present in a molecule of $C_2O$?

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

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

A student mixed 25 $cm^3$ of 0.10 mol $dm^{-3}$ sodium hydroxide solution with 25 $cm^3$ of 0.10 mol $dm^{-3}$ hydrochloric acid and noted a temperature rise of 2.5 °C.

What is the enthalpy change of the reaction per mole of NaOH?

**A** –209 kJ $mol^{-1}$

**B** –104.5 kJ $mol^{-1}$

**C** –209 J $mol^{-1}$

**D** –522.5 J $mol^{-1}$

**11** Which energy change corresponds to the enthalpy change of atomisation of hydrogen at 298 K?

**A** the bond energy of a H – H bond

**B** half the bond energy of a H – H bond

**C** minus half the bond energy of a H – H bond

**D** minus the bond energy of a H – H bond

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**12** Propanone has molecular formula $C_3H_6O$.

The enthalpy change of combustion of hydrogen is $-286\,kJ\,mol^{-1}$.

The enthalpy change of combustion of carbon is $-394\,kJ\,mol^{-1}$.

The enthalpy change of formation of propanone is $-254\,kJ\,mol^{-1}$.

Using this information, what is the enthalpy change of combustion of propanone?

**A** $-2644\,kJ\,mol^{-1}$

**B** $-2294\,kJ\,mol^{-1}$

**C** $-1786\,kJ\,mol^{-1}$

**D** $-426\,kJ\,mol^{-1}$

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

Magnesium nitrate, $Mg(NO_3)_2$, will decompose when heated to give a white solid and a mixture of gases. One of the gases released is oxygen.

29.7 g of anhydrous magnesium nitrate is heated until no further reaction takes place.

What mass of oxygen is produced?

**A** 3.2 g **B** 6.4 g **C** 12.8 g **D** 19.2 g

**14** In which row of the table are all statements comparing the compounds of calcium and barium correct?

| | solubility of calcium hydroxide | solubility of barium hydroxide | thermal stability of calcium carbonate | thermal stability of barium carbonate |
|---|---|---|---|---|
| **A** | higher | lower | higher | lower |
| **B** | higher | lower | lower | higher |
| **C** | lower | higher | higher | lower |
| **D** | lower | higher | lower | higher |

**15** Many modern cars are fitted with halogen lamps. When such lamps are first switched on, a distinct purple colour can be seen.

Which species is responsible for this purple colour?

**A** $I_2(s)$ **B** $I_2(l)$ **C** $I_2(g)$ **D** $I(g)$

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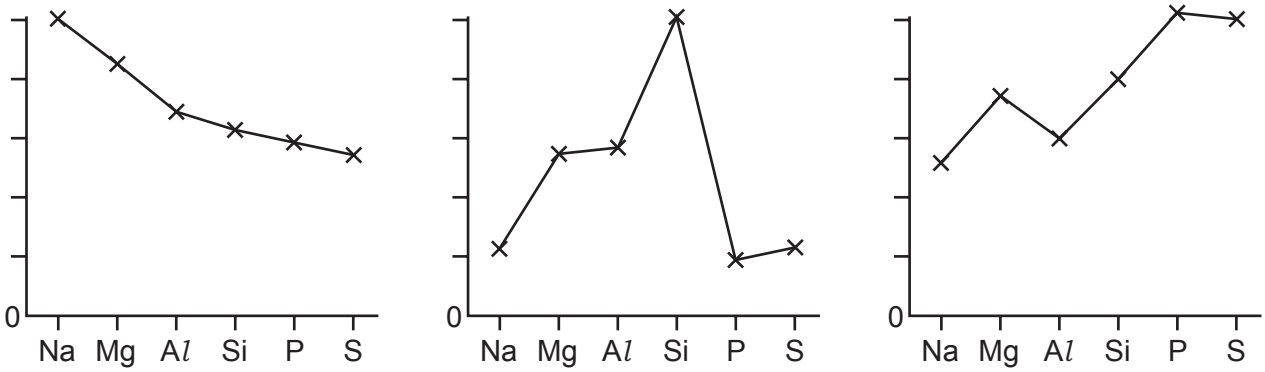
**16** The trends in three physical properties of the elements Na, Mg, A*l*, Si, P and S are shown in the graphs.




Which physical property is **not** illustrated?

**A** atomic radius

**B** electrical conductivity

**C** first ionisation energy

**D** melting point

**17** Which statement about ammonia is completely correct?

**A** Ammonia acts as a nucleophile by accepting a pair of electrons when it reacts with bromoethane.

**B** Ammonia can form a co-ordinate bond with a hydrogen ion to form an ammonium ion.

**C** Ammonia is a base and accepts hydroxide ions.

**D** The shape of the ammonia molecule is pyramidal with bond angles of 109.5°.

**18** What happens when bromine solution is added to a solution of sodium iodide?

**A** A reaction occurs without changes in oxidation state.

**B** Bromine atoms are oxidised, iodide ions are reduced.

**C** Bromine atoms are reduced, iodide ions are oxidised.

**D** No reaction occurs.

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**19** The halogens exist as diatomic molecules, $X_2$.

The boiling points of the Group VII elements increase as the group is descended from chlorine to iodine.

Which statement helps to explain this increase in boiling point as Group VII is descended?

**A** The electronegativity of X decreases as the group is descended.

**B** The number of electrons in each $X_2$ molecule increases as the group is descended.

**C** The size of the permanent dipole in the $X_2$ molecule increases as the group is descended.

**D** The X–X bond strength increases as the group is descended.

**20** The compound hex-3-en-1-ol, **P**, has a strong 'leafy' smell of newly cut grass and is used in perfumery.

$$CH_3CH_2CH{=}CHCH_2CH_2OH$$

**P**

What is produced when **P** is treated with an excess of hot concentrated acidified $KMnO_4$?

**A** $CH_3CH_2CH(OH)CH(OH)CH_2CH_2OH$

**B** $CH_3CH_2CH{=}CHCH_2CO_2H$

**C** $CH_3CH_2CHO$ and $OCHCH_2CH_2OH$

**D** $CH_3CH_2CO_2H$ and $HO_2CCH_2CO_2H$

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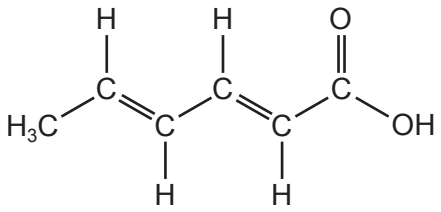
**21** Sorbic acid is used as a food preservative because it kills fungi and moulds.



sorbic acid

Sorbic acid will react with

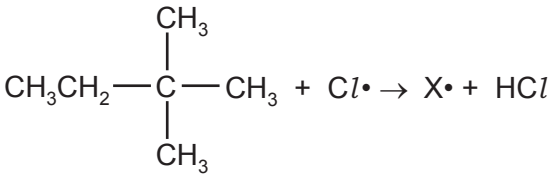
- hydrogen in the presence of a nickel catalyst,
- bromine in an organic solvent.

How many moles of hydrogen and of bromine will be incorporated into one mole of sorbic acid by these reactions?

| | moles of hydrogen | moles of bromine |
|---|---|---|
| **A** | 2 | 2 |
| **B** | 2 | $2\frac{1}{2}$ |
| **C** | 3 | 2 |
| **D** | 3 | $2\frac{1}{2}$ |

**22** When heated with chlorine, the hydrocarbon 2,2-dimethylbutane undergoes free radical substitution.

In a propagation step a free radical X• is formed.



How many different forms of X• are possible?

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

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**23** Aqueous sodium hydroxide reacts with 2-bromo-2-methylpropane to give 2-methylpropan-2-ol.

The reaction proceeds by an $S_N1$ mechanism.

How should the first step in the mechanism be described?

**A** by a curly arrow from a lone pair on the $OH^-$ ion to the $C^{\delta+}$ atom of 2-bromopropane

**B** by a curly arrow from the C–Br bond to the Br atom

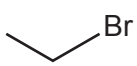
**C** by a curly arrow from the C–Br bond to the C atom

**D** by the homolytic fission of the C–Br bond

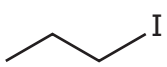
**24** Compound **Y** can be hydrolysed by warm aqueous silver nitrate to form a precipitate that is soluble in dilute aqueous ammonia. Compound **Y** can undergo an elimination reaction to form an alkene.

What could be the skeletal formula of compound **Y**?

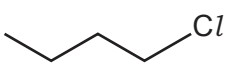
**A**



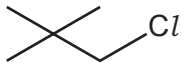

**B**



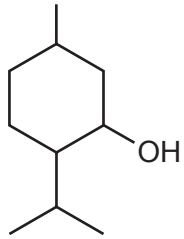

**C**




**D**




**25** The compound shown is menthol, a naturally-occurring alcohol found in peppermint oil.

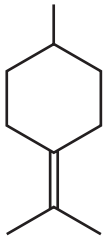



menthol

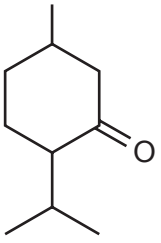
When menthol is heated with concentrated sulfuric acid it reacts. The products that form include compound **T**.

What could be the structure of compound **T**?

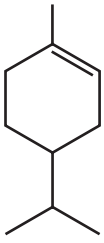
**A**



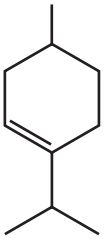
**B**




**C**



**D**



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

Which volume of oxygen measured at room temperature and pressure is needed for complete combustion of 0.1 mol of propan-1-ol?

**A** 10.8 $dm^3$ **B** 12.0 $dm^3$ **C** 21.6 $dm^3$ **D** 24.0 $dm^3$

**27** Which carbonyl compound reacts with hydrogen cyanide to form a product that has **no** chiral carbon atom?

**A** butanone

**B** ethanal

**C** propanal

**D** propanone

**28** How many of the following compounds produce a carboxylic acid on heating under reflux with hot acidified $K_2Cr_2O_7$?

$CH_3CH_2CHO$

$CH_3COCH_3$

$CH_3CH_2CH_2OH$

$CH_3CHOHCH_3$

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

**29** Compound **Y** has $M_r$ of 88. It does not fizz when added to a solution of sodium hydrogencarbonate. It can be hydrolysed by dilute sulfuric acid to produce two organic products with $M_r$ values of 46 and 60.

What is the identity of compound **Y**?

**A** butanoic acid

**B** ethyl ethanoate

**C** 3-hydroxybutanal

**D** butyl methanoate

**30** Polymerisation of ethene gives poly(ethene).

How does the carbon-carbon bond in poly(ethene) compare with that in ethene?

**A** The carbon-carbon bond is longer and stronger in poly(ethene).

**B** The carbon-carbon bond is longer and weaker in poly(ethene).

**C** The carbon-carbon bond is shorter and stronger in poly(ethene).

**D** The carbon-carbon bond is shorter and weaker in poly(ethene).

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

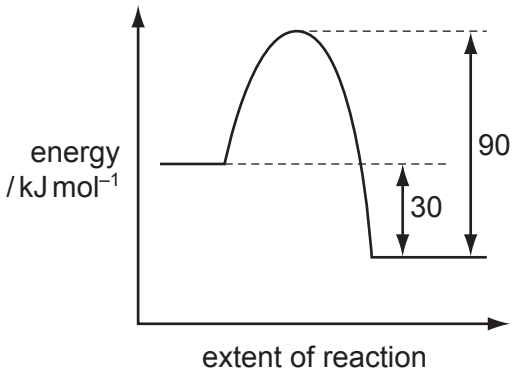
In which pairs do both species have the same number of unpaired p electrons?

**1** $Al^{2-}$ and $O^{+}$

**2** N and $Cl^{2+}$

**3** C and $Cl^{+}$

**32** The diagram shows the reaction pathway for a reversible reaction.




Which statements are correct?

**1** The enthalpy change for the backward reaction is +90 kJ mol$^{-1}$.

**2** The forward reaction is exothermic.

**3** The enthalpy change for the forward reaction is –30 kJ mol$^{-1}$.

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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** Which substances contain delocalised electrons?

**1** cyclohexene

**2** graphite

**3** sodium

**34** Solids **W**, **X**, **Y** and **Z** are compounds of two different Group II metals. Some of their applications are described below.

Compound **W** is used as a refractory lining material in kilns.

Compound **X** is used as a building material. It can also be heated in a kiln to form compound **Y**. When **Y** is hydrated, it forms compound **Z** which is used agriculturally to treat soils.

Which statements about these compounds are correct?

**1** Adding **W** to water has less effect on pH than adding **Y**.

**2** Adding **Z** to soil increases the pH of the soil.

**3** The metallic element in **Y** reacts with cold water more quickly than the metallic element in **W**.

**35** Which properties increase in the sequence hydrogen chloride, hydrogen bromide and hydrogen iodide?

**1** thermal stability

**2** bond length

**3** ease of oxidation

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**36** Sulfur dioxide is an atmospheric pollutant that causes acid rain. One of the reactions in this process is the oxidation of sulfur dioxide to sulfur trioxide.

This oxidation takes place by a two stage reaction involving oxygen and nitrogen monoxide, NO.

$$NO + \tfrac{1}{2}O_2 \rightarrow NO_2$$

$$NO_2 + SO_2 \rightarrow SO_3 + NO$$

Which statements are correct?

**1** Nitrogen monoxide is acting as a catalyst for the oxidation.

**2** Nitrogen atoms are oxidised in the second stage.

**3** Oxygen atoms are first reduced and are then oxidised.

**37** Which are properties of fluoroalkanes?

**1** They are less reactive than the corresponding chloroalkanes.

**2** They are non-flammable.

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

**38** What can be produced when an aqueous solution of butan-2-ol is oxidised under suitable conditions?

**1** butanone

**2** butanoic acid

**3** butanal

**39** The $M_r$ of compound X is 72. The composition by mass of X is 66.7 % carbon, 11.1 % hydrogen and 22.2 % oxygen. X gives an orange precipitate with 2,4-dinitrophenylhydrazine reagent. X does **not** react with Fehling's reagent.

What can be deduced from this information?

**1** X is a carbonyl compound.

**2** X is a ketone.

**3** X is butanone.

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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.

**40** An organic compound, **Z**, will react with calcium metal to produce a salt with the empirical formula $CaC_4H_6O_4$.

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

**1** ethanoic acid

**2** butanedioic acid

**3** methylpropanedioic acid

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