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

**CHEMISTRY** **9701/13**

Paper 1 Multiple Choice **October/November 2013**

**1 hour**

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

* 2 3 4 0 9 5 3 0 9 3 *

**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 **12** printed 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** Ammonium nitrate, $NH_4NO_3$, can decompose explosively when heated.

$$NH_4NO_3 \rightarrow N_2O + 2H_2O$$

What are the changes in the oxidation numbers of the two nitrogen atoms in $NH_4NO_3$ when this reaction proceeds?

**A** –2, –4 **B** +2, +6 **C** +4, –6 **D** +4, –4

**2** In the extraction of aluminium by electrolysis, why is it necessary to dissolve aluminium oxide in molten cryolite?

**A** to reduce the very high melting point of the electrolyte

**B** cryolite is a base; aluminium oxide is amphoteric

**C** cryolite reacts with the aluminium oxide to form ions

**D** molten aluminium oxide alone would not conduct electricity

**3** A $10\,cm^3$ sample of $0.30\,mol\,dm^{-3}$ $Tl^+NO_3^-$ required $20\,cm^3$ of $0.10\,mol\,dm^{-3}$ acidified $NH_4VO_3$ to oxidise it to $Tl^{3+}$ in solution. Vanadium is the only element reduced in this reaction.

What is the oxidation number of the vanadium in the reduced form?

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

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

Element X forms $X^-$ ions that can be oxidised to element X by acidified potassium manganate(VII).

What could be the values of the first four ionisation energies of X?

| | 1st | 2nd | 3rd | 4th |
|---|---|---|---|---|
| **A** | 418 | 3070 | 4600 | 5860 |
| **B** | 577 | 1820 | 2740 | 11 600 |
| **C** | 590 | 1150 | 4940 | 6480 |
| **D** | 1010 | 1840 | 2040 | 4030 |

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**5** $Na_2S_2O_3$ reacts with dilute HC*l* to give a pale yellow precipitate. If 1 $cm^3$ of 0.1 mol $dm^{-3}$ HC*l* is added to 10 $cm^3$ of 0.02 mol $dm^{-3}$ $Na_2S_2O_3$ the precipitate forms slowly.

If the experiment is repeated with 1 $cm^3$ of 0.1 mol $dm^{-3}$ HC*l* and 10 $cm^3$ of 0.05 mol $dm^{-3}$ $Na_2S_2O_3$ the precipitate forms more quickly.

Why is this?

**A** The activation energy of the reaction is lower when 0.05 mol $dm^{-3}$ $Na_2S_2O_3$ is used.

**B** The collisions between reactant particles are more violent when 0.05 mol $dm^{-3}$ $Na_2S_2O_3$ is used.

**C** The reactant particles collide more frequently when 0.05 mol $dm^{-3}$ $Na_2S_2O_3$ is used.

**D** The reaction proceeds by a different pathway when 0.05 mol $dm^{-3}$ $Na_2S_2O_3$ is used.

**6** Which stage in the free radical substitution of ethane by chlorine will have the lowest activation energy?

**A** $Cl_2 \rightarrow 2Cl\bullet$

**B** $Cl\bullet + C_2H_6 \rightarrow C_2H_5\bullet + HCl$

**C** $C_2H_5\bullet + Cl_2 \rightarrow C_2H_5Cl + Cl\bullet$

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

**7** Measured values of the pressure, volume and temperature of a known mass of a gaseous compound are to be substituted into the equation $pV = nRT$.

The measurements are used to calculate the relative molecular mass, $M_r$, of a compound.

Which conditions of pressure and temperature would give the most accurate value of $M_r$?

| | pressure | temperature |
|---|---|---|
| **A** | high | high |
| **B** | high | low |
| **C** | low | high |
| **D** | low | low |

**8** Which solid contains more than one kind of bonding?

**A** copper

**B** diamond

**C** ice

**D** magnesium oxide

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

When an evacuated fluorescent light tube of volume 300 $cm^3$ is filled with a gas at 300 K and 101 kPa, the mass of the tube increases by 1.02 g. The gas obeys the ideal gas equation $pV = nRT$.

What is the identity of the gas?

**A** argon

**B** krypton

**C** neon

**D** nitrogen

**10** Nitrogen reacts with hydrogen to produce ammonia.

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

A mixture of 1.00 mol of nitrogen, 3.00 mol of hydrogen and 1.98 mol of ammonia is allowed to reach equilibrium in a sealed vessel under certain conditions. It was found that 1.64 mol of nitrogen were present in the equilibrium mixture.

What is the value of $K_c$ under these conditions?

**A** $\dfrac{(0.70)^2}{(1.64)(4.92)^3}$

**B** $\dfrac{(1.34)^2}{(1.64)(3.64)^3}$

**C** $\dfrac{(1.64)(4.92)^3}{(0.70)^2}$

**D** $\dfrac{(1.64)(3.64)^3}{(1.34)^2}$

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

Which calcium compound contains 54.1 % by mass of calcium?

**A** calcium hydroxide

**B** calcium nitrate

**C** calcium oxide

**D** calcium sulfate

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

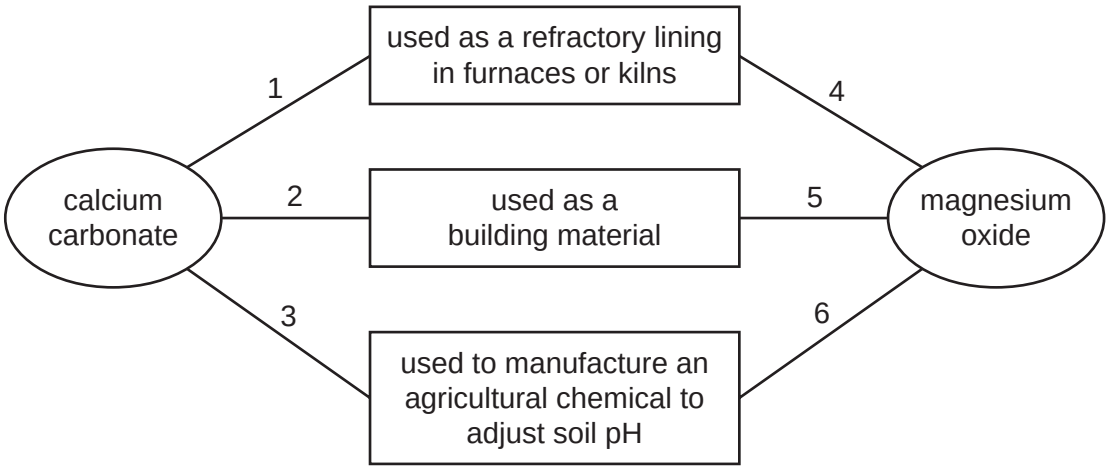
The reaction between aluminium powder and anhydrous barium nitrate is used as the propellant in some fireworks. The reaction produces the metal oxides and nitrogen.

$$10Al + 3Ba(NO_3)_2 \rightarrow 5Al_2O_3 + 3BaO + 3N_2$$

Which mass of barium oxide is produced when 5.40 g of aluminium powder reacts with an excess of anhydrous barium nitrate?

**A** 1.62 g **B** 3.06 g **C** 9.18 g **D** 10.2 g

**13** The diagram shows some applications of compounds of Group II elements.




Which numbered links are correct?

| | calcium carbonate | magnesium oxide |
|---|---|---|
| **A** | 1, 2 and 3 | 4 and 5 only |
| **B** | 1, 2 and 3 | 5 and 6 only |
| **C** | 2 and 3 only | 4 only |
| **D** | 2 and 3 only | 6 only |

**14** River water in a chalky agricultural area may contain $Ca^{2+}$, $Mg^{2+}$, $CO_3^{2-}$, $HCO_3^-$, $Cl^-$ and $NO_3^-$ ions. In a water treatment plant, such water is treated by adding a calculated quantity of calcium hydroxide.

What will be precipitated from the river water following the addition of calcium hydroxide?

**A** $CaCl_2$ **B** $CaCO_3$ **C** $Ca(NO_3)_2$ **D** $Mg(NO_3)_2$

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**15** Ammonia exists as simple covalent molecules, $NH_3$. Ammonia can react with suitable reagents to form products containing ammonium ions, $NH_4^+$. Ammonia can also react with suitable reagents to form products containing amide ions, $NH_2^-$.

Which of these nitrogen-containing species are present in an aqueous solution of ammonia?

**A** ammonia molecules, ammonium ions and amide ions

**B** ammonia molecules and ammonium ions only

**C** ammonia molecules only

**D** ammonium ions only

**16** Carbon, nitrogen and sulfur are non-metals.

Which statement about their oxides, $XO_2$, is correct? (Where X represents carbon, nitrogen or sulfur.)

**A** All of the $XO_2$ molecules are linear.

**B** In $XO_2$, each element has its highest oxidation number.

**C** All $XO_2$ molecules dissolve in water to form dibasic acids.

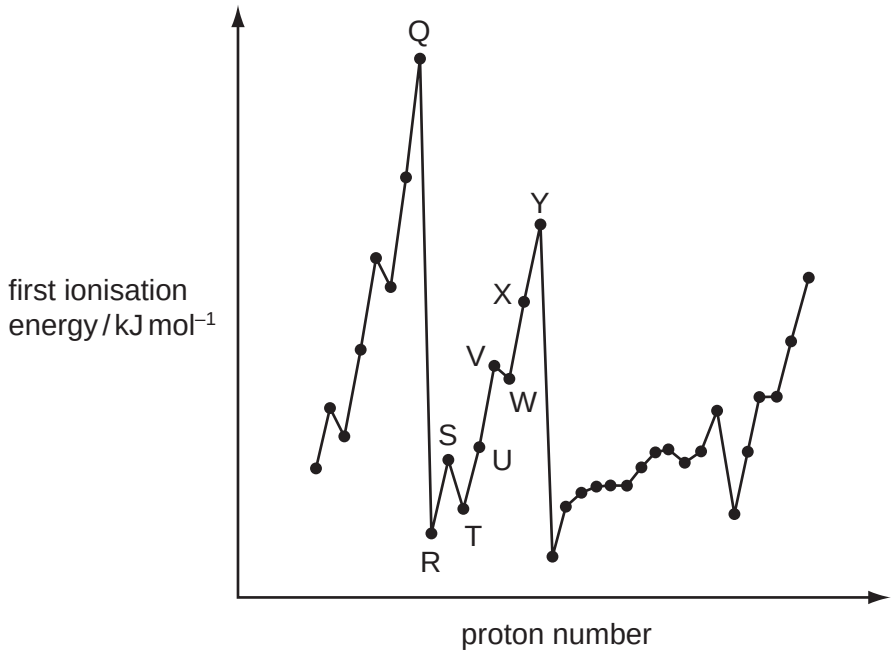
**D** All $XO_2$ molecules are formed as a result of burning petrol in a car engine.

**17** Which oxide is insoluble in aqueous sodium hydroxide?

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

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**18** The graph below shows the variation of the first ionisation energy with the number of protons for some elements.




Which statement is correct?

**A** Elements Q and Y are in the same period in the Periodic Table.

**B** The general increase from elements R to Y is due to increasing atomic radius.

**C** The small decrease between elements S and T is due to decreased shielding.

**D** The small decrease between elements V and W is due to repulsion between paired electrons.

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

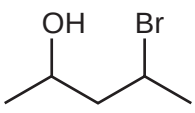
Elements **J** and **K** react together to form compound **L**. Elements **J** and **K** are both in Period 3. Element **J** has the smallest atomic radius in Period 3. There are only two elements in Period 3 which have a lower melting point than element **K**.

Which compound could be **L**?

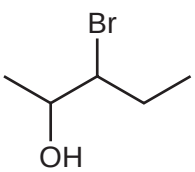
**A** $MgCl_2$ **B** MgS **C** $Na_2S$ **D** $PCl_3$

**20** Which diagram gives the skeletal formula of 2-bromopentan-4-ol?

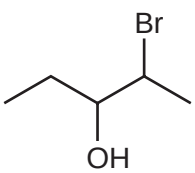
**A**



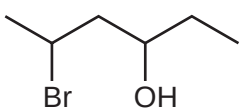

**B**




**C**




**D**



**21** Including structural and stereoisomers, how many isomers are there of $C_2H_2Br_2$?

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

**22** Which reaction will give the best yield of 2-chloropropane?

**A** chlorine gas with propane gas in the presence of uv light

**B** chlorine gas with propene gas in the dark

**C** propan-2-ol with dilute NaC$l$(aq)

**D** propan-2-ol with PC$l_5$

**23** Pent-2-ene, $CH_3CH_2CH{=}CHCH_3$, reacts in a similar way to ethene.

Pent-2-ene is reacted with cold, dilute, acidified manganate(VII) ions.

What will be produced in the greatest amount?

**A** $CH_3CH_2CH(OH)CH(OH)CH_3$

**B** $CH_3CH_2COCOCH_3$

**C** a mixture of $CH_3CH_2CH(OH)CH_2CH_3$ and $CH_3CH_2CH_2CH(OH)CH_3$

**D** $CH_3CH_2COOH$ and $CH_3COOH$

**24** Including structural and stereoisomers, how many isomeric products are produced when alcoholic KOH reacts with 2-chlorobutane?

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

**25** Chlorofluorocarbons, CFCs, can be used as refrigerants, aerosol propellants and fire extinguishers.

CFCs such as CC$l_3$F and CC$l_2$F$_2$ are more stable than chloroalkanes such as CC$l_4$.

What is the reason for their greater stability?

**A** Fluorine has a higher first ionisation energy than chlorine.

**B** Fluorine radicals are more stable than chlorine radicals.

**C** The C–F bond energy is larger than the C–C$l$ bond energy.

**D** The C–F bond is more polar than the C–C$l$ bond.

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**26** Halogenoalkanes react with aqueous NaOH to give alcohols. The mechanism involved is either $S_N1$ or $S_N2$.

Which halogenoalkane produces the highest percentage of product by an $S_N1$ mechanism, when treated with aqueous NaOH?

**A** 2-bromopropane

**B** 2-chloropropane

**C** 1-iodo-2-methylpropane

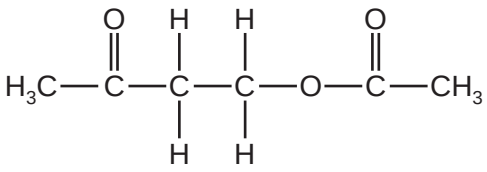
**D** 2-iodo-2-methylpropane

**27** An alcohol with molecular formula $C_nH_{2n+1}OH$ has a chiral carbon atom but does not react with hot, acidified $K_2Cr_2O_7$.

What is the smallest possible value for $n$?

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

**28** Compound X reacts with ethanoic acid in the presence of an $H^+$ catalyst to produce the compound below.



What is the molecular formula of compound X?

**A** $C_2H_6O_2$ **B** $C_2H_6O_3$ **C** $C_4H_8O$ **D** $C_4H_8O_2$

**29** How many hydrogen atoms are added to each molecule of ethanal when it is reacted with $NaBH_4$ in water?

**A** 1 **B** 2 **C** 4 **D** 6

**30** Which fragment could appear in the chain produced by polymerising 1,1-dichloroethene?

**A** $-CH_2-CH_2-CCl_2-CCl_2-CH_2-CH_2-$

**B** $-CHCl-CHCl-CHCl-CHCl-CHCl-CHCl-$

**C** $-CH_2-CCl_2-CH_2-CH_2-CH_2-CCl_2-$

**D** $-CCl_2-CCl_2-CH_2-CH_2-CH_2-CCl_2-$

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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** The $^{1}H_{3}^{+}$ ion was first characterised by J. J. Thomson over a century ago. $^{6}Li$ is a rare isotope of lithium which forms the $^{6}Li^{+}$ ion.

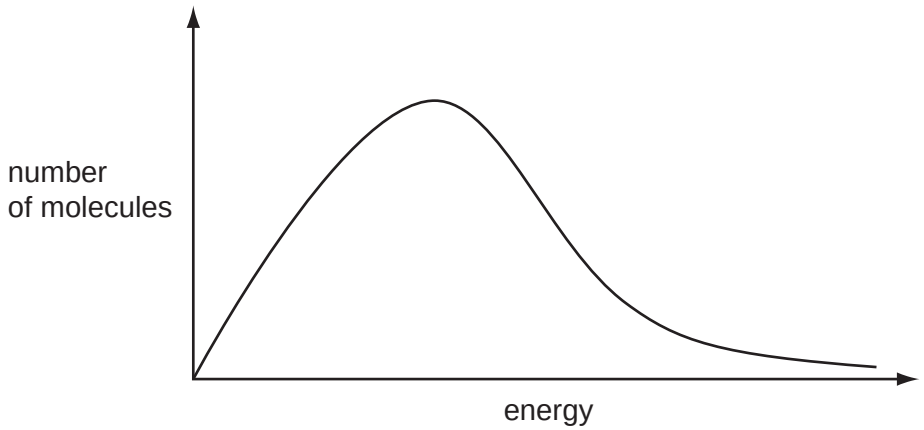
Which statements are correct?

**1** Both ions contain the same number of protons.

**2** Both ions contain the same number of electrons.

**3** Both ions contain the same number of neutrons.

**32** The diagram represents the Boltzmann distribution of molecular energies at a given temperature.




Which of the factors that affect the rate of a reaction can be explained using such a Boltzmann distribution?

**1** increasing the concentration of reactants

**2** increasing the temperature

**3** the addition of a catalyst

**33** Methanoic acid molecules, $HCO_2H$, and hydrogen carbonate ions, $HCO_3^-$, can both behave as acids.

Why does a solution of methanoic acid have a lower pH than a solution of sodium hydrogen carbonate of the same concentration?

**1** $HCO_2H$ molecules dissociate more fully than $HCO_3^-$ ions do.

**2** Each $HCO_2H$ molecule has two hydrogen atoms; each $HCO_3^-$ ion only has one.

**3** Methanoic acid is a weaker acid than sodium hydrogen carbonate.

**34** The following equilibrium is an exothermic reaction in the forward direction.

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$$

What happens when the concentration of $CrO_4^{2-}$ ions **increases and** the temperature **decreases**?

**1** The concentration of $Cr_2O_7^{2-}$ ions increases.

**2** The equilibrium constant increases.

**3** The activation energy decreases.

**35** Which processes involve the conversion of sulfur dioxide into sulfur trioxide?

**1** the combustion of sulfur contaminated fossil fuels

**2** the Contact process for manufacturing sulfuric acid

**3** the catalytic oxidation of sulfur dioxide by oxides of nitrogen

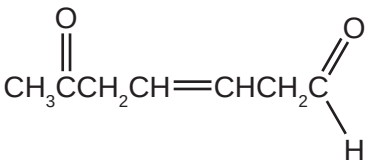
**36** Which chlorides of Period 3 elements will form a neutral solution when added to water?

**1** NaC$l$

**2** A$l_2$C$l_6$

**3** PC$l_5$

**37** A series of tests was carried out on the compound shown below.



Which pairs of reagents would **both** give a positive result for this compound?

**1** Tollens' reagent and a solution containing acidified dichromate(VI) ions

**2** aqueous bromine and Fehling's reagent

**3** 2,4-dinitrophenylhydrazine reagent and sodium carbonate

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.

**38** The reaction of ethanal, $CH_3CHO$, with HCN to form a cyanohydrin is catalysed by NaCN.

What are features of the intermediate of this reaction?

**1** It is chiral.

**2** It has a single negative charge on one of its atoms.

**3** It is a nucleophile.

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

What might be the identity of compound **X**?

**1** $CH_3CH_2CH_2OH$

**2** $CH_3CH_2CHO$

**3** $CH_3COCH_3$

**40** The structural formulae of two compounds are shown below.




Which statements about these compounds are correct?

**1** The two compounds are structural isomers of each other.

**2** The empirical formula of both compounds is $C_3H_6O$.

**3** Both compounds are carboxylic acids.

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