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

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

Paper 1 Multiple Choice **October/November 2010**

**1 hour**

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

* 2 8 9 9 4 4 8 6 1 9 *

**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.

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.



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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 ability of an atom in a covalent bond to attract electrons to itself is called its electronegativity.

The greater the difference between the electronegativities of the two atoms in the bond, the more polar is the bond.

Which pair will form the most polar covalent bond between the atoms?

**A** chlorine and bromine

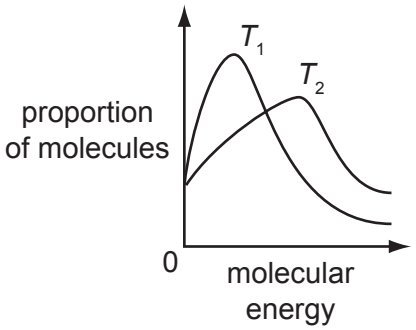
**B** chlorine and iodine

**C** fluorine and chlorine

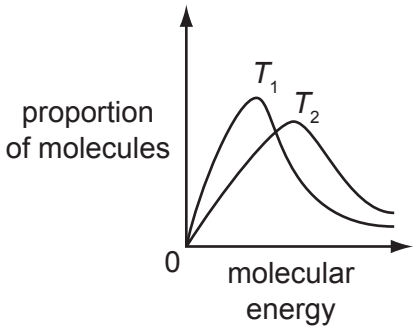
**D** fluorine and iodine

**2** Which diagram correctly represents the Boltzmann distribution of molecular energies at two temperatures $T_1$ and $T_2$, where $T_1 = 300\,K$ and $T_2 = 310\,K$?

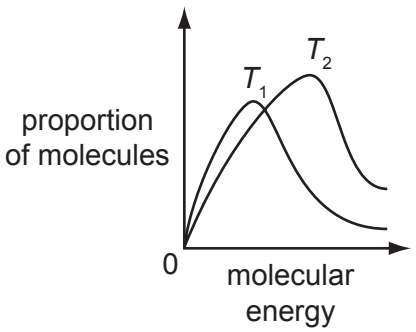
**A**



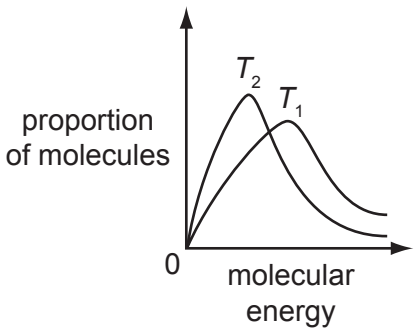

**B**




**C**




**D**

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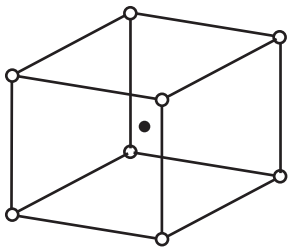
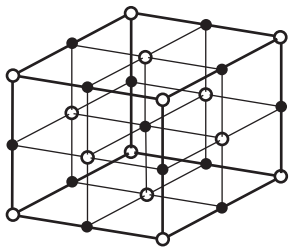
**3** The table gives the radii, in pm, of some ions. [1 pm = $10^{-12}$ m]

| ion | radii |
|---|---|
| $Na^+$ | 102 |
| $Mg^{2+}$ | 72 |
| $Cs^+$ | 167 |
| $Cl^-$ | 181 |
| $O^{2-}$ | 140 |

Caesium chloride, CsC*l*, has a different lattice structure from both sodium chloride, NaC*l*, and magnesium oxide, MgO.



CsC*l* lattice



NaC*l* and MgO lattice

Which factor appears to determine the type of lattice for these three compounds?

**A** the charge on the cation

**B** the ratio of the ionic charges

**C** the ratio of the ionic radii

**D** the sum of the ionic charges

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**[Turn over**

**4** Methanol may be prepared by the reaction between carbon monoxide and hydrogen.

$$CO(g) + 2H_2(g) \rightarrow CH_3OH(g)$$

The relevant average bond energies are given below.

| | |
|---|---|
| $E$(C≡O) | 1077 kJ mol$^{-1}$ |
| $E$(C–O) | 360 kJ mol$^{-1}$ |
| $E$(C–H) | 410 kJ mol$^{-1}$ |
| $E$(H–H) | 436 kJ mol$^{-1}$ |
| $E$(O–H) | 460 kJ mol$^{-1}$ |

What is the enthalpy change of this reaction?

**A** –537 kJ mol$^{-1}$

**B** –101 kJ mol$^{-1}$

**C** +101 kJ mol$^{-1}$

**D** +537 kJ mol$^{-1}$

**5** Which solid has a simple molecular lattice?

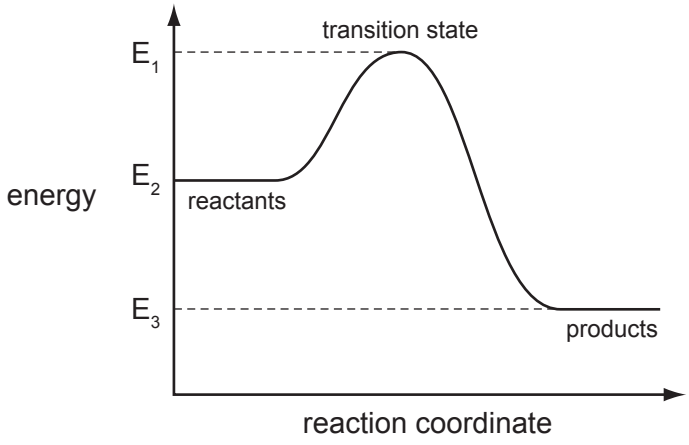
**A** calcium fluoride

**B** nickel

**C** silicon(IV) oxide

**D** sulfur

**6** The reaction pathway diagram below illustrates the energies of reactants, products and the transition state of a reaction.




Which expression represents the activation energy of the forward reaction?

**A** $E_1 - E_2$ **B** $E_1 - E_3$ **C** $E_2 - E_3$ **D** $(E_1 - E_2) - (E_2 - E_3)$

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**7** Flask X contains 5 $dm^3$ of helium at 12 kPa pressure and flask Y contains 10 $dm^3$ of neon at 6 kPa pressure.

If the flasks are connected at constant temperature, what is the final pressure?

**A** 8 kPa **B** 9 kPa **C** 10 kPa **D** 11 kPa

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

The enthalpy change of formation, $\Delta H_f$, of hydrated calcium ions is the enthalpy change of the following reaction.

$$Ca(s) + aq - 2e^- \rightarrow Ca^{2+}(aq)$$

The following enthalpy changes are **not** quoted in the *Data Booklet*.

$$Ca(s) \rightarrow Ca(g) \qquad \Delta H_a = 177\ kJ\ mol^{-1}$$
$$Ca^{2+}(g) + aq \rightarrow Ca^{2+}(aq) \qquad \Delta H_{hyd} = -1565\ kJ\ mol^{-1}$$

What is the enthalpy change of formation of hydrated calcium ions?

**A** $-1388\ kJ\ mol^{-1}$

**B** $-798\ kJ\ mol^{-1}$

**C** $-238\ kJ\ mol^{-1}$

**D** $+352\ kJ\ mol^{-1}$

**9** The following equilibrium is set up in a mixture of concentrated nitric and sulfuric acids.

$$HNO_3 + H_2SO_4 \rightleftharpoons H_2NO_3^+ + HSO_4^-$$

Which row correctly describes the behaviour of each substance in the equilibrium mixture?

| | $HNO_3$ | $H_2SO_4$ | $H_2NO_3^+$ | $HSO_4^-$ |
|---|---|---|---|---|
| **A** | acid | acid | base | base |
| **B** | acid | base | base | acid |
| **C** | base | acid | acid | base |
| **D** | base | acid | base | acid |

**10** Which molecule or structure does **not** contain three atoms bonded at an angle between 109° and 110°?

**A** ethanoic acid

**B** graphite

**C** propane

**D** silicon(IV) oxide

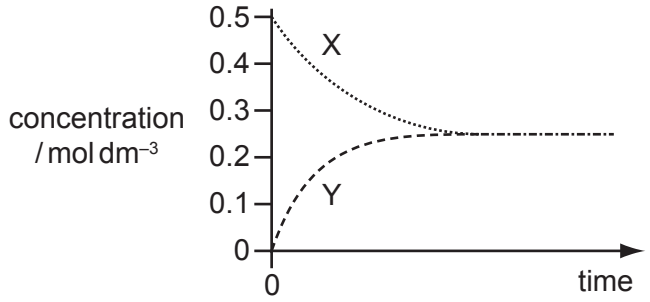
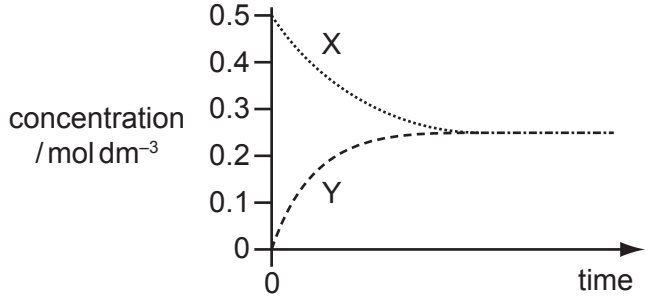
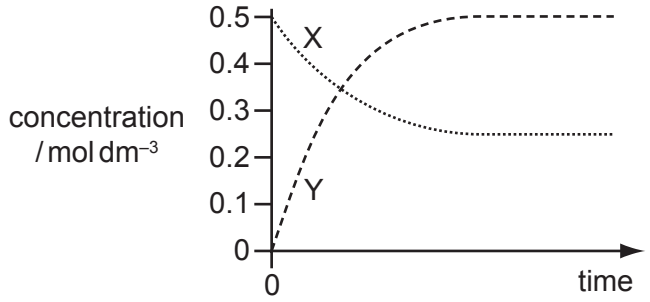
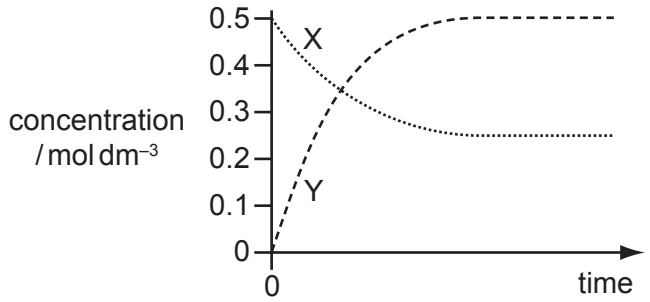
**11** A dimer, X, is stable when solid but a dynamic equilibrium is set up in solution.

$$X(aq) \rightleftharpoons 2Y(aq)$$

A solution of X has an initial concentration of 0.50 mol dm$^{-3}$. When equilibrium has been reached [X(aq)] has fallen to 0.25 mol dm$^{-3}$.

The changes in [X(aq)] and [Y(aq)] are plotted against time until equilibrium is reached. The value of $K_c$ is then calculated.

Which graph and value for $K_c$ are correct?

| | graph | $K_c$ / mol dm$^{-3}$ |
|---|---|---|
| **A** |  | 1 |
| **B** |  | 2 |
| **C** |  | 1 |
| **D** |  | 2 |

**12** Equimolar quantities of magnesium carbonate and strontium carbonate are separately heated to bring about complete thermal decomposition. The minimum temperature for this to occur is called $T_d$.

The cold residues are separately added to equal volumes of water and the change in pH is measured. The change in pH is called $\Delta$pH.

Which metal has the higher value of $T_d$, and the greater value of $\Delta$pH?

| | $T_d$ | $\Delta$pH |
|---|---|---|
| **A** | Mg | Mg |
| **B** | Mg | Sr |
| **C** | Sr | Mg |
| **D** | Sr | Sr |

**13** In aqueous solution, the acid HIO disproportionates according to the following equation where **m**, **n**, **p** and **q** are simple whole numbers in their lowest ratios.

$$\mathbf{m}HIO \rightarrow \mathbf{n}I_2 + \mathbf{p}HIO_3 + \mathbf{q}H_2O$$

This equation can be balanced using oxidation numbers.

What are the values for **n** and **p**?

| | **n** | **p** |
|---|---|---|
| **A** | 1 | 2 |
| **B** | 2 | 1 |
| **C** | 4 | 1 |
| **D** | 4 | 2 |

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

Which mass of solid residue can be obtained from the thermal decomposition of 4.10 g of anhydrous calcium nitrate?

**A** 0.70 g **B** 1.00 g **C** 1.40 g **D** 2.25 g

**15** Which statement explains the observation that magnesium hydroxide dissolves in aqueous ammonium chloride, but not in aqueous sodium chloride?

**A** The ionic radius of the $NH_4^+$ ion is similar to that of $Mg^{2+}$ but not that of $Na^+$.

**B** $NH_4Cl$ dissociates less fully than $NaCl$.

**C** The $Na^+$ and $Mg^{2+}$ ions are isoelectronic (have the same number of electrons).

**D** The $NH_4^+$ ion can donate a proton.

**16** What happens when chlorine is bubbled through aqueous potassium iodide?

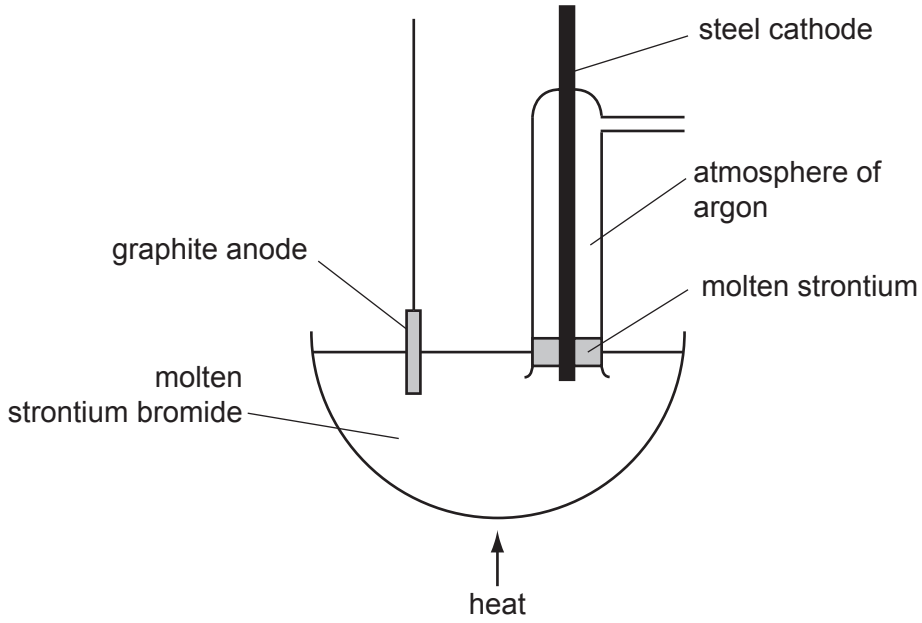
**A** Chlorine is oxidised to chlorate(V) ions.

**B** Chlorine is oxidised to chloride ions.

**C** Iodide ions are oxidised to iodine.

**D** There is no observable reaction.

**17** Strontium metal can be obtained by the electrolysis of molten strontium bromide, $SrBr_2$, using the apparatus shown in the diagram.




Why is an atmosphere of argon used around the cathode?

**A** A thin film of a compound of strontium and argon forms on the surface protecting the freshly formed metal.

**B** The argon keeps the strontium molten.

**C** The argon stops the molten strontium rising too high in the tube.

**D** Without the argon, strontium oxide would form in the air.

**18** 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 vapourise significantly under normal conditions.

**D** Gaseous bromine is purple.

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**19** Concentrated sulfuric acid reacts with both solid sodium chloride at room temperature and with solid sodium iodide at room temperature.

Which row correctly describes how concentrated sulfuric acid behaves in each of these reactions?

| | with sodium chloride | with sodium iodide |
|---|---|---|
| **A** | as an oxidising agent only | as an oxidising agent only |
| **B** | as a strong acid and as an oxidising agent | as a strong acid only |
| **C** | as a strong acid only | as a strong acid and as an oxidising agent |
| **D** | as a strong acid only | as a strong acid only |

**20** How many structural isomers are there of trichloropropane, $C_3H_5Cl_3$?

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

**21** Nine compounds have molecular formula $C_4H_8Br_2$.

Which compound may be synthesised from an alkene by an addition reaction?

**A** 1,1-dibromobutane

**B** 1,2-dibromobutane

**C** 1,3-dibromobutane

**D** 1,3-dibromomethylpropane

**22** When ethanal, $CH_3CHO$, reacts with HCN and the organic product is hydrolysed by aqueous acid, organic compound Y is formed.

When propanal, $C_2H_5CHO$, is heated under reflux with acidified potassium dichromate(VI), organic compound Z is formed.

What is the difference in relative molecular mass of compounds Y and Z?

**A** 12 **B** 14 **C** 16 **D** 17

**23** Which sequence of reagents may be used in the laboratory to convert propan-1-ol into 2-bromopropane?

**A** concentrated sulfuric acid, followed by bromine

**B** concentrated sulfuric acid, followed by hydrogen bromide

**C** ethanolic sodium hydroxide, followed by bromine

**D** ethanolic sodium hydroxide, followed by hydrogen bromide

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**24** Esters are frequently used as solvents and as flavouring agents in fruit drinks and confectionery.

An ester $C_8H_{12}Br_2O_4$ can be prepared in low yield by the reaction shown.

$$CH_3C(Br)(CH_2Br)CO_2H + (CH_3)_2C(OH)CO_2H \rightleftharpoons C_8H_{12}Br_2O_4 + H_2O$$

What is the structural formula of the ester $C_8H_{12}Br_2O_4$?

**A** $CH_3C(Br)(CH_2Br)CO_2C(CH_3)_2CO_2H$

**B** $CH_3C(Br)(CH_2Br)CO_2C(OH)(CH_3)CO_2CH_3$

**C** $CH_3C(Br)(CH_3)CO_2C(CH_3)_2CO_2CH_2Br$

**D** $(CH_3)_2C(Br)C(CO_2H)(CH_2Br)CO_2CH_3$

**25** Many, but not all, organic reactions need to be heated before reaction occurs.

Which reaction occurs at a good rate at room temperature (20 °C)?

**A** $C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$

**B** $CH_3CH_2CH_2Br + NH_3 \rightarrow CH_3CH_2CH_2NH_2 + HBr$

**C** $CH_3CH_2OH + KBr \rightarrow CH_3CH_2Br + KOH$

**D** $(CH_3)_2CO + H_2NNHC_6H_3(NO_2)_2 \rightarrow (CH_3)_2C{=}NNHC_6H_3(NO_2)_2 + H_2O$

**26** Which pair of reagents will take part in a redox reaction?

**A** $CH_3CH_2OH$ + concentrated $H_2SO_4$

**B** $CH_3CHO$ + Tollens' reagent

**C** $CH_3CO_2C_2H_5$ + dilute $H_2SO_4$

**D** $CH_3COCH_3$ + Fehling's solution

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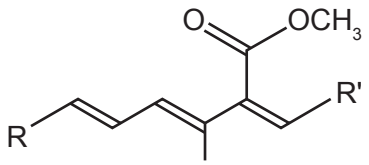
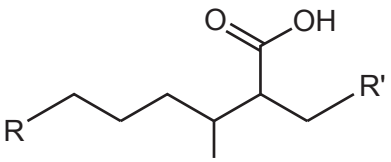
**27** Part of the structure of strobilurin, a fungicide, is shown. R and R' are inert groups.

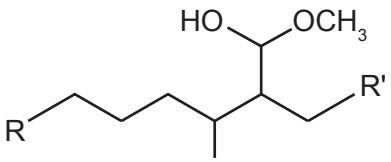



If strobilurin is first warmed with aqueous sulfuric acid, and its product then treated with hydrogen in the presence of a palladium catalyst, what could be the structure of the final product?

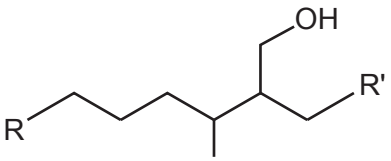
**A**



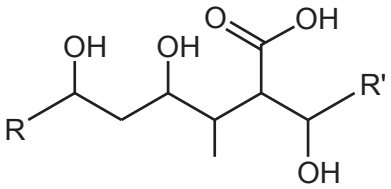

**B**




**C**

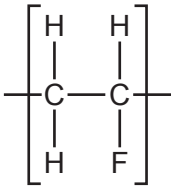



**D**



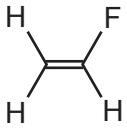

**28** Fluoroalkenes are used to make polymers such as poly(vinyl)fluoride (PVF).

PVF is used to make non-flammable interiors for aircraft. The diagram shows the repeat unit of the polymer PVF.




What is the skeletal formula of the monomer of PVF?

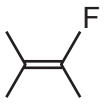
**A**



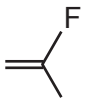

**B**




**C**




**D**



**29** $CH_3CH_2COCH_2CH_3$ reacts with hydrogen cyanide to form a cyanohydrin.

Which feature applies to the product?

**A** It has one chiral centre.

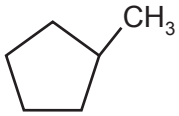
**B** It is formed by electrophilic addition.

**C** It is formed via a C–OH intermediate.

**D** Its formation requires the use of cyanide ions as a catalyst.

**30** Which of the compounds shown have chiral carbon atoms?

1

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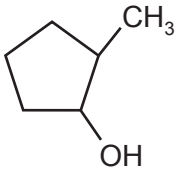


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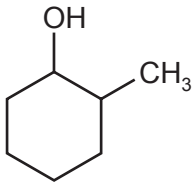


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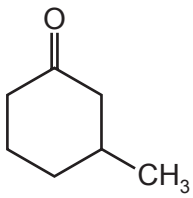


**A** 1, 2, 3 and 4

**B** 1 and 4 only

**C** 2 and 3 only

**D** 2, 3 and 4 only

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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** When ammonia, $NH_3$, is produced in a school or college laboratory, it is usually dried before being collected.

Which drying agents may be used to dry ammonia?

**1** calcium oxide, CaO

**2** phosphorus(V) oxide, $P_4O_{10}$

**3** concentrated sulfuric acid, $H_2SO_4$

**32** Zirconium, Zr, proton number 40, is a metal which is used in corrosion-resistant alloys.

Zirconium metal is extracted from the oxide $ZrO_2$ by the following sequence of reactions.

reaction 1 $ZrO_2 + 2Cl_2 + 2C \rightarrow ZrCl_4 + 2CO$

reaction 2 $ZrCl_4 + 2Mg \rightarrow Zr + 2MgCl_2$

Which statements about this extraction process are correct?

**1** Carbon in reaction 1 behaves as a reducing agent.

**2** Magnesium in reaction 2 behaves as a reducing agent.

**3** Chlorine in reaction 1 behaves as a reducing agent.

**33** Which statements about covalent bonds are correct?

**1** A triple bond consists of one $\pi$ bond and two $\sigma$ bonds.

**2** The electron density in a $\sigma$ bond is highest along the axis between the two bonded atoms.

**3** A $\pi$ bond restricts rotation about the $\sigma$ bond axis.

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.

**34** A student puts 10 $cm^3$ of 0.100 mol $dm^{-3}$ sulfuric acid into one test-tube and 10 $cm^3$ of 0.100 mol $dm^{-3}$ ethanoic acid into another test-tube. He then adds 1.0 g (an excess) of magnesium ribbon to each test-tube and takes suitable measurements. Both acids have the same starting temperature.

Neither reaction is complete after 2 minutes, but both are complete after 20 minutes.

Which statements are correct?

**1** After 2 minutes, the sulfuric acid is at a higher temperature than the ethanoic acid.

**2** After 2 minutes, the sulfuric acid has produced more gas than the ethanoic acid.

**3** After 20 minutes, the sulfuric acid has produced more gas than the ethanoic acid.

**35** In which ways are the main reactions in the Haber and Contact processes similar?

**1** A higher yield is favoured by higher pressures.

**2** The reaction is a redox process.

**3** The forward reaction is exothermic.

**36** A car burning lead-free fuel has a catalytic converter fitted to its exhaust. On analysis its exhaust gases are shown to contain small quantities of nitrogen oxides.

Which modifications would result in lower exhaust concentrations of nitrogen oxides?

**1** an increase in the surface area of the catalyst in the converter

**2** an increase in the rate of flow of the exhaust gases through the converter

**3** a much higher temperature of combustion in the engine

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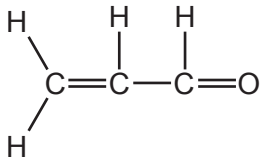
**37** The diagram shows a compound present in smoke from burning garden waste.



Which reagents would undergo a colour change on reaction with this compound?

**1** aqueous bromine

**2** Fehling's reagent

**3** warm acidified $K_2Cr_2O_7$

**38** Organic acids and alcohols react together to form esters.

Which pairs of compounds could produce a product of molecular formula $C_4H_6O_4$?

**1** $CH_3CO_2H$ and $C_2H_5OH$

**2** $HCO_2H$ and $HOCH_2CH_2OH$

**3** $HO_2CCO_2H$ and $CH_3OH$

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

In an organic synthesis, a 62 % yield of product is achieved.

Which of these conversions are consistent with this information?

**1** 74.00g of butan-2-ol $\rightarrow$ 44.64 g of butanone

**2** 74.00g of butan-1-ol $\rightarrow$ 54.56 g of butanoic acid

**3** 74.00g of 2-methylpropan-1-ol $\rightarrow$ 54.56 g of 2-methylpropanoic acid

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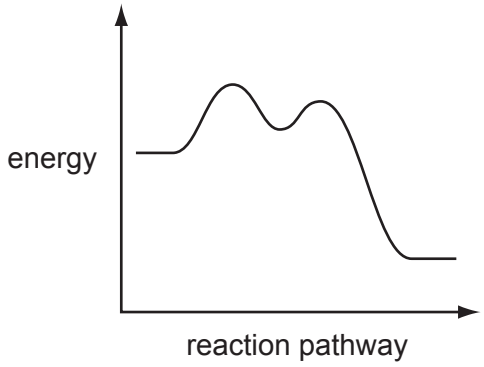
The responses **A** to **D** should be selected on the basis of

| 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** A reaction pathway diagram is shown.




Which reactions would have such a profile?

**1** $(CH_3)_3CBr + NaOH \rightarrow (CH_3)_3COH + NaBr$

**2** $CH_3CH_2Br + NaOH \rightarrow CH_3CH_2OH + NaBr$

**3** $(CH_3)_3CCH_2CH_2Cl + 2NH_3 \rightarrow (CH_3)_3CCH_2CH_2NH_2 + NH_4Cl$

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