



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

CHEMISTRY

9701/11

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



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.



Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

- 1 Solutions containing chlorate(I) ions are used as household bleaches and disinfectants. These solutions decompose on heating as shown.



Which oxidation state is shown by chlorine in each of these three ions?

	ClO^-	ClO_3^-	Cl^-
A	+1	+3	-1
B	-1	+3	+1
C	+1	+5	-1
D	-1	+5	+1

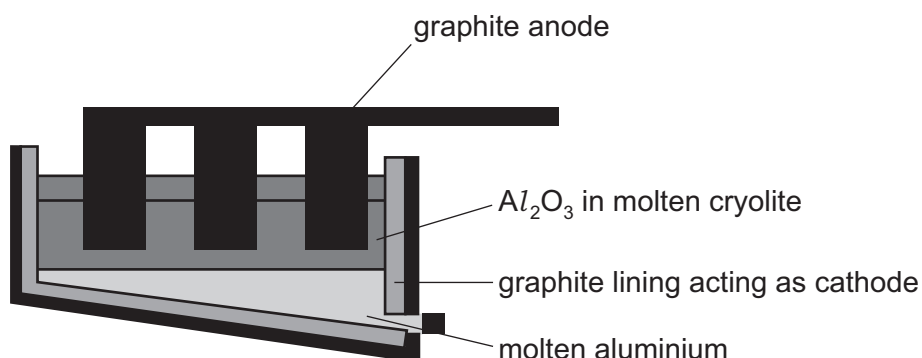
- 2 A mixture of 10 cm^3 of methane and 10 cm^3 of ethane was sparked with an excess of oxygen. After cooling to room temperature, the residual gas was passed through aqueous potassium hydroxide.

All gas volumes were measured at the same temperature and pressure.

What volume of gas was absorbed by the alkali?

- A** 15 cm^3 **B** 20 cm^3 **C** 30 cm^3 **D** 40 cm^3

- 3 The diagram shows an electrolytic cell for the extraction of aluminium.



Which statement is correct?

- A** Aluminium ions are oxidised in this process.
B Aluminium is liberated at the anode by the reaction $\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$.
C Cryolite is purified aluminium oxide.
D The graphite anode burns away.

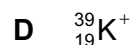
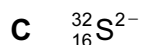
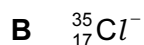
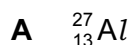
- 4 Use of the Data Booklet is relevant to this question.

The elements radon (Rn), francium (Fr) and radium (Ra) have proton numbers 86, 87 and 88 respectively.

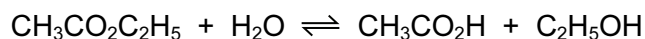
What is the order of their first ionisation energies?

	least endothermic	—————→	most endothermic
A	Fr	Ra	Rn
B	Fr	Rn	Ra
C	Ra	Fr	Rn
D	Rn	Ra	Fr

- 5 In which species are the numbers of protons, neutrons and electrons all different?



- 6 An experiment is set up to measure the rate of hydrolysis of ethyl ethanoate.

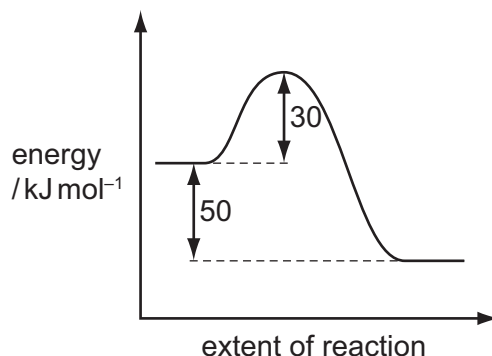


The hydrolysis is found to be slow in neutral aqueous solution but it proceeds at a measurable rate when the solution is acidified with hydrochloric acid.

What is the function of the hydrochloric acid?

- A** to dissolve the ethyl ethanoate
- B** to ensure that the reaction reaches equilibrium
- C** to increase the reaction rate by catalytic action
- D** to suppress ionisation of the ethanoic acid formed

- 7 The reaction pathway for a reversible reaction is shown below.



Which statement is correct?

- A** The activation energy of the reverse reaction is $+80 \text{ kJ mol}^{-1}$.
- B** The enthalpy change for the forward reaction is $+30 \text{ kJ mol}^{-1}$.
- C** The enthalpy change for the forward reaction is $+50 \text{ kJ mol}^{-1}$.
- D** The enthalpy change for the reverse reaction is $+30 \text{ kJ mol}^{-1}$.
- 8 Why does the rate of a gaseous reaction increase when the pressure is increased at a constant temperature?
- A** More particles have energy that exceeds the activation energy.
- B** The particles have more space in which to move.
- C** The particles move faster.
- D** There are more frequent collisions between particles.
- 9 Which would behave the **least** like an ideal gas at room temperature?
- A** carbon dioxide
- B** helium
- C** hydrogen
- D** nitrogen
- 10 The general gas equation can be used to calculate the M_r value of a gas.

For a sample of a gas of mass $m \text{ g}$, which expression will give the value of M_r ?

- A** $M_r = \frac{mpV}{RT}$ **B** $M_r = \frac{pVRT}{m}$ **C** $M_r = \frac{mRT}{pV}$ **D** $M_r = \frac{pV}{mRT}$

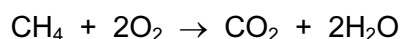
- 11 A solution of Sn^{2+} ions will reduce an acidified solution of MnO_4^- ions to Mn^{2+} ions. The Sn^{2+} ions are oxidised to Sn^{4+} ions in this reaction.

How many moles of Mn^{2+} ions are formed when a solution containing 9.5 g of SnCl_2 (M_r : 190) is added to an excess of acidified KMnO_4 solution?

- A 0.010 B 0.020 C 0.050 D 0.125

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

This question should be answered using bond enthalpy data. The equation for the complete combustion of methane is given below.



What is the enthalpy change of combustion of methane?

- A $-1530 \text{ kJ mol}^{-1}$
 B $-1184 \text{ kJ mol}^{-1}$
 C -770 kJ mol^{-1}
 D -688 kJ mol^{-1}

- 13 In which row of the table are all statements comparing the compounds of magnesium and barium correct?

	solubility of hydroxides		solubility of sulfates	
	solubility of magnesium hydroxide	solubility of barium hydroxide	solubility of magnesium sulfate	solubility of barium sulfate
A	higher	lower	higher	lower
B	higher	lower	lower	higher
C	lower	higher	higher	lower
D	lower	higher	lower	higher

- 14 What happens when iodine solution is added to a solution of sodium bromide?

- A A reaction occurs without changes in oxidation state.
 B Bromide ions are oxidised, iodine atoms are reduced.
 C Bromide ions are reduced, iodine atoms are oxidised.
 D No reaction occurs.

- 15** Element 85, astatine, is in Group VII. Concentrated sulfuric acid is added to sodium astatide. The mixture of products includes astatine, hydrogen astatide, hydrogen sulfide, and sodium sulfate.

Which product is formed by the oxidation of one of the constituents of sodium astatide?

- A** astatine
- B** hydrogen astatide
- C** hydrogen sulfide
- D** sodium sulfate

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

Magnesium nitrate, $\text{Mg}(\text{NO}_3)_2$, will decompose when heated to give a white solid and a mixture of gases. One of the gases released is an oxide of nitrogen, X.

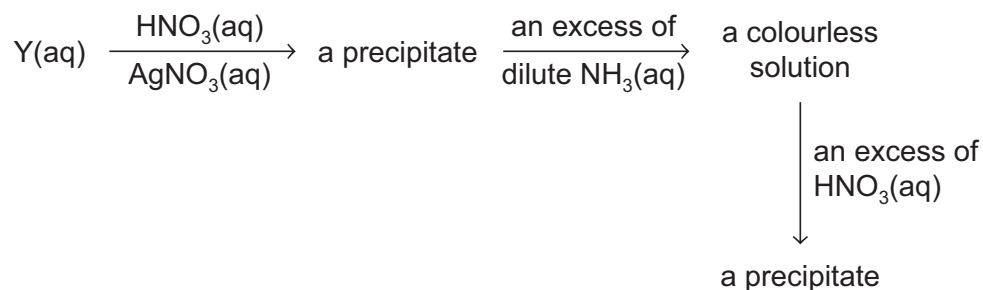
7.4 g of anhydrous magnesium nitrate is heated until no further reaction takes place.

What mass of X is produced?

- A** 1.5 g
- B** 2.3 g
- C** 3.0 g
- D** 4.6 g

- 17** Y is a salt of one of the halogens chlorine, bromine, iodine, or astatine (element 85).

The reaction scheme shows a series of reactions using a solution of Y as the starting reagent.



What could Y be?

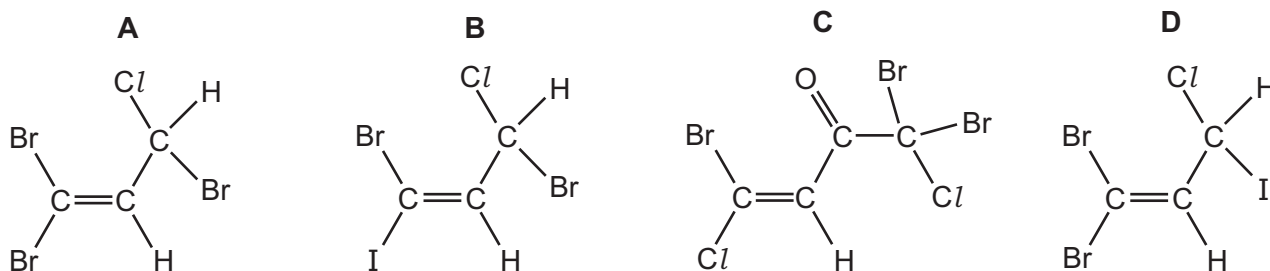
- A** sodium chloride
- B** sodium bromide
- C** potassium iodide
- D** potassium astatide

- 18 Sulfur trioxide is manufactured from sulfur dioxide and oxygen, using the Contact process.

Which condition affects the value of the equilibrium constant, K_c ?

- A adjusting the temperature
 - B increasing the pressure
 - C removing SO_3 from the equilibrium mixture
 - D using a catalyst
- 19 Which reagent, when mixed and heated with ammonium sulfate, liberates ammonia?
- A aqueous bromine
 - B dilute hydrochloric acid
 - C limewater
 - D potassium dichromate(VI) in acidic solution
- 20 The following compounds are found in the seaweed *Asparagopsis taxiformis*.

Which compound could show **both** *cis-trans* isomerism and optical isomerism?



- 21 Lactic acid (2-hydroxypropanoic acid), $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H}$, is found in sour milk.

Which reaction could occur with lactic acid?

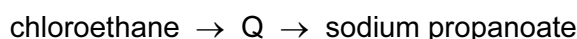
- A $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H} + \text{CH}_3\text{OH} \rightarrow \text{CH}_3\text{CH}(\text{OCH}_3)\text{CO}_2\text{H} + \text{H}_2\text{O}$
- B $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H} + \text{HCO}_2\text{H} \rightarrow \text{CH}_3\text{CH}(\text{O}_2\text{CH})\text{CO}_2\text{H} + \text{H}_2\text{O}$
- C $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H} + \text{NaHCO}_3 \rightarrow \text{CH}_3\text{CH}(\text{ONa})\text{CO}_2\text{H} + \text{H}_2\text{O} + \text{CO}_2$
- D $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H} + \text{Cl}_2 \rightarrow \text{CH}_3\text{CH}(\text{Cl})\text{CO}_2\text{H} + \text{HOCl}$

- 22 Bromine reacts with ethene to form 1,2-dibromoethane.

What is the correct description of the organic intermediate in this reaction?

- A It has a negative charge.
- B It is a free radical.
- C It is a nucleophile.
- D It is an electrophile.

- 23 Chloroethane can be used to make sodium propanoate.



The intermediate, Q, is hydrolysed with boiling aqueous sodium hydroxide, to give sodium propanoate.

Which reagent would produce the intermediate, Q, from chloroethane?

- A concentrated ammonia solution
- B dilute sulfuric acid
- C hydrogen cyanide
- D potassium cyanide

- 24 Aqueous sodium hydroxide reacts with 1-bromopropane to give propan-1-ol.

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 $\text{C}^{\delta+}$ atom of 1-bromopropane
- B by a curly arrow from the $\text{C}^{\delta+}$ atom of 1-bromopropane to the OH^- ion
- C by a curly arrow from the C–Br bond to the C atom
- D by the homolytic fission of the C–Br bond

- 25 Pentane, C_5H_{12} , is reacted with chlorine in the presence of ultraviolet light. A compound R is found in the products. R has molecular formula $\text{C}_5\text{H}_{10}\text{Cl}_2$. Each molecule of R contains **one** chiral carbon atom.

Which two atoms of the pentane chain could be bonded to chlorine atoms in this isomer?

- A 1 and 3
- B 1 and 5
- C 2 and 3
- D 2 and 4

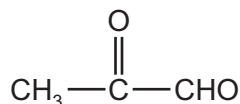
26 Use of the Data Booklet is relevant to this question.

2.30 g of ethanol were mixed with an excess of aqueous acidified potassium dichromate(VI). The reaction mixture was then boiled under reflux for one hour. The desired organic product was then collected by distillation. The yield of product was 60.0 %.

What mass of product was collected?

- A 1.32 g B 1.38 g C 1.80 g D 3.20 g

27 Burnt sugar has a characteristic smell caused partly by the following compound.

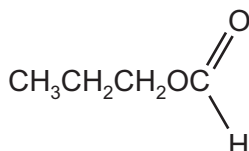


This compound contains two functional groups.

Which reagent will react with **only one** of the functional groups?

- A acidified potassium dichromate(VI)
 B 2,4-dinitrophenylhydrazine
 C hydrogen cyanide
 D sodium hydroxide

28 The structural formula of a compound **X** is shown below.

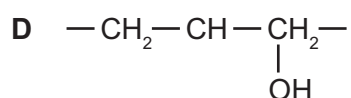
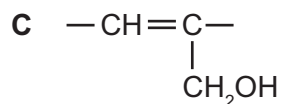
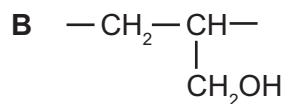
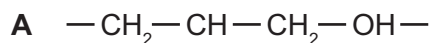


What is the name of compound **X** and how does its boiling point compare with that of butanoic acid?

	name of X	boiling point of X
A	methyl propanoate	higher
B	methyl propanoate	lower
C	propyl methanoate	higher
D	propyl methanoate	lower

- 29 Synthetic resins, plasticisers and many other chemicals can be made by polymerisation of a variety of monomers including prop-2-en-1-ol, $\text{CH}_2=\text{CHCH}_2\text{OH}$.

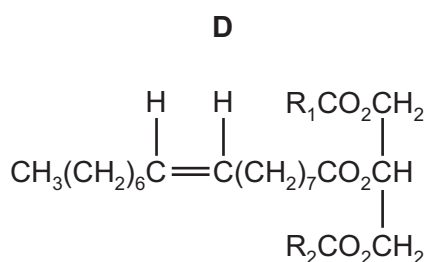
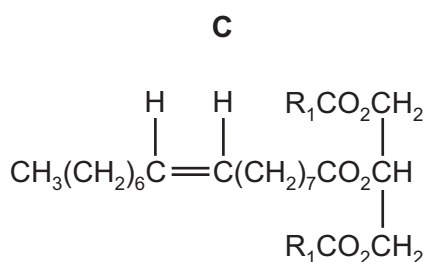
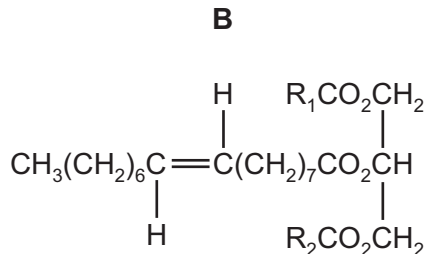
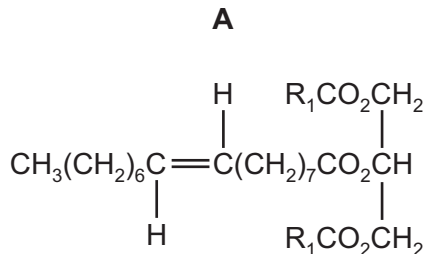
Which structure represents the repeat unit in poly(prop-2-en-1-ol)?



- 30 Some vegetable oils contain 'trans fats' that are associated with undesirable increases in the amount of cholesterol in the blood.

In the diagrams below, R_1 and R_2 are different hydrocarbon chains.

Which diagram correctly illustrates an optically active 'trans fat'?



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.*

Free-radicals play an important part in reactions involving the destruction of the ozone layer and the substitution of alkanes by chlorine.

Some free-radicals contain two unpaired electrons. Such species are called diradicals.

Which species are diradicals?

- 1** O
- 2** Cl
- 3** CH₃

32 The Group II metals have higher melting points than the Group I metals.

Which factors could contribute towards the higher melting points?

- 1** There are smaller interatomic distances in the metallic lattices of the Group II metals.
- 2** More electrons are available from each Group II metal atom for bonding the atom into the metallic lattice.
- 3** Group II metals have a higher first ionisation energy than the corresponding Group I metal.

33 Valence shell electron pair repulsion theory should be used to answer this question.

Which species are trigonal planar?

- 1** BH₃
- 2** CH₃⁺
- 3** PH₃

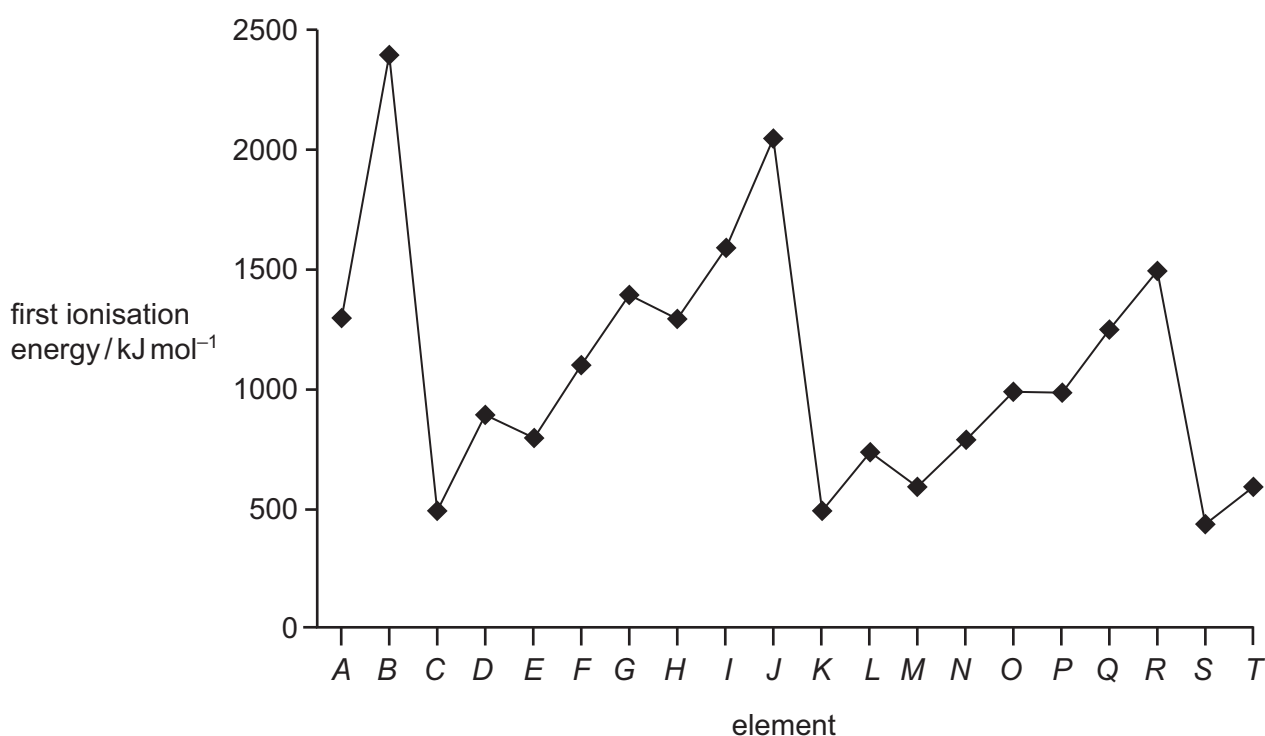
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No other combination of statements is used as a correct response.

- 34** The first ionisation energies of twenty successive elements in the Periodic Table are represented in the graph.

The letters given are not the normal symbols for these elements.



Which statements about this graph are correct?

- 1** Elements *B*, *J* and *R* are in Group 0 of the Periodic Table.
- 2** Atoms of elements *D* and *L* contain two electrons in their outer shells.
- 3** Atoms of elements *G* and *O* contain a half-filled p subshell.

- 35** 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 More acid is neutralised by 1 g of **W** than by 1 g of **X**.
 - 2 The metallic element in **W** reacts with water more quickly than the metallic element in **Y**.
 - 3 Adding **Z** to a soil decreases the pH of the soil.
- 36** When a red-hot platinum wire is plunged into a test tube of hydrogen iodide, the gas is decomposed into its elements. If the experiment is repeated with hydrogen chloride, no change occurs.

Which factors contribute to this behaviour?

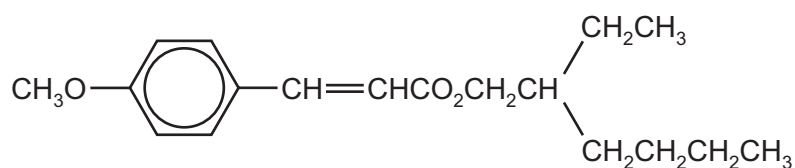
- 1 the strength of the hydrogen-halogen bond
 - 2 the size of the halogen atom
 - 3 the standard enthalpy of formation, $\Delta H_f^\ominus$, of each of the products of decomposition
- 37** Which molecules would be present in the mixture produced by the photochemical chlorination of methane?
- 1 hydrogen
 - 2 hydrogen chloride
 - 3 dichloromethane
- 38** In which reactions is the organic compound oxidised by the given reagent?
- 1 $\text{CH}_3\text{CH}_2\text{CHO}$ + Fehling's reagent
 - 2 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$ + Tollens' reagent
 - 3 CH_3CHO + 2,4-dinitrophenylhydrazine reagent

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

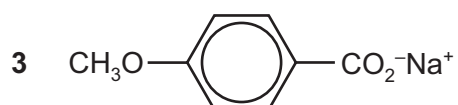
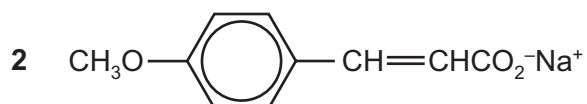
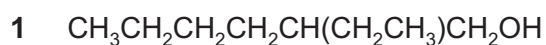
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No other combination of statements is used as a correct response.

39 A sun protection cream contains the following ester as its active ingredient.



Which substances are present in the products of its hydrolysis by aqueous sodium hydroxide?



40 Which reagents, when used in an excess, can be used to make sodium lactate, $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{Na}$, from lactic acid, $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H}$?



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CHEMISTRY

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Paper 1 Multiple Choice

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Section A

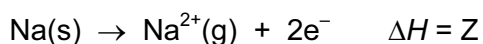
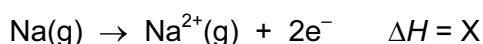
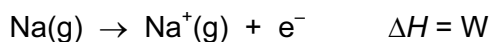
For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

- 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.



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 = ${}^1_1\text{H}$; D = ${}^2_1\text{H}$; O = ${}^{16}_8\text{O}$]

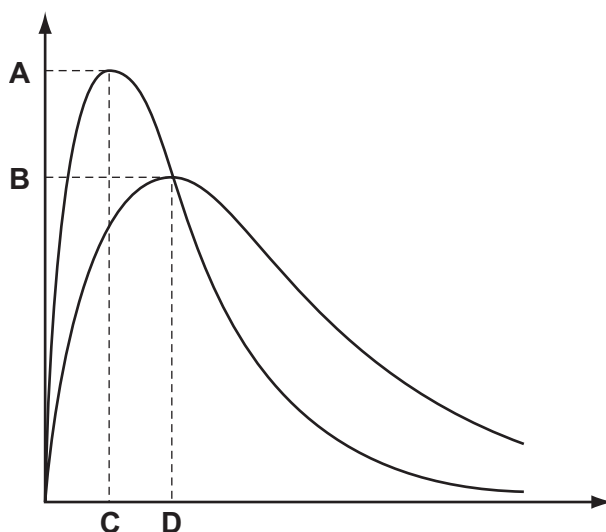
- A** D[–]
- B** H₃O⁺
- C** OD[–]
- D** OH[–]

- 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

- 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?

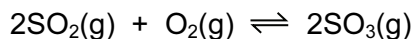


- 6 Which pair of elements has chemical bonds of the same type between their atoms in the solid state?
- A aluminium and phosphorus
B chlorine and argon
C magnesium and silicon
D sulfur and chlorine
- 7 Ethanol has a boiling point of 78°C . At 101 kPa and 79°C ethanol vapour does not perfectly obey the 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.

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



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 $\text{C}-\text{C}-\text{O}$. 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 $-104.5\text{ kJ mol}^{-1}$
 - 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 $\text{H}-\text{H}$ bond
 - B half the bond energy of a $\text{H}-\text{H}$ bond
 - C minus half the bond energy of a $\text{H}-\text{H}$ bond
 - D minus the bond energy of a $\text{H}-\text{H}$ bond

- 12 Propanone has molecular formula $\text{C}_3\text{H}_6\text{O}$.

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 $-2644 \text{ kJ mol}^{-1}$
 B $-2294 \text{ kJ mol}^{-1}$
 C $-1786 \text{ kJ mol}^{-1}$
 D -426 kJ mol^{-1}

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

Magnesium nitrate, $\text{Mg}(\text{NO}_3)_2$, 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?

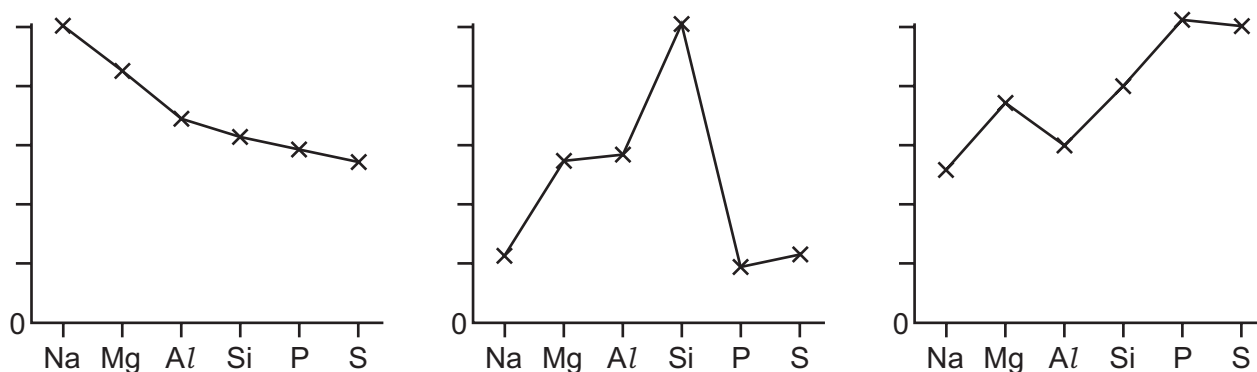
	solubility of calcium hydroxide	solubility of barium hydroxide	thermal stability of calcium carbonate	thermal stability of barium carbonate
A	higher	lower	higher	lower
B	higher	lower	lower	higher
C	lower	higher	higher	lower
D	lower	higher	lower	higher

- 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 $\text{I}_2(\text{s})$ B $\text{I}_2(\text{l})$ C $\text{I}_2(\text{g})$ D $\text{I}(\text{g})$

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



Which physical property is **not** illustrated?

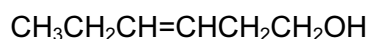
- A atomic radius
 - B electrical conductivity
 - C first ionisation energy
 - D melting point
- 17 Which statement about ammonia is completely correct?
- A Ammonia acts as a nucleophile by accepting a pair of electrons when it reacts with bromoethane.
 - B Ammonia can form a co-ordinate bond with a 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.

- 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.

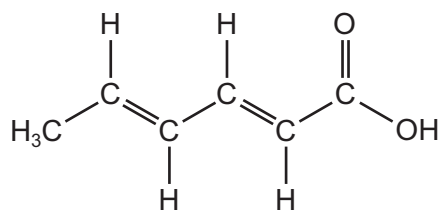


P

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

- A $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}(\text{OH})\text{CH}_2\text{CH}_2\text{OH}$
- B $\text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}_2\text{CO}_2\text{H}$
- C $\text{CH}_3\text{CH}_2\text{CHO}$ and $\text{OCHCH}_2\text{CH}_2\text{OH}$
- D $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$ and $\text{HO}_2\text{CCH}_2\text{CO}_2\text{H}$

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



sorbic acid

Sorbic acid will react with

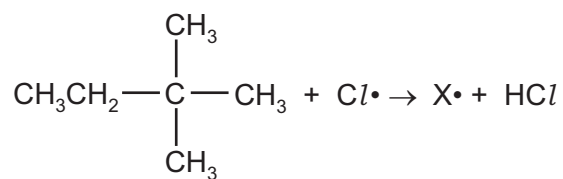
- hydrogen in the presence of a nickel catalyst,
- bromine in an organic solvent.

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 $\text{X}\bullet$ is formed.



How many different forms of $\text{X}\bullet$ are possible?

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

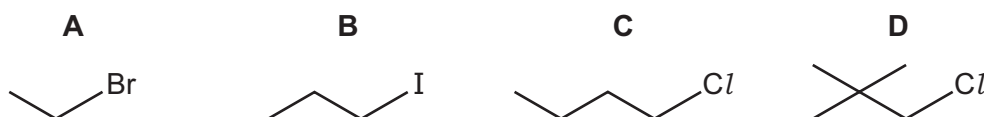
- 23** Aqueous sodium hydroxide reacts with 2-bromo-2-methylpropane to give 2-methylpropan-2-ol.

The reaction proceeds by an S_N1 mechanism.

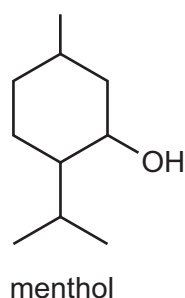
How should the first step in the mechanism be described?

- A** by a curly arrow from a lone pair on the OH^- ion to the $\text{C}^{\delta+}$ 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**?

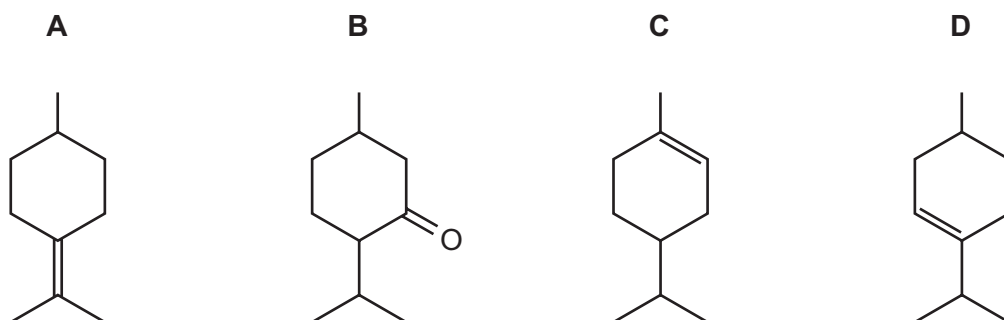


- 25** The compound shown is menthol, a naturally-occurring alcohol found in peppermint oil.



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**?



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

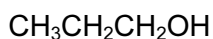
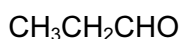
Which volume of oxygen measured at room temperature and pressure is needed for complete combustion of 0.1 mol of propan-1-ol?

- A 10.8 dm³ B 12.0 dm³ C 21.6 dm³ D 24.0 dm³

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 K₂Cr₂O₇?



- 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).

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

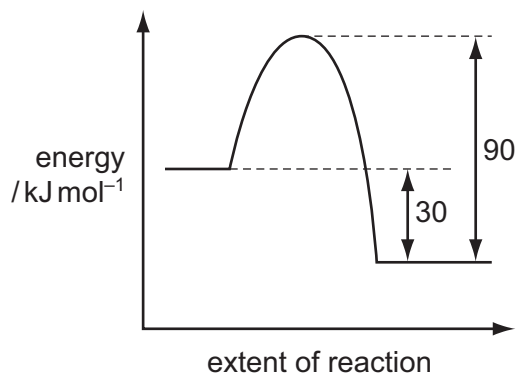
No other combination of statements is used as a correct response.

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 $+90 \text{ kJ mol}^{-1}$.
- 2** The forward reaction is exothermic.
- 3** The enthalpy change for the forward reaction is -30 kJ mol^{-1} .

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?

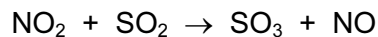
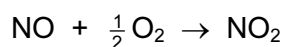
- 1** Adding **W** to water has less effect on pH than adding **Y**.
- 2** Adding **Z** to soil increases the pH of the soil.
- 3** The metallic element in **Y** reacts with cold water more quickly than the metallic element in **W**.

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

- 1** thermal stability
- 2** bond length
- 3** ease of oxidation

- 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.



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–Cl 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.

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 $\text{CaC}_4\text{H}_6\text{O}_4$.

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

- 1** ethanoic acid
- 2** butanedioic acid
- 3** methylpropanedioic acid

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

CHEMISTRY

Paper 1 Multiple Choice

9701/13

May/June 2013

1 hour

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



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.

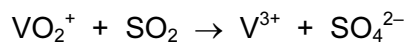
This document consists of **14** printed pages and **2** blank pages.



Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

- 1 In the redox reaction shown, how do the oxidation states of vanadium and sulfur change?



	vanadium		sulfur	
	from	to	from	to
A	+1	+3	0	−2
B	+1	+3	+4	+6
C	+5	+3	0	−2
D	+5	+3	+4	+6

- 2 Use of the Data Booklet is relevant to this question.

In which species are the numbers of protons, neutrons and electrons **all** different?

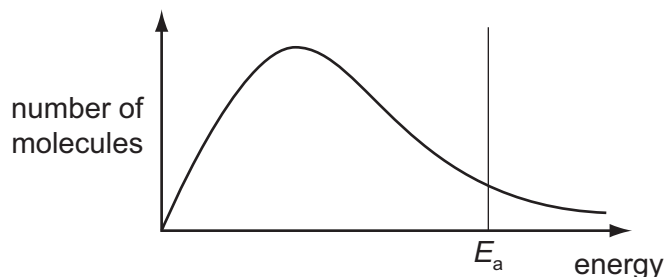


- 3 The first six ionisation energies of four elements are given.

Which element is most likely to be in Group IV of the Periodic Table?

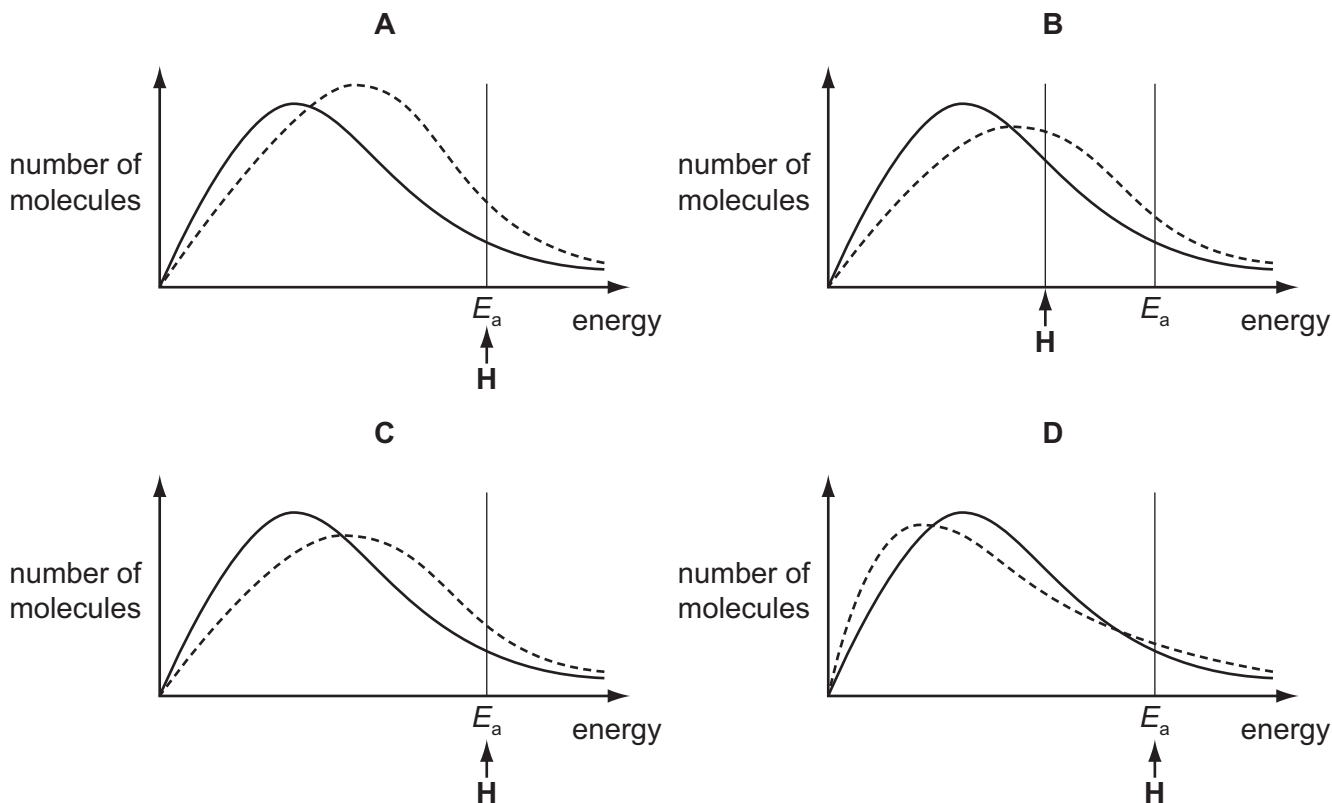
	ionisation energy / kJ mol^{-1}					
	1st	2nd	3rd	4th	5th	6th
A	494	4 560	6 940	9 540	13 400	16 600
B	736	1 450	7 740	10 500	13 600	18 000
C	1 090	2 350	4 610	6 220	37 800	47 000
D	1 400	2 860	4 590	7 480	9 400	53 200

- 4 The diagram represents, for a given temperature, the Boltzmann distribution of the kinetic energies of the molecules in a mixture of two gases that will react together. The activation energy for the reaction, E_a , is marked.



The dotted curves below show the Boltzmann distribution for the same reaction at a higher temperature. On these diagrams, **H** represents the activation energy at the higher temperature.

Which diagram is correct?



- 5 Crotonaldehyde, $\text{CH}_3\text{CH}=\text{CHCHO}$, can be obtained by oxidising butadiene, $\text{CH}_2=\text{CHCH}=\text{CH}_2$, using air or oxygen. One method is to pass a mixture of butadiene and oxygen through a hot aqueous solution of palladium(II) ions, $\text{Pd}^{2+}(\text{aq})$, which catalyse the reaction.

Which statement is **not** correct about the action of the $\text{Pd}^{2+}(\text{aq})$ ions?

- A Changing the concentration of the $\text{Pd}^{2+}(\text{aq})$ will have an effect on the rate of the reaction.
- B $\text{Pd}^{2+}(\text{aq})$ increases the energy of the reacting molecules.
- C $\text{Pd}^{2+}(\text{aq})$ lowers the activation energy for the reaction.
- D $\text{Pd}^{2+}(\text{aq})$ provides a different route for the reaction.

6 Which **least** resembles an ideal gas at room temperature and pressure?

- A ammonia
- B helium
- C hydrogen
- D methane

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

When 0.15 g of an organic compound is vaporised, it occupies a volume of 65.0 cm^3 at 405 K and $1.00 \times 10^5 \text{ Nm}^{-2}$.

Using the expression $pV = nRT$, which of the following expressions should be used to calculate the relative molecular mass, M_r , of the compound?

A
$$\frac{0.15 \times 65 \times 10^{-6} \times 1 \times 10^5}{8.31 \times 405}$$

B
$$\frac{0.15 \times 8.31 \times 405}{1 \times 10^5 \times 65 \times 10^{-3}}$$

C
$$\frac{0.15 \times 65 \times 10^{-3} \times 1 \times 10^5}{8.31 \times 405}$$

D
$$\frac{0.15 \times 8.31 \times 405}{1 \times 10^5 \times 65 \times 10^{-6}}$$

8 Which compound is the only gas at room temperature and pressure?

- A $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$ $M_r = 59.0$
- B $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ $M_r = 60.0$
- C $\text{CH}_2\text{OHCH}_2\text{OH}$ $M_r = 62.0$
- D $\text{CH}_3\text{CH}_2\text{Cl}$ $M_r = 64.5$

9 Which formula represents the empirical formula of a compound?

- A CH_4O
- B C_2H_4
- C C_6H_{12}
- D H_2O_2

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

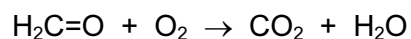
A washing powder contains sodium hydrogencarbonate, NaHCO_3 , as one of the ingredients. In a titration, a solution containing 1.00 g of washing powder requires 7.15 cm^3 of $0.100 \text{ mol dm}^{-3}$ sulfuric acid for complete reaction. The sodium hydrogencarbonate is the only ingredient that reacts with the acid.

What is the percentage by mass of sodium hydrogencarbonate in the washing powder?

- A 3.0
- B 6.0
- C 12.0
- D 24.0

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

This question should be answered using bond enthalpy data. The equation for the complete combustion of methanal is given below.



What is the enthalpy change of combustion of methanal?

- A** +416 kJ mol⁻¹
B +396 kJ mol⁻¹
C -344 kJ mol⁻¹
D -690 kJ mol⁻¹

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

Anhydrous magnesium nitrate, Mg(NO₃)₂, will decompose when heated, giving a white solid and a mixture of two gases **X** and **Y**.

Y is oxygen.

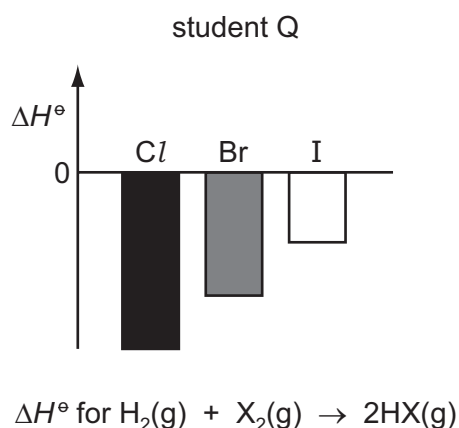
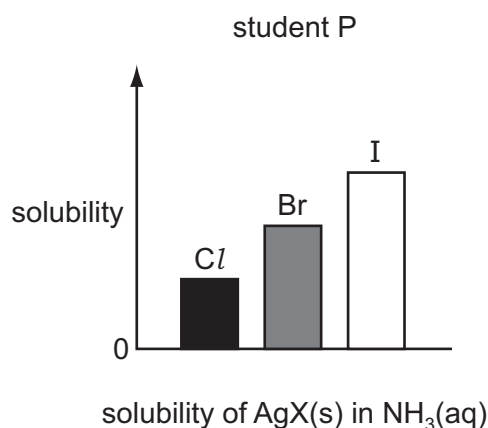
What is the ratio $\frac{\text{mass of X released}}{\text{mass of Y released}}$?

- A** $\frac{1}{0.174}$ **B** $\frac{1}{0.267}$ **C** $\frac{1}{0.348}$ **D** $\frac{1}{3.43}$

13 In which row of the table are all statements comparing magnesium and barium correct?

	fourth ionisation energy of magnesium	fourth ionisation energy of barium	reaction of magnesium with cold water	reaction of barium with cold water
A	higher	lower	faster	slower
B	higher	lower	slower	faster
C	lower	higher	faster	slower
D	lower	higher	slower	faster

- 14 Two students, P and Q, were asked to draw bar charts to represent how some properties of the halogens and their compounds differ in magnitude. Their diagrams are shown.



Which of the student's diagrams are correct?

- A** both P and Q
B P only
C Q only
D neither P nor Q
- 15 When iodine is heated, a vapour is produced.

Which row of the table correctly identifies the species in the vapour and its colour?

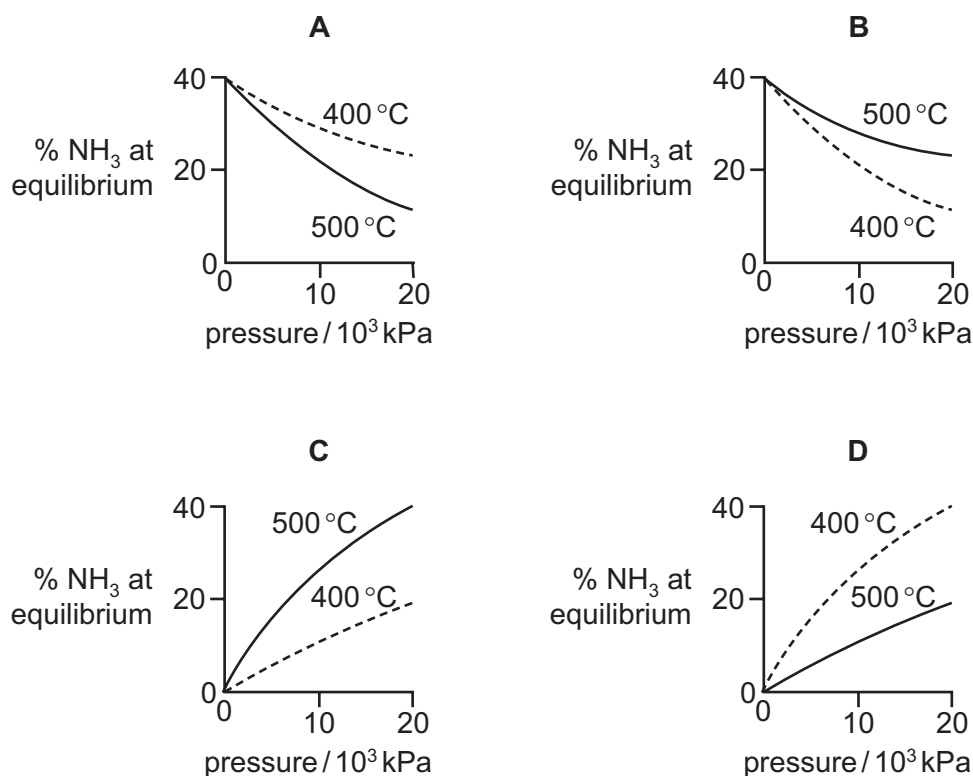
	species	colour
A	I(g)	brown
B	I(g)	purple
C	$\text{I}_2(\text{g})$	brown
D	$\text{I}_2(\text{g})$	purple

- 16 How do the strengths of the covalent bonds within molecules, and the van der Waals' forces between molecules, vary going down Group VII from chlorine to bromine to iodine?

	strength of covalent bonds	strength of van der Waals' forces
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

- 17 Graphs can be drawn to show the percentage of ammonia at equilibrium when nitrogen and hydrogen are mixed at different temperatures and pressures.

Which diagram correctly represents these two graphs?



- 18 In a famous experiment, Wöhler heated 'inorganic' ammonium cyanate in the absence of air. The only product of the reaction was 'organic' urea, $\text{CO}(\text{NH}_2)_2$. No other products were formed in the reaction.

What is the formula of the cyanate ion present in ammonium cyanate?

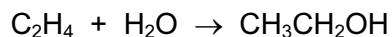
- A CNO^- B CNO^{2-} C CO^- D NO^-

- 19 Transition elements and their compounds are important as catalysts.

In which process is a transition element compound used, rather than the element itself?

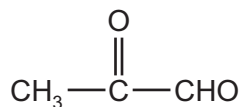
- A catalytic converters
B Contact process
C Haber process
D hydrogenation of oils

- 20 Ethene reacts with steam in the presence of sulfuric acid.



What type of reaction is this?

- A acid/base
 - B addition
 - C hydrolysis
 - D substitution
- 21 What is true of every nucleophile?
- A It attacks a double bond.
 - B It has a lone pair of electrons.
 - C It is a single atom.
 - D It is negatively charged.
- 22 How many isomers, including structural and stereoisomers, with the formula C_4H_8 have structures that involve π bonding?
- A 1 B 2 C 3 D 4
- 23 Burnt sugar has a characteristic smell caused partly by the following compound.



This compound contains two functional groups.

Which reagent will react with **both** functional groups?

- A acidified potassium dichromate(VI)
- B Fehling's solution
- C hydrogen cyanide
- D sodium hydroxide

24 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

25 A carbanion is an organic ion in which a carbon atom has a negative charge. A carbocation is an organic ion in which a carbon atom has a positive charge.

What is involved in the mechanism of the reaction between aqueous sodium hydroxide and 2-bromo-2-methylbutane?

- A** heterolytic bond fission followed by an attack by an electrophile on a carbanion
- B** heterolytic bond fission followed by an attack by a nucleophile on a carbocation
- C** homolytic bond fission followed by an attack by an electrophile on a carbanion
- D** homolytic bond fission followed by an attack by a nucleophile on a carbocation

26 Which compound gives an organic product with a lower boiling point when it is heated under reflux with an excess of acidified potassium dichromate(VI)?

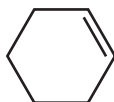
- A** 2-methylbutan-1-ol
- B** 2-methylbutan-2-ol
- C** pentan-1-ol
- D** pentan-2-ol

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

Which volume of oxygen, at room temperature and pressure, is needed for complete combustion of 0.1 mol of ethanol?

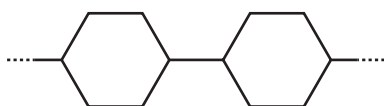
- A** 7.2 dm³ **B** 8.4 dm³ **C** 14.4 dm³ **D** 16.8 dm³

- 28 Cyclohexene, shown below, can form an addition polymer.

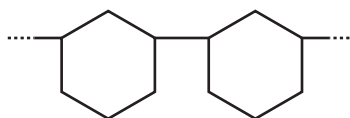


Which structure represents a section of the polymer including two cyclohexene residues?

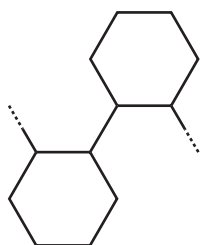
A



B



C



D



- 29 How many isomeric esters, including structural isomers and stereoisomers, can be made with the molecular formula $C_5H_{10}O_2$, if methanoic acid is one of the two reactants used?

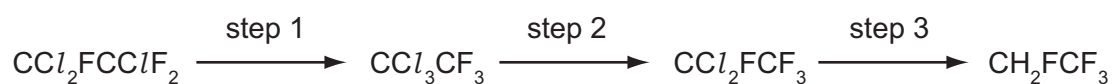
A 2

B 3

C 4

D 5

- 30 CCl_2FCClF_2 can be converted into CH_2FCF_3 by the following route.



What type of reaction is step 1?

- A** addition
B elimination
C isomerisation
D oxidation

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

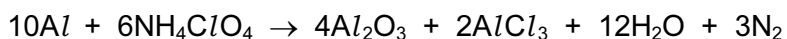
Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

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** A space shuttle's upward thrust came from the following reaction between aluminium and ammonium perchlorate.



Which statements about this reaction are correct?

- 1** Aluminium is oxidised.
- 2** Chlorine is reduced.
- 3** Nitrogen is oxidised.

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

Which statements are correct when referring to the atoms ^{23}Na and ^{24}Mg ?

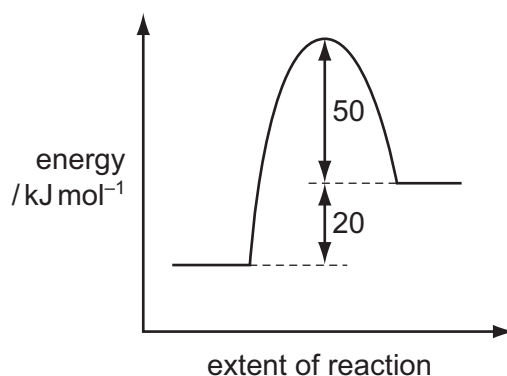
- 1** They have the same number of full electron orbitals.
- 2** They have the same number of neutrons.
- 3** They are both reducing agents.

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.

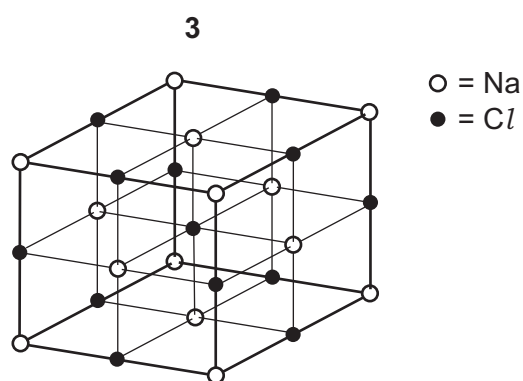
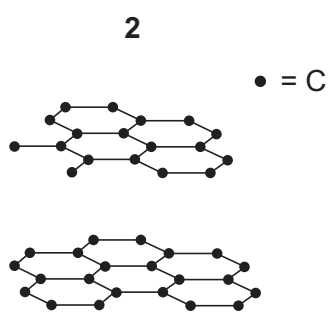
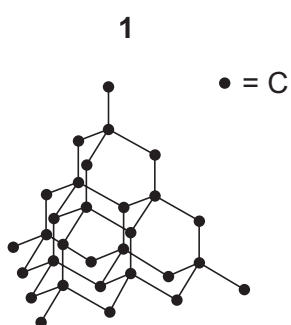
33 The reaction pathway for a reversible reaction is shown below.



Which statements are correct?

- 1** The enthalpy change for the backward reaction is -20 kJ mol^{-1} .
- 2** The forward reaction is endothermic.
- 3** The activation energy for the forward reaction is $+70 \text{ kJ mol}^{-1}$.

34 Which diagrams represent part of a giant molecular structure?



- 35 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 More acid is neutralised by 2.0 g of **X** than by 2.0 g of **W**.
- 2 The M_r of **X** is greater than the M_r of **Y** by 44.0.
- 3 The metallic element in **Y** reacts with cold water more quickly than the metallic element in **W**.

- 36 Element **J** is a solid. It occurs as a contaminant of fossil fuels.

Its oxide **K** is formed in car engines.

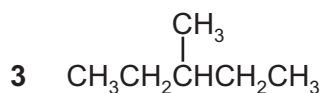
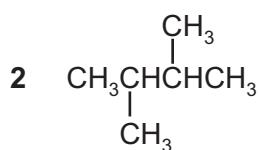
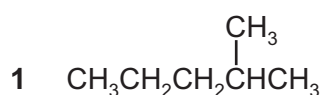
In the atmosphere, **K** can be further oxidised to **L**.

Which statements about **J**, **K** and **L** are correct?

- 1 Atoms of **J** have paired p electrons.
- 2 The atmospheric oxidation of **K** to **L** is a catalysed reaction.
- 3 With water, **L** forms a strong acid.

- 37 During the bromination of methane, the free radical $\text{CH}_3\bullet$ is generated. A possible terminating step of this reaction is the formation of C_2H_6 by the combination of two free radicals.

What could be produced in a terminating step during the bromination of **propane**?



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 Fabrics for use in aircraft seating are treated with a coating containing a halogenoalkane.

Why is this coating used?

- 1** The treated fabric burns less easily, improving safety.
- 2** The treated fabric forms hydrogen bonds to water more readily, so it is easier to wash.
- 3** The halogenoalkane undergoes addition polymerisation, stiffening the fabric.

39 A liquid **X** is known to be either a single organic compound or a mixture of organic compounds. When treated with sodium, **X** gives off hydrogen gas.

When treated with 2,4-dinitrophenylhydrazine reagent, **X** gives orange crystals.

Which deductions about **X** can definitely be made?

- 1** At least one component of **X** is a carbonyl compound.
- 2** Only one of the components of **X** is a carbonyl compound.
- 3** At least one component of **X** is an alcohol.

40 Ethanoic acid, $\text{CH}_3\text{CO}_2\text{H}$, is an important chemical which is used in the industrial manufacture of rayon and aspirin.

Which processes can be used to make ethanoic acid?

- 1** hydrolysis of ethanenitrile
- 2** oxidation of ethanol
- 3** oxidation of ethanal

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