Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/13**

Paper 1 Multiple Choice **October/November 2016**

1 hour

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

6322213597 5

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Electronic calculators may be used.

This document consists of **16** printed pages.

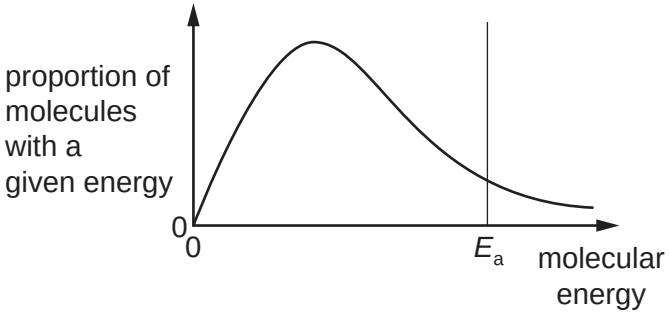
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Section A

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

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

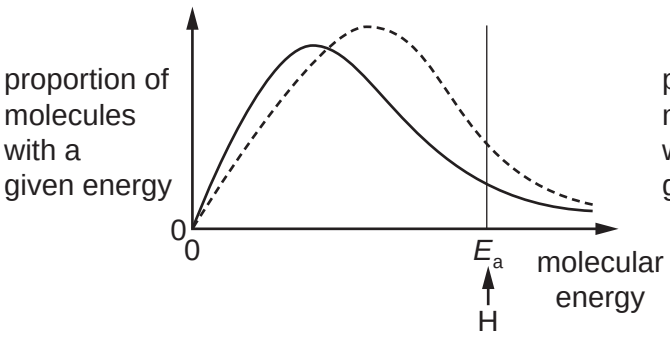
1 The diagram represents, for a given temperature, the Boltzmann distribution of the kinetic energies of the molecules in a mixture of two gases that react together. The activation energy for the reaction, E_a, is marked.



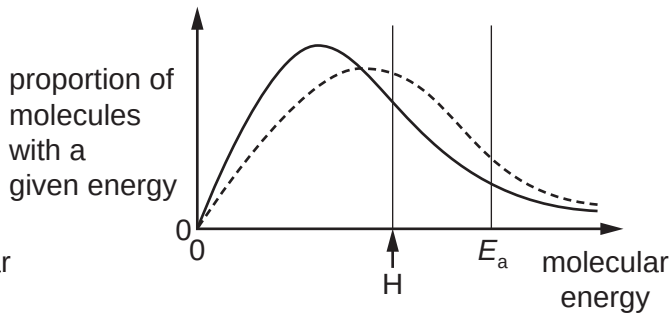
The dotted curves below show the Boltzmann distribution for the same reaction at a higher temperature. On these diagrams, H represents the activation energy at the higher temperature.

Which diagram is correct?

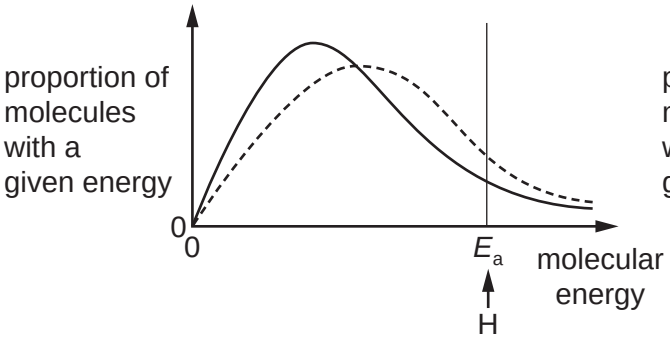
A



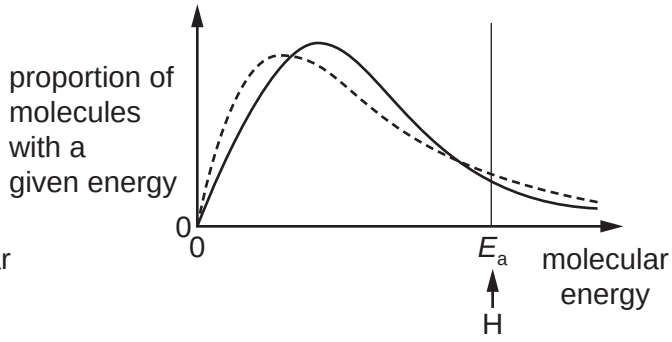
B



C



D



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2 In the ideal gas equation, $pV = nRT$, what are the units of n and T?

	n	T
A	no units	°C
B	no units	K
C	mol	°C
D	mol	K

3 The reaction between acidified dichromate(VI) ions, $Cr_2O_7^{2-}$, and aqueous Fe^{2+} ions results in the dichromate(VI) ions being reduced to Cr^{3+} ions.

What is the correct equation for this reaction?

A $Cr_2O_7^{2-} + Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + Fe^{3+} + 7H_2O$

B $Cr_2O_7^{2-} + 2Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 2Fe^{3+} + 7H_2O$

C $Cr_2O_7^{2-} + 3Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 3Fe^{3+} + 7H_2O$

D $Cr_2O_7^{2-} + 6Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$

4 Sodium azide, NaN_3 is an explosive used to inflate airbags in cars when they crash. It consists of positive sodium ions and negative azide ions.

What are the numbers of electrons in the sodium ion and the azide ion?

	sodium ion	azide ion
A	10	20
B	10	22
C	12	20
D	12	22

5 The ^{68}Ge isotope is medically useful because it undergoes a natural radioactive process to give an isotope of a different element, ^{68}X, which can be used to detect tumours. This transformation of ^{68}Ge occurs when an electron enters the nucleus and changes a proton into a neutron.

Which statement about the composition of an atom of ^{68}X is correct?

A It has 4 electrons in its outer p orbitals.

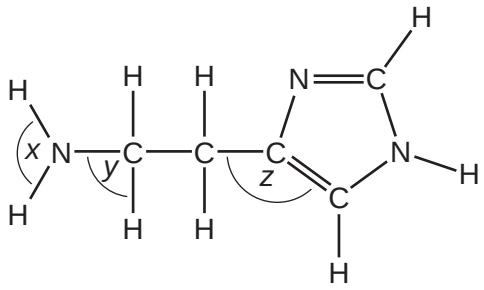
B It has 13 electrons in its outer shell.

C It has 37 neutrons.

D Its proton number is 32.

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6 Histamine is produced in the body to help fight infection. Its shape allows it to fit into receptors which expand blood vessels.



histamine

What are the bond angles *x*, *y* and *z* in histamine, from the smallest to the largest?

	smallest bond angle → largest bond angle		
A	*x*	*y*	*z*
B	*y*	*x*	*z*
C	*y*	*z*	*x*
D	*z*	*y*	*x*

7 The approximate percentage composition of the atmospheres on four different planets is given in the table below.

Which mixture of gases has the greatest density?

	planet	major gases / % by number of molecules		
		H_2	He	CH_4
A	Jupiter	89.8	10.2	0.0
B	Neptune	80.0	19.0	1.0
C	Saturn	96.3	3.3	0.4
D	Uranus	82.5	15.2	2.3

8 An important reaction in the manufacture of nitric acid is the catalytic oxidation of ammonia.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

For every mole of O_2 that reacts in this way, 181.8 kJ of energy are released.

A factory makes 2.50×10^5 mol of NO every day.

How much energy, in kJ, is released every day?

A 3.64×10^7 **B** 4.55×10^7 **C** 5.68×10^7 **D** 2.27×10^8

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9 Sodium chromate(VI), Na_2CrO_4, is manufactured by heating chromite, $FeCr_2O_4$, with sodium carbonate in an oxidising atmosphere. Chromite contains $Cr_2O_4^{2-}$ ions.

$$2FeCr_2O_4 + 4Na_2CO_3 + 3\tfrac{1}{2}O_2 \rightarrow 4Na_2CrO_4 + Fe_2O_3 + 4CO_2$$

What happens in this reaction?

A Chromium and iron are the only elements oxidised.

B Chromium, iron and carbon are oxidised.

C Only chromium is oxidised.

D Only iron is oxidised.

10 The table shows the partial pressures in an equilibrium mixture formed by the Haber process.

substance	partial pressure / kPa
nitrogen	7000
hydrogen	8000
ammonia	4000

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

What is the numerical value of the equilibrium constant, K_p, for this reaction?

A 4.46×10^{-9}

B 4.76×10^{-5}

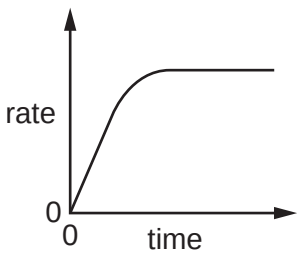
C 7.14×10^{-5}

D 2.24×10^{8}

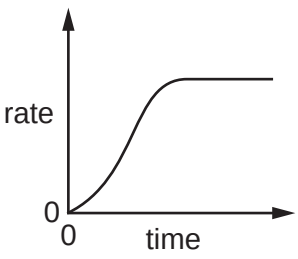
11 An autocatalytic reaction is a reaction in which one of the products catalyses the reaction.

Which curve would be obtained if the rate of an autocatalytic reaction is plotted against time?

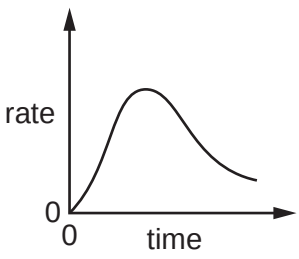
A



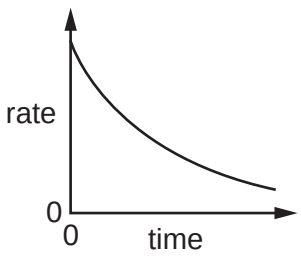
B



C



D



12 1.15 g of a metallic element needs 300 cm^3 of oxygen for complete reaction, at 298 K and 1 atm pressure, to form an oxide which contains O^{2-} ions.

What could be the identity of this metallic element?

A calcium

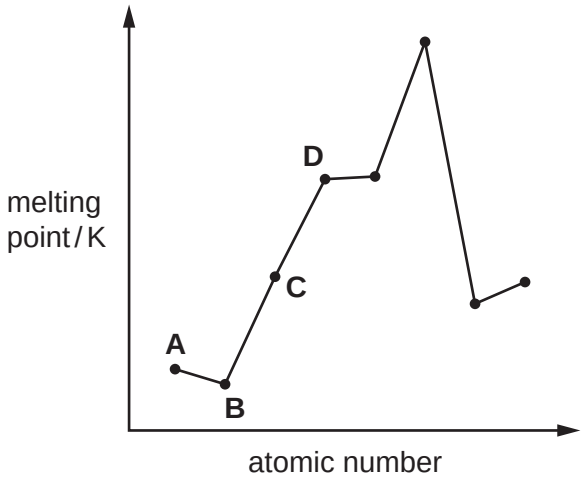
B magnesium

C potassium

D sodium

13 The diagram shows the melting points of eight elements with consecutive atomic numbers.

Which element could be sodium?



14 The properties of chlorine, bromine and their compounds are compared.

Which property is **smaller** for chlorine than for bromine?

A bond strength of the hydrogen-halide bond

B first ionisation energy

C solubility of the silver halide in NH_3(aq)

D strength of the van der Waals' forces between molecules of the element

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15 At 550 °C nitrogen dioxide reacts with unburnt hydrocarbon fragments such as $CH_3\bullet$ in the catalytic converter of a motor vehicle.

$$4CH_3\bullet + 7NO_2 \rightarrow 3\tfrac{1}{2}N_2 + 4CO_2 + 6H_2O$$

The following table lists types of energy change for this reaction and possible reasons for them.

Which row gives the energy change for this reaction and the reason for it?

	energy change of reaction	reason why the reaction is endothermic or exothermic
A	endothermic	chemical energy is converted to heat energy
B	endothermic	the N≡N bond energy is very high
C	exothermic	CO_2 and H_2O have large negative $\Delta H_f^{\ominus}$ values
D	exothermic	double bonds are broken in NO_2

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

When a sample of **T** was mixed with aqueous sodium hydroxide and heated, a pungent smelling gas was produced which turned damp red litmus paper blue. This same gas produced dense white smoke with hydrogen chloride gas.

Further testing of a solution of **T** with barium chloride solution produced a dense white precipitate which did not dissolve when dilute hydrochloric acid was added to the mixture.

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

A ammonium carbonate

B ammonium sulfate

C sodium carbonate

D sodium sulfate

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18 Which row of the table gives correct comparisons between the solubilities of calcium and barium hydroxide and the thermal stabilities of calcium and barium carbonate?

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

19 X, Y and Z represent different halogens. The table shows the results of nine experiments in which aqueous solutions of X_2, Y_2 and Z_2 were separately added to separate aqueous solutions containing X^-, Y^- and Z^- ions.

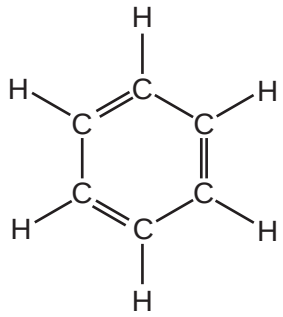
	$X^-(aq)$	$Y^-(aq)$	$Z^-(aq)$
$X_2(aq)$	no reaction	no reaction	no reaction
$Y_2(aq)$	X_2 formed	no reaction	Z_2 formed
$Z_2(aq)$	X_2 formed	no reaction	no reaction

Which row of the following table contains the ions X^-, Y^- and Z^- in order of their **decreasing** strength as reducing agents?

	strongest ⟶		weakest
A	X^-	Y^-	Z^-
B	X^-	Z^-	Y^-
C	Y^-	Z^-	X^-
D	Z^-	X^-	Y^-

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20 In 1865 Kekulé suggested a ring structure for benzene, C_6H_6, in which a hydrogen atom is attached to each carbon atom.

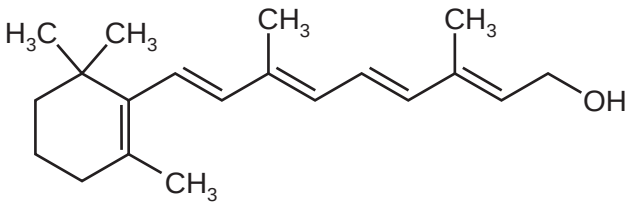


Kekulé structure

In this structure all of the bonds remain in the places shown. Assuming this is the structure of benzene, how many isomers of dichlorobenzene, $C_6H_4Cl_2$, would exist?

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

21 The diagram shows the structure of vitamin A.



vitamin A

How many chiral centres are present in one vitamin A molecule?

A 0 **B** 1 **C** 2 **D** 3

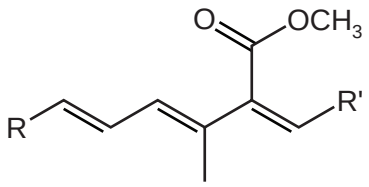
22 PVC is difficult to dispose of. Two possible methods are burying it in landfill sites and disposal by combustion.

Which row of the table is correct?

	rate of biodegradation of PVC in landfill sites	gases produced when PVC combusts
A	fast	CO_2, H_2O, HCl
B	fast	CO_2, H_2O, Cl_2
C	slow	CO_2, H_2O, Cl_2
D	slow	CO_2, H_2O, HCl

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

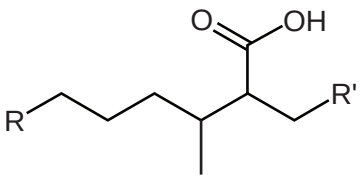


strobilurin

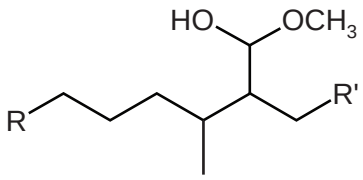
In this reaction, strobilurin is warmed with aqueous sulfuric acid producing compound X. Compound X is then treated with hydrogen in the presence of a nickel catalyst producing compound Y.

What could be the structure of compound Y?

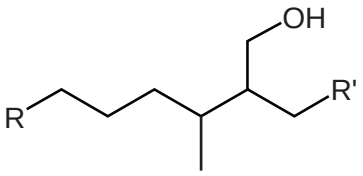
A



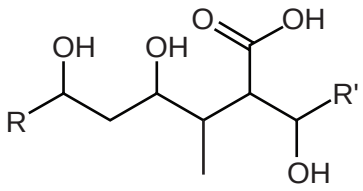
B



C



D



24 Chloroethane can be used to make sodium propanoate.

chloroethane $\rightarrow$ Q $\rightarrow$ 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 in water

D potassium cyanide in ethanol

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25 X, Y and Z are three isomeric alcohols.

X $CH_3CH_2CH_2CH_2CH_2OH$

Y $CH_3CH_2CH(OH)CH_2CH_3$

Z $(CH_3)_2C(OH)CH_2CH_3$

Two or more of these alcohols react with mild oxidising agents.

One of these alcohols, when dehydrated, will give a pair of cis-trans isomers with molecular formula C_5H_{10}.

Which row is correct?

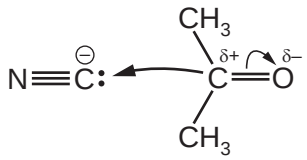
	reacts with mild oxidising reagents	gives cis-trans isomers
A	X, Y and Z	Y only
B	X, Y and Z	Z only
C	X and Y only	Y only
D	X and Y only	Z only

26 Propanone reacts with an aqueous mixture of HCN and NaCN by a nucleophilic addition mechanism.

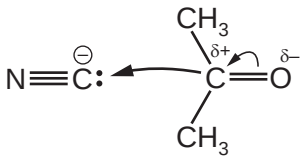
The first stage of the mechanism involves attack by cyanide ions.

Which diagram correctly represents this?

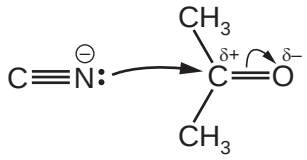
A



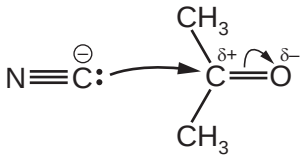
B



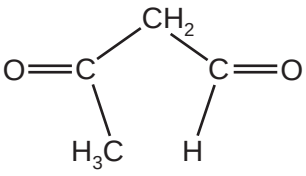
C



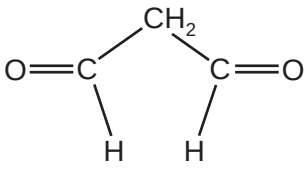
D



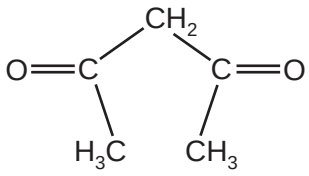
27 P, Q and R are carbonyl compounds.



P



Q



R

Fehling's solution can be used to help identify these compounds.

Which compounds form a red-brown precipitate on warming with Fehling's solution?

A P, Q and R **B** P and Q only **C** P only **D** Q only

28 Which reaction would **not** give ethanoic acid?

A heating ethanenitrile under reflux with dilute sodium hydroxide

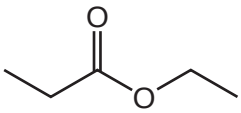
B heating ethanenitrile under reflux with dilute sulfuric acid

C heating ethanal under reflux with acidified sodium dichromate(VI)

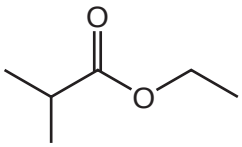
D heating ethanol under reflux with acidified sodium dichromate(VI)

29 Which formula represents an ester that will form propanoic acid on hydrolysis with dilute sulfuric acid?

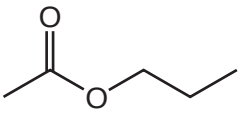
A



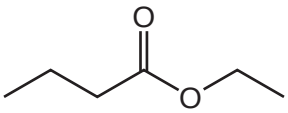
B



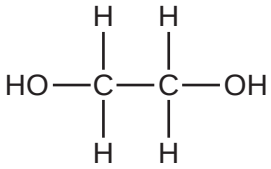
C



D



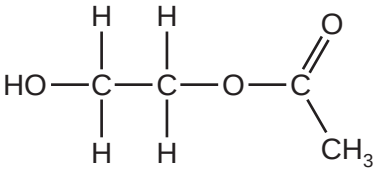
30 A solvent, **X**, used in printing inks has a molecular formula $C_6H_{10}O_4$. It may be made by reacting ethane-1,2-diol with ethanoic acid in the presence of an acid catalyst.



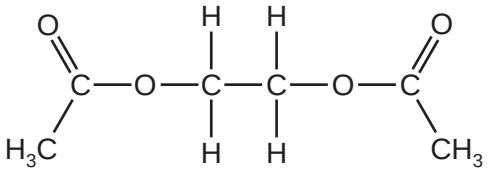
ethane-1,2-diol

What is the structure of solvent **X**?

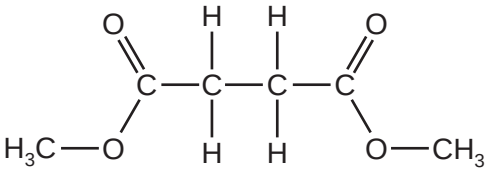
A



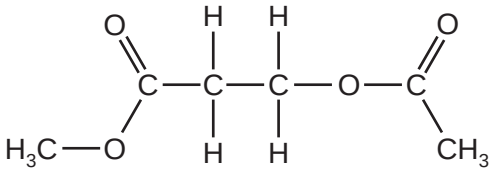
B



C



D



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 sample of boron contains aluminium as the only impurity. A mass spectrum of the mixture shows three lines corresponding to three ions, X^+, Y^+ and Z^+.

ion	X^+	Y^+	Z^+
m/e	10	11	27
percentage abundance	15.52	74.48	10.00

Which statements are correct?

1 There are more electrons in Z^+ than in X^+.

2 The A_r of boron in the sample is 10.83 to four significant figures.

3 There are more protons in Y^+ than in X^+.

32 Which elements can form π bonds in their compounds?

1 carbon

2 oxygen

3 nitrogen

33 For which enthalpy changes is the value of ΔH always negative?

1 combustion

2 hydration

3 solution

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34 In the manufacture of sulfuric acid, the following exothermic reaction occurs.

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

Which changes will move the position of the equilibrium to the right?

1 increasing the pressure

2 increasing the temperature

3 using twice as much catalyst

35 Water is added to anhydrous aluminium chloride to make a $0.1\,mol\,dm^{-3}$ solution.

Which observations are correct?

1 The reaction is endothermic.

2 The solution is acidic.

3 The solution contains the ion $[Al(H_2O)_6]^{3+}$.

36 Catalytic converters are used to modify exhaust emissions from motor vehicles.

Which reactions occur in catalytic converters?

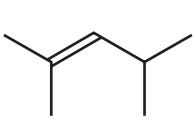
1 $C_8H_{18} + 12\frac{1}{2}O_2 \rightarrow 8CO_2 + 9H_2O$

2 $2NO + 2CO \rightarrow N_2 + 2CO_2$

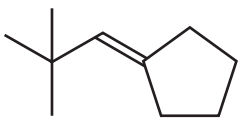
3 $NO + SO_3 \rightarrow NO_2 + SO_2$

37 Which compounds would produce a carboxylic acid and a ketone when treated with hot, concentrated, acidified $KMnO_4$?

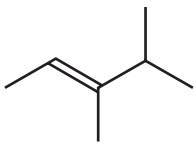
1



2



3



38 Bromoethane reacts with NaOH in different ways depending on the solvent used.

Which statements about these reactions are correct?

	solvent used	main organic product
1	water	ethane-1,2-diol
2	ethanol	ethene
3	water	ethanol

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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.

39 Several structural isomers of $C_3H_6O_3$ are listed below.

$HOCH_2COCH_2OH$

$HOCH_2CH(OH)CHO$

$HOCH_2CH_2CO_2H$

$CH_3CH(OH)CO_2H$

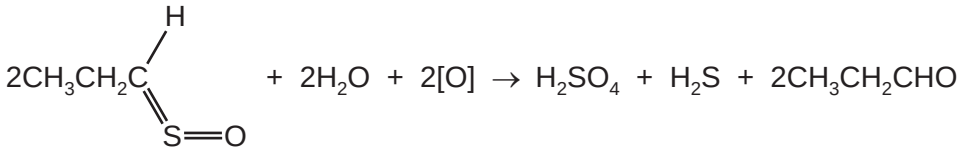
Which statements about these structural isomers are correct?

1 One mole of each reacts with two moles of sodium.

2 Only one of the isomers contains a tertiary alcohol group.

3 They all contain a primary alcohol group.

40 When onions are peeled in air, the reaction shown is thought to occur.



Which tests would give a positive reaction with the organic product?

1 warming with Tollens' reagent

2 warming with acidified potassium manganate(VII)

3 warming with alkaline aqueous iodine

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