Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/13**

Paper 1 Multiple Choice **October/November 2019**

1 hour

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

9112073881

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.

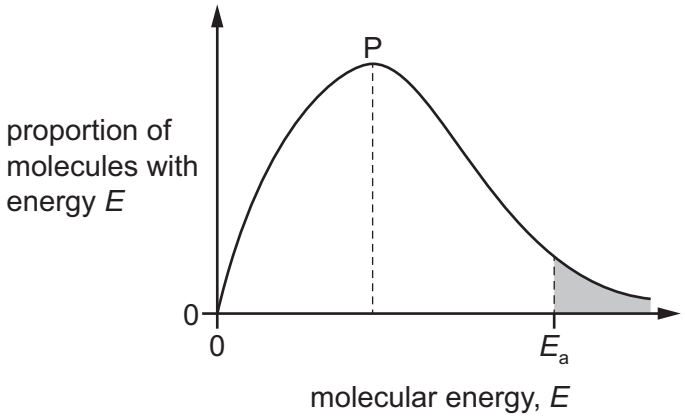
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Section A

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 shows the Boltzmann distribution of energies in a gas. The gas undergoes a reaction with an activation energy, E_a. The peak of the distribution is labelled P.



If the same reaction is carried out in the presence of a catalyst, which statement is correct?

A The peak P is at a lower height and the position of E_a moves to the left.

B The peak P is at a lower height and the position of E_a moves to the right.

C The peak P remains at the same height and the position of E_a moves to the left.

D The peak P remains at the same height and the position of E_a moves to the right.

2 Diamond is a pure form of carbon. The mass of a diamond can be measured in carats. One carat is 0.200 g of carbon.

Which expression gives the number of carats that contain 6.02×10^{23} carbon atoms?

A 0.200×12.0

B $\dfrac{0.200}{12.0}$

C $\dfrac{12.0}{0.200}$

D $\dfrac{0.200}{6.02 \times 10^{23}} \times 12.0$

3 Which molecule or ion contains the smallest bond angle?

A C_2H_4 **B** CH_3COCH_3 **C** NH_4^+ **D** NH_3

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4 Four compounds are shown.

C_2H_4 C_2H_5OH CH_3CHO CH_3CO_2H

How many of these compounds have an odd number of σ bonds?

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

5 Ethanal, CH_3CHO, ethanol, C_2H_5OH, and methoxymethane, CH_3OCH_3, are three organic compounds.

Which compound has the highest boiling point and what is the interaction that causes this boiling point to be the highest?

	highest boiling point	interaction
A	methoxymethane	permanent dipole-dipole forces
B	ethanal	hydrogen bonds
C	ethanol	hydrogen bonds
D	ethanal	permanent dipole-dipole forces

6 What is the oxidation number of sulfur in each species?

	H_2S	SO_2	H_2SO_3
A	–2	+4	+4
B	–2	+4	+6
C	+2	–4	+4
D	+2	–4	+6

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7 The following data are needed for this question.

$\Delta H_f^\ominus(N_2H_4(l)) = 50.6\,kJ\,mol^{-1}$

$\Delta H_f^\ominus(N_2O_4(g)) = 9.2\,kJ\,mol^{-1}$

$\Delta H_f^\ominus(H_2O(g)) = -241.8\,kJ\,mol^{-1}$

Hydrazine, $N_2H_4(l)$, reacts with dinitrogen tetraoxide, $N_2O_4(g)$, to form nitrogen gas and water vapour.

$$2N_2H_4(l) + N_2O_4(g) \rightarrow 3N_2(g) + 4H_2O(g)$$

What is the enthalpy change for this reaction?

A $-1077.6\,kJ\,mol^{-1}$

B $-856.8\,kJ\,mol^{-1}$

C $-301.6\,kJ\,mol^{-1}$

D $-182.0\,kJ\,mol^{-1}$

8 Sodium burns in oxygen giving out heat energy and forming the compound Na_2O. The equation for this reaction is shown.

$$2Na(s) + \tfrac{1}{2}O_2(g) \rightarrow Na_2O(s)$$

Which statement about the reaction is correct?

A $\Delta H^\ominus$ for the reaction is equal to twice the bond energy of the Na–O bond.

B $\Delta H^\ominus$ for the reaction is positive.

C The equation represents the standard enthalpy change of combustion of sodium.

D The equation represents the standard enthalpy change of formation of sodium oxide.

9 In the chemical equation, w, x, y and z are all whole numbers.

$$wClO_3^- + xMnO_4^- + yH^+ \rightarrow wClO_4^- + xMnO_2 + zH_2O$$

When the equation is balanced, what are w, x and y?

	w	x	y
A	1	1	2
B	2	2	2
C	2	3	8
D	3	2	2

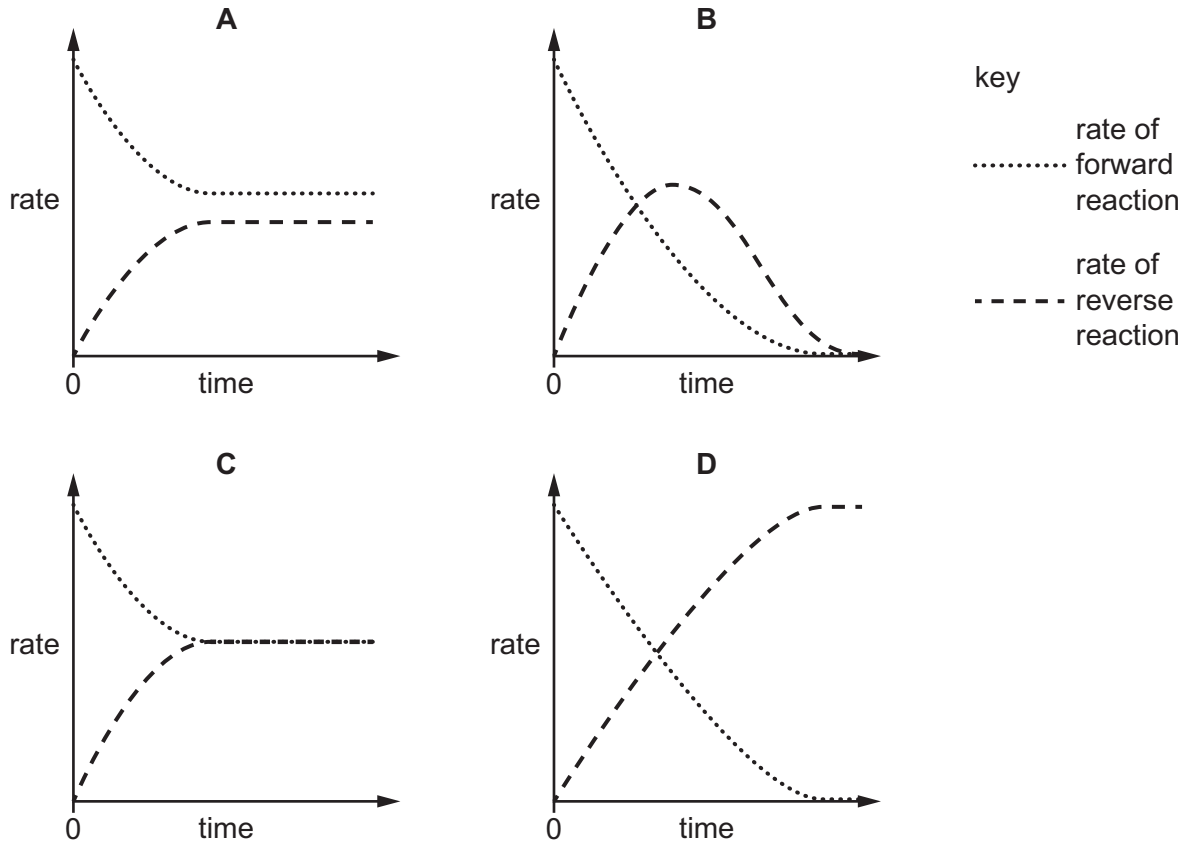
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10 Two compounds X and Y react to produce compound Z. The reaction is reversible.

$$X + Y \rightleftharpoons Z$$

When X and Y are mixed together in a closed system a dynamic equilibrium is gradually established.

Which graph could represent the change in the rates of the forward and reverse reactions over time?



11 The reaction between sulfur dioxide and oxygen is reversible.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad K_c = 280\,mol^{-1}\,dm^3 \text{ at } 1000\,K$$

In an equilibrium mixture at 1000 K the sulfur dioxide concentration is 0.200 mol dm^{-3} and the oxygen concentration is 0.100 mol dm^{-3}.

What is the sulfur trioxide concentration?

A 1.058 mol dm^{-3}

B 1.120 mol dm^{-3}

C 2.366 mol dm^{-3}

D 5.600 mol dm^{-3}

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12 Which oxide will cause an increase in pH when added to water?

A MgO **B** Al_2O_3 **C** SiO_2 **D** SO_2

13 X, Y and Z are consecutive elements in Period 3 of the Periodic Table. Element Y has the highest first ionisation energy and the lowest melting point of these three elements.

What are the identities of X, Y and Z?

	X	Y	Z
A	Na	Mg	Al
B	Mg	Al	Si
C	Al	Si	P
D	Si	P	S

14 A 5.00 g sample of an anhydrous Group 2 metal nitrate loses 3.29 g in mass when heated strongly.

Which metal is present?

A magnesium

B calcium

C strontium

D barium

15 Solutions P and Q each contain a different Group 2 ion at the same concentration. One contains Mg^{2+}, the other contains Ba^{2+}. Tests are carried out on separate 5 cm^3 samples of P and Q.

test 1: add 1 cm^3 of 0.1 mol dm^{-3} Na_2SO_4(aq)

test 2: add 1 cm^3 of 0.1 mol dm^{-3} NaOH(aq)

What are the results of these tests?

	results in test 1	results in test 2
A	more precipitate with Ba^{2+}	more precipitate with Ba^{2+}
B	more precipitate with Ba^{2+}	more precipitate with Mg^{2+}
C	more precipitate with Mg^{2+}	more precipitate with Ba^{2+}
D	more precipitate with Mg^{2+}	more precipitate with Mg^{2+}

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16 Chlorine and bromine have different volatilities.

Which row identifies the more volatile of the two elements, and gives the correct explanation?

	identity of the more volatile element	explanation for the difference in volatility
A	bromine	instantaneous dipole-induced dipole forces are greater in bromine than they are in chlorine
B	bromine	instantaneous dipole-induced dipole forces are greater in chlorine than they are in bromine
C	chlorine	instantaneous dipole-induced dipole forces are greater in bromine than they are in chlorine
D	chlorine	instantaneous dipole-induced dipole forces are greater in chlorine than they are in bromine

17 Sodium azide, NaN_3, is dissolved in water. Acidified silver nitrate is added to the solution and a white precipitate forms. Aqueous ammonia is then added to the white precipitate.

The azide ion, N_3^-, has similar chemical properties to the Cl^- ion.

Which row of the table can be predicted from this information?

	formula of white precipitate	observation on adding aqueous ammonia
A	AgN_3	colourless solution formed
B	AgN_3	precipitate remains
C	Ag_3N	colourless solution formed
D	Ag_3N	precipitate remains

18 Which type of reaction occurs when solid ammonium sulfate is heated with an excess of sodium hydroxide solution?

A acid-base

B precipitation

C redox

D thermal decomposition

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[Turn over

19 Catalytic converters are fitted in the exhaust systems of many cars.

Which gas:

- causes acid rain if it is released into the air
- is removed from car exhaust fumes by a catalytic converter?

A carbon dioxide

B carbon monoxide

C hydrocarbon vapour

D nitrogen dioxide

20 Which substance reacts with trichloroethene to give a chiral product?

A Br_2 **B** HCl **C** NaCN **D** NaOH

21 Alkanes are saturated hydrocarbons.

Which type of reaction are alkanes most likely to undergo?

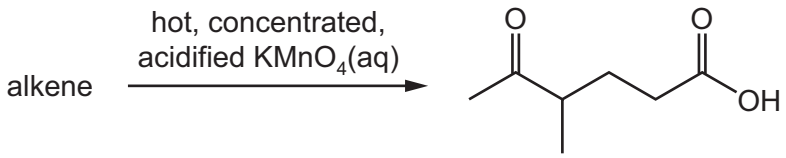
A electrophilic addition

B electrophilic substitution

C free radical substitution

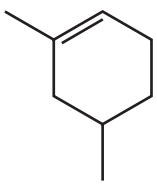
D nucleophilic addition

22 An alkene reacts with hot, concentrated, acidified potassium manganate(VII) to produce a single organic product as shown.

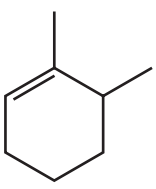


What is the structure of the alkene?

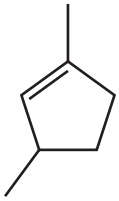
A



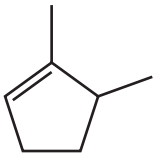
B



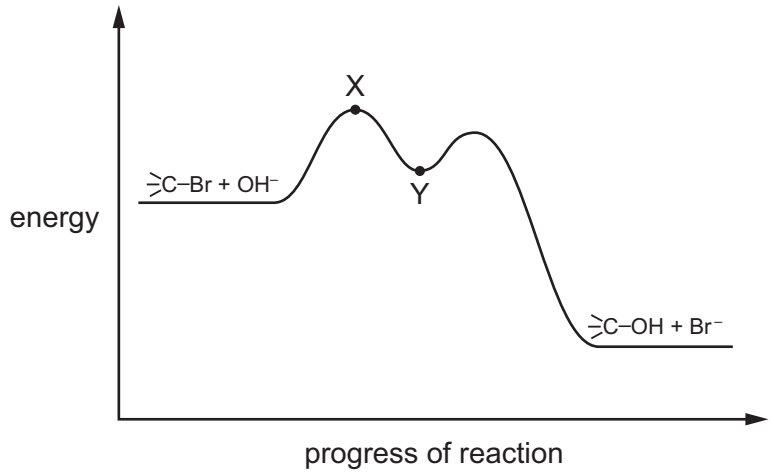
C



D

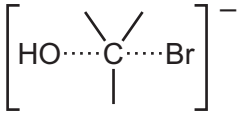


23 A tertiary bromoalkane, indicated here by $\geq C–Br$, reacts with aqueous NaOH. The mechanism has the reaction pathway shown.

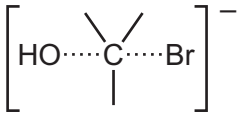


Which point in the diagram is correctly identified?

A X is $\geq C^+$

B X is 

C Y is $\geq C^+$

D Y is 

24 Bromoethane and chloroethane are added separately to water. Hydrolysis reactions occur.

Which compound hydrolyses more rapidly and what is the mechanism?

	compound that hydrolyses more rapidly	mechanism
A	bromoethane	electrophilic substitution
B	bromoethane	nucleophilic substitution
C	chloroethane	electrophilic substitution
D	chloroethane	nucleophilic substitution

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25 Alcohol X is oxidised to form compound Y.

The composition of Y is 54.54% carbon, 36.36% oxygen and 9.10% hydrogen. The M_r of Y is 88.0.

What could be the structure of alcohol X?

A $CH_3CH_2CH(OH)CH_3$

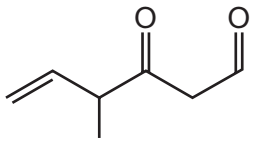
B $CH_3CH_2CH_2CH_2CH_2OH$

C $CH_3CH_2CH_2CH_2OH$

D $CH_3CH_2CH(OH)CH_2CH_3$

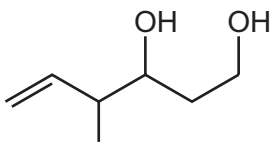
26 The diagram shows the structure of compound Z.

Z

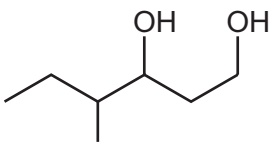


What is the product of the reaction between compound Z and an excess of $NaBH_4$?

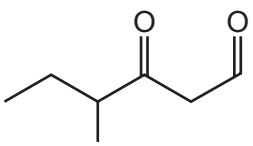
A



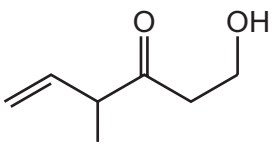
B



C



D



27 Compound Q shows the following reactions.

- It gives an orange precipitate with 2,4-dinitrophenylhydrazine.
- It gives a red-brown precipitate with Fehling's reagent.
- It gives a pale yellow precipitate with alkaline aqueous iodine.

What could be the identity of Q?

A ethanal

B propan-2-ol

C propanal

D propanone

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28 Tartaric acid, $HO_2CCH(OH)CH(OH)CO_2H$, is found in many plants.

A sample of tartaric acid reacts with an excess of $LiAlH_4$ to form the organic product J.

What happens when NaOH(aq) is added to separate samples of tartaric acid and J?

A Both tartaric acid and J react.

B Only tartaric acid reacts.

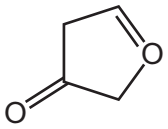
C Only J reacts.

D Neither tartaric acid nor J react.

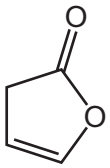
29 When $CH_2(OH)CH=CHCO_2H$ is warmed with a little concentrated sulfuric acid, a cyclic compound is formed.

What is the skeletal formula of the cyclic compound?

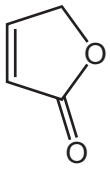
A



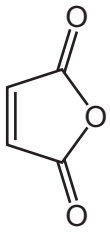
B



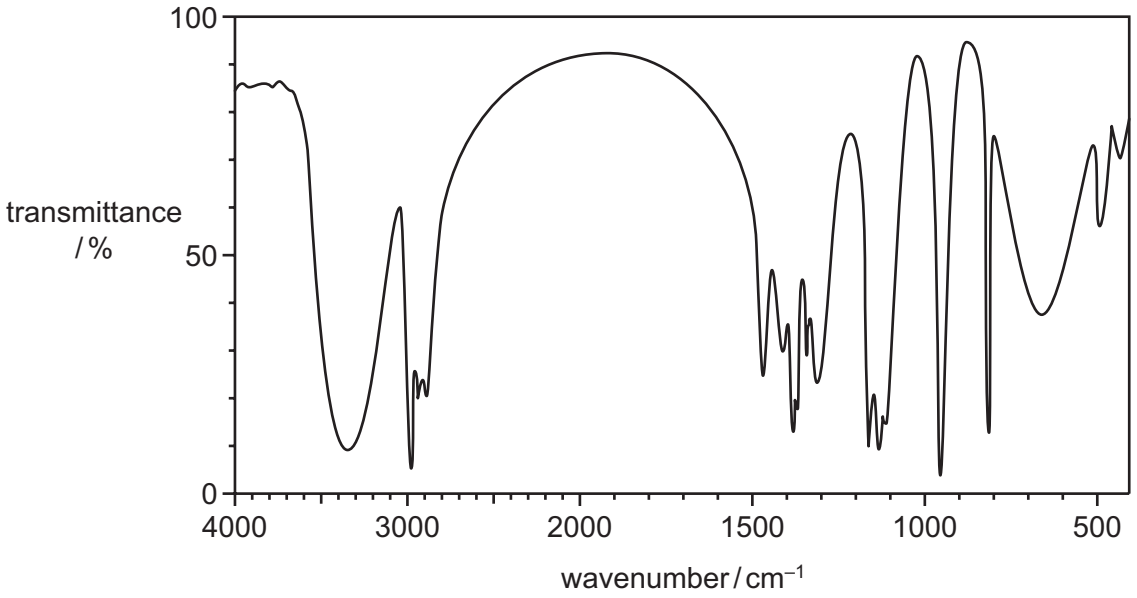
C



D



30 The infra-red spectrum of compound P is shown.



What could be compound P?

A methyl ethanoate

B propanal

C propanoic acid

D propan-2-ol

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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.

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

31 A particular atom of germanium, Ge, has a nucleon number of 70.

Which statements about a $^{70}_{32}Ge$ atom are correct?

1 It has the same number of electrons as a $^{79}_{34}Se^{2+}$ ion.

2 It has the same number of neutrons as an atom of $^{68}_{30}Zn$.

3 It has half as many protons as an atom of $^{160}_{64}Gd$.

32 The first ionisation energy of chlorine is greater than that of sulfur.

Which factors contribute to this?

1 Chlorine has more protons in its nucleus than sulfur does.

2 Chlorine has greater electron shielding than sulfur does.

3 The covalent bonds in chlorine molecules are stronger than those in sulfur molecules.

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 Liquids X and Y do not react with one another. They have identical boiling points.

When a particular volume of X is shaken with a similar volume of Y, they form a liquid mixture Z.

The average intermolecular forces in liquid Z are stronger than the average of the forces in X and the forces in Y.

Which deductions from this information are correct?

1 The mixing of X and Y is exothermic.

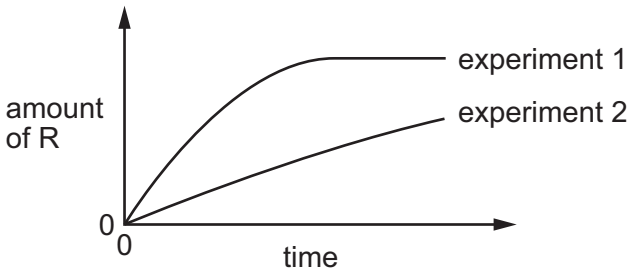
2 The vapour pressure of liquid Z will be less than that of either liquid X or liquid Y at the same temperature.

3 The boiling point of liquid Z will be lower than that of either liquid X or liquid Y at the same pressure.

34 The stoichiometry of a catalysed reaction is shown by the equation below.

$$P(g) + Q(g) \rightleftharpoons R(g) + S(l)$$

Two experiments are carried out in which the amount of R is measured. The results are shown in the diagram.



Which changes in the conditions could explain the results shown?

1 A lower pressure was used in experiment 2.

2 A different catalyst was used in experiment 2.

3 Product S was continuously removed from the reaction vessel in experiment 2.

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35 Which statements are correct?

1 Chloride ions are oxidised when concentrated sulfuric acid is added to NaCl(s).

2 A disproportionation reaction takes place when chlorine is added to cold NaOH(aq).

3 An acidic solution forms when chlorine is added to water.

36 Nitrogen gas is unreactive, whereas oxygen gas and chlorine gas are reactive.

Which statements help to explain this difference?

1 The two N atoms in an N_2 molecule are held together by a very strong triple bond.

2 The triple bond between two N atoms is not polar. The bonds in O_2 and Cl_2 are polar.

3 The atoms in N_2 have a full outer shell of electrons. The atoms in O_2 and Cl_2 do not have a full outer shell of electrons.

37 The structure of tiglic acid is $CH_3CH{=}C(CH_3)CO_2H$.

Which statements about the properties of one molecule of this acid are correct?

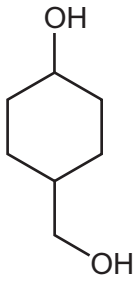
1 It contains two π bonds.

2 It contains four lone pairs of electrons.

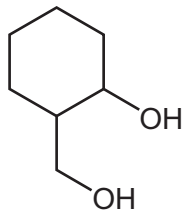
3 It has all its atoms in the same plane.

38 Which compounds, on heating with an excess of concentrated sulfuric acid, produce **only one** product with molecular formula C_7H_{10}?

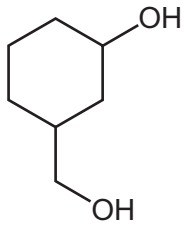
1



2



3



39 Hydrogen cyanide reacts with propanone in the presence of potassium cyanide.

Which statements about this reaction are correct?

1 The cyanide ion is a catalyst for the reaction.

2 This is an addition reaction.

3 The intermediate behaves as a base.

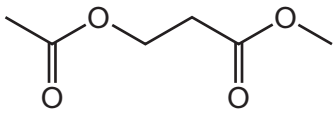
The responses **A** to **D** should be selected on the basis of

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

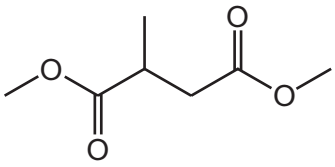
No other combination of statements is used as a correct response.

40 Which compounds produce three **different** organic products when hydrolysed?

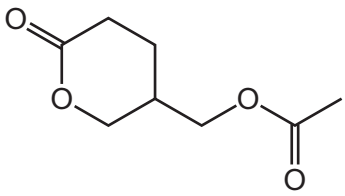
1



2



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