



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

CHEMISTRY

9701/11

Paper 1 Multiple Choice

October/November 2012

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.

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.

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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 In which reaction does an element undergo the largest change in oxidation state?

- A** $\text{Cl}_2 + 2\text{OH}^- \rightarrow \text{OCl}^- + \text{Cl}^- + \text{H}_2\text{O}$
- B** $3\text{Cl}_2 + 6\text{OH}^- \rightarrow \text{ClO}_3^- + 5\text{Cl}^- + 3\text{H}_2\text{O}$
- C** $\text{Cr}_2\text{O}_7^{2-} + 6\text{Fe}^{2+} + 14\text{H}^+ \rightarrow 2\text{Cr}^{3+} + 6\text{Fe}^{3+} + 7\text{H}_2\text{O}$
- D** $3\text{MnO}_4^{2-} + 4\text{H}^+ \rightarrow \text{MnO}_2 + 2\text{MnO}_4^- + 2\text{H}_2\text{O}$

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

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

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

- A** It has 4 electrons in its outer p subshell.
- B** It has 13 electrons in its outer shell.
- C** It has 37 neutrons.
- D** Its proton number is 32.

3 Sodium borohydride, NaBH_4 , and boron trifluoride, BF_3 , are compounds of boron.

What are the shapes around boron in the borohydride ion and in boron trifluoride?

	borohydride ion	boron trifluoride
A	square planar	pyramidal
B	square planar	trigonal planar
C	tetrahedral	pyramidal
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A reaction which causes the presence of oxides of nitrogen in car exhausts is the formation of NO.



What is the bond energy in kJ mol^{-1} of the bond between the atoms in NO?

- A** 655 **B** 835 **C** 1310 **D** 1670

5 In the table below,

- '+' means that this type of standard enthalpy change can **only** have positive values,
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- '+/-' means that **either** positive **or** negative values are possible.

Which row is correct?

	atomisation	formation	solution
A	+	+	+/-
B	+	+/-	+/-
C	-	+/-	-
D	-	-	+

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The volume of a sample of ammonia is measured at a temperature of 60°C and a pressure of 103 kPa. The volume measured is $5.37 \times 10^{-3} \text{ m}^3$.

What is the mass of the sample of ammonia, given to two significant figures?

- A** 0.00019 g **B** 0.0034 g **C** 0.19 g **D** 3.4 g

7 Aluminium is extracted by the electrolysis of a molten mixture containing aluminium oxide. By a similar method, magnesium is extracted by the electrolysis of a molten mixture containing magnesium chloride.

Which statement about the extraction of magnesium is correct?

- A** Magnesium ions travel to the anode and are oxidised to magnesium metal.
B Magnesium ions travel to the anode and are reduced to magnesium metal.
C Magnesium ions travel to the cathode and are oxidised to magnesium metal.
D Magnesium ions travel to the cathode and are reduced to magnesium metal.

- 8 Some car paints contain small flakes of silica, SiO_2 .

In the structure of solid SiO_2

- each silicon atom is bonded to **x** oxygen atoms,
- each oxygen atom is bonded to **y** silicon atoms,
- each bond is a **z** type bond.

What is the correct combination of **x**, **y** and **z** in this statement?

	x	y	z
A	2	1	covalent
B	2	1	ionic
C	4	2	covalent
D	4	2	ionic

- 9 John Dalton's atomic theory, published in 1808, contained four predictions about atoms.

Which of his predictions is still considered to be correct?

- A** All atoms are very small in size.
- B** All the atoms of a particular element have the same mass.
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- 10 A student calculated the standard enthalpy change of formation of ethane, C_2H_6 , using a method based on standard enthalpy changes of combustion.

He used correct values for the standard enthalpy change of combustion of ethane ($-1560 \text{ kJ mol}^{-1}$) and hydrogen (-286 kJ mol^{-1}) but he used an incorrect value for the standard enthalpy change of combustion of carbon. He then performed his calculation correctly. His final answer was -158 kJ mol^{-1} .

What did he use for the standard enthalpy change of combustion of carbon?

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- B** -860 kJ mol^{-1}
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- 11 Which process could be used to calculate the bond energy for the covalent bond X-Y by dividing its ΔH by n ?
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- B $2XY_n(g) \rightarrow 2XY_{n-1}(g) + Y_2(g)$
- C $Y(g) + XY_{n-1}(g) \rightarrow XY_n(g)$
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16 In a car engine, non-metallic element *X* forms a pollutant oxide *Y*. *Y* can be further oxidised to *Z*. Two students made the following statements.

Student P The molecule of *Y* contains lone pairs of electrons.

Student Q The oxidation number of *X* increases by 1 from *Y* to *Z*.

X could be carbon or nitrogen or sulfur.

Which student could be correct if *X* were any of these elements?

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What could be the identity of the metal?

- A** calcium
- B** magnesium
- C** potassium
- D** sodium

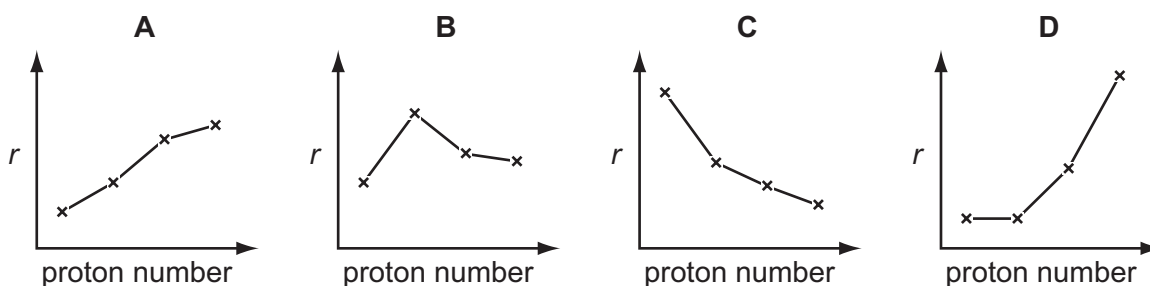
- 18 Elements **X** and **Y** are both in period three.

When the chloride of **X** is added to water, it reacts and a solution of pH 2 is produced.

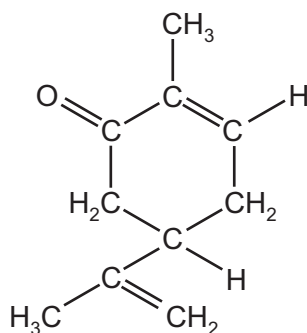
When the chloride of **Y** is added to water, it dissolves and a solution of pH 7 is produced.

Which statement explains these observations?

- A** Both chlorides hydrolyse in water.
B **X** is phosphorus and **Y** is aluminium.
C **X** is silicon and **Y** is sodium.
D **X** is sodium and **Y** is phosphorus.
- 19 Which diagram shows the variation of the metallic radius r of the Group I elements, Li, Na, K and Rb, with increasing proton (atomic) number?



- 20 Carvone is found in spearmint.



carvone

How many σ and π bonds are present in this molecule?

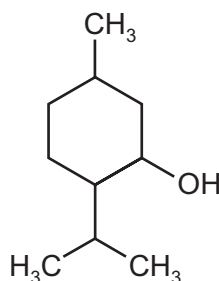
	σ	π
A	13	3
B	22	3
C	22	6
D	25	3

- 21 An alkene has the formula $\text{CH}_3\text{CH}=\text{CRCH}_2\text{CH}_3$ and does **not** possess *cis-trans* isomers.

What is *R*?

- A H B Cl C CH_3 D C_2H_5

- 22 Menthol is an important compound extracted from the peppermint plant.



menthol

How many chiral centres are there in one molecule of menthol?

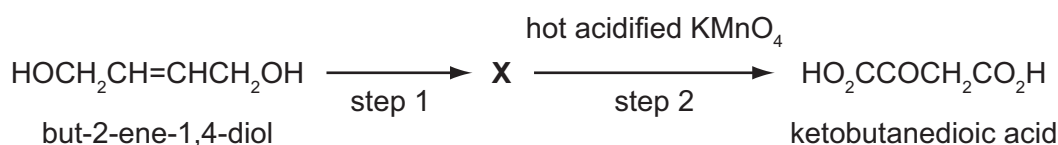
- A 1 B 2 C 3 D 4

- 23 The cracking of a single hydrocarbon molecule, $\text{C}_n\text{H}_{2n+2}$, produces two hydrocarbon molecules only. Each hydrocarbon product contains the same number of carbon atoms in one molecule. Each hydrocarbon product has non-cyclic structural isomers.

What is the value of *n*?

- A 4 B 6 C 8 D 9

- 24 But-2-ene-1,4-diol is converted in two steps through an intermediate **X** into ketobutanedioic acid.



What could be the reagent for step 1 and the intermediate **X**?

	reagent for step 1	X
A	cold acidified KMnO_4	$\text{HOCH}_2\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{OH}$
B	hot acidified KMnO_4	$\text{OHCCH}(\text{OH})\text{CH}_2\text{CHO}$
C	steam and concentrated H_2SO_4	$\text{HOCH}_2\text{CH}(\text{OH})\text{CH}_2\text{CH}_2\text{OH}$
D	warm acidified $\text{K}_2\text{Cr}_2\text{O}_7$	$\text{HO}_2\text{CCH}=\text{CHCO}_2\text{H}$

- 25 One of the reactions taking place in a catalytic converter in a car exhaust system is between nitrogen oxide and octane (unburned petrol). The products of this reaction are non-toxic.

Which is the correct equation for the reaction?

- A $\text{C}_8\text{H}_{16} + 16\text{NO} \rightarrow 8\text{CO} + 8\text{N}_2 + 8\text{H}_2\text{O}$
 B $\text{C}_8\text{H}_{16} + 24\text{NO} \rightarrow 8\text{CO}_2 + 12\text{N}_2 + 8\text{H}_2\text{O}$
 C $\text{C}_8\text{H}_{18} + 17\text{NO} \rightarrow 8\text{CO} + 8\frac{1}{2}\text{N}_2 + 9\text{H}_2\text{O}$
 D $\text{C}_8\text{H}_{18} + 25\text{NO} \rightarrow 8\text{CO}_2 + 12\frac{1}{2}\text{N}_2 + 9\text{H}_2\text{O}$

- 26 High-energy radiation in the stratosphere produces free-radicals from chlorofluoroalkanes, commonly known as CFCs.

Which free-radical is most likely to result from the irradiation of $\text{CHFClCF}_2\text{Cl}$?

- A $\text{CHFCl}\dot{\text{C}}\text{FCl}$
 B $\dot{\text{C}}\text{HClCF}_2\text{Cl}$
 C $\dot{\text{C}}\text{HFCF}_2\text{Cl}$
 D $\dot{\text{C}}\text{FClCF}_2\text{Cl}$

- 27 Which reagent reacts with ethanol and also reacts with ethanoic acid?

- A acidified potassium dichromate(VI)
 B sodium
 C sodium carbonate
 D sodium hydroxide

- 28 In 1903 Arthur Lapworth became the first chemist to investigate a reaction mechanism. The reaction he investigated was that of hydrogen cyanide with propanone.

What do we now call the mechanism of this reaction?

- A electrophilic addition
 B electrophilic substitution
 C nucleophilic addition
 D nucleophilic substitution

- 29 Many, but not all, organic reactions need to be heated before reaction occurs.

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

- A** $\text{CH}_3\text{OH} + \text{PCl}_5 \rightarrow \text{CH}_3\text{Cl} + \text{POCl}_3 + \text{HCl}$
B $\text{CH}_3\text{CH}_2\text{Br} + \text{KCN} \rightarrow \text{CH}_3\text{CH}_2\text{CN} + \text{KBr}$
C $\text{CH}_3\text{CH}_2\text{OH} \rightarrow \text{C}_2\text{H}_4 + \text{H}_2\text{O}$
D $\text{CH}_3\text{CH}_2\text{CN} + 2\text{H}_2\text{O} \rightarrow \text{CH}_3\text{CH}_2\text{CO}_2\text{H} + \text{NH}_3$

- 30 Compound **X**, $\text{C}_6\text{H}_{12}\text{O}$, is oxidised by acidified sodium dichromate(VI) to compound **Y**.

Compound **Y** reacts with ethanol in the presence of a little concentrated sulfuric acid to give liquid **Z**.

What is the formula of **Z**?

- A** $\text{CH}_3(\text{CH}_2)_4\text{COCH}_2\text{CH}_3$
B $\text{CH}_3(\text{CH}_2)_4\text{CO}_2\text{CH}_2\text{CH}_3$
C $\text{CH}_3\text{CH}_2\text{CO}_2(\text{CH}_2)_4\text{CH}_3$
D $\text{CH}_3\text{CO}_2(\text{CH}_2)_5\text{CH}_3$

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 How may nitrogen exist in compounds?

- 1** bonded by a triple covalent bond
- 2** as part of a cation
- 3** having lost 3 electrons to form an anion

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

The isotope ^{99}Tc is radioactive and has been found in lobsters and seaweed adjacent to nuclear fuel reprocessing plants.

Which statements are correct about an atom of ^{99}Tc ?

- 1** It has 13 more neutrons than protons.
- 2** It has 43 protons.
- 3** It has 99 nucleons.

33 Which of these substances have a giant structure?

- 1** silicon(IV) oxide
- 2** baked clay found in crockery
- 3** phosphorus(V) oxide

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

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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

34 The element astatine, At, is below iodine in Group VII of the Periodic Table.

Which statements concerning At will be correct?

- 1** It is a dark-coloured solid at room temperature.
- 2** It is a more powerful oxidising agent than iodine.
- 3** Its hydride is thermally stable.

35 Which equations represent stages in the Contact process for manufacturing sulfuric acid?

- 1** $\text{SO}_2 + \frac{1}{2} \text{O}_2 \rightarrow \text{SO}_3$
- 2** $\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3$
- 3** $\text{H}_2\text{SO}_3 + \frac{1}{2} \text{O}_2 \rightarrow \text{H}_2\text{SO}_4$

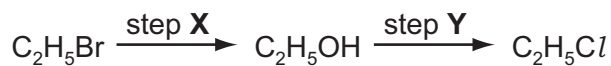
36 When added to water, which oxides will **not** cause a change in pH?

- 1** Al_2O_3
- 2** SiO_2
- 3** P_4O_{10}

37 Which reagents and conditions will convert propane into 1-chloropropane?

- 1** Cl_2 and sunlight
- 2** conc. HCl , reflux
- 3** PCl_5

38 Chloroethane can be formed from bromoethane in two steps.



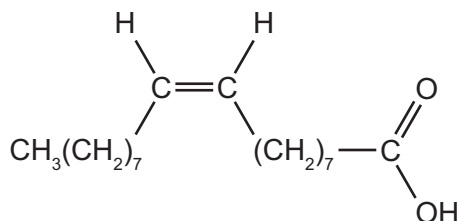
Which statements about these steps are correct?

- 1 Step X involves nucleophilic substitution.
- 2 Hot aqueous sodium hydroxide is the reagent in step X.
- 3 Hot aqueous sodium chloride is the reagent in step Y.

39 Which reagents react with butanone, $\text{C}_2\text{H}_5\text{COCH}_3$?

- 1 Tollens' reagent
- 2 sodium borohydride
- 3 2,4-dinitrophenylhydrazine reagent

40 Oleic acid is found in olive oil. It has the following formula.



Which reagents will give a positive result with oleic acid?

- 1 aqueous bromine
- 2 acidified potassium dichromate(VI)
- 3 Fehling's reagent

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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 In which reaction does an element undergo the largest change in oxidation state?

- A** $\text{Cl}_2 + 2\text{OH}^- \rightarrow \text{OCl}^- + \text{Cl}^- + \text{H}_2\text{O}$
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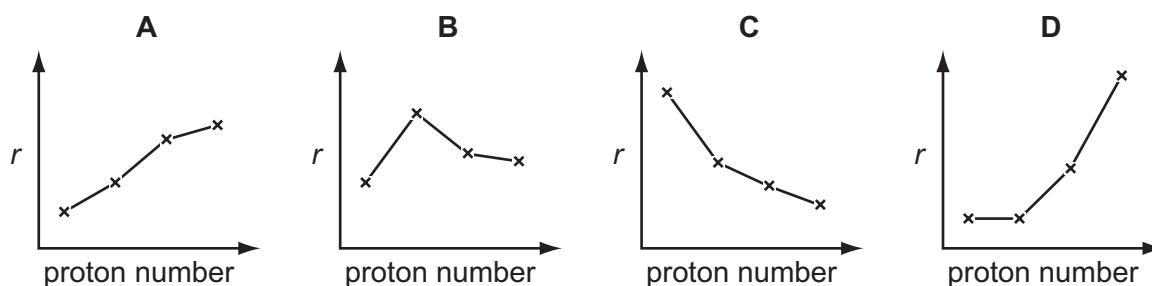
- 18 Elements **X** and **Y** are both in period three.

When the chloride of **X** is added to water, it reacts and a solution of pH 2 is produced.

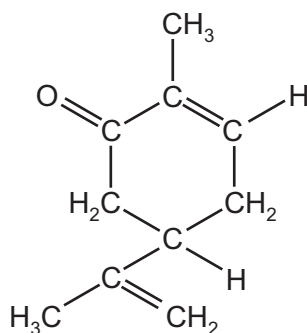
When the chloride of **Y** is added to water, it dissolves and a solution of pH 7 is produced.

Which statement explains these observations?

- A** Both chlorides hydrolyse in water.
B **X** is phosphorus and **Y** is aluminium.
C **X** is silicon and **Y** is sodium.
D **X** is sodium and **Y** is phosphorus.
- 19 Which diagram shows the variation of the metallic radius r of the Group I elements, Li, Na, K and Rb, with increasing proton (atomic) number?



- 20 Carvone is found in spearmint.



carvone

How many σ and π bonds are present in this molecule?

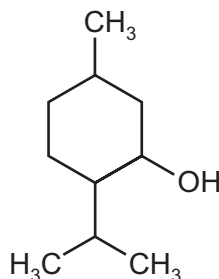
	σ	π
A	13	3
B	22	3
C	22	6
D	25	3

- 21 An alkene has the formula $\text{CH}_3\text{CH}=\text{CRCH}_2\text{CH}_3$ and does **not** possess *cis-trans* isomers.

What is *R*?

- A H B Cl C CH_3 D C_2H_5

- 22 Menthol is an important compound extracted from the peppermint plant.



menthol

How many chiral centres are there in one molecule of menthol?

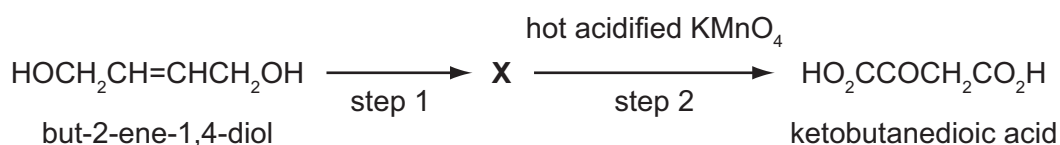
- A 1 B 2 C 3 D 4

- 23 The cracking of a single hydrocarbon molecule, $\text{C}_n\text{H}_{2n+2}$, produces two hydrocarbon molecules only. Each hydrocarbon product contains the same number of carbon atoms in one molecule. Each hydrocarbon product has non-cyclic structural isomers.

What is the value of *n*?

- A 4 B 6 C 8 D 9

- 24 But-2-ene-1,4-diol is converted in two steps through an intermediate **X** into ketobutanedioic acid.



What could be the reagent for step 1 and the intermediate **X**?

	reagent for step 1	X
A	cold acidified KMnO_4	$\text{HOCH}_2\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{OH}$
B	hot acidified KMnO_4	$\text{OHCCH}(\text{OH})\text{CH}_2\text{CHO}$
C	steam and concentrated H_2SO_4	$\text{HOCH}_2\text{CH}(\text{OH})\text{CH}_2\text{CH}_2\text{OH}$
D	warm acidified $\text{K}_2\text{Cr}_2\text{O}_7$	$\text{HO}_2\text{CCH}=\text{CHCO}_2\text{H}$

- 25 One of the reactions taking place in a catalytic converter in a car exhaust system is between nitrogen oxide and octane (unburned petrol). The products of this reaction are non-toxic.

Which is the correct equation for the reaction?

- A $\text{C}_8\text{H}_{16} + 16\text{NO} \rightarrow 8\text{CO} + 8\text{N}_2 + 8\text{H}_2\text{O}$
- B $\text{C}_8\text{H}_{16} + 24\text{NO} \rightarrow 8\text{CO}_2 + 12\text{N}_2 + 8\text{H}_2\text{O}$
- C $\text{C}_8\text{H}_{18} + 17\text{NO} \rightarrow 8\text{CO} + 8\frac{1}{2}\text{N}_2 + 9\text{H}_2\text{O}$
- D $\text{C}_8\text{H}_{18} + 25\text{NO} \rightarrow 8\text{CO}_2 + 12\frac{1}{2}\text{N}_2 + 9\text{H}_2\text{O}$

- 26 High-energy radiation in the stratosphere produces free-radicals from chlorofluoroalkanes, commonly known as CFCs.

Which free-radical is most likely to result from the irradiation of $\text{CHFClCF}_2\text{Cl}$?

- A $\text{CHFCl}\dot{\text{C}}\text{FCl}$
- B $\dot{\text{C}}\text{HClCF}_2\text{Cl}$
- C $\dot{\text{C}}\text{HFCF}_2\text{Cl}$
- D $\dot{\text{C}}\text{FClCF}_2\text{Cl}$

- 27 Which reagent reacts with ethanol and also reacts with ethanoic acid?

- A acidified potassium dichromate(VI)
- B sodium
- C sodium carbonate
- D sodium hydroxide

- 28 In 1903 Arthur Lapworth became the first chemist to investigate a reaction mechanism. The reaction he investigated was that of hydrogen cyanide with propanone.

What do we now call the mechanism of this reaction?

- A electrophilic addition
- B electrophilic substitution
- C nucleophilic addition
- D nucleophilic substitution

- 29 Many, but not all, organic reactions need to be heated before reaction occurs.

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

- A** $\text{CH}_3\text{OH} + \text{PCl}_5 \rightarrow \text{CH}_3\text{Cl} + \text{POCl}_3 + \text{HCl}$
B $\text{CH}_3\text{CH}_2\text{Br} + \text{KCN} \rightarrow \text{CH}_3\text{CH}_2\text{CN} + \text{KBr}$
C $\text{CH}_3\text{CH}_2\text{OH} \rightarrow \text{C}_2\text{H}_4 + \text{H}_2\text{O}$
D $\text{CH}_3\text{CH}_2\text{CN} + 2\text{H}_2\text{O} \rightarrow \text{CH}_3\text{CH}_2\text{CO}_2\text{H} + \text{NH}_3$

- 30 Compound **X**, $\text{C}_6\text{H}_{12}\text{O}$, is oxidised by acidified sodium dichromate(VI) to compound **Y**.

Compound **Y** reacts with ethanol in the presence of a little concentrated sulfuric acid to give liquid **Z**.

What is the formula of **Z**?

- A** $\text{CH}_3(\text{CH}_2)_4\text{COCH}_2\text{CH}_3$
B $\text{CH}_3(\text{CH}_2)_4\text{CO}_2\text{CH}_2\text{CH}_3$
C $\text{CH}_3\text{CH}_2\text{CO}_2(\text{CH}_2)_4\text{CH}_3$
D $\text{CH}_3\text{CO}_2(\text{CH}_2)_5\text{CH}_3$

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 How may nitrogen exist in compounds?

- 1** bonded by a triple covalent bond
- 2** as part of a cation
- 3** having lost 3 electrons to form an anion

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

The isotope ^{99}Tc is radioactive and has been found in lobsters and seaweed adjacent to nuclear fuel reprocessing plants.

Which statements are correct about an atom of ^{99}Tc ?

- 1** It has 13 more neutrons than protons.
- 2** It has 43 protons.
- 3** It has 99 nucleons.

33 Which of these substances have a giant structure?

- 1** silicon(IV) oxide
- 2** baked clay found in crockery
- 3** phosphorus(V) oxide

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

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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

34 The element astatine, At, is below iodine in Group VII of the Periodic Table.

Which statements concerning At will be correct?

- 1** It is a dark-coloured solid at room temperature.
- 2** It is a more powerful oxidising agent than iodine.
- 3** Its hydride is thermally stable.

35 Which equations represent stages in the Contact process for manufacturing sulfuric acid?

- 1** $\text{SO}_2 + \frac{1}{2} \text{O}_2 \rightarrow \text{SO}_3$
- 2** $\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3$
- 3** $\text{H}_2\text{SO}_3 + \frac{1}{2} \text{O}_2 \rightarrow \text{H}_2\text{SO}_4$

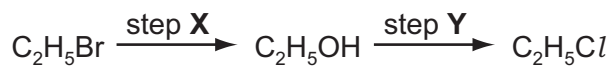
36 When added to water, which oxides will **not** cause a change in pH?

- 1** Al_2O_3
- 2** SiO_2
- 3** P_4O_{10}

37 Which reagents and conditions will convert propane into 1-chloropropane?

- 1** Cl_2 and sunlight
- 2** conc. HCl , reflux
- 3** PCl_5

38 Chloroethane can be formed from bromoethane in two steps.



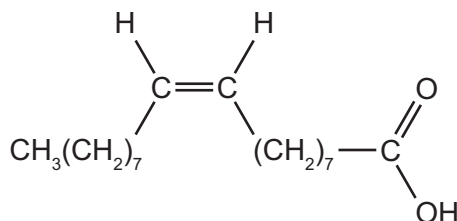
Which statements about these steps are correct?

- 1 Step X involves nucleophilic substitution.
- 2 Hot aqueous sodium hydroxide is the reagent in step X.
- 3 Hot aqueous sodium chloride is the reagent in step Y.

39 Which reagents react with butanone, $\text{C}_2\text{H}_5\text{COCH}_3$?

- 1 Tollens' reagent
- 2 sodium borohydride
- 3 2,4-dinitrophenylhydrazine reagent

40 Oleic acid is found in olive oil. It has the following formula.



Which reagents will give a positive result with oleic acid?

- 1 aqueous bromine
- 2 acidified potassium dichromate(VI)
- 3 Fehling's reagent

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

CHEMISTRY

9701/13

Paper 1 Multiple Choice

October/November 2012

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.

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.

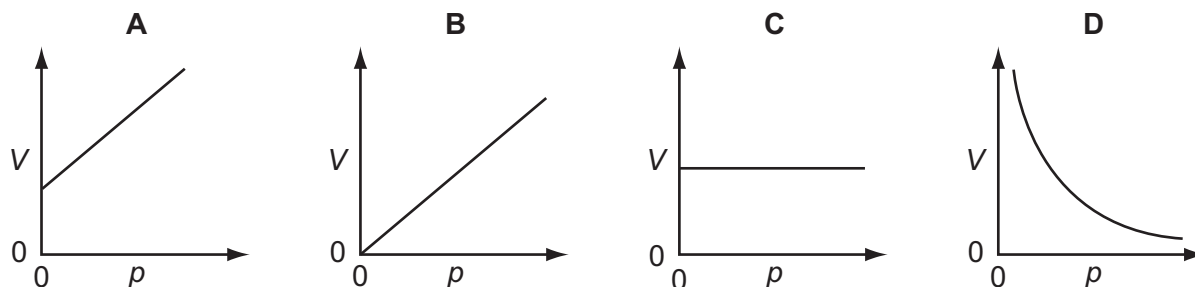
This document consists of **14** printed pages and **2** blank pages.



Section A

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

- 1 Which diagram shows the correct graph of V against p for a fixed mass of an ideal gas at constant temperature?



- 2 Which statement can be explained by intermolecular hydrogen bonding?

- A** Butane has a higher boiling point than propane.
- B** Hydrogen bromide forms an acidic solution when dissolved in water.
- C** SiH_4 has a higher boiling point than CH_4 .
- D** Water has a higher boiling point than CH_4 .

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

The volume of a sample of ammonia was measured at a temperature of 40°C and a pressure of 95 kPa . The volume measured was $4.32 \times 10^{-5}\text{ m}^3$.

What is the mass of the sample of ammonia?

- A** $2.7 \times 10^{-5}\text{ g}$ **B** $2.1 \times 10^{-4}\text{ g}$ **C** $2.7 \times 10^{-2}\text{ g}$ **D** $2.1 \times 10^{-1}\text{ g}$

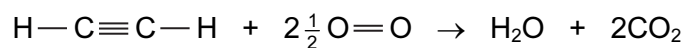
- 4 Aluminium is extracted by the electrolysis of a molten mixture containing aluminium oxide.

By a similar method, magnesium is extracted by the electrolysis of a molten mixture containing magnesium chloride.

Which statement about this electrolysis is correct?

- A** Chloride ions travel to the anode and are oxidised to chlorine gas.
- B** Chloride ions travel to the anode and are reduced to chlorine gas.
- C** Chloride ions travel to the cathode and are oxidised to chlorine gas.
- D** Chloride ions travel to the cathode and are reduced to chlorine gas.

- 5 Ethyne, C_2H_2 , completely combusts, as shown in the equation.

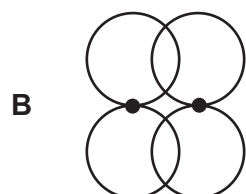
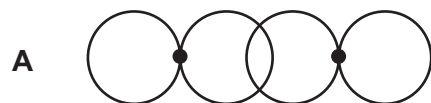


Using the average bond enthalpies in the table, what is the enthalpy change of combustion of ethyne?

bond	average bond enthalpy / kJ mol^{-1}
$\text{C}-\text{H}$	410
$\text{C}\equiv\text{C}$	840
$\text{O}=\text{O}$	496
$\text{C}=\text{O}$	740
$\text{O}-\text{H}$	460
$\text{C}-\text{O}$	360

- A** -980 kJ mol^{-1} **B** -540 kJ mol^{-1} **C** $+540 \text{ kJ mol}^{-1}$ **D** $+980 \text{ kJ mol}^{-1}$

- 6 Which diagram represents the overlap of two orbitals which will form a π bond?



- 7 The table gives the successive ionisation energies for an element X.

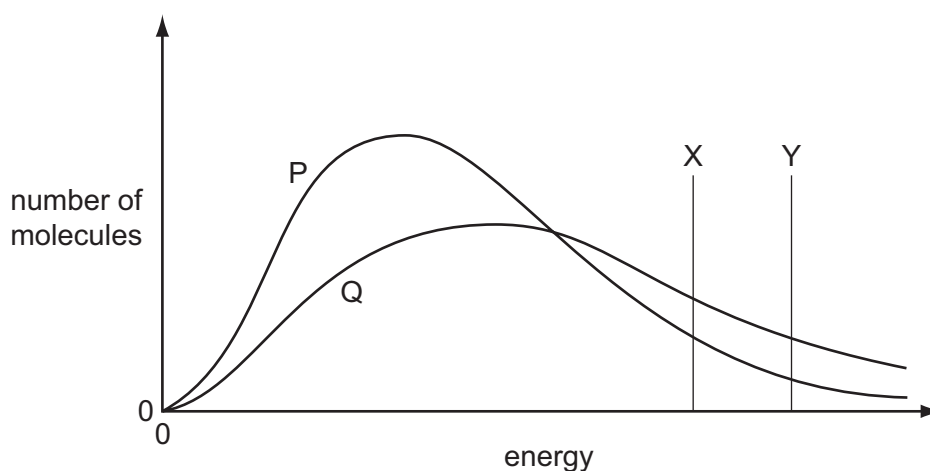
	1st	2nd	3rd	4th	5th	6th
ionisation energy / kJ mol^{-1}	950	1800	2700	4800	6000	12300

What could be the formula of the chloride of X?

- A** XCl **B** XCl_2 **C** XCl_3 **D** XCl_4

- 8 The gaseous compound Z decomposes on heating.

In the diagram below, Boltzmann distributions for Z at two different temperatures P and Q are shown. The lines X and Y indicate activation energies for the decomposition of Z with and without a catalyst.



Which curve and which line describe the decomposition of Z at a higher temperature and with a catalyst present?

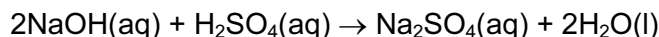
	higher temperature	catalyst present
A	P	X
B	P	Y
C	Q	X
D	Q	Y

- 9 During steel-making the impurity P_4O_{10} is removed by reacting it with calcium oxide. The only product of this reaction is the salt calcium phosphate, $\text{Ca}_3(\text{PO}_4)_2$.

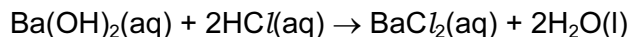
In this reaction, how many moles of calcium oxide react with one mole of P_4O_{10} ?

- A** 1 **B** 1.5 **C** 3 **D** 6

- 10 The enthalpy change of the neutralisation given below is -114 kJ mol^{-1} .



By using this information, what is the most likely value for the enthalpy change of the following neutralisation?



- A -57 kJ mol^{-1} B -76 kJ mol^{-1} C -114 kJ mol^{-1} D -228 kJ mol^{-1}
- 11 Which molecule is planar?
- A C_2Cl_4 B C_3H_6 C C_3H_8 D NF_3
- 12 Use of the Data Booklet is relevant to this question.
- Why is the ionic radius of a sulfide ion larger than the ionic radius of a potassium ion?
- A Ionic radius always decreases with increasing atomic number.
- B Positive ions have smaller radii than negative ions.
- C The potassium ion has more protons in its nucleus than the sulfide ion.
- D The sulfide ion is doubly charged; the potassium ion is singly charged.
- 13 Mohr's salt is a pale green crystalline solid which is soluble in water. It contains two cations, one of which is Fe^{2+} and one anion which is SO_4^{2-} .

The identity of the second cation was determined by heating solid Mohr's salt with solid sodium hydroxide and a colourless gas was evolved. The gas readily dissolved in water giving an alkaline solution.

A grey-green solid residue was also formed which was insoluble in water.

What are the identities of the gas and the solid residue?

	gas	residue
A	NH_3	$\text{Fe}(\text{OH})_2$
B	NH_3	Na_2SO_4
C	SO_2	$\text{Fe}(\text{OH})_2$
D	SO_2	Na_2SO_4

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

When 3.00 g of an anhydrous nitrate of a Group II metal is decomposed, 1.53 g of gas is produced.

What is the nitrate compound?

- A beryllium nitrate
- B calcium nitrate
- C magnesium nitrate
- D strontium nitrate

- 15 The reaction between KI and concentrated H_2SO_4 is a redox reaction.



What is the change in oxidation state of the element that is reduced?

- A 1 B 4 C 6 D 8

- 16 Rat poison needs to be insoluble in rain water but soluble at the low pH of stomach contents.

What is a suitable barium compound to use for rat poison?

- A barium carbonate
- B barium chloride
- C barium hydroxide
- D barium sulfate

- 17 In the Haber process, the reaction between the two gaseous reactants requires the use of a catalyst that contains a transition element.

What is the metal and in what mole ratio do the gases react?

	metal	mole ratio
A	Fe	1:2
B	Fe	1:3
C	V	1:2
D	V	1:3

- 18 Which oxide, when mixed with water, will produce the solution with the lowest pH?

- A CO_2 B Na_2O C P_4O_{10} D SiO_2

- 19 Deposits of ammonium sulfate have been discovered in areas of high atmospheric pollution.

They are believed to arise from the following reaction.

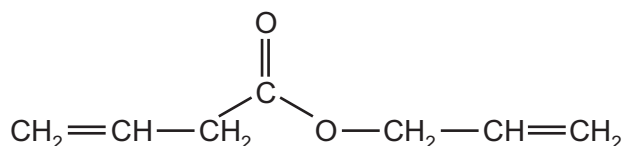


What does **not** occur in this reaction?

- A acid/base neutralisation
 B dative bond formation
 C ionic bond formation
 D oxidation/reduction
- 20 An organic compound X
- is unaffected by hot acidified potassium manganate(VII),
 - reacts with ethanoic acid in the presence of concentrated sulfuric acid.

What is compound X?

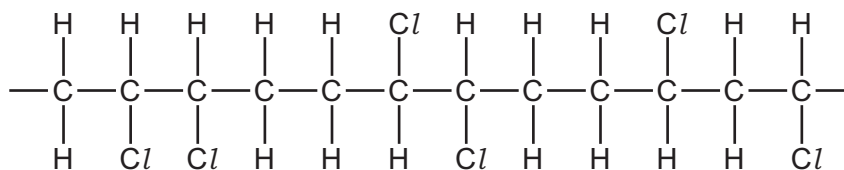
- A $\text{CH}_3\text{CO}_2\text{C}_2\text{H}_5$
 B $\text{CH}_3\text{CH}_2\text{COCH}_3$
 C $(\text{CH}_3)_3\text{COH}$
 D $\text{CH}_3\text{CH}_2\text{CHOHCH}_3$
- 21 The diagram shows a molecule that has σ bonds and π bonds.



How many σ bonds are present in this molecule?

- A 15 B 17 C 18 D 21

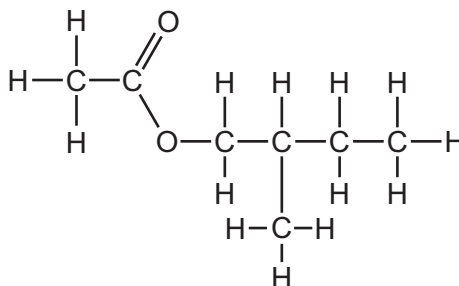
22 A molecule of a polymer contained the sequence shown.



Which monomer could produce this polymer by addition polymerisation?

- A** $\text{CHCl}=\text{CHCl}$
B $\text{CH}_2=\text{CHCl}$
C $\text{CH}_3\text{CCl}=\text{CHCl}$
D $\text{CH}_3\text{CCl}=\text{CH}_2$

23 Bees use 2-methylbutyl ethanoate as an 'alarm' pheromone to alert other bees.



2-methylbutyl ethanoate

Which starting materials would be required to synthesise 2-methylbutyl ethanoate?

- A** $\text{CH}_3\text{CH}_2\text{OH}$ and $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CO}_2\text{H}$
- B** $\text{CH}_3\text{CO}_2\text{H}$ and $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$
- C** $\text{CH}_3\text{CH}_2\text{OH}$ and $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CO}_2\text{H}$
- D** $\text{CH}_3\text{CO}_2\text{H}$ and $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CO}_2\text{H}$

24 Complete combustion of compound **X** produces carbon dioxide and water only. **X** produces steamy fumes with PCl_5 . **X** does not give any visible product with 2,4-dinitrophenylhydrazine reagent.

What can be deduced with certainty from this information?

- A** X is a carboxylic acid.
B X is a hydrocarbon.
C X is an alcohol.
D X is not an aldehyde.

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

2.30 g of ethanol were mixed with aqueous acidified potassium dichromate(VI) and the desired organic product was collected by immediate distillation under gentle warming. The yield of product was 70.0 %.

What mass of product was collected?

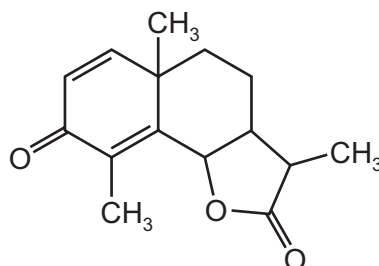
- A 1.54 g B 1.61 g C 2.10 g D 2.20 g

26 Which pair of reactions *could* have the same common intermediate?

- W $\text{CH}_3\text{CH}_2\text{CH}_3 \rightarrow \text{intermediate} \rightarrow (\text{CH}_3)_2\text{CHCN}$
 X $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3 \rightarrow \text{intermediate} \rightarrow (\text{CH}_3)_2\text{C}(\text{OH})\text{CN}$
 Y $\text{CH}_3\text{CH}=\text{CH}_2 \rightarrow \text{intermediate} \rightarrow \text{CH}_3\text{CH}(\text{OH})\text{CH}_3$
 Z $\text{CH}_3\text{CO}_2\text{CH}_2\text{CH}_2\text{CH}_3 \rightarrow \text{intermediate} \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$

- A W and X B W and Y C X and Z D Y and Z

27 Santonin is a drug that was once widely used to expel parasitic worms from the body.



santonin

When santonin is first treated with warm dilute H_2SO_4 , and then the product of this reaction is treated with cold acidified KMnO_4 , a final product **X** is obtained.

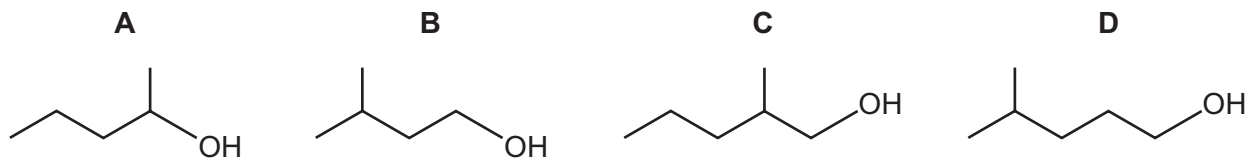
How many atoms of hydrogen in each molecule of product **X** can be displaced with sodium metal?

- A 2 B 4 C 5 D 6

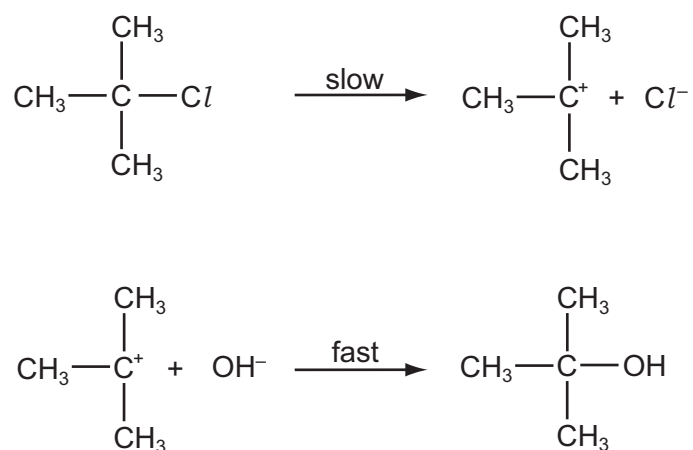
28 Which compound is optically active and could also be oxidised to a ketone?

- A 2-methylbutan-1-ol
 B 3-methylhexan-3-ol
 C 3-methylpentan-2-ol
 D propan-2-ol

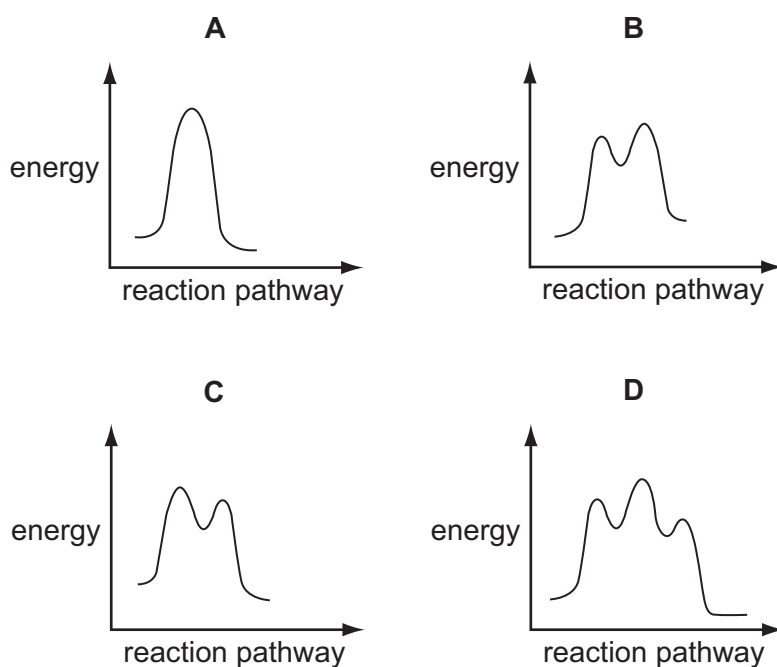
29 What is the skeletal formula of 2-methylpentan-1-ol?



30 A possible mechanism for the exothermic hydrolysis of 2-chloro-2-methylpropane is shown.



Which diagram represents the reaction pathway diagram for this mechanism?



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 How may nitrogen exist in compounds?

- 1** bonded by a triple covalent bond
- 2** as part of a cation
- 3** in an oxidation state of +5

32 The phosphide ion $^{31}_{15}\text{P}^{3-}$ and sulfide ion $^{32}_{16}\text{S}^{2-}$ have the same number of which sub-atomic particles?

- 1** neutrons
- 2** electrons
- 3** protons

33 Which substances have a giant structure?

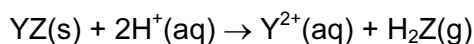
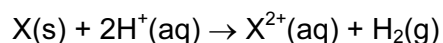
- 1** calcium oxide
- 2** calcium
- 3** baked clay found in crockery

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

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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

34 An element X and compound YZ react separately with acid as shown.



When 1.0 g of either X or YZ is reacted with an excess of acid, the total volume of gas formed is the same.

Which statements are correct?

- 1** $A_r(\text{X}) = M_r(\text{YZ})$
- 2** X and Y are metals.
- 3** X and Y must both be in the same Group of the Periodic Table.

35 In the gas phase, aluminium chloride exists as the dimer, Al_2Cl_6 .

By using this information, which of the following are structural features of the Al_2Cl_6 molecule?

- 1** Each aluminium atom is surrounded by four chlorine atoms.
- 2** There are twelve non-bonded electron pairs in the molecule.
- 3** Each aluminium atom contributes electrons to four covalent bonds.

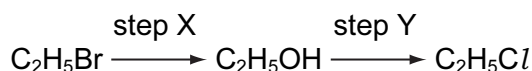
36 The table describes some of the chemistry and thermodynamic properties of the halogens.

process	name and symbol of quantity
$2\text{HX}(\text{g}) \rightarrow \text{H}_2(\text{g}) + \text{X}_2(\text{g})$	enthalpy change of reaction, $\Delta H^\ominus$
$\text{H}_2(\text{g}) + \text{X}_2(\text{g}) \rightleftharpoons 2\text{HX}(\text{g})$	equilibrium constant, K_p
$\text{X}(\text{g}) \rightarrow \text{X}^+(\text{g}) + \text{e}^-$	ionisation energy, $\Delta H^\ominus_{\text{I}}$

Which statements about the relative values of these quantities are correct?

- 1 $\Delta H^\ominus$ for $\text{HCl} > \Delta H^\ominus$ for HBr
- 2 K_p for $\text{HBr} > K_p$ for HI
- 3 $\Delta H^\ominus_{\text{I}}$ for $\text{I} > \Delta H^\ominus_{\text{I}}$ for Cl

37 Chloroethane can be formed from bromoethane in two steps.



Which statements about these steps are correct?

- 1 Hot aqueous sodium hydroxide is the reagent in step X.
- 2 SOCl_2 is the reagent in step Y.
- 3 Step X is a substitution reaction.

38 Which pairs of reagents will react together in a redox reaction?

- 1 $\text{CH}_3\text{CHO} + \text{Fehling's reagent}$
- 2 $\text{CH}_4 + \text{Cl}_2$
- 3 $\text{CH}_3\text{COCH}_3 + \text{Tollens' reagent}$

39 An organic compound, **X**, will react with calcium metal to produce a salt with the empirical formula $\text{CaC}_4\text{H}_4\text{O}_4$.

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

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

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 changes in bonding occur during the reaction of ethanal and hydrogen cyanide?

- 1** A carbon-carbon bond is formed.
- 2** A carbon-hydrogen bond is broken.
- 3** A carbon-nitrogen bond is broken.

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