Cambridge International AS & A Level

**Cambridge International Examinations**
Cambridge International Advanced Subsidiary and Advanced Level

**CHEMISTRY** **9701/13**

Paper 1 Multiple Choice **May/June 2017**

**1 hour**

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

*7608339960*

**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 **15** printed pages and **1** blank page.


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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 ion $Y^{3-}$ contains 18 electrons and has a mass number of 31.

How many protons and neutrons does $Y^{3-}$ contain?

| | protons | neutrons |
|---|---|---|
| **A** | 15 | 16 |
| **B** | 15 | 18 |
| **C** | 18 | 13 |
| **D** | 21 | 10 |

**2** A 0.216 g sample of an aluminium compound X reacts with an excess of water to produce a single hydrocarbon gas. This gas burns completely in $O_2$ to form $H_2O$ and $CO_2$ only. The volume of $CO_2$ at room temperature and pressure is 108 $cm^3$.

What is the formula of X?

**A** $Al_2C_3$ **B** $Al_3C_2$ **C** $Al_3C_4$ **D** $Al_4C_3$

**3** Which equation correctly describes the complete combustion of an alkene, $C_nH_{2n}$?

**A** $C_nH_{2n} + \frac{3}{2}nO_2 \rightarrow nCO_2 + 2nH_2O$

**B** $C_nH_{2n} + \frac{3}{2}nO_2 \rightarrow nCO_2 + nH_2O$

**C** $C_nH_{2n} + 2nO_2 \rightarrow nCO_2 + nH_2O$

**D** $C_nH_{2n} + 2nO_2 \rightarrow nCO_2 + 2nH_2O$

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**4** Two conversions are shown.

$$NH_4^+ \rightarrow NH_3$$

$$C_2H_4 \rightarrow C_2H_6$$

Which similar feature do these two conversions have?

**A** change in oxidation state of an element

**B** decrease in bond angle

**C** formation of a lone pair of electrons

**D** loss of a $\pi$ bond

**5** All gases listed are at the same pressure.

Which gas will most closely approach ideal behaviour?

**A** ammonia at 100 K

**B** ammonia at 500 K

**C** neon at 100 K

**D** neon at 500 K

**6** The following data are needed for this question.

$\Delta H_f^\ominus(CO(g)) = -111\,kJ\,mol^{-1}$

$\Delta H_f^\ominus(CO_2(g)) = -394\,kJ\,mol^{-1}$

$\Delta H_f^\ominus(Fe_2O_3(s)) = -822\,kJ\,mol^{-1}$

Carbon monoxide reacts with iron(III) oxide.

$$3CO(g) + Fe_2O_3(s) \rightarrow 3CO_2(g) + 2Fe(s)$$

What is the enthalpy change when 55.8 g of iron are produced by this reaction?

**A** –27.0 kJ **B** –13.5 kJ **C** +13.5 kJ **D** +27.0 kJ

**7** Vanadium reacts with dilute sulfuric acid to form $V_2(SO_4)_3$ and hydrogen gas.

What happens to vanadium atoms in this reaction?

**A** They lose three electrons and are oxidised.

**B** They lose three electrons and are reduced.

**C** They lose two electrons and are oxidised.

**D** They lose two electrons and are reduced.

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**8** $Na_2S_2O_3$ reacts with HC*l* as shown.

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + SO_2(g) + S(s)$$

When calculating the oxidation number of sulfur in $Na_2S_2O_3$, the **average** oxidation number of the two sulfur atoms should be found.

What is the oxidation number of sulfur in each of $Na_2S_2O_3$, $SO_2$, and S?

| | $Na_2S_2O_3$ | $SO_2$ | S |
|---|---|---|---|
| **A** | +2 | +2 | +1 |
| **B** | +2 | +4 | 0 |
| **C** | +4 | +4 | 0 |
| **D** | +5 | +4 | 0 |

**9** Ammonia is produced by the Haber process.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3 \qquad \Delta H^{\ominus} = -92\,kJ\,mol^{-1}$$

A fault in the temperature control during the process resulted in the temperature changing to 600 °C for two hours.

What effect did this have on the ammonia production during this time?

**A** Ammonia was formed faster. The equilibrium yield decreased.

**B** Ammonia was formed faster. The equilibrium yield increased.

**C** Ammonia was formed slower. The equilibrium yield decreased.

**D** Ammonia was formed slower. The equilibrium yield increased.

**10** For the reaction shown, an equilibrium is established at a temperature of 700 K.

The equilibrium constant, $K_p$, for the reaction is 9.80 kPa. The partial pressure of $N_2O_4$ at equilibrium is 80.0 kPa.

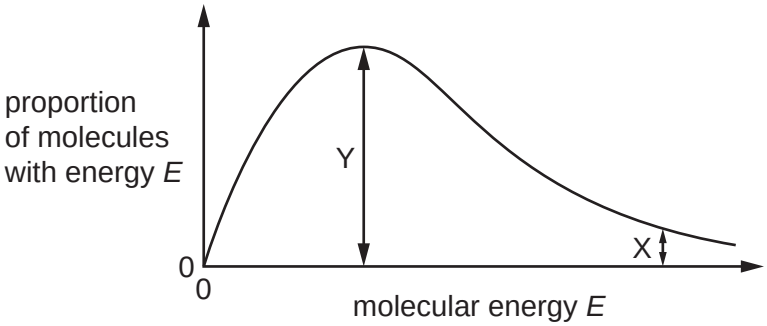
$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

What is the partial pressure of $NO_2$ at equilibrium?

**A** 8.16 kPa **B** 28.0 kPa **C** 66.6 kPa **D** 784 kPa

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**11** The diagram shows the Boltzmann distribution of the energy of gaseous molecules at a particular temperature.




Which statement is correct?

**A** If the temperature of the gas is raised, the height of the maximum of the curve increases.

**B** If the temperature of the gas is raised, the maximum of the curve moves to the right.

**C** The length of the line labelled X shows the activation energy for the reaction.

**D** The length of the line labelled Y shows the enthalpy change of the reaction.

**12** Magnesium chloride, $MgCl_2$, and silicon tetrachloride, $SiCl_4$, are separately added to water.

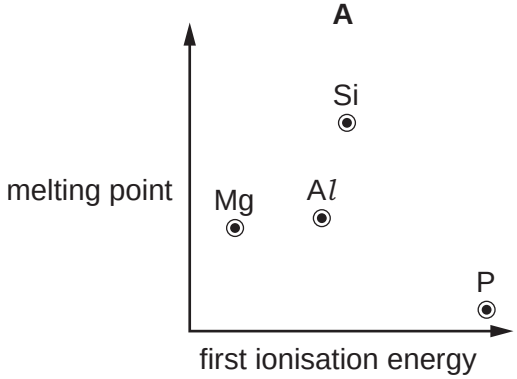
What are the approximate pH values of the solutions formed?

| | $MgCl_2$ | $SiCl_4$ |
|---|---|---|
| **A** | 0–3 | 0–3 |
| **B** | 0–3 | 6–7 |
| **C** | 6–7 | 0–3 |
| **D** | 6–7 | 6–7 |

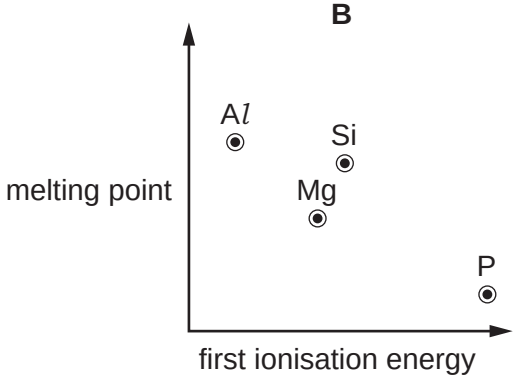
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**13** Which graph correctly shows the relative melting points of the elements Mg, A*l*, Si and P plotted against their relative first ionisation energies?

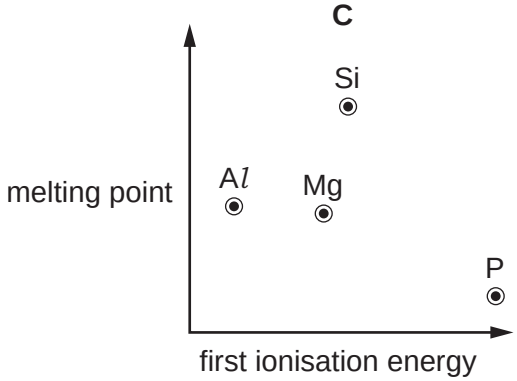
**A**



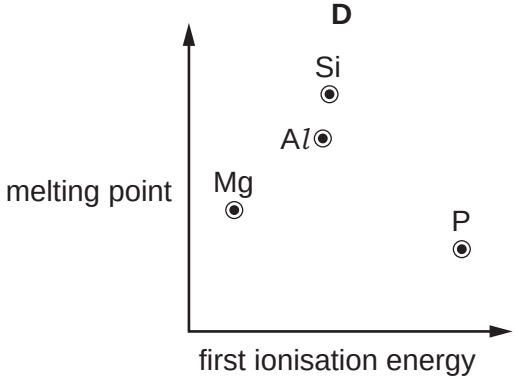

**B**




**C**




**D**




**14** The table gives information about calcium carbonate and calcium hydroxide.

Which row is correct?

| | calcium carbonate is more soluble than calcium hydroxide | calcium hydroxide can be manufactured using calcium carbonate as a starting material |
|---|---|---|
| **A** | no | no |
| **B** | no | yes |
| **C** | yes | no |
| **D** | yes | yes |

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**15** Which row correctly describes the reactions of calcium and strontium with water?

| | substance reduced | substance oxidised | more vigorous reaction |
|---|---|---|---|
| **A** | calcium or strontium | water | calcium + water |
| **B** | calcium or strontium | water | strontium + water |
| **C** | water | calcium or strontium | calcium + water |
| **D** | water | calcium or strontium | strontium + water |

**16** Chlorine gas is added to cold, aqueous sodium hydroxide.

In a separate experiment, chlorine gas is added to hot, aqueous sodium hydroxide.

Which oxidation states of chlorine are found in the reactants and products of the two reactions that take place?

**A** 0, –1, +1 and +5

**B** 0, –1 and +1 only

**C** 0, –1 and +5 only

**D** 0, +1 and +5 only

**17** A test-tube of HBr(g) and a separate test-tube of HI(g) are heated to the same temperature.

Which combination of observations is possible?

| | test-tube of HBr(g) | test-tube of HI(g) |
|---|---|---|
| **A** | a brown vapour appears | no change |
| **B** | a purple vapour appears | no change |
| **C** | no change | a brown vapour appears |
| **D** | no change | a purple vapour appears |

**18** Ammonia exists as simple covalent molecules, $NH_3$. Ammonia can react with suitable reagents to form products containing ammonium ions, $NH_4^+$. Ammonia can also react with suitable reagents to form products containing amide ions, $NH_2^-$.

Which of these nitrogen-containing species are present in an aqueous solution of ammonia?

**A** ammonia molecules and amide ions only

**B** ammonia molecules and ammonium ions only

**C** ammonia molecules only

**D** ammonium ions only

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**19** What would be produced when 60 g of nitrogen monoxide react with an excess of carbon monoxide in a catalytic converter?

**A** 12 g of carbon and 92 g of nitrogen dioxide

**B** 24 g of carbon and 92 g of nitrogen dioxide

**C** 88 g of carbon dioxide and 28 g of nitrogen

**D** 88 g of carbon dioxide and 56 g of nitrogen

**20** Structural isomerism and stereoisomerism should be considered when answering this question.

Which formula identifies a **single** substance?

**A** $CH_3CHCl CH_2CHO$

**B** $CH_3CHCHCH_3$

**C** $CH_2Cl CH_2CHCl_2$

**D** $C_4H_{10}$

**21** Structural isomerism and stereoisomerism should be considered when answering this question.

If a molecule contains two non-identical chiral carbon atoms, four optical isomers exist.

How many isomers are there with

- molecular formula $C_7H_{14}O$ **and**
- a five-membered ring **and**
- a tertiary alcohol group?

**A** 4 **B** 5 **C** 9 **D** 13

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**22** The formulae of three compounds are shown.

$C_3H_7CHO$ $C_2H_5COCH_3$ $CH_2CHCH_2CH_2OH$

Only one of these compounds will decolourise bromine water. Only one of these compounds will produce a silver mirror with Tollens' reagent.

Which row shows the correct results?

| | decolourises bromine water | forms a silver mirror with Tollens' reagent |
|---|---|---|
| **A** | $C_3H_7CHO$ | $C_2H_5COCH_3$ |
| **B** | $C_2H_5COCH_3$ | $C_3H_7CHO$ |
| **C** | $CH_2CHCH_2CH_2OH$ | $C_2H_5COCH_3$ |
| **D** | $CH_2CHCH_2CH_2OH$ | $C_3H_7CHO$ |

**23** Carboxylic acids may be prepared by several different methods.

In which reaction would propanoic acid be formed?

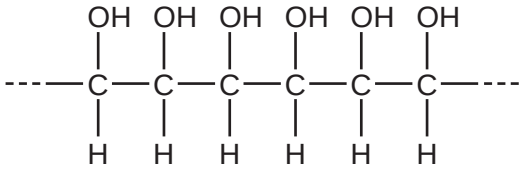
**A** adding ammonium propanoate to dilute sulfuric acid

**B** heating ethyl propanoate with aqueous sodium hydroxide

**C** heating propan-2-ol with acidified potassium manganate(VII) under reflux

**D** heating propyl ethanoate with dilute sulfuric acid

**24** The diagram represents the structure of a polymer.




By which method might this polymer be made?

**A** polymerise ethene followed by hydration

**B** polymerise ethene followed by oxidation with cold, acidified $KMnO_4$

**C** polymerise 1,2-dichloroethene followed by hydrolysis

**D** polymerise 1,2-dichloroethene followed by oxidation with cold, acidified $KMnO_4$

**25** Bromine reacts with ethene in the dark.

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

**A** It has a negative charge.

**B** It is a free radical.

**C** It is a nucleophile.

**D** It is an electrophile.

**26** Which statement about butan-1-ol, butan-2-ol, and 2-methylbutan-2-ol is **not** correct?

**A** They all react with methanoic acid to form an ester.

**B** They all react with sodium.

**C** They can all be dehydrated to form an alkene.

**D** They can all be oxidised to a carbonyl compound.

**27** Which compound will react with acidified potassium dichromate(VI) **and** with alkaline aqueous iodine?

**A** $CH_3COCH_2CH_3$

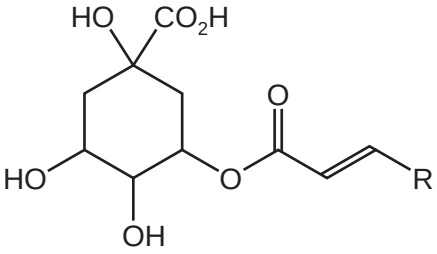
**B** $CH_3CH(OH)CH_2CH_3$

**C** $CH_3CH_2CH_2CHO$

**D** $CH_3CH_2CH_2CH_2OH$

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**28** Chlorogenic acid is found in green coffee beans and is used in treatments for weight loss.

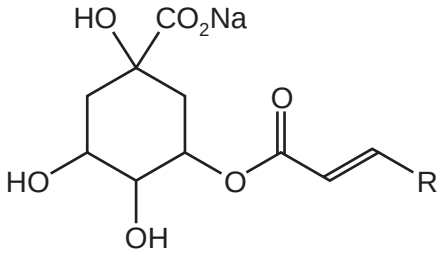



chlorogenic acid

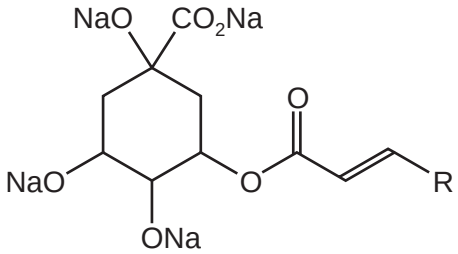
R = $C_6H_5O_2$ and takes no part in the reaction with sodium carbonate.

What is produced in good yield when chlorogenic acid is treated with an excess of sodium carbonate solution at room temperature?

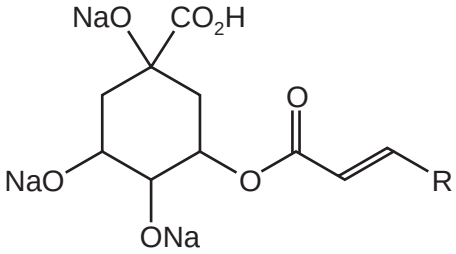
**A**



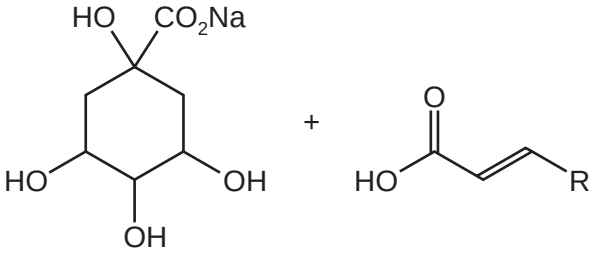

**B**



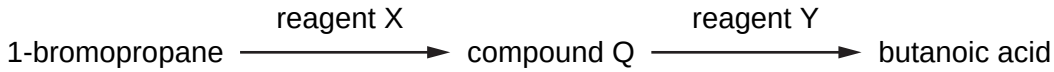

**C**




**D**



**29** Butanoic acid can be produced from 1-bromopropane using reagents X and Y as shown.




What could be reagents X and Y?

| | X | Y |
|---|---|---|
| **A** | KCN in ethanol | HC$l$(aq) |
| **B** | KCN in ethanol | NaOH(aq) |
| **C** | $NH_3$ in ethanol | HC$l$(aq) |
| **D** | NaOH(aq) | $H^+ / Cr_2O_7^{2-}$(aq) |

**30** How many esters with the molecular formula $C_5H_{10}O_2$ can be made by reacting a **primary** alcohol with a carboxylic acid?

**A** 4 **B** 5 **C** 6 **D** 8

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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** Which statements about the atoms $^{23}Na$ and $^{24}Mg$ are correct?

**1** They have the same number of filled electron orbitals.

**2** They have the same number of neutrons.

**3** They are both reducing agents.

**32** Which compounds contain covalent bonds?

**1** aluminium chloride

**2** ammonia

**3** calcium fluoride

**33** Ethylene glycol, $HOCH_2CH_2OH$, is used as a de-icer. It allows ice to melt at temperatures below 0 °C.

Which statements are correct?

**1** Ethylene glycol changes the extensive network of hydrogen bonds in ice.

**2** Ethylene glycol molecules form hydrogen bonds with other ethylene glycol molecules.

**3** Ethylene glycol molecules will dissolve in the water formed from the ice.

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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.

**34** A student carried out two experiments using $MnO_2$ as a catalyst to decompose hydrogen peroxide. The equation for this reaction is shown.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The student's results are recorded in the table.

| | mass $MnO_2$ | conditions | vol $H_2O_2$ | final vol $O_2$ | time taken |
|---|---|---|---|---|---|
| experiment 1 | 0.25 g | room conditions | 10.0 $cm^3$ | 480 $cm^3$ | 200 s |
| experiment 2 | 0.25 g | room conditions | 10.0 $cm^3$ | 480 $cm^3$ | 500 s |

Which statements are correct?

**1** The activation energy was the same for both experiments.

**2** The concentration of the hydrogen peroxide solution used was 4.0 mol $dm^{-3}$.

**3** The $MnO_2$ used in experiment 1 was in larger pieces than the $MnO_2$ used in experiment 2.

**35** The formula of a solid magnesium compound is $Mg(NO_3)_2.6H_2O$. When the solid compound is heated in a hard-glass test-tube, one or more changes are observed.

Which statements are correct?

**1** Strong heating produces a basic residue.

**2** Strong heating produces a brown gas.

**3** Gentle heating produces colourless droplets of liquid on the upper parts of the test-tube.

**36** Sulfur dioxide is an atmospheric pollutant.

What might result from the release of sulfur dioxide gas into the atmosphere?

**1** reduction of $NO_2$ to NO

**2** depletion of aquatic life

**3** corrosion of limestone statues

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**37** Which mechanisms are represented in this sequence of reactions?

$$CH_3CH_2CH_3 \rightarrow CH_3CH_2CH_2Cl \rightarrow CH_3CH_2CH_2OH \rightarrow CH_3CHCH_2 \rightarrow CH_3CHBrCH_2Br$$

**1** electrophilic addition

**2** nucleophilic substitution

**3** free radical substitution

**38** Which compounds, on heating with ethanolic NaOH, produce more than one product with molecular formula $C_4H_8$?

**1** 2-bromobutane

**2** 2-bromo-2-methylpropane

**3** 1-bromo-2-methylpropane

**39** Substance M is refluxed with aqueous sodium hydroxide. One of the products of this reaction reacts with alkaline aqueous iodine to give a pale yellow precipitate.

Which compounds could be substance M?

**1** $CH_3CO_2CH_3$

**2** $CH_3CO_2CH_2CH_3$

**3** $HCO_2CH(CH_3)_2$

**40** Propanal will react with hydrogen cyanide to form 2-hydroxybutanenitrile. A suitable catalyst for this reaction is sodium cyanide.

$$CH_3CH_2CHO + HCN \overset{NaCN}{\rightleftharpoons} CH_3CH_2CH(OH)CN$$

Which statements about this reaction of propanal with hydrogen cyanide are correct?

**1** The $CN^-$ ion attacks the propanal molecule to form an intermediate ion.

**2** The product of the reaction has a chiral carbon atom.

**3** The $CN^-$ ion is a stronger electrophile than the HCN molecule.

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