Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/13**

Paper 1 Multiple Choice **May/June 2016**

1 hour

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

* 5 7 6 1 6 0 1 2 6 6 *

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.

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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 Enthalpy changes, ΔH, can be positive or negative.

Which row is correct?

	ΔH positive	ΔH negative
A	atomisation	bond breaking
B	bond breaking	neutralisation
C	bond making	combustion
D	combustion	bond making

2 What will make it more likely that a gas will approach ideal behaviour?

A higher pressure

B lower temperature

C more polar molecules

D weaker intermolecular forces

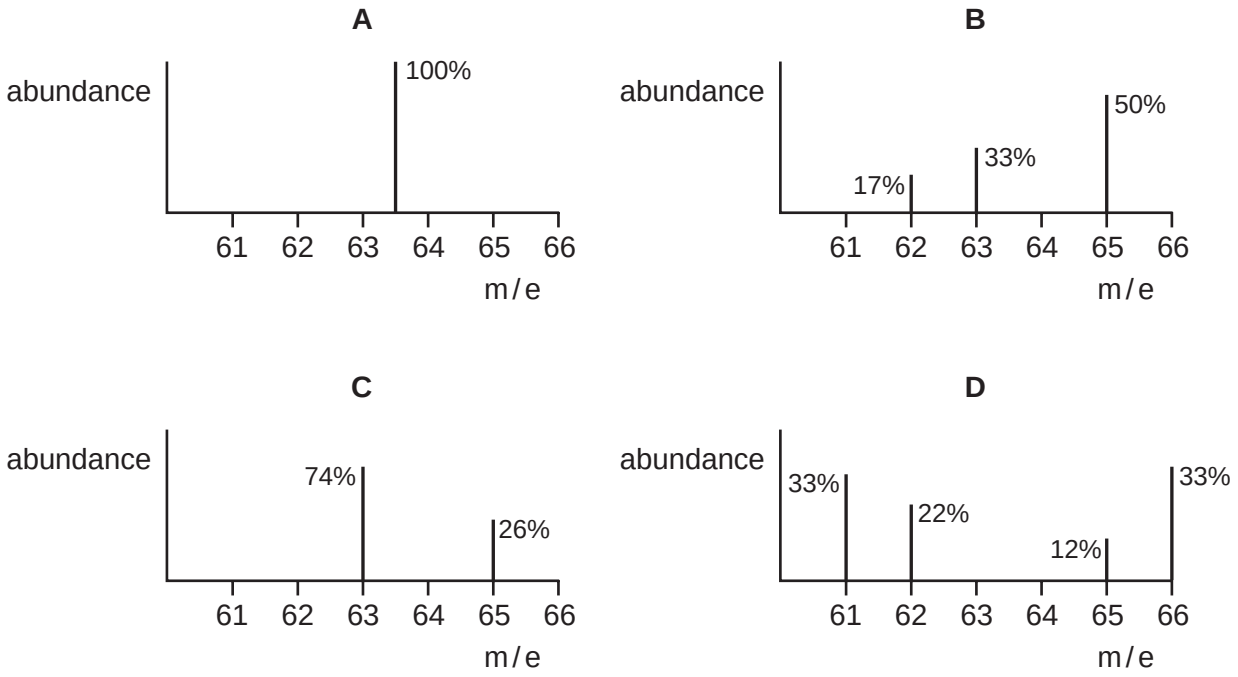
3 Which mass of urea, $CO(NH_2)_2$, contains the same mass of nitrogen as 101.1 g of potassium nitrate?

A 22 g **B** 30 g **C** 44 g **D** 60 g

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4 The relative atomic mass of copper is 63.5.

Which chart is a correct mass spectrum that would lead to this value?



5 Which isolated gaseous atom has a total of five electrons occupying spherically shaped orbitals?

A boron

B fluorine

C sodium

D potassium

6 Carbon and silicon have the same outer electronic structure.

Why is a Si–Si bond weaker than a C–C bond?

A Silicon atoms have a larger atomic radius than carbon atoms.

B Silicon has a greater nuclear charge than carbon.

C Silicon has a smaller first ionisation energy than carbon.

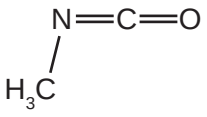
D Silicon is more metallic than carbon.

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7 Methyl isocyanate, CH_3NCO, is a toxic liquid which is used in the manufacture of some pesticides.

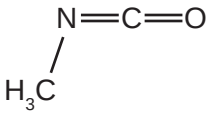
What is the approximate angle between the bonds formed by the N atom in a molecule of methyl isocyanate?

A



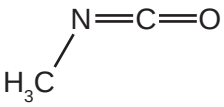
104°

B



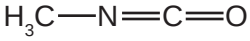
109°

C



120°

D



180°

8 Methanol may be prepared by the reaction between carbon monoxide and hydrogen.

$$CO(g) + 2H_2(g) \rightarrow CH_3OH(g)$$

The relevant average bond energies are given below.

$E(C \equiv O)$ 1077 kJ mol^{-1}

$E(C-O)$ 360 kJ mol^{-1}

$E(C-H)$ 410 kJ mol^{-1}

$E(H-H)$ 436 kJ mol^{-1}

$E(O-H)$ 460 kJ mol^{-1}

What is the enthalpy change of this reaction?

A –537 kJ mol^{-1}

B –101 kJ mol^{-1}

C +101 kJ mol^{-1}

D +537 kJ mol^{-1}

9 The equilibrium constant, K_c, for the reaction shown is 2 mol^{-2} dm^6, at 600 K.

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

What is the concentration of NH_3 at equilibrium, at 600 K, when the equilibrium concentrations of N_2 and H_2 are both 2 mol dm^{-3}?

A $\sqrt{8}$ mol dm^{-3} **B** $\sqrt{16}$ mol dm^{-3} **C** $\sqrt{32}$ mol dm^{-3} **D** 32 mol dm^{-3}

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10 Sulfur dioxide is used as a preservative in wine making.

The following equations describe the reactions that occur when sulfur dioxide dissolves in water.

$$H_2O + SO_2 \rightleftharpoons HSO_3^- + H^+$$

$$HSO_3^- + H^+ \rightleftharpoons SO_3^{2-} + 2H^+$$

Which statement about **these two reactions** is correct?

A HSO_3^- acts as a base.

B SO_2 acts as an oxidising agent.

C SO_3^{2-} acts as an acid.

D SO_3^{2-} acts as a reducing agent.

11 Catalysts are an important feature of many industrial processes and biochemical reactions.

Which row correctly describes the effect of a catalyst on a reversible chemical reaction?

	position of equilibrium	effect on value of ΔH
A	moved to right	decreased
B	unaffected	decreased
C	unaffected	increased
D	unaffected	unaffected

12 The oxide and chloride of an element **X** are separately mixed with water. The two resulting solutions have the same effect on litmus.

What could element **X** be?

A A*l* **B** Ca **C** Na **D** P

13 Each pair below consists of a sample of two separate elements. Each element is in its standard state at room temperature and pressure.

Which pair of elements has chemical bonds of the same type between their atoms?

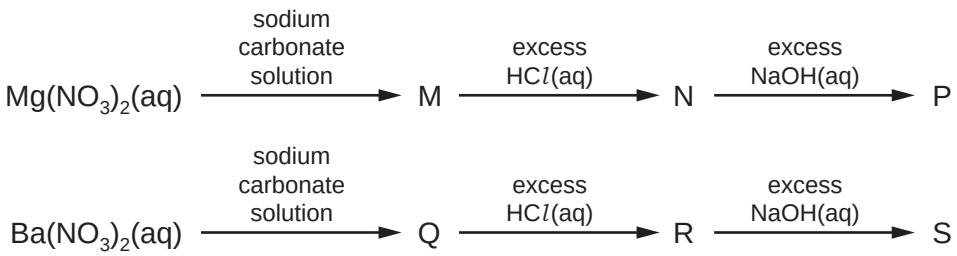
A aluminium and phosphorus

B chlorine and argon

C magnesium and silicon

D sulfur and chlorine

14 Solutions of $Mg(NO_3)_2$ and $Ba(NO_3)_2$ separately undergo a series of reactions.



M, N and P are magnesium compounds.

Q, R and S are barium compounds.

How many of M, N, P, Q, R and S are white precipitates?

A 2 **B** 3 **C** 4 **D** 5

15 Anhydrous magnesium nitrate, $Mg(NO_3)_2$, will decompose when heated, giving a white solid and a mixture of two gases X and Y.

Y is oxygen.

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

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

16 Steam is passed over heated magnesium to give compound J and hydrogen.

What is **not** a property of compound J?

A It has an M_r of 40.3.

B It is basic.

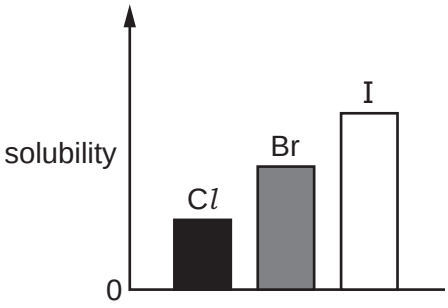
C It is a white solid.

D It is very soluble in water.

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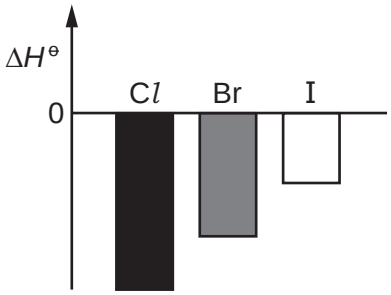
17 Two students, P and Q, were asked to draw bar charts to represent how some properties of the halogens and their compounds differ in magnitude. Their diagrams are shown. The bar charts show trends only and not actual values.

student P



solubility of AgX(s) in $NH_3(aq)$

student Q



$\Delta H^{\ominus}$ for $H_2(g) + X_2(g) \rightarrow 2HX(g)$

Which of the students have drawn bar charts which show the trends correctly?

A both P and Q

B P only

C Q only

D neither P nor Q

18 In a series of nine experiments to test the reactivity of the halogens, an aqueous solution of each halogen was added to an equal volume of an aqueous solution containing halide ions as shown in the table below.

solution	sodium chloride (aq)	sodium bromide (aq)	sodium iodide (aq)
chlorine (aq)	experiment 1	experiment 2	experiment 3
bromine (aq)	experiment 4	experiment 5	experiment 6
iodine (aq)	experiment 7	experiment 8	experiment 9

The nine resulting mixtures were then shaken with hexane. The nine tubes were corked and left to stand so that the aqueous and organic solvents could separate into layers.

How many test-tubes contained a purple upper layer?

A 1 **B** 2 **C** 3 **D** 5

19 Which statement does **not** describe an effect of acid rain on the environment?

A Acid rain causes erosion of stone buildings.

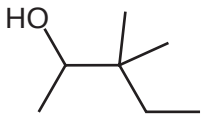
B Acid rain causes ozone depletion.

C Acid rain increases the corrosion of some metals.

D Acid rain increases the leaching away of essential nutrients and minerals from soils.

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20 What is the correct name of the molecule with the skeletal formula shown?



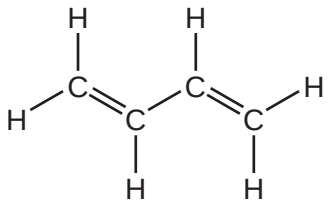
A 1,2,2-trimethylbutan-3-ol

B 2-ethyl-2-methylbutan-2-ol

C 3,3-dimethylpentan-2-ol

D 4-hydroxy-3,3-dimethylpentane

21 The diagram shows the structure of 1,3-butadiene.



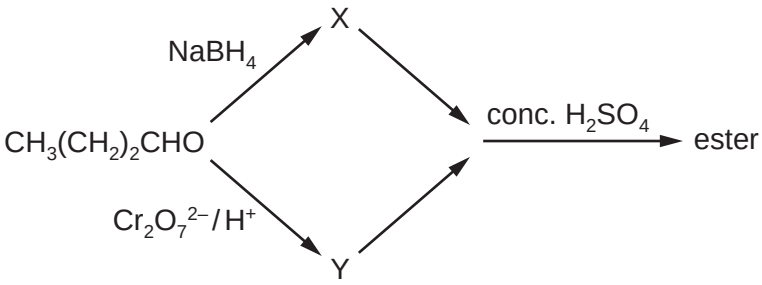
1,3-butadiene

The addition reaction between 1,3-butadiene and two molecules of hydrogen bromide can produce three structurally isomeric products.

How many of these products have at least one chiral centre?

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

22 An ester with an aroma of pineapples can be synthesised in the laboratory from butanal using this reaction scheme.



What is the structural formula of the **ester**?

A $CH_3(CH_2)_2CO_2(CH_2)_2CH_3$

B $CH_3(CH_2)_2CO_2(CH_2)_3CH_3$

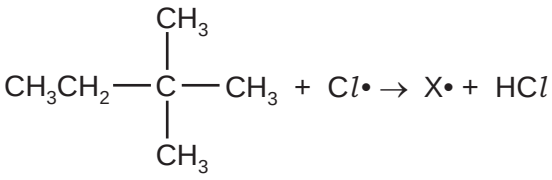
C $CH_3(CH_2)_3CO_2(CH_2)_2CH_3$

D $CH_3(CH_2)_3CO_2(CH_2)_3CH_3$

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23 When heated with chlorine, the hydrocarbon 2,2-dimethylbutane undergoes free radical substitution.

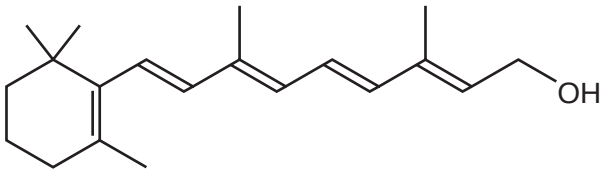
In a propagation step a free radical X• is formed.



How many different structures of X• are possible?

A 2 **B** 3 **C** 4 **D** 5

24 Vitamin A contains retinol.



retinol

Under appropriate conditions, acidified $KMnO_4(aq)$ can be used to break apart C=C bonds.

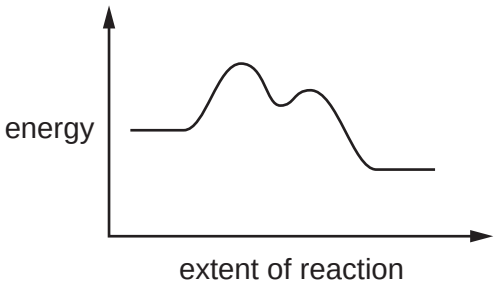
After these bonds have been broken, further oxidation of the fragments may occur.

Under which conditions is the acidified $KMnO_4(aq)$ used and what do the final oxidation products include?

	conditions	final oxidation products
A	cold, dilute	aldehydes and carboxylic acids
B	cold, dilute	ketones and carboxylic acids
C	hot, concentrated	aldehydes and carboxylic acids
D	hot, concentrated	ketones and carboxylic acids

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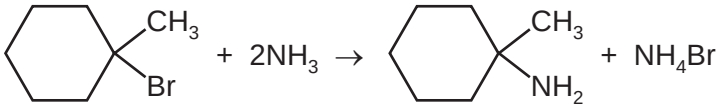
25 A reaction pathway diagram is shown.

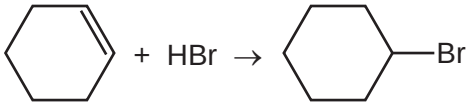


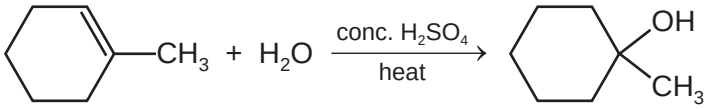
The four reactions that follow are all exothermic.

Which reaction would **not** have such a pathway?

A $CH_3I + NaCN \rightarrow CH_3CN + NaI$

B 

C 

D 

26 Which volume of oxygen, at room temperature and pressure, is needed for complete combustion of 1.0 mol of methylpropan-1-ol?

A 108 dm^3 **B** 144 dm^3 **C** 156 dm^3 **D** 288 dm^3

27 An unknown organic compound reacts with sodium to give a combustible gas as one product but does **not** give a yellow precipitate with alkaline aqueous iodine.

What is a possible identity of the unknown organic compound?

A propanal

B propan-1-ol

C propan-2-ol

D propanone

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28 Which reaction will give 2-chloropropane in the best yield?

A propane gas with chlorine gas in the presence of ultraviolet light

B propan-2-ol with dilute NaCl(aq)

C propan-2-ol with SOCl_2(l)

D propene with dilute HCl(aq)

29 The ester, $CH_3CH_2CO_2CH_3$, is hydrolysed by boiling with aqueous sodium hydroxide.

Which compound is one of the products?

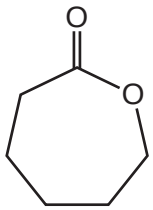
A ethanol

B propan-1-ol

C sodium methanoate

D sodium propanoate

30 Caprolactone is a cyclic ester. It is being used increasingly for the manufacture of specialist polymers.



caprolactone

From which compound could caprolactone be made by a single reaction?

A $OHCCH_2CH_2CH_2CH_2CHO$

B $HOCH_2CH_2CH_2CH_2CH_2CH_2OH$

C $HOCH_2CH_2CH_2CH_2CH_2CO_2H$

D $HO_2CCH_2CH_2CH_2CH_2CO_2H$

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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.

31 Compound X is made from two elements. One element has the second highest value of first ionisation energy in its group and the other element has the third highest value of first ionisation energy in its group.

Which compounds could be compound X?

1 calcium chloride

2 magnesium bromide

3 potassium sulfide

32 Water has some unusual physical properties compared to other hydrides of Group 16 elements. Some of these properties are due to hydrogen bonds. These intermolecular forces are much stronger in water than they are in H_2S, for example.

Which statements are correct?

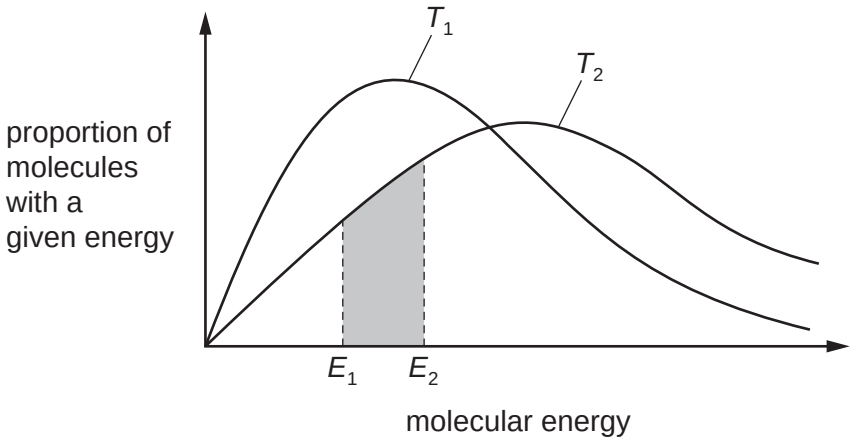
1 Hydrogen bonds cause the melting point of ice to be higher than expected.

2 Hydrogen bonds cause the surface tension of water to be higher than expected.

3 Hydrogen bonds cause the viscosity of water to be higher than expected.

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33 The diagram shows the Boltzmann distribution of molecular energies in one mole of a gas at two temperatures, T_1 and T_2.



Which statements are correct?

1 The shaded area represents the proportion of molecules with energies between E_1 and E_2 at temperature T_2.

2 No particles have zero energy at either temperature.

3 T_2 is a lower temperature than T_1.

34 When $KClO_3$ is heated, the following reaction occurs.

$$4KClO_3 \rightarrow 3KClO_4 + KCl$$

Which statements are correct?

1 The oxidation state of Cl in $KClO_3$ is +5.

2 The oxidation state of some Cl atoms decreases by 6.

3 The reaction involves disproportionation.

35 Why is the first ionisation energy of aluminium less than that of magnesium?

1 The outer electron in the aluminium atom is more shielded from the nuclear charge.

2 The outer electron in the aluminium atom is in a higher energy orbital.

3 The outer electron in the aluminium atom is further from the nucleus.

36 Ammonia is a colourless gas that is produced by the Haber process.

Which statements about ammonia are correct?

1 An ammonia molecule has three bond pairs and one lone pair of electrons.

2 If ammonia is bubbled into water the pH of the solution will increase.

3 Ammonia gas can be made by warming ammonium sulfate with aqueous hydrochloric acid.

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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.

37 Halogenoalkanes show trends in their physical and chemical properties.

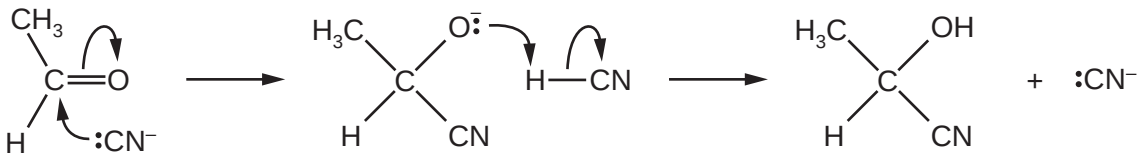
Which properties steadily increase from C_2H_5Cl to C_2H_5Br to C_2H_5I ?

1 the polarity of the carbon-halogen bond

2 the boiling point of the halogenoalkane

3 the rate of reaction of the halogenoalkane with nucleophiles

38 Ethanal and hydrogen cyanide react together to form a compound used in the production of acrylic fibres. The reaction mechanism involves cyanide ions.



Which statements about this mechanism are correct?

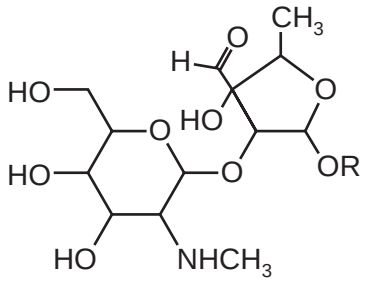
1 CN^- acts as a catalyst.

2 CN^- is a nucleophile.

3 It is an addition reaction.

39 Which compounds will give an orange precipitate with 2,4-dinitrophenylhydrazine reagent?

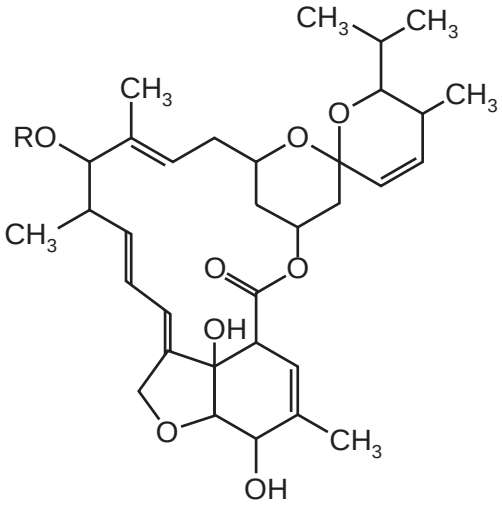
1



[R is an inert group]

streptomycin

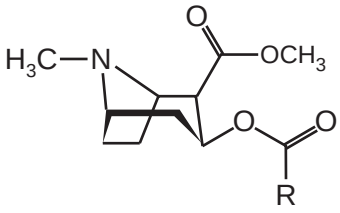
2



[R is an inert group]

avermectin B_{1b}

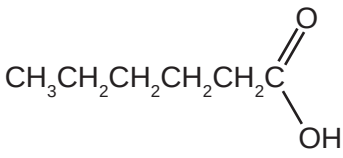
3

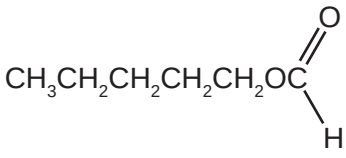


[R is an inert group]

cocaine

40 The structural formulae of two compounds are shown below.





Which statements about these compounds are correct?

1 The two compounds are structural isomers of each other.

2 The empirical formula of both compounds is C_3H_6O.

3 Both compounds are carboxylic acids.

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