

Cambridge AS & A Level

CHEMISTRY

Paper 1

Topical Past Paper Questions
+ Answer Scheme

2015 - 2021



Chapter 13

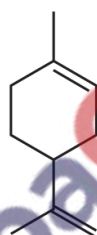
An introduction to AS Level organic chemistry

13.1 Formulae, functional groups and the naming of organic compounds

741. 9701_s21_qp_11 Q: 23

Limonene is a hydrocarbon found in the rind of citrus fruits.

limonene



What is the molecular formula of limonene?

- A** $C_{10}H_{12}$ **B** $C_{10}H_{14}$ **C** $C_{10}H_{16}$ **D** $C_{10}H_{18}$
-

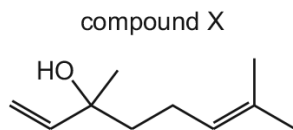
742. 9701_m20_qp_12 Q: 2

For which hydrocarbon are the molecular and empirical formulae the same?

- A** butane
B ethane
C pent-1-ene
D propane
-

743. 9701_w20_qp_11 Q: 30

The skeletal formula of compound X is shown.

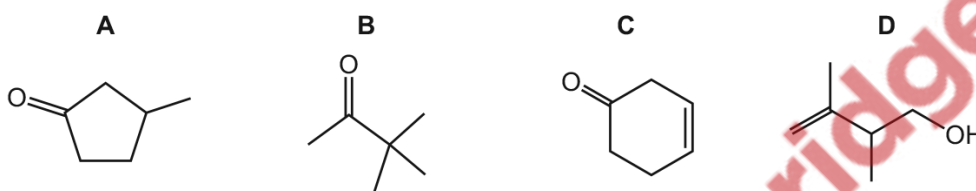


What is the molecular formula of compound X?

- A $C_{10}H_{18}O$ B $C_{10}H_{20}O$ C $C_{11}H_{22}O$ D $C_{11}H_{24}O$

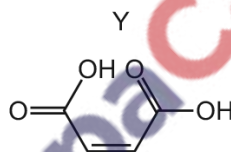
744. 9701_s19_qp_11 Q: 21

Which compound has the molecular formula $C_6H_{10}O$?



745. 9701_s19_qp_13 Q: 21

The diagram shows the skeletal formula of compound Y.

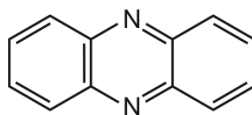


What is the empirical formula of Y?

- A CHO B CH_2O_2 C C_2HO_2 D $C_4H_4O_4$

746. 9701_w19_qp_12 Q: 21

The diagram shows the skeletal formula of phenazine.



phenazine

What is the empirical formula of phenazine?

- A C_6H_4N B C_6H_6N C $C_{12}H_8N_2$ D $C_{12}H_{12}N_2$

747. 9701_m18_qp_12 Q: 23

Which compound reacts with 2,4-dinitrophenylhydrazine reagent but does **not** react with Tollens' reagent?

- A $\text{CH}_3\text{COCO}_2\text{H}$
- B $\text{CH}_3\text{CH}(\text{OH})\text{CHO}$
- C CH_3COCHO
- D $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$

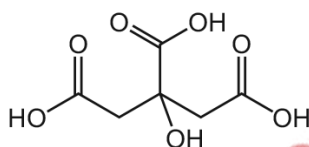
748. 9701_s18_qp_11 Q: 2

Which compound has a boiling point that is influenced by hydrogen bonding?

- A CH_3CHO
- B CH_3OCH_3
- C HCO_2CH_3
- D HCO_2H

749. 9701_w17_qp_12 Q: 21

The diagram shows the skeletal formula of citric acid.



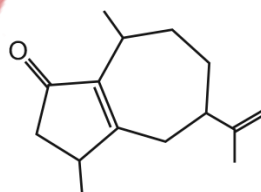
citric acid

What is the molecular formula of citric acid?

- A $\text{C}_6\text{H}_8\text{O}_7$
- B $\text{C}_6\text{H}_4\text{O}_7$
- C $\text{C}_8\text{H}_8\text{O}_7$
- D $\text{C}_{10}\text{H}_8\text{O}_7$

750. 9701_w16_qp_12 Q: 21

The compound rotundone is responsible for the peppery smell of pepper and is also found in some red wines.



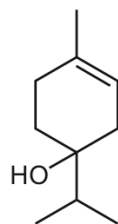
rotundone

How many hydrogen atoms are in one molecule of rotundone?

- A 15
- B 19
- C 22
- D 24

751. 9701_s15_qp_12 Q: 25

Terpinen-4-ol is one of the active ingredients in tea tree oil.



terpinen-4-ol

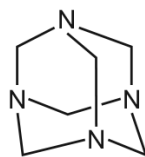
What is the molecular formula of terpinen-4-ol?

- A** C₇H₁₁O **B** C₁₀H₁₆O **C** C₁₀H₁₇O **D** C₁₀H₁₈O

752. 9701_w15_qp_11 Q: 9

Hexamine is a crystalline solid used as a fuel in portable stoves.

The diagram shows its skeletal structure.

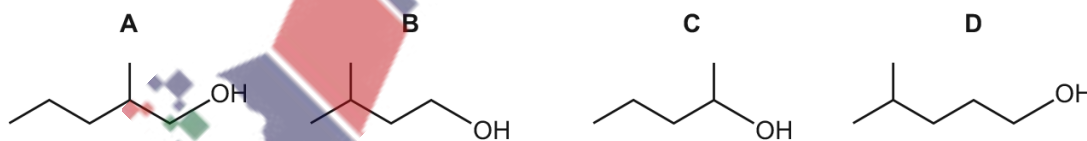


What is the empirical formula of hexamine?

- A** CH₂N **B** C₃H₆N₂ **C** C₄H₈N₄ **D** C₆H₁₂N₄

753. 9701_w15_qp_12 Q: 29

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



13.2 Characteristic organic reactions

754. 9701_m21_qp_12 Q: 22

Which row is correct?

	type of reaction	mechanism
A	addition	electrophilic
B	addition	nucleophilic
C	substitution	nucleophilic
D	substitution	free-radical

755. 9701_w18_qp_11 Q: 20

What is true of **every** nucleophile?

- A** It attacks a double bond.
- B** It donates a lone pair of electrons.
- C** It is a single atom.
- D** It is negatively charged.

756. 9701_w17_qp_11 Q: 24

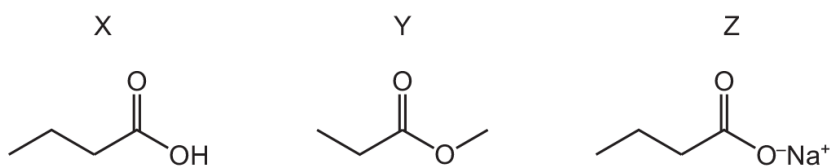
Which organic reaction is an example of nucleophilic substitution?

- A** $\text{CH}_3\text{CH}_2\text{Br} + \text{NaOH} \rightarrow \text{CH}_2\text{CH}_2 + \text{H}_2\text{O} + \text{NaBr}$
 - B** $\text{CH}_3\text{CH}_2\text{Br} + \text{NaOH} \rightarrow \text{CH}_3\text{CH}_2\text{OH} + \text{NaBr}$
 - C** $\text{CH}_2\text{CH}_2 + \text{HCl} \rightarrow \text{C}_2\text{H}_5\text{Cl}$
 - D** $\text{C}_2\text{H}_6 + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{HCl}$
-

13.3 Shapes of organic molecules; σ and π bonds

757. 9701_s21_qp_12 Q: 3

The structures represent three compounds, each with four carbon atoms per molecule.

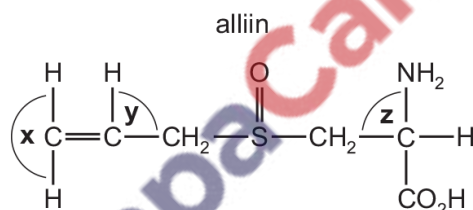


Which row is correct?

	lowest boiling point	→	highest boiling point
A	X	Y	Z
B	Y	X	Z
C	Z	X	Y
D	Z	Y	X

758. 9701_s21_qp_12 Q: 4

The structural formula of alliin is shown.



What are the approximate bond angles x , y and z in a molecule of alliin?

	x	y	z
A	90°	90°	109°
B	120°	109°	90°
C	120°	120°	109°
D	180°	109°	109°

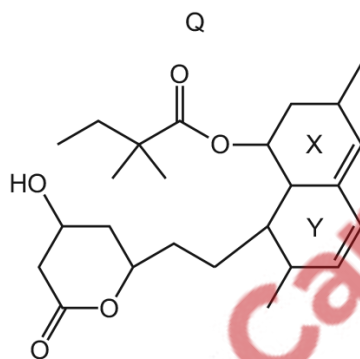
759. 9701_w21_qp_11 Q: 18

Which row is correct?

	shape		bonds present	
	ammonia molecule	ammonium ion	ammonia molecule	ammonium ion
A	pyramidal	regular tetrahedral	σ	σ
B	pyramidal	regular tetrahedral	σ	π
C	regular tetrahedral	pyramidal	σ	σ
D	regular tetrahedral	pyramidal	π	σ

760. 9701_m20_qp_12 Q: 30

The diagram shows the structure of compound Q.



Two of the rings, X and Y, contain a C=C bond.

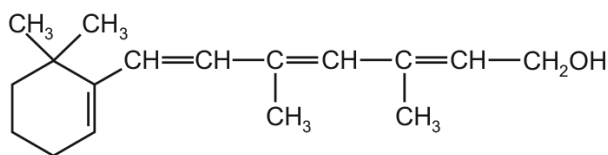
Which row is correct?

	number of ester groups in one molecule of Q	description of rings X and Y
A	1	both are planar
B	1	neither is planar
C	2	both are planar
D	2	neither is planar

761. 9701_w20_qp_12 Q: 4

The structure of compound A is shown.

compound A



Some of the carbon atoms in compound A have a tetrahedral arrangement of bonds.

Some of the carbon atoms in compound A have a trigonal planar arrangement of bonds.

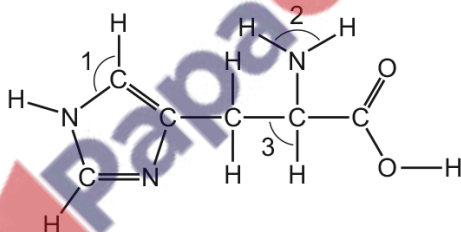
How many carbon atoms are there of each type?

	tetrahedral	trigonal planar
A	5	12
B	8	8
C	9	6
D	9	8

762. 9701_m19_qp_12 Q: 5

Histidine is an amino acid.

histidine



What are the approximate bond angles 1, 2, and 3?

	1	2	3
A	109.5	107	90
B	120	107	109.5
C	120	120	90
D	120	120	109.5

763. 9701_w19_qp_11 Q: 4

Four compounds are shown.


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

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

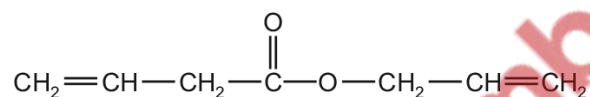
764. 9701_w19_qp_12 Q: 20

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

 How many isomers with the formula C_5H_{10} have structures that involve π bonding?

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

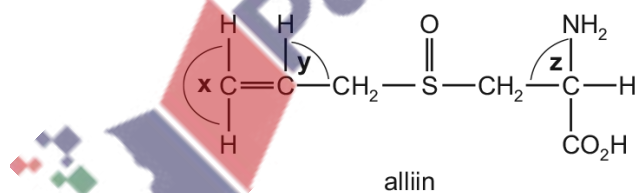
765. 9701_w18_qp_12 Q: 21

 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

766. 9701_m17_qp_12 Q: 5

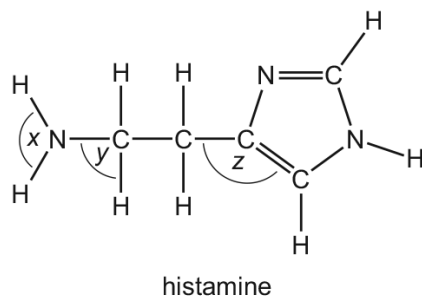
The characteristic smell of garlic is due to alliin.


 What are the approximate bond angles **x**, **y** and **z** in a molecule of alliin?

	x	y	z
A	90°	90°	109°
B	120°	109°	90°
C	120°	120°	109°
D	180°	109°	109°

767. 9701_w16_qp_11 Q: 6

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

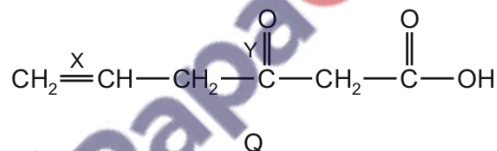


What are the bond angles *x*, *y* and *z* in histamine, from the smallest to the largest?

	smallest bond angle	→	largest bond angle
A	<i>x</i>		<i>z</i>
B	<i>y</i>		<i>z</i>
C	<i>y</i>		<i>x</i>
D	<i>z</i>		<i>x</i>

768. 9701_w15_qp_11 Q: 23

Compound Q contains three double bonds per molecule.



Which bond, X or Y, will be ruptured by hot, concentrated acidified KMnO₄ and how many lone pairs of electrons are present in one molecule of Q?

	bond ruptured by hot, concentrated acidified KMnO ₄	number of lone pairs
A	X	5
B	X	6
C	Y	5
D	Y	6

13.4 Isomerism: structural and stereoisomerism

769. 9701_m22_qp_12 Q: 26

In this question, alkenes and cyclic alkanes should be considered.

How many **structural** isomers of C_4H_8 are there?

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

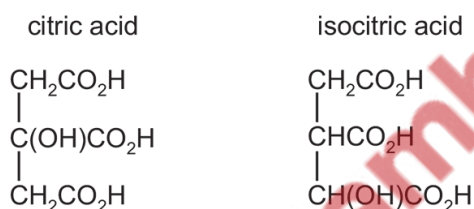
770. 9701_m22_qp_12 Q: 36

What is the least number of carbon atoms in a non-cyclic alkane molecule that has a chiral centre?

- A** 7 **B** 8 **C** 9 **D** 10

771. 9701_m21_qp_12 Q: 20

The structures of citric acid and isocitric acid are shown.

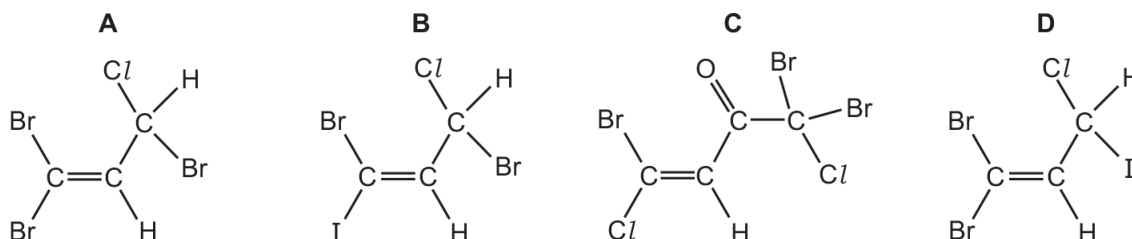


How many chiral centres does each acid possess?

	citric acid	isocitric acid
A	1	1
B	1	2
C	0	1
D	0	2

772. 9701_s21_qp_11 Q: 22

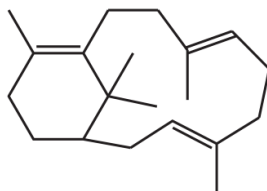
Which compound could show **both** *cis-trans* isomerism and optical isomerism?



773. 9701_s21_qp_12 Q: 20

Compound P is treated with an excess of hydrogen gas in the presence of a nickel catalyst. The product Q is fully saturated.

compound P



What is the number of chiral carbon atoms in the product Q?

- A 4 B 5 C 6 D 7

774. 9701_s21_qp_13 Q: 20

Which compound shows stereoisomerism?

- A 2-methylbut-2-ene
 B 2-chloropropan-1-ol
 C difluorochlorobromomethane
 D pent-1-ene

775. 9701_w21_qp_11 Q: 22

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

A colourless liquid, $C_5H_{11}Cl$, exists as a mixture of two optical isomers.

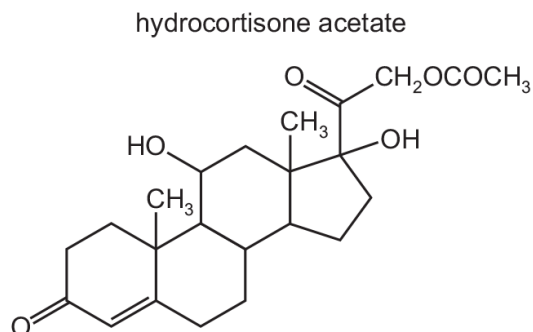
When heated with sodium hydroxide in ethanol, a mixture of **only two** alkenes is formed.

What could the colourless liquid be?

- A $(CH_3CH_2)_2CHCl$
 B $CH_3CH_2CH_2CHClCH_3$
 C $CH_3CH_2CCl(CH_3)_2$
 D $(CH_3)_2CHCHClCH_3$

776. 9701_w21_qp_12 Q: 20

The formula of hydrocortisone acetate is shown.



Which row is correct?

	number of C atoms in one molecule	number of chiral atoms in one molecule
A	22	7
B	22	8
C	23	7
D	23	8

777. 9701_w21_qp_12 Q: 22

Structural and stereoisomerism should be taken into account when answering this question.

Y is a gaseous hydrocarbon which decolourises aqueous bromine. It contains no rings.

10.0 g of Y occupies a volume of 3.43 dm³ under room conditions.

How many isomeric structures are possible for Y?

- A** 4 **B** 5 **C** 6 **D** 7

778. 9701_m20_qp_12 Q: 20

Which pair of compounds are functional group isomers of each other?

- A** butan-1-ol and butanal
B ethylpropanoate and pentanoic acid
C hex-1-ene and hex-2-ene
D propylamine and propanenitrile

779. 9701_m20_qp_12 Q: 25

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

How many non-cyclic isomers have the molecular formula C_5H_{10} ?

- A 3 B 4 C 5 D 6

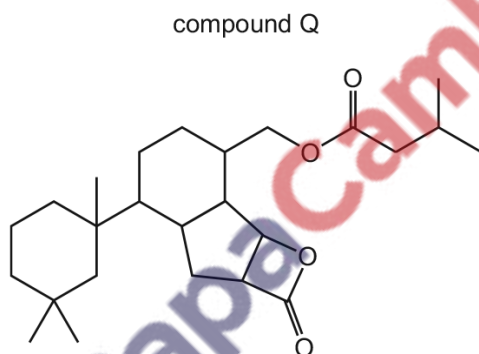
780. 9701_s20_qp_11 Q: 21

Which statement is correct?

- A 2,2-dimethylpropanoic acid is an isomer of propyl methanoate.
 B 2-methylbutan-2-ol is an isomer of hexan-3-ol.
 C 3-methylbutan-2-one is an isomer of pentanal.
 D 3,3-dimethylbutan-2-one is an isomer of pentan-3-one.

781. 9701_s20_qp_11 Q: 28

The structure of compound Q is shown.

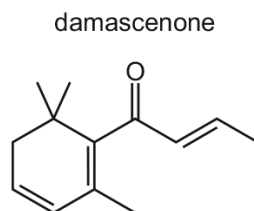


How many chiral centres are present in a molecule of Q?

- A 4 B 5 C 6 D 7

782. 9701_s20_qp_12 Q: 26

The structure of damascenone is shown.



Including damascenone, how many stereoisomers exist with this structural formula?

- A** 1 **B** 2 **C** 4 **D** 8

783. 9701_s20_qp_12 Q: 27

How many isomeric esters have the molecular formula $C_4H_8O_2$?

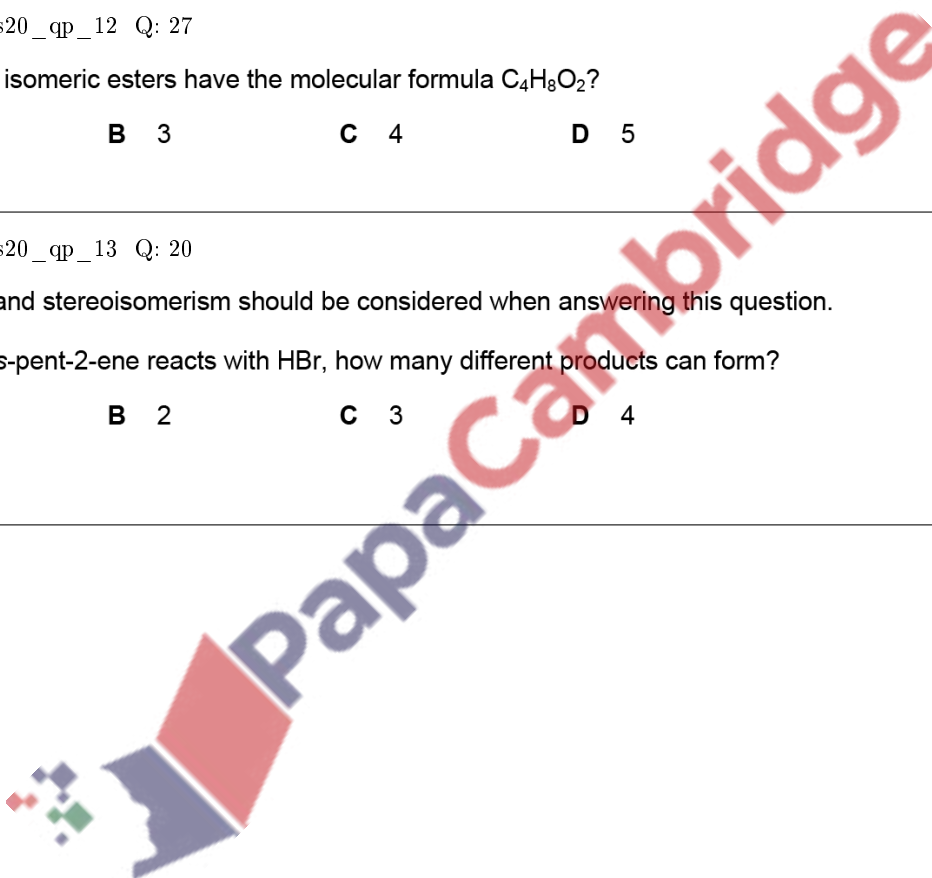
- A** 2 **B** 3 **C** 4 **D** 5

784. 9701_s20_qp_13 Q: 20

Structural and stereoisomerism should be considered when answering this question.

When *trans*-pent-2-ene reacts with HBr, how many different products can form?

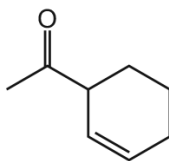
- A** 1 **B** 2 **C** 3 **D** 4



785. 9701_s20_qp_13 Q: 30

Compound X has the structure shown.

compound X



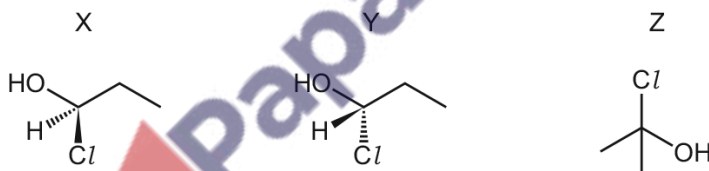
Which type of carbonyl group is present and how many chiral centres are there in one molecule of X?

	carbonyl group	chiral centres
A	aldehyde	0
B	aldehyde	1
C	ketone	0
D	ketone	1

786. 9701_w20_qp_11 Q: 20

Structural and stereoisomerism should be considered when answering this question.

Compounds X, Y and Z are shown.



How many other isomers of C_3H_7ClO are there that are alcohols?

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

787. 9701_w20_qp_12 Q: 20

The unsaturated hydrocarbon octa-1,3,5,7-tetraene, C_8H_{10} , can display geometric isomerism.

octa-1,3,5,7-tetraene



How many isomers exist?

- A** 2 **B** 3 **C** 4 **D** 8

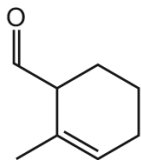
788. 9701_m19_qp_12 Q: 20

 How many structural isomers are there of trichloropropane, $C_3H_5Cl_3$?

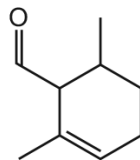
- A** 3 **B** 4 **C** 5 **D** 6

789. 9701_s19_qp_11 Q: 20

The diagrams show two different compounds.



1



2

What is

- the total number of structural isomers, including compound 2, that could be formed by adding a second methyl group to the ring of compound 1,
- the number of π electrons in each compound?

	number of isomers	number of π electrons
A	3	2
B	3	4
C	5	2
D	5	4

790. 9701_s19_qp_11 Q: 30

Which compound is chiral?

- A** 1-chloro-3-methylbutane
B 2-chloro-2-methylbutane
C 2-chloro-3-methylbutane
D 3-chloropentane

791. 9701_s19_qp_12 Q: 21

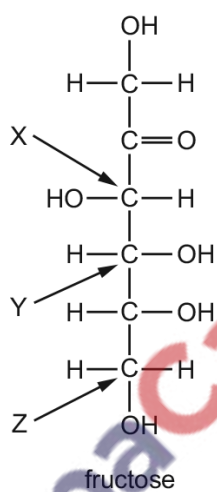
Compound X does **not** show cis-trans isomerism.

What could be the identity of compound X?

- A 1,1,2-trichloropropene
- B 1,2,3-trichloropropene
- C 1-chlorobut-1-ene
- D 1-chlorobut-2-ene

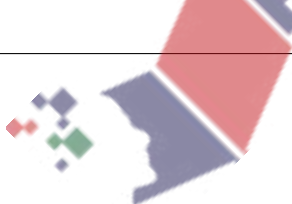
792. 9701_s18_qp_11 Q: 20

Fructose is a sugar with more than one chiral centre. The fructose molecule is shown with X, Y and Z indicating three carbon atoms.



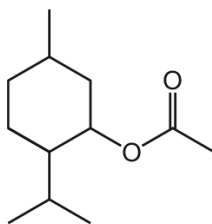
Which carbon atoms are chiral centres?

- A X, Y and Z
- B X and Y only
- C X only
- D Y only



793. 9701_s18_qp_13 Q: 20

Molecule G is shown.



G

How many chiral centres are present in each molecule of G?

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

794. 9701_s18_qp_13 Q: 27

 Considering **only** structural isomers, what is the number of alcohols of each type with the formula $C_5H_{12}O$?

	primary	secondary	tertiary
A	3	3	2
B	4	2	2
C	4	3	1
D	5	2	1

795. 9701_w18_qp_11 Q: 21

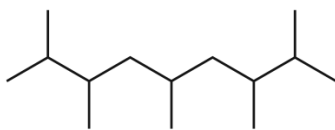
 X has the molecular formula $C_5H_{12}O$. X has a branched carbon skeleton and a secondary alcohol functional group.

 How many **structural isomers** fit this description of X?

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

796. 9701_w18_qp_11 Q: 22

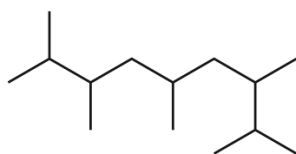
A new jet fuel has been produced that is a mixture of different structural isomers of compound Q.



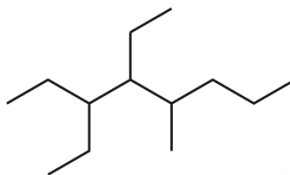
Q

Which skeletal formula represents a **structural isomer** of Q?

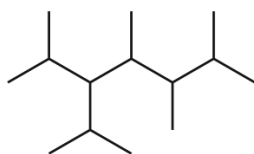
A



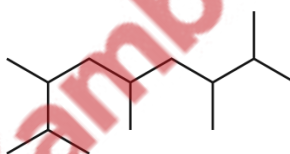
B



C



D



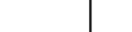
797. 9701_w18_qp_12 Q: 20

There are three structural isomers with the formula C_5H_{12} .

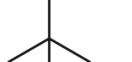
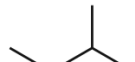
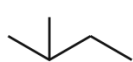
Which formulae correctly represent these three structural isomers?

- A $CH_3CH_2CH_2CH_2CH_3$ $CH_3CH(CH_3)CH_2CH_3$ $C(CH_3)_4$
 B $CH_3CH_2CH_2CH_2CH_3$ $CH_3CH(CH_3)CH_2CH_3$ $CH_3CH_2CH(CH_3)CH_3$

C



D



798. 9701_m17_qp_12 Q: 20

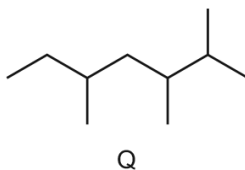
Structural isomerism and stereoisomerism should be considered when answering this question.

How many isomers with the formula C_4H_8 have structures that contain a π bond?

- A 1 B 2 C 3 D 4

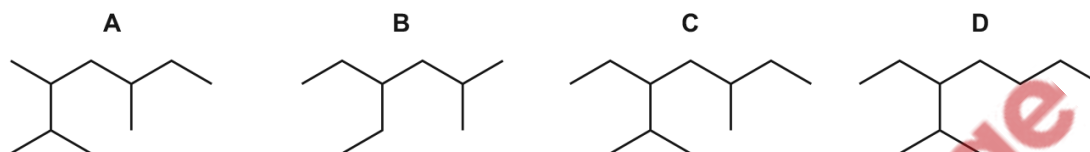
799. 9701_m17_qp_12 Q: 21

Kerosene is used as an aircraft fuel. Q is one of the molecules in kerosene and has the skeletal formula shown.



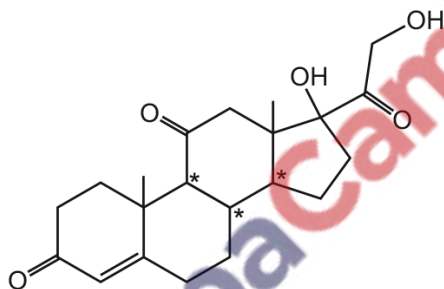
Other structural isomers of this molecule are also found in kerosene.

Which structure is a structural isomer of Q?



800. 9701_s17_qp_11 Q: 21

The drug cortisone has the formula shown.

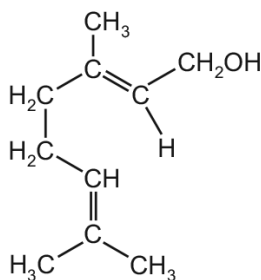


In addition to those chiral centres marked by an asterisk (*), how many **other** chiral centres are present in the cortisone molecule?

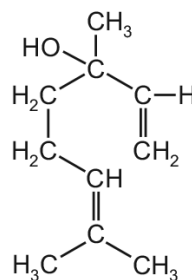
- A** 0 **B** 1 **C** 2 **D** 3

801. 9701_s17_qp_12 Q: 21

Geraniol and linalool are compounds found in some flower fragrances.



geraniol



linalool

Which statement is correct?

- A They are chain isomers of each other.
 B They are geometrical isomers of each other.
 C They are optical isomers of each other.
 D They are positional isomers of each other.

802. 9701_s17_qp_13 Q: 20

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

Which formula identifies a **single** substance?

- A $\text{CH}_3\text{CHClCH}_2\text{CHO}$
 B $\text{CH}_3\text{CHCHCH}_3$
 C $\text{CH}_2\text{ClCH}_2\text{CHCl}_2$
 D C_4H_{10}

803. 9701_s17_qp_13 Q: 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.

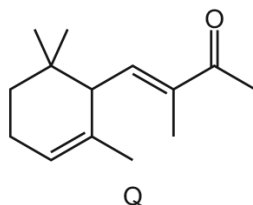
How many isomers are there with

- molecular formula $\text{C}_7\text{H}_{14}\text{O}$ and
- a five-membered ring and
- a tertiary alcohol group?

- A 4 B 5 C 9 D 13

804. 9701_w17_qp_11 Q: 20

The structural formula of compound Q is shown.



How many stereoisomers exist with this structural formula?

- A 1 B 2 C 4 D 8

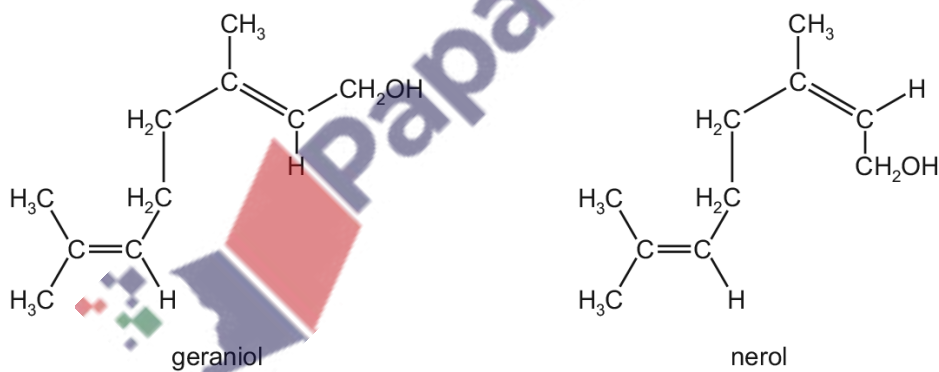
805. 9701_w17_qp_12 Q: 20

Which compound does **not** exhibit stereoisomerism?

- A $\text{CH}_3\text{CHClCH}_2\text{CHO}$
 B $\text{CH}_3\text{CHCHCH}_3$
 C $\text{CH}_2\text{ClCH}_2\text{CCl}_2\text{H}$
 D CHClCHCl

806. 9701_m16_qp_12 Q: 21

Geraniol and nerol are compounds found in some flower fragrances. They are isomers of each other.

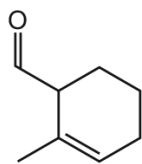


Which type of isomerism is shown here?

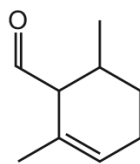
- A chain
 B geometrical (cis-trans)
 C optical
 D positional

807. 9701_s16_qp_11 Q: 20

The diagrams show two different compounds.



1



2

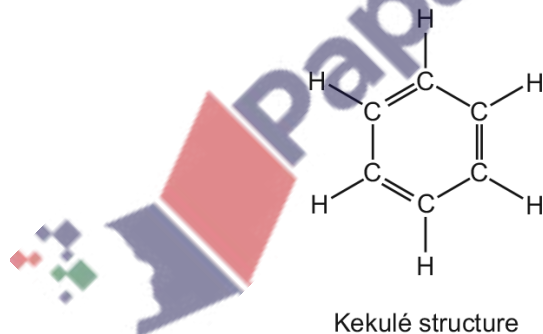
What is

- the total number of structural isomers, including compound 2, that could be formed by adding a second methyl group to the ring of compound 1,
- the number of π electrons in each compound?

	number of isomers	number of π electrons
A	3	2
B	3	4
C	5	2
D	5	4

808. 9701_w16_qp_11 Q: 20

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

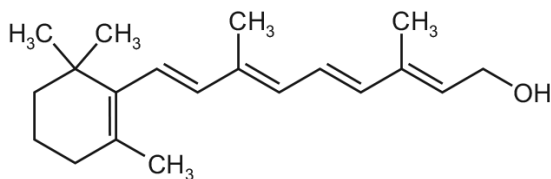


In this structure all of the bonds remain in the places shown. Assuming this is the structure of benzene, how many isomers of dichlorobenzene, $C_6H_4Cl_2$, would exist?

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

809. 9701_w16_qp_11 Q: 21

The diagram shows the structure of vitamin A.



vitamin A

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

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

810. 9701_w16_qp_12 Q: 24

Which statement about stereoisomers is correct?

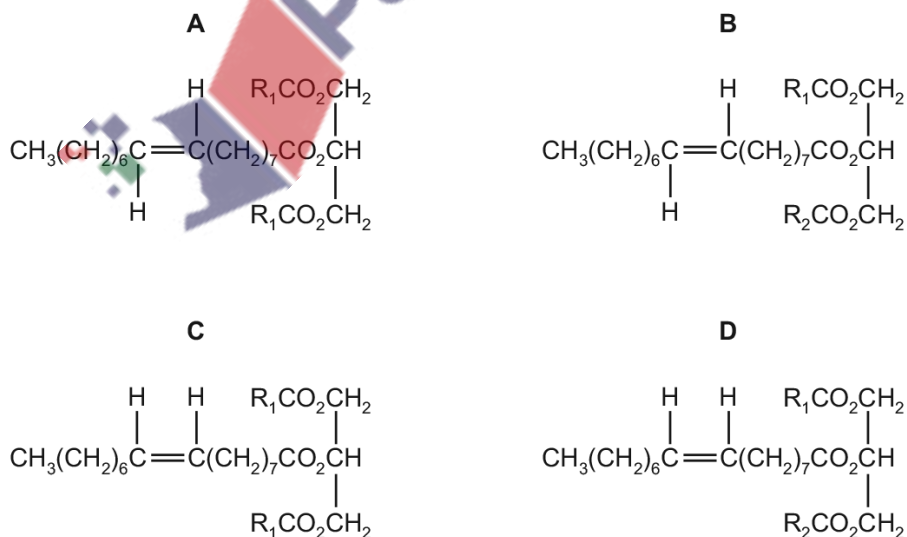
- A** Cis-trans isomers are mirror images of each other.
B Optical isomers must contain a double bond that restricts rotation.
C Stereoisomers have the same structural formula as each other.
D Stereoisomers must contain a chiral centre.

811. 9701_w16_qp_12 Q: 30

Some vegetable oils contain 'trans fats' that are associated with undesirable increases in the amount of cholesterol in the blood. In these oils the word 'trans' describes, in the usual way, the arrangement of groups at a C=C double bond.

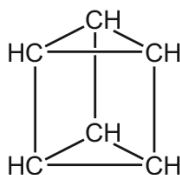
In the diagrams below, R₁ and R₂ are different unbranched hydrocarbon chains.

Which diagram correctly shows an optically active 'trans fat'?



812. 9701_s15_qp_11 Q: 28

In 1869 Ladenburg suggested a structure for benzene, C_6H_6 , in which one hydrogen atom is attached to each carbon atom.



Ladenburg structure

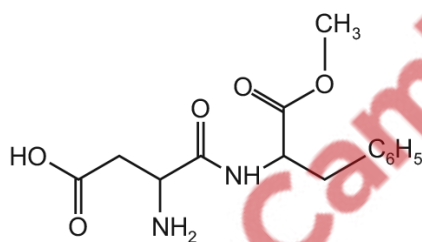
A compound $C_6H_4Cl_2$ could be formed with **the same** carbon skeleton as the Ladenburg structure.

How many **structural** isomers would this compound have?

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

813. 9701_s15_qp_13 Q: 27

The compound *aspartame* is widely used as a sweetener in 'diet' soft drinks.



aspartame

Aspartame is chiral. (There are no chiral carbon atoms in C_6H_5 .)

How many chiral carbon atoms are present in a molecule of *aspartame*?

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

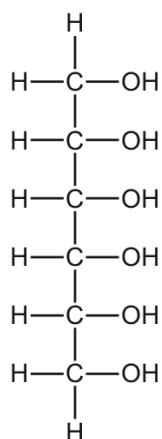
814. 9701_w15_qp_11 Q: 20

How many isomeric esters have the molecular formula $C_4H_8O_2$?

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

815. 9701_w15_qp_11 Q: 29

Sorbitol is a naturally-occurring compound with a sweet taste. It is often used as a substitute for sucrose by the food industry.



sorbitol

How many chiral centres are present in sorbitol?


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

816. 9701_w15_qp_12 Q: 21

Which compound shows optical isomerism?

- A** 2-chloropropane
B 1,2-dichloropropane
C 1,3-dichloropropane
D 2,2-dichloropropane
-



 PapaCambridge