CAMBRIDGE INTERNATIONAL AS & A LEVEL CHEMISTRY · 9701

CHEMISTRY



EXAM QUESTION PACK

13 AN INTRODUCTION TO AS LEVEL ORGANIC CHEMISTRY

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Chapter 13

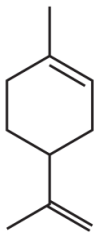
An introduction to AS Level organic chemistry

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** $C_{10}H_{18}$

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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

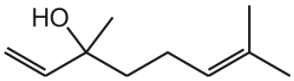
D propane

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743. 9701_w20_qp_11 Q: 30

The skeletal formula of compound X is shown.

compound X



What is the molecular formula of compound X?

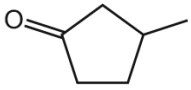
A $C_{10}H_{18}O$ **B** $C_{10}H_{20}O$ **C** $C_{11}H_{22}O$ **D** $C_{11}H_{24}O$

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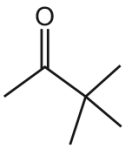
744. 9701_s19_qp_11 Q: 21

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

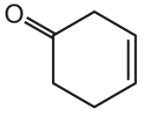
A



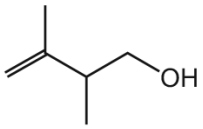
B



C



D

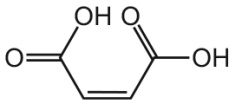


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745. 9701_s19_qp_13 Q: 21

The diagram shows the skeletal formula of compound Y.

Y



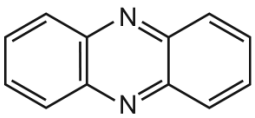
What is the empirical formula of Y?

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 CH_3COCO_2H

B $CH_3CH(OH)CHO$

C CH_3COCHO

D $CH_3CH(OH)CH_3$

---

748. 9701_s18_qp_11 Q: 2

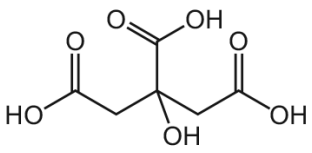
Which compound has a boiling point that is influenced by hydrogen bonding?

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

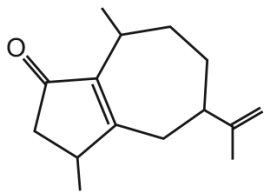
What is the molecular formula of citric acid?

A $C_6H_8O_7$ **B** $C_6H_4O_7$ **C** $C_8H_8O_7$ **D** $C_{10}H_8O_7$

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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

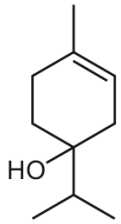
How many hydrogen atoms are in one molecule of rotundone?

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?

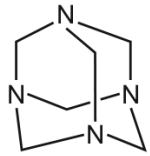
A $C_7H_{11}O$ **B** $C_{10}H_{16}O$ **C** $C_{10}H_{17}O$ **D** $C_{10}H_{18}O$

---

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?

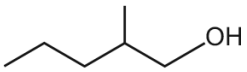
A CH_2N **B** $C_3H_6N_2$ **C** $C_4H_8N_4$ **D** $C_6H_{12}N_4$

---

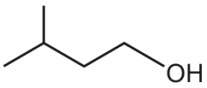
753. 9701_w15_qp_12 Q: 29

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

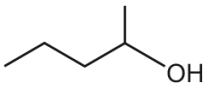
A



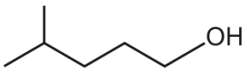
B



C



D



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 $CH_3CH_2Br + NaOH \rightarrow CH_2CH_2 + H_2O + NaBr$

B $CH_3CH_2Br + NaOH \rightarrow CH_3CH_2OH + NaBr$

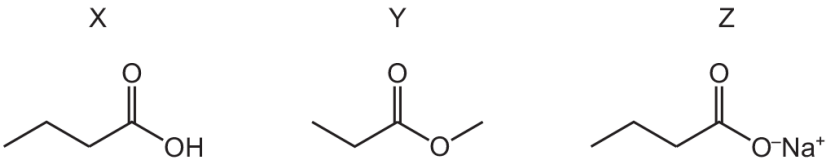
C $CH_2CH_2 + HCl \rightarrow C_2H_5Cl$

D $C_2H_6 + Cl_2 \rightarrow C_2H_5Cl + HCl$

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?

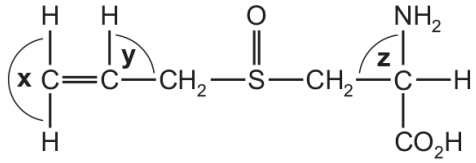
	lowest boiling point	→	highest boiling point
A	X	Y	Z
B	Y	X	Z
C	Z	X	Y
D	Z	Y	X

---

758. 9701_s21_qp_12 Q: 4

The structural formula of alliin is shown.

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°

---

759. 9701_w21_qp_11 Q: 18

Which row is correct?

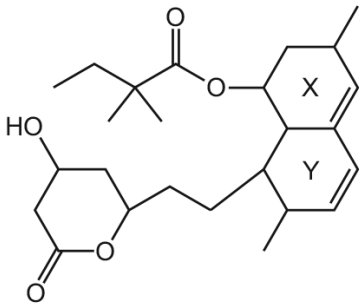
	shape		bonds present	
	ammonia molecule	ammonium ion	ammonia molecule	ammonium ion
A	pyramidal	regular tetrahedral	σ	σ
B	pyramidal	regular tetrahedral	σ	π
C	regular tetrahedral	pyramidal	σ	σ
D	regular tetrahedral	pyramidal	π	σ

---

760. 9701_m20_qp_12 Q: 30

The diagram shows the structure of compound Q.

Q



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

Which row is correct?

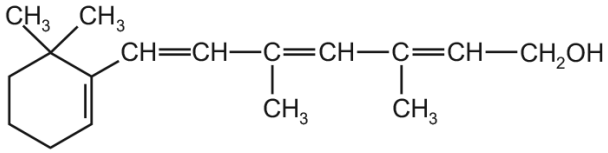
	number of ester groups in one molecule of Q	description of rings X and Y
A	1	both are planar
B	1	neither is planar
C	2	both are planar
D	2	neither is planar

---

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?

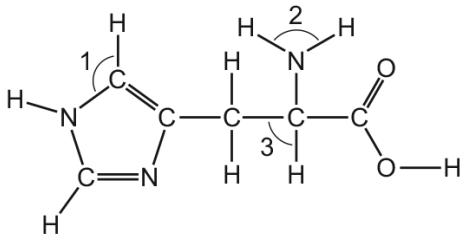
	tetrahedral	trigonal planar
A	5	12
B	8	8
C	9	6
D	9	8

---

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.

C_2H_4 C_2H_5OH CH_3CHO CH_3CO_2H

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

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

---

764. 9701_w19_qp_12 Q: 20

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

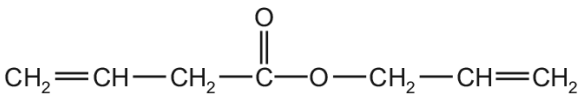
How many isomers with the formula C_5H_{10} have structures that involve π bonding?

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.



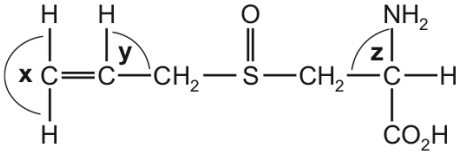
How many σ bonds are present in this molecule?

A 15 **B** 17 **C** 18 **D** 21

---

766. 9701_m17_qp_12 Q: 5

The characteristic smell of garlic is due to alliin.



alliin

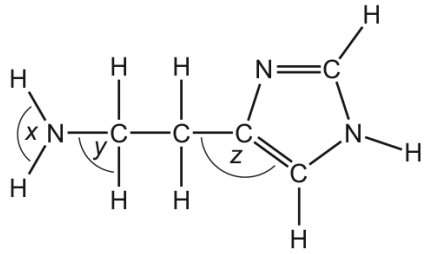
What are the approximate bond angles **x**, **y** and **z** in a molecule of alliin?

	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.



histamine

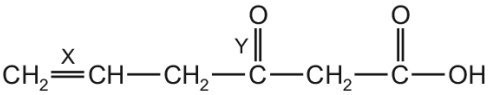
What are the bond angles *x*, *y* and *z* in histamine, from the smallest to the largest?

	smallest bond angle → largest bond angle		
A	*x*	*y*	*z*
B	*y*	*x*	*z*
C	*y*	*z*	*x*
D	*z*	*y*	*x*

---

768. 9701_w15_qp_11 Q: 23

Compound Q contains three double bonds per molecule.



Q

Which bond, X or Y, will be ruptured by hot, concentrated acidified $KMnO_4$ 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?

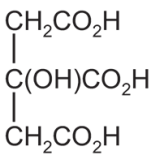
A 7 **B** 8 **C** 9 **D** 10

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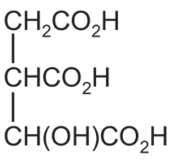
771. 9701_m21_qp_12 Q: 20

The structures of citric acid and isocitric acid are shown.

citric acid



isocitric acid



How many chiral centres does each acid possess?

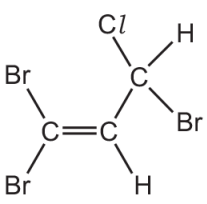
	citric acid	isocitric acid
A	1	1
B	1	2
C	0	1
D	0	2

---

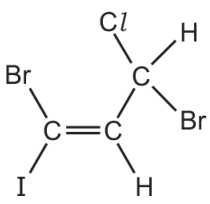
772. 9701_s21_qp_11 Q: 22

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

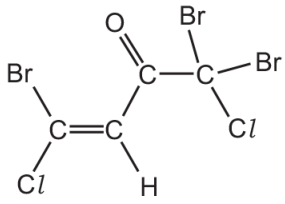
A



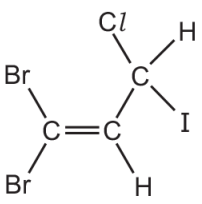
B



C



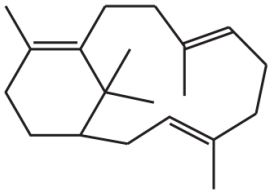
D



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 $CH_3CH_2CCl(CH_3)_2$

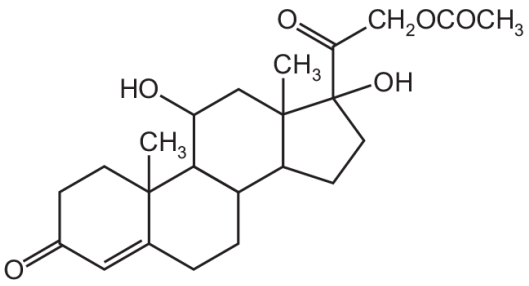
D $(CH_3)_2CHCHClCH_3$

---

776. 9701_w21_qp_12 Q: 20

The formula of hydrocortisone acetate is shown.

hydrocortisone acetate



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 dm^3 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.

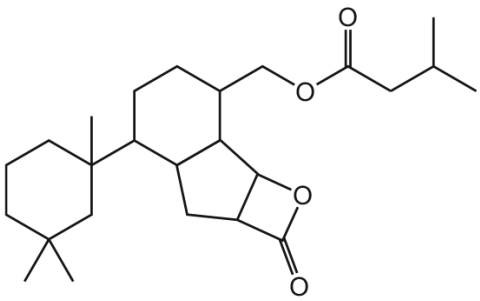
D 3,3-dimethylbutan-2-one is an isomer of pentan-3-one.

---

781. 9701_s20_qp_11 Q: 28

The structure of compound Q is shown.

compound Q



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

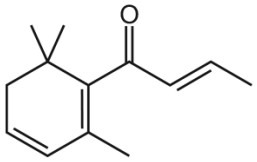
A 4 **B** 5 **C** 6 **D** 7

---

782. 9701_s20_qp_12 Q: 26

The structure of damascenone is shown.

damascenone



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?

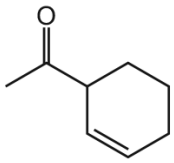
A 1 **B** 2 **C** 3 **D** 4

---

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

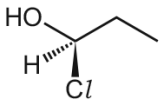
---

786. 9701_w20_qp_11 Q: 20

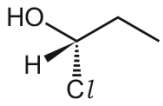
Structural and stereoisomerism should be considered when answering this question.

Compounds X, Y and Z are shown.

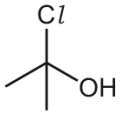
X



Y



Z



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

CH_2=CHCH=CHCH=CHCH=CH_2

How many isomers exist?

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

---

788. 9701_m19_qp_12 Q: 20

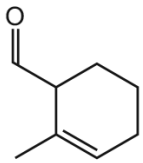
How many structural isomers are there of trichloropropane, $C_3H_5Cl_3$?

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

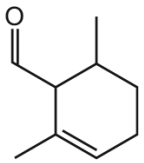
---

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

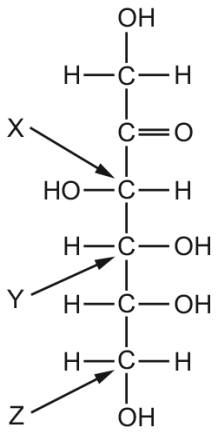
C 1-chlorobut-1-ene

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.



fructose

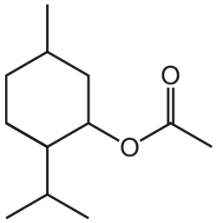
Which carbon atoms are chiral centres?

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.

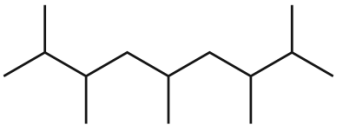
How many **structural** isomers fit this description of X?

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

---

796. 9701_w18_qp_11 Q: 22

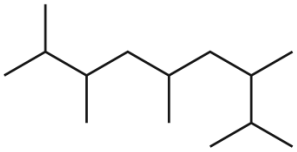
A new jet fuel has been produced that is a mixture of different structural isomers of compound Q.



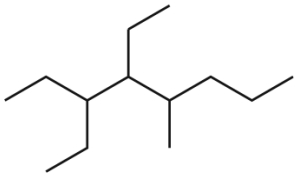
Q

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

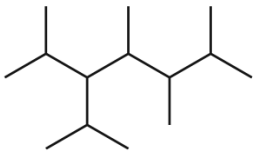
A



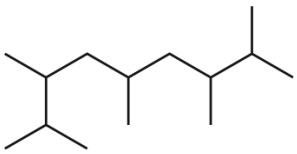
B



C



D



---

797. 9701_w18_qp_12 Q: 20

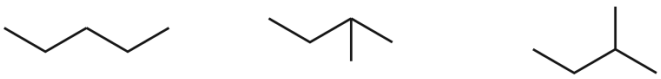
There are three structural isomers with the formula C_5H_{12}.

Which formulae correctly represent these three structural isomers?

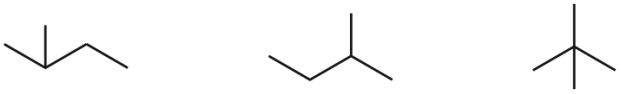
A $CH_3CH_2CH_2CH_2CH_3$ $CH_3CH(CH_3)CH_2CH_3$ $C(CH_3)_4$

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.

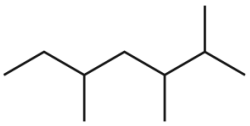
How many isomers with the formula C_4H_8 have structures that contain a π bond?

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.

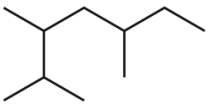


Q

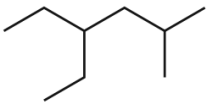
Other structural isomers of this molecule are also found in kerosene.

Which structure is a structural isomer of Q?

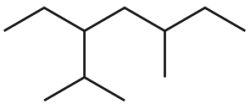
A



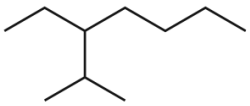
B



C



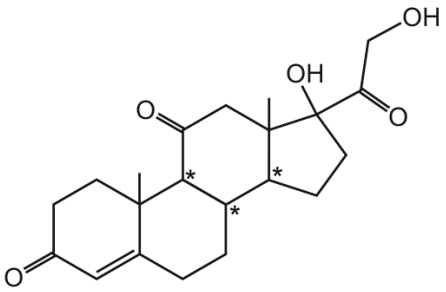
D



---

800. 9701_s17_qp_11 Q: 21

The drug cortisone has the formula shown.



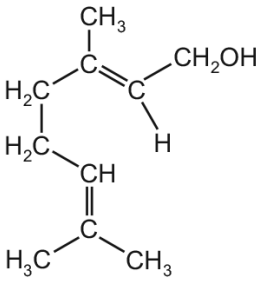
In addition to those chiral centres marked by an asterisk (*), how many **other** chiral centres are present in the cortisone molecule?

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

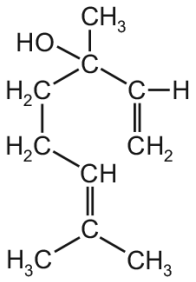
---

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 $CH_3CHCl CH_2CHO$

B $CH_3CHCHCH_3$

C $CH_2Cl CH_2CHCl_2$

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

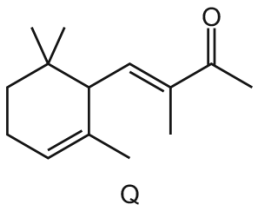
- molecular formula $C_7H_{14}O$ **and**
- a five-membered ring **and**
- a tertiary alcohol group?

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

---

804. 9701_w17_qp_11 Q: 20

The structural formula of compound Q is shown.



Q

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 $CH_3CHClCH_2CHO$

B $CH_3CHCHCH_3$

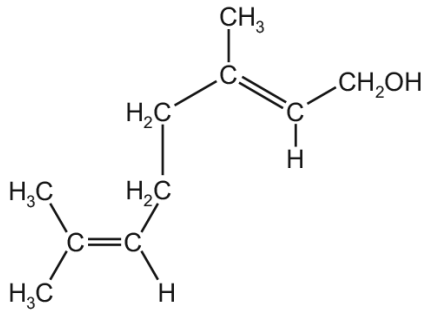
C $CH_2ClCH_2CCl_2H$

D $CHClCHCl$

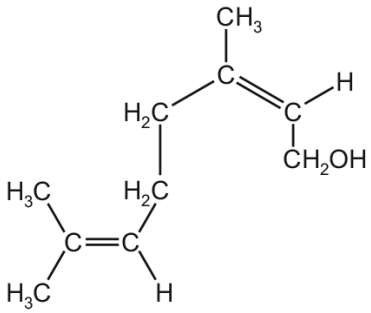
---

806. 9701_m16_qp_12 Q: 21

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



geraniol



nerol

Which type of isomerism is shown here?

A chain

B geometrical (cis-trans)

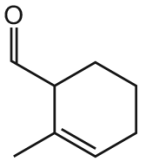
C optical

D positional

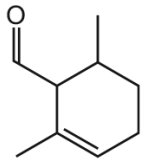
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807. 9701_s16_qp_11 Q: 20

The diagrams show two different compounds.



1



2

What is

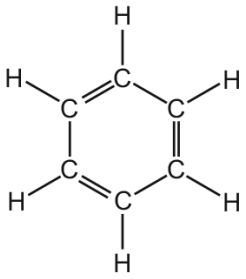
- the total number of structural isomers, including compound 2, that could be formed by adding a second methyl group to the ring of compound 1,
- the number of π electrons in each compound?

	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.



Kekulé structure

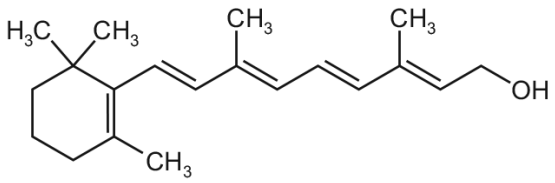
In this structure all of the bonds remain in the places shown. Assuming this is the structure of benzene, how many isomers of dichlorobenzene, $C_6H_4Cl_2$, would exist?

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.

---

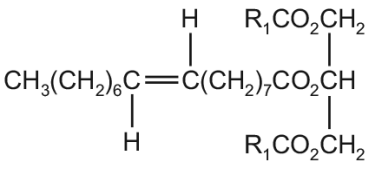
811. 9701_w16_qp_12 Q: 30

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.

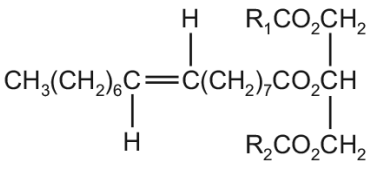
In the diagrams below, R_1 and R_2 are different unbranched hydrocarbon chains.

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

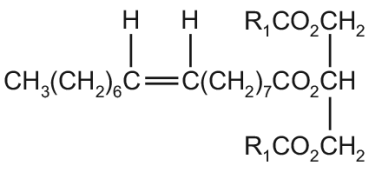
A



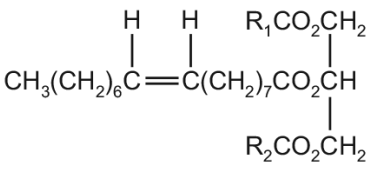
B



C



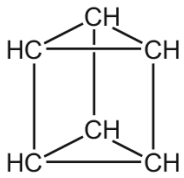
D



---

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.

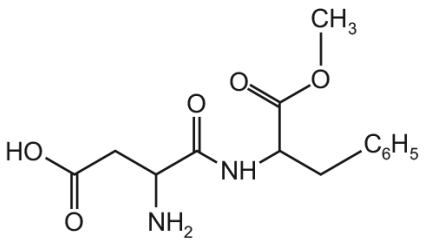
How many **structural** isomers would this compound have?

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

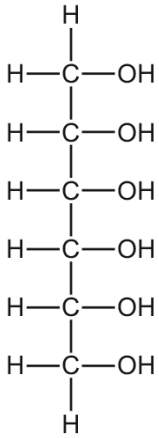
How many isomeric esters have the molecular formula $C_4H_8O_2$?

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

Chapter 13

An introduction to organic chemistry

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13.1 Formulae, functional groups, the naming of organic compounds

88. 9701_w16_qp_21 Q: 4

In each section of this question an organic compound is shown. For each compound give its name and answer the questions about it.

(a) $CH_3CH_2CH(CH_3)CH=CHCH_3$

(i) name ..... [1]

(ii) This compound shows stereoisomerism.

Define *stereoisomerism.*

.....

.....

..... [1]

(iii) State and explain how many stereoisomers of this structure there are.

.....

.....

.....

.....

.....

..... [4]

(b) $(CH_3)_2C=C(CH_3)_2$

(i) name ..... [1]

(ii) Draw the **skeletal** formula of the organic product of the reaction of this compound with cold, dilute, acidified manganate(VII) ions.

[1]

(iii) Name the organic product of the reaction of this compound with hot, concentrated, acidified manganate(VII) ions.

..... [1]

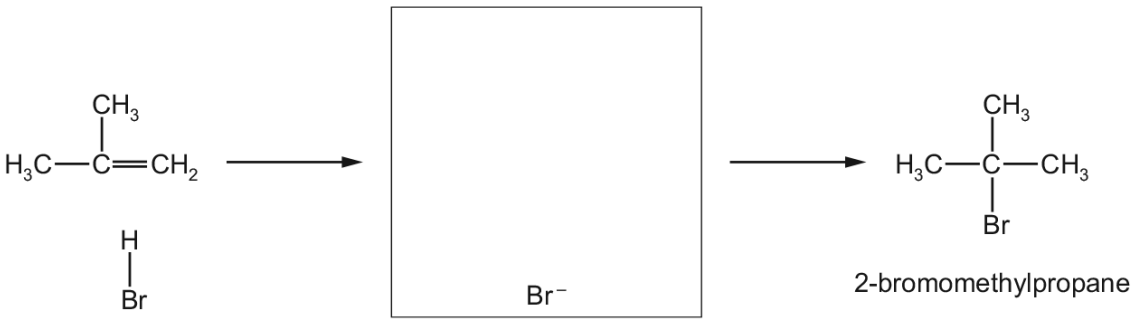
(iv) Draw the structure of part of a molecule of the addition polymer formed from this compound, showing exactly **three** repeat units.

[1]

(c) $(CH_3)_2C=CH_2$

(i) name ..... [1]

(ii) Complete the mechanism for the reaction of this compound with hydrogen bromide. Include all necessary curly arrows, lone pairs, charges and partial charges.



[4]

(iii) Explain fully why 2-bromomethylpropane is the major product of this reaction while only relatively small amounts of 1-bromomethylpropane are produced.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 18]

13.2 Shapes of organic molecules; σ and π bonds

89. 9701_m20_qp_22 Q: 1

Group 2 metals form alkaline solutions in water.

(a) (i) Write the equation for the reaction of calcium oxide with water.

..... [1]

(ii) Identify the ion that causes an aqueous solution to be alkaline.

..... [1]

(b) The table shows the melting points of some Group 2 metal oxides.

compound	melting point/°C
MgO	2825
CaO	2613
SrO	2531
BaO	1923

Explain the trend in the melting points of the oxides down Group 2.

.....

.....

..... [2]

(c) Oxygen reacts readily with some metals, but each Group 2 metal requires strong heating to start the reaction with oxygen.

Suggest why strong heating is required to start these reactions.

.....

..... [1]

(d) Beryllium oxide reacts with hydrochloric acid to form molecules of $BeCl_2$.

Deduce the bond angle in $BeCl_2$.

..... [1]

(e) Unlike the other oxides of Group 2 metals, beryllium oxide is amphoteric.

(i) Give the meaning of the term *amphoteric*.

.....

..... [1]

(ii) Beryllium oxide and aluminium oxide have similar chemical properties.

The $Be(OH)_4^{2-}$ anion is a product of the reaction between beryllium oxide and excess concentrated $OH^-(aq)$.

Construct an equation for this reaction.

..... [1]

(f) Magnesium oxide reacts reversibly with chlorine according to the following equation.

$$2MgO(s) + 2Cl_2(g) \rightleftharpoons 2MgCl_2(s) + O_2(g)$$

Under certain conditions, a dynamic equilibrium is established.

(i) State **two** features of a reaction that is in dynamic equilibrium.

1 .....

2 .....
[2]

(ii) The equilibrium constant, K_p, is given by the following expression.

$$K_p = \frac{p_{O_2}}{p_{Cl_2}^2}$$

At 1.00×10^5 Pa and 500 K, 70% of the initial amount of $Cl_2(g)$ has reacted.

Calculate K_p and state its units.

K_p = ...

units = ...
[3]

(g) Magnesium peroxide, MgO_2, is made in the following reaction.

$$MgO(s) + H_2O_2(l) \rightarrow MgO_2(s) + H_2O(l) \qquad \Delta H = -96\,kJ\,mol^{-1}$$

compound	enthalpy change of formation, ΔH_f / kJ mol^{-1}
MgO(s)	–602
$H_2O_2(l)$	–188
$H_2O(l)$	–286

(i) The peroxide ion is O_2^{2-}.

Deduce the average oxidation number of oxygen in the peroxide ion.

..... [1]

(ii) Define the term *enthalpy change of formation*.

.....

.....

..... [2]

(iii) Use the data given to calculate the enthalpy change of formation of $MgO_2(s)$.

ΔH_f $MgO_2(s)$ = ... kJ mol^{-1} [2]

(iv) Magnesium peroxide decomposes slowly to form magnesium oxide and oxygen.

$$MgO_2(s) \rightarrow MgO(s) + \tfrac{1}{2}O_2(g)$$

Use your answer to **(g)(iii)** and the data in the table to calculate the enthalpy change of this reaction.

If you were unable to obtain an answer to **(g)(iii)**, *use the value* $\Delta H_f = -550\,kJ\,mol^{-1}$. *This is* ***not*** *the correct answer.*

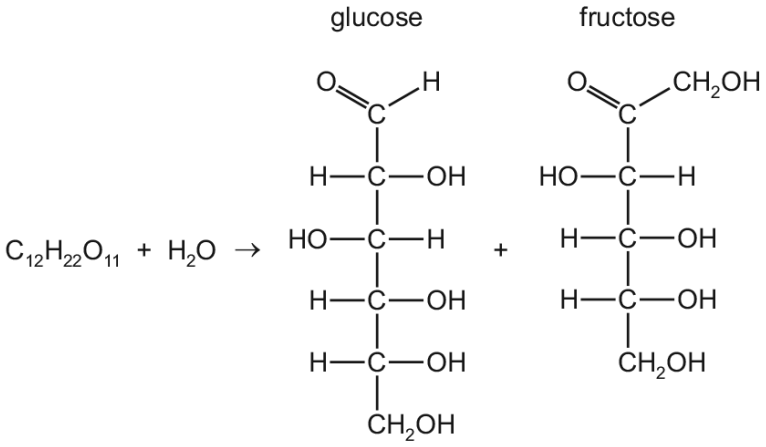
enthalpy change of reaction = ... $kJ\,mol^{-1}$ [1]

[Total: 19]

13.3 Isomerism: structural and stereoisomerism

90. 9701_s20_qp_22 Q: 3

Sucrose, $C_{12}H_{22}O_{11}$, reacts with water to form glucose and fructose in reaction **A**.



reaction **A**

(a) Suggest a name for this type of reaction.

..... [1]

(b) Explain in detail, why glucose and fructose are a pair of structural isomers. Your answer should refer specifically to these two molecules.

.....

.....

..... [2]

(c) Reaction **A** occurs faster in the presence of an enzyme. This is reaction **B**.

(i) The activation energy for reaction **B** is +29 kJ mol^{-1}.

Predict a value for the activation energy of reaction **A**.

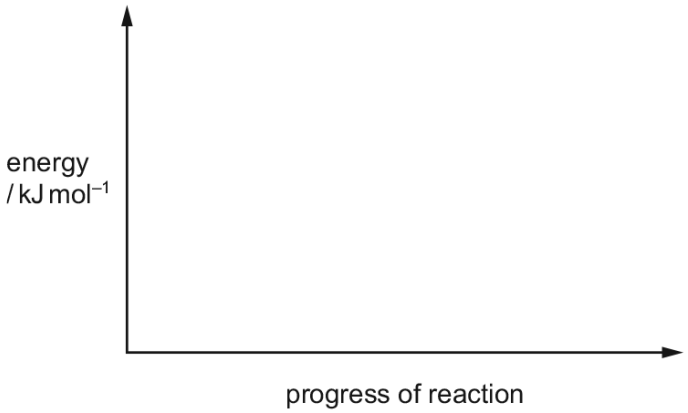
..... [1]

(ii) The enthalpy change for reaction **A** is –14 kJ mol^{-1}.

Predict a value for the enthalpy change for reaction **B**.

..... [1]

(iii) Sketch a labelled energy level diagram for reaction **B**. Use relevant values from **(c)(i)** and **(c)(ii)**.



[2]

(d) 1.00 g of sucrose, $C_{12}H_{22}O_{11}$, is completely combusted. The heat energy produced is used to increase the temperature of 250 g of water inside a calorimeter from 25.0 °C to 40.7 °C.

These data can be used to calculate the enthalpy change of combustion of sucrose.

(i) Explain what is meant by the term *enthalpy change of combustion of sucrose*.

.....

.....

..... [2]

(ii) Use the *Data Booklet* to calculate the enthalpy change, in kJ mol^{-1}, for the combustion of sucrose.
Assume that all of the heat energy produced is transferred to the water.

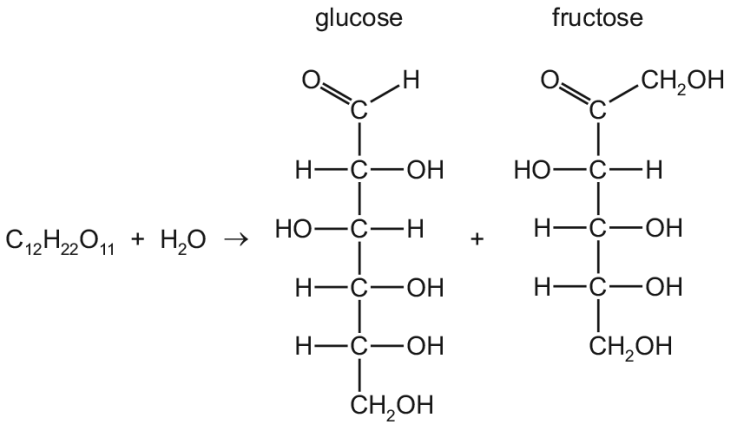
Show your working.

enthalpy change of combustion of sucrose = ... kJ mol^{-1}
[3]

[Total: 12]

91. 9701_s20_qp_23 Q: 3

Sucrose is a white crystalline solid, $C_{12}H_{22}O_{11}$. In reaction **Z**, sucrose reacts with water in the presence of a catalyst, aqueous hydrochloric acid, to form glucose and fructose.



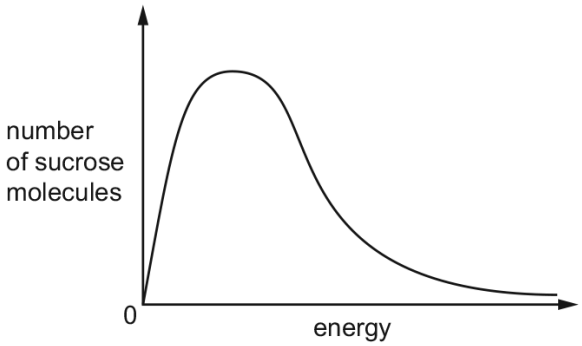
reaction **Z**

(a) (i) Suggest a name for the reaction that occurs when sucrose reacts with water to form glucose and fructose.

..... [1]

(ii) If no catalyst is added in reaction **Z**, the reaction is very slow.

Label the Boltzmann distribution to show the effect of adding a catalyst to the sample of sucrose and water molecules at constant temperature.



Explain your labelled diagram.

.....

.....

.....

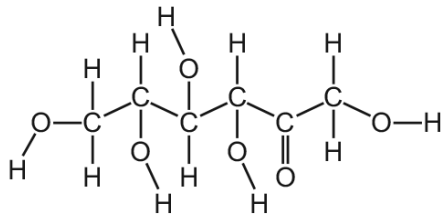
[3]

(b) Both fructose and glucose contain chiral centres.

(i) Explain what is meant by the term *chiral centre*.

..... [1]

(ii) On the diagram of the fructose molecule, label all the chiral centres with an asterisk (*).



[1]

(iii) Determine the empirical formula of fructose.

..... [1]

(c) (i) Explain what is meant by the term *enthalpy change of combustion*.

.....

..... [2]

(ii) Write the equation for the complete combustion of sucrose.

..... [1]

The enthalpy change of reaction **Z**, ΔH_r, can be calculated using the enthalpy change of combustion data given in the table.

substance	enthalpy change of combustion, ΔH_c / kJ mol^{-1}
sucrose	–5643
glucose	–2805
fructose	–2810

(iii) Use the data in the table to calculate the enthalpy change for the reaction occurring when sucrose reacts with water, ΔH_r. You should draw a labelled Hess' cycle to show your working.

ΔH_r = ... kJ mol^{-1} [2]

[Total: 12]

92. 9701_s19_qp_21 Q: 5

Ethanal reacts with a mixture of HCN and NaCN to make 2-hydroxypropanenitrile, $CH_3CH(OH)CN$.

The reaction mechanism is nucleophilic addition.

(a) Explain the meaning of the term *nucleophile* and identify the species which acts as the nucleophile during this reaction.

.....

.....

species acting as nucleophile .....

[2]

(b) $CH_3CH(OH)CN$ exists as a pair of stereoisomers.

(i) Name the type of stereoisomerism shown by $CH_3CH(OH)CN$.

..... [1]

(ii) Draw three-dimensional diagrams of this pair of stereoisomers.

Indicate with an asterisk (*) the chiral centre on one of the structures drawn.

[3]

(c) Give the structure of the organic product of the reaction of $CH_3CH(OH)CN$ with dilute sulfuric acid.

..... [1]

[Total: 7]

93. 9701_s19_qp_22 Q: 1

Methylpropane, $(CH_3)_2CHCH_3$, is an isomer of butane, $CH_3(CH_2)_2CH_3$.

(a) (i) Explain why methylpropane and butane are a pair of isomers.

.....

..... [2]

(ii) Identify the type of isomerism shown by methylpropane and butane.

..... [1]

(b) When a sample of butane is heated to 373 K, in the presence of a catalyst, and allowed to reach equilibrium the following reaction occurs.

$$CH_3(CH_2)_2CH_3(g) \rightleftharpoons (CH_3)_2CHCH_3(g) \qquad \Delta H = -8.0\,kJ\,mol^{-1}$$

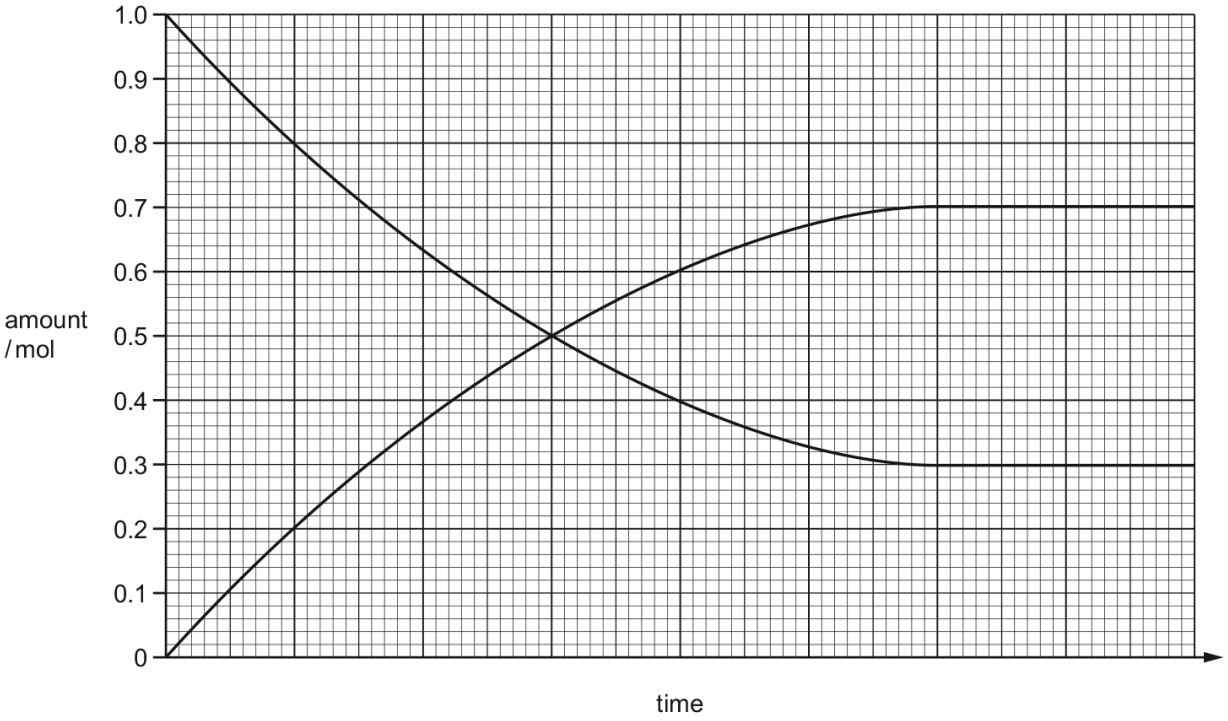
State and explain the effect on the composition of this equilibrium mixture when the temperature is increased to 473 K.

.....

.....

..... [2]

(c) 1 mole of butane gas was added to a 1 dm^3 closed system, at a constant temperature and pressure. The amount of butane and methylpropane was measured at regular time intervals.



(i) Label the graph with a *t* to show the time taken to reach dynamic equilibrium. [1]

(ii) Use the graph to find the concentration of butane and methylpropane in the mixture at equilibrium.

concentration of butane = ... mol dm^{-3}

concentration of methylpropane = ... mol dm^{-3}

[1]

(iii) Write an expression for K_c for this reaction.

[1]

(iv) Calculate a value for K_c and state its units.

K_c = ... units = ... [2]

[Total: 10]

94. 9701_s18_qp_23 Q: 2

One reason for the wide variety of organic compounds is isomerism, either structural isomerism or stereoisomerism.

(a) (i) Explain the meaning of the term *structural isomerism*.

.....

.....

..... [2]

(ii) Explain the meaning of the term *stereoisomerism*.

.....

.....

..... [2]

(b) Pent-1-ene, $CH_2=CH(CH_2)_2CH_3$, does not show stereoisomerism.

(i) Give **two** reasons why pent-1-ene does **not** show stereoisomerism.

reason 1 .....

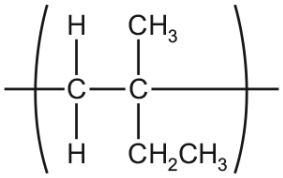
.....

reason 2 .....

.....

[2]

(ii) A structural isomer of pent-1-ene is used as the monomer to form a polymer. The repeat unit of this polymer is shown.



Draw the **displayed** formula of the monomer used to make this polymer.

Give the name of the monomer.

.....

[2]

(iii) A different structural isomer of pent-1-ene shows geometrical isomerism.

Draw the structure of **one** of the two geometrical isomers with the formula C_5H_{10}.

Give the full name of this isomer.

.....

[2]

[Total: 10]

95. 9701_s17_qp_23 Q: 3

Sulfur trioxide, SO_3, is manufactured from sulfur dioxide and oxygen by the Contact process.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -196.0\,kJ\,mol^{-1}$$

(a) The enthalpy change of formation of SO_2, $\Delta H_f\ SO_2(g)$, is $-296.8\,kJ\,mol^{-1}$.

(i) Define the term *enthalpy change of formation*.

.....

.....

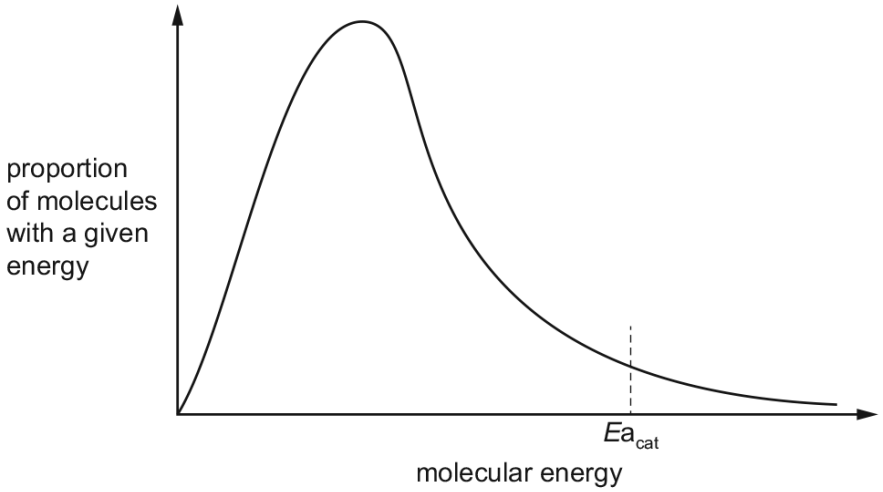
..... [2]

(ii) Use the data to calculate the enthalpy change of formation of $SO_3(g)$.

$\Delta H_f\ SO_3(g)$ = ... $kJ\,mol^{-1}$ [2]

(b) The Contact process is usually carried out at a temperature of approximately 700 K, a pressure of approximately 150 kPa and in the presence of a vanadium(V) oxide catalyst, V_2O_5.

The Boltzmann distribution for a mixture of SO_2 and O_2 at 700 K is shown.
Ea_{cat} represents the activation energy for the reaction in the presence of the catalyst.



(i) Add a labelled mark, Ea_{uncat}, to the diagram to indicate the activation energy in the absence of the catalyst. [1]

(ii) State the benefit of using a catalyst in this reaction. Explain how it achieves this effect.

.....

.....

.....

..... [2]

(iii) State and explain how an increase in pressure would affect both the rate of reaction and the yield of SO_3 in the Contact process.

rate .....

.....

.....

.....

yield .....

.....

.....

.....

[4]

(c) At a pressure of 1.50×10^5 Pa, 1.00 mol of sulfur dioxide gas, SO_2, was mixed with 1.00 mol of oxygen gas, O_2. The final equilibrium mixture formed was found to contain 0.505 mol of O_2.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(i) Calculate the amount, in mol, of SO_2 and SO_3 in the equilibrium mixture.

SO_2 = ... mol

SO_3 = ... mol [1]

(ii) Calculate the partial pressure of oxygen gas, pO_2, in the equilibrium mixture.

pO_2 = ... Pa [2]

(d) In another equilibrium mixture formed from different starting amounts of SO_2 and O_2, the partial pressures of SO_2, O_2 and SO_3 were as shown.

$pSO_2 = 8.42 \times 10^2$ Pa

$pO_2 = 6.00 \times 10^4$ Pa

$pSO_3 = 9.10 \times 10^4$ Pa

(i) Write the expression for the equilibrium constant, K_p, for the production of SO_3 from SO_2 and O_2.

K_p =

[1]

(ii) Calculate the value of K_p for this reaction and state the units.

K_p = ...

units = ...

[2]

[Total: 17]

96. 9701_s17_qp_23 Q: 4

A, **B** and **C** all have the formula C_4H_8. They all decolourise bromine and are structural isomers of each other.

(a) State the name of the process by which **A**, **B** and **C** could be obtained from $C_{10}H_{22}$.

..... [1]

(b) Draw the structures of these three **structural** isomers.

[1]

(c) Only **A** shows geometrical isomerism.

(i) Explain the meaning of the term *geometrical isomerism*.

.....

.....

.....

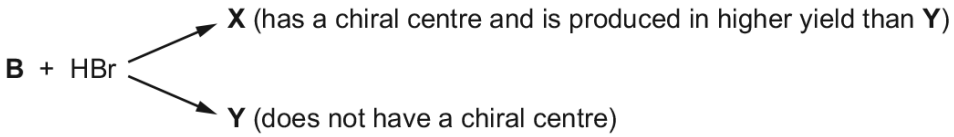
..... [2]

(ii) Draw the displayed formula of **A** and use it to show the mechanism of the reaction of **A** with HBr. Include all necessary charges, dipoles, lone pairs and curly arrows.

[4]

(d) **B** does **not** show geometrical isomerism.

B reacts with HBr to form a mixture of two structural isomers, **X** and **Y**.



(i) State the meaning of the term *chiral centre*.

.....

.....

.....

..... [1]

(ii) Name **B**.

..... [1]

(iii) **X** exists as a pair of optical isomers.

Draw these isomers using the conventional three-dimensional representation.

[2]

(iv) Explain why **X** is produced in higher yield than **Y**.

.....

.....

.....

..... [2]

(e) **C** does **not** show geometrical isomerism.

C reacts with HBr to form a mixture of two structural isomers, neither of which has a chiral centre.

(i) Name **C**.

..... [1]

(ii) Draw the **displayed** formula of each of the structural isomers produced by the reaction of **C** with HBr.

[2]

[Total: 17]

97. 9701_s16_qp_21 Q: 4

This question is about molecules with molecular formula C_4H_8.

(a) Give the structures of a pair of **positional** isomers with the formula C_4H_8.

[1]

(b) Give the structures of a pair of **chain** isomers with the formula C_4H_8, that do **not** exhibit stereoisomerism.

[1]

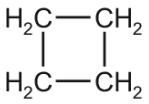
(c) Give the structures and full names of a pair of **stereoisomers** with the formula C_4H_8.

....

[2]

(d) The structure of a molecule, **A**, of formula C_4H_8 is shown.

Draw a functional group isomer of molecule **A** in box **B**. Explain how molecules **A** and **B** could be distinguished by a chemical test.



A **B**

.....

.....

..... [3]

[Total: 7]

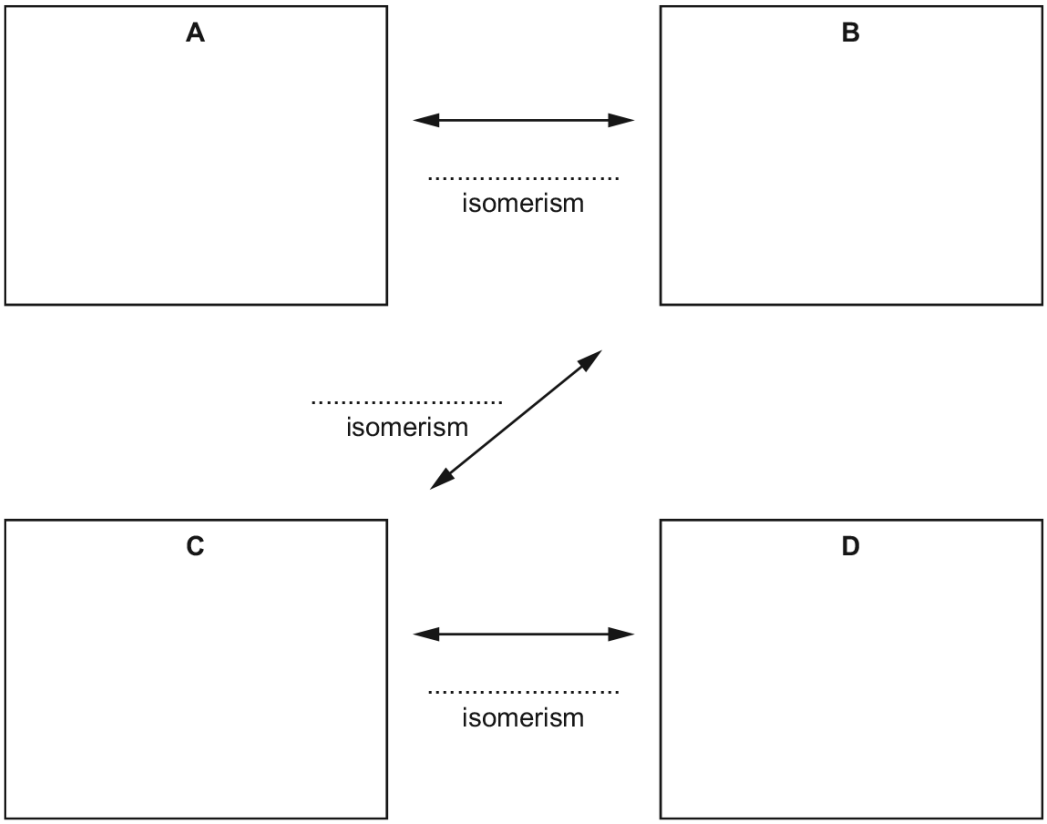
98. 9701_S15_qp_21 Q: 4

There are four alcohols, **A**, **B**, **C** and **D**, which are structural isomers with the molecular formula $C_4H_{10}O$.

Alcohol **A** does not react with acidified potassium dichromate(VI) solution but **B**, **C** and **D** do.

All four alcohols react with hot, concentrated sulfuric acid to form products with the molecular formula C_4H_8. **A**, **C** and **D** each give a single product in this reaction. **B** gives a mixture of two structural isomers, one of which shows stereoisomerism.

(a) Give the **skeletal** formula for each of the four alcohols and complete the diagram with the names of the types of structural isomerism shown by each linked pair of compounds.



[7]

(b) (i) Give the names of the two structural isomers produced by the reaction of **B** with hot, concentrated sulfuric acid

.... [2]

(ii) State which of these two isomers shows stereoisomerism. Explain why this molecule is capable of showing stereoisomerism.

.....

.....

.....

..... [2]

(iii) Draw **displayed** formulae to show the two stereoisomers.

stereoisomer 1

stereoisomer 2

[2]

[Total: 13]

1.

What is the total number of different chloroethanes (formula $C_2H_{6-n}Cl_n$, where n can be any integer from 1 to 6)?

A 6 **B** 8 **C** 9 **D** 10

[2002 M/J (21)]

2.

Which compound on reaction with hydrogen cyanide produces a compound with a chiral centre?

A CH_3CHO

B $CH_3CH_2COCH_2CH_3$

C $CH_3CO_2CH_3$

D HCHO

[2002 M/J (25)]

3.

Which pairs of compounds have the same empirical formula?

1 ethane and ethene

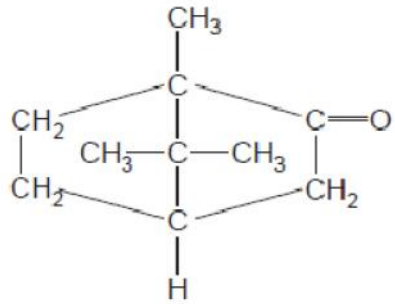
2 ethene and cyclohexane

3 cyclohexane and oct-1-ene

[2002 M/J (31)]

4.

Camphor is used for medical purposes, the diagram shows its structure.



How many chiral centres are present in one molecule of camphor?

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

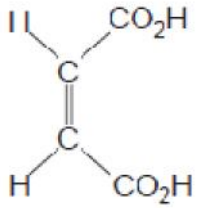
[2002 O/N (21)]

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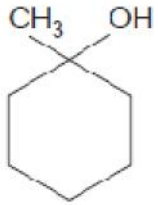
5.

Which compound is both chiral and acidic?

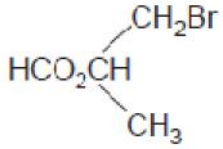
A



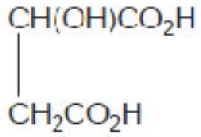
B



C



D



[2002 O/N (29)]

6.

Which compounds have the empirical formula CH_2O?

1 methanal

2 ethanoic acid

3 methyl methanoate

[2002 O/N (31)]

7.

Which compounds show *cis trans* isomerism?

1 but-2-ene

2 but-1-ene

3 2-methylpropene

[2002 O/N (37)]

8.

How many structural and *cis-trans* isomers are there for dichloropropene, $C_3H_4Cl_2$?

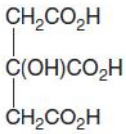
A 3 **B** 5 **C** 6 **D** 7

[2003 M/J (20)]

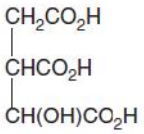
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9.

The isomers, citric acid and isocitric acid, are intermediates in the Krebs cycle of the oxidation of glucose in living cells.



citric acid



isocitric acid

How many chiral centres does each acid possess?

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

[2003 M/J (21)]

10.

Which reaction is **not** an electrophilic addition?

A $CH_2{=}CH_2 + HI \longrightarrow CH_3CH_2I$

B $CH_3CH{-}CH_2 + Br_2 \longrightarrow CH_3CHBrCH_2Br$

C $CH_3CH{=}CH_2 + H_2O \xrightarrow{\text{conc } H_2SO_4} CH_3CH(OH)CH_3$

D $CH_3CHO + HCN \longrightarrow CH_3CH(OH)CN$

[2003 M/J (25)]

11.

How many alcohols (including both structural isomers and stereoisomers) can have the molecular formula $C_4H_{10}O$?

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

[2003 O/N (20)]

12.

On strong heating a hydrocarbon produces ethene, propane and but-1-ene in the mole ratio 5 : 1 : 1.

What is the molecular formula of the hydrocarbon?

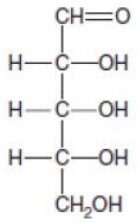
A $C_{17}H_{34}$ **B** $C_{17}H_{36}$ **C** $C_{19}H_{38}$ **D** $C_{19}H_{40}$

[2003 O/N (22)]

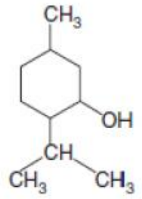
13.

38 The taste buds on the tongue are chiral and can distinguish one optical isomer from another.

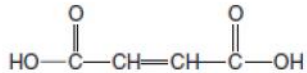
Which naturally-occurring compounds will have optical isomers that may be distinguished by taste?

1 

ribose

2 

menthol

3 

maleic acid

[2003 O/N (38)]

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14.

Which of these always applies to a nucleophile?

A It attacks a double bond.

B It has a lone pair of electrons.

C It is a single atom.

D It is negatively charged.

[2004 M/J (21)]

15.

What can behave as an electrophilic reagent?

A Br_2

B Na

C NH_3

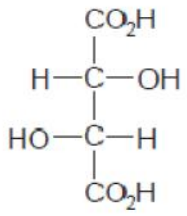
D CN^-

[2004 O/N (20)]

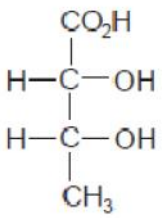
16.

Which molecule does not have a chiral centre?

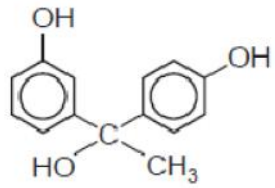
A



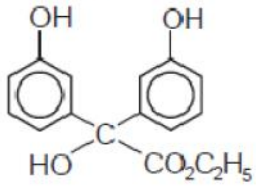
B



C



D

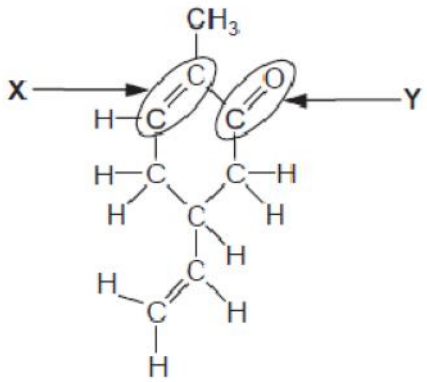


[2004 O/N (21)]

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17.

This molecule is responsible for the flavour of spearmint chewing gum.



What is a true statement about the functional groups **X** or **Y**?

A **X** will undergo nucleophilic addition.

B **Y** will undergo nucleophilic addition.

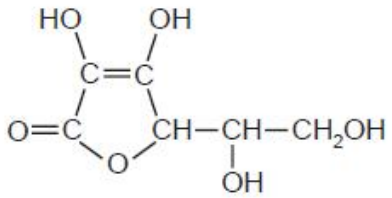
C **X** will undergo electrophilic substitution.

D **Y** will undergo electrophilic substitution.

[2004 O/N (24)]

18.

The diagram shows the structure of vitamin C.



How many chiral centres are there in one molecule?

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

[2005 O/N (19)]

19.

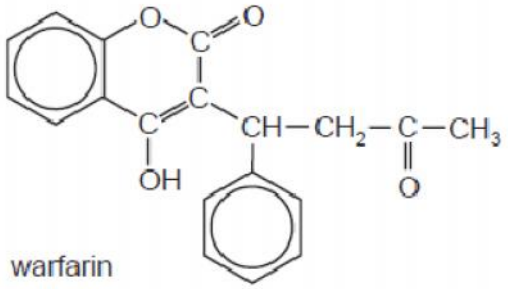
What is the number of isomers of $C_2H_2Cl_2$ including *cis-trans* isomers?

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

[2005 O/N (20)]

20.

Warfarin is used as a rat poison.



warfarin

How many chiral centres are present in the warfarin molecule?

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

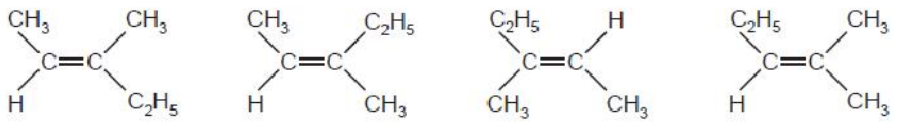
[2006 M/J (21)]

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21.

The structures below show isomers of C_6H_{12}.

1 2 3 4



In which pair are the members *cis-trans* isomers of each other?

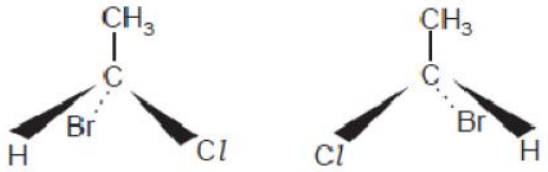
A 1 and 2 **B** 1 and 3 **C** 1 and 4 **D** 2 and 4

[2006 M/J (22)]

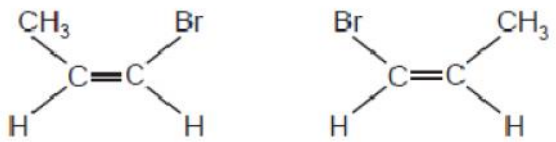
22.

In which pairs are the members stereoisomers of each other?

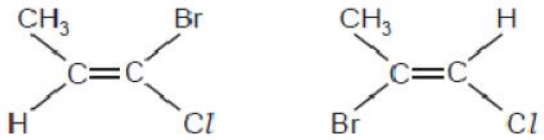
1



2



3



[2006 M/J (37)]

23.

In which class of compound, in its general formula, is the ratio of hydrogen atoms to carbon atoms the highest?

A alcohols

B aldehydes

C carboxylic acids

D halogenoalkanes

[2006 O/N (20)]

24.

What is the total number of different chloroethanes, formula $C_2H_{6-n}Cl_n$, where n can be any integer from 1 to 4?

A 4 **B** 6 **C** 7 **D** 8

[2006 O/N (21)]

25.

Which reaction is an example of nucleophilic substitution?

A $CH_3CH_2Br \rightarrow CH_2{=}CH_2 + HBr$

B $CH_2{=}CH_2 + HBr \rightarrow CH_3CH_2Br$

C $C_3H_7Br + H_2O \rightarrow C_3H_7OH + HBr$

D $C_2H_6 + Br_2 \rightarrow C_2H_5Br + HBr$

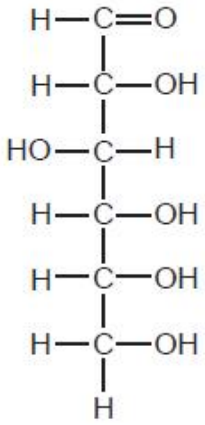
[2006 O/N (22)]

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26.

Glucose, $C_6H_{12}O_6$, is a product of photosynthesis.

It has the following structure.



How many *chiral* centres does the molecule have?

A 1 **B** 2 **C** 4 **D** 6

[2007 M/J (19)]

27.

Which molecules, each with a linear carbon chain, can have an optically active isomer?

I	II	III	IV
C_3H_6BrI	C_3H_4BrI	$C_3H_6I_2$	$C_3H_4Br_2$

A I and II only

B I, II and III only

C II and III only

D I, II and IV only

[2007 O/N (19)]

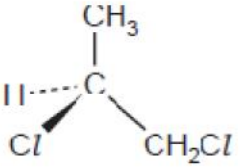
28.

In which pair do the isomers have identical boiling points?

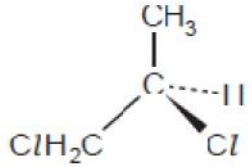
A $CH_3CH_2CH_2CH_2OH$ and $(CH_3)_2CHCH_2OH$

B $CH_3(CH_2)_4CH_3$ and $(CH_3)_2CHCH(CH_3)_2$

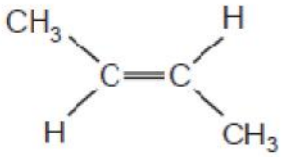
C



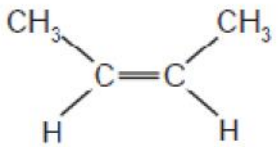
and



D



and

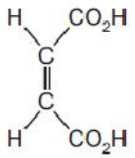


[2007 O/N (20)]

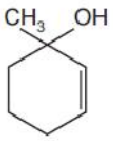
29.

Which compound is both chiral and acidic?

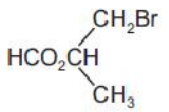
A



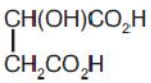
B



C



D



[2008 M/J (29)]

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30.

For complete combustion, 1 mol of an organic compound **X** was found to require 2.5 mol of molecular oxygen.

Which compounds could be **X**?

1 C_2H_5OH

2 C_2H_2

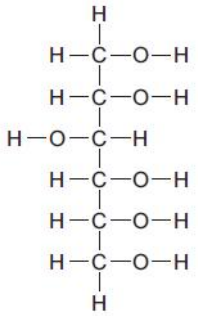
3 CH_3CHO

[2008 M/J (31)]

31.

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

The diagram shows its structure.



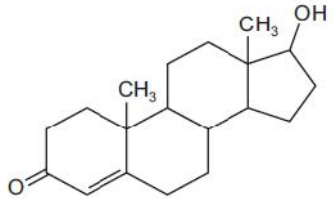
How many chiral centres are present in sorbitol?

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

[2008 O/N (20)]

32.

In recent years a number of athletes have been banned from sports because of their illegal use of synthetic testosterone, a naturally occurring hormone in the body.



testosterone

How many chiral centres are present in a testosterone molecule?

A 1 **B** 2 **C** 3 **D** 6

[2009 M/J (19)]

33.

The compound known as 'gamma-linolenic acid' is found in significant amounts in the seeds of the Evening Primrose plant. There is evidence that the compound may help patients with diabetes.

$CH_3(CH_2)_4CH=CHCH_2CH=CHCH_2CH=CH(CH_2)_4CO_2H$

gamma-linolenic acid

How many *cis-trans* isomers does gamma-linolenic acid have?

A 3 **B** 6 **C** 8 **D** 12

[2009 M/J (20)]

34.

What always applies to a nucleophile?

A It attacks a double bond.

B It has a lone pair of electrons.

C It is a single atom.

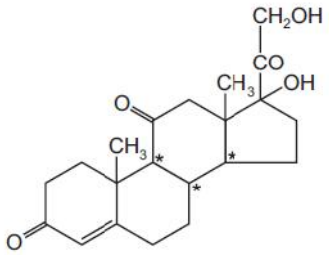
D It is negatively charged.

[2009 M/J (21)]

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35.

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

[2009 O/N-11 (20)]

36.

Which compound exhibits both *cis-trans* and optical isomerism?

A $CH_3CH{=}CHCH_2CH_3$

B $CH_3CHBrCH{=}CH_2$

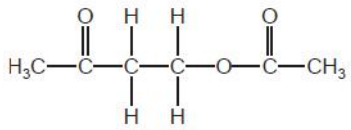
C $CH_3CBr{=}CBrCH_3$

D $CH_3CH_2CHBrCH{=}CHBr$

[2010 M/J-11 (30)]

37.

Compound X reacts with ethanoic acid in the presence of an H^+ catalyst to produce the compound below.



What is the molecular formula of compound X?

A $C_2H_6O_2$ **B** $C_2H_6O_3$ **C** C_4H_8O **D** $C_4H_8O_2$

[2010 O/N-11 (21)]

38.

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

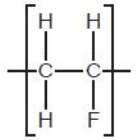
A 3 **B** 4 **C** 5 **D** 6

[2010 O/N-12 (20)]

39.

Fluoroalkenes are used to make polymers such as poly(vinyl)fluoride (PVF).

PVF is used to make non-flammable interiors for aircraft. The diagram shows the repeat unit of the polymer PVF.



What is the skeletal formula of the monomer of PVF?

A  **B**  **C**  **D** 

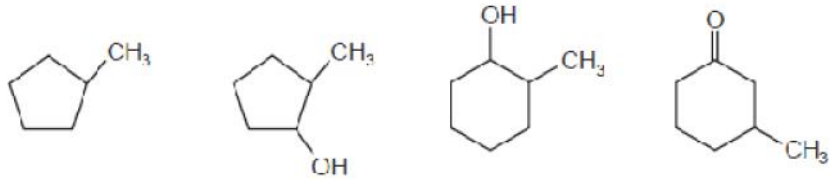
[2010 O/N-12 (28)]

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40.

Which of the compounds shown have chiral carbon atoms?

1 2 3 4



A 1, 2, 3 and 4

B 1 and 4 only

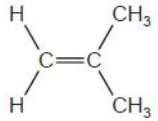
C 2 and 3 only

D 2, 3 and 4 only

[2010 O/N-12 (30)]

41.

The compound 2-methylpropene, C_4H_8, is a monomer used in the production of synthetic rubber.



In addition to 2-methylpropene there are x other isomers of C_4H_8, structural or otherwise, which contain a double bond.

What is the value of x?

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

[2010 O/N-13 (29)]

42.

The formula CH_3 can represent an anion, a cation or a free radical. Species with the molecular formula CH_3 can act as an electrophile, a free radical or a nucleophile depending on the number of outer shell electrons on the central carbon atom.

How many outer shell electrons must be present for CH_3 to act in these different ways?

	CH_3 as an electrophile	CH_3 as a free radical	CH_3 as a nucleophile
A	6	7	8
B	6	8	7
C	7	6	8
D	8	7	6

[2011 M/J-11 (22)]

43.

Pentanol, $C_5H_{11}OH$, has four structural isomers that are primary alcohols.

How many of these primary alcohols contain a chiral carbon atom?

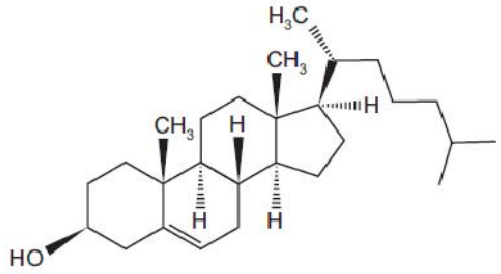
A 0 **B** 1 **C** 2 **D** 3

[2011 M/J-11 (23)]

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44.

The diagram shows the structure of the naturally-occurring molecule cholesterol.



cholesterol

Student X claimed that the seventeen carbon atoms in the four rings all lie in the same plane.

Student Y claimed that this molecule displays *cis-trans* isomerism at the C=C double bond.

Which of the students are correct?

A both X and Y

B neither X nor Y

C X only

D Y only

[2011 M/J-11 (24)]

45.

The products obtained by cracking an alkane, **X**, are methane, ethene and propene.

The mole fraction of ethene in the products is 0.5.

What is the identity of **X**?

A C_6H_{14} **B** C_8H_{18} **C** C_9H_{20} **D** $C_{11}H_{24}$

[2011 M/J-12 (23)]

46.

Which compound does **not** show cis-trans isomerism?

A 2-methylpent-2-ene

B 3-methylpent-2-ene

C 3,4-dimethylhex-3-ene

D pent-2-ene

[2011 M/J-12 (24)]

47.

Which formulae show propanone and propanal as different compounds?

A empirical, molecular, structural **and** displayed formulae

B molecular, structural and displayed formulae **only**

C structural and displayed formulae **only**

D displayed formulae **only**

[2011 M/J-12 (25)]

48.

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

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

[2011 M/J-12 (26)]

49.

In the general formula of which class of compound, is the ratio of hydrogen atoms to carbon atoms the highest?

A alcohols

B aldehydes

C carboxylic acids

D halogenoalkanes

[2011 O/N-11 (22)]

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50.

Disaccharides, $C_{12}H_{22}O_{11}$, are important in the human diet. For example, sucrose is found in pastries and lactose occurs in milk products.

Both of these compounds can be hydrolysed.

$$\text{sucrose} + H_2O \rightarrow \underset{\text{glucose}}{CH_2OH(CHOH)_4CHO} + \underset{\text{fructose}}{CH_2OH(CHOH)_3COCH_2OH}$$

$$\text{lactose} + H_2O \rightarrow \underset{\text{glucose}}{CH_2OH(CHOH)_4CHO} + \underset{\text{galactose}}{CH_2OH(CHOH)_4CHO}$$

Which statements about these hydrolysis products are correct?

1 Glucose and fructose have structural isomers.

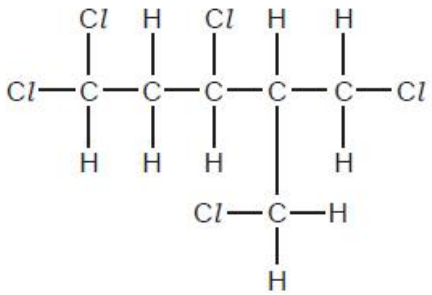
2 Glucose and galactose are optical isomers.

3 Glucose and galactose are ketones.

[2011 O/N-11 (37)]

51.

The molecule shown is optically active.



How many chiral carbon atoms are present in this molecule?

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

[2011 O/N-12 (27)]

52.

Which pairs of homologous series have the same C:H ratio in their general formulae?

1 aldehydes and ketones

2 carboxylic acids and esters

3 alkenes and ketones

[2011 O/N-12 (40)]

53.

In the general formula of which class of compound, is the ratio of hydrogen atoms to carbon atoms the highest?

A alcohols

B aldehydes

C carboxylic acids

D halogenoalkanes

[2011 O/N-13 (23)]

54.

An organic compound **J** reacts with sodium to produce an organic ion with a charge of –3. **J** reacts with NaOH(aq) to produce an organic ion with a charge of –1.

What could be the structural formula of **J**?

A $HO_2CCH(OH)CH_2CO_2H$

B $HO_2CCH(OH)CH_2CHO$

C $HOCH_2CH(OH)CH_2CO_2H$

D $HOCH_2COCH_2CHO$

[2012 M/J-11 (21)]

55.

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

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

[2012 M/J-11 (24)]

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56.

What is **always** involved in a carbon-carbon π bond?

1 a shared pair of electrons

2 a sideways overlap of p orbitals

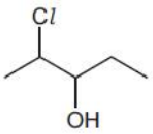
3 delocalised electrons

[2012 M/J-11 (37)]

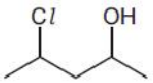
57.

Which diagram gives the skeletal formula of 2-chloropentan-3-ol?

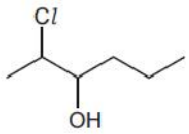
A



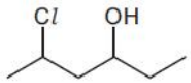
B



C



D



[2012 M/J-12 (21)]

58.

What are the same for a pair of optical isomers?

1 their empirical formula

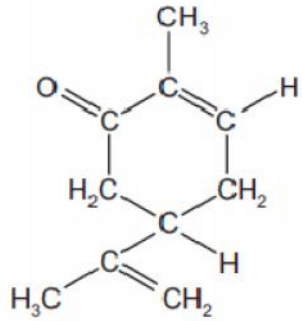
2 their functional groups

3 their structural formula

[2012 M/J-12 (38)]

59.

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

[2012 O/N-11 (20)]

60.

An alkene has the formula $CH_3CH{=}CRCH_2CH_3$ and does **not** possess *cis-trans* isomers.

What is *R*?

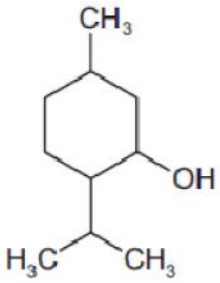
A H **B** Cl **C** CH_3 **D** C_2H_5

[2012 O/N-11 (21)]

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61.

Menthol is an important compound extracted from the peppermint plant.



menthol

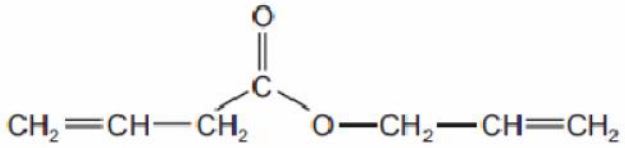
How many chiral centres are there in one molecule of menthol?

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

[2012 O/N-11 (22)]

62.

The diagram shows a molecule that has σ bonds and π bonds.



How many σ bonds are present in this molecule?

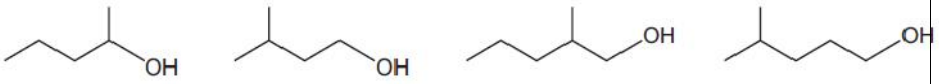
A 15 **B** 17 **C** 18 **D** 21

[2012 O/N-13 (21)]

63.

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

A **B** **C** **D**



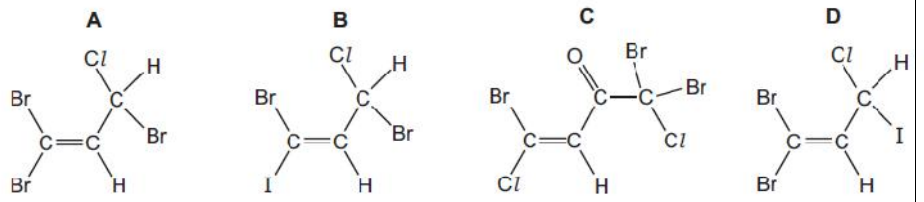
[2012 O/N-13 (29)]

64.

20 The following compounds are found in the seaweed *Asparagopsis taxiformis*.

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

A **B** **C** **D**



[2013 M/J-11 (20)]

65.

What is true of every nucleophile?

A It attacks a double bond.

B It has a lone pair of electrons.

C It is a single atom.

D It is negatively charged.

[2013 M/J-13 (21)]

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66.

How many isomers, including structural and stereoisomers, with the formula C_4H_8 have structures that involve π bonding?

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

[2013 M/J-13 (22)]

67.

Which compound exhibits stereoisomerism?

A $CH_3CHClCH_3$

B $CH_3CHClCH_2Cl$

C $CH_3CCl_2CH_3$

D $CH_2ClCH_2CH_2Cl$

[2013 O/N-11 (23)]

68.

Including structural and stereoisomers, how many isomers are there of $C_2H_2Br_2$?

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

[2013 O/N-11 (23)]

69.

How many geometrical (cis-trans) isomers are there of hex-2,4-diene, $CH_3CH=CHCH=CHCH_3$?

A none; hex-2,4-diene does not show geometric isomerism

B 2

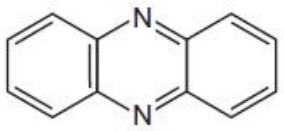
C 3

D 4

[2014 M/J-11 (29)]

70.

The diagram shows the skeletal formula of phenazine.



phenazine

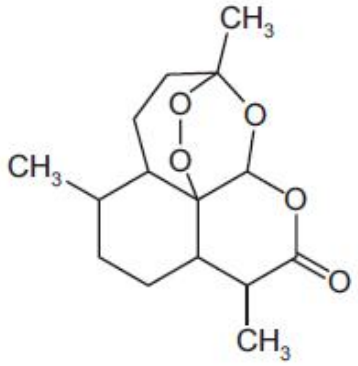
What is the empirical formula of phenazine?

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

[2014 M/J-12 (20)]

71.

Artemisinin is a powerful anti-malarial drug.



artemisinin

How many chiral centres are there in each molecule of artemisinin?

A 4 **B** 6 **C** 7 **D** 8

[2014 M/J-12 (30)]

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72.

Use of the Data Booklet is relevant to this question.

Which compound has an M_r of 84 and will react with HBr to give a product with an M_r of 164.9?

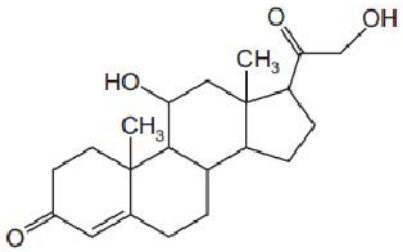
A **B** **C** **D**



[2014 O/N-11 (21)]

73.

Corticosterone is a hormone involved in the metabolism of carbohydrates and proteins.



corticosterone

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

A 5 **B** 6 **C** 7 **D** 8

[2014 O/N-11 (26)]

74.

The compound known as 'gamma-linolenic acid' is found in the seeds of the evening primrose plant.

$CH_3(CH_2)_4CH=CHCH_2CH=CHCH_2CH=CH(CH_2)_4CO_2H$

gamma-linolenic acid

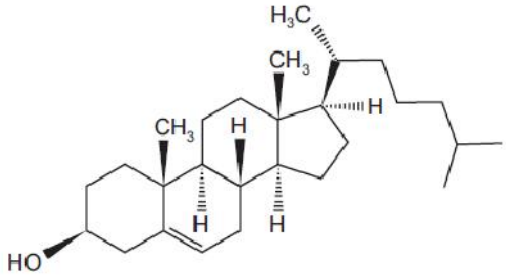
How many *cis-trans* isomers are there with this structural formula?

A 3 **B** 6 **C** 8 **D** 12

[2014 O/N-13 (25)]

75.

The diagram shows the structure of the naturally-occurring molecule cholesterol.



cholesterol

Student X stated that the seventeen carbon atoms in the four rings all lie in the same plane.

Student Y stated that this molecule displays *cis-trans* isomerism at the C=C double bond.

Which of the students are correct?

A both X and Y

B neither X nor Y

C X only

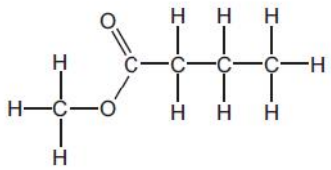
D Y only

[2014 O/N-13 (29)]

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76.

Methyl butanoate, $C_5H_{10}O_2$, is an ester used in the food industry to give products the flavour of apples.



methyl butanoate

Including methyl butanoate, how many **structural** isomers are there of $C_5H_{10}O_2$ that are esters?

A 6 **B** 8 **C** 9 **D** 10

[2014 O/N-13 (30)]

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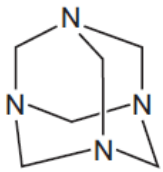
Introduction to Organic Chemistry – 2023 AS Chemistry 9701

1. Nov/2023/Paper_ 9701/11/No.25

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

The diagram shows its skeletal structure.

hexamine



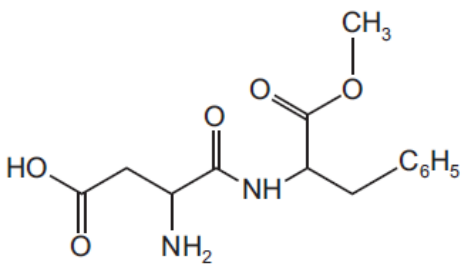
What is the empirical formula of hexamine?

A CH_2N **B** $C_3H_6N_2$ **C** $C_4H_8N_4$ **D** $C_6H_{12}N_4$

2. Nov/2023/Paper_ 9701/11/No.26

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

3. Nov/2023/Paper_ 9701/11/No.27

How many σ and π bonds are in the molecule $HCCCH_2CH_2CHC(CH_3)_2$?

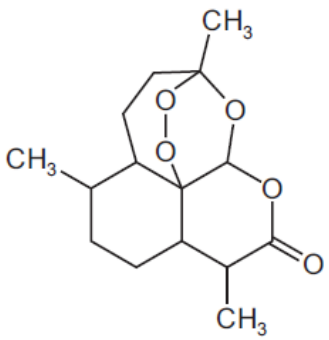
A 17 σ 3 π **B** 17 σ 5 π **C** 18 σ 4 π **D** 19 σ 3 π

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4. Nov/2023/Paper_ 9701/12/No.27

Artemisinin is a powerful anti-malarial drug.

artemisinin



How many chiral centres are there in each molecule of artemisinin?

A 4 **B** 6 **C** 7 **D** 8

5. Nov/2023/Paper_ 9701/12/No.29

How many geometrical (cis/trans) isomers are there of hex-2,4-diene, $CH_3CH=CHCH=CHCH_3$?

A none; hex-2,4-diene does **not** show geometric isomerism

B 2

C 3

D 4

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