Cambridge AS & A Level

CHEMISTRY

Paper 1

Topical Past Paper Questions

+ Answer Scheme

2015 - 2021

PapaCambridge

Chapter 14

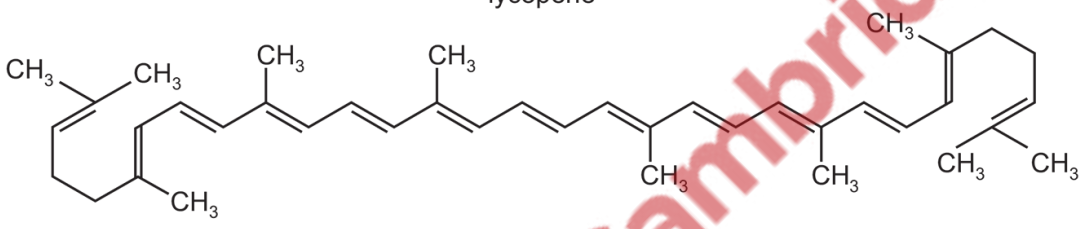
Hydrocarbons

14.1 Alkanes

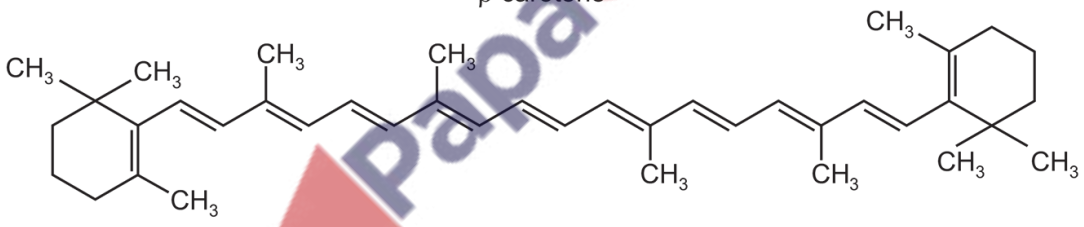
817. 9701_m22_qp_12 Q: 39

The diagrams show the structures of lycopene and β-carotene.

lycopene



β-carotene



When lycopene is converted into β-carotene, what is the gain or loss of hydrogen atoms per molecule?

A 4 gained

B 2 gained

C no change

D 2 lost

818. 9701_s21_qp_12 Q: 23

Methane and bromine react by free radical substitution.

P and Q are involved in the reaction mechanism.

P and Q:

- are **both** involved in propagation steps as reactants
- are **both** involved in termination steps as reactants.

What could be P and Q?

A Br and H **B** Br and CH_3 **C** Br and C_2H_6 **D** CH_3 and CH_3Br

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819. 9701_w21_qp_12 Q: 21

Bromomethane, CH_3Br, decomposes in the stratosphere forming methyl free radicals and bromine free radicals.

Which row correctly describes this decomposition?

	type of bond fission	number of electrons in a bromine free radical
A	homolytic	35
B	heterolytic	35
C	homolytic	36
D	heterolytic	36

---

820. 9701_w21_qp_12 Q: 23

Which equation represents a valid propagation step in the chlorination of ethane?

A $C_2H_5Cl + Cl\bullet \rightarrow C_2H_4Cl\bullet + HCl$

B $C_2H_6 + Cl\bullet \rightarrow C_2H_5Cl + H\bullet$

C $C_2H_5Cl + H\bullet \rightarrow C_2H_5\bullet + HCl$

D $C_2H_5\bullet + Cl\bullet \rightarrow C_2H_5Cl$

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821. 9701_s20_qp_12 Q: 19

Most modern cars are fitted with catalytic converters in the exhaust system.

Which three gases are removed by a catalytic converter?

A carbon monoxide, hydrocarbons, nitrogen oxides

B carbon monoxide, carbon dioxide, nitrogen oxides

C carbon monoxide, nitrogen oxides, sulfur dioxide

D hydrocarbons, nitrogen oxides, sulfur dioxide

---

822. 9701_w20_qp_12 Q: 28

Which statement about the use of alkane fuels in internal combustion engines is correct?

A C_8H_{18} is used as fuel in internal combustion engines and reacts with oxygen and nitrogen from the air.

B In limited oxygen, CO is produced which oxidises SO_2 to SO_3 in the atmosphere.

C The catalytic converter removes polluting gases including NO_2 and CO_2.

D Unburnt hydrocarbons and NO_2 can react in sunlight to produce photochemical smog.

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823. 9701_m19_qp_12 Q: 22

Many reactions take place in the engine and catalytic converter of a car.

Which pair of substances is produced **both** by the reactions in a car engine and in a catalytic converter?

A carbon dioxide and unburnt hydrocarbons

B carbon dioxide and water

C carbon monoxide and nitrogen

D carbon monoxide and unburnt hydrocarbons

---

824. 9701_s19_qp_11 Q: 18

At 550 °C nitrogen dioxide reacts with unburnt hydrocarbon fragments such as CH_3 in the catalytic converter of a motor vehicle.

$$4CH_3 + 7NO_2 \rightarrow 3\tfrac{1}{2}N_2 + 4CO_2 + 6H_2O$$

Which row gives the energy change for this reaction and a possible reason for it?

	energy change of reaction	reason why the reaction is endothermic or exothermic
A	endothermic	chemical energy is converted to heat energy
B	endothermic	the N≡N bond energy is very high
C	exothermic	CO_2 and H_2O have negative $\Delta H_f^{\ominus}$ values
D	exothermic	double bonds are broken in NO_2

---

825. 9701_w19_qp_11 Q: 21

Alkanes are saturated hydrocarbons.

Which type of reaction are alkanes most likely to undergo?

A electrophilic addition

B electrophilic substitution

C free radical substitution

D nucleophilic addition

---

826. 9701_s18_qp_11 Q: 3

Which fuel would produce the largest mass of CO_2 when 10 kg of the fuel undergo complete combustion?

A biodiesel, $C_{17}H_{34}O_2$

B ethanol, C_2H_6O

C octane, C_8H_{18}

D propane, C_3H_8

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827. 9701_s18_qp_12 Q: 21

Which equation represents a valid propagation step in the chlorination of ethane?

A $C_2H_6 + Cl\bullet \rightarrow C_2H_5Cl + H\bullet$

B $C_2H_5Cl + Cl\bullet \rightarrow C_2H_4Cl\bullet + HCl$

C $C_2H_5Cl + H\bullet \rightarrow C_2H_5\bullet + HCl$

D $C_2H_5\bullet + Cl\bullet \rightarrow C_2H_5Cl$

---

828. 9701_s17_qp_12 Q: 22

Which equation represents the initiation step of the substitution reaction between methane and chlorine?

A $CH_4 \rightarrow CH_3\bullet + H\bullet$

B $CH_4 \rightarrow CH_3^- + H^+$

C $Cl_2 \rightarrow 2Cl\bullet$

D $Cl_2 \rightarrow Cl^+ + Cl^-$

---

829. 9701_s16_qp_11 Q: 23

The **first** propagation step in the reaction between methane and chlorine is shown.

$$CH_4 + Cl\bullet \rightarrow CH_3\bullet + HCl$$

How many different **first** propagation steps are possible in the reaction between pentane and chlorine?

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

---

830. 9701_s16_qp_12 Q: 11

Which stage in the free radical substitution of ethane by chlorine has the lowest activation energy?

A $Cl_2 \rightarrow 2Cl\bullet$

B $Cl\bullet + C_2H_6 \rightarrow C_2H_5\bullet + HCl$

C $C_2H_5\bullet + Cl_2 \rightarrow C_2H_5Cl + Cl\bullet$

D $Cl\bullet + C_2H_5\bullet \rightarrow C_2H_5Cl$

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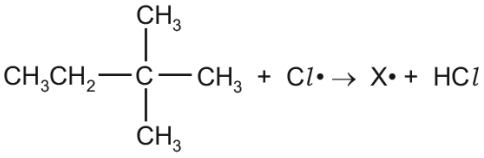
831. 9701_s16_qp_13 Q: 23

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

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



How many different structures of X• are possible?

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

---

832. 9701_w16_qp_12 Q: 23

The equation shows a reaction that occurs between carbon monoxide and nitrogen monoxide in a catalytic converter.

$$2CO(g) + 2NO(g) \rightarrow 2CO_2(g) + N_2(g)$$

Which statement is correct?

A The catalyst used is finely divided iron.

B The reaction prevents greenhouse gas emissions into the atmosphere.

C The reaction reduces the possibility of the formation of photochemical smog.

D The reaction results in increased ozone depletion.

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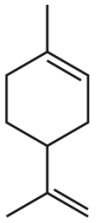
833. 9701_s15_qp_11 Q: 29

The citrus flavour of lemons is due to the compound limonene, present in both the peel and the juice.



limonene

What is the mole ratio of carbon dioxide to water produced when limonene is completely burnt in oxygen?

	number of moles carbon dioxide	number of moles water
A	4	3
B	5	4
C	5	8
D	9	7

---

834. 9701_w15_qp_11 Q: 22

Crude oil is a mixture of many hydrocarbons ranging in size from 1 to 40 carbon atoms per molecule. The alkanes in crude oil can be separated because they have different boiling points.

The table below shows the boiling points of some alkanes.

alkane	boiling point /°C	M_r
butane	0	58
pentane	36	72
hexane	69	86
2-methylbutane	28	72
dimethylpropane	10	72
2,3-dimethylbutane	58	86

What is the correct explanation for the difference in the boiling points of the three isomers with $M_r = 72$?

A Boiling point is dependent upon the length of the carbon chain **only**.

B Increased branching on a carbon chain increases the boiling point.

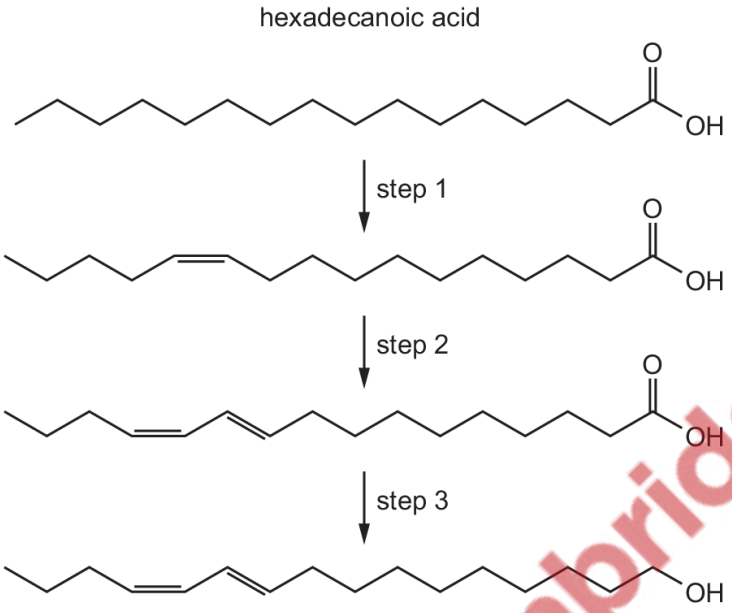
C Increased branching reduces the strength of the intermolecular hydrogen bonding.

D Increased branching reduces the strength of the intermolecular van der Waals' forces.

14.2 Alkenes

835. 9701_s21_qp_12 Q: 21

Hexadeca-10,12-dien-1-ol is produced by silk moths from hexadecanoic acid in a three-step enzymic process.



Which row contains correct descriptions of the three steps?

	step 1	step 2	step 3
A	elimination	elimination	dehydration
B	elimination	reduction	reduction
C	oxidation	elimination	oxidation
D	oxidation	oxidation	reduction

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836. 9701_s21_qp_13 Q: 21

Two carbon-containing products result from the reaction of alkene Z with a hot, concentrated, acidified solution of potassium manganate(VII).

One product forms an orange precipitate with 2,4-dinitrophenylhydrazine reagent. The other product is a gas which gives a white precipitate with aqueous calcium hydroxide.

Which alkene could be alkene Z?

A but-2-ene

B 2-methylpropene

C 2-methylbut-2-ene

D propene

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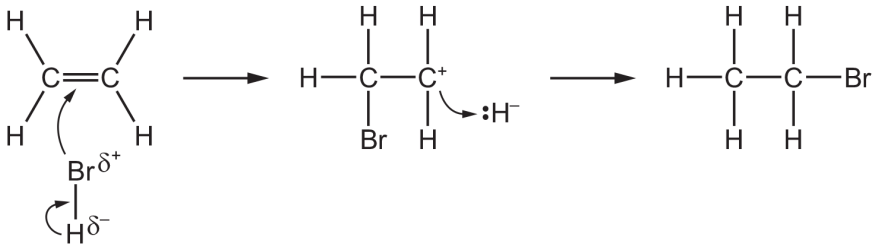
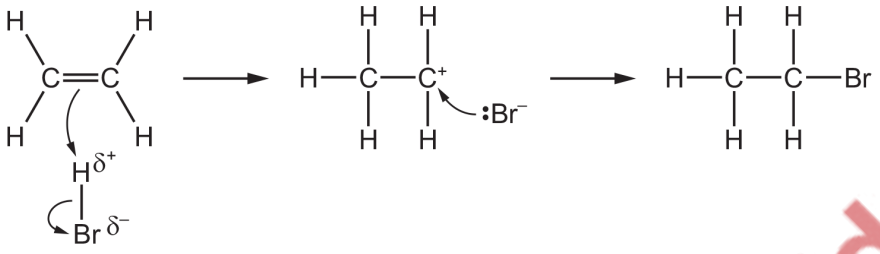
837. 9701_s21_qp_13 Q: 22

What is the correct mechanism for the addition of hydrogen bromide to ethene?

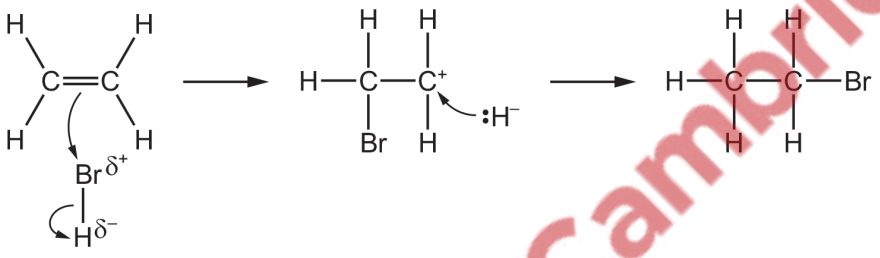
A



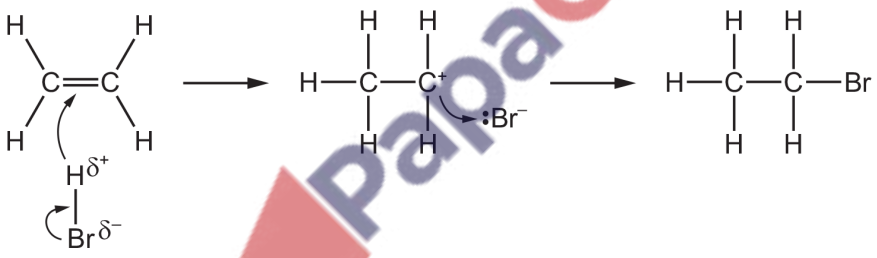
B



C

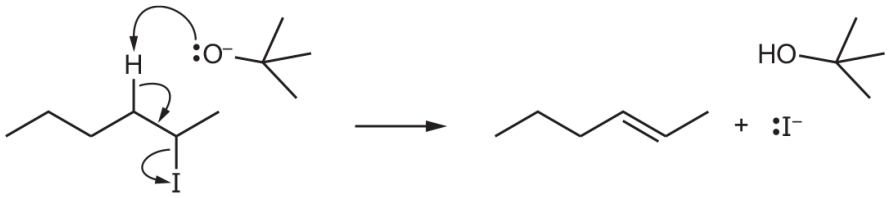


D



838. 9701_w21_qp_11 Q: 20

Hex-2-ene can be made by the reaction shown.



Which statement about this reaction is correct?

A $(CH_3)_3CO^-$ is behaving as a Brønsted-Lowry base.

B $(CH_3)_3CO^-$ is behaving as an oxidising agent.

C The C–I bond breaks via homolytic fission.

D This is a hydrolysis reaction.

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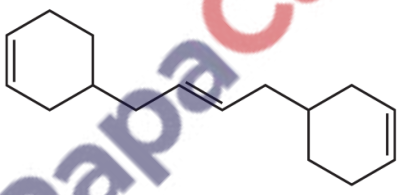
839. 9701_w21_qp_11 Q: 21

Structural isomerism **only** should be considered when answering this question.

Molecule X contains three C=C double bonds. One mole of X is reacted with three moles of HBr. The carbon skeleton is unchanged.

molecule X



How many different products are formed?

A 3 **B** 4 **C** 6 **D** 8

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840. 9701_s20_qp_11 Q: 22

But-1-ene and but-2-ene are treated separately with cold, dilute acidified manganate(VII) ions.

Four students, W, X, Y and Z, make statements about these alkenes and the diols formed from them.

W One diol contains two primary alcohol groups.

X One diol contains a primary and a secondary alcohol group.

Y One diol contains two secondary alcohol groups.

Z Both alkenes exhibit *cis-trans* isomerism.

Which two students are correct?

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

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841. 9701_s20_qp_11 Q: 24

Poly(propene) is an addition polymer.

What are the C–C–C bond angles along its polymer chain?

A They are all 109°.

B Half of them are 109° and half are 120°.

C Half of them are 90° and half are 180°.

D They are all 120°.

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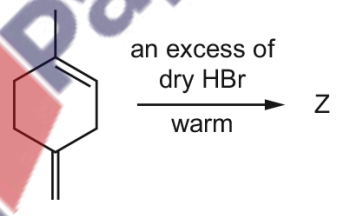
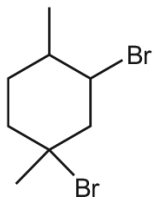
842. 9701_s20_qp_11 Q: 27

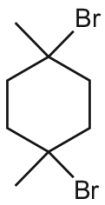
What is the major product Z of the following reaction?



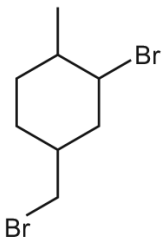
A



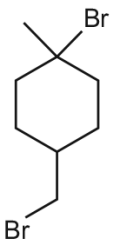
B



C



D



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843. 9701_s20_qp_12 Q: 25

Which substance forms propanoic acid as one of the products when it reacts with hot concentrated acidified potassium manganate(VII)?

A but-1-ene

B but-2-ene

C 2-methylpropene

D 2-methylbut-1-ene

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844. 9701_s20_qp_12 Q: 28

Ethene reacts with aqueous bromine to give two products, CH_2BrCH_2Br and CH_2BrCH_2OH.

Which statement about these products is correct?

A Both products are obtained in this reaction by nucleophilic substitution.

B Both products are obtained in this reaction by nucleophilic addition.

C Both products can be hydrolysed to form the same organic compound.

D Both products can form hydrogen bonds with water.

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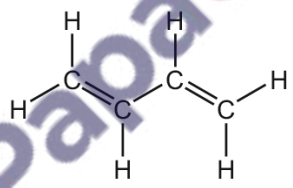
845. 9701_s20_qp_12 Q: 30

The diagram shows the structure of buta-1,3-diene.

buta-1,3-diene



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

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

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

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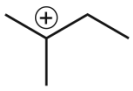
846. 9701_s20_qp_13 Q: 28

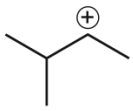
2-methylbut-2-ene reacts with HBr(g) to form two isomeric products. During the reaction two positively charged intermediates can be made.

Which diagram shows the more stable of the two positively charged intermediates?

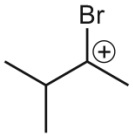
A



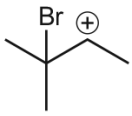
B



C



D



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847. 9701_w20_qp_11 Q: 21

Two students each make a statement about 2-methylbut-1-ene.

Student 1 states that 2-methylbut-1-ene has geometrical isomers.

Student 2 states that 2-methylbut-1-ene reacts with HBr in an addition reaction to give 1-bromo-2-methylbutane as the main product.

Which students are correct?

A both 1 and 2

B 1 only

C 2 only

D neither 1 nor 2

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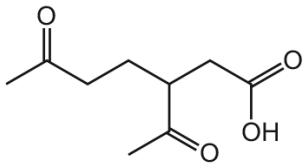
848. 9701_m19_qp_12 Q: 21

Compound L has the molecular formula $C_{10}H_{16}$.

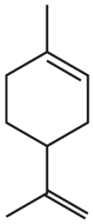
A sample of L reacted with an excess of hot, concentrated, acidified potassium manganate(VII). Compound M is produced.

M

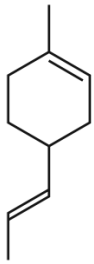


What could be the structure of compound L?

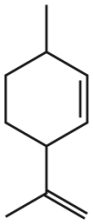
A



B



C



D

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849. 9701_s19_qp_11 Q: 22

What is the structural formula of the major product when hydrogen bromide reacts with 2-methylbut-2-ene?

A $CH_2BrCH(CH_3)CH_2CH_3$

B $(CH_3)_2CBrCH_2CH_3$

C $(CH_3)_2CHCHBrCH_3$

D $(CH_3)_2CHCH_2CH_2Br$

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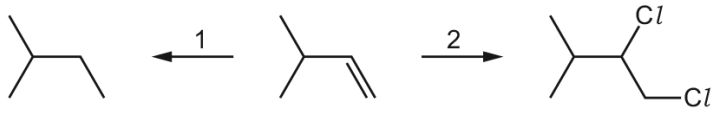
850. 9701_s19_qp_12 Q: 20

3-methylbut-1-ene can undergo different types of reaction.



Which row correctly identifies the reaction types?

	reaction 1	reaction 2
A	oxidation	electrophilic addition
B	oxidation	nucleophilic addition
C	reduction	electrophilic addition
D	reduction	nucleophilic addition

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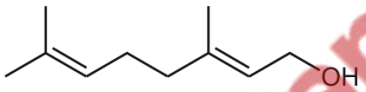
851. 9701_s19_qp_12 Q: 23

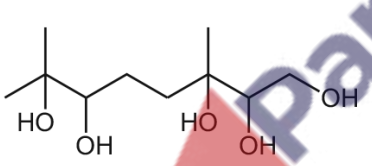
A molecule of geraniol is shown.

geraniol

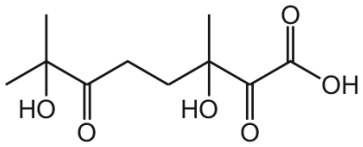


What is formed when geraniol is reacted with an excess of cold, dilute, acidified manganate(VII) ions?

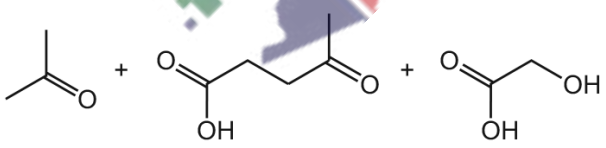
A



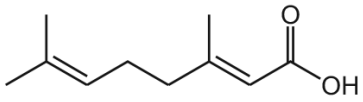
B



C



D



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852. 9701_s19_qp_12 Q: 26

Propene, bromine and hydrogen bromide are mixed in the dark.

A number of products are formed, some in very small quantities.

Which substance will **not** be present in the mixture of products?

A 1-bromopropane

B 2-bromopropane

C 1,1-dibromopropane

D 1,2-dibromopropane

---

853. 9701_s19_qp_13 Q: 22

In polymer Z every carbon atom in the polymer chain is bonded to one hydrogen atom and one methyl group.

Which alkene could be polymerised to make polymer Z?

A but-1-ene

B but-2-ene

C methylpropene

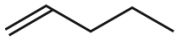
D propene

---

854. 9701_s19_qp_13 Q: 23

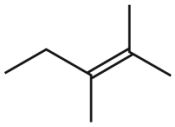
Which compound would produce a carboxylic acid and a ketone when treated with hot, concentrated acidified manganate(VII) ions?

A

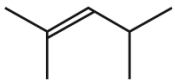


B

C



D



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855. 9701_w19_qp_11 Q: 20

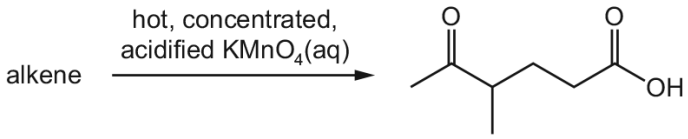
Which substance reacts with trichloroethene to give a chiral product?

A Br_2 **B** HCl **C** NaCN **D** NaOH

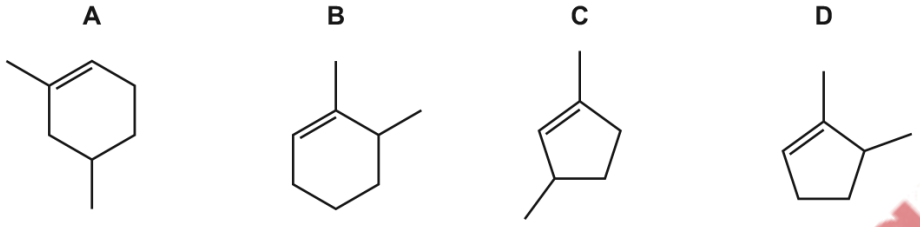
---

856. 9701_w19_qp_11 Q: 22

An alkene reacts with hot, concentrated, acidified potassium manganate(VII) to produce a single organic product as shown.



What is the structure of the alkene?



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857. 9701_w19_qp_12 Q: 22

An organic compound X reacts with hot, concentrated acidified potassium manganate(VII) solution to give a single carbon-containing product.

What could be X?

A $CH_2C(CH_3)_2$

B $CH_3CHCHCH_3$

C $CH_2CHCH_2CH_3$

D $CH_3CH_2CH_2CH_3$

---

858. 9701_s18_qp_12 Q: 1

Which feature is present in both ethene and poly(ethene)?

A bond angles of 109°

B π covalent bonds

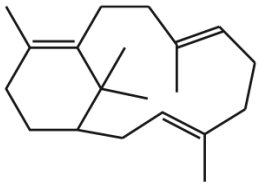
C σ covalent bonds

D sp^3 orbitals

---

859. 9701_s18_qp_12 Q: 20

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



compound Y

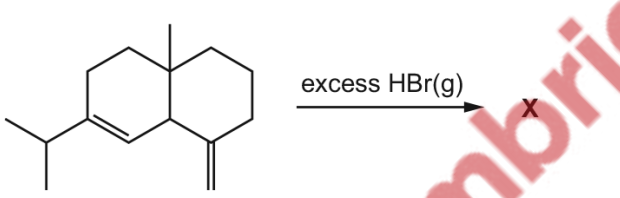
What is the number of chiral carbon atoms in the product?

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

---

860. 9701_s18_qp_13 Q: 21

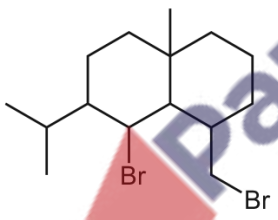
Sibirene, $C_{15}H_{24}$, is reacted with an excess of HBr(g). The major product is **X**.



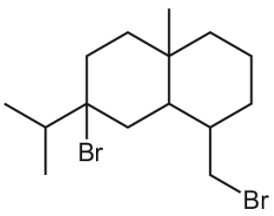
sibirene

What is the skeletal formula of **X**?

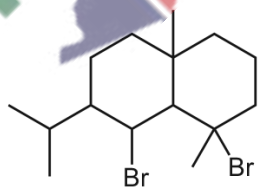
A



B



C



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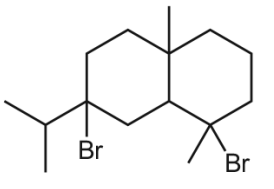

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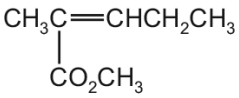
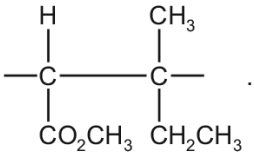
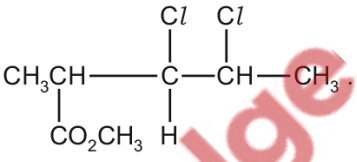
861. 9701_w18_qp_12 Q: 24

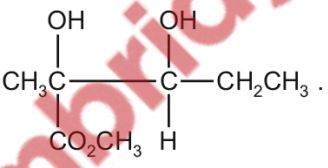
Which statement about compound Q is correct?

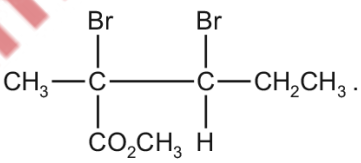


Q

A It could be polymerised to give a polymer with the repeat unit  .

B It reacts with chlorine by a free radical mechanism to give  .

C It reacts with cold, dilute acidified manganate(VII) to give  .

D It reacts with bromine via a free radical mechanism to give  .

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862. 9701_m17_qp_12 Q: 23

Propene undergoes a variety of reactions.

Which row is correct?

	reagent added to propene	products include
A	$Br_2(aq)$	1-bromopropane
B	cold, dilute, acidified $KMnO_4(aq)$	propanoic acid
C	HBr(g)	2-bromopropane
D	hot, concentrated, acidified $KMnO_4(aq)$	propanoic acid

---

863. 9701_s17_qp_11 Q: 22

An alkene is reacted with acidified manganate(VII) ions, MnO_4^-. The desired organic product has a relative molecular mass greater than that of the alkene by 34.

What conditions should be used?

A cold, concentrated MnO_4^-

B cold, dilute MnO_4^-

C hot, concentrated MnO_4^-

D hot, dilute MnO_4^-

---

864. 9701_s17_qp_13 Q: 25

Bromine reacts with ethene in the dark.

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

A It has a negative charge.

B It is a free radical.

C It is a nucleophile.

D It is an electrophile.

---

865. 9701_w17_qp_11 Q: 22

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

Which reaction occurs quickly at room temperature, 20 °C?

A $C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$

B $C_2H_4 + H_2O \rightarrow CH_3CH_2OH$

C $CH_3CH_2OH \rightarrow C_2H_4 + H_2O$

D $CH_3CH_2OH + HBr \rightarrow CH_3CH_2Br + H_2O$

---

866. 9701_w17_qp_11 Q: 29

Ethene is reacted with steam in the presence of concentrated H_3PO_4. The product of this reaction is added to acidified potassium dichromate(VI) and heated under reflux for one hour. The final organic product is collected and labelled X.

But-2-ene is treated with hot, concentrated, acidified potassium manganate(VII). The final organic product is collected and labelled Y.

Which statement is correct?

A One molecule of X has more carbon atoms than one molecule of Y.

B One molecule of Y has more carbon atoms than one molecule of X.

C X and Y have different functional groups.

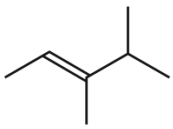
D X is the same compound as Y.

---

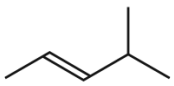
867. 9701_w17_qp_12 Q: 22

Which compound would produce two different carboxylic acids when treated with hot, concentrated, acidified manganate(VII) ions?

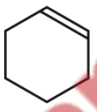
A



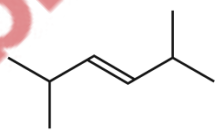
B



C



D



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868. 9701_w17_qp_12 Q: 23

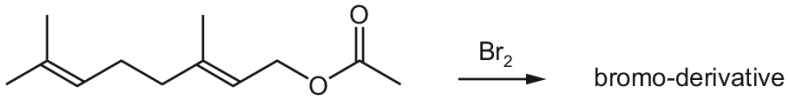
Which types of bond are broken and formed in the addition polymerisation of alkenes?

	type of bond broken	type of bond formed
A	π only	σ only
B	π only	σ and π
C	σ and π	σ only
D	σ and π	σ and π

---

869. 9701_s16_qp_11 Q: 30

Geranyl ethanoate is present in ginger and cocoa, and is used in shampoos and soaps as a perfume. It reacts with an excess of bromine in an organic solvent to give X, a bromo-derivative.



geranyl ethanoate X

Including geranyl ethanoate, how many cis-trans isomers are there of geranyl ethanoate, and how many chiral centres are there in X?

	cis-trans isomers	chiral centres in X
A	2	3
B	2	4
C	4	3
D	4	4

---

870. 9701_s16_qp_12 Q: 22

Oct-1-ene, $CH_3(CH_2)_5CH{=}CH_2$, can be thermally cracked.

Which combination of compounds W, X, Y and Z can be obtained by thermally cracking oct-1-ene?

$CH_2{=}CH_2$	$CH_3CH{=}CH_2$	$CH_3CH_2CH_3$	$CH_2{=}CHCH{=}CH_2$
W	X	Y	Z

A W, X, Y and Z

B W, X and Y only

C W, X and Z only

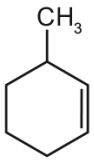
D W and X only

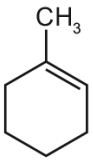
---

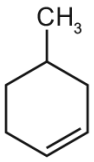
871. 9701_s16_qp_12 Q: 23

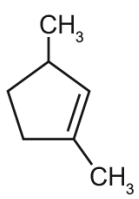
A cycloalkene with the molecular formula C_7H_{12} was oxidised by hot concentrated acidified MnO_4^-. The only organic product was 2-methylhexane-1,6-dioic acid.

What is the identity of the cycloalkene?

A 

B 

C 

D 

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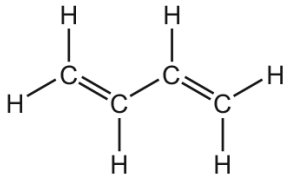
872. 9701_s16_qp_13 Q: 21

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



1,3-butadiene

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

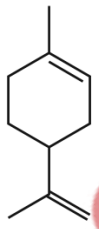
How many of these products have at least one chiral centre?

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

---

873. 9701_w16_qp_12 Q: 20

Limonene is found in lemon and orange oils.



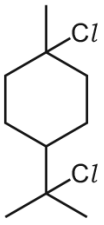
limonene

What will be the major product when limonene is reacted with an excess of dry hydrogen chloride?

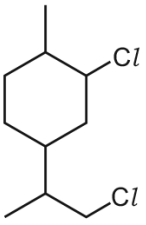
A

B

C



D



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874. 9701_s15_qp_11 Q: 22

Cottonseed oil contains large amounts of polyunsaturated carboxylic acids. When this oil is used to make margarine, the C=C double bonds in the unsaturated carboxylic acids are hydrogenated.

What reagents and conditions would be suitable to bring about this hydrogenation reaction?

A H_2 gas, nickel catalyst, 400 °C

B $LiAlH_4$ in dry ether

C $NaBH_4$, aqueous solution

D steam, concentrated H_2SO_4, 300 °C and 60 atm pressure

---

875. 9701_s15_qp_11 Q: 23

Which intermediate ion forms in the greatest amount during the addition of HBr to propene?

A $CH_3CH^+CH_3$

B $CH_3CH_2CH_2^+$

C $CH_3CH^-CH_2Br$

D $CH_3CHBrCH_2^-$

---

876. 9701_s15_qp_12 Q: 22

Four students, W, X, Y and Z, made the following statements about alkanes and alkenes.

W 'Bromine reacts with alkanes by electrophilic substitution.'

X 'Bromine reacts with alkenes by a free-radical addition mechanism.'

Y 'Alkenes can be oxidised by acidified manganate(VII) ions.'

Z 'Alkenes are formed from alkanes by cracking.'

Which two students are correct?

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