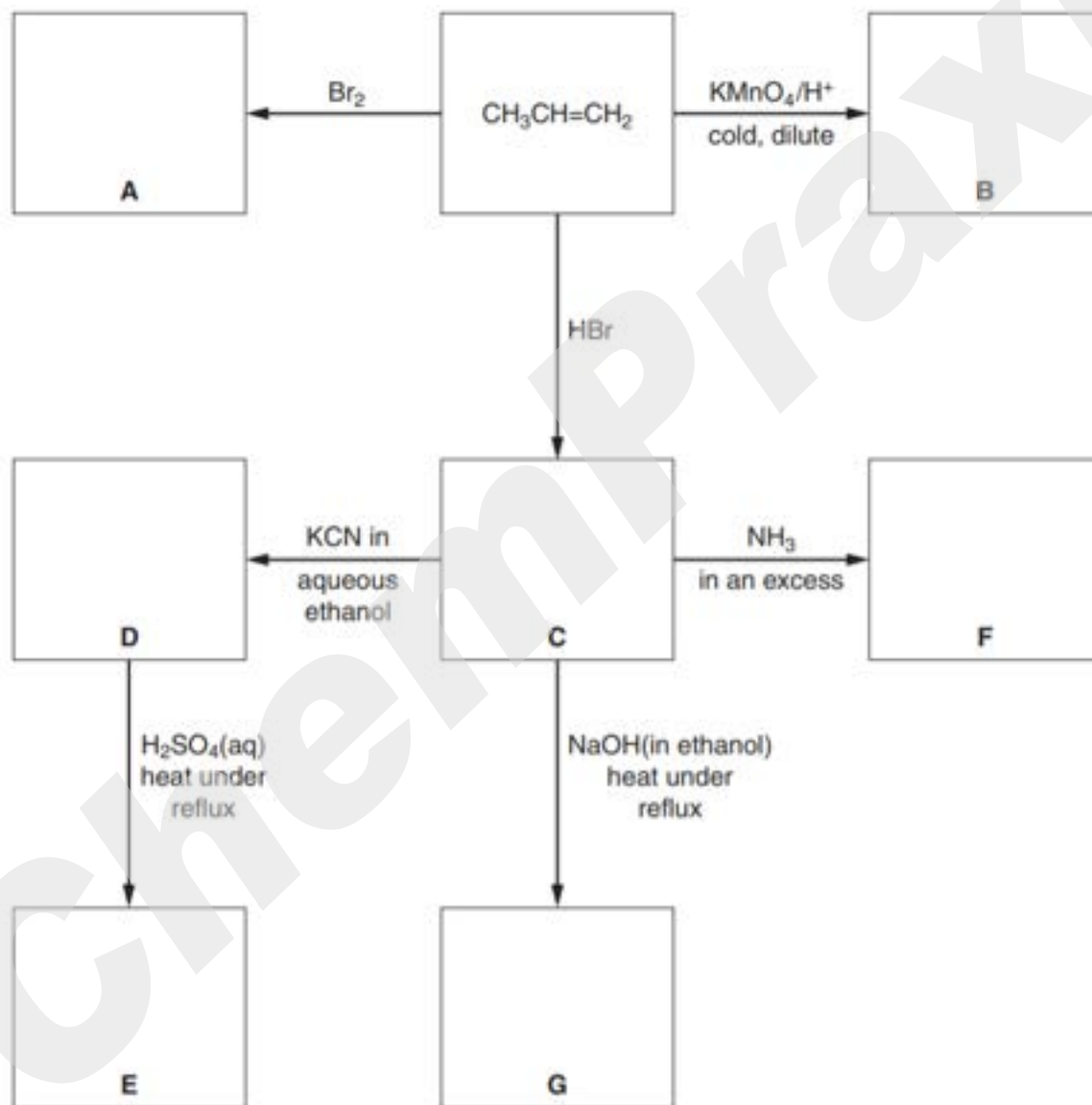


Hydrocarbon

(Past Year Topical Questions 2010-2015)

May/June 2010 (21)

- 4 (a) Complete the following reaction scheme which starts with propene. In each empty box, write the structural formula of the organic compound that would be formed.



[7]

(b) Under suitable conditions, compound **E** will react with compound **B**.

(i) What functional group is produced in this reaction?

.....

(ii) How is this reaction carried out in a school or college laboratory?

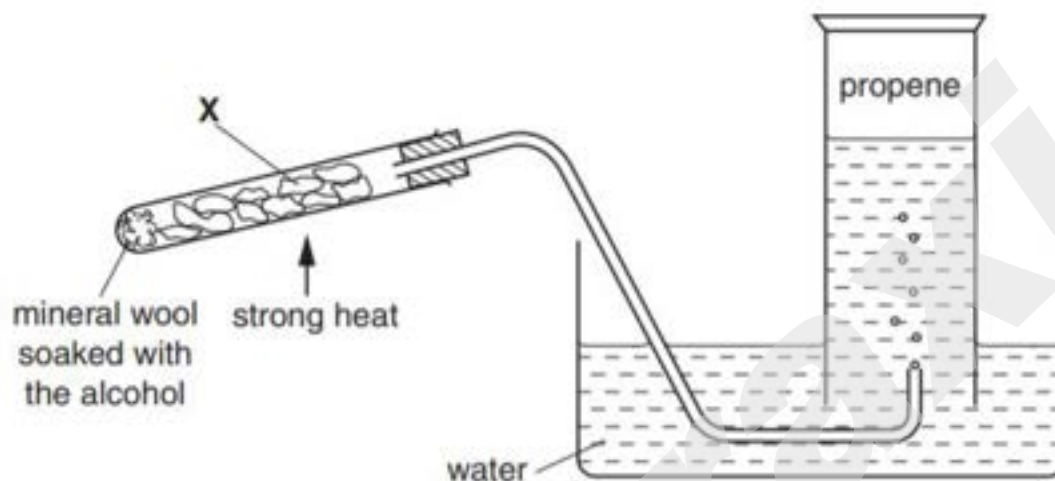
.....

.....

[3]

May/June 2010 (22)

- 5 Alkenes such as propene can be readily prepared from alcohols in a school or college laboratory by using the apparatus below.



- (a) (i) Give the **name** of an alcohol that can be used in this apparatus to prepare propene.

.....

- (ii) Draw the **skeletal** formula of the alcohol you have named in (i).

- (iii) What type of reaction occurs in this case?

.....

[3]

- (b) (i) During the reaction, the material **X** becomes black in colour. Suggest the identity of the black substance and suggest how it is produced during the reaction.

.....
.....
.....

- (ii) At the end of the experiment, when no more propene is being produced, the delivery tube is removed from the water before the apparatus is allowed to cool.

Suggest why this done.

.....
.....
.....

- (iii) The material labelled **X** can be broken crockery, broken brick or pumice.

Give the chemical formula of a compound that is present in one of these materials.

.....

- (iv) State another reagent that could be used to produce propene from an alcohol.

.....

[5]

(c) Give the structural formula of the organic product formed when propene reacts separately with **each** of the following substances.

(i) bromine

(ii) cold, dilute manganate(VII) ions

(iii) hot, concentrated manganate(VII) ions

[3]

(d) Propene may be polymerised.

(i) What is the essential condition for such a polymerisation?

.....

(ii) The disposal of waste poly(propene) is very difficult.
Give **one** important reason for this.

.....

.....

[2]

May/June 2010 (23)

4 Organic reactions involve substances which may be

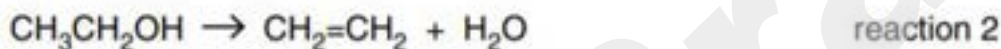
atoms, molecules, ions or free radicals.

We also apply the terms

electrophilic, nucleophilic, addition, elimination and substitution

to organic reactions.

Consider the following reactions.



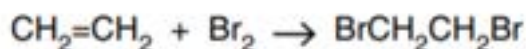
(a) Using the terms mentioned above, state as clearly as you can the nature of each of the following reactions.

reaction 1

reaction 2

[2]

(e) One characteristic reaction of ethene is its ability to decolourise bromine.



In this reaction, ethene behaves as a nucleophile.

Suggest an explanation for how ethene can behave in this way.

.....

..... [1]

Oct/Nov 2010 (21)

3 Crude oil is a naturally occurring flammable liquid which consists of a complex mixture of hydrocarbons. In order to separate the hydrocarbons the crude oil is subjected to fractional distillation.

(a) Explain what is meant by the following terms.

(i) *hydrocarbon*

.....

(ii) *fractional distillation*

..... [2]

(b) Undecane, $C_{11}H_{24}$, is a long chain hydrocarbon which is present in crude oil. Such long chain hydrocarbons are 'cracked' to produce alkanes and alkenes which have smaller molecules.

(i) Give the conditions for **two** different processes by which long chain molecules may be cracked.

process 1

.....

process 2

.....

(ii) Undecane, $C_{11}H_{24}$, can be cracked to form pentane, C_5H_{12} , and an alkene. Construct a balanced equation for this reaction.

..... [3]

Pentane, C_5H_{12} , exhibits structural isomerism.

(c) (i) Draw the three structural isomers of pentane.

isomer B	isomer C	isomer D

(ii) The three isomers of pentane have different boiling points.

Which of your isomers has the highest boiling point?

isomer

Suggest an explanation for your answer.

.....

.....

..... [6]

Oct/Nov 2010 (23)/Q3

Two derivatives of ethene which have been detected in dust clouds in Space are acrylonitrile (2-propenenitrile), $\text{CH}_2=\text{CHCN}$, and vinyl alcohol (ethenol), $\text{CH}_2=\text{CHOH}$.

(b) Like ethene, acrylonitrile can be polymerised. The resulting polymer can be used to make carbon fibres.

(i) Draw the structural formula of the polymer made from acrylonitrile, showing two repeat units.

(ii) What type of polymerisation is this reaction?

..... [2]

May/June 2011 (21)

- 2 Crude oil contains a mixture of hydrocarbons together with other organic compounds which may contain nitrogen, oxygen or sulfur in their molecules.

At an oil refinery, after the fractional distillation of crude oil, a number of other processes may be used including 'cracking', 'isomerisation', and 'reforming'.

- (a) (i) What is meant by the term '*cracking*' and why is it carried out?

.....

.....

.....

.....

- (ii) Outline briefly how the cracking of hydrocarbons would be carried out.

.....

.....

- (iii) Construct a balanced equation for the formation of heptane, C_7H_{16} , by cracking tetradecane, $C_{14}H_{30}$.

.....

[4]

- 5 The gas ethyne, C_2H_2 , more commonly known as acetylene, is manufactured for use in the synthesis of organic compounds. It is also used, in combination with oxygen, in 'oxy-acetylene' torches for the cutting and welding of metals.

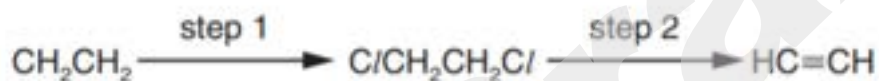
Industrially, ethyne is made from calcium carbide, CaC_2 , or by cracking liquid hydrocarbons.

- (a) When calcium carbide is reacted with water, ethyne and calcium hydroxide are formed.

Construct a balanced equation for this reaction.

..... [1]

Ethyne can also be obtained from ethene by using the following sequence of reactions.



- (b) (i) What types of reaction are step 1 and step 2?

step 1

step 2

- (ii) Suggest what reagent and conditions would be used in a laboratory in step 2.

reagent

conditions

[5]

When ethyne is passed into water at 60°C, in the presence of a little H₂SO₄ and Hg²⁺ ions, a pungent, colourless organic liquid, **Q**, with *M_r* of 44 is obtained. This is step 3.

When **Q** is warmed with Tollens' reagent in a test-tube, a silver mirror is formed. On acidification, the solution remaining in the test-tube is found to contain the organic compound **R** which has *M_r* of 60. This is step 4.

(c) (i) Give the structural formulae of **Q** and **R**.



(ii) What type of reaction is step 3 and step 4?

step 3

step 4

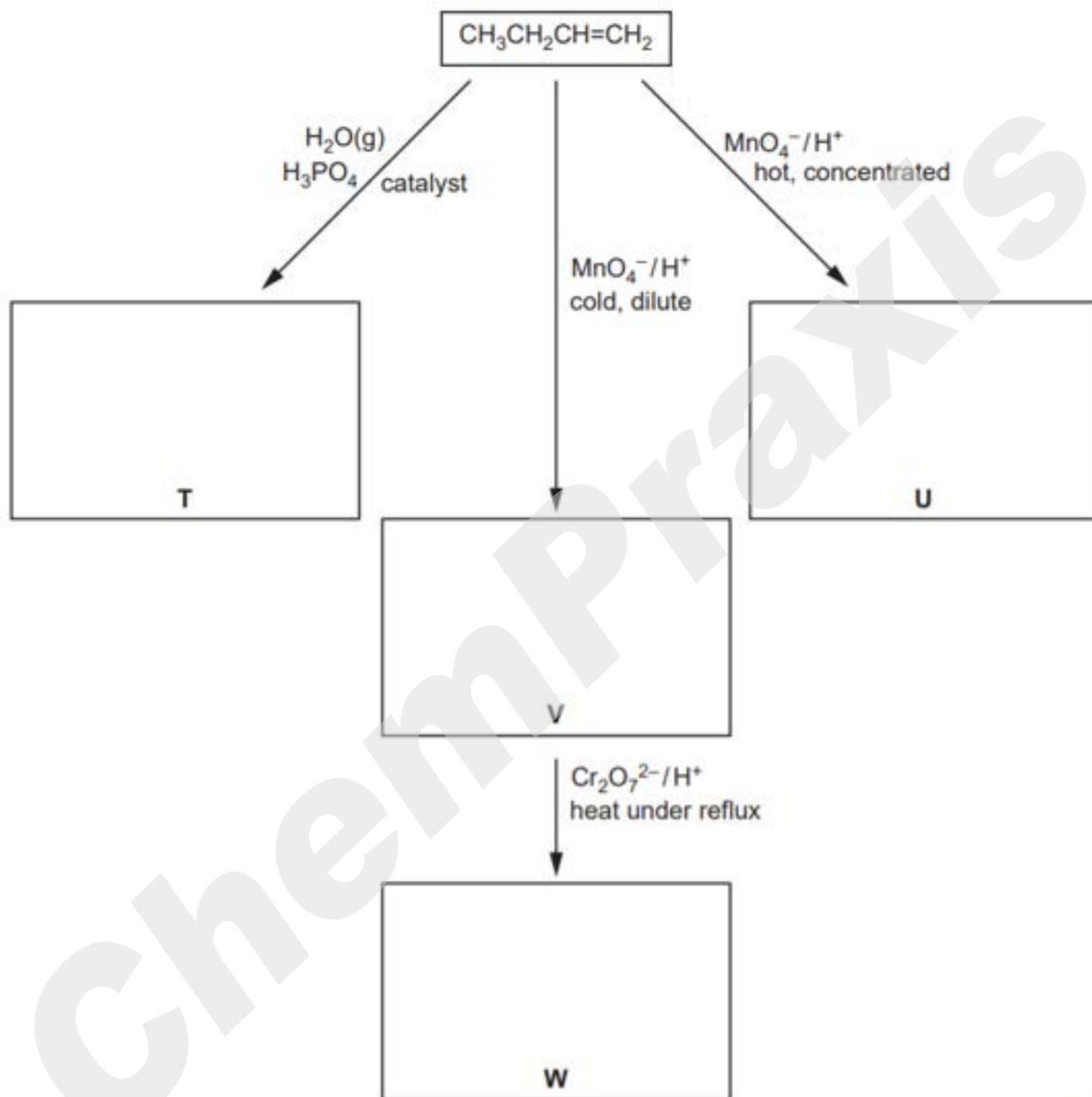
[4]

Oct/Nov 2011 (21)

4 But-1-ene, CH₃CH₂CH=CH₂, is an important compound in the petrochemical industry.

(a) Some reactions of but-1-ene are given below.

In each empty box, draw the structural formula of the organic compound formed.



[5]

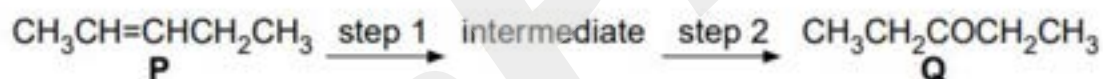
(b) Compound T reacts with compound U.

Draw the **displayed** formula of the organic product of this reaction.

[2]

Oct/Nov 2011 (23)/Q4

(d) Compound P may be converted into compound Q in a two-step reaction.



(i) What is the structural formula of the intermediate compound formed in this sequence?

(ii) Outline how step 1 may be carried out to give this intermediate compound.

.....

.....

.....

(iii) What reagent would be used for step 2?

.....

[4]

May/June 2012 (21)/Q4

- (b) Ethene is bubbled into two separate test-tubes, one containing aqueous hydrogen bromide and the other containing cold, dilute acidified potassium manganate(VII).

In **each** case, describe any colour changes you would see and give the structural formula of the organic product.

	aqueous hydrogen bromide	cold, dilute acidified potassium manganate(VII)
colour at start		
colour after reaction		
structural formula of organic product		

[4]

- (c) Cyclohexene has the following structural formula.



- (i) What is the molecular formula of cyclohexene?

.....

(ii) Draw the structural formula of the compound formed when cyclohexene is reacted with bromine.

(iii) State as fully as you can what *type of reaction* this is.

.....

(iv) Draw the structural formula of the compound formed when cyclohexene is reacted with hot concentrated acidified potassium manganate(VII).

[5]

May/June 2012 (23)

4 But-2-ene, $\text{CH}_3\text{CH}=\text{CHCH}_3$, is an important compound which is obtained from the cracking of hydrocarbons present in crude oil.

(a) Give **two** different conditions under which long chain hydrocarbons may be cracked.

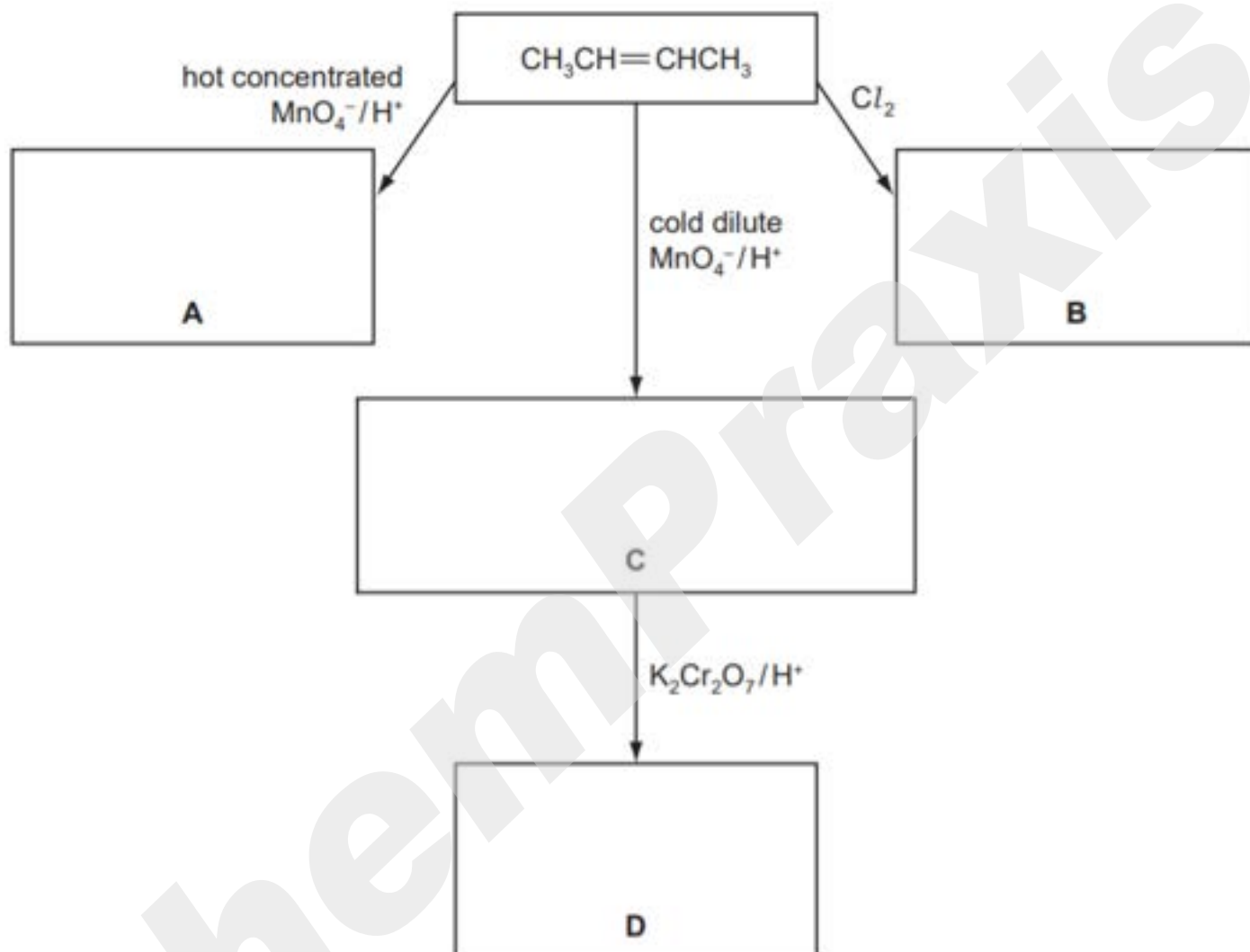
.....
.....
..... [2]

(b) Dodecane, $\text{C}_{12}\text{H}_{26}$, is a long chain hydrocarbon which is present in crude oil and which can be cracked to form but-2-ene and an alkane.

Write a balanced equation for this reaction.

..... [1]

- (c) Some reactions of but-2-ene are shown below.
 In the boxes below, give the **structural** formulae of the organic compounds A to D.



[4]

(d) (i) Draw the **skeletal** formula of compound **D**.

(ii) By using the letters **A** to **D** as appropriate, identify those compounds which are chiral. If there are none, write 'none'.

.....

[3]

- (e) But-2-ene can be polymerised to give poly(butene).

Draw the **structural** formula of a portion of the polymer chain in poly(butene) showing **two** repeat units.

[1]

- (f) Compound **C** is a liquid which can be reacted with concentrated sulfuric acid to give a gas, **E**, which will decolourise aqueous bromine when passed through it.

(i) Suggest the **structural** formula of **E**.

(ii) Suggest the **structural** formula of the product of the reaction between **E** and an excess of bromine.

(iii) What *type of reaction* occurs between **E** and an excess of bromine?

.....

[3]

May/June 2013 (21)

5 Crotonaldehyde, $\text{CH}_3\text{CH}=\text{CHCHO}$, occurs in soybean oils.

- (a) In the boxes below, write the **structural formula** of the organic compound formed when crotonaldehyde is reacted separately with each reagent under suitable conditions. If you think no reaction occurs, write 'NO REACTION' in the box.

reaction	reagent	product
A	Br_2 in an inert organic solvent	
B	PCl_3	
C	H_2 and Ni catalyst	
D	NaBH_4	
E	$\text{K}_2\text{Cr}_2\text{O}_7/\text{H}^+$	

[5]

(d) The product of reaction E in the table opposite will react with a solution containing acidified manganate(VII) ions.
Draw the **structural formulae** of the organic products when the reagent is

(i) cold, dilute;

(ii) hot, concentrated.

[3]

May/June 2013 (23)

- 5** Compounds containing the allyl group, $\text{CH}_2=\text{CHCH}_2-$, have pungent smells and are found in onions and garlic.

Allyl alcohol, $\text{CH}_2=\text{CHCH}_2\text{OH}$, is a colourless liquid which is soluble in water.

- (a)** Allyl alcohol behaves as a primary alcohol and as an alkene.

Give the structural formula of the organic compound formed when allyl alcohol is reacted separately with each of the following reagents.

- (i)** acidified potassium dichromate(VI), heating under reflux

- (ii)** bromine in an inert organic solvent

- (iii)** cold, dilute, acidified potassium manganate(VII)

- (iv)** hot, concentrated, acidified potassium manganate(VII)

[5]

(b) Allyl alcohol undergoes the following reactions.

(i) When reacted with concentrated HCl at 100 °C, CH₂=CHCH₂Cl is formed.

State as fully as you can what *type of reaction* this is.

.....

(ii) When reacted with MnO₂ at room temperature, CH₂=CHCHO is formed.

What *type of reaction* is this?

.....

[2]

(c) Allyl alcohol can be converted into propanal in two steps.



(i) What reagents and conditions would be used for **each** step?

step I

reagent(s)

condition(s)

step II

reagent(s)

condition(s)

(ii) Allyl alcohol and propanal are isomers.

What form of isomerism do they display?

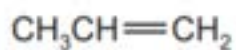
.....
[5]**(d)** Allyl alcohol may also be converted into propanal by using a ruthenium(IV) catalyst in water.

Suggest what is unusual about this single step reaction.

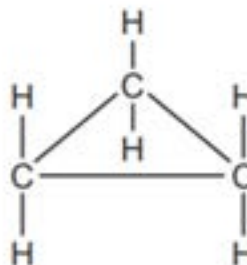
.....
..... [1]

Oct/Nov 2013 (21)

2 The molecular formula C_3H_6 represents the compounds propene and cyclopropane.



propene



cyclopropane

(a) What is the H–C–H bond angle at the terminal =CH₂ group in propene?

.....

[1]

(b) Under suitable conditions, propene and cyclopropane each react with chlorine.

(i) With propene, 1,2-dichloropropane, $CH_3CHClCH_2Cl$ is formed.

State fully what type of reaction this is.

..... [1]

- (ii) When cyclopropane reacts with chlorine, three different compounds with the molecular formula $C_3H_4Cl_2$ can be formed.

Draw displayed structures of **each** of these three compounds.

[3]

5 Propane, C_3H_8 , and butane, C_4H_{10} , are components of Liquefied Petroleum Gas (LPG) which is widely used as a fuel for domestic cooking and heating.

(a) (i) To which class of compounds do these two hydrocarbons belong?

.....

(ii) Write a balanced equation for the complete combustion of butane.

..... [2]

(b) When propane or butane is used in cooking, the saucepan may become covered by a solid black deposit.

(i) What is the chemical name for this black solid?

.....

(ii) Write a balanced equation for its formation from butane.

..... [2]

(e) The boiling points of methane, ethane, propane, and butane are given below.

compound	CH ₄	CH ₃ CH ₃	CH ₃ CH ₂ CH ₃	CH ₃ (CH ₂) ₂ CH ₃
boiling point/K	112	185	231	273

(i) Suggest an explanation for the increase in boiling points from methane to butane.

.....

.....

.....

(ii) The isomer of butane, 2-methylpropane, (CH₃)₃CH, has a boiling point of 261 K. Suggest an explanation for the difference between this value and that for butane in the table above.

.....

.....

.....

[4]

Oct/Nov 2013 (23)

2 Petrol and diesel fuel are both used in internal combustion engines. Petrol may be regarded as having the formula C₉H₂₀ and diesel fuel as having the formula C₁₄H₃₀.

(a) (i) To which class of compounds do these two hydrocarbons belong?

.....

(ii) Write a balanced equation for the complete combustion of petrol.

.....

[2]

(b) When petrol or diesel fuel are used in internal combustion engines, several different products of the incomplete combustion of the fuel may be formed.

(i) Name **two** of these products that do not contain hydrogen.

..... and

(ii) Choose one of these and state a hazard it causes.

product

hazard

(iii) Write a balanced equation for the formation of **one** of the products in (i) from diesel fuel.

..... [4]

May/June 2014 (21)

4 Alkanes and alkenes both react with bromine.

(a) Explain how and why bromine can be used to distinguish between an alkene and an alkane.

.....
.....
..... [2]

(b) The reaction of ethane with bromine forms a mixture of products.

(i) State the essential conditions for this reaction to occur.

..... [1]

(ii) Give the full name of the mechanism of this reaction.

..... [2]

(iii) Give the equation for a **termination** step that could occur, producing a **hydrocarbon**.

..... [1]

(iv) Give the equation for one **propagation** step involved in the formation of dibromoethane from bromoethane during this reaction.

..... [1]

(ii) Complete the diagram below to illustrate this mechanism.
Include all relevant charges, partial charges, curly arrows and lone pairs.



[4]

May/June 2014 (22)

4 Crude oil is processed to give a wide variety of hydrocarbons.

(a) Give the names of one physical process and one chemical process carried out during the processing of crude oil.

physical process

chemical process

[2]

(b) Alkanes and alkenes can both be obtained from crude oil.

(i) Explain why alkanes are unreactive.

.....

..... [2]

(ii) State the bond angles in a molecule of

ethane,

ethene. [1]

(iii) State the shape of each molecule in terms of the arrangement of the atoms bonded to each carbon atom.

ethane ethene [1]

(iv) Explain why these molecules have different shapes in terms of the carbon-carbon bonds present.

.....

..... [1]

- (c) (i) Use a series of equations to describe the mechanism of the reaction of ethane with chlorine to form chloroethane. Name the steps in this reaction.

.....
.....
.....
.....
..... [5]

- (ii) Write an equation to show how butane could be produced as a by-product of this reaction.

..... [1]

- 5 A hydrocarbon, **P**, with the formula C_6H_{12} readily decolourises bromine.

On reaction with hot, concentrated, acidified potassium manganate(VII) solution a single organic product, **Q**, is obtained.

Q gives an orange precipitate when reacted with 2,4-dinitrophenylhydrazine, 2,4-DNPH reagent, but has no reaction with Tollens' reagent.

- (ii) Draw the skeletal formula of **P** and give its name.

name of **P** [2]

- (b) There are several structural isomers of **P** that also decolourise bromine, but only four of these structural isomers exhibit geometrical (cis-trans) isomerism.

Give the structures of any **three** structural isomers of **P** that exhibit geometrical (cis-trans) isomerism.

[3]

May/June 2014 (23)/Q1

- (c) Another hydrocarbon, **W**, with the formula C_4H_8 , reacts with hydrogen bromide, HBr , to give two products **X** and **Y**. **X** and **Y** are structural isomers of molecular formula C_4H_9Br .

Reaction of **X** with aqueous alkali produces an alcohol, **Z**, that has **no** reaction with acidified dichromate(VI).

- (i) Give the structures and names of the compounds **W**, **X**, **Y**, and **Z**

W

X

.....

Y

Z

.....

[4]

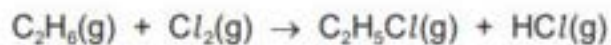
- (ii) When **W** reacts with hydrogen bromide, more **X** than **Y** is produced. Explain why.

.....
.....
.....

[2]

May/June 2015 (22)

3 Ethane reacts with chlorine to form chloroethane.



(ii) State the conditions needed for this reaction to occur.

..... [1]

(iii) Use a series of equations to describe the mechanism of this reaction including the names of each stage and an indication of how butane can be produced as a minor by-product.

.....
.....
.....
.....
.....
.....
..... [5]

May/June 2015 (23)/Q3

(b) **D**, **E** and **F** all decolourise bromine and effervesce slowly with sodium metal.

E shows geometrical isomerism. Only **D** has a branched chain.

None of these isomers contains an oxygen atom bonded to a carbon atom involved in π bonding.

None of these isomers contains a chiral centre.

(i) Give the structures of **D**, **E** and **F**. Show the two stereoisomers of **E** and label the stereoisomerism shown.

D		
E	E	
F		

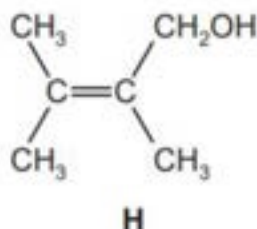
[5]

(ii) Identify the gas produced during the reaction of each of these isomers with sodium metal.

..... [1]

May/June 2015 (23)

4 The structure of H is shown.



(a) H reacts with both cold, dilute, acidified potassium manganate(VII) and with hot, concentrated, acidified potassium manganate(VII).

(i) Give the structure of the organic product of the reaction of H with cold, dilute, acidified potassium manganate(VII).

[1]

(ii) Give the structures of the organic products of the reaction of H with hot, concentrated, acidified potassium manganate(VII).

[2]

- (b) (i) Complete the reaction scheme to show the mechanism of the reaction of H with bromine to form J.

Include all necessary curly arrows, lone pairs and charges.



[3]

Oct/Nov 2015 (21)/Q3

- (b) (i) Write an equation for the complete combustion of heptane.

..... [1]

- (ii) Write an equation for the incomplete combustion of heptane leading to the production of a solid pollutant.

..... [1]

- (iii) Incomplete combustion can also lead to emission of unburnt hydrocarbons.

State one environmental consequence of this.

..... [1]

