AQA A-LEVEL CHEMISTRY · 7405

CHEMISTRY



EXAM QUESTION PACK

3.3.2 ALKANES

SCORE	PERCENTAGE
/226	%

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Q1.

This question is about the reactions of alkanes.

(a) Alkanes can be used as fuels.

Give an equation for the combustion of heptane (C_7H_{16}) in an excess of oxygen.

_____

(1)

(b) Heptane can be obtained from the catalytic cracking of hexadecane ($C_{16}H_{34}$) at a high temperature.

Identify a suitable catalyst for this process.
Give **one** condition other than high temperature.
Give an equation for the catalytic cracking of one molecule of hexadecane to produce one molecule of heptane, one molecule of cyclohexane and one other product.

Catalyst _____

Condition _____

Equation _____

_____

(3)

(c) Alkanes can be used in free-radical substitution reactions to produce halogenoalkanes.

Give equations for the propagation steps in the reaction of butane to form 2-chlorobutane.

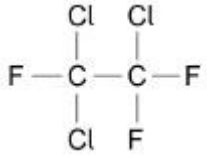
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_____

(2)

(d) Chlorofluorocarbons (CFCs) are a group of halogenoalkanes currently banned in many countries. They cannot be used as solvents or refrigerants because of their effect on the environment.

The structure of a CFC is shown.



Identify the radical produced from this CFC that is responsible for the depletion of ozone in the atmosphere.

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Explain, with the aid of equations, why a single radical can cause the decomposition of many molecules of ozone.

Radical _____

Explanation _____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 10 marks)

Q2.

Which equation represents a termination step?

A $CH_3CH_2CH_3 + Br\bullet \rightarrow CH_3\dot{C}HCH_3 + HBr$ ⬭

B $ClO\bullet + O_3 \rightarrow Cl\bullet + 2O_2$ ⬭

C $RO\bullet + CH_2 = CH_2 \rightarrow ROCH_2\dot{C}H_2$ ⬭

D $CH_3\dot{C}FCl + Cl\bullet \rightarrow CH_3CFCl_2$ ⬭

(Total 1 mark)

Q3.

Which equation is a propagation step in the conversion of trichloromethane into tetrachloromethane by reaction with chlorine in the presence of ultraviolet light?

A $CHCl_3 + Cl_2 \longrightarrow CCl_4 + HCl$ ⬭

B $\bullet CCl_3 + \bullet Cl \longrightarrow CCl_4$ ⬭

C $CHCl_3 + \bullet Cl \longrightarrow CCl_4 + \bullet H$ ⬭

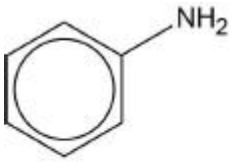
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D $\bullet CCl_3 + Cl_2 \longrightarrow CCl_4 + \bullet Cl$ ⬭

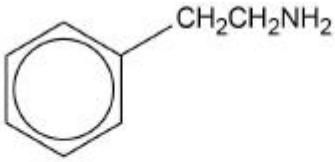
(Total 1 mark)

Q4.

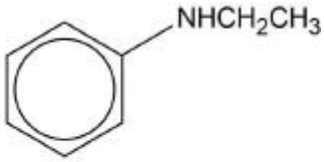
This question is about the three amines, **E**, **F** and **G**.



E



F



G

(a) Amines **E**, **F** and **G** are weak bases.

Explain the difference in base strength of the three amines and give the order of increasing base strength.

(6)

(b) Amine **F** can be prepared in a three-step synthesis starting from methylbenzene.

Suggest the structures of the two intermediate compounds.

For each step, give reagents and conditions only. Equations and mechanisms are **not** required.

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(5)

(Total 11 marks)

Q5.

Which of the following mechanisms does **not** occur in reactions of bromoethane?

A Electrophilic addition ⬭

B Elimination ⬭

C Nucleophilic substitution ⬭

D Radical substitution ⬭

(Total 1 mark)

Q6.

Which species is produced in a propagation step during the reaction of propane with an excess of chlorine in the presence of UV light?

A H• ⬭

B C_3H_5Cl ⬭

C $C_3H_6CL_2$ ⬭

D C_6H_{14} ⬭

(Total 1 mark)

Q7.

Which molecule is **not** produced when ethane reacts with bromine in the presence of ultraviolet light?

A $C_2H_4Br_2$ ⬭

B HBr ⬭

C H_2 ⬭

D C_4H_{10} ⬭

(Total 1 mark)

Q8.

Refrigerants are substances used to cool refrigerators and freezers. Until recently, many of the compounds used as refrigerants were chlorofluorocarbons (CFCs), but these are now known to form chlorine radicals. CFCs have been phased out in many countries by

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international agreement.

(a) Write **two** equations to show how chlorine radicals react with ozone molecules in the upper atmosphere.

1. _____

2. _____

(2)

(b) Chloropentafluoroethane is a CFC that has been used as a refrigerant.

Draw its displayed formula.

(1)

(c) 1,1,1-trifluoroethane (CF_3CH_3) is one of the molecules that has been used as a refrigerant in place of CFCs.

Explain why 1,1,1-trifluoroethane does not lead to the depletion of the ozone in the upper atmosphere.

_____

_____

_____

(1)

(d) One of the steps in the synthesis of 1,1,1-trifluoroethane (CF_3CH_3) is the reaction of 1,1-difluoroethane (CHF_2CH_3) with fluorine in a free-radical substitution reaction.

Write **two** equations to represent the propagation steps in this conversion of CHF_2CH_3 into CF_3CH_3

Propagation step 1

_____

Propagation step 2

_____

(2)

(e) A refrigerator contains 1.41 kg of 1,1,1-trifluoroethane (CF_3CH_3).

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Calculate the number of molecules of 1,1,1-trifluoroethane in the refrigerator.
Give your answer to an appropriate number of significant figures.
(The Avogadro constant L = 6.022×10^{23} mol^{-1})

_____

_____

_____

(2)

(f) There are growing concerns about the use of 1,1,1-trifluoroethane as a refrigerant as it is a greenhouse gas that absorbs some of Earth's infrared radiation.

Give **one** reason why bonds in molecules such as carbon dioxide and 1,1,1-trifluoroethane absorb infrared radiation.

_____

_____

(1)

(Total 9 marks)

Q9.

Haloalkanes are used as refrigerants, solvents and anaesthetics.

(a) Trichloromethane ($CHCl_3$) is a haloalkane that can be formed by heating a mixture of chloromethane (CH_3Cl) and chlorine.

(i) Write an overall equation for the formation of trichloromethane by the reaction of chloromethane with chlorine.

_____

(1)

(ii) Name the mechanism for this formation of trichloromethane.

_____

(1)

(iii) Dichloromethane (CH_2Cl_2) is an intermediate in this formation of trichloromethane.

Write an equation for each of the following steps in the mechanism for the reaction of dichloromethane with chlorine.

Initiation step

_____

First propagation step

_____

Second propagation step

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_____

A termination step leading to the formation of a compound with formula $C_2H_2Cl_4$

_____

(4)

(b) Chlorotrifluoromethane ($CClF_3$) is used as a refrigerant, but is being phased out due to concerns about ozone depletion in the upper atmosphere.
In the upper atmosphere, $CClF_3$ decomposes in the presence of UV light forming a reactive intermediate that catalyses the decomposition of ozone.

(i) Write an equation to show how $CClF_3$ decomposes to form the reactive intermediate.

_____

(1)

(ii) Write two equations to show how this reactive intermediate is involved in catalysing the decomposition of ozone.

1. _____

2. _____

(2)

(Total 9 marks)

Q10.

Trifluoromethane (CHF_3) can be used to make the refrigerant chlorotrifluoromethane($CClF_3$).

(a) Chlorotrifluoromethane is formed when trifluoromethane reacts with chlorine.

$$CHF_3 + Cl_2 \longrightarrow CClF_3 + HCl$$

The reaction is a free-radical substitution reaction similar to the reaction of methane with chlorine.

(i) Write an equation for each of the following steps in the mechanism for the reaction of CHF_3 with Cl_2

Initiation step

_____

First propagation step

_____

Second propagation step

_____

Termination step to form hexafluoroethane

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_____

(4)

(ii) Give **one** essential condition for this reaction.

_____

(1)

(b) In some refrigeration systems, CHF_3 has replaced $CClF_3$ because of concerns about ozone depletion.

(i) Identify the species formed from $CClF_3$ that is responsible for the catalytic decomposition of ozone in the upper atmosphere.

_____

(1)

(ii) Write an overall equation to represent the decomposition of ozone into oxygen.

_____

(1)

(Total 7 marks)

Q11.

There are many uses of halogenated organic compounds despite environmental concerns.

(a) Bromotrifluoromethane is used in fire extinguishers in aircraft.
Bromotrifluoromethane is formed when trifluoromethane reacts with bromine.

$$CHF_3 + Br_2 \longrightarrow CBrF_3 + HBr$$

The reaction is a free-radical substitution reaction similar to the reaction of methane with chlorine.

(i) Write an equation for each of the following steps in the mechanism for the reaction of CHF_3 with Br_2

Initiation step

_____

First propagation step

_____

Second propagation step

_____

A termination step

_____

(4)

(ii) State **one** condition necessary for the initiation of this reaction.

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_____

(1)

(b) Bromine-containing and chlorine-containing organic compounds may have a role in the decomposition of ozone in the upper atmosphere.

(i) Draw an appropriate **displayed formula** in the space provided to complete the following equation to show how $CBrF_3$ may produce bromine atoms in the upper atmosphere.

$CBrF_3 \longrightarrow$ _____ + $Br^{\bullet}$

(1)

(ii) In the upper atmosphere, it is more likely for $CBrF_3$ to produce bromine atoms than it is for $CClF_3$ to produce chlorine atoms.

Suggest **one** reason for this.

_____

_____

_____

(1)

(iii) Bromine atoms have a similar role to chlorine atoms in the decomposition of ozone.
The overall equation for the decomposition of ozone is

$$2O_3 \longrightarrow 3O_2$$

Write **two** equations to show how bromine atoms ($Br^{\bullet}$) act as a catalyst in the decomposition of ozone.

Explain how these two decomposition equations show that bromine atoms behave as a catalyst.

Equation 1

_____

Equation 2

_____

Explanation _____

_____

_____

(3)

(Total 10 marks)

Q12.

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Chlorine can be used to make chlorinated alkanes such as dichloromethane.

(a) Write an equation for each of the following steps in the mechanism for the reaction of chloromethane (CH_3Cl) with chlorine to form dichloromethane (CH_2Cl_2).

Initiation step

_____

First propagation step

_____

Second propagation step

_____

The termination step that forms a compound with empirical formula CH_2Cl.

_____

(4)

(b) When chlorinated alkanes enter the upper atmosphere, carbon-chlorine bonds are broken. This process produces a reactive intermediate that catalyses the decomposition of ozone. The overall equation for this decomposition is

$$2O_3 \rightleftharpoons 3O_2$$

(i) Name the type of reactive intermediate that acts as a catalyst in this reaction.

_____

(1)

(ii) Write **two** equations to show how this intermediate is involved as a catalyst in them decomposition of ozone.

Equation 1 _____

Equation 2 _____

(2)

(Total 7 marks)

Q13.

The refrigerant R410A, used in air conditioners, is a mixture of two fluoroalkanes, pentafluoroethane and difluoromethane.

(a) (i) The mechanism for the reaction of fluorine with either an alkane or a fluoroalkane is similar to that for the reaction of chlorine with methane.

Name the type of mechanism for the reaction of chlorine with methane.

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_____

(1)

(ii) Write equations for the following steps in the mechanism for the reaction of fluorine with fluoromethane (CH_3F) to form difluoromethane (CH_2F_2).

Initiation step

_____

First propagation step

_____

Second propagation step

_____

A termination step leading to the formation of 1,2-difluoroethane.

_____

(4)

(iii) Write an overall equation for the reaction of fluorine with ethane to form pentafluoroethane (CF_3CHF_2) by this mechanism.

_____

(1)

(b) The refrigerant R112A (CCl_3CF_2Cl) has been banned because of concerns about ozone depletion.

Give the IUPAC name for CCl_3CF_2Cl

_____

(1)

(c) Nitrogen monoxide (NO) catalyses the decomposition of ozone into oxygen.

(i) Write the overall equation for this decomposition.

_____

(1)

(ii) Use the overall equation to deduce Step **3** in the following mechanism that shows how nitrogen monoxide catalyses this decomposition.

Step **1** $O_3 \longrightarrow O + O_2$

Step **2** $NO + O_3 \longrightarrow NO_2 + O_2$

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Step **3** _____

(1)

(Total 9 marks)

Q14.

Chloromethanes, such as dichloromethane and trichloromethane, are produced in industry as they have many uses.
Trichloromethane has been used in the manufacture of the refrigerant chlorodifluoromethane.

(a) Chlorine can react with dichloromethane (CH_2Cl_2) to form trichloromethane ($CHCl_3$).

(i) Write an equation for each of the following steps in the mechanism for this reaction.

Initiation step

_____

First propagation step

_____

Second propagation step

_____

(3)

(ii) Give **one** essential condition for this reaction and name the type of mechanism.

Essential condition _____

Type of mechanism _____

(2)

(b) An organic product, **X**, with M_r = 154.0 is obtained when chlorine reacts with trichloromethane.

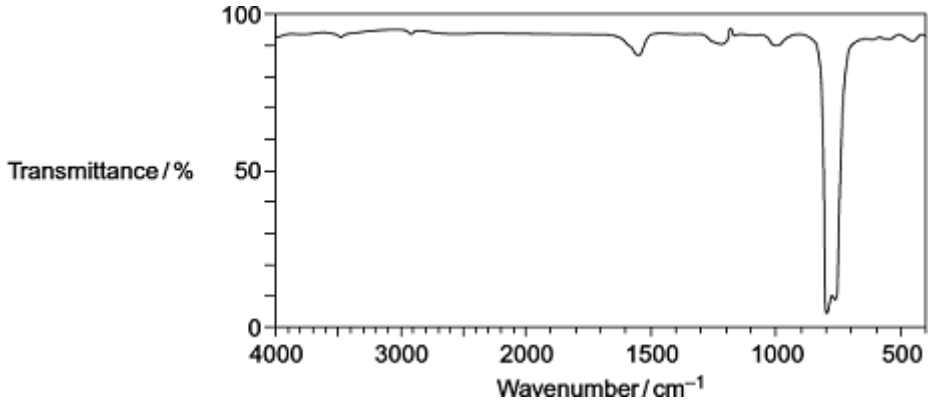
(i) Write an equation for the overall reaction of chlorine with trichloromethane to form **X**, by the same mechanism as that outlined in part (a)(i).

_____

(1)

(ii) The following infrared spectrum was obtained for a sample of **X** produced in this reaction.

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Use this infrared spectrum to explain why it is possible to deduce that this sample of **X** contains no trichloromethane.
You may find it helpful to refer to **Table 1** on the Data Sheet.

(2)

(c) Explain, with the aid of equations and the intermediates that form in the ozone layer, why the European Union has banned the use of chlorodifluoromethane ($CHClF_2$) as a refrigerant.

(4)

(d) The compound 2,3,3,3-tetrafluoropropene is the refrigerant used in all new car air conditioners.

(i) Draw the displayed formula for 2,3,3,3-tetrafluoropropene.

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(1)

(ii) Give **one** reason why 2,3,3,3-tetrafluoropropene is a more **environmentally** acceptable refrigerant than chlorodifluoromethane.

_____

_____

_____

(1)

(Total 14 marks)

Q15.

Halogens are used to make halogenated organic compounds.

(a) The refrigerant used in air conditioners is a mixture of fluorinated alkanes. These compounds are made by fluorination reactions.
The mechanism for the reaction of fluorine with an alkane or with a fluoroalkane is a free-radical substitution similar to the reaction of chlorine with methane.

(i) Write the overall equation for the reaction of fluorine with methane to form trifluoromethane (CHF_3).

_____

(1)

(ii) Write equations for the following steps in the mechanism for the reaction of fluorine with trifluoromethane (CHF_3) to form tetrafluoromethane (CF_4).

Initiation step

_____

First propagation step

_____

Second propagation step

_____

A termination step leading to the formation of hexafluoroethane.

_____

(4)

(b) Chlorofluorocarbons (CFCs) were used as refrigerants.
In the upper atmosphere, ultra-violet radiation breaks bonds in the CFCs to produce a reactive intermediate that catalyses the decomposition of ozone.

(i) An example of a CFC is 1,1,1-trichloro-2,2-difluoroethane.
Draw the displayed formula of this CFC.

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(1)

(ii) Identify a bond in a CFC that is broken by ultra-violet radiation to produce a reactive intermediate.
Give the name of this reactive intermediate that catalyses the decomposition of ozone.
Write an overall equation for this decomposition of ozone.

Bond broken

_____

Name of the reactive intermediate _____

Overall equation

_____

(3)

(Total 9 marks)

Q16.

(a) The reaction of bromine with propane is similar to that of chlorine with methane. Three steps in the mechanism for the bromination of propane to form 1-bromopropane are shown below.

Step **1** $Br_2 \longrightarrow 2Br\bullet$

Step **2** $Br\bullet + CH_3CH_2CH_3 \longrightarrow CH_3CH_2CH_2\bullet + HBr$

Step **3** $CH_3CH_2CH_2\bullet + Br_2 \longrightarrow CH_3CH_2CH_2Br + Br\bullet$

(i) Name the type of mechanism in this reaction.

_____

(1)

(ii) Give an essential condition for Step **1** to occur.

_____

(1)

(iii) Name the type of step illustrated by Steps **2** and **3**.

_____

(1)

(iv) In this mechanism, a different type of step occurs in which free radicals combine. Name this type of step.

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Write an equation to show how hexane could be formed from two free radicals in the mechanism of this reaction.

Type of step _____

Equation _____

(2)

(v) Write an overall equation for the reaction between bromine and propane by the same mechanism to produce octabromopropane (C_3Br_8).

_____

(1)

(b) Bromine reacts with alkenes, even though bromine is a non-polar molecule.

(i) Explain why bromine molecules react with the double bonds in alkenes.

_____

_____

_____

_____

_____

_____

(2)

(ii) Name the type of mechanism involved in this reaction.

_____

(1)

(iii) Draw the structure of the compound with M_r = 387.6 formed when penta-1,4-diene ($H_2C{=}CHCH_2CH{=}CH_2$) reacts with an excess of bromine.

(1)

(c) Two products are formed when propene reacts with hydrogen bromide.
Draw the structure of the intermediate that leads to the formation of the major product in the reaction of propene with hydrogen bromide.
Give the name of this type of intermediate.

Structure of intermediate

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Type of intermediate _____

(2)

(Total 12 marks)

Q17.

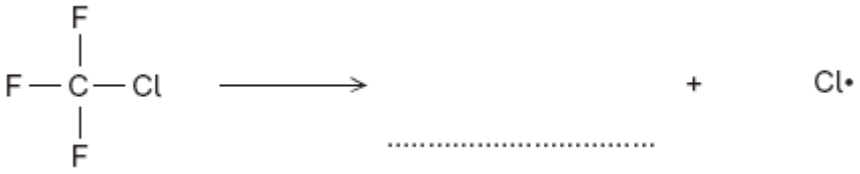
Oxygen and ozone (O_3) both occur as gases in the upper atmosphere.
Chlorine atoms catalyse the decomposition of ozone and contribute to the formation of a hole in the ozone layer.
These chlorine atoms are formed from chlorofluorocarbons (CFCs) such as CF_3Cl

(a) (i) Give the IUPAC name of CF_3Cl

_____

(1)

(ii) Complete the following equation that shows the formation of a chlorine atom from a molecule of CF_3Cl



(1)

(iii) State what the • represents in Cl•

_____

(1)

(b) Write two equations that show how chlorine atoms catalyse the decomposition of ozone into oxygen.

Equation 1 _____

Equation 2 _____

(2)

(c) An equilibrium is established between oxygen and ozone molecules as shown below.

$$3O_2(g) \rightleftharpoons 2O_3(g) \qquad \Delta H = +284 \text{ kJ mol}^{-1}$$

(i) State Le Chatelier's principle.

_____

_____

_____

(1)

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(ii) Use Le Chatelier's principle to explain how an increase in temperature causes an increase in the equilibrium yield of ozone.

_____

_____

_____

_____

(2)

(d) Chemists supported the legislation to ban the use of CFCs. Modern refrigerators use pentane rather than CFCs as refrigerants.
With reference to its formula, state why pentane is a more environmentally acceptable refrigerant.

_____

_____

(1)

(Total 9 marks)

Q18.

One of the first substances used as an anaesthetic in medicine was chloroform (trichloromethane, $CHCl_3$). By 1950, *halothane* was in common use but by 1990 this had been replaced by more acceptable anaesthetics such as *desflurane*.

$CF_3CHBrCl$	$CF_3CHFOCHF_2$
halothane	*desflurane*

One reason for replacing *halothane* was that it is an organic compound that contains chlorine. Chlorine-containing organic compounds are thought to cause damage to the ozone layer in the upper atmosphere.

(a) Name and outline a mechanism for the reaction of chlorine with methane to form chloromethane (CH_3Cl).

Write an overall equation for the reaction of chlorine with methane to form trichloromethane ($CHCl_3$).

_____

_____

_____

_____

_____

_____

_____

_____

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_____

(5)

(b) Explain how chlorine atoms are formed from chlorine-containing organic compounds in the upper atmosphere.

Explain, with the aid of equations, how chlorine atoms act as a catalyst in the decomposition of ozone into oxygen.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(6)

(c) Use the formulae of the two anaesthetics, *halothane* and *desflurane*, to help to explain why *desflurane* is considered to be a more **environmentally** acceptable anaesthetic than *halothane*.

_____

_____

_____

_____

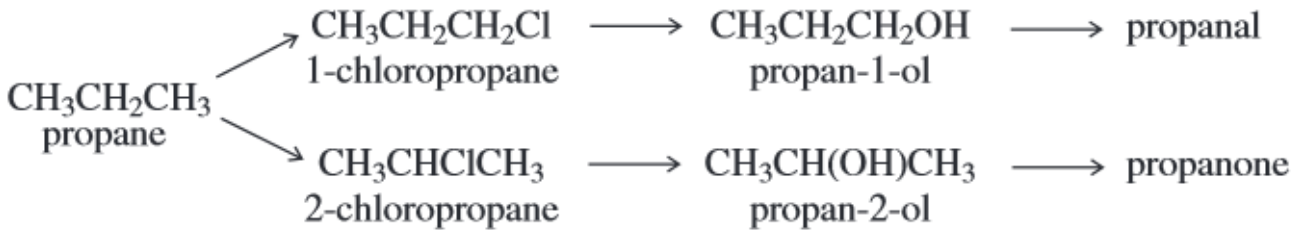
(2)

(Total 13 marks)

Q19.

Consider the following scheme of reactions.

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(a) State the type of structural isomerism shown by propanal and propanone.

_____

(1)

(b) A chemical test can be used to distinguish between separate samples of propanal and propanone.

Identify a suitable reagent for the test.
State what you would observe with propanal and with propanone.

Test reagent _____

Observation with propanal _____

Observation with propanone _____

(3)

(c) State the structural feature of propanal and propanone which can be identified from their infrared spectra by absorptions at approximately 1720 cm^{-1}.

_____

(1)

(d) The reaction of chlorine with propane is similar to the reaction of chlorine with methane.

(i) Name the type of mechanism in the reaction of chlorine with methane.

_____

(1)

(ii) Write an equation for each of the following steps in the mechanism for the reaction of chlorine with propane to form l-chloropropane ($CH_3CH_2CH_2Cl$).

Initiation step

_____

First propagation step

_____

Second propagation step

_____

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A termination step to form a molecule with the empirical formula C_3H_7

_____

(4)

(e) High resolution mass spectrometry of a sample of propane indicated that it was contaminated with traces of carbon dioxide.

Use the data in the table to show how precise M_r values can be used to prove that thesample contains both of these gases.

Atom	Precise relative atomic mass
^{12}C	12.00000
^{1}H	1.00794
^{16}O	15.99491

_____

_____

_____

(2)

(Total 12 marks)

Q20.

The reaction of bromine with ethane is similar to that of chlorine with ethane. Three steps in the bromination of ethane are shown below.

Step **1** $Br_2 \longrightarrow 2Br^{\bullet}$

Step **2** $Br^{\bullet} + CH_3CH_3 \longrightarrow CH_3CH_2^{\bullet} + HBr$

Step **3** $CH_3CH_2^{\bullet} + Br_2 \longrightarrow CH_3CH_2Br + Br^{\bullet}$

(a) (i) Name this type of mechanism.

_____

(ii) Suggest an essential condition for this reaction.

_____

(iii) Steps **2** and **3** are of the same type. Name this type of step.

_____

(iv) In this mechanism, another type of step occurs in which free-radicals combine. Name this type of step. Write an equation to illustrate this step.

Type of step _____

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*Equation*_____

(5)

(b) Further substitution in the reaction of bromine with ethane produces a mixture of liquid organic compounds.

(i) Name a technique which could be used to separate the different compounds in this mixture.

_____

(ii) Write an equation for the reaction between bromine and ethane which produces hexabromoethane, C_2Br_6, by this substitution reaction.

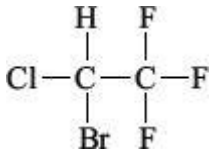
_____

(2)

(c) The compound 1,2-dibromo-1,1,2,2-tetrafluoroethane is used in some fire extinguishers. Draw the structure of this compound.

(1)

(d) Halothane is used as an anaesthetic and has the following structure.



(i) Give the systematic name of *halothane*.

_____

(ii) Calculate the M_r of halothane.

_____

(iii) Calculate the percentage by mass of fluorine in halothane.

_____

(3)

(Total 11 marks)

Q21.

(a) Dichloromethane, CH_2Cl_2, is one of the products formed when chloromethane, CH_3Cl, reacts with chlorine.

(i) Name the type of mechanism involved in this reaction and write an equation for each of the steps named below.

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Name of type of mechanism _____

Initiation step

_____

First propagation step

_____

Second propagation step

_____

(ii) Write an overall equation for the formation of dichloromethane from chloromethane.

_____

(5)

(b) A compound contains 10.1% carbon and 89.9% chlorine by mass. Calculate the molecular formula of this compound, given that its relative molecular mass (M_r) is 237.0

_____

_____

_____

_____

_____

(3)

(c) Suggest the formulae of two bromine-containing organic compounds formed when dibromomethane, CH_2Br_2, reacts with bromine.

Compound 1

_____

Compound 2

_____

(2)

(Total 10 marks)

Q22.

Chlorination of ethane follows a free-radical substitution mechanism. This mechanism is similar to that which occurs when methane is chlorinated. The overall equation for the reaction of ethane to form chloroethane is given below.

$$C_2H_6 + Cl_2 \longrightarrow C_2H_5Cl + HCl$$

State the conditions and outline a mechanism for this reaction. Show how butane can be formed in this reaction.

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_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(Total 5 marks)

Q23.

The mechanism for the reaction of methane with fluorine is a free-radical substitution similar to the chlorination of methane.

(a) Outline the following steps in the mechanism for the reaction of methane with fluorine to form fluoromethane, CH_3F

Initiation step

_____

First propagation step

_____

Second propagation step

_____

A termination step

_____

(4)

(b) Write an overall equation for the reaction of fluorine with fluoromethane to form tetrafluoromethane.

_____

(1)

(Total 5 marks)

Q24.

(a) Bromomethane, CH_3Br, can be formed by a reaction between bromine and methane.

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The mechanism for this reaction is similar to the mechanism for the chlorination of methane.

(i) Name the mechanism for this reaction.

_____

(ii) Give the name of, and state an essential condition for, the first step in the mechanism for this reaction.

Name _____

Essential condition _____

(iii) Write an equation for a termination step in the mechanism for this reaction which gives ethane as a product.

_____

(iv) Bromomethane can undergo further substitution. Write an overall equation for the reaction between bromomethane and bromine in which dibromomethane is formed.

_____

(5)

(b) Bromomethane reacts with the nucleophile ammonia according to the following equation.

$CH_3Br + 2NH_3 \rightarrow CH_3NH_2 + NH_4Br$

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

_____

_____

(ii) Name the organic product of this reaction.

_____

(iii) Outline a mechanism for this reaction.

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(6)
(Total 11 marks)

Q25.

(a) Chloromethane can be made by the reaction of chlorine with methane.

(i) Give **one** essential condition for this reaction.

_____

(ii) Name the mechanism for this reaction.

_____

(iii) Further substitution can occur during this reaction. Identify the main organic product when a large excess of chlorine is used in this reaction.

_____

(3)

(b) Ethanenitrile can be made by reacting chloromethane with potassium cyanide.

(i) Write an equation for this reaction.

_____

(ii) Name the mechanism for this reaction.

_____

(iii) Explain, in terms of bond enthalpies, why bromomethane reacts faster than chloromethane with potassium cyanide.

_____

_____

_____

(3)

(c) Ethanenitrile can be hydrolysed to a carboxylic acid by heating it under reflux with a dilute acid. Identify the carboxylic acid formed in this reaction.

_____

(1)

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(d) Chloromethane can react with ammonia to produce a primary amine.

(i) What feature of the chloromethane molecule makes it susceptible to attack by an ammonia molecule?

_____

(ii) Name the amine produced in this reaction.

_____

(iii) Outline a mechanism for this reaction.

(6)
(Total 13 marks)

Q26.

When chlorine reacts with trichloromethane, tetrachloromethane, CCl_4, is formed.

(a) (i) Write the overall equation for this reaction.

_____

(ii) State **one** essential condition for this reaction.

_____

(2)

(b) The mechanism for the chlorination of trichloromethane is free-radical substitution, which proceeds by a series of steps. Write equations for the steps named below in this chlorination.

Initiation step

_____

First propagation step

_____

Second propagation step

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_____

A termination step

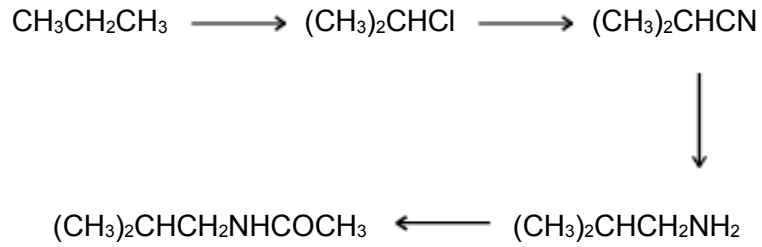
_____

(4)

(Total 6 marks)

Q27.

Which one of the following types of reaction mechanism is **not** involved in the above sequence?



A free-radical substitution

B nucleophilic substitution

C elimination

D nucleophilic addition-elimination

(Total 1 mark)

Q28.

In the presence of ultraviolet light, methane and chlorine react to form a number of chlorine-containing products, including CH_2Cl_2 and $CHCl_3$

(i) Write an equation for the initiation step in the mechanism for this reaction.

_____

(ii) Write the overall equation for the formation of $CHCl_3$ from CH_2Cl_2 and Cl_2

_____

(iii) Write equations for the two propagation steps by which CH_2Cl_2 is converted into $CHCl_3$

Equation 1 _____

Equation 2 _____

(iv) Suggest what effect increasing the intensity of the ultraviolet light would have on the rate of the reaction between methane and chlorine. Explain your answer.

Effect on rate _____

Explanation _____

(Total 6 marks)

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Q29.

The equation below represents a reaction between methane and chlorine.

$$CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$$

(a) State an essential condition required for this reaction to occur. Explain why this condition is essential.

Condition _____

Explanation _____

(2)

(b) (i) State the type of mechanism involved in the above reaction.

_____

(ii) Name the three types of step involved in this mechanism.

Step 1 _____

Step 2 _____

Step 3 _____

(4)

(c) In addition to CH_3Cl, compounds such as CH_2Cl_2 and CH_3CH_2Cl may also be formed when chlorine reacts with methane.

(i) Write equations for the two steps in the mechanism by which CH_2Cl_2 is formed from CH_3Cl

Equation 1 _____

Equation 2 _____

(ii) Write an equation to represent a step in the mechanism in which CH_3CH_2Cl is formed.

_____

(3)

(Total 9 marks)

Q30.

Which one of the following mechanisms is **not** involved in the reaction sequence below?

$$CH_3CH_3 \rightarrow CH_3CH_2Cl \rightarrow CH_3CH_2OH \rightarrow CH_2{=}CH_2 \rightarrow CH_3CH_2Br$$

A electrophilic addition

B electrophilic substitution

C nucleophilic substitution

D free-radical substitution

(Total 1 mark)

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Q31.

Which one of the following reactions involves nucleophilic addition?

A $CH_3CH = CH_2 + HBr \rightarrow CH_3CHBrCH_3$

B $CH_3CH_2CH_3 + Cl_2 \rightarrow CH_3CHClCH_3 + HCl$

C $CH_3CH_2CH_2Br + NaOH \rightarrow CH_3CH_2CH_2OH + NaBr$

D $CH_3CH_2CHO + HCN \rightarrow CH_3CH_2CH(OH)CN$

(Total 1 mark)

Q32.

Which one of the following is least likely to occur in the reaction between methane and chlorine?

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

B $CH_3\bullet + HCl \rightarrow CH_3Cl + H\bullet$

C $CH_3\bullet + Cl_2 \rightarrow CH_3Cl + Cl\bullet$

D $CH_3Cl + Cl\bullet \rightarrow CH_2Cl\bullet + HCl$

(Total 1 mark)

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