Airdrie Academy

Higher Chemistry

Natures Chemistry

Problem Solving Questions

**1.** The element boron forms many useful compounds.

Borane (BH3) is used to synthesize alcohols from alkenes.

The reaction occurs in two stages.

**Stage 1 Addition Reaction**

The boron atom bonds to the carbon atom of the double bond which already has the most hydrogen’s **directly** attached to it.



**Stage 2 Oxidation Reaction**

The organoborane compound is oxidised to form the alcohol.



**(a)** Name the alcohol produced in Stage 2.

**(b)** Draw a structural formula for the **alcohol** which would be formed from the alkene shown below.



**2.** When ozone is bubbled through a solution containing an alkene, an ozonolysis reaction takes place.

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Draw a structural formula for the alkene which, on ozonolysis, would produce propanal and butan-2-one.

**3.** Compounds containing sulphur occur widely in nature.

The compound dimethyldisulphide, CH3S2CH3, is present in garlic and onions.

Draw a full structural formula for this compound.

**4.** The chemical name for tartaric acid is 2,3-dihydroxybutanedioic acid.

Draw a structural formula for tartaric acid.

**5.** Urea, H2NCONH2, has several uses, e.g. as a fertiliser and for the manufacture of some thermosetting plastics.

Draw a structural formula for urea.

**6.** Hydrogen cyanide is of great importance in organic chemistry. It offers a route to increasing the chain length of a molecule. If ethanal is reacted with hydrogen cyanide and the product hydrolysed with acid, lactic acid is formed.



Draw a structural formula for the acid produced when propanone is used instead of ethanal in the above reaction sequence.

**7.** Primary, secondary and tertiary alkanols can be prepared by the reaction of carbonyl compounds with Grignard reagents.

**Step 1**

The Grignard reagent reacts with the carbonyl compound.

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**Step 2**

The reaction of the product of **Step 1** with dilute acid produces the alkanol.



**(a)** Describe the difference between a primary, a secondary and a tertiary alkanol.

You may wish to include labelled structures in your answer.

**(b)** Suggest a name for the type of reaction that takes place in **Step 1**.

**(c)** The same Grignard reagent can be used to produce the alkanol below.

Name the carbonyl compound used in this reaction.

**8.** Chlorine is used in the manufacture of herbicides such as 2,4-dichlorophenoxyethanoic acid.



Another commonly used herbicide is 4-chloro-2-methylphenoxyethanoic acid.

Draw a structural formula for 4-chloro-2-methylphenoxyethanoic acid.

**9.** For many years, carbohydrates found in plants have been used to provide chemicals.

Lactic acid can be produced by fermenting the carbohydrates in corn.

Lactic acid has the structure:



The first stage in the polymerisation of lactic acid involves the condensation of two lactic acid molecules to form a cyclic structure called a lactone.

Draw a structural formula for the lactone formed when two molecules of lactic acid undergo condensation with each other.

**10.** Aldehydes and ketones can take part in a reaction sometimes known as an aldol condensation.

The simplest aldol reaction involves two molecules of ethanal. In the reaction, the carbon atom next to the carbonyl functional group of one molecule forms a bond with the carbonyl carbon atom of the second molecule.



(a) Draw a structural formula for the product formed when propanone is used instead of ethanal in this type of reaction.

**(b)** Name an aldehyde that would **not** take part in an aldol condensation.

**(c)** Apart from the structure of the reactants, suggest what is unusual about applying the term “condensation” to this particular type of reaction.

**11.** Amines can be produced by reacting ammonia with an aldehyde or a ketone. This reaction, an example of reductive amination, occurs in two stages.

**Stage 1 Amination**

**Stage 2 Reduction**



**(i)** Give another name for the type of reaction taking place in Stage 2.

**(ii)** Draw the structural formula for the amine produced when butanal undergoes reductive amination with ammonia.

**12.** The structures of two antiseptics are shown. Both are aromatic.



The systematic name for TCP is 2,4,6-trichlorophenol. The systematic name for Dettol, another antiseptic, is 4-chloro-3,5-dimethylphenol.

Draw a structural formula for Dettol.

**13.** As a result of both containing the carbonyl group, aldehydes and ketones react in a similar way with hydrogen cyanide.

The equation for the reaction of propanal and hydrogen cyanide is shown.



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

**(ii)** Draw a structure for the product of the reaction between propanone and hydrogen cyanide.

14. Markovnikoff’s rule states:

 “*Addition of hydrogen chloride to an alkene can give two products. The hydrogen of the hydrogen chloride mainly attaches to the carbon atom of the souble bond which already has the most hydrogen attached to it”.*

(a) Draw the full structural formula for the major product formed when hydrogen chloride reacts with propene.

(b) Why is it not necessary to consider Markovnikoff’s rule when hydrogen chloride reacts with but-2-ene?

15. Three dicholorbenzenes are known. Their structure depends on the positions of the chlorine atoms in the benzene ring. Two of the isomers are shown.

  

 A B

1. Draw the structure of the third isomer and name it.
2. Why is molecule A polar while molecule B is non-polar?

16. Chlorofluorocarbons, commonly known as CFC’s are widely used in fridges, aerosols, and to preserve blood in blood banks. Information about three CFC’s is shown in the table.

|  |  |  |
| --- | --- | --- |
| **CFC** | **Name** | **Structure** |
| 12 | Dichlorodifluoromethane |  |
| 13 | 1,1,2 – trichloro-1,2,2-triflouroethane |  |
| 114 |  |  |

 Copy out the table and

1. Draw the full structural formula for CFC 12.
2. Give the name for CFC 114.

17. Ethyne is the first member of the homologous series called the alkynes.

 Ethyne can undergo addition reactions as shown below in the flow diagram,

 HCl

 compound 1 compound 2

 HCl

  1,2-dichloroethane

 reagent A reagent B

 compound 3

 reagent C

 monochloroethane

 (a) Compound 2 is an isomer of 1,2-dichloroethane.

 Draw a structural formula for compound 2. (b) Reagents A,B and C are three different diatomic gases.

 Using information in the follow diagram, identify reagents A,B and C.

18. Carbon compounds take part in many different types of reactions.



(a) Name the type of reaction that takes place in the formation of ethene from ethanol.

(b)Draw a structural formula for

 (i) compound **Y**;

 (ii) compound **Z**.

19. **A ratio line can be used to illustrate the carbon to hydrogen ratio in different compounds.**

0

1.2

1.0

0.8

0.6

0.4

0.2

**A**

Cyclopentane, C5H10, with a carbon to hydrogen ratio of 5:10, would appear at point **A**.

1. At what value would ethyne appear?
2. A hydrocarbon **X** with 6 carbon atoms per molecule also has a carbon to hydrogen ratio of 0.5 (point **A**.) **X** does not immediately decolourise bromine solution. Name compound **X**.

**20.** Pyrolysis (thermal decomposition) of esters can produce two compounds, an alkene and an alkanoic acid, according to the following equation.



Draw a structural formula for the ester that would produce 2-methylbut – l – ene and methanoic acid on pyrolysis.

**21.** The compound diazomethane, CH2N2 undergoes an unusual reaction called **insertion**. Under certain experimental conditions, the CH2 group produced can insert itself into **any** bond which includes an atom of hydrogen.

**CH2N2**

Nitrogen is a product in every reaction.

 Draw the full structural formual for the three organic products formed when diazomethane reacts with ethanol.

22. Aspirin can be made by reacting **2-hydroxybenzenecarboxylic** acid with ethanoic anhydride.



**(a)**Write the molecular formula for aspirin.

**(b)**Cellulose ethanoate fibres can be made from cellulose in a similar way. Complete the structure for the unit of cellulose ethanoate.



23. The compound diazomethane undergoes an unusual reaction called insertion.

Under certain conditions, the CH2 group produced can insert itself into any bond which includes an atom of hydrogen.

Nitrogen is produced in every reaction.

One of the products for the reaction of diazomethane with ethanol is shown below.



Name the product shown.

 Draw the full structural formula for the other **two** organic products which could be formed in this reaction.