KEEP IT SIMPLE SCIENCE

Chemistry Module 7

Organic Chemistry WORKSHEETS

Worksheet 1 Names of Organic Chemicals

Answer in the spaces provided

Student Name.....

1.
The various homologous series have different name endings, but the prefixes follow the same rules. How many carbon atoms in:

a) pentanone? **b) butanal?**

c) propanamine? **d) octyne?**

e) methanoic acid? **f) hexanol?**

2.
Name each compound from its formula.

a) C_5H_{12} **.....**

b) C_3H_7COOH **.....**

c) $C_6H_{13}OH$ **.....**

d) C_4H_6 **.....**

e) C_2H_5Br **.....**

3.
A student describes a branched-chain alkane as "2-ethylbutane".

a) Sketch the structure suggested by this name.

b) Explain why this name is incorrect and give the correct name.

4.
Sketch the structure and give the name for the simplest tertiary alcohol.

5.
Sketch the structural formula for:

a) 2-chloropropanal

b) 2-methylbutanoic acid

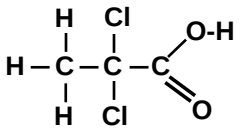
c) 1,1,3,3-tetrafluoropentane

d) 4-methyl-2-pentyne

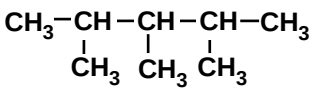
e) 3-ethyl-2-hexanone

6.
Name each of the following:

a)



b)



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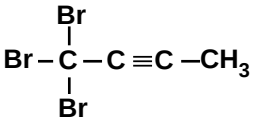
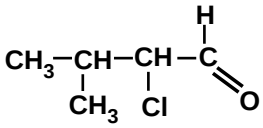
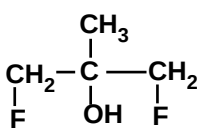


d)



e)



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Worksheet 2 Reactions of Hydrocarbons

Answer in the spaces provided.
(on reverse, if insufficient room)

Student Name.....

Write a balanced equation (states not required) for:

1. the complete <u>combustion</u> of:
a) butane.

b) propyne

2. a single <u>substitution reaction</u> between F_2 and:
a) ethane.

b) hexane.

3. the <u>addition reaction</u> between H_2 and butene.

4. the <u>addition reaction</u> between Br_2 and
a) 1-pentene. Name the product(s).

b) 2-pentene. Name the product(s).

5. the <u>addition reaction</u> between H_2O and 1-butene.

6. propene reacting with HF.

<u>Tutorial Note</u>: You should see in Q5 & Q6 that two isomers are possible products of each reaction. Both isomers will form, but one will predominate according to "<u>Markovnikov's Law</u>". Research this, and name ONLY the predominate isomer in your answers above.

Worksheet 3 About the Hydrocarbons

Fill in the blanks

Student Name.....

The huge variety of carbon compounds is due to the ability of carbon atoms to each form a)..... (number) b)..... bonds. Carbon atoms readily bond with each other forming c)....., rings or networks. They can form single, d)..... or ..... bonds.

The simplest carbon compounds, containing only carbon and hydrogen, are collectively called the e)....., of which there are 3 f)..... series. These are the g)....., ... and .....

Hydrocarbons are named by using a prefix for the number of h)....., and adding an ending to identify which precise type it is.

The alkanes have names ending in "i).....". They all contain j)..... C-C bonds and have a general formula k)..... Alkanes are l)..... in water and have relatively m)..... melting and boiling points. Their properties relate to their molecules being non-n)..... The only inter-molecular forces are the very weak o)..... forces.

Melting and boiling points show a very regular pattern of rising steadily as molecular size p).....

The alkenes have very q)..... properties to the alkanes. Alkenes contain one r)..... bond, and have general formula s).....

The alkynes have a t)..... bond and general formula u).....

Another property of hydrocarbons is that they are highly volatile. This means that they tend to v)..... readily. This has important safety consequences for these highly inflammable, w).....-energy compounds.

Crude petroleum is a complex x)..... of many compounds. At a refinery, it is separated into useful "y)....." by the process of z)..... ..... The crude mixture is vaporised and as the vapours rise and the temperature aa)....., each fraction ab)..... at a different level in the tower and is collected separately.

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Worksheet 4 Practice Questions

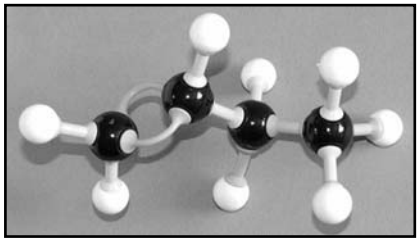
Answer in the spaces provided.
(on reverse, if insufficient room)

Student Name.....

Multiple Choice Questions

1. The compound with molecula formula $C_{15}H_{32}$ is likely to:
A. be a member of the alkene homologous series.
B. contain a triple carbon-carbon bond.
C. have a name ending in "-ANE".
D. have polar molecules.

2. The molecular model shown is
A. pentene
B. butene
C. propane
D. butane



3. Which of the following is NOT a property of the alkanes?
A. soluble in water
B. relatively low melting & boiling points
C. non-conductors of electricity
D. hydrophobic

4. In petroleum refining, fractional distillation separates the mixture according to differences in:
A. melting point
B. density
C. solubility
D. boiling point

5. The reaction between 2-hexene and Br_2 would produce:
A. 2,3-dibromohexene.
B. 2-bromohexane + HBr.
C. 2,3-dibromohexane.
D. a variety of isomers of bromohexane.

Longer Response Questions

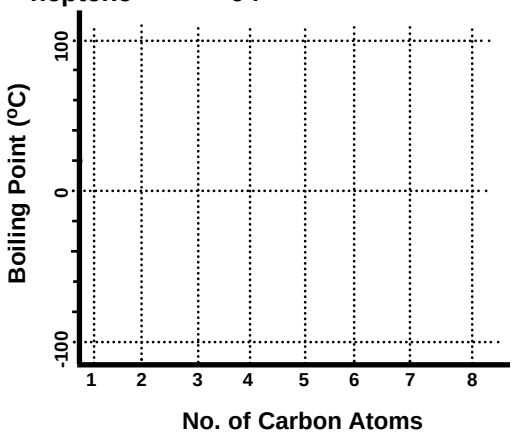
6.
a) Explain, with the help of simple equations or diagrams, how the substitution reaction between an alkane (say methane) and a halogen (say Cl_2) proceeds when exposed to UV light.

b) Explain, with a simple example, how this reaction may result in a mixture of multiple products.

7.
a) Plot the following data on the grid provided.

The boiling points (^oC) for some alkenes:

ethene	-104
propene	-48
hexene	64
heptene	94



b) Use the graph to estimate b.p.'s for butene and pentene.

c) Account for the generally low mp & bp of the hydrocarbons.

8.
Write a balanced chemical equation (no states) for:

a) the complete combustion of hexane.

b) the addition reaction between water & propene.

9.
Give an outline of:
a) the difference between saturated & unsaturated hydrocarbons, with examples.

b) differences in the geometry of hydrogen atoms attached to carbon atoms with single, double and triple C-C bonds.

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Worksheet 5 The Alcohols

Fill in the blanks

Student Name.....

The alkanols are an a)..... series of carbon compounds with general formula b)..... They are also as the "c)....." Each alkanol has an d)..... group attached to a carbon atom. This group contains a e)..... covalent bond which creates an electric f)..... on the molecule. This causes quite strong g)..... bonds between the molecules, which result in the following properties:

- m.p.'s & b.p.'s are h)..... than the corresponding alkanes.
- alkanols are generally i)..... in water.
- they are excellent j)....., because they can dissolve both k)..... and ..... (opposites) solutes.
- they are inflammable, and can be used as l)....., although their m)..... ..... is lower than the alkanes.

Ethene can be converted to ethanol by an n)..... reaction, adding o)..... across the double bond. Dilute p)..... acts as a catalyst for this reaction. The reverse reaction, converting q)..... to ..... is also possible if r)..... H_2SO_4 is the catalyst. This reaction could be considered as a "condensation", but is usually referred to as "s)....."

Biologically, ethanol can be made from t)..... by the process of u)..... The catalysts are the v)..... in living w)..... cells.
The requirements for the reaction are:
- a suitable source of x)..... from fruits or grains.
- live y).....
- temperature maintained around z)..... ^oC
- aa)..... conditions (no oxygen).

Fermentation can produce a mixture containing a maximum ab).....% ethanol. This can be purified by ac)..... to obtain about ad).....% purity. Industrial scale fermentation (apart from beer & wine production) uses materials from the ae)..... industry, and then fractional af)..... to obtain near-pure ethanol for making ag)..... (food use) or for solvent and cleaning purposes.

When alkanols burn, the products of complete combustion are ah)..... and .....

The "Molar Heat of Combustion" is defined as ai)..... with all reactant & products in their aj).....

Although the reaction is always ak).....-thermic and should have a al)..... value for ΔH, the value is stated as a am)..... quantity because of the definition.

Generally, the values for ΔH_c for the alkanols an)..... with increasing molecular size, but are much lower than the values for an ao).....

The <u>advantages</u> of using ethanol as a fuel are
- it is a ap)..... resource
- the aq)..... is known & proven
- it is "ar).....-friendly"
- it can be mixed with petrol to about as).....% without any modifications to existing car engines.

Disadvantages include:
- to totally replace petrol, vast areas of land would have to be at).....
- large amounts of energy are needed for the au)..... process, and we cannot yet do this in a renewable and eco-friendly way.
- vehicle av)..... would have to be totally re-designed and replaced to run on pure ethanol.

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Worksheet 6 Alcohols Again

Guided Notes & Questions

(Make your own summary)

Student Name.....

1.
Account for the fact that the alcohols have much higher mp's & bp's than the corresponding alkanes.

2.
Outline the conditions required for fermentation and summarise the overall reaction with an equation.

3.
In an experiment butanol was burned under a "tin-can calorimeter" containing 50g of water, initially at 18^{o}C. After burning 0.60g of butanol, the water temperature rose to 47^{o}C.

a) Write a balanced equation for this combustion.

b) Calculate the "heat of combustion" from this data, per gram AND per mol.

c) The listed value of ΔH_c = 2676 kJmol^{-1}. Comment on the <u>accuracy</u> of this experiment and analyse possible reasons for errors.

d) Suggest ways to improve the <u>reliability</u> of the experiment.

4.
Give the structural formula and name for the product of the reaction of concentrated HCl with:
a) 1-butanol

b) 2-butanol

5. Outline the "alcohol dehydration" reaction, including reactants, products and catalyst involved.

6.
Summarise the differences between the oxidation (with potassium dichromate) of primary, secondary & tertiary alcohols.

7.
a) Ethanol, as a fuel to replace petrol, is described as being "renewable". Explain why.

b) Ethanol is also claimed to be "carbon-neutral". What does this mean?

c) Is it actually "carbon-neutral" with current technology? Explain.

d) What is the major problem with the idea of totally replacing petrol with ethanol fuel?

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Worksheet 7 Esters

Fill in the blanks

Student Name.....

The alkanols, also called a)....., all contain the functional group b)..... and have the general formula c)..... The -OH group contains a chemical bond which is d)....., and allows e)..... bonding between molecules. This is why the alkanols have m.p's & b.p's much higher than the corresponding f).....

The alkanoic acids contain the functional group g)..... This group contains 2 polar bonds, so 2 h)..... bonds can form between molecules. This is why i)..... ..... than the alkanols.

Esters are formed by the reaction of j)..... with ..... The other product is k)..... Esters are named by the l)..... first (with its ending changed to m)....., followed by the n)..... name (with its ending changed to o).....)

Esters are made using the technique of p)..... The reaction flask is open to the atmosphere to avoid any dangerous build-up of q)..... Volatile chemicals vapourise, but are r)..... by the s)..... and drip back into the flask. t)..... is used as a catalyst and also improves the yield by shifting the u)....., because it absorbs water.

Esters occur widely in nature, being responsible for many of the v)..... and ..... of foods, especially w)..... Long-chain esters of glycerol are the x)..... and .....

Artificially manufactured esters are used as y)..... ..... in processed foods, as z)..... in industry and as ingredients in many products such as aa)..... and .....

Worksheet 8 More Esters Practice Exercises

Student Name.....

1. Names of Esters

Name the ester formed from:

a) ethanol & propanoic acid

b) propanol & ethanoic acid

c) pentanol & methanoic acid

d) methanol and pentanoic acid

e) hexanoic acid and butanol

f) ethanoic acid and octanol

2. Condensed Structural Formulas

For each of the compounds above, give the condensed structural formula for the

i) alkanol
ii) alkanoic acid
and iii) ester

The first has been done for you as an example.

Answer

a) i) ethanol = CH_3CH_2OH
ii) propanoic acid = CH_3CH_2COOH
iii) ester = $CH_3CH_2COOCH_2CH_3$

Note: although the alkanol comes first in naming, it may be more convenient to place the acid remnant first in the structural formula. This system is used here.

c) i)
ii)
iii)

d) i)
ii)
iii)

e) i)
ii)
iii)

f) i)
ii)
iii)

3. Names from Structures

For each of the following esters:

i) give the name of the ester
ii) name the alkanol and acid use to make it

a) $HCOO(CH_2)_3CH_3$

b) $CH_3CH_2COO(CH_2)_3CH_3$

c) $CH_3(CH_2)_3COO(CH_2)_4CH_3$

d) $C_4H_9COOCH_3$

e) $C_5H_{11}COOC_7H_{15}$

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Worksheet 9 Fats, Oils, Soap, Detergents

Guided Notes & Questions

Student Name.....

Answer in the spaces provided.
(on reverse, if insufficient room)

1.
a) Describe the chemical structure of a "fatty acid".

b) Draw the structural formula for "glycerol".

c) Use a labelled, schematic diagram to explain the structure of a triglyceride. Explain why it is an ester.

2.
a) Name the process by which soap is made, and write a <u>word equation</u> for the process.

b) Give an outline of a simple procedure by which soap can be made in the laboratory.

3.
a) What is an "emulsion"?

b) Explain how emulsification results in cleaning things.

c) Explain, with the aid of simple diagrams, how soap acts as an emulsifier.

4.
Compare a soap molecule with a typical detergent molecule to outline
a) any basic similarity in structure and properties.

b) performance as emulsifiers in "hard water".

Worksheet 10 Organic Acids & Bases

Student Name.....

Answer in the spaces provided.
(on reverse, if insufficient room)

1.
a) Complete this general equation to show how a carboxylic acid acts as a Bronsted-Lowry (B-L) acid in water solution.

$$R\text{-}COOH + H_2O \longrightarrow$$

b) Identify the B-L acid and B-L base in the reaction above AND the conjugate partner of each.

2. Name and give formula for the conjugate base of:
a) butanoic acid.
b) methanoic acid.
c) octanoic acid.

3.
a) Complete this general equation to show how an amine acts as a Bronsted-Lowry (B-L) base in water solution.

$$R\text{-}NH_2 + H_2O \longrightarrow$$

b) Identify the B-L acid and B-L base in the reaction above AND the conjugate partner of each.

4. Name and give formula for the conjugate acid of:
a) butylamine.
b) dimethylamine.
c) octylamine.

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Worksheet 11 Reaction Pathways

Answer in the spaces provided. **Student Name.....**
(on reverse, if insufficient room)

A pure organic compound is liquid at room temperature. It has an empirical formula C_3H_8O and a molecular mass about 60.

It was divided into 4 identical samples labelled P,Q,R & S. Each of these was subjected to a different chemical treatments as follows:

1. Sample P
was treated with concentrated HCl.
A new organic compound was formed, plus water.

2. Samples Q and R
Q was treated with acidified dichromate ions with strong heating and reflux. A new organic compound formed.

This product was labelled "Q-2".

Q-2 was separated & purified, then reacted with sample R under reflux in the presence of concentrated sulfuric acid.

At the end of the reaction, a noticeable odour resembling pineapple was present.

3. Sample S
was treated with concentrated H_2SO_4. The sample was dehydrated, forming a gaseous product.

The gas was collected, then some brown $Br_{2(aq)}$ was introduced into the flask. The bromine immediately discoloured and a colourless liquid began to condense in the flask.

Now Come the Questions...

1.
Using the clues in the first paragraph, identify the starting compound. Explain your reasoning.

If more than one isomer is possible, identify them specifically and show structural formulas.

2.
Write the balanced equation for a possible reaction of sample P with conc. HCl.

Name the organic product of this reaction.

3.
a) During the reaction of Q-2 & R, what is the significance of the "noticeable odour"?

b) What therefore, is the identity of the product which was labelled Q-2?

c) Look back to Q1.
If there was a possibility of isomers, what does the identity of Q-2 tell you? Explain.

d) Write a word equation for the reaction between Q-2 and sample R.

e) i) In the earlier reaction with sample Q, what was the purpose of the acidified dichromate reagent?

ii) What was a probable intermediate product in the conversion

Q ⟶ intermediate product ⟶ Q-2

4.
Using structural formulas, describe the reactions which occurred to sample S.

All organic compounds should be named.

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Worksheet 12 Polymers

Fill in the blanks

Student Name.....

When petroleum is refined the main products are for use as a)....., but there are also other chemicals extracted for use in manufacturing. These chemicals are collectively called "b)....." and the most important is c).....

The reason for ethene's great usefulness is the d)..... carbon-carbon bond. This bond is highly e)..... and readily "splits open" allowing other atoms/groups to join onto the molecule. This is called an f)..... reaction.

In the laboratory, compounds containing a double bond can be identified using a solution of g)..... If this is added to an alkene, the g)..... will be h)..... because of an addition reaction. With an alkane, the colour may change and shift from one solvent to the other, but will not be h).....

The yield of ethene from petroleum is greatly increased by the process of "i)....." in which long-chain alkanes are broken into smaller fragments by either j)..... or ..... This increases the yield of valuable fuel fractions such as k)..... and increases the yield of ethene which is extracted from the l)..... fraction.

The major use of ethene is the manufacture of m)..... Thousands of ethene monomers join together by n)..... reactions to form o)..... If the reaction is carried out at high p)..... and ..... with an "initiator" chemical, the result is q).....-density polyethylene. The long chain molecules have many r)..... ..... and cannot pack close together, so the plastic is soft and s)....., ideal for soft plastic bags and t)..... film.

If the reaction is carried out at lower pressure and temperature with a u)....., the polymer molecules lack branches and can v)..... ..... to form w).....-density polyethene, used (for example) in x)..... .....

Other important polymers include P.V.C. which stands for y)..... The monomer is commonly called z)..... ....., but its correct chemical name is aa).....

The added chlorine atom makes the molecular mass much higher, so that the ab)..... forces between molecules are stronger.

The plastic is ac)..... and more ad)..... so it is used for ae).....

Polystyrene is made from the monomer af)..... for which the correct systematic name is ag)..... ..... The "side group" on this molecule is the ring-shaped ah)..... group. This increases the molecular mass so that the ai)..... forces hold the polymer molecules even more strongly so the plastic is aj)..... and .....

Polymers can also form by a ak)..... reaction. This occurs when 2 monomer molecules join together by elimination of a al)..... ..... Examples of condensation polymers are nylon and am)..... All biological polymers, such as an)..... and ..... are condensation polymers.

One important biological polymer is ao)..... which is a polymer of ap)..... and is found in large amounts in all plants, where it forms the cell aq)..... which strengthens and protects all plant tissues. We already use cellulose for fabrics such as ar)..... and ..... and process it to make as)..... When the petroleum supplies run out, cellulose has great potential to supply our needs.

Its monomer at)..... can easily be turned into the alcohol au)..... which can be used as a fuel, or chemically converted to av)..... to feed the plastics industry. Unfortunately, we have not yet developed a simple, efficient and economical way to convert cellulose to aw)..... to begin the process.

Research is also progressing in the use of engineered "biopolymers" such as ax)..... (abbreviation). This polymer has properties similar to some petrochemical plastics, but is made naturally by microbes such as the bacterium ay)..... ..... (scientific name). The Monsanto company has used az)..... ..... techniques to transfer the genes for PHB into ba)..... plants. After normal growth and harvesting, PHB can be extracted from the "waste" leaves and stems of the crop.

Although this is very promising, it is unlikely to be used on a large scale while cheaper petrochemicals are still available.

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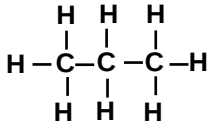
Worksheet 13 Practice Test-Style Questions

Student Name.....

Multiple Choice

1. If propene (C_3H_6) underwent an addition reaction with water, the correct structural formula for the product would be

A.



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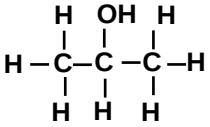
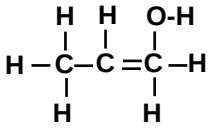
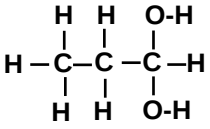


C.



D.



2. Alkenes can be identified by their reaction with bromine water, in which the bromine:
A. moves from one liquid layer to the other.
B. changes colour from brown to purple.
C. completely loses its colour.
D. changes from colourless to purple.

3. In the "cracking" of the alkane $C_{20}H_{42}$, the molecule happened to break up into 4 pieces; 1 molecule of ethene, one of octane, 1 of hexene, and another hydrocarbon molecule. The formula for the 4th fragment would be:

A. C_4H_8 B. C_6H_{12} C. C_2H_4 D. C_3H_8

4. An "addition polymer" is formed when:
A. long-chain alkane molecules combine.
B. C= C double bonds are formed in monomer molecules.
C. molecules join by removing atoms to create bonds.
D. monomers join by splitting C= C double bonds.

5. In general terms, increasing the size and mass of any "side groups" in an ethene-based plastic, will probably result in the plastic being:
A. softer and more flexible.
B. less soluble in water.
C. a better conductor of electricity.
D. harder and more rigid.

6. Cellulose is:
A. an addition polymer of ethylene.
B. a condensation polymer of glucose.
C. an addition polymer of glucose.
D. a monomer which can be polymerised.

Longer Response Questions

7.
Using structural formulas, show the addition reaction between ethene and hydrogen bromide (HBr). Show the reactants and product(s).
You do not need to name any compounds.

8.
Explain, using chemical equation(s) when needed, why liquid hexene will de-colourise a bromine solution, but liquid hexane will not.

9.
The main industrial source of ethene is "cat-cracking" of certain molecules in petroleum.
a) Outline the general process of "cat-cracking", including the meaning of the term.

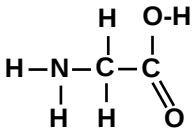
b) Outline the process of "addition polymerisation" of ethene.

c) Draw a structural formula for a section of a polyethene molecule containing 3 monomer units.

10.
A common plastic is known as P.V.C.
a) Draw a structural formula for the monomer from which PVC is made, and give both its common name and systematic chemical name.

b) Account for the differences in properties and typical uses of PVC compared to polyethene.

11.
The amino acid "Glycine" has the following structure:



The condensation polymer "polyglycine" can be formed by joining together many glycine molecules.

a) Use structural diagrams to show the 2 products formed when two glycine monomers join together.

b) Explain why this is called "condensation" polymerisation.

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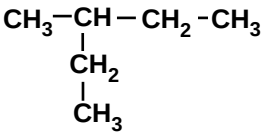
Answer Section

Worksheet 1

1.
a) 5 b) 4 c) 3 d) 8 e) 1 f) 6

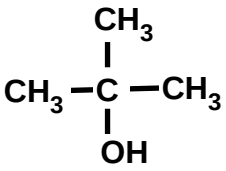
2.
a) pentane
b) butanoic acid
c) hexanol
d) butyne
e) bromoethane

3.
a)

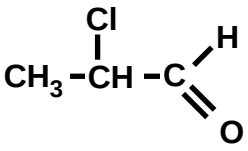


b) The longest carbon "backbone" has 5 carbons, with a methyl side-branch on the 3rd. Correct name is "3-methylpentane".

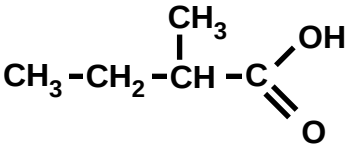
4.
2-methyl-2-propanol



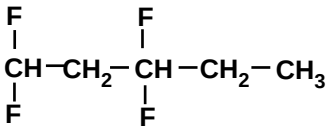
5.
a)



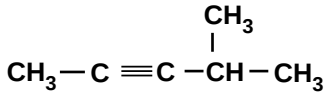
b)



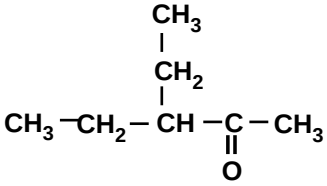
c)



d)



e)



6.
a) 2,2-dichloropropanoic acid
b) 1,2,3-trimethylpentane
c) 1,1,1-tribromo-2-butyne
d) 2-chloro-3-methylbutanal
e) 1,3-difluoro-2-methyl-2-propanol

Worksheet 2

1.
a) $C_4H_{10} + {}^{13}/_{2}\ O_2 \longrightarrow 4CO_2 + 5H_2O$

b) $C_3H_4 + 4O_2 \longrightarrow 3CO_2 + 2H_2O$

2.
a) $C_2H_6 + F_2 \longrightarrow C_2H_5F + HF$

b) $C_6H_{14} + F_2 \longrightarrow C_6H_{13}F + HF$

3. $C_4H_8 + H_2 \longrightarrow C_4H_{10}$

4.
a) $C_5H_{10} + Br_2 \longrightarrow C_5H_{10}Br_2$
1,2-dibromopentane

b) $C_5H_{10} + Br_2 \longrightarrow C_5H_{10}Br_2$
2,3-dibromopentane

Tutorial Note: Markovnikov's Rule can be expressed in various ways, but its simplest form is that a hydrogen atom predominately attaches to the carbon atom which already has the most hydrogens on it. In these cases it means that (predominately) the isomer formed will have the extra hydrogen on the terminal carbon.

5.
$C_4H_8 + H_2O \longrightarrow C_4H_9OH$ **(2-butanol)**

6.
$C_3H_6 + HF \longrightarrow C_3H_7F$ **(2-fluoropropane)**

Worksheet 3

a) 4 **b) covalent**
c) chains **d) double or triple**
e) hydrocarbons **f) homologous**
g) alkanes, alkenes & alkynes
h) carbon atoms **i) -ANE**
j) single **k)** C_nH_{2n+2}
l) insoluble **m) low**
n) polar **o) dispersion**
p) increases **q) similar**
r) double C= C **s)** C_nH_{2n}
t) triple **u)** C_nH_{2n-2}
v) vaporise **w) high**
x) mixture **y) fractions**
z) fractional distillation **aa) falls**
ab) condenses

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Answer Section

Worksheet 4

1. C 2. B 3. A 4. D 5. C

6.

a) UV energy can split Cl_2 to form 2 Cl• , "free-radicals". These are highly reactive and may attack CH_4 as follows:

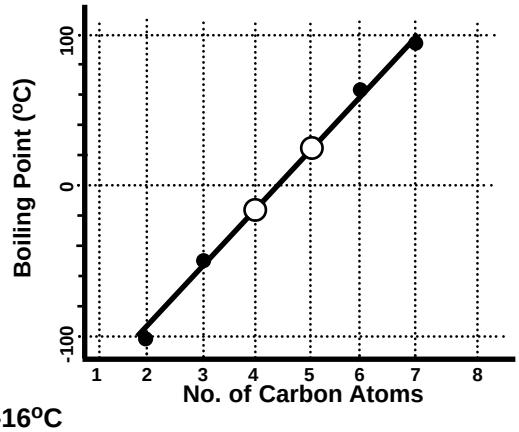
$$CH_4 + Cl\bullet \longrightarrow CH_3\bullet + HCl$$

This forms another free-radical which might attack Cl_2, thus perpetuating a chain of reactions which (overall) substitute Cl for H atoms in the alkane.

$$CH_3\bullet + Cl_2 \longrightarrow CH_3Cl + Cl\bullet$$

b) A molecule already substituted, may react again. This way, many different products may form.
eg $CH_3Cl + Cl_2 \longrightarrow CH_2Cl_2 + HCl$

7. a)



b) butene -16°C
approx (listed value -6) pentene approx 25°C(listed value 30)
(Errors probably due to the small graph scale)

c) The only inter-molecular forces are weak dispersion forces. Molecules are not held together strongly.

8.

a) $C_6H_{14} + {}^{19}/_{2}\ O_2 \longrightarrow 6CO_2 + 7H_2O$

b) $C_3H_6 + H_2O \longrightarrow C_3H_7OH$ **(propanol)**

9.

a) Saturated hydrocarbons are the alkanes which have all single C- C bonds and the maximum "saturation" with H atoms.
Unsaturated refers to alkenes & alkynes, with double & triple bonds & therefore, less than maximum H atoms.
These words can also be applied to other homologous series.

b) Covalent bonds are arranged at the points of a tetrahedron around a C atom and therefore, molecules have 3D geometry.
A double bond is rigid (no rotation) and forces the H atoms (on the carbons which are double-bonded) into a 2D flat plane around the carbons.
The triple bond is rigid and allows only 1 other bond on each C atom involved. This bond is forced into the same 1-D line as the triple bond.
eg ethyne is a linear molecule.

Worksheet 5

a) homologous	**b)** $C_nH_{2n+1}OH$
c) alcohols	**d) -OH**
e) polar	**f) dipole**
g) hydrogen	**h) higher**
i) soluble	**j) solvents**
k) polar & non-polar	**l) fuels**
m) energy content	**n) addition**
o) water	**p) sulfuric acid**
q) ethanol to ethene	**r) concentrated**
s) dehydration	**t) glucose**
u) fermentation	**v) enzymes**
w) yeast	**x) sugar/carbohydrate**
y) yeast	**z) 25**
aa) anaerobic	**ab) about 15%**
ac) fractional distillation	**ad) 95%**
ae) sugar	**af) distillation**
ag) vinegar	**ah) carbon dioxide & water**

ai) heat given out when 1 mole of fuel is burned completely
aj) standard states at standard conditions
ak) exo-

al) negative	**am) positive**
an) increases	**ao) alkane**
ap) renewable	**aq) technology**
ar) greenhouse, eco,	**as) 20%**

at) cultivated for "ethanol farming"

au) distillation	**av) engines**

Worksheet 6

1.
The OH group contains a polar bond which creates an electric dipole on the molecule. Inter-molecular hydrogen bonding occurs, which results in higher mp & bp.

2.
For fermentation, a source of sugar (or other carbohydrate) is needed, plus the presence of live yeast cells. Temperatures near 25°C favour the growth of the yeast and anaerobic conditions (no oxygen) favours the formation of ethanol rather than just CO_2.

Glucose $\longrightarrow$ **Ethanol + Carbon dioxide**

$$C_6H_{12}O_{6(aq)} \longrightarrow 2\ C_2H_5OH_{(aq)} + 2\ CO_{2(g)}$$

3.

a) $C_4H_9OH + 6\ O_2 \longrightarrow 4CO_2 + 5H_2O$

b) Heat absorbed by calorimeter:
$Q = m.c.\Delta T = 0.050 \times 4{,}183 \times 29 = 6{,}065\ J \cong 6.1\ kJ$

c) This is for 0.60g butanol, so energy = 10.1 kJ / g
MM = 74, so $\Delta H_c = 747\ kJmol^{-1}$.
This is very inaccurate because most of the heat released is NOT captured & measured by the primitive calorimeter.

d) Reliability can still be achieved if all parameters are kept constant from one measurement to the next. eg same distance from burner to can, same time of burning, same degree of wind protection and so on.

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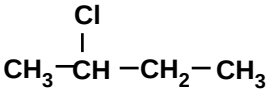
Answer Section

Worksheet 6 (cont.)

4.

a) 1-chlorobutane $Cl-CH_2-CH_2-CH_2-CH_3$

b) 2-chlorobutane



5. Reaction occurs when ethanol is treated with a conc.sulfuric acid catalyst. The concentrated acid has a great affinity for water and chemically extracts it from ethanol, forming ethene.

ethanol ⟶ ethene + water

6.

1º alcohols oxidise firstly to aldehydes, then (with more heat and reflux) to a carboxylic acid.
2º alcohols oxidise to the corresponding ketone.
3º alcohols do NOT oxidise.

7.a)
It can be made by fermentation from plant carbohydrates (eg sugar) which can be grown over & over and never run out.
b)
The CO_2 released when the ethanol is burned is exactly the same as that absorbed by the plant during growth. Therefore, using ethanol fuel should NOT add extra CO_2 to the atmosphere.
c)
Probably not, because our transport and the large energy input for distillation, still come largely from fossil fuels.
d)
Vast areas of food production land would need to be allocated to growing crops to make ethanol. This could create a food supply crisis.

Worksheet 7

a) alcohols **b) -OH**
c) $C_nH_{2n+1}OH$ **d) polar**
e) hydrogen **f) alkanes**
g) COOH **h) hydrogen**
i) m.p. & b.p. is even higher than
j) alkanols with alkanoic acids
k) water **l) alkanol**
m) -yl **n) alkanoic acid**
o) -oate **p) reflux**
q) pressure / vapours **r) condensed**
s) reflux condenser **t) Sulfuric acid**
u) equilibrium **v) odours and tastes**
w) fruits **x) fats and oils**
y) artificial flavourings **z) solvents**
aa) shampoo/cosmetics/plastics

Worksheet 8

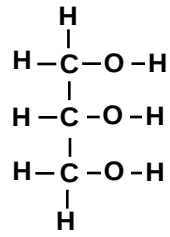
1. Names of Esters
a) ethyl propanoate **b) propyl ethanoate**
c) pentyl methanoate **d) methyl pentanoate**
e) butyl hexanoate **f) octyl ethanoate**

2. Condensed Structural Formulas
a) i) CH_3CH_2OH **ii) CH_3CH_2COOH**
iii) $CH_3CH_2COOCH_2CH_3$
b) i) $CH_3CH_2CH_2OH$ **ii) CH_3COOH**
iii) $CH_3COO(CH_2)_2CH_3$
c) i) $CH_3(CH_2)_3CH_2OH$ **ii) $HCOOH$**
iii) $HCOO(CH_2)_4CH_3$
d) i) CH_3OH **ii) $CH_3(CH_2)_3COOH$**
iii) $CH_3(CH_2)_3COOCH_3$
e) i) $CH_3(CH_2)_2CH_2OH$ **ii) $CH_3(CH_2)_4COOH$**
iii) $CH_3(CH_2)_4COO(CH_2)_3CH_3$
f)i) $CH_3(CH_2)_6CH_2OH$ **ii) CH_3COOH**
iii) $CH_3COO(CH_2)_7CH_3$

3. Names from Structures
a) butyl methanoate. **butanol + methanoic acid**
b) butyl propanoate. **butanol + propanoic acid**
c) pentyl pentanoate. **pentanol + pentanoic acid**
d) methyl pentanoate. **methanol + pentanoic acid**
e) heptyl hexanoate. **heptanol + hexanoic acid.**

Worksheet 9

1.
a) It is a hydrocarbon chain of 12 to 24 carbons, with a COOH acid group at one end.
b)Structural formula for glycerol



c) Triglyceride is a molecule of glycerol linked to 3 fatty acids.

Schematically:

Triglycerides (fats & oils) are esters because they are the product of a condensation reaction between a carboxylic acid & an alcohol.

2.
a) Saponification
fat + sodium hydroxide ⟶ soap + glycerol

b) Simply add oil to a strong base solution and heat gently. Cooling and adding salt will help separate the soap from the water phase.

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Answer Section

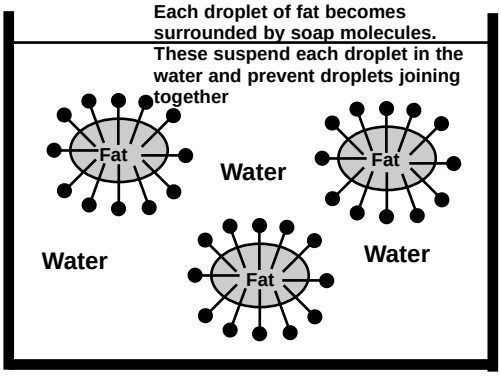
Worksheet 9 (cont.)

3.

a) An emulsion is a stable mixture containing 2 normally immiscible liquids. An emulsifier acts to keep one of the liquids dispersed in the other, as tiny, separate droplets.

b) "Dirt" often contains fat/oil so it will not simply wash away in water. Emulsifiers like soap can emulsify the fat, so that it becomes suspended in water and washes away.

c)



4.

a) Both soap and the most common detergents are long-chain hydrocarbons with a negative ionic group on one end. The hydrocarbon is non-polar and hydrophobic, while the ion is hydrophilic.

b) Soap does not work in "hard water" because the calcium salt of the fatty acid is insoluble and forms a greasy scum. Detergents continue to work perfectly as emulsifiers because the ions remain soluble in the presence of Ca^{2+} ions.

Worksheet 10

1.

a) $R\text{-}COOH + H_2O \longrightarrow R\text{-}COO^- + H_3O^+$

b) acid base conj.base conj.acid

2.

a) butanoate ion
b) methanoate ion
c) octanoate ion

3.

a) $R\text{-}NH_2 + H_2O \longrightarrow R\text{-}NH_3^+ + OH^-$

b) base acid conj.acid conj.base

4.

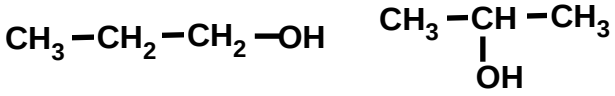
a) butylammonium ion
b) dimethylammonium ion
c) octylammonium ion

Worksheet 11

1.

The empirical formula matches with propanol C_3H_7OH and also matches with the molar mass.

It could be 1-propanol or 2-propanol.



2.

$C_3H_7OH + HCl \longrightarrow C_3H_7Cl + H_2O$

Applying Markovnikov's Rule suggests that the predominate product (probably about 90%) would be 2-chloropropane. This will be the case no matter which isomer of propane you begin with.

3

a) It hints at the formation of an ester.

b) Q-2 must be a carboxylic acid. Since it came from the oxidation of propanol, it must be propanoic acid.

c) Only a primary alcohol can be oxidised to carboxylic acid. (2_o alcohols give ketones) Therefore, the stating chemical was 1-propanol and NOT 2-propanol.

d)

propanoic acid + propanol → propylpropanoate + water

e)

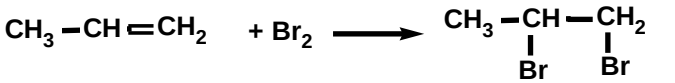
i) it acts as an oxidising agent.
ii) propanal

4. dehydration reaction

$$CH_3\text{-}CH_2\text{-}CH_2\text{-}OH \xrightarrow{\text{conc. } H_2SO_4} CH_3\text{-}CH{=}CH_2$$

$$\text{propanol} \xrightarrow{+H_2O} \text{propene} + \text{water}$$

Reaction with bromine:



propene + bromine → 1,2-dibromopropane

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Answer Section

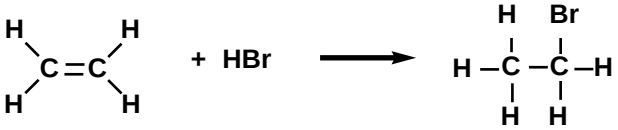
Worksheet 12

a) fuels
b) petrochemicals
c) ethene
d) double
e) reactive
f) addition
g) bromine
h) de-colourised
i) cracking
j) heat or catalysts
k) octane
l) gas
m) polymers/polythene
n) addition
o) polyethene
p) pressure & temperature
q) low
r) side-branches
s) flexible
t) cling-wrap
u) catalyst
v) pack together
w) high
x) tough plastic carry bags
y) polyvinyl chloride
z) vinyl chloride
aa) chloroethene
ab) dispersion
ac) harder
ad) rigid
ae) drain pipes & gutters
af) styrene
ag) ethenylbenzene
ah) benzene
ai) dispersion
aj) hard and rigid
ak) condensation
al) water molecule
am) polyesters
an) proteins & starch/DNA
ao) cellulose
ap) glucose
aq) wall
ar) cotton & linen
as) rayon
at) glucose
au) ethanol
av) ethene
aw) glucose
ax) PHB
ay) Bacillus magaterium
az) Genetic Engineering
ba) corn

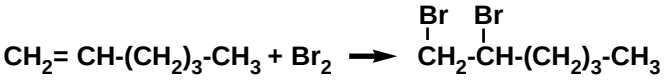
Worksheet 13

1. B 2. C 3. A 4. D 5.D 6. B

7.



8.
Hexene will undergo an addition reaction across the C= C double bond.



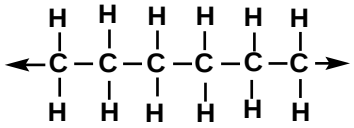
The Br_2 is consumed and its colour disappears.

Hexane has no double C= C bond, so does not react.

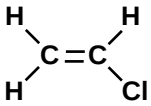
9.
a) "Cat-cracking" refers to catalytic cracking; the use of a catalyst to break long chain hydrocarbons into smaller molecules.

b) The double C= C bond in ethylene molecules allows thousands of them to undergo addition reactions with each other. They join in very long chains of polyethene.

c)



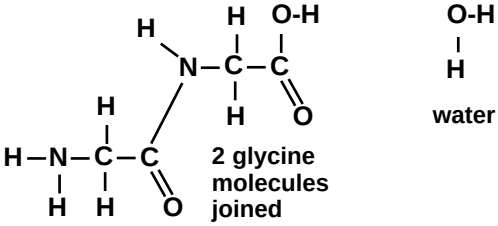
10.
a) Common name = vinyl chloride
Systematic = chloroethene



b) Compared to polyethylene, PVC has one chlorine atom in place of a hydrogen on each monomer unit. This greatly increases the molecular weight, and therefore the dispersion forces between PVC molecules. The PVC molecules "stick" together much more strongly, making the plastic harder and more rigid.

While its properties make polyethylene suitable for cling-wrap film, the tougher PVC is used for drainage pipes and guttering.

11.
a)



b) as each pair of glycines join together, a molecule of water is formed. The appearance of water is termed "condensation".