BioMedical Admissions Test (BMAT)

Section 2: Chemistry

Questions by Topic

C13 - Carbon-Organic Chemistry

C13: Carbon-Organic Chemistry - Question by Topic

(Mark Scheme and explanations at the end)

1 Which of the following reactions produces a fuel that can be used to produce more energy?

1 Complete combustion of methane
2 Applying heat to the compound C_4H_{10}
3 Reacting nitrogen and hydrogen under specific conditions
4 Reacting sodium metal with water

A 2 only
B 3 and 4 only
C 1 and 4 only
D 1, 2, 3 and 4
E 2 and 3 only
F 3 only
G 1 and 4 only

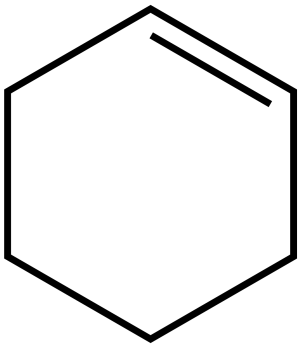
2 A compound contains 1 atom of carbon, four atoms of hydrogen, and one atom of oxygen.

Which of the following statements about this compound are true?

1 It contains the functional group -COOH.
2 It is highly flammable.
3 It is unsaturated.
4 It belongs to a homologous series.
5 It is produced by the Haber process.

A 1 only
B 2, 3, 4 and 5 only
C 1 and 2 only
D 1, 2, 3 and 4 only
E 4 only
F 2 and 4 only
G 1 and 3 only

3 A cyclic organic compound is shown below:



Deduce the molecular formula of this compound, and suggest which observation will be seen when the compound is shaken with bromine water.

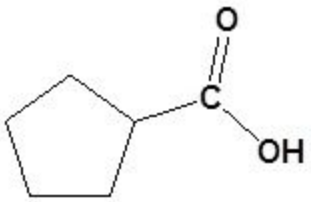
A C_6H_{12}, effervescence
B C_6H_{12}, decolourisation
C C_6H_{10}, effervescence
D C_6H_{10}, decolourisation
E C_6H_6, effervescence
F C_6H_6, decolourisation

4 Which option contains only compounds from the homologous series which has members that are:

- Flammable
- Fully soluble in water
- Form hydrogen and alkoxides when reacting with sodium

A CH_4O, CH_2O_2, CH_3O, C_2H_6O
B CH_4O, CHO, CH_3O, C_2H_6O
C CH_4O, $C_4H_{10}O$, C_2H_6O, $C_5H_{12}O$
D $C_{11}H_{22}O$, $C_4H_{10}O$, $C_6H_{14}O$, $C_7H_{16}O$

5 What is the percentage by mass of oxygen in the below compound?



(Molecular weights: C = 12, O = 16, H = 1)

A 28.1%
B 35.6%
C 19.2%
D 12.3%
E 41.0%

6 Which of the following statements are true about 1-bromo-hex-2,3-diene?
(Molecular weights: Br = 80, C = 12, H = 1)

1 It contains 3 double bonds
2 It has a molar mass of 162
3 It contains 2 double bonds
4 It contains 1 C-Br bond, 2 C=C double bonds, and 4 C-C single bonds.
5 It is a cyclic compound

A 1 only
B 2 only
C 1, 2, 3 and 4 only
D 3 only
E 1 and 4 only
F 2 and 4 only
G 2, 3 and 4 only

7 A company wishes to create a new synthetic polymer for use in clothing. They have narrowed down the selection of suitable monomers to the following.

Which of the following could **not** be used to form an additional polymer?

1 Pent-1-ene
2 Cyclopent-1,3-diene
3 $C_4H_7Br_2Cl$
4 CH_2FCF_3
5 $C_{13}H_{26}$

A 3 only
B 5 only
C 1, 2, and 3 only
D 3 only
E 1, 2 and 4 only
F 3 and 4 only
G 1 and 2 only

8 An unknown, straight chain, saturated hydrocarbon compound, with a molar mass of 100 g/mol, is heated strongly in a reaction chamber.

Which is not a possible product of this reaction?

(Molecular weights: C = 12, H = 1)

A C_8H_{10}
B C_2H_4
C C_6H_{14}
D C_3H_6
E C_6H_{12}

9 Compound Z is a hydrocarbon compound with a single double bond, and a relative formula mass of 140 g/mol.

What is the molecular formula of Compound Z?

A C_2H_4
B C_7H_{14}
C $C_{10}H_{20}$
D C_3H_6
E C_6H_6

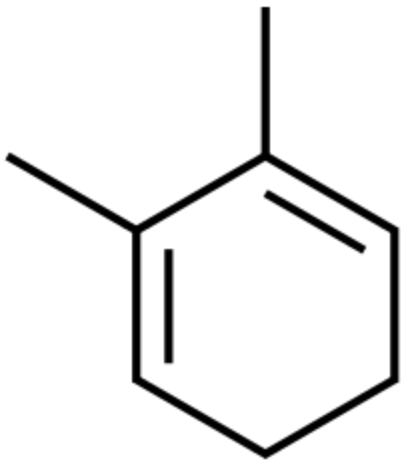
10 3-methyl-1,2-butadiene is reacted with an excess of hydrochloric acid.

What is the name of the organic product that is formed in this reaction?

A 3-methyl-1,2butadichloride
B 3-methyl-1-chlorobutane
C 2-chloro-1,3-butadiene
D 3-methyl-1,2-dichlorobutane
E 3-methyl-2-chlorobutane

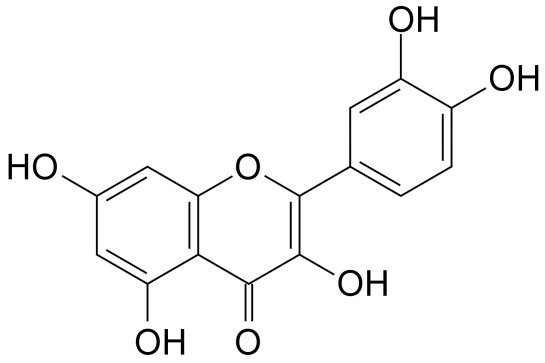
11 Examine the structure below.

What is the difference in relative atomic mass between this structure and 3-ethyl-2,4-dimethylhexane?



A 25
B 32
C 93
D 34
E 18
F 27

12 An organic compound Q is shown below.



Which of the following statements is/are most likely to apply to this compound?

1 It can be used to dissolve hydrocarbons
2 It can be used to make esters
3 It is a cyclic compound
4 It is found in alcoholic beverages
5 It is a saturated compound

A 1 only
B 2 and 4 only
C 3 and 4 only
D 1, 2 and 3 only
E 2, 3 and 4 only

13 Ketone bodies are compounds produced by the metabolism of fatty acids in the human liver. Ketone bodies are ketones, which contain carbonyl functional groups (C=O), and under certain conditions can be reduced to form alcohols.

Consider the ketone 4-methylpentan-2-one. What is the relative formula mass of the compound produced when this is reduced, as described above?

A 100 g/mol
B 90 g/mol
C 102 g/mol
D 108 g/mol
E 46 g/mol

14 A chemist has three samples of the alkene 1-bromopent-3-ene. She reacts the first sample with steam, the second with hydrogen, and the third with pure bromine gas.

Which product has the highest relative formula mass, and what is it?

A Bromine product - 309 g/mol
B Bromine product - 229 g/mol
C Hydrogen product - 149 g/mol
D Steam product - 183 g/mol
E Hydrogen product - 151 g/mol
F Hydrogen product - 358 g/mol
G Steam product - 257 g/mol
H Bromine product - 455 g/mol

Answers and Explanations

1 **The answer is B** - Statements 3 and 4 are correct.

Statement 1 only produces carbon dioxide and water, neither of which can be used as efficient fuels.
Statement 2 refers to the 'cracking' of an alkane, producing an alkene (which are not used as fuels).
Statement 3 describes the Haber process: the formation of ammonia from nitrogen and hydrogen on an industrial scale - ammonia is a renewable fuel that is widely used.
Statement 4 refers to an explosive reaction which produces sodium hydroxide and **hydrogen,** which can be used as a fuel.

2 **The answer is F**

The only possible compound this could be is methanol, CH_4O. This is an alcohol, so it contains the functional group -OH, is highly flammable and belongs to the homologous series of alcohols (with the general formula $C_nH_{2n+1}OH$). The other statements do not apply.

3 **The answer is D**

This is cyclohexene, C_6H_{10}. This can be deduced by counting the corners (carbon atoms) in the skeletal formula, and, taking into account the double bond, counting the hydrogen atoms that will 'fit' onto each carbon atom. When mixed with bromine water, the double bond will 'accept' a bromine atom via electrophilic addition, turning the bromine water colourless. (Test for alkenes)

4 **The answer is C**

The homologous series with these properties is the alcohols, with general formula $C_nH_{2n+1}OH$. The molecular, rather than structural formulas are given in this question. Option A contains a carboxylic acid (CH_2O_2), Option 2 contains a functional group (CHO) whereas the question asks for compounds. Option 4 contains a formula which has a single O at the end, but if examined more closely does not have the correct numbers of carbon and hydrogen atoms to follow the alcohol general formula.

5 **The answer is A**

The relative atomic mass of this compound (cyclopentanecarboxylic acid, $C_5H_9CO_2H$) is 114. There are two oxygen atoms in the compound, so the calculation is:
100 x (16 x 2) / 114 = **28.1% oxygen by mass.**

6 **The answer is D** - the only correct statement here is **3.**

The molar mass of the compound is 161 (eliminating **statement 2**).
It contains **3 C-C single bonds, not 4** (eliminating **statement 4**)
It is not a cyclic compound, as the name does not contain a cyclo- suffix. (eliminating **statement 5**).

7 **The answer is F -** 3 and 4.

All other options are unsaturated, allowing them to be used in addition polymerisation reactions. 3 and 4 are saturated halogenoalkanes, which cannot be polymerised in this way.

8 **The answer is A**

The hydrocarbon compound is saturated and straight chain, meaning it must be an alkane. Working up the list of alkanes, the first (and only) alkane with a relative formula mass of 100 is **heptane, C_7H_{16}.** Cracking of alkanes can only produce alkanes and alkenes of shorter chain lengths, therefore the only compound that cannot be produced from this reaction is octane, C_8H_{10}, as it has a longer carbon chain length than heptane.

9 **The answer is C**

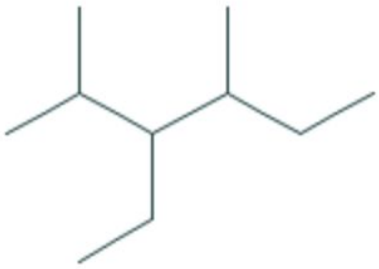
The information given identifies Compound Z as an alkene, which means it must have the empirical formula CH_2. The empirical formula mass is first calculated, which is 12 + 2 = 14. Dividing 140 by 14 gives 10, and multiplying this by the empirical formula gives $C_{10}H_{20}$.

10 **The answer is D**

The key here is the **excess** of hydrochloric acid. This means that both double bonds in the compound will react with HCl, and the final product will be 3-methyl-1,2-dichlorobutane (the methyl group does not change position).

11 **The answer is D**

The structure shown is 2,3-Dimethyl-1,3-cyclohexadiene, C_8H_{12}, with a molar mass of 108. 3-Ethyl-2,4-dimethylhexane has a structure as follows:



It has a molecular formula of $C_{10}H_{22}$, which can be determined by drawing out this structure. Its molar mass is 142 g/mol. **142 - 108 = 34.**

12 **The answer is D**

The -OH groups mean that this compound is classified as an alcohol. Hence, it can be used to dissolve hydrocarbons and make esters. It is a cyclic compound due to the multiple ring structures within it. Although it is an alcohol, it is not ethanol, and thus is not used in alcoholic beverages. It is not a saturated compound as it contains several carbon-carbon double bonds.

13 **The answer is C**

The oxygen in the C=O group, and the double bond by which it attaches to carbon, are removed to make way for the alcohol group (OH). C-O is a single bond here, allowing room for another hydrogen to bond to the carbon. Hence, the relative formula mass increases by 2, from 100 to 102 g/mol.

14 **The answer is A**

This question tests your knowledge of addition reactions. The double bond in the alkene 'opens up' to accept the bromine, oxygen, or hydroxyl (-OH) groups in these reactions. The reaction with bromine produces 1,2,3-bromopentane (309 g/mol), the reaction with steam produces 1-bromopentan-2,3-ol (183 g/mol), and the hydrogen reaction produces 1-bromopentane (151 g/mol). It is important to remember that **two** of each group are added in each reaction, as both carbons on either side of the double bond are able to accept an extra atom.