Introduction to Organic Chemistry — Complete Exercise Solution

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Multiple Choice Questions (MCQs)

Q(i): Which of the following is an organic compound?

Answer: D) C_2H_2

Organic compounds must contain carbon AND hydrogen both. C_2H_2 (acetylene) has both, so it is organic. CO and CO_2 are oxides of carbon and are considered inorganic. $NaHCO_3$ is also inorganic because it is a salt and has no C–H bond.

Q(ii): Which one of the following is the general formula of alkanes?

Answer: A) C_nH_{2n+2}

Alkanes are the simplest hydrocarbons with only single bonds. Their general formula is C_nH_{2n+2}. For example, when n=1 we get CH_4 (methane), and when n=2 we get C_2H_6 (ethane). Easy trick — alkanes always have the maximum number of hydrogen atoms possible.

Q(iii): The homologues have the same:

Answer: D) Chemical properties

Members of a homologous series differ in physical properties like boiling point and density. But since they all have the same functional group, they all react in the same way — so their chemical properties are always the same.

Q(iv): Carbon atom usually:

Answer: A) Forms four covalent bonds

Carbon has 4 electrons in its outer shell. Instead of gaining or losing electrons (which needs too much energy), carbon simply shares its 4 electrons with other atoms to form 4 covalent bonds. This is called tetravalency and it is the main reason carbon can form such a huge number of compounds.

Q(v): Organic radical with general formula C_nH_{2n+1} is:

Answer: C) Alkyl

When you remove one hydrogen atom from an alkane (C_nH_{2n+2}), you get an alkyl group with the formula C_nH_{2n+1}. For example, removing H from CH_4 gives CH_3– which is called the methyl group. These groups are always attached to something else and cannot exist alone.

Q(vi): The next homologue of C_8H_{18} is:

Answer: B) C_9H_{20}

In a homologous series, each next member has one more CH_2 group than the previous one. So C_8H_{18} + CH_2 = C_9H_{20}. Just add 1 to the carbon count and 2 to the hydrogen count.

Q(vii): Methane is the first member of:

Answer: A) Alkane series

Methane (CH_4) fits the general formula C_nH_{2n+2} perfectly when n=1. It has only single bonds and no functional group, which are the defining characteristics of the alkane series.

Q(viii): The compound C_3H_8 must have:

Answer: A) All single bonds

For alkanes the formula is C_nH_{2n+2}. When n=3, we get C_3H_8. Since C_3H_8 perfectly matches the alkane formula, it belongs to the alkane family which only has single bonds — no double or triple bonds at all.

Q(ix): Organic compounds are originated from:

Answer: D) Living organisms

Historically, organic compounds were thought to come only from living things like plants and animals. That is why the word "organic" is used. Even today, most organic compounds are either found in nature or are based on the carbon framework found in living organisms.

Q(x): The name of C_6H_{14} is:

Answer: C) Hexane

C_6H_{14} has 6 carbon atoms. In organic chemistry, "hex" means 6. Since it fits the alkane formula (n=6 gives C_6H_{14}), its name is hexane. Memory tip — think of a hexagon which also has 6 sides!

Q(xi): Which one of the following organic compounds has different chemical properties?

Answer: B) C_2H_5COOH

CH_3OH, C_2H_5OH, and $C_5H_{11}OH$ are all alcohols — they all have the –OH functional group. But C_2H_5COOH is a carboxylic acid with the –COOH functional group. Since chemical properties depend on the functional group, C_2H_5COOH behaves completely differently from the rest.

Q(xii): Which of the following is inorganic?

Answer: C) NaCN

Even though NaCN contains carbon, it has no hydrogen and no C–H bond. It is an ionic compound — a salt of sodium. CH_4, CH_3OH, and CH_3Cl all have C–H bonds and are organic. NaCN behaves like a salt, not an organic compound, so it is classified as inorganic.

Short Answer Questions

Q(i): Why are organic compounds volatile in nature?

Answer: Organic compounds are volatile because they are held together by very weak intermolecular forces called van der Waals forces. These forces are much weaker than the strong ionic bonds found in inorganic compounds. Because of this weakness, very little energy or heat is needed to separate organic molecules from each other, so they evaporate easily even at room temperature. That is why you can smell petrol, perfume, or nail polish remover from a distance — their molecules escape into the air very easily and quickly.

Q(ii): Organic compounds are insoluble in water but soluble in organic solvents — explain.

Answer: There is a famous rule in chemistry: "like dissolves like." Water is a polar solvent, meaning it has a positive end and a negative end. Most organic compounds are non-polar because they are made up of C–H and C–C bonds, which do not have any significant charges on them. Since water (polar) and organic compounds (non-polar) are completely unlike each other, they do not dissolve in each other just like oil and water never mix. However, when an organic compound is placed in an organic solvent like benzene, ether, or chloroform which are also non-polar the forces between them are similar and the compound dissolves easily.

Q(iii): Functional group is a group of atoms but not a molecule — explain.

Answer: A molecule is a complete and independent unit that can exist on its own. A functional group, on the other hand, is just a specific arrangement of atoms within a larger molecule. It cannot exist by itself and it is not complete on its own. For example, the hydroxyl group (–OH) is a functional group found in alcohols. But OH alone is not a complete molecule. It needs to be attached to a carbon chain to form a complete compound like CH_3OH (methanol). Think of a functional group like an engine. It does all the work and gives the compound its properties, but it always needs to be part of a bigger structure to actually exist and function.

Q(iv): Organic substances can be made from inorganic substances — explain.

Answer: For a long time, scientists believed that organic compounds could only be made inside living bodies through a mysterious "vital force." This idea was completely destroyed in 1828 by a German scientist named Friedrich Wöhler. He simply heated an inorganic compound called ammonium cyanate (NH_4CNO) in his laboratory and converted it into urea (NH_2CONH_2), which is a well-known organic compound found in human urine. No living organism was involved. No vital force was needed. Just a simple chemical reaction. This proved that organic compounds can absolutely be made from inorganic starting materials. Today, thousands of organic compounds including medicines, plastics, and dyes are manufactured in factories from simple inorganic raw materials.

Q(v): Why was the vital force theory discarded?

Answer: The vital force theory was proposed by the Swedish chemist Jöns Jacob Berzelius. He believed that organic compounds could only be produced inside living organisms through a special supernatural energy called the "vital force," and that humans could never make them artificially in a lab. This theory was completely discarded in 1828 when Friedrich Wöhler successfully made urea — an organic compound — from ammonium cyanate, which is an inorganic substance, by simply heating it. No living body was involved, no vital force was needed, and the experiment was done entirely in a laboratory. After this, other scientists also began making more organic compounds artificially. It became clear that organic compounds follow the same laws of chemistry as all other compounds. The idea of a mysterious vital force was permanently abandoned.

Q(vi): Why are hydrocarbons combustible?

Answer: Hydrocarbons are made up of only carbon and hydrogen atoms. Both carbon and hydrogen have a very strong tendency to react with oxygen. When a hydrocarbon is ignited, the carbon atoms react with oxygen to form carbon dioxide (CO_2) and the hydrogen atoms react with oxygen to form water (H_2O). This reaction releases a very large amount of energy in the form of heat and light. The general reaction is: Hydrocarbon + $O_2 \rightarrow CO_2 + H_2O$ + Energy Because so much energy is released, hydrocarbons burn very well. This is exactly why fuels like petrol, natural gas (methane), and diesel — which are all hydrocarbons — are used all over the world as energy sources.

Q(vii): The chemical properties of a homologous series are always the same — explain.

Answer: All members of a homologous series share the same functional group. Chemical reactions of organic compounds depend almost entirely on the functional group, not on the length of the carbon chain attached to it. So whether the alcohol is small like methanol (CH_3OH) or large like pentanol ($C_5H_{11}OH$), both will undergo the exact same types of reactions — like combustion, oxidation, and reaction with sodium metal — because both have the same –OH functional group. The carbon chain may slightly affect the speed or energy of the reaction, but the type of reaction always remains the same. This is one of the most useful features of the homologous series because it allows chemists to predict the behaviour of any new member just by knowing the reactions of one existing member.

Long / Detailed Questions

Q(i): What is a homologous series? Give the names of alkane homologous series up to ten carbon atoms.

Answer: Definition of Homologous Series A homologous series is a family of organic compounds that share the same general formula, have the same functional group, show similar chemical properties, and differ from one another by a constant unit of CH_2 (called a methylene group). Each successive member has a molecular mass 14 units higher than the previous one. Think of it like a staircase — every step is exactly the same height (one CH_2 unit) and all steps are made of the same material (same functional group).

Key Characteristics of a Homologous Series All members have the same general formula. All members have the same functional group. Each successive member differs by one CH_2 unit and 14 mass units. Physical properties like boiling point and melting point change gradually as the chain length increases. All members show the same chemical properties. Each member can be prepared by similar methods.

Alkane Homologous Series up to Ten Carbon Atoms

Carbon Atoms	Molecular Formula	Name
1	CH_4	Methane
2	C_2H_6	Ethane
3	C_3H_8	Propane
4	C_4H_{10}	Butane
5	C_5H_{12}	Pentane
6	C_6H_{14}	Hexane
7	C_7H_{16}	Heptane
8	C_8H_{18}	Octane
9	C_9H_{20}	Nonane
10	$C_{10}H_{22}$	Decane

Memory tip: **M**y **E**xcited **P**uppy **B**ites **P**eople, **H**e **H**its **O**ld **N**eighbour **D**aily (Methane, Ethane, Propane, Butane, Pentane, Hexane, Heptane, Octane, Nonane, Decane)

Q(ii): What are alkyl groups? Name and derive the alkyl groups from the first five members of the alkane series.

Answer: Definition of Alkyl Groups An alkyl group is an organic radical that is formed when one hydrogen atom is removed from an alkane molecule. The general formula of an alkyl group is C_nH_{2n+1}. Alkyl groups are not complete molecules — they cannot exist on their own. They are always attached to some other atom or group in a compound. They are represented by the letter "R" in general formulas. The name of an alkyl group is made by replacing the "-ane" ending of the parent alkane with "-yl."

Derivation of Alkyl Groups from First Five Alkanes

1. Methane → Methyl Group Methane formula: CH_4 Remove one H atom → CH_3– Name: Methyl group This is the most commonly found alkyl group in organic compounds.

2. Ethane → Ethyl Group Ethane formula: C_2H_6 Remove one H atom → C_2H_5– Name: Ethyl group Found in ethanol (C_2H_5OH) and many other compounds.

3. Propane → Propyl Group Propane formula: C_3H_8 Remove one H atom → C_3H_7– Name: Propyl group

4. Butane → Butyl Group Butane formula: C_4H_{10} Remove one H atom → C_4H_9– Name: Butyl group **5. Pentane → Pentyl Group** Pentane formula: C_5H_{12} Remove one H atom → C_5H_{11}– Name: Pentyl group

Parent Alkane	Formula	Alkyl Group	Group Formula
Methane	CH_4	Methyl	CH_3–
Ethane	C_2H_6	Ethyl	C_2H_5–
Propane	C_3H_8	Propyl	C_3H_7–
Butane	C_4H_{10}	Butyl	C_4H_9–

Q(iii): Give characteristic properties of organic compounds. Why are organic compounds placed in a separate branch of chemistry?

Answer: Characteristic Properties of Organic Compounds

- **1. Presence of Carbon** All organic compounds must contain carbon as their essential element. Most also contain hydrogen, and many contain oxygen, nitrogen, sulphur, or halogens.
- **2. Covalent Bonding** Organic compounds are held together by covalent bonds (shared electrons), not ionic bonds. This is very different from most inorganic compounds which are ionic.
- **3. Volatility** Because organic compounds have weak intermolecular forces, they evaporate easily and have low boiling points. This is why petrol, alcohol, and ether have strong smells.
- **4. Solubility** Organic compounds are generally insoluble in water but dissolve easily in organic solvents like benzene, ether, acetone, and chloroform.
- **5. Combustibility** Most organic compounds burn in oxygen to produce CO_2 and H_2O while releasing energy. This makes them excellent fuels.
- **6. Low Melting and Boiling Points** Due to weak intermolecular forces, organic compounds have much lower melting and boiling points compared to inorganic compounds.
- **7. Slow Reactions** Organic reactions are generally slower than inorganic reactions and often need heat, light, or a catalyst to proceed.
- **8. Isomerism** Many organic compounds can have the same molecular formula but different structural arrangements. This property is called isomerism and is almost unique to organic chemistry.
- **9. The huge number of Compounds** Carbon's ability to form chains, rings, and branches with itself (called catenation) produces millions of different organic compounds.

Why Organic Compounds are in a Separate Branch Organic compounds are placed in a separate branch because of their enormous number — over 10 million organic compounds are known today, compared to only about 100,000 inorganic compounds. The unique bonding ability of carbon, the property of catenation, the existence of isomers, and the special rules needed to name and classify these compounds make organic chemistry so vast and complex that it requires its own dedicated field of study. Also, organic chemistry is directly connected to life itself — proteins, fats, carbohydrates, and DNA are all organic. This deep connection to living systems makes it a critically important and completely distinct branch of science.

Q(iv): What is organic chemistry? Briefly discuss how organic and inorganic compounds differ.

Answer: Definition of Organic Chemistry Organic chemistry is the branch of chemistry that deals with the study of carbon-containing compounds — especially those that also contain hydrogen — along with their properties, structures, reactions, preparation, and uses. The word "organic" comes from the old belief that such compounds could only be produced by living organisms. Today, organic chemistry covers not just natural compounds but also millions of synthetic compounds made in laboratories and industries, including plastics, medicines, dyes, fuels, and fertilisers.

Difference Between Organic and Inorganic Compounds

Property	**Organic Compounds**	**Inorganic Compounds**
Composition	Always contain C and H	Do not necessarily contain C or H
Bonding	Covalent bonds	Mostly ionic bonds
Solubility	Soluble in organic solvents	Mostly soluble in water
Melting/Boiling Point	Low	Generally high
Combustibility	Most burn easily	Usually do not burn
Reaction Speed	Slow	Usually fast
Volatility	Volatile, evaporate easily	Non-volatile mostly
Isomerism	Very common	Very rare

Number of Compounds	Over 10 million	About 100,000
Electrical Conductivity	Poor conductors	Many conduct electricity

In short, organic compounds are special because of the remarkable versatility of the carbon atom. Carbon can bond with itself and with many other elements in countless arrangements, producing the enormous variety of molecules that make up all living things and most materials used in modern life.