

## Unit C: Chemical Changes of Organic Compounds – Solutions

### Question 1

It is easiest to eliminate the inorganic exceptions.

$\text{Fe}_3\text{C}(\text{s})$  (**2**) is NOT organic. It is iron carbide, also known as cementite. Carbide compounds, those formed between metal ions and carbide ions, are not considered to be organic.

$\text{CO}(\text{g})$  (**5**), carbon monoxide, is NOT organic. Oxides of carbon are not considered to be organic.

$\text{NaCN}(\text{s})$  (**7**), sodium cyanide, is NOT organic. Compounds that contain the cyanide **ion** ( $\text{CN}^-$ ) are not considered to be organic.

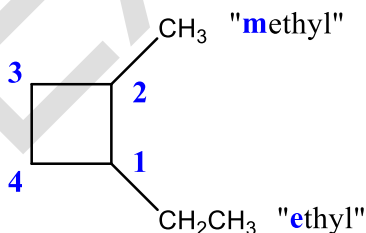
$\text{MgCO}_3(\text{s})$  (**8**), magnesium carbonate, is NOT organic. Compounds that contain the carbonate ion ( $\text{CO}_3^{2-}$ ) are not considered to be organic.

All other options,  $\text{CCl}_4(\text{g})$  (**1**),  $\text{C}_2\text{H}_2(\text{g})$  (**3**),  $\text{C}_2\text{H}_5\text{OH}(\text{l})$  (**4**), and  $\text{C}_3\text{H}_8(\text{l})$  (**6**) are organic. Three of the four have an abundance of carbon and hydrogen. All of them have carbon atoms as their backbones.

There is probably some wonder as to why  $\text{CCl}_4(\text{l})$  (**1**) is organic. This compound is derived from methane,  $\text{CH}_4(\text{g})$ , which IS organic. In fact,  $\text{CCl}_4(\text{l})$  can be named tetrachloromethane.

The correct answer is **1346**.

### Question 4



1-ethyl-2-methylcyclobutane

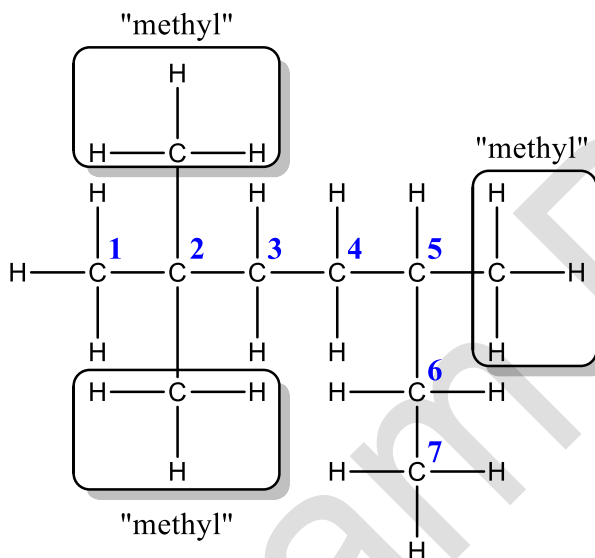
The parent chain carbon that is attached to the substituent that is higher in alphabetical rank gets the lower number.

**Option D is correct!** *i = ethyl, ii = methyl*

### Question 5

The structure is drawn in such a way that makes it difficult to identify the longest carbon chain of the molecule.

The longest carbon chain is numbered below and it is a 7-carbon chain. The parent chain is **heptane**.



**2,2,5-trimethylheptane**

There are two methyl groups on the 2-carbon and a single methyl group on the 5-carbon for a total of three methyl groups.

**The correct answer is A, 2,2,5-trimethylheptane.**

### Question 7

Option B is incorrect. Alkanes are indeed unreactive at room temperature.

Option C is incorrect. Because of their non-polar nature and through London dispersion forces, alkanes have weak intermolecular attraction.

Option D is incorrect. Because of increasing London dispersion forces of attraction with increasing molecular size, the boiling point of an alkane increases as the number of carbons increase.

**Option A is correct!** Because of their non-polar nature, alkanes are NOT soluble in water.

### Question 9

The general formula of an alkyne, with one triple bond, is  $C_nH_{2n-2}$ .

The ratio of carbon atoms to hydrogen atoms is:

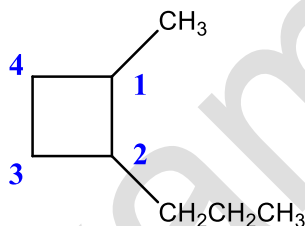
$$\begin{array}{cc} \text{carbon} & \text{hydrogen} \\ n & 2n - 2 \end{array}$$

Each option has 5 carbon atoms. The correct option should satisfy the above ratio.

$$\begin{array}{cc} \text{carbon} & \text{hydrogen} \\ 5 & 2(5) - 2 = 8 \end{array}$$

**Option A is correct!**  $C_5H_8$

### Question 11



Option A is incorrect. The compound drawn is indeed an aliphatic alkane, but it contains a four-carbon parent, NOT a three-carbon one.

Option B is incorrect. No benzene ring is present and it is impossible for a four-carbon ring structure to be aromatic.

Option C is incorrect. No double bonds are present in this compound.

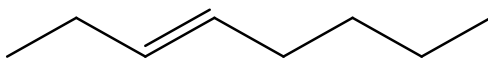
**Option D is correct!** The compound contains a four-carbon parent with only single bonds.

### Question 12

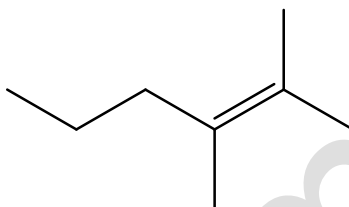
A compound containing a single ring structure will have the same carbon to hydrogen ratio as a straight-chained or branched alkene with one double bond that has the same number of carbons.

Correct options will contain ONE RING with only single bonds or ONE DOUBLE BOND with no ring!

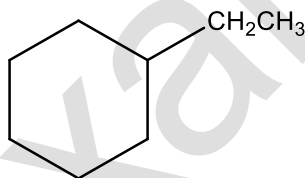
Oct-3-ene (2):



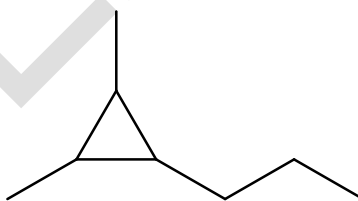
2,3-dimethylhex-2-ene (3):



Ethylcyclohexane (5):



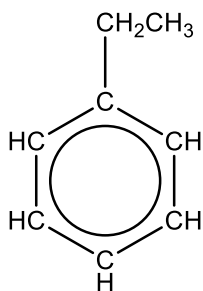
2,3-dimethyl-1-propylcyclopropane (6):



The correct answer is **2356**.

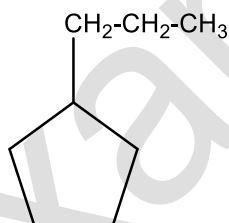
### Question 16

Option A is incorrect. Its molecular formula is  $C_8H_{10}$ .



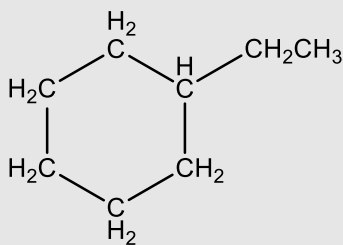
Option C is incorrect. Cyclopentylpropane is not the correct name for the structure. The parent chain should be cyclopentane as it contains five carbons which is greater than the three-carbon propane parent chain which the name denotes.

Option D is incorrect. Propylcyclopentene is not the correct name for the structure. The “ene” suffix denotes the presence of a double bond which is not seen in the structure. The correct name for the structure is shown below.



propylcyclopentane

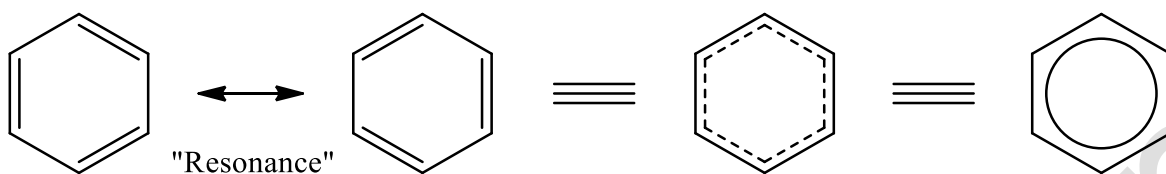
**Option B is correct!**



ethylcyclohexane

Its chemical formula is indeed  $C_8H_{16}(l)$  and the structure contains only ONE RING and only single bonds. Also, the structure is correctly named!

### Question 17



Because of a property called resonance, the benzene ring's pi-bond electrons are delocalized over the ENTIRE ring. This makes each carbon-carbon bond a **hybrid between a double and single bond**.

**Option D is correct!**

### Question 19

Remember that boiling point increases with increasing alkane chain length.

The correct option will be the compound with the longest carbon chain.

Option A is incorrect. Butane is a four-carbon alkane.

Option B is incorrect. Ethane is a two-carbon alkane.

Option D is incorrect. Methane is a one-carbon alkane.

**Option C is correct!** Heptane is a seven-carbon alkane and the longest straight-chained alkane with the highest boiling point of the options.

### Question 23

Option A is incorrect. Titration is a procedure done to determine the concentration of an acidic or basic solution.

Option B is incorrect. Precipitation purifies solids by using their insolubility in certain solvents.

Option C is incorrect. Solvent extraction separates compounds based on their differing solubility in water vs. organic solvents.

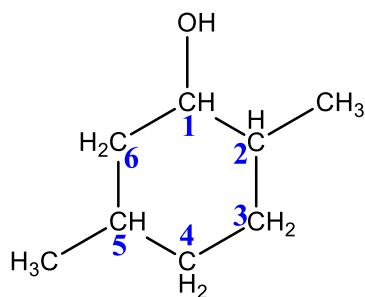
**Option D is correct!** It is **fractional distillation** that separates a crude oil mixture into individual hydrocarbons based on their boiling points.

### Question 24

Options B, C, and D are incorrect. They are non-polar compounds which are insoluble in water. Water is extremely polar and capable of hydrogen bonding.

**Option A is correct!** Alcohols (R-OH) contain a **hydroxyl group** which is capable of hydrogen bonding and makes them likely soluble in the hydrogen-bonding solvent, water.

### Question 26



**Option D is correct!**  $C_8H_{16}O$

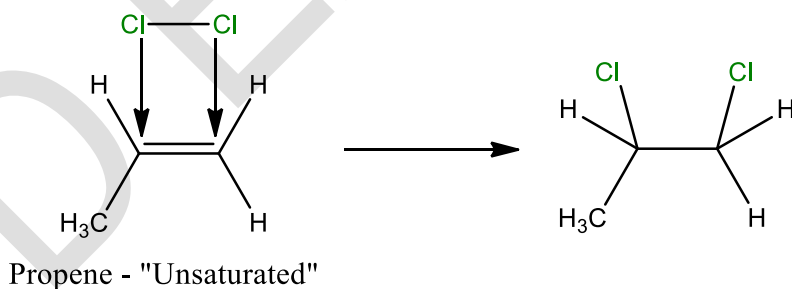
### Question 28

Options B and D are incorrect. Neither  $CH_4(g)$  nor  $CH_2O(g)$  are products of combustion.

Option C is incorrect. Burning ethanol with insufficient oxygen will result in incomplete combustion.  $CO_2(g)$  is a prominent product of complete combustion.

**Option A is correct!**  $CO(g)$  is one of the expected products of incomplete combustion.

### Question 33



In an unsaturated compound, such as propene, at each carbon of the double bond, there is room to **add** the atoms of a diatomic molecule such as  $Cl_2(g)$ .

The above reaction is an **addition** reaction.

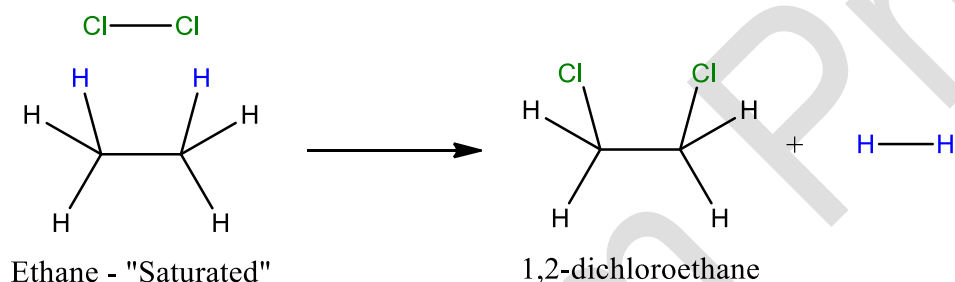
**Option A is correct!**

### Question 35

Options A and B are incorrect. In a saturated molecule, such as ethane, there is no room to add additional atoms. Addition reactions cannot happen.

Option D is incorrect. Yes, a substitution reaction is possible with a saturated compound because instead of adding atoms, substituting atoms with others can be done. However, the product will not be an unsaturated molecule such as 1-chloroethene.

**Option C is correct!** A **substitution (i)** reaction happens where two hydrogens are replaced by two chlorines and the product, **1,2-dichloroethane (ii)**, remains saturated.



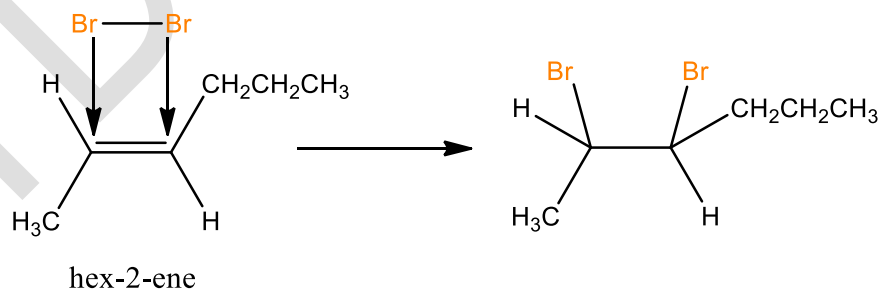
### Question 38

Option A is incorrect. Hex-2-ene is not a saturated compound.

Option B is incorrect. Cyclopentane does not have the chemical formula of  $C_6H_{12}(l)$ .

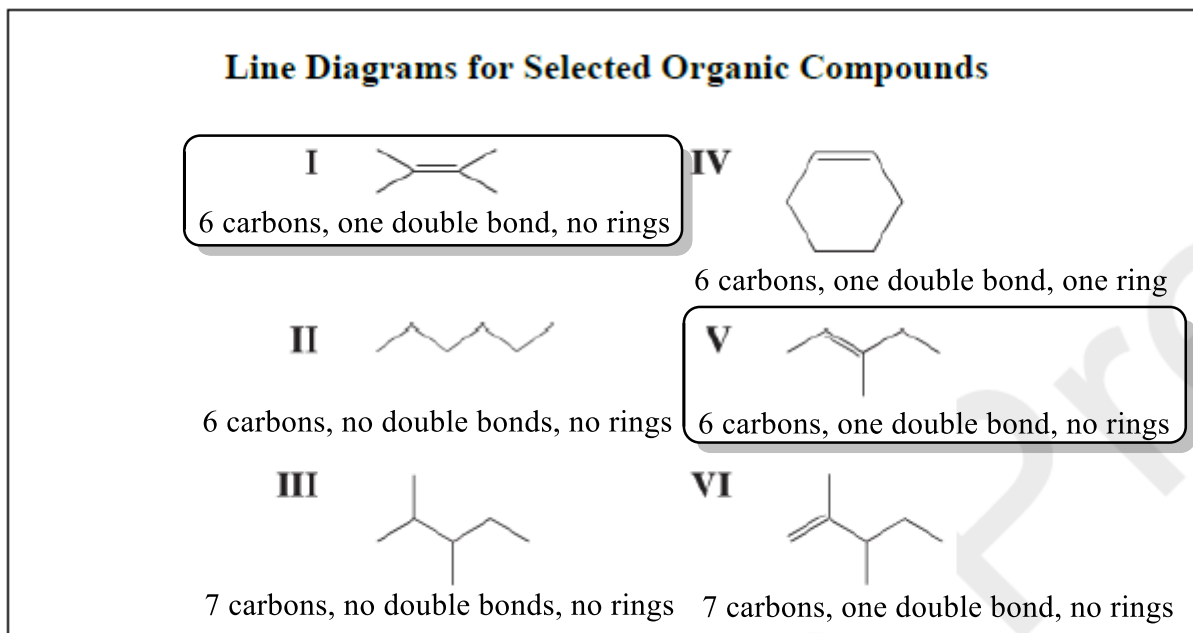
Option D is incorrect. Cyclopentane is not an unsaturated compound.

**Option C is correct!** Light is needed for a hydrocarbon to undergo a substitution reaction with bromine. If  $C_6H_{12}(l)$  undergoes a reaction with bromine in the absence of light, it is an **addition reaction** that happens. Saturated compounds do NOT do addition reactions.  $C_6H_{12}(l)$  is **unsaturated (i)**! An IUPAC name of the sample could be **hex-2-ene (ii)**.





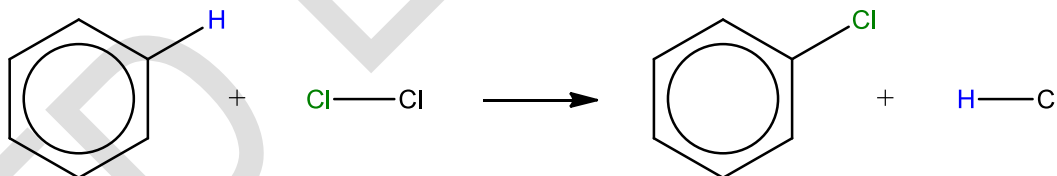
### Question 40



**Option C is correct, I and V only.**

### Question 44

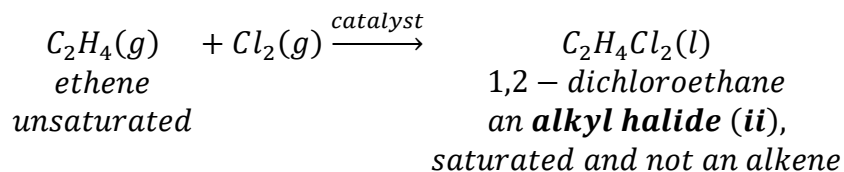
Aromaticity is a stability that benzene derivatives want to maintain. Reactions where a hydrogen atom on a benzene ring substitutes with a halogen atom from a diatomic halogen molecule are possible. Aromaticity is maintained in the product.



**Option C is correct!** What separates this from the other options is that the products shown complete a **balanced** chemical reaction.

### Question 49

The organic reactant in Equation I is the unsaturated molecule, ethene. Unsaturated molecules undergo **addition (i)** reactions with diatomic halogen molecules.

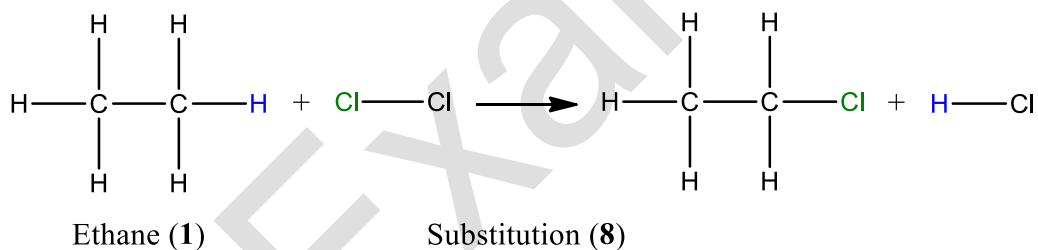


**Option B is correct!** *i = an addition, ii = alkyl halide*

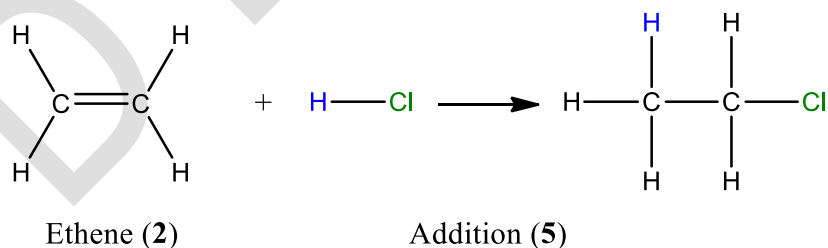
### Question 52

The reactant in Method I cannot be ethene. As seen in the solution for Question 49, ethene reacts with  $Cl_2$  via an addition reaction to form 1,2-dichloroethane which is NOT the product of Method I.

The reactant in Method I is **ethane (1)** which undergoes a **substitution (8)** reaction to form chloroethane.



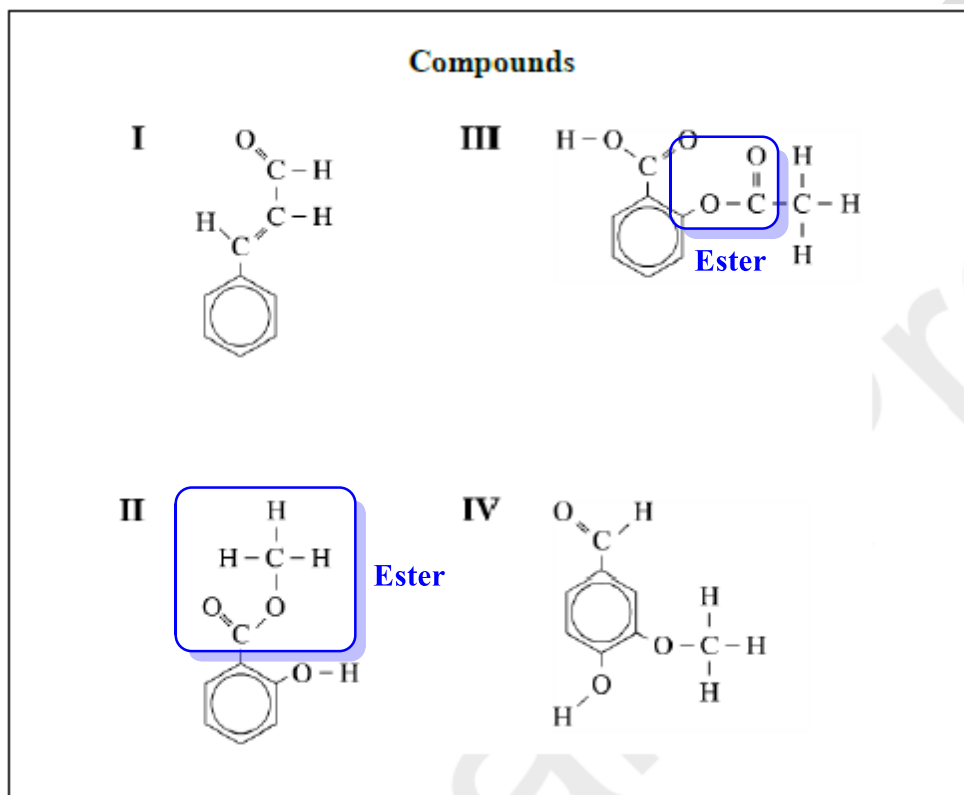
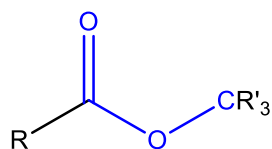
Ethene (2) CAN undergo an addition reaction with HCl to form chloroethane.



The correct answer is **1825**.

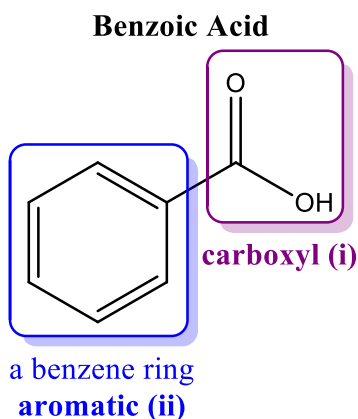
**Question 53**

Esters are compounds of the form:



**The correct answer is D, II and III only.**

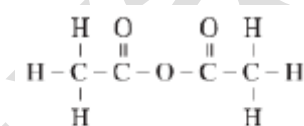
### Question 56



**Option A is correct!** *i = carboxyl, ii = aromatic*

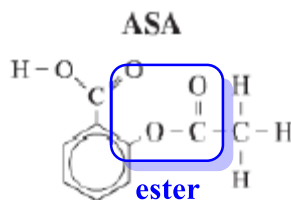
### Question 58

This is a great question because the background information displays an alternative way to make an ester. Just focus on specifically for what the question is asking and the question can be made quite simple.



**I**

Compound **I** is NOT aromatic as no benzene rings are present. It is therefore **aliphatic (i)**.



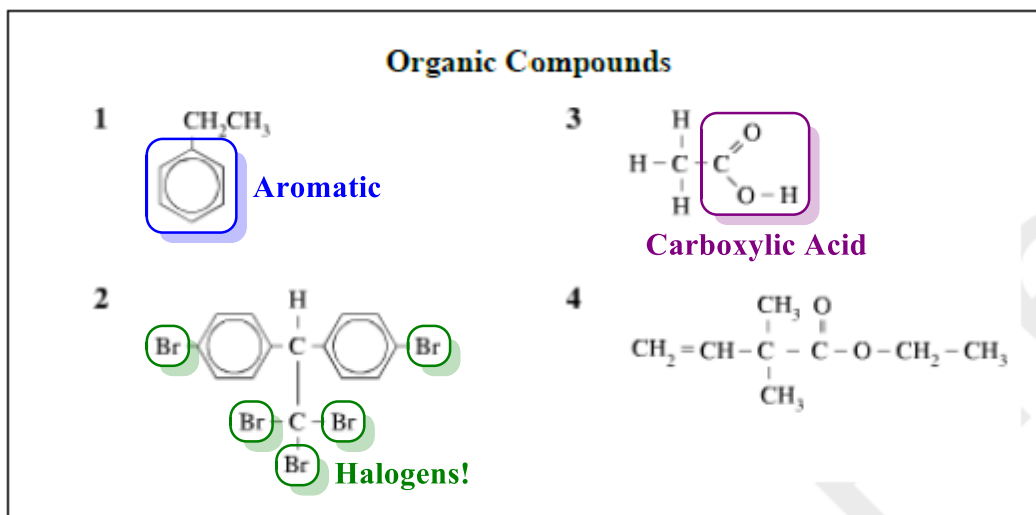
**II**

No alcohol group is present in compound **II**. There is, however, an **ester (ii)** group present!

**Option A is correct!** *i = aliphatic, ii = ester*

### Question 61

This question is kind of tricky because each pair of certain options can fall under the same category. The trick is to eliminate which option definitely falls under one category and fill in the last two with what remains.



The most obvious identification is that compound **3** is a **carboxylic acid** (second digit).

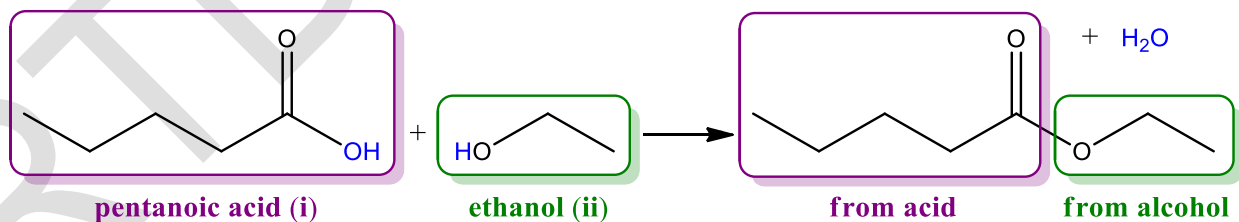
Compound **2** contains halogens so it can be labelled as the **halogenated hydrocarbon** (fourth digit)

With those two eliminated, compound **1** can be labelled as **aromatic** (first digit)

Compound **4** is **unsaturated and aliphatic** (third digit)

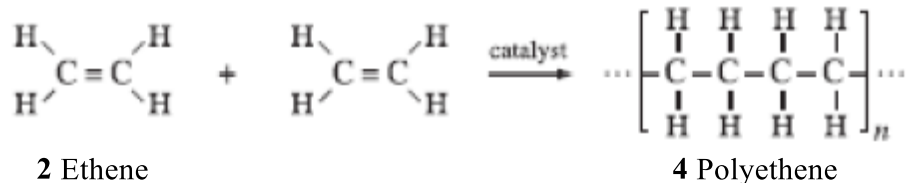
The correct answer is **1342**.

### Question 69



**Option D is correct!** *i = pentanoic acid, ii = ethanol*

### Question 79



**First digit:** The product is **polyethene** (4). Polymer names are obtained by simply adding “poly” to the beginning of the monomer reactant name.

**Second digit:** The reactant is **ethene** (2).

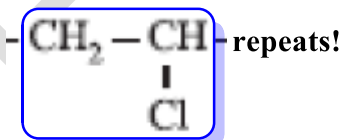
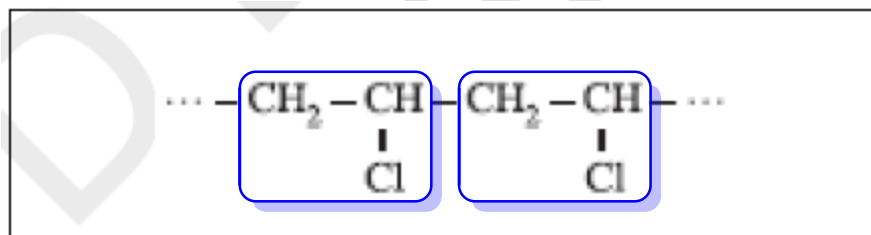
**Third digit:** This type of organic reaction is a **polymerization** (7). Multiple monomer units combine to form a long polymer.

**Fourth digit:** The product can be classified as a **polymer** (6).

The correct answer is **4276**.

### Question 80

Look for the **repeating unit**. The **monomer** will have the **same molecular connectivity**!



**Option C is correct!**

