

Degree of unsaturation

Degree of Unsaturation of hydrocarbons– Worksheet and solutions limited to organic acids, straight chain alkenes with cyclic substituents.

Definition

The degree of unsaturation (DOU) refers to the total number of rings and double or triple bond present in a compound.

Each DOU represents either:

- One double bond
 - One ring structure
 - Two hydrogens missing from the fully saturated formula (C_nH_{2n+2} for alkanes)
- or
- two degrees of unsaturation for each triple bond.

Let's take a look at some examples and solutions

1. What is the DOU for C_5H_8

This formula represents a pentene molecule with two double bonds. Pentane has a formula of C_5H_{10} . But this compound has 4 hydrogen atoms less representing two double bonds. Two hydrogen less for each double bond.

$$DOU = (2 \times 5 + 2 - 8) / 2 = (10 + 2 - 8) / 2 = 4 / 2 = 2$$

2 degrees of unsaturation

2. What is the DOU for the organic acid shown in figure 1

*Ignore oxygen for DOU:
1 ring structure = 1 degree of unsaturation*

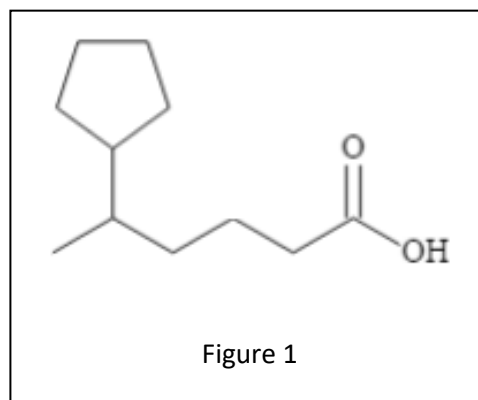


Figure 1

3. Which statement is correct?

- Compound A has a DOU of 1
- Compounds A and B have DOU of 1
- Compounds A and B have DOU of 2.

*Option C is correct.
DOU of 2 can be 2 double bonds or
1 triple bond.*

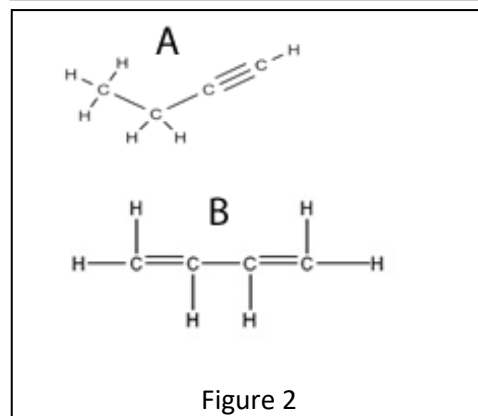


Figure 2

4. Consider a compound with the formula C_7H_7Cl . What is its DOU?

A saturated organic compound with 7 carbons should have 16 single covalent bonds with hydrogens or halogens attached. We are missing 8 hence it has 4 DOU.

Include Cl as X = 1:

$$DOU = (2 \times 7 + 2 - 7 - 1) / 2 = (14 + 2 - 8) / 2 = 8 / 2 = 4$$

4 DOU is likely an aromatic ring (benzene = 4 DOU) or a compound with 1 triple (C-C) and 2 double (C=C) bonds.

Figure 3 shows some possible combinations structural isomers

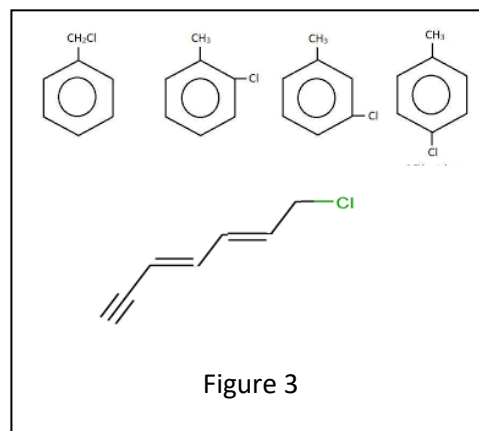


Figure 3

5. A molecule with a 5-carbon straight chain and a benzene ring on C-3 with the formula $C_{11}H_{16}$

a) Determine the degree of unsaturation of this compound.

Draw the structure as per fig. 4

Benzene ring = 4 DOU; Straight-chain adds no unsaturation.

Total = 4 DOU

Assume formula: $C_{11}H_{16}$ (the structure of this compound is shown in fig 4.)

$$DOU = (2 \times 11 + 2 - 16) / 2 = (24 - 16) / 2 = 8 / 2 = 4$$

or three for each C=C bond and one for the ring structure, total of 4 DOU.

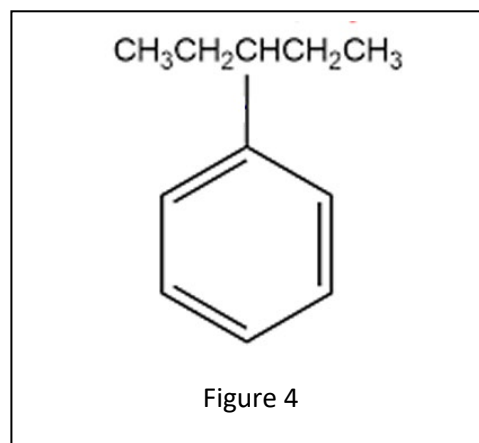


Figure 4

b) If 14.8 grams of this compound (148g/mol) is reacted with iodine (I_2 , 254 g/mol) in the presence of a catalyst what mass of iodine would react with this compound in an addition reaction?

Step 1 find the mol of compound => $14.8/148 = 0.100$ mol

Step 2 find the mol of iodine molecule that will react with 0.100 mol of compound

=> $3 \times 0.100 = 0.300$ mol of iodine

Step 3 find the mass of iodine

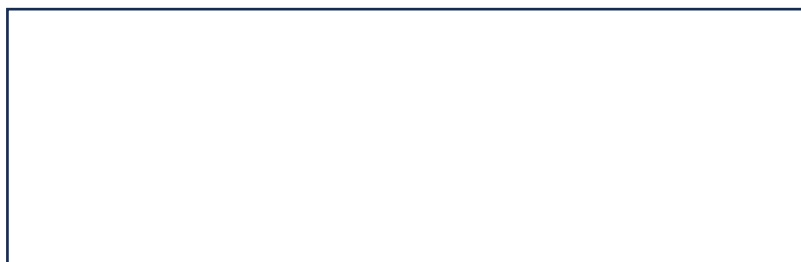
=> $0.300 \times 254 = 75.0$ grams.

Over the page are several exercises for you to attempt. Solutions are articulated in the accompanying video.

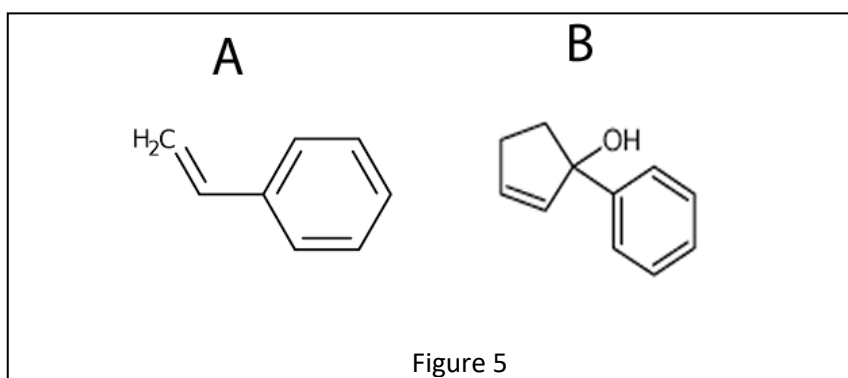
1. 1. Which of the following molecules has a degree of unsaturation (DOU) of 2?

A. C_4H_8
B. C_5H_{10}
C. C_6H_{12}
D. C_4H_6
E. C_3H_8

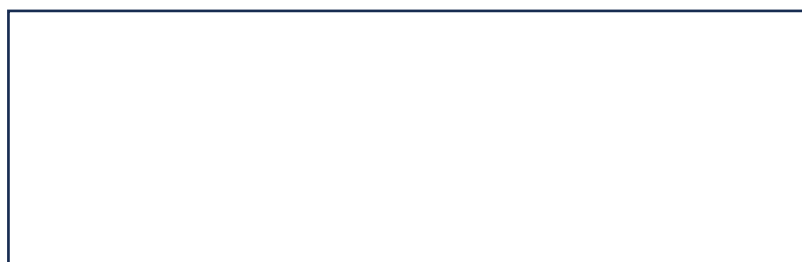
2. Given the formula C_6H_{10} , draw one possible non-straight carbon chain structure of a molecule with a DOU of 2, in the box below.



3. Examine the structures below in figure 5. What is the degree of unsaturation of each compound?



4. A compound has the formula C_5H_8 has a DOU = 2 and contains no double bonds or ring structure. Draw its structure in the box below and name the molecule.



5. A compound has the formula C_5H_{10} , a degree of unsaturation (DOU) = 1,. It includes a methyl substituent group. Draw its structure .

