Wurtz Reaction Chemistry Questions with Solutions

Q1: Write the product of the reaction:

$CH_3Br + CH_3CH_2Br + 2Na \xrightarrow[Ether]{Dry}$

Answer: This is a Wurtz reaction and a mixture of 3 alkanes is obtained namely ethane, propane and butane. This is because the two different alkyl halides not only react with each other but also react among themselves.

$CH_3Br + CH_3CH_2Br + 2Na \xrightarrow[Ether]{Dry} CH_3CH_3 + CH_3CH_2CH_3 + CH_3CH_2CH_2CH_3$

Q2. Why only alkyl bromide and alkyl iodide are used in the Wurtz Reaction?

Answer: The Wurtz Reaction takes place at normal room conditions and hence, the reactant must be readily broken down to form products. Only the iodide and bromide groups are easily separable from RX. Hence, only RI and RBr are used in this reaction.

Q3. What is the difference between Wurtz Reaction and Wurtz Fittig Reaction?

Answer: In Wurtz Reaction, two alkyl halides (preferably the same) react with the Na metal in the presence of dry ether to form a symmetrical alkane having even number of C-atoms. While Wurtz Fittig reactions involve an alkyl halide and an aryl halide that react with the Na-metal in the presence of dry ether to form substituted aromatic compounds.

Q4. Which mechanism takes place in the Wurtz reaction?

a. Ion-exchange mechanism
b. Free Radical
c. Addition-elimination
d. Concerted

Answer: (b.)

Explanation: Wurtz reaction proceeds via free-radical mechanism.

Q5. Why Wurtz Reaction only forms alkanes with even number of carbons

Answer: The alkane formed in the Wurtz reaction has double the number of C-atoms that are present in the alkyl halide. Even if the two alkyl halides containing the odd number of C-atoms are taken, a

mixture of products of alkanes is obtained. And hence, this reaction is only useful to form alkanes with even numbers of C-atoms.

Q6. Which of the following solutions will decolourize the cold alkaline $KMnO_4$ solution?

a. CH_3CH_3
b. CH_3Cl
c. $(CH_3)_4C$
d. $CH_2=CHCH_3$

Answer: (d.)

Explanation: The $KMnO_4$ solution gives the test for unsaturation of organic compounds. This test is also called Baeyer's test. In this test, the deep violet coloured solution of $KMnO_4$ turns colourless.

Q7. The Wurtz reaction results in the formation of an even number of C-atoms containing alkanes. Which other reaction also gives the alkanes with an even number of carbons?

Answer: Kolbe's reaction also results in the formation of alkanes with even no. of carbons. Kolbe's reaction involves the electrolysis of the Na- or K-salts of carboxylic acids which result in the formation of symmetric even numbered carbon alkanes.

Q8. The melting points of some alkanes is shown hereunder.

Alkane	Melting point (K)
C_3H_8	85.9
C_4H_{10}	138
C_5H_{12}	143.3
C_6H_{14}	178.5
C_7H_{16}	182.5

Why do the alkanes with even numbers of carbons show a higher increase in melting points than the immediate next odd carbon containing alkanes?

Answer: The even numbered carbon alkanes show higher increase in the melting points than the odd numbered carbon alkanes. This is because the even numbered carbon alkanes have symmetrical structure which result in the close-packing in the crystal structure. Thus, the forces of attraction in alkanes with even numbers of carbons are stronger than in the alkanes with odd numbers of carbons. And hence, the melting point varies accordingly.

Q9. Hybridization in C_3H_4 (allene) molecule is

a. 2 sp^2 and 1 sp hybrid carbon
b. 1 sp^2 and 2 sp hybrid carbon
c. 2 sp^2 and 1 sp^3 hybrid carbon
d. None of the above

Answer: The structure of C_3H_4 (allene) molecule is $CH_2=C=CH_2$. The central carbon is bonded to two other carbon atoms by two double bonds. Hence, it has two pi and two sigma bonds. The pi-bonds are not involved in the hybridization. Thus, the hybridization of the central carbon is sp.
Both the terminal carbons are attached to two hydrogen atoms and 1 C each by 3 sigma and 1 pi bond. Thus, the hybridization of terminal carbons is sp^2.

Q10. Write the order of halogenation of alkanes in the presence of heat or UV light..

Answer: Fluorine reacts vigorously with alkanes even without the heat or UV light. Chlorine and Bromine readily react with alkanes in UV light. Iodine reacts with alkanes upon heating. Thus the order of halogenation of alkanes is $F_2 > Cl_2 > Br_2 > I_2$.

Q11. Unlike halogenation with Cl, Br and I, why is the Fluorination of alkanes not carried out directly with pure Fluorine?

Answer: Fluorination of alkanes with pure Fluorine is a highly vigorous reaction. This reaction often involves the cleavage of C-C bonds and hence results in a number of products. Due to this reason, pure F_2 is not reacted with alkanes. Instead, Fluorine diluted with an inert gas like nitrogen or inorganic fluoride such as AsF_3 are used.

Q12. In which conformation does the ethane exist at absolute zero temperature?

Answer: Ethane exists in staggered conformation at absolute zero temperature.

Q13. Write the reagents used for the isomerization of alkanes.

Answer: N-alkanes upon reaction with $AlCl_3$ (anhyd.) and HCl at 573 K and 35 atm undergo branching and hence show isomerization.

Q14. Can Br_2-water test be used for differentiating between the ethene and ethyne solutions?

Answer: The Bromine water is a reddish orange coloured liquid. It turns colourless upon reaction with unsaturated organic compounds. This is because the Br_2 forms a bond at the place of unsaturation of carbon. Hence, Br_2 cannot differentiate between ethene and ethyne.

$CH_2=CH_2 + Br_2/H_2O$ (orange) → CH_2BrCH_2Br (colourless)
$C_2H_2 + Br_2/H_2O$ (orange) → $CHBr_2CHBr_2$ (colourless)

Q15. Can pure staggered ethane and pure eclipsed ethane be separated at room temperature?

Answer: The only energy difference between the staggered and eclipsed forms of ethane is 12.55 kJ/mol. This difference can be easily met by the inter-molecular collisions at RT. Hence, pure staggered and eclipsed ethane cannot be isolated at RT.

Practise Questions on Wurtz Reaction

Q1. What is the alternation effect?

Answer: The melting points of even number of C containing alkanes are higher than the odd number of C containing alkanes. This is known as the alternation effect.

Q2. Arrange the following in increasing order of boiling point.

a. 2-methylpentane
b. 2,3-dimethylbutane
c. 2,2-dimethylbutane

Answer: The Boiling point depends upon the intermolecular forces of attraction i.e. the van der waals forces. The van der waals forces depend on the surface area of the compound.
Hence, (a.) has the highest b.pt.. Due to branching on the same carbon, (c.) has smaller surface area than (b.). Hence the increasing order of boiling points is:

d. 2,2-dimethylbutane < 2,3-dimethylbutane < 2-methylpentane

Q3. During the cracking of alkanes, why do the C-C bonds break instead of the C-H bonds?

Answer: The energy required for breaking the C-C bond, the bond dissociation energy for C-C bond is 348 kJ/mol; while that of C-H bond is 414 kJ/mol. Hence, C-C bonds break rather than the C-H bonds during the cracking of alkanes.

Q4. Compare the melting points of n-pentane, isopentane and neopentane.

Answer: In general, branching reduces the m.pt.. This is because the branching tends to reduce the close-packing of the molecules in the crystal structure. However, if branching leads to symmetry in the molecule, the packaging of the molecules in the crystal structure becomes closer.

In this regard, isopentane is less symmetric than n-pentane. Neopentane has even more symmetrical structure than n-pentane. Hence, neopentane has the highest m.pt. i.e. 256 K. n-pentane has an intermediate m.pt. I.e. 143 K; while isopentane has the lowest m.pt. i.e. 113 K.

Q5. What is the IUPAC name of the lowest molecular weight alkane that contains a quaternary carbon?

Answer: 2,2-dimethylpropane