Tutorial Letter 201/2/2017

General Chemistry 1B

CHE1502

Semester 2

Department of Chemistry

This tutorial letter contains important information about your module.

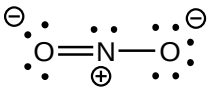
BARCODE

ONLY FOR SEMESTER 2 STUDENTS
ANSWERS TO ASSIGNMENT 1 QUESTIONS

1. Correct Answer: (2) Covalent bonds can only be polar.

The above statement is incorrect. The corrected statement is: Covalent bonds can be polar or non-polar

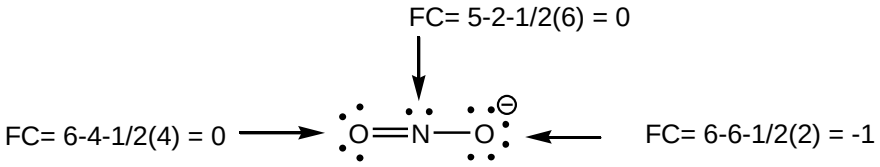
2. Correct Answer: (1)



The above is NOT a valid Lewis structure of NO_2^-. The formal charges are incorrect.

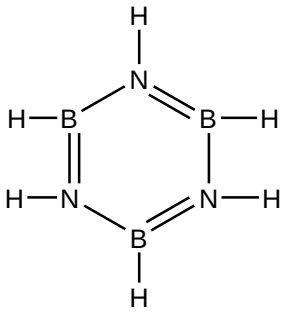
The total electrons available for bonding is: 5 ē (of N) + 2 [6 ē (of O)] + 1 ē (from -1 charge) = 18.

The correct structure and formal charges are shown below:



3. Correct Answer: (3) +1 on each N and -1 on each B

The above are the formal charges in the structure below:



Formal Charge, FC = Group number of the atom - no of lone pair electrons – ½[no of bonding electrons]

The bonding in the molecule is the same for all the N atoms, FC = 5 -0 -1/2 [8] = 5-4=1; FC (N) = +1.

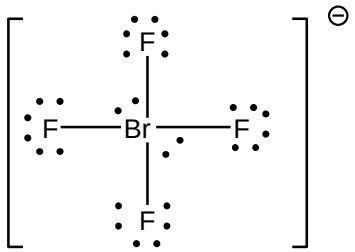
All the B atoms in the molecule has the same type of bonds, FC = 3 -0 -1/2 [8] = 3-4=-1; FC (B) = -1.

4. Correct Answer: (4) two

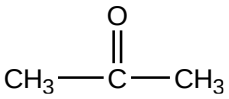
From the Lewis structure of BrF_4^- two lone pairs of electrons are in the valence shell of the central atom. The number of electrons available for bonding in BrF_4^- is:

No of valence ē of Br + 4 (no of valence ē of F) + 1 ē (for charge of-1) = 7 + 4(7) +1 = 36 electrons

The Lewis structure of BrF_4^- is:

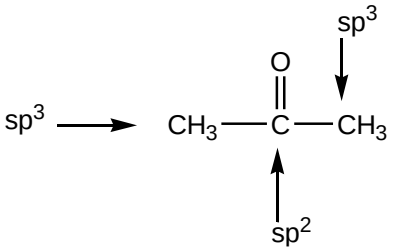


5. Correct Answer: (1)

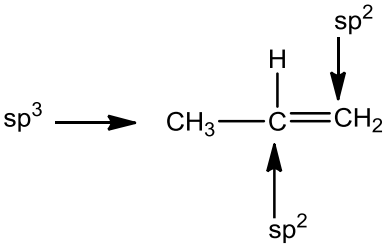


The structure shown above contains two sp^3 and one sp^2 hybridized carbon atoms.

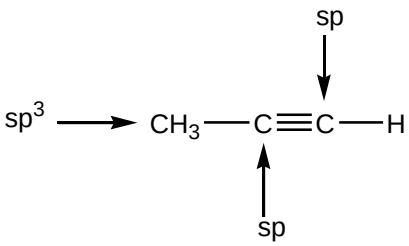
(1)



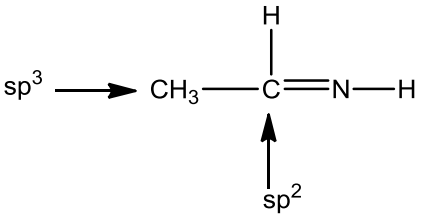
(2)



(3)



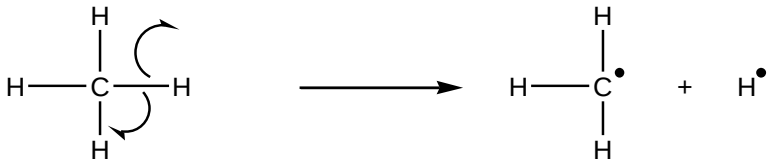
(4)



6. Correct Answer: (**2**) **This is an example of a substitution reaction**

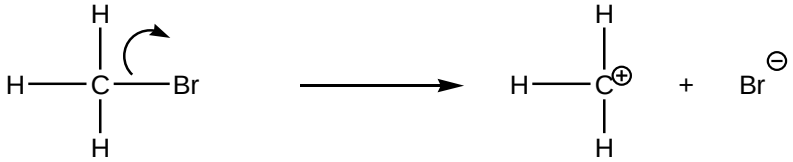
Concerning the given reaction, the above statement is incorrect. In a substitution reaction, a group or atom is replaced by another atom or group. This is an acid-base reaction.

7. Correct Answer: (3)



The above is an example of homolysis – the bond breaks in such a way that each species depart with one bonding electron. The correct bond-breaking processes for the other options:

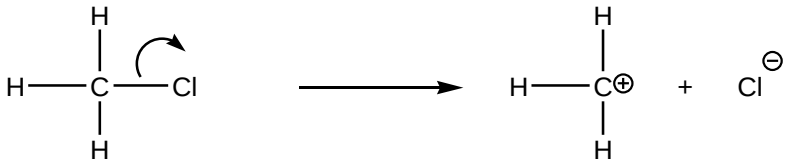
(1)



The reaction in (1) is a bond breaking process. Since Br is more electronegative than C, the polar C-Br bond breaks in such a manner that Br departs with the 2 bonding electrons. This mode of bond breaking is called heterolysis or heterolytic cleavage, shown above.

(2) The electronegativity of Br is much greater than the electronegativity of C – so the bond breaks as shown in (1)

(4) The reaction is a bond breaking process. Since Cl is more electronegative than C, the polar C-Cl bond breaks in such a manner that Cl departs with the 2 bonding electrons. This mode of bond breaking is called heterolysis or heterolytic cleavage, shown below:



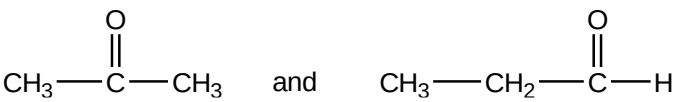
8. Correct Answer: (2) Carbocations are strongly basic

The above statement is incorrect. A base donates a pair of electrons and since carbocations are electron-deficient, they cannot be basic. The other options:

(1) Carbanions are nucleophilic because they have excess electrons (negative charge) which can be donated to an electrophile.

(4) Carbocations are electron deficient and is therefore electrophilic.

9. Correct Answer: (2)



The above pair of compounds are constitutional isomers.

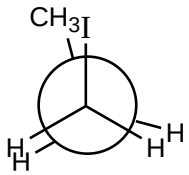
The two compounds above are constitutional isomers because they have the SAME MOLECULAR FORMULA but some of the hydrogen atoms are connected at different positions.

(1) The two structures are the same.

(3) The two compounds have the same molecular formulas. The two compounds have the same molecular formulas. The C-2 and C-3 atoms of each ring contain Cl and H atoms. The difference between the two compounds is in the orientation of the groups relative to the ring. In the first structure, the Cl groups are on the same side of the ring and are called *cis* and in the second structure the Cl groups are on opposite sides of the ring and are called *trans*. The two compounds are geometric isomers because the atoms have the same bonding sequence but different arrangement of their atoms in space.

(4) These are different conformations of the same compound, butane, represented as the Newman projection formulas.

10. Correct Answer: (3)



All the structures represent different conformations of 1-iodo-propane. The above is the totally eclipsed conformation (the largest groups are eclipsed). The largest groups are the closest to one another which makes the conformation the least stable conformation with the highest energy.

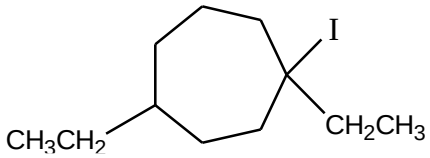
(1) Is an eclipsed conformation, which is less stable than the staggered conformations.

(2) Is a staggered conformation, called the Gauche conformation. The largest groups are closer to one another than in (4). This conformation is less stable (higher energy) than the conformation in (4) but more stable than the eclipsed conformations, i.e. (1) and (2) and thus has lower energy than (1) and (2).

(4) Is a staggered conformation with the largest groups being the furthest apart and is called the anti-conformation. The anti-conformation is the most stable conformation and therefore has the lowest energy.

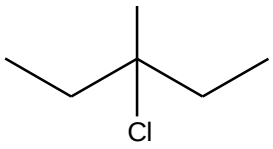
11. Correct Answer: (2) 1,4-diethyl-1-iodocycloheptane

The above is the correct IUPAC name of the molecule shown below:

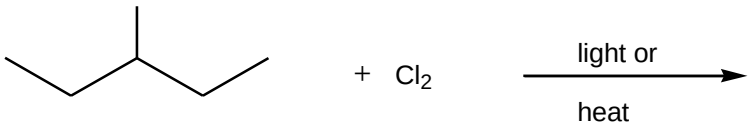


According to the IUPAC convention, the longest continuous carbon chain is a ring with 7 C's→ cycloheptane. This is an alkyl halide - begin numbering at a position on the ring to give the halogen substituent the lowest possible number; on C-1 there is a iodine atom → 1-iodo; on C-1 and C-4 there are CH_2CH_3 substituent → 1,4-ethyl; name substituents in alphabetical order.

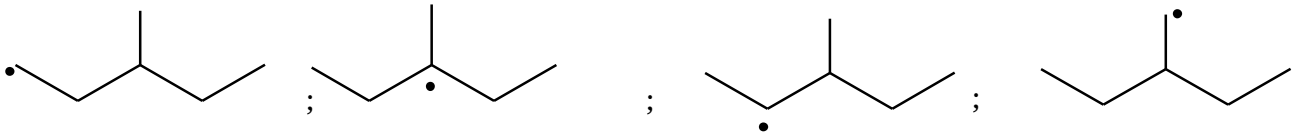
12. Correct Answer: (4)



The above structure is the MAJOR mono-chlorinated product formed in the following reaction:



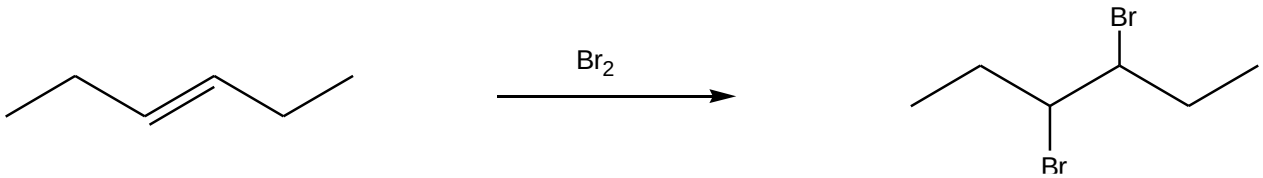
The halogenation reaction of alkanes proceeds via a radical intermediate. Possible radicals that can form in the reaction are:



1^o C radical 3^o C radical 2^o C radical 1^o C radical

The tertiary (3^o) carbon radical is the most stable radical and produces the major product.

13. Correct Answer: (4)



The above reaction is an example of an addition reaction. The other options:

(1) Is a substitution reaction

(2) Is an elimination reaction

(3) Is a substitution reaction

14. Correct Answer: (1) PhS^-

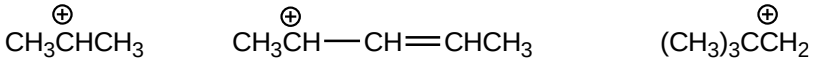
The above compound is MOST likely to react as a nucleophile in an S_N2-type reaction.

Strong nucleophiles favour the S_N2 reaction and PhS^- is a strong nucleophile.

(2) is a weak nucleophile - S_N1 reaction
(3) it reacts as an electrophile
(4) it is not nucleophilic –is a carboxylic acid which can donate protons.

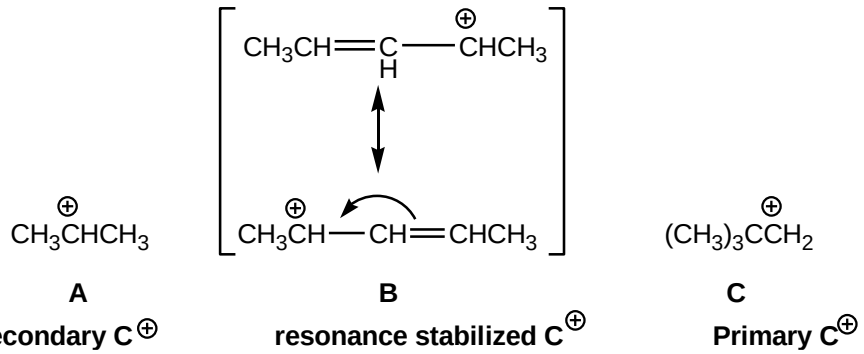
15. Correct Answer: (4) the carbocation, **B**, is stabilized by resonance delocalization which is absent in the other carbocations.

Consider the carbocations shown below.



A **B** **C**

The MOST stable carbocation is **B** because the carbocation, **B**, is stabilized by resonance delocalization, which is absent in the other carbocations.



A **B** **C**

Secondary C⊕ **resonance stabilized C⊕** **Primary C⊕**

16. Correct Answer: (1) $(CH_3)_3C$-I

The above species will react the FASTEST in a nucleophilic substitution reaction with H_2O.

In a nucleophilic substitution reaction the nucleophile, water, is a weak nucleophile, and it will react via a S_N1 reaction mechanism. The tertiary alkyl halide will produce a stable tertiary carbocation.

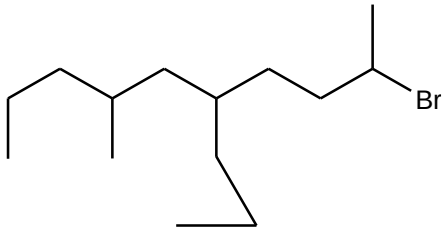
(2)The secondary alkyl halide will produce a secondary carbocation that is less stable than the tertiary carbocation and therefore the reaction proceeds slower than the reaction with (4)

(3) This is a methyl halide which produces an unstable methyl carbocation and the S_N1 reaction will not take place.

(4) This is a primary alkyl halide which produces an unstable primary carbocation and the S_N1 reaction will not take place;

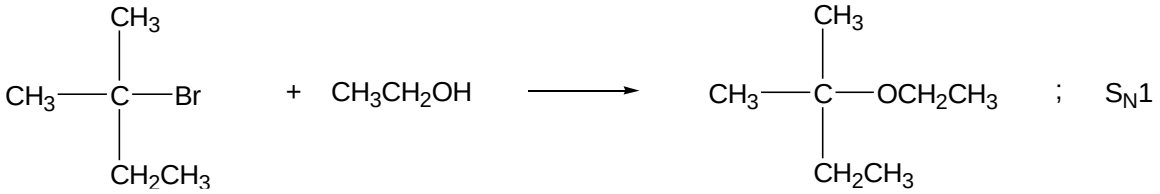
17. Correct Answer: (2) 2-bromo-7-methyl -5-propyldecane

The above is the IUPAC name of the molecule shown below:



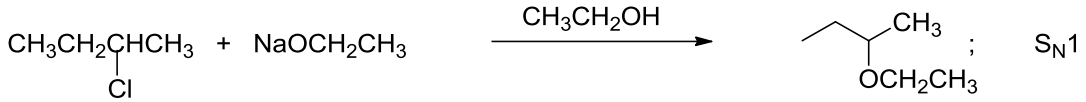
According to the IUPAC convention, the longest continuous carbon chain contains 10 C's → decane. Numbering at the end of the carbon chain to give the substituent(s) the lowest possible number i.e. from the side closest to the Br group. On C-2 there is a bromine atom → 2-bromo; on C-2, on C- 5 there is a $CH_2CH_2CH_3$ group → 5-propyl and C-7 there is a CH_3 substituent → 7-methyl; name substituents in alphabetical order.

18. Correct Answer: (2)

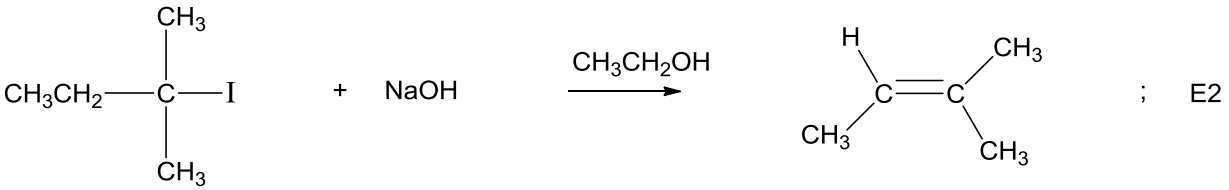


The above reaction is CORRECT as indicated by the major products formed and the mechanism for the reaction. The other options are corrected as follows:

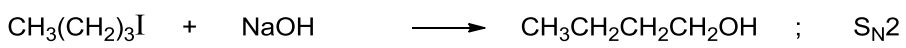
(1)



(3)



(4)



19. Correct Answer: (4) The second order nucleophilic substitution reactions involve inversion of configuration.

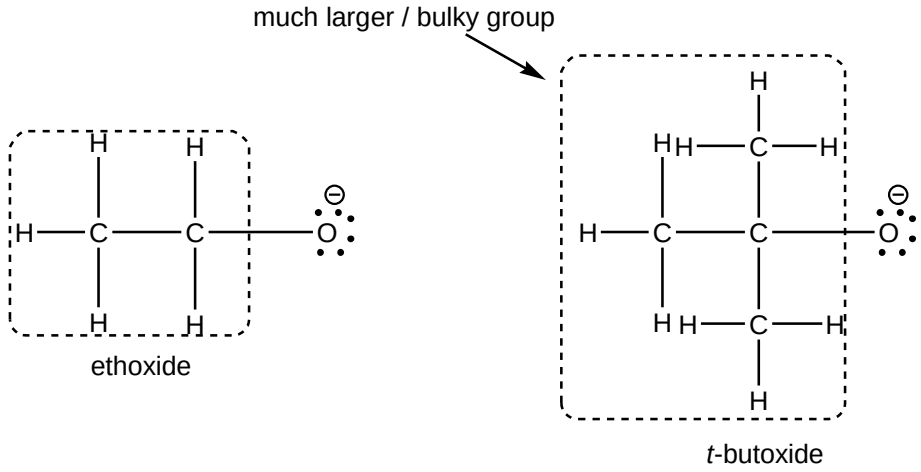
The above statement is CORRECT with reference to the nucleophilic substitution reactions of alkyl halides. All the other options are incorrect.

20. Correct Answer: (1) There is no intermediate in this reaction

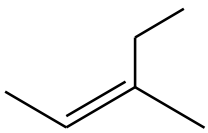
The reaction of cyanide ion with bromoethane proceeds via the S_N2 reaction with no intermediate formed in the reaction. The reaction proceeds via a transition state.

21. Correct Answer: (3) The bulkiness of *t*-butoxide causes steric hindrance when approaching the electrophilic reaction site.

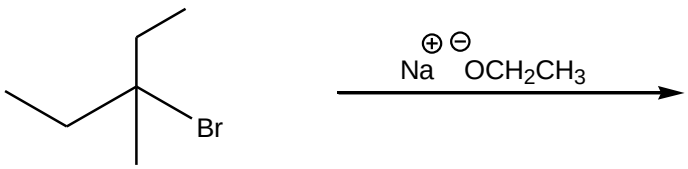
The above statement best explain why ethoxide, $CH_3CH_2O^-$, is a better nucleophile than *t*-butoxide, $(CH_3)_3CO^-$.



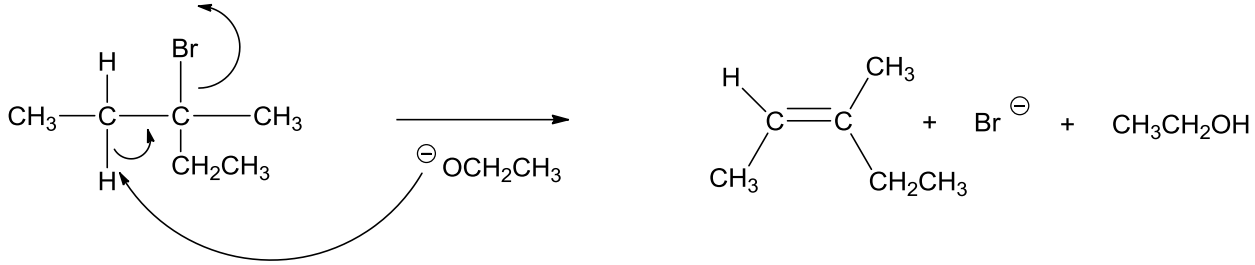
22. Correct Answer: (3)



The above if the structure of the major product formed in the following reaction:

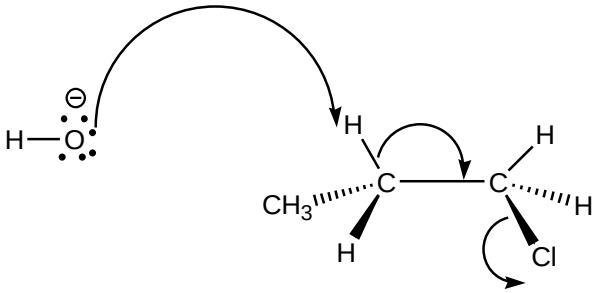


The ethoxide ion is a strong base and it therefore predominantly participates in an E2 elimination reaction with the alkyl halide. The mechanism for the E2 elimination reaction is:



According to Zaitsev's rule, the product with the most substituted double bond will predominate. Therefore, the product formed above is the major product. The product formed (1) is a minor elimination product. The products shown in (2) and (4) will not form in this reaction.

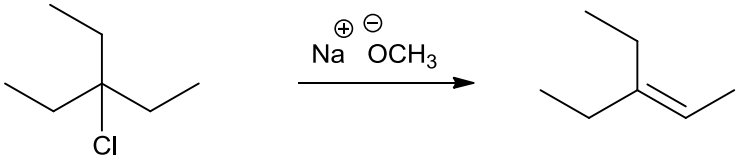
23. Correct Answer: (4)



The above process is the mechanism for the E2 reaction of 1-chloropropane with hydroxide anion in the presence of heat.

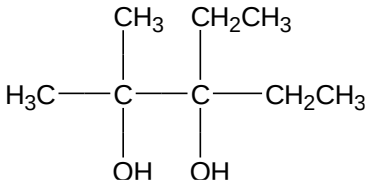
24. Correct Answer: (2) 3-chloro-3-ethylpentane

When the alkyl halide is subjected to a reaction with sodium methoxide, it produces only ONE alkene product as shown below. All the other options produce more than one product.



25. Correct Answer: (4) 3-ethyl-2-methylpentane-2,3-diol

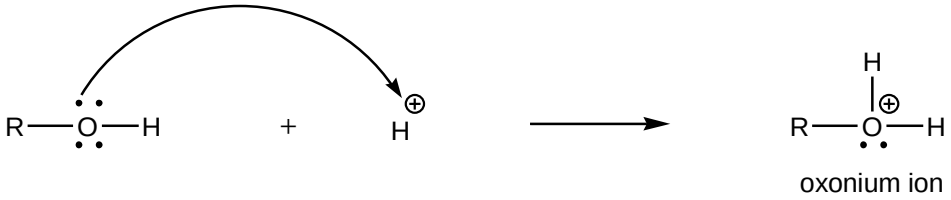
The above is the IUPAC name of the following compound:



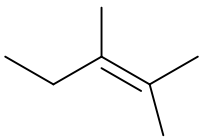
This compound has two OH groups – this is a diol. According to the IUPAC convention, the longest continuous carbon chain that contains the OH groups has 5 C's→ pentane. Begin numbering at the end that will give the OH substituents the lowest possible numbers; the OH's are on C-2 and C-3, add 2,3-diol after the ending -*e*. On C-2 there is a CH_3 group → 2–methyl and on C-3 there is a CH_2CH_3 group → 3– ethyl. Write the name in alphabetical order.

26. Correct Answer: (1) an oxonium ion

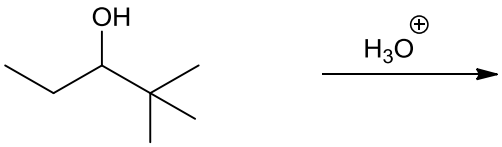
When alcohols are protonated, the conjugate acid formed is called an oxonium ion.



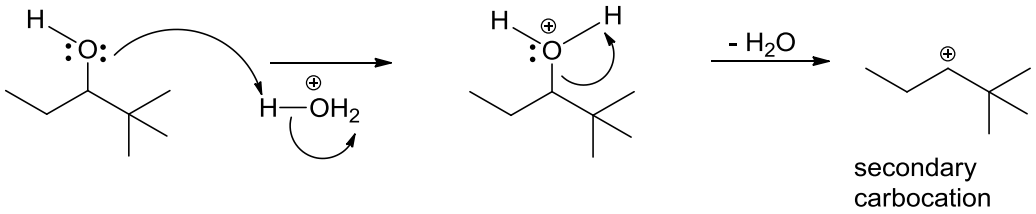
27. Correct Answer: (3)



The above is the structure of the MAJOR product formed in the following reaction:

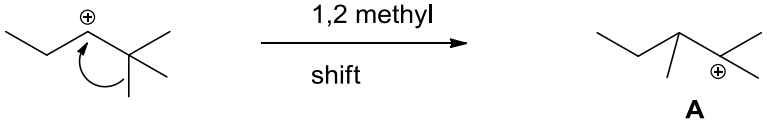


In the reaction, protonation of the OH group gives in an oxonium ion. The loss of water results in a carbocation, the process is shown below:



In the carbocation intermediate shown above, one of the carbon atoms that is adjacent to the C^+ has an H that can be abstracted to form an alkene, shown in option (1).

The carbocation shown above is a secondary carbocation and it can undergo rearrangement (1,2 methyl shift i.e. a CH_3 with the bonding electron pair migrates to an adjacent carbon atom) to form carbocation, **A**, (process shown below).

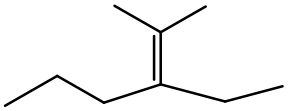


A

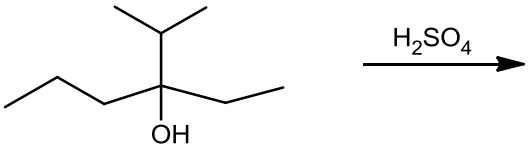
Carbocation **A**, is a tertiary carbocation which is more stable than a secondary carbocation. Abstraction of the H on the newly formed tertiary carbon in **A** produces the product shown in (3).

According to Zaitsev's rule, the product with the most substituted double bond will predominate.

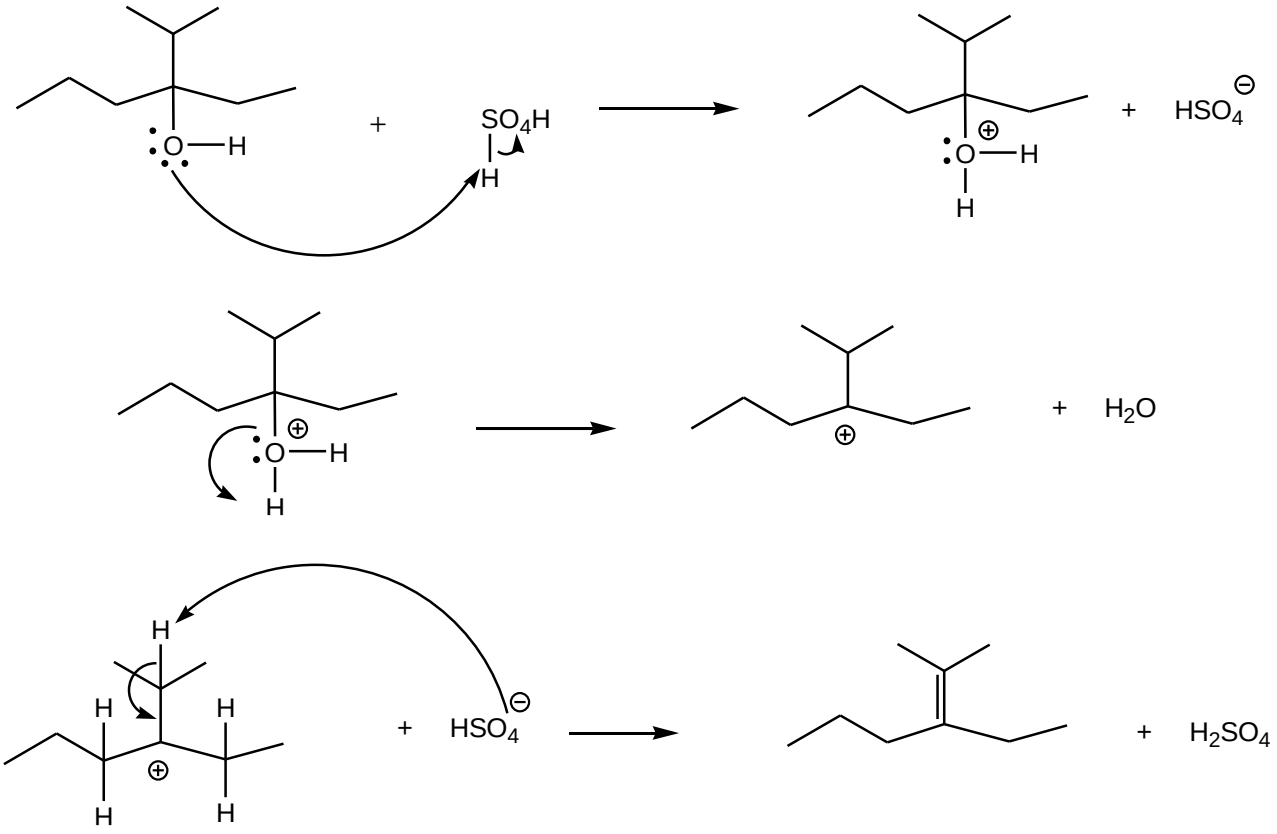
28. Correct Answer: (2)



The above is the structure of the major organic product formed in the following reaction:



The reaction proceeds as follows:



The other H's on the carbons adjacent to the carbocation can also be lost but the products formed will be the minor products.
According to Zaitsev's rule, the product with the most substituted double bond will predominate.

Evaluation of the individual products:

(1) The product has 3 alkyl groups attached to the C=C and is therefore a minor product.

(2) The product has 4 alkyl groups attached to the C=C and is therefore the major product.

(3) The product has 3 alkyl groups attached to the C=C and is therefore a minor product.

(4) The product will not form at all.

29. Correct Answer: (1) CH_3-CH_2-OH

The above compound is the most soluble in water.

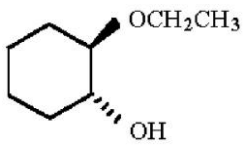
Alcohol molecules that are soluble in water form hydrogen bonds and exhibit dipole-dipole interactions with H_2O. The alkyl portion of the alcohol is a hydrophobic region that can disrupt the hydrogen bonds and dipole-dipole interactions with water. The solubility in water decreases as the alkyl groups become larger.

30. Correct Answer: (4) Molecules of diethyl ether can undergo hydrogen bonding with each other.

The above statement is INCORRECT because ethers do not have O-H groups and therefore cannot take part in hydrogen bonding. The corrected statement is: Molecules of diethyl ether cannot undergo hydrogen bonding with each other. All the other options are correct.

31. Correct Answer: (2) *trans*-2-ethoxycyclohexan-1-ol

The above is the IUPAC name of the following compound:

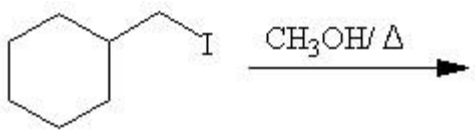


According to the IUPAC convention, the longest continuous carbon chain is a ring with 6 C's→

parent name is cyclohexane. The numbering must begin at a position on the ring to give most

of the substituents the lowest possible number there is however an OH group and an OCH_2CH_3 on the ring. The OH group gets priority in the numbering i.e. on C-1 is the OH group and since this is an alcohol then ending changes from 'e' to 'ol' → 1-ol (the 1-ol may also be written as –ol in a cyclic structure); there is an OCH_2CH_3 group on C-2 → 2-ethoxy. Since the OH group and the OCH_2CH_3 group are on opposite sides of the ring, the *trans* geometry with respect to each other must be shown in the name.

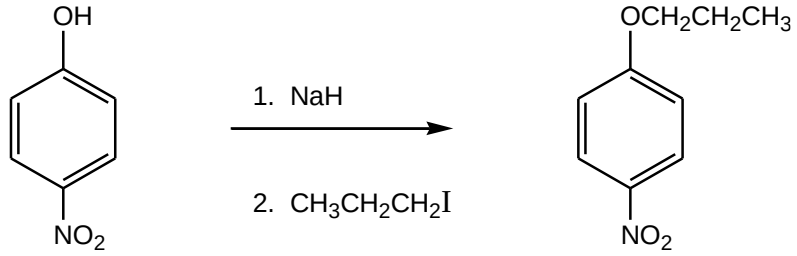
32. Correct Answer: (2)



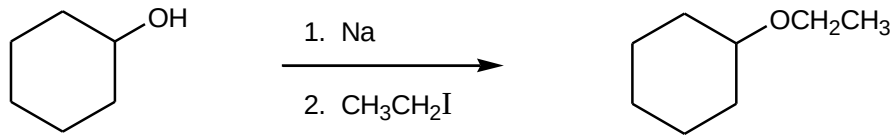
The above reaction will NOT give an ether as final product. The CH_3OH is a weak nucleophile and the substitution reaction will go via a S_N1 reaction mechanism. However, in this mechanism the C-I bond has to break to form a primary carbocation which is unstable and is unlikely to form – i.e. the S_N1 reaction will not take place.

The products formed in the other options are:

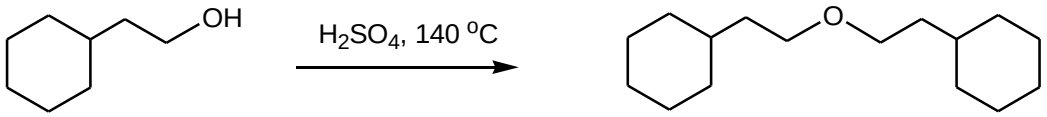
(1)



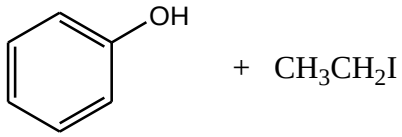
(3)



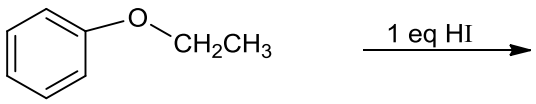
(4)



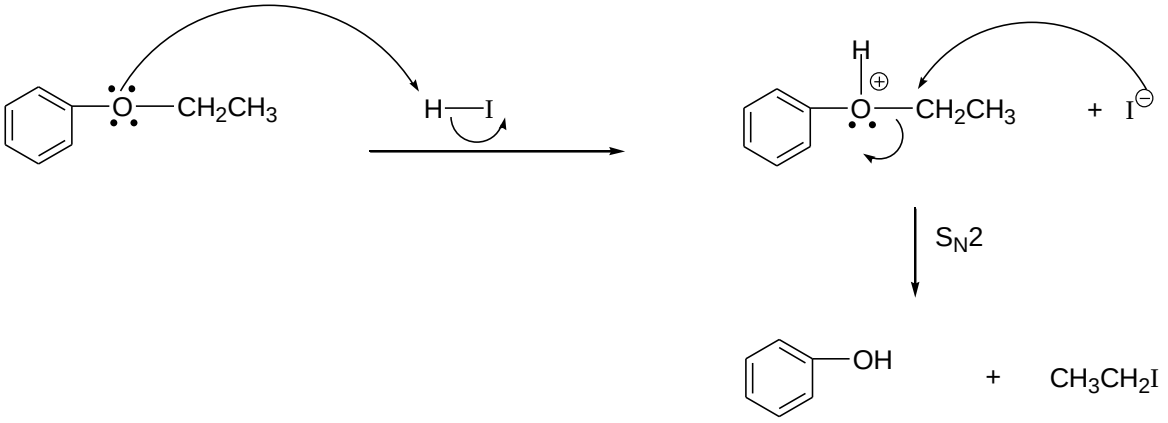
33. Correct Answer: (3)



The above structures are the major products formed in the following reaction:



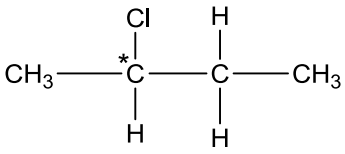
The reaction proceeds as follows:



34. Correct Answer: (2) 2-chlorobutane

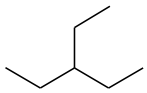
The above molecule has a chiral (asymmetric) carbon atom.

Structure of 2-chlorobutane:

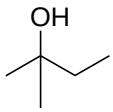


The above molecule has a chiral (asymmetric) carbon atom. It has a carbon with 4 different groups/atoms attached to it – i.e. the carbon that is marked by an * - it is attached to a CH_3, H, CH_2CH_3 and Cl groups. The other options do not have a carbon with 4 different groups / atoms attached to it as shown below:

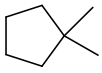
(1) 3-ethylpentane – groups the same



(3) 2-Methylbutan-2-ol - 2 groups on C-2 are the same

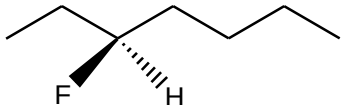


(4) 1,1-dimethylcyclopentane – on C has two CH_3 groups and the other C's each has two H's



35. Correct Answer: (1) (S)-3-fluoroheptane

The above is the correct name for the following compound according to the Cahn-Ingold-Prelog rules.



First, we should name the compound according to the IUPAC convention. The longest continuous carbon chain contains 7 C's→ heptane. There is fluorine group in the chain – begin numbering at the end of the chain to give the halogen substituent the lowest possible number; therefore, on C-3 there is an F atom → 3-fluoro; → 3-fluoroheptane.

Next, we have to designate R- or S- configuration to the compound using the Cahn-Ingold-Prelog rules. According to the Cahn-Ingold-Prelog rules, assigning priorities to the groups/atoms around the chiral center:

Group	**Priority**
F	1
$CH_2CH_2CH_2CH_3$	2
CH_2CH_3	3
H	4

We next have to determine whether the compound must be assigned (R)- or (S)- notation. We must make sure the lowest priority group points away from you in the 3-dimensional drawing, i.e. the bond must be indicated as ·····. The fourth-priority group is the lowest priority group, which in our example is H, and in the given 3-dimensional structure, the H is drawn as pointing away from the reader. Next, we draw an arrow from the first-priority group, through the second, to the third priority group. If the arrow points clockwise, the chiral carbon is called (R) and if the arrow points counterclockwise, the chiral carbon is labelled as (S).
The given compound: