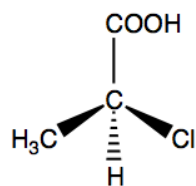
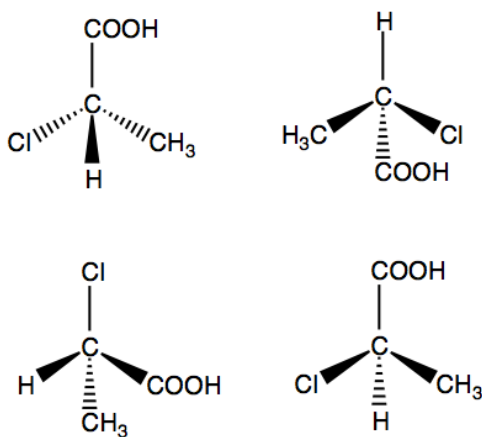


Question 1. *Chirality of $\text{CH}_3\text{CHClCOOH}$*

One chirality of $\text{CH}_3\text{CHClCOOH}$ is shown below.



Identify the image(s) below that exhibit the opposite chirality. Select all that apply.




Solution 1.

Question 2. *Constitutional Isomers of Some Molecules*

(a): Name the straight-chain alkane that is a constitutional isomer of 2,4-dimethylhexane. It is not one of the other three molecules in the image - those are for part B.

(b): Which of the following is not a constitutional isomer of nonane?



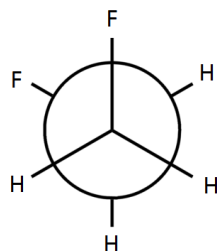
constitutional.png

Solution 2.

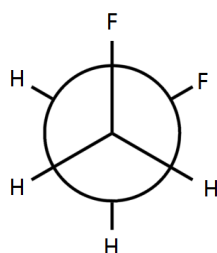
Question 3. *Conformational and Stereoisomers*

(a): Which conformational isomer of 1,2-difluoroethane does not have a dipole moment?

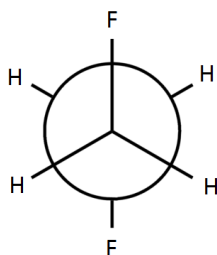
(1): Gauche+



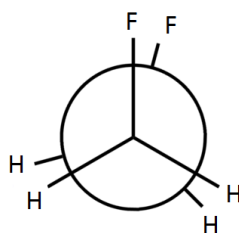
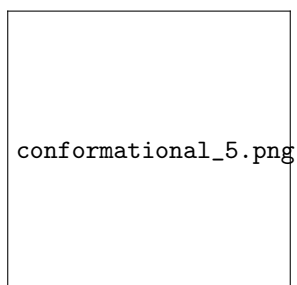
(2): Gauche-



(3): Anti



(4): Eclipsed, with the fluorines overlapping

(b): 1,2-difluoroethene $\text{HFC}=\text{CFH}$ has two stereoisomers. Which has the lower boiling point? Why?

1. cis-1,2-difluoroethene, because the Van der Waals interactions are greater

2. cis-1,2-difluoroethene, because it does not have a dipole moment
3. trans-1,2-difluoroethene, because it does not have a dipole moment
4. trans-1,2-difluoroethene, because it has a dipole moment

Solution 3.

Question 4. *Anionic Polymerization*

(a): Which of the following are requirements for anionic polymerization?

1. A double bond
2. End groups which can react by releasing a small molecule
3. A strong base to initiate the reaction
4. A strong acid to initiate the reaction
5. An electron-withdrawing group near the double bond

(b) Which of the following groups are indicative of anionic polymerization?

1. F
2. Cl
3. COOCH_3
4. H
5. CH_2CH_3

Solution 4.

Question 5. *Condensation Polymerization of Nylon*

(a): Nylon is a common polymer used in fabrics. Nylon is generally made by the spontaneous reaction of a diamine (a short carbon chain with an -NH_2 group on each end) and a dicarboxylic acid (a short carbon chain with a -COOH group on each end). What type of polymerization do you expect from these reagents?

1. Anionic polymerization
2. Addition polymerization
3. Condensation polymerization

(b): If Nylon is made by condensation polymerization, what is the byproduct?

1. Water H_2O
2. Ammonia NH_3
3. Methane CH_4
4. There is no byproduct.

(c): Does Nylon manufacturing require a chain initiator and terminator? Why?

1. Yes - all types of polymerization must be initiated by a free radical.
2. Yes - Nylon is made by anionic polymerization and requires a radical to form the anion.
3. No - the reagents react spontaneously to form long chains.

(d): Would it be better to manufacture Nylon in a humid environment or a dry environment? Why?

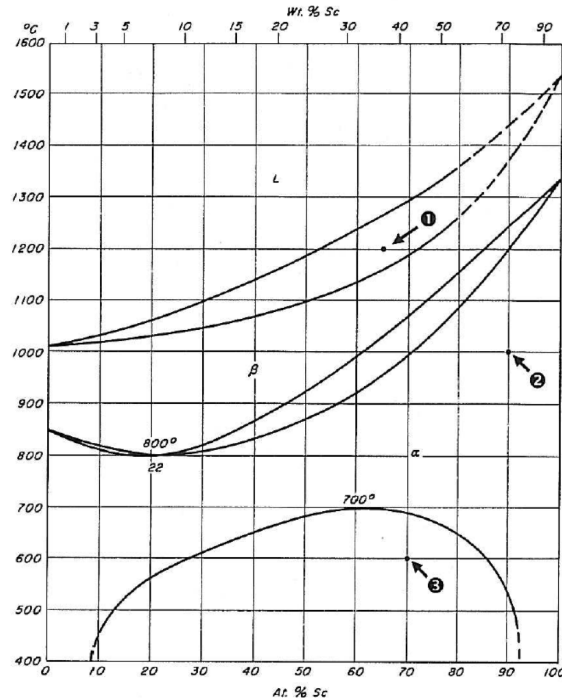
1. Humid - the condensation product is water, so if there is more water, the reaction will occur at a faster rate.
2. Dry - the condensation product is water, so if water accumulates, the chemical equilibrium will be pushed away from further polymerization.
3. Humid - anionic polymerization requires small amounts of hydroxide ions, which come from the auto-ionization of water
4. Does not matter - the condensation product is methane.
5. Does not matter - the condensation product is ammonia.

Solution 5.

Question 6. *Neodymium-scandium (Nd-Sc) Binary System*

(a): The phase diagram of the binary system, neodymium-scandium (Nd-Sc) is given below. There are two polymorphs in the solid state: α which is hexagonal close packed (HCP) and β which is body-centered cubic (BCC).

Identify all phases present at points 1, 2, and 3.



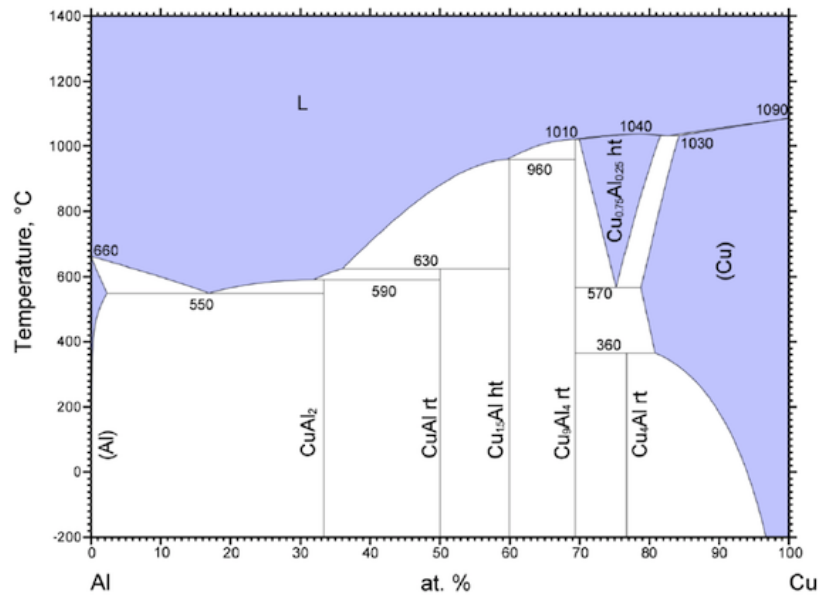
1. Liquid
2. Vapor
3. β -phase
4. Sc-rich β -phase
5. Nd-rich β -phase
6. α -phase
7. Sc-rich α -phase
8. Nd-rich α -phase

(b): Are there any examples of a three-phase equilibrium in this phase diagram?

1. Yes, there is a eutectic at 700 degrees C and 60 at. % Sc.
2. Yes, there is a eutectoid at 800 degrees C and 22 at. % Sc.
3. Yes, there is a peritectic at 800 degrees C and 22 at. % Sc.
4. No, there are no three-phase equilibrium points in this diagram.

(c): At point 3, calculate the phase fraction of the phase richest in Nd.

Solution 6.

Question 7. *Cu-Al Phase Diagram*

(a): What is the lowest temperature at which a liquid can be found in a system of any composition of Cu-Al?

(b): A common alloy composition used in airplanes is 4 at. % Cu - 96 at. % Al. For this overall system composition, identify what phases are present at 500 degrees C. Select all phases present:

1. Liquid
2. Vapor
3. Al
4. Cu
5. Cu Al 2
6. Cu Al
7. Cu 1.5 Al
8. Cu 9 Al 4
9. Cu 4 Al
10. Cu 0.25 Al 0.25

(c) What phases are present at a 50/50 mixture of Al/Cu at 660 degrees C? Select all phases present:

1. Liquid
2. Vapor
3. Al
4. Cu
5. Cu Al 2
6. Cu Al
7. Cu 1.5 Al
8. Cu 9 Al 4
9. Cu 4 Al

10. Cu 0.25 Al 0.25

Solution 7.