

## Learning Guide for Chapter 4 - Alkanes

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### I. Introduction to Alkanes

What is an alkane?

Why are we starting with them?

#### Straight-chain alkanes

Draw the line structure for the alkanes given below, and give their molecular formula.

methane

hexane

ethane

heptane

propane

octane

butane

nonane

pentane

decane

What pattern do each of the formulas follow?

Why does this pattern occur?

#### Branched alkanes

Draw all of the branched alkanes having 6 carbons. What are these compounds called?

What formula do all of these alkanes have?

We will learn how to name these compounds later in this chapter.

Cyclic alkanes

Draw the line structure for the cyclic alkanes given below, and give their molecular formula.

cyclopropane

cyclohexane

cyclobutane

cycloheptane

cyclopentane

cyclooctane

What pattern do these molecular formulas have, and why?

Draw the line structures of all of the constitutional isomers of cyclopentane.

Bicyclic alkanes

Draw an example of each of the following, and give their molecular formula.

separate

spiro

fused

bridged

What happens to the molecular formula when more than one ring is present?

### III. Physical properties, sources, and uses of alkanes

#### Physical Properties of Alkanes

What intermolecular force affects alkanes?

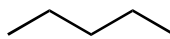
What is the surface tension like, and how would you see this?

Are alkanes soluble in water? Why or why not?

Are alkanes more or less dense than water? Why?

Match up the following alkanes with their boiling points.

-42.1°C



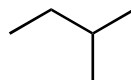
-0.5°C



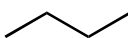
30.2°C



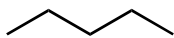
36.1°C



68.7°C



Which of the following molecules would you expect to have a higher melting point, and why?



What state of matter would you expect to find the following substances in at 25°C, 1 atm:

propane

hexane

decane

eicosane

### Sources of alkanes

What are the two principle sources of alkanes?

List some products of petroleum distillation. Which do you think is the most profitable?

What happens to the properties of the distillation products as the temperature goes up?

### Uses of alkanes

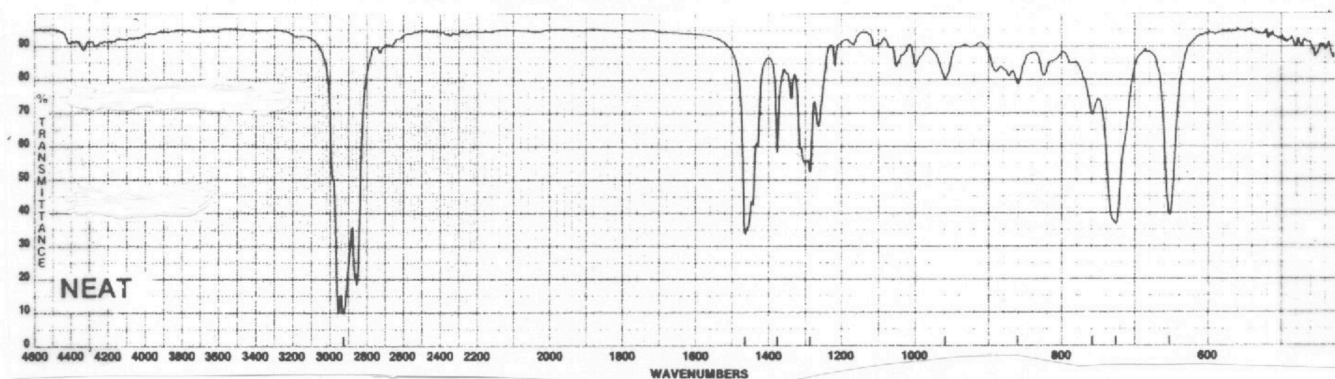
What is the most common use of alkanes?

What is the problem with this?

What else can alkanes be used for?

### IR Spectroscopy

What bands do alkanes have?



Why is it especially useful to remember these frequencies?

How can you tell alkanes apart from other functional groups?

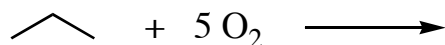
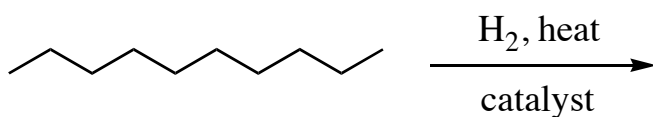
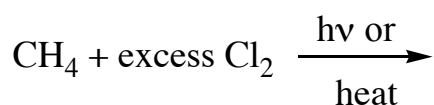
### III. Reactions of Alkanes

How reactive are alkanes?

What are the three most common reactions of alkanes?

Why aren't these reactions used in the laboratory?

Complete the following reactions and give what type they are:



When can halogenation be useful?

Why is hydrocracking useful?

Why is combustion useful?

Why is it hazardous?

What can happen when combustion takes place without enough heat or oxygen?

## IV. Nomenclature of Alkanes, Cycloalkanes, and Bicyclic Alkanes

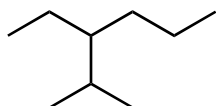
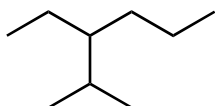
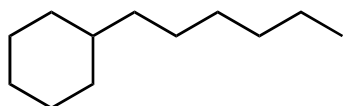
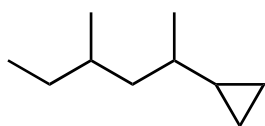
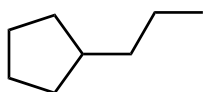
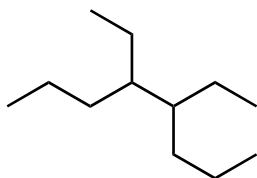
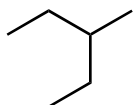
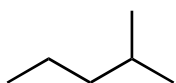
Who created the current rules for naming organic compounds?

What is the purpose behind these rules?

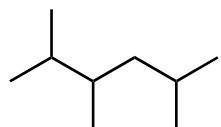
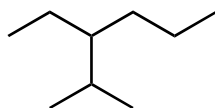
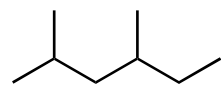
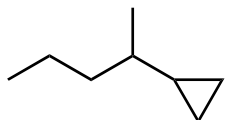
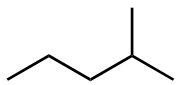
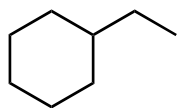
1)

2)

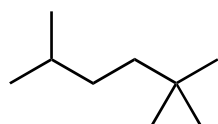
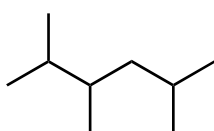
Step 1: Finding the principle chain (or ring).



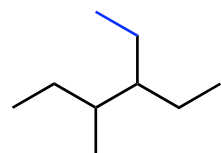
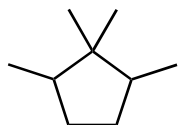
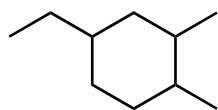
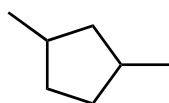
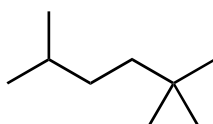
Step 2: Number the principle chain (or ring).



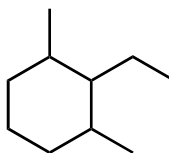
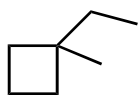
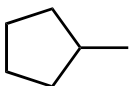
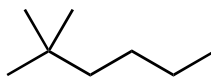
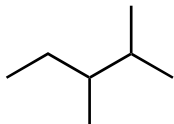
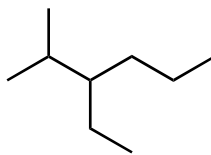
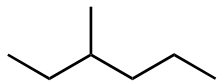
or



or



Step 3: Name and order the substituents, add them to the root name.



Names of the alkyl substituents:



methyl



cyclopropyl



ethyl



cyclobutyl



propyl

etc

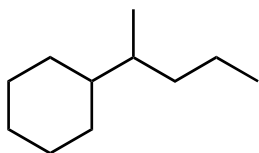
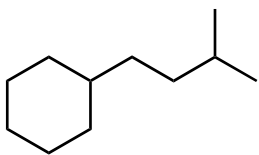
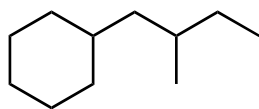


butyl

etc

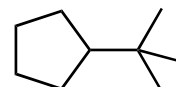
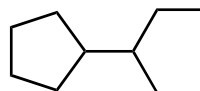
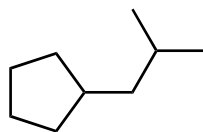
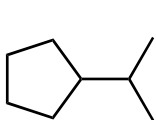


What if the substituents are branched?

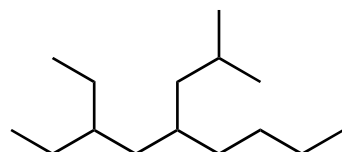
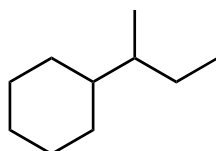
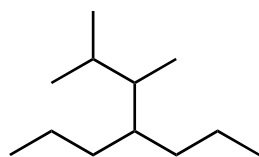


Will you ever have an "ane" inside the name of a compound?

Common names for branched substituents:



Name the following compounds.



## IV. Conformations of Straight and Branched Alkanes

When we imagine an organic molecule, say methanol, we picture the atoms as holding still. Give some examples of why this isn't accurate.

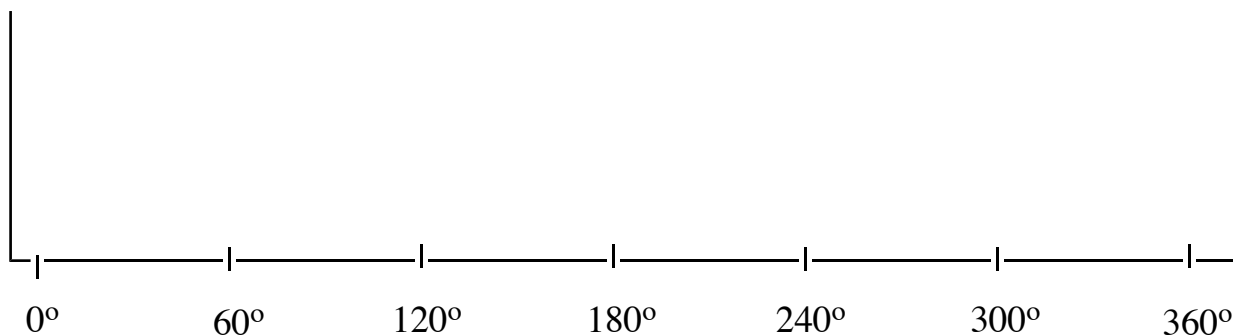
As a molecule rotates around a single bond, what are the different positions called?

### Ethane

Make a model of ethane. Turn it so that you are looking down the C-C bond. Then draw a Newmann projection, and label one of the dihedral angles.

Now turn the top atom so that the H's in front fall in between the H's in back. Label the two conformations. Which is higher in energy? Why?

Plot the energy of the molecule as it rotates all the way around:

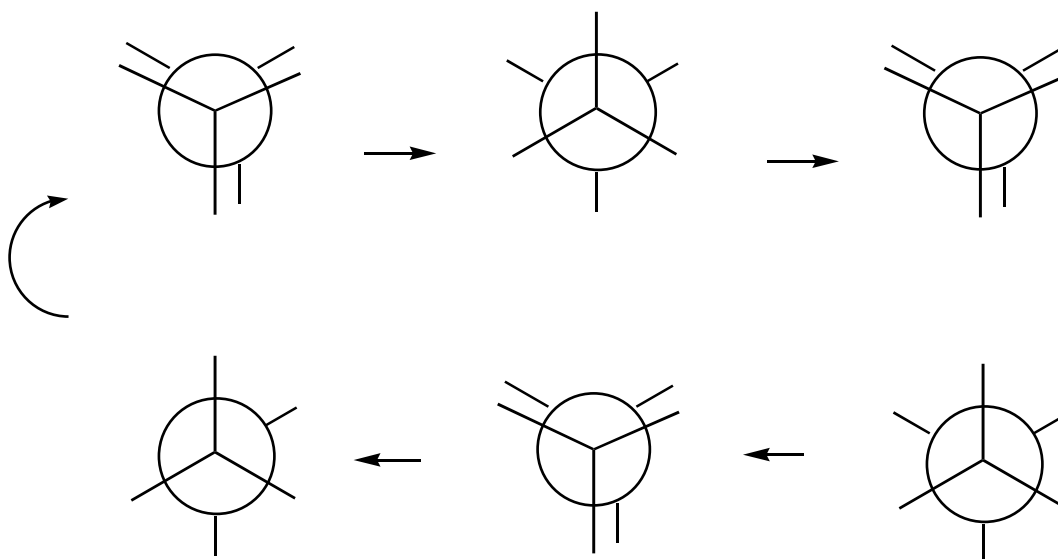


Propane

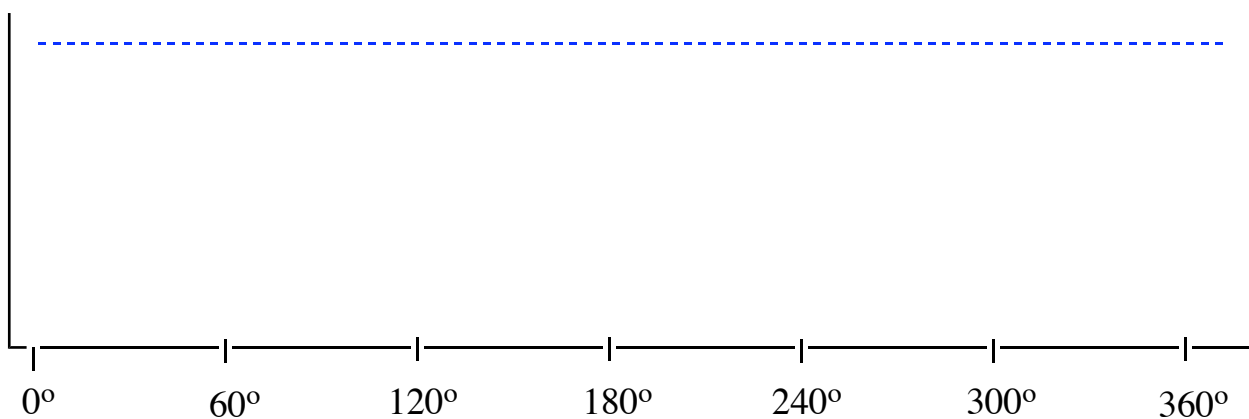
Make a model of propane. What would its two conformations look like?

What would a graph of their energy look like?

Make a model of butane. How many different conformation does it have? Which are the highest and lowest energies? Draw them in a circle as you rotate around the bond, starting at a 0° angle for the two methyl groups.



Graph the energy of these bonds.

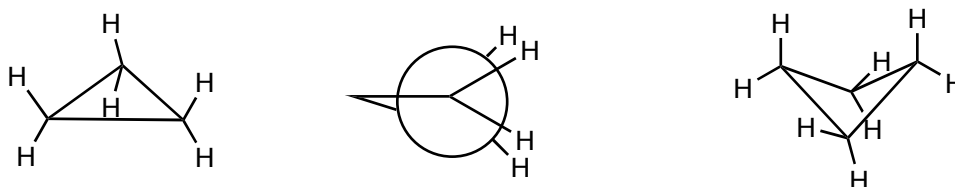


## V. Stability of cycloalkanes

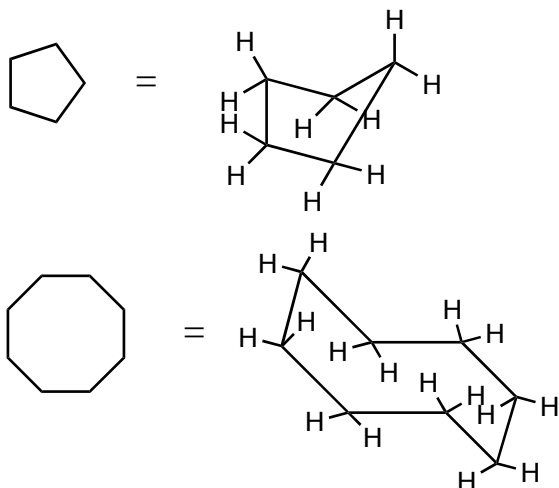
Below are the heats of formation of the first 6 cyclic alkanes. Which is the most stable? Which have more energy than their constituent elements?

cyclopropane	+17.8 kJ/mol
cyclobutane	+6.9 kJ/mol
cyclopentane	-15.3 kJ/mol
cyclohexane	-20.7 kJ/mol
cycloheptane	-17.0 kJ/mol
cyclooctane	-15.7 kJ/mol

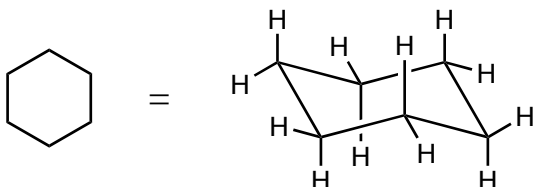
What makes the least stable rings so high in energy?



Why don't cyclopentane and cyclooctane have these problems?



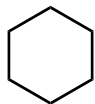
Why does cyclohexane have the lowest energy of all the rings?



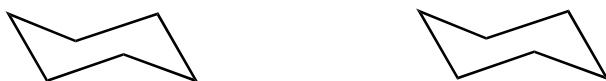
## VI. Conformations of Cyclohexane

Why do we study the conformations of cyclohexane in more detail than other rings?

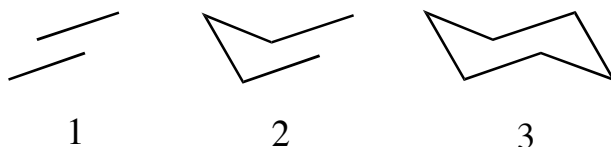
Below is a representation of a cyclohexane as seen from the top. Draw in the H's, showing their orientation.



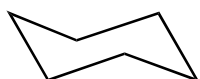
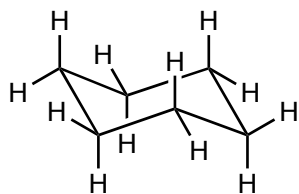
Below is a representation of a cyclohexane as seen from the side. What is it called, and why?



How to draw:

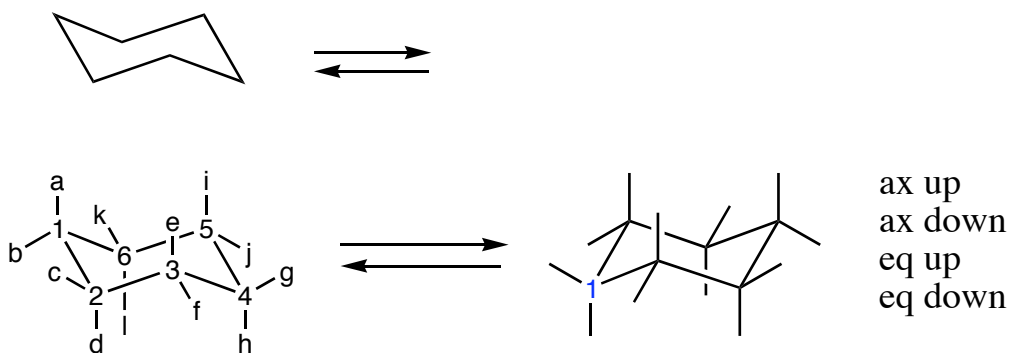


Here is a representation including the H's. Label them as going up or down.



What pattern do you see?

Flip the structures below into the other chair conformation.



Draw the compounds below in both chair conformations. Which one is lowest in energy?

