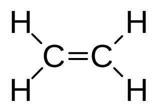
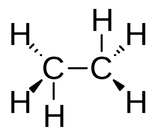
CH1011 Tutorial 3 Answers

1. What is the fundamental difference between saturated and unsaturated hydrocarbons? Illustrate your answer with a simple example of each.

   Saturated hydrocarbons are those organic compounds containing carbon and hydrogen which have no multiple bonds in the carbon skeleton whereas unsaturated hydrocarbons contain at least one double (or triple) CC bond.

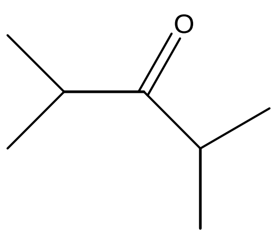


Unsaturated
Ethene

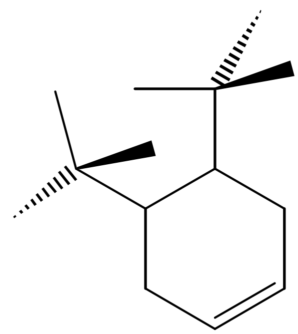


Saturated
Ethane

2. Name the class of compound that each one belongs to:

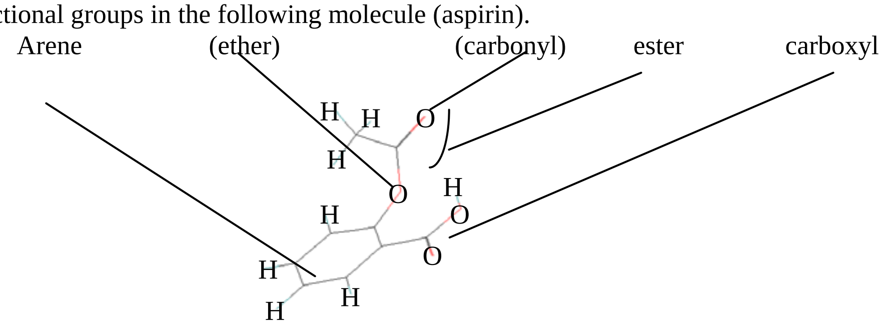


ketone

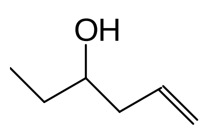


cycloalkene

3. Identify the functional groups in the following molecule (aspirin).

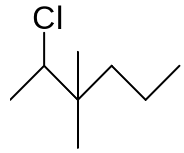


4. Draw a condensed structure for:

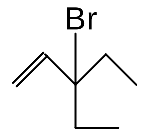


$CH_3CH_2CH(OH)CH_2CHCH_2$

5. Draw skeletal structures for the following compounds:

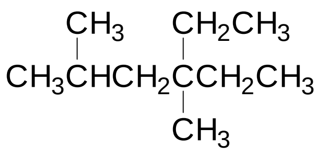


(a) 2-chloro-3,3-dimethylhexane

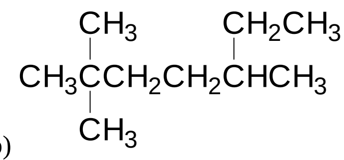


(b) 3-bromo-3-ethyl-1-pentene

6. Name the following compounds::



(a)
4-ethyl-2,4-dimethylhexane

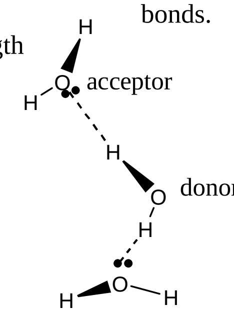


(b)
2,2,5-trimethylheptane

7. Clearly define a hydrogen bond using water as an example.

- What is a typical physical property of water that is influenced by hydrogen bonding?

A hydrogen bond is a weak bond (Van der Waals force) between a very polarised, covalently bonded H (high positive charge density) and an adjacent atom with excess negative electron density (typically a lone pair), it thus results from a special type of dipole-dipole force. The bond is of the type X-H···A where X is a small electronegative donor atom and A is an acceptor atom with excess electron density, X and A are often the same element type the most common being F, O, N. H bonds within the molecule are called intramolecular H-bonds while bonds between molecules are called intermolecular H-bonds. The H bond distance is typically 1.1 - 1.9A, the X-H···A angle 180^o and the bond strength around 20 kJ/mol.



The second molecule will participate in intermolecular hydrogen bonding the

The freezing point: 0^{o}C

The H bonding results in a higher f.p. than would be expected for a cmpd of this M.W. The H-bond network in the liquid results in the molecules sticking together. The process of freezing relies on the intermolecular forces within the liquid becoming greater than the kinetic energy and the molecules freeze into the position they will occupy in the solid. For water the H-bonds are very strong intermolecular forces and so they overcome the kinetic energy of the molecules at a significantly higher temperature than would be expected for a complex of comparable molecular weight without H-bonding.

Density of ice: 0.92 g/cm^3

The structure of ice is an open hexagonal arrangement of water molecules each hydrogen bonded to up to 4 adjacent water molecules. This open arrangement gives ice a lower density than liquid water 1.00 g/cm^3 (4^{o}C)

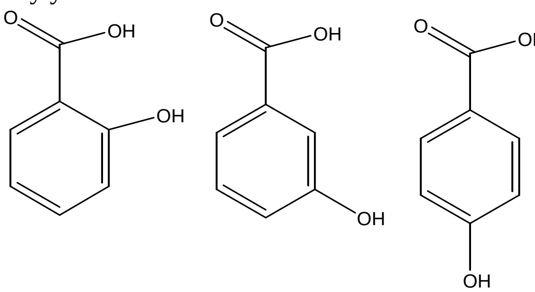
The boiling point: 100^{o}C

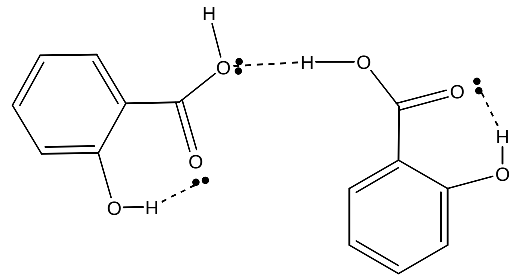
Boiling occurs when the vapour pressure above the liquid is equal to the external pressure. At 1 atm. water boils at the very high temperature of 100oC (it should be about -90^{o}C). This comes about as at the surface of water the water molecules are extensively H-bonded with their neighbours this attraction lowers the vapour pressure and results also in a very high enthalpy of vapourisation.

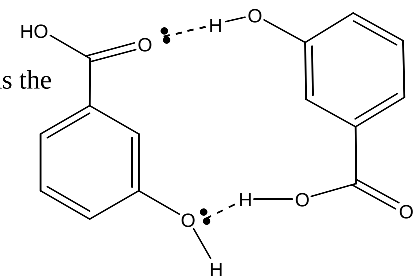
The surface tension: 7.3 x 10^{-2} J / m^2

Surface tension is the amount of energy that it takes to increase the area of a liquid surface. Water has a high surface tension as it takes a large amount of energy to disrupt the H-bonding forces which hold the surface water molecules together.

8. Which of the following aromatic compounds will have the **lowest boiling point**:
Justify your answer.







The 2-hydroxybenzoic acid will have the lowest boiling point as it has the weakest intermolecular hydrogen bonding. It is more volatile and so less energy (T) is required to take the liquid to boiling point.
In the 2-substituted molecule the C=O oxygen is involved in an intramolecular hydrogen bond. This leaves only the carboxyl OH group to be involved intermolecular hydrogen bonding with adjacent molecules.
In the 3-substituted and 4-substituted molecule there are a greater range of intermolecular H-bonding possibilities as there is no intramolecular hydrogen bonding (as the distance from the carbonyl to the adjacent OH group is too large).