Chapter 15 – Answers to end of chapter questions

1  a  i  Pent-1-ene
   ii  trans-hex-2-ene
   iii cis-hex-3-ene
   iv  But-2-yne
   v  Cyclohexene

b
(i)  \(CH_2=CH=CH_2\)
(ii)  \(\text{CH}_3\)\(=\)\(\text{C}\)\(=\)\(\text{CH}_2\text{CH}_3\)
(iii)  \(\text{C}_8\text{H}_8\)
(iv)  \(\text{CH}_3\)\(=\)\(\text{C}\)\(=\)\(\text{CH}_2\text{CH}_3\)

2  A  propane, \(\text{CH}_3\text{CH}_2\text{CH}_3\)
   B  steam, using a catalyst at high temperature and pressure
   C  2-bromopropane
      \(\text{CH}_3\)\(\text{CH}_2\)\(=\)\(\text{C}\)\(\text{Br}\)\(\text{CH}_2\text{CH}_3\)
   D  chlorine gas
   E  propane-1,2-diol
      \(\text{CH}_3\)\(=\)\(\text{C}\)\(=\)\(\text{CH}_3\)
      \(\text{OH}\)\(\text{OH}\)
   F  catalyst at 60 °C and 1 atm
3  a  \( \text{CH}_3\text{-CH}_2\text{-CH=CH-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_3 \)

b  \( \text{CH}_3\text{-CH}_2\text{-CH-CH-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_3 \)

\[
\begin{array}{c}
\text{OH} \\
\text{OH}
\end{array}
\]

c Higher, because the intermolecular forces will be greater.

4  a  poly(1,1-dichlororethene)

b

\[
\begin{array}{c}
\text{Cl} \\
\text{C} \\
\text{Cl}
\end{array}
\]

\[
\begin{array}{c}
\text{H} \\
\text{C} \\
\text{H}
\end{array}
\]

\[
\begin{array}{c}
\text{Cl} \\
\text{Cl}
\end{array}
\]

\( n \)

c Higher, because the intermolecular forces will be greater.

5  a  No

b

\[
\begin{array}{c}
\text{C} \\
\text{C}
\end{array}
\]

\[
\begin{array}{c}
\text{C} \\
\text{C}
\end{array}
\]

\[
\begin{array}{c}
\text{C} \\
\text{C}
\end{array}
\]

\[
\begin{array}{c}
\text{Cl} \\
\text{H}
\end{array}
\]

\[
\begin{array}{c}
\text{Cl} \\
\text{C}
\end{array}
\]

\[
\begin{array}{c}
\text{Cl} \\
\text{C}
\end{array}
\]

\[
\begin{array}{c}
\text{Cl} \\
\text{C}
\end{array}
\]

\( n \)

c  No

d
6  
a  Proportion by moles
\[
\begin{align*}
\text{C} & \quad \frac{87.8}{12} : \text{H} \quad \frac{12.2}{1} \\
& = 1 : 1.67
\end{align*}
\]
Empirical formula is C₃H₆.

b  C₆H₁₀

c  Moles H₂: \( \frac{273}{22.400} = 1.22 \times 10^{-3} \)
moles A: \( \frac{0.12}{82} = 1.22 \times 10^{-3} \)
so 1 mole of H₂ reacts with 1 mole of A.

d  One

e  C₆H₁₂

f

7  Cation A is most stable because there are three methyl groups attached to the positively-charged carbon atom. These methyl groups push electrons towards the carbon atom by the positive inductive effect, resulting in the positive charge being somewhat stabilised.

The other cations have fewer methyl groups pushing electrons towards the positively-charged carbon atom, so the positive charge is stabilised to a lesser extent.

8  

a  

i  Ethene reacts with gaseous HBr or a concentrated solution of HBr in the cold.

ii  Hydrogen ions act as electrophiles. They attack the double bond and form an intermediate carbon cation.

![Diagram of electrophilic addition reaction]

The ion then reacts with bromide ions to form the product:

![Diagram of electrophilic substitution reaction]

This is an electrophilic addition reaction.

b  

i
ii  2-bromopropane and 1-bromopropane

iii  The major product is 2-bromopropane. This is because two carbocations are formed in the first step of the reaction, when H\(^{+}\) ions attack the double bond.

\[
\begin{array}{cc}
A & B \\
\text{H--C--C--C--H} & \text{H--C--C--C--H} \\
\text{H H } & \text{H H} \\
\end{array}
\]

The carbocation on the right (B) is more stable than the carbocation on the left (A). This is the result of the positive inductive effect of the two methyl groups next to the positively charged central carbon atom in B. In A, only one ethyl group is pushing electrons towards the positively charged carbon atom, so A is less stable. This means that B persists longer than A, so B is more likely to combine with Br\(^{-}\) to form the product, 2-bromopropane.

c i  2-methylbut-1-ene

c ii

\[
\text{H H C--C--C--C--H} \\
\text{H Br H H H}
\]

iii  Markovnikoff’s rule.

9  

a  140°C and Ni catalyst  

b  252 kJ mol\(^{-1}\)  

c  436 kJ mol\(^{-1}\)  

d  826 kJ mol\(^{-1}\)  

e  –138 kJ mol\(^{-1}\)

10  The \(\pi\)-bond in alkenes is relatively easily broken, so ethene and propene are relatively reactive. They react with various reagents to form useful products: e.g. with hydrogen – manufacture of margarine; with H\(_2\)O(g) – manufacture of ethanol. They react with themselves to form polymers, e.g. polyethene and polypropene.  

Alkanes have no \(\pi\)-bonds, only \(\sigma\)-bonds which are more difficult to break. Therefore alkanes are less reactive and less useful for making other compounds.

11  

a  A, B  

b  C, D  

c  A, B  

d  A  

e  A, B
12 a Polymerisation is the joining of many small units (monomers) to form a chain with a repeating pattern.

b

\[
\begin{array}{c}
\text{Cl} \\
H \\
C = C \\
\text{H} \\
\text{H} \\
\downarrow \\
\text{Cl} \\
\text{H} \\
\text{Cl} \\
\text{Cl} \\
\text{Cl} \\
\text{Cl} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{C} = C \\
\text{C} \\
\text{H} \\
\text{CH}_2 \rightarrow \text{CH}_3 
\end{array}
\]

+ 3HCl

c A double bond.
d