Quiz (Boiling Point of Homologous Series)

1. Arrange the following haloalkanes in increasing order of boiling points. Explain briefly.

   CH_3F, CH_3Cl, CH_3Br, CH_3I

2. The boiling points of some chloroalkanes are given below:

Name	Formula	Boiling point (°C)
Chloromethane	CH_3Cl	–23.8
Dichloromethane	CH_2Cl_2	40.2
Trichloromethane	$CHCl_3$	61.2
Tetrachloromethane	CCl_4	76.8

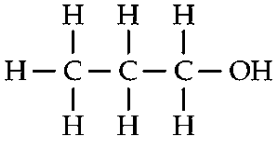
   (a) What is the relationship between the number of chlorine atoms and the boiling points of the above chloroalkanes?

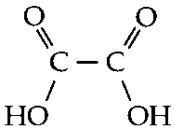
   (b) Explain the observation in (a).

3. Explain briefly why hexanoic acid has a much higher boiling point than methyl hexanoate.

$CH_3CH_2CH_2CH_2CH_2COOH$	$CH_3CH_2CH_2CH_2CH_2COOCH_3$
hexanoic acid	methyl hexanoate
b.p.: 205°C	b.p.: 149.5°C

4. Consider the following compounds:


(1)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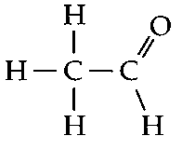
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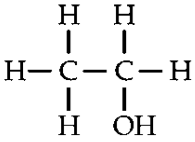
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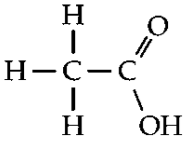
(5)

   (a) Which of the above compounds are alcohols?

   (b) Which of the above compounds are carboxylic acids?

   (c) Which of the above compounds can form hydrogen bonds among their molecules?

   (d) Arrange the above compounds in increasing order of boiling points. Explain your answer.

5. The table below shows some information about propanone, butane and propan-1-ol:

	Propanone	**Butane**	**Propan-1-ol**
Structural formula	CH_3COCH_3	$CH_3CH_2CH_2CH_3$	$CH_3CH_2CH_2OH$
Relative molecular mass	58.0	58.0	60.0
Physical state at R.T.P.	Liquid	Gas	Liquid

(a) Explain the difference in boiling point between propanone and butane.

(b) State and explain whether propanone or propan-1-ol has a higher boiling point.

6. Consider the following three compounds:
C_2H_6, C_3H_8, C_3H_7Cl

Arrange the three compounds in increasing order of boiling points. Explain your answer in terms of the intermolecular forces between their molecules.

Suggested Answer

1. The order of boiling point is: $CH_3F < CH_3Cl < CH_3Br < CH_3I$.

   The boiling point increases in the order of $CH_3F < CH_3Cl < CH_3Br < CH_3I$, which is an order of **decreasing polarity** of the molecules.

   In this case, the effect of molecular size is **much more important** than the molecular polarity on the strength of van der Waals' forces.

   The increase in size of halogen atoms (from F to I) results in an obvious increase in van der Waals' forces between molecules.

2. (a) The boiling points of the above chloroalkanes increase with the number of chlorine atoms.

   (b) This is because the strength of van der Waals' forces increases with the molecular size of the chloroalkanes.

3. There are extensive hydrogen bonds between hexanoic acid molecules, but not between methyl hexanoate molecules.

   There are only weak van der Waals' forces between methyl hexanoate molecules (in which all hydrogen atoms are attached to carbon atoms and not capable of forming hydrogen bonds).

   Therefore, hexanoic acid has a much higher boiling point than methyl hexanoate.

4. (a) (1) and (4)

   (b) (2) and (5)

   (c) (1), (2), (4) and (5) only

   (d) The order is: (3) < (4) < (1) < (5) < (2).

   Since there is no hydrogen bond between molecules of compound (3), it has the lowest boiling point.

   In general, carboxylic acids have higher boiling points than alcohols as they can form more extensive hydrogen bonds.

   Thus, compounds (2) and (5) have the highest boiling points of all.

   Compound (2) has two carboxyl groups in each molecule, this leads to a larger number of hydrogen bonds among their molecules.

   Hence, it has the highest boiling point.

As molecules of compound (1) have a larger size than molecules of compound (4), the van der Waals' forces are stronger among molecules of compound (1).

Therefore, compound (1) has a higher boiling point than compound (4).

5. (a) Propanone is polar while butane is non-polar.

The intermolecular forces between propanone molecules are stronger than those between butane molecules.

Thus, propanone has a higher boiling point.

(b) Propan-1-ol molecules are held together mainly by hydrogen bonds, while propanone molecules are held together by weak van der Waals' forces only.

The intermolecular forces between propan-1-ol molecules are stronger than those between propanone molecules.

Thus, propan-1-ol has a higher boiling point.

6. The strength of van der Waals' forces increases with the molecular size.

As the molecular size of C_2H_6 is the smallest, while that of C_3H_7Cl is the largest among the three, the van der Waals' forces between C_2H_6 molecules are the weakest, while those between C_3H_7Cl molecules are the strongest.

Thus, the increasing order of boiling points of the three compounds is: C_2H_6, C_3H_8, C_3H_7Cl.