Quiz (Effect of Hydrogen Bonding)

1. Consider the following three compounds with **comparable molecular masses**. Explain the difference in their boiling points in terms of intermolecular forces.

Compound	**propane**	**methoxymethane**	**ethanol**
Boiling point	–42.0°C	–24.8°C	78.5°C
Relative molecular mass	44.0	46.0	46.0

2. Arrange the following alcohols in order of increasing viscosity. Explain your answer.

3. Propane (C_3H_8), methoxymethane (CH_3OCH_3) and ethanol (CH_3CH_2OH) have comparable relative molecular masses. However, they have different solubilities in water.
   (a) Arrange propane, methoxymethane and ethanol in order of increasing solubility in water.

   (b) Explain your answer in (a).

4. The physical properties of four substances labelled *A*, *B*, *C* and *D* are summarized in the following table. Classify *A*, *B*, *C* and *D* as substance with a giant ionic structure, substance with a simple molecular structure (consisting of polar molecules), substance with a simple molecular structure (consisting of non-polar molecules) and substance with a giant covalent structure.

Substance	**Solubility in water**	**Electrical conductivity in the molten state**	**Electrical conductivity in the solid state**	**Relative melting point (1: lowest; 4: highest)**
A	✗	✗	✗	4
B	✗	✗	✗	1
C	✓	✗	✗	2
D	✓	✓	✗	3

Suggested Answer

1. There are **hydrogen bonds in addition to van der Waals' forces** between ethanol molecules. Hence, ethanol has the highest boiling point.

   Methoxymethane and propane have much lower boiling points because there are **only van der Waals' forces** between their molecules. Methoxymethane has a **larger molecular size** than propane. Therefore, it has a higher boiling point than propane.

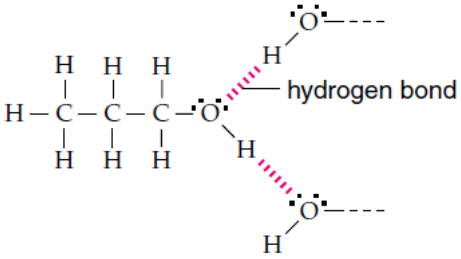
2. The viscosity of the alcohols increases in the order: propan-1-ol, propane-1,2-diol, propane-1,2,3-triol.

   For alcohols possessing different numbers of hydroxyl groups, the viscosity **increases** as the **number of hydroxyl groups per molecule increases**.

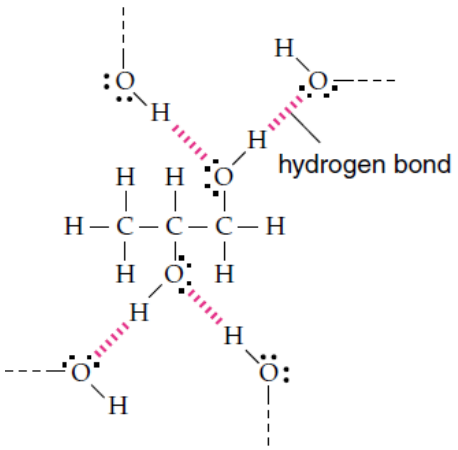
   Each propan-1-ol molecule can form only **one** hydrogen bond with neighbouring propan-1-ol molecules on average. See Figure (a).

   Propane-1,2-diol is more viscous than propan-1-ol because each of the molecules can form **two** hydrogen bonds with neighbouring propane-1,2-diol molecules on average. See Figure (b).

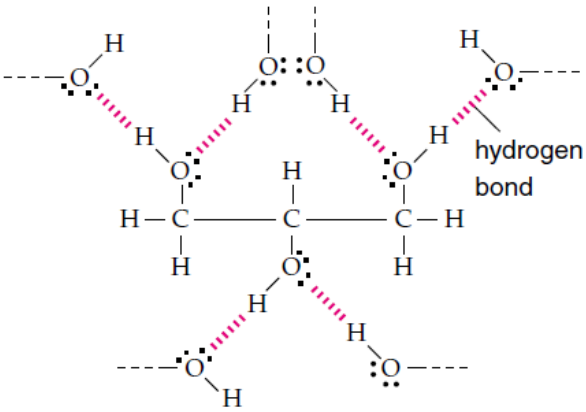
   Propane-1,2,3-triol is even more viscous because each of its molecules can form **three** hydrogen bonds with neighbouring propane-1,2,3-triol molecules on average. See Figure (c).



(a)



(b)



(c)

3. (a) The solubility in water increases from propane to methoxymethane, then to ethanol.

   (b) Propane is non-polar. It cannot form hydrogen bond with water molecules and thus is insoluble in water.

   In methoxymethane, the lone pairs of electrons on the oxygen atom enable its molecules to form hydrogen bonds with water molecules. As a result, it is slightly soluble in water.

   In ethanol, the oxygen and hydrogen atoms in the –OH group enable its molecules to form extensive hydrogen bonds with water molecules. As a result, ethanol is very soluble in water.

4. *A*: substance with a giant covalent structure

   B: substance with a simple molecular structure (consisting of non-polar molecules)

   C: substance with a simple molecular structure (consisting of polar molecules)

   D: substance with a giant ionic structure