Example #2: Can benzene, C_6H_6, dissolve in water? Why or why not?

Too much "C_6H_6 is non-polar with has a dipole moment of zero, and so it can only form weak dipole-induced dipole interactions with water, which are not as strong as the hydrogen bonds that already exist between water molecules, so C_6H_6 won't dissolve in water."

Just right "C_6H_6 is non-polar and can only form weak intermolecular attractions with water, which are not as strong as the hydrogen bonds that already exist between water molecules, so C_6H_6 won't dissolve in water."

Not enough "C_6H_6 is non-polar, so it won't dissolve in a polar substance like water."

polar + FON non-polar

Example FR question: Which is more likely to be soluble in water, liquid methanol (CH_3OH) or liquid hexane (C_6H_{14})? Justify your answer.

- CH_3OH is more likely to be soluble in H_2O than C_6H_{14}
- CH_3OH is polar + can form strong hydrogen bonds with water
- C_6H_{14} is non-polar + can only form weak dipole-induced dipole attractions with water

Free Response Practice!

Directions: Use principles of atomic structure, bonding, and intermolecular forces to answer the following questions. Your responses must include specific information about all substances referred to in each part.

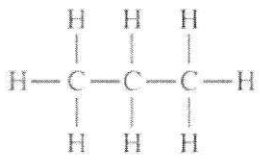
1. Ammonia, NH_3, is very soluble in water, whereas phosphine, PH_3, is only moderately soluble in water. Explain.

- NH_3 can form strong hydrogen bonds w/ water ⇒ highly soluble in H_2O
- PH_3 can form dipole-dipole attractions w/ water, which are not as strong as the hydrogen bonds that already exist between H_2O molecules ⇒ only moderately soluble in H_2O

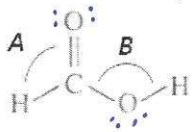
2. Indicate whether you agree or disagree with the statement in the box below. Justify your answer.

H_2O has a much higher boiling point than H_2S because it has very strong hydrogen bonding forces between its molecules as well as dipole–dipole forces and London dispersion forces, while H_2S has only dipole-dipole and dispersion forces. The stronger hydrogen bonding IMFs between water molecules mean that the bonds between water molecules are harder to break. NOPE!

- Disagree!
- There are no bonds between H_2O molecules, only IMFs



Propane



Methanoic Acid

3. The complete structural formulas of propane, C_3H_8, and methanoic acid, HCOOH, are shown above.
   a. In the table below, write the type(s) of intermolecular attractive force(s) that occur in each substance.

Substance	Boiling Point	Intermolecular Attractive Force(s)
Propane	229 K	LDFs
Methanoic acid	374 K	Hydrogen bonding, dipole-dipole, LDFs

   b. Explain why methanoic acid has a higher boiling point than propane.

Methanoic acid exhibits stronger IMFs than propane, which means molecules of methanoic acid are more attracted to each other than propane molecules, so more energy (higher T) is required to separate methanoic acid molecules (boiling) than propane molecules.

   c. Which bond angle would you predict to be larger: angle A (H – C – O) or angle B (C – O – H) in methanoic acid? Justify your answer.

- Angle A > angle B.
- The central atom of C in A has 3 regions of e^- density $\Rightarrow e^-/e^-$ repulsion leads to a bond angle of 120°
- The central oxygen atom in B has 4 regions of e^- density $\Rightarrow$ bond angle of about 109.5°.