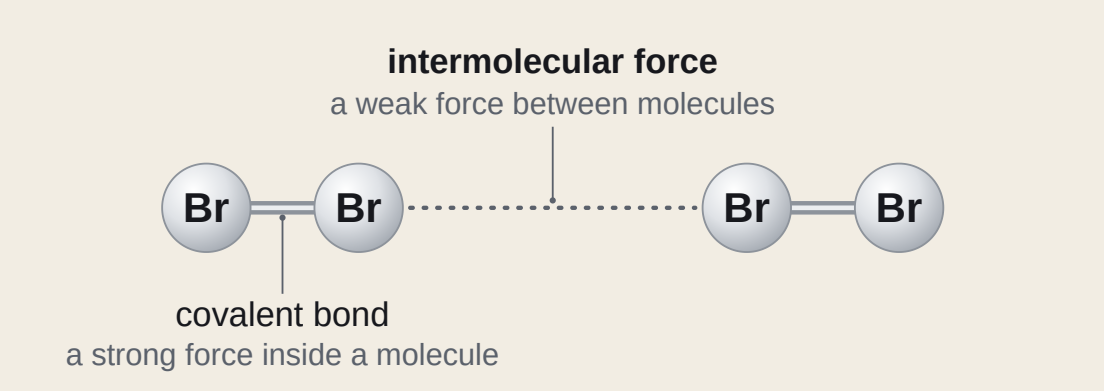
A11 · Intermolecular forces · Completed notes

Goals: Explain the difference between a bond inside a molecule and a force between molecules. Describe London forces, dipole-dipole forces and hydrogen bonding. List the intermolecular forces of a substance from its formula and structure.

These are the completed notes. The blanks are filled in and each question is worked.

Slide 1 of 6 · Forces between molecules

In lessons A5 to A10 you studied the bonds inside one molecule. Bonds hold a molecule together. Something else holds molecules near each other.



Key ideas

A bond inside a substance is an **intramolecular force**.

An **intermolecular force** is an attraction between one molecule and the next.

Intermolecular forces are much **weaker** than bonds.

Example

Liquid water is made of H_2O molecules. Name the force inside one molecule and the force between molecules.

1. Covalent bonds hold the atoms of one molecule together. They are intramolecular forces.
2. Intermolecular forces hold the molecules near each other.

Try it

Which is stronger, a covalent bond or an intermolecular force?

1. A covalent bond is stronger.
2. Intermolecular forces are much weaker than bonds.

Slide 2 of 6 · London forces

The last slide said molecules attract each other. Start with the weakest attraction. Even a non-polar molecule has it.



for an instant, the electrons are more on one side

Molecule	Count	Electrons
Cl_2	2 × 17	34
Br_2	2 × 35	70
I_2	2 × 53	106

stronger London forces

electrons in a molecule = the sum of its atomic numbers

Key ideas

Every molecule has **London forces**.

More **electrons** give stronger London forces.

To count the electrons, add the **atomic numbers** of the atoms.

Br_2 has **70** electrons.

Example

How many electrons are in one molecule of fluorine, F_2? Show your count.

1. The atomic number of fluorine is 9.
2. 9 + 9 = 18 electrons.

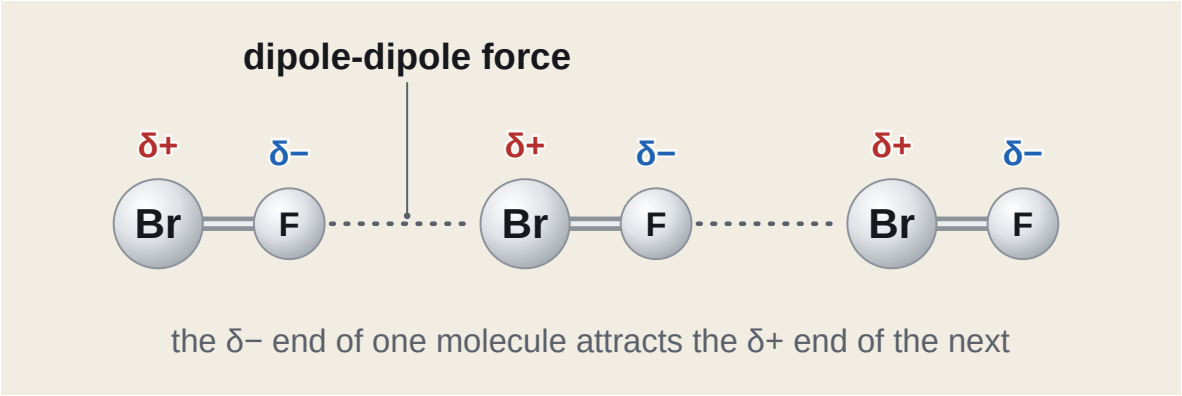
Try it

Methane is CH_4 and propane is C_3H_8. Which has stronger London forces? Show your counts.

1. CH_4 has 6 + 4 = 10 electrons.
2. C_3H_8 has 18 + 8 = 26 electrons.
3. Propane has more electrons, so its London forces are stronger.

Slide 3 of 6 · Dipole-dipole forces

On the last slide, a molecule had a δ− side for an instant. A polar molecule has a negative side and a positive side all the time.



Key ideas

The δ− side of one molecule attracts the **δ+ side** of the next.

This attraction is a **dipole-dipole force**.

Only **polar molecules** have dipole-dipole forces.

Example

HCl is a polar molecule. Does it have dipole-dipole forces? Say why.

1. Yes. HCl has a δ− side and a δ+ side.
2. The δ− side of one molecule attracts the δ+ side of the next.

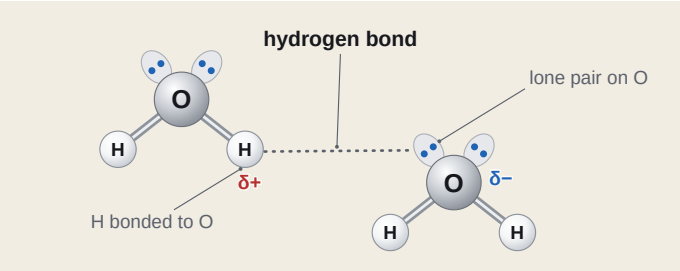
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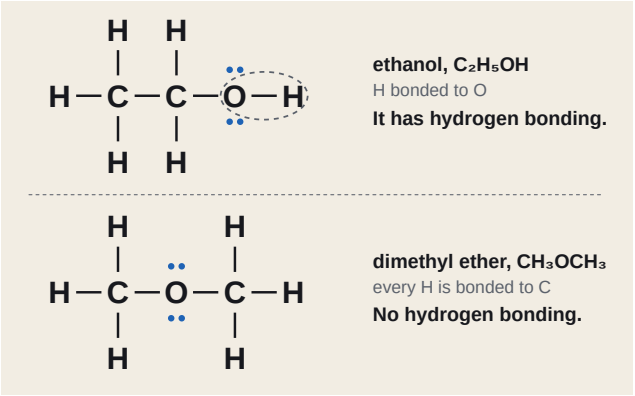
CO_2 is a non-polar molecule. Does it have dipole-dipole forces? Say why.

1. No. Only polar molecules have dipole-dipole forces.
2. CO_2 has London forces only.

Slide 4 of 6 · Hydrogen bonding

On the last slide, polar molecules attracted each other. One kind of polar bond gives an attraction strong enough to have its own name.





Key ideas

Hydrogen bonding needs a hydrogen atom bonded to N, O or F.

It also needs a **lone pair** on N, O or F in the next molecule.

A hydrogen atom bonded to **carbon** does not count.

Example

Does ammonia, NH_3, have hydrogen bonding? Say why.

1. Yes. Each hydrogen is bonded to nitrogen.
2. Nitrogen in the next molecule has a lone pair.

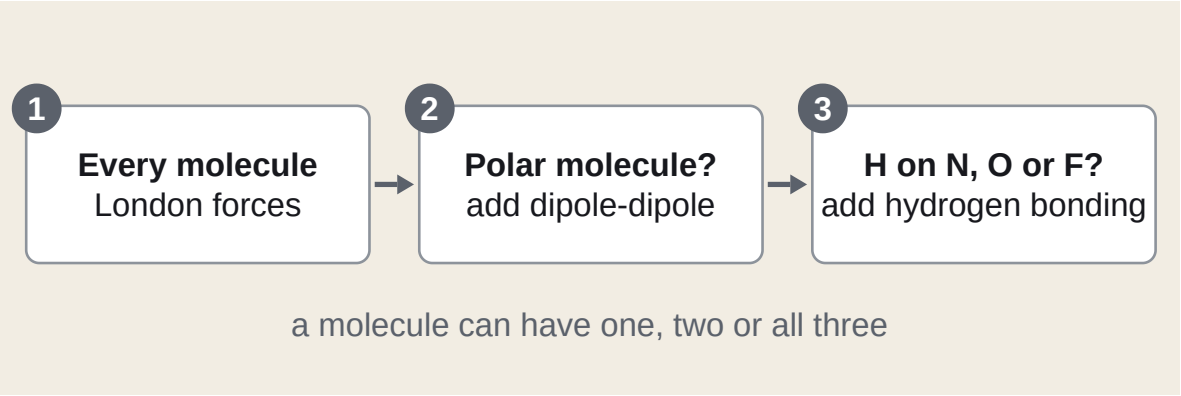
Try it

Does methane, CH_4, have hydrogen bonding? Say why.

1. No. Every hydrogen is bonded to carbon.
2. A hydrogen atom bonded to carbon does not count.

Slide 5 of 6 · List the forces

You have now met three intermolecular forces: London forces, dipole-dipole forces and hydrogen bonding. Three questions find which ones a substance has.



Key ideas

Every molecule has **London forces**.

If the molecule is **polar**, add dipole-dipole forces.

If a hydrogen is bonded to N, O or F, add **hydrogen bonding**.

Example

Name the intermolecular forces of hydrogen fluoride, HF.

1. Every molecule has London forces.
2. HF is polar, so add dipole-dipole forces.
3. Hydrogen is bonded to F, so add hydrogen bonding.

Try it

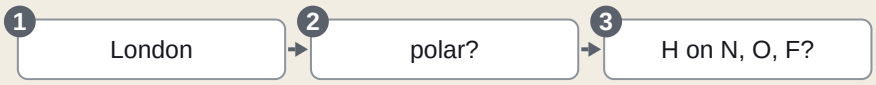
Name the intermolecular forces of carbon tetrachloride, CCl_4.

1. Every molecule has London forces.
2. CCl_4 is non-polar and has no hydrogen.
3. So it has London forces only.

Slide 6 of 6 · Method: how to list the intermolecular forces of a substance

You just listed the forces of three substances. Each time you asked the same three questions. Here they are as steps.

1. **Write** London forces. Every molecule has them.
2. **Add** dipole-dipole forces if the molecule is polar.
3. **Add** hydrogen bonding if H is on N, O or F.



Check: H bonded to carbon does not count.

Used again in: lesson A12

Key ideas

Step 1: write **London** forces.

Step 2: ask if the molecule is **polar**.

Step 3: look for a **hydrogen** bonded to N, O or F.

Example

Use the three steps on ammonia, NH_3.

1. Step 1: NH_3 has London forces.
2. Step 2: NH_3 is polar, so add dipole-dipole forces.
3. Step 3: hydrogen is bonded to N, so add hydrogen bonding.

Try it

Use the three steps on hydrogen chloride, HCl.

1. Step 1: HCl has London forces.
2. Step 2: HCl is polar, so add dipole-dipole forces.
3. Step 3: hydrogen is bonded to Cl, not to N, O or F.
4. So HCl has no hydrogen bonding.