

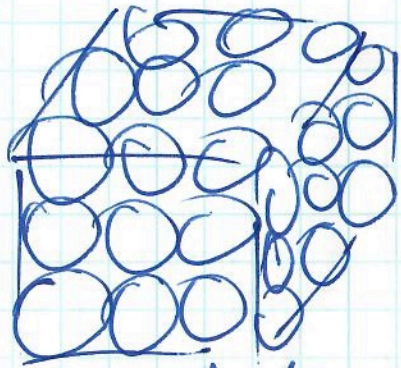
Class 5

①

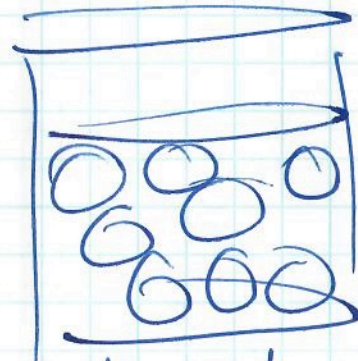
Liquids (Chapter 16)

- Ideal gases are assumed to comprise particles (atoms or molecules) that do not interact, and that possess no volume.
- Real gases have particles that interact (but weakly) and the particles possess volume. At low densities (ie. at high T , low p , high V) most gases behave like ideal gases.

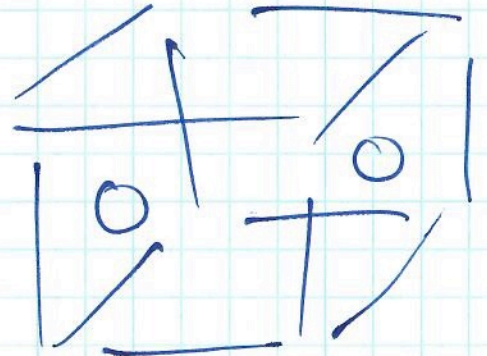
In contrast to gases, liquids and solids
 (collectively called condensed phases)
 have particles with finite volume and relatively
 strong interaction



solid



liquid



gas

Separation
 between particles

$\approx 0.1 \text{ nm}$

$\approx 0.1 \text{ nm}$

$\approx 1 \text{ nm}$

Density

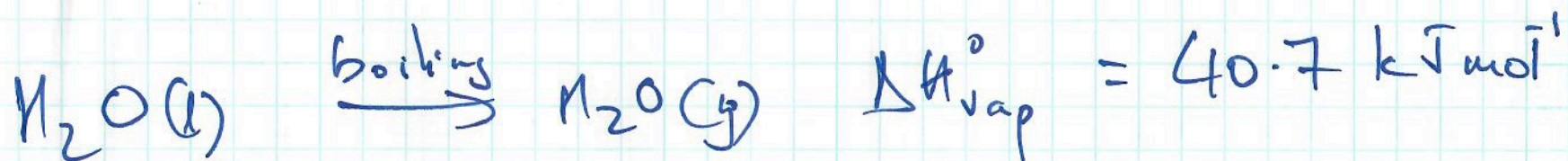
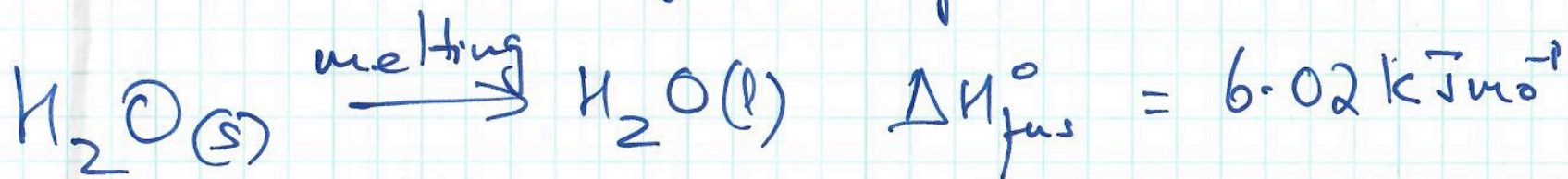
$\approx 1 \text{ g cm}^{-3}$

1 g cm^{-3}

$10^{-4} \text{ g cm}^{-3}$

(3)

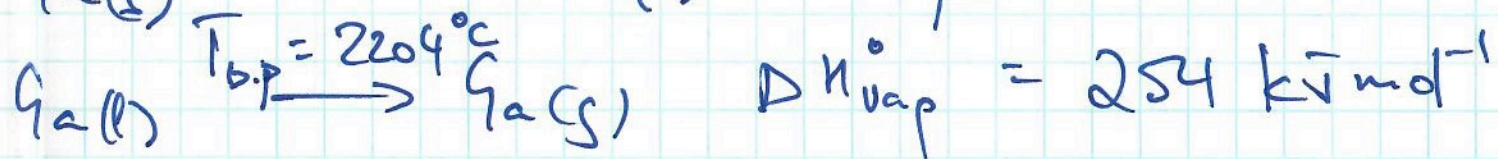
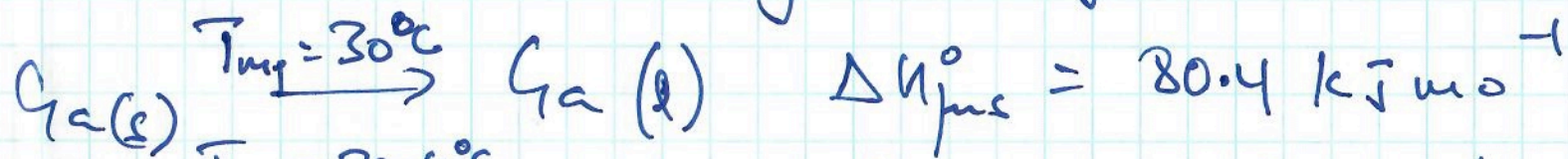
Liquids have strong intermolecular forces, almost close to solids. This is seen in the following



\Rightarrow easy to go from solid to liquid.

Harder to make the gas.

Even more interesting is gallium



atoms & molecules in
How do liquids interact?

(4)

1. Quantum mechanics: Examples are

Ga(l) or Hg(l) on any molten metal. We will not cover these

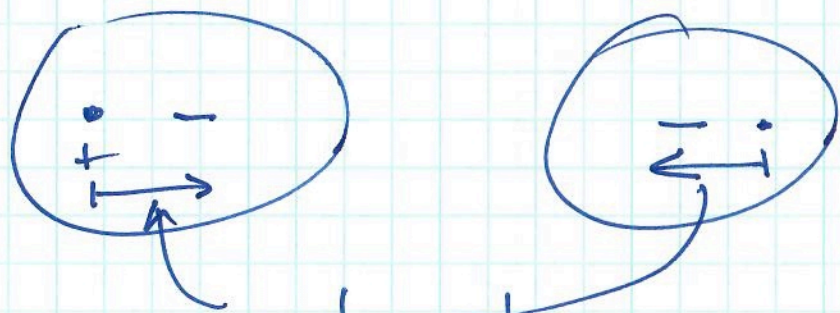
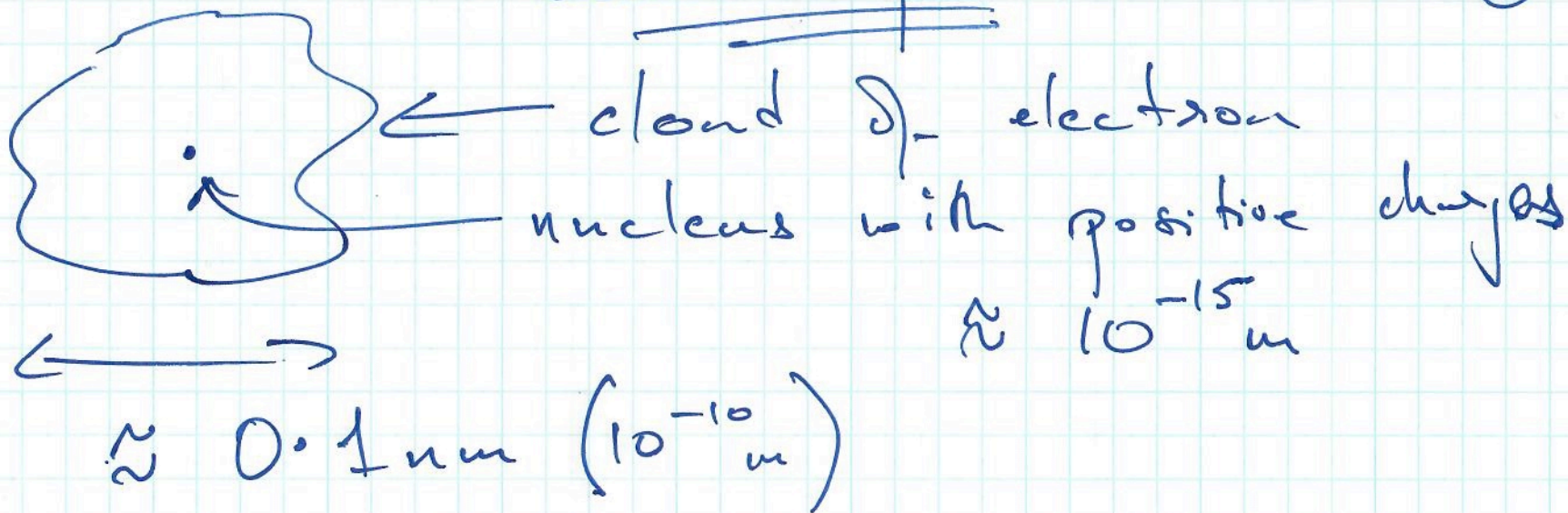
2. For molecular liquids

a) London dispersion or Van der Waals forces from instantaneous dipoles

because the shapes of atoms are not precisely spherical all the time

London Dispersion

(5)



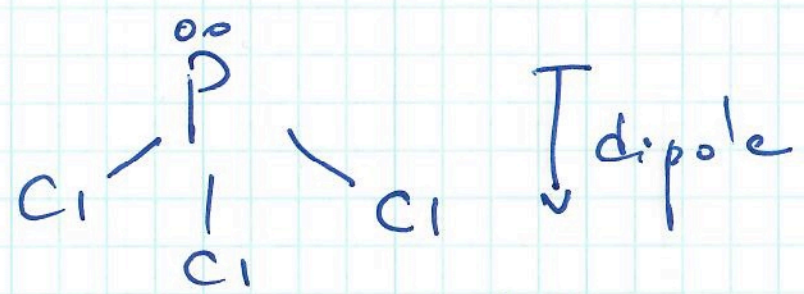
instantaneous dipoles in a floppy
 B.P.

atom

He	4.2 K
Ne	27.1 K
Ar	87.3 K
Kr	120.8 K
Xe	166 K

increases with
 size/mass/
 "floppiness"
 "FLOPPY atoms"

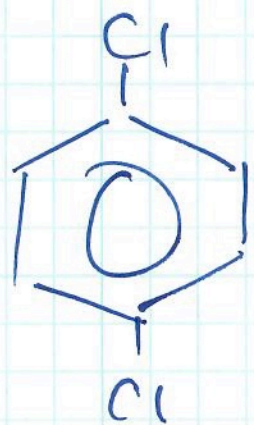
b) Dipole-dipole interactions



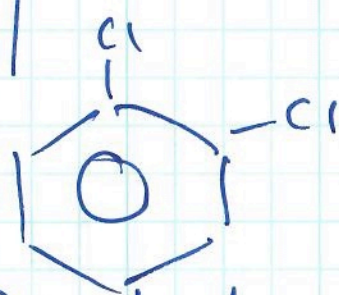
neighboring dipoles can interact

strongly

eg



para-dichlorobenzene

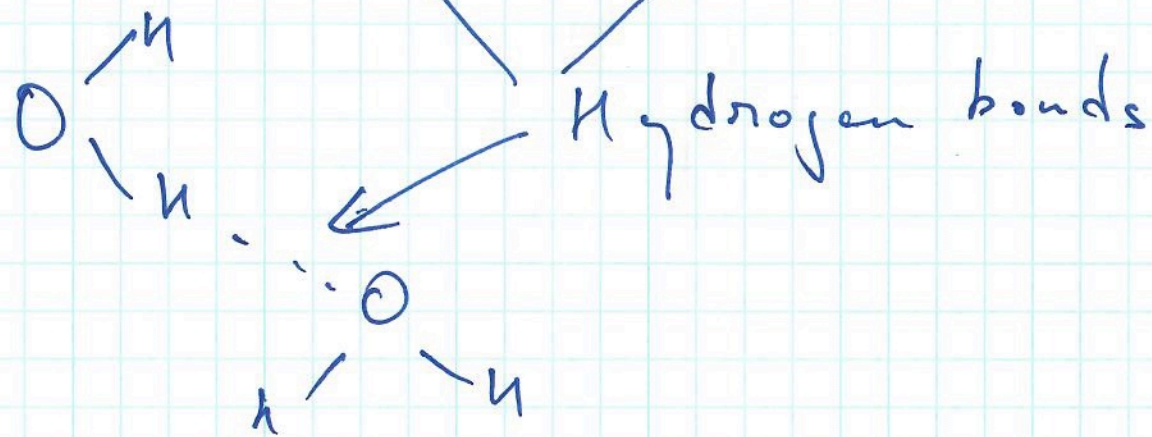


ortho-dichlorobenzene

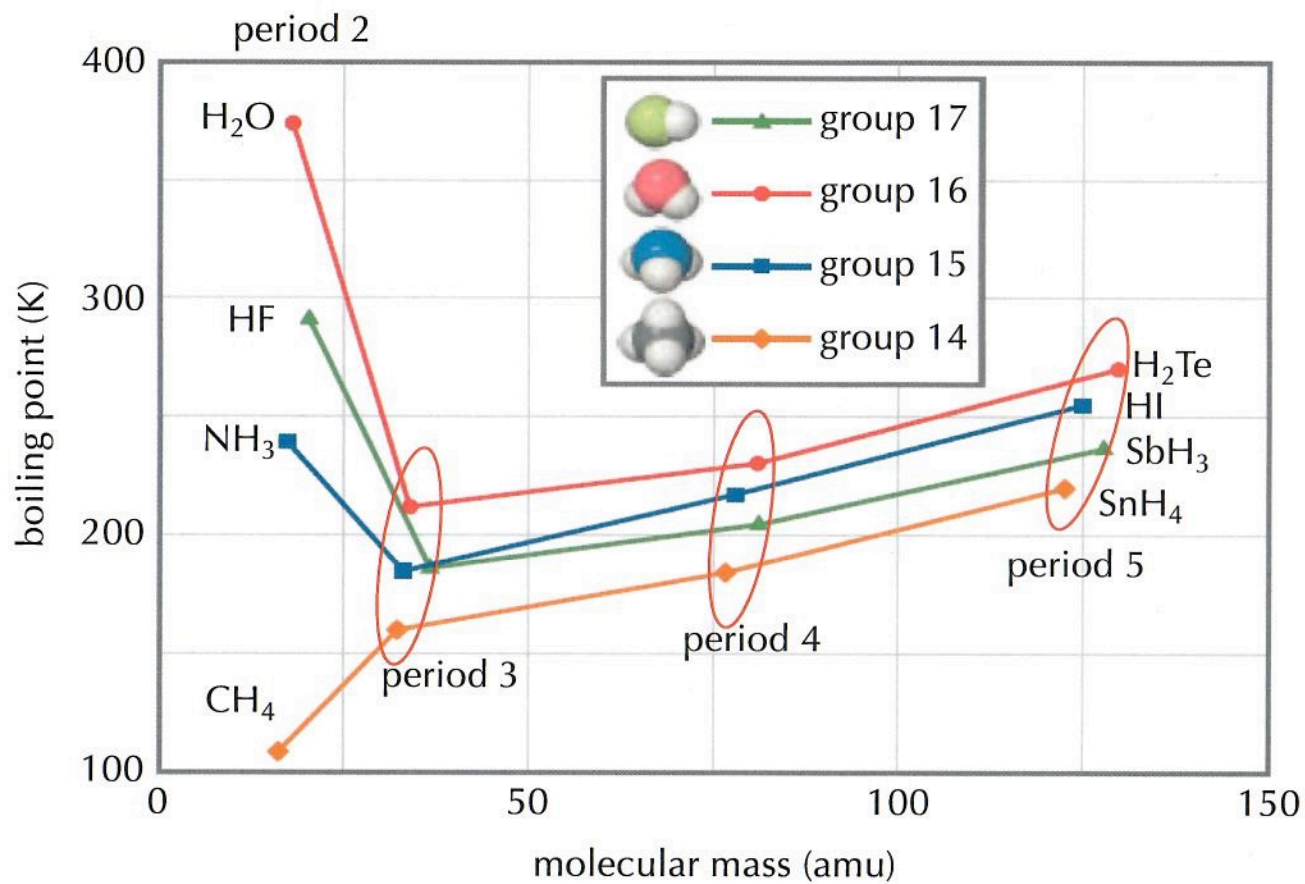
Which has a dipole & which would have a higher boiling point

c) Hydrogen bonding

A special interaction that is found with hydrogen that is bonded to an electronegative element



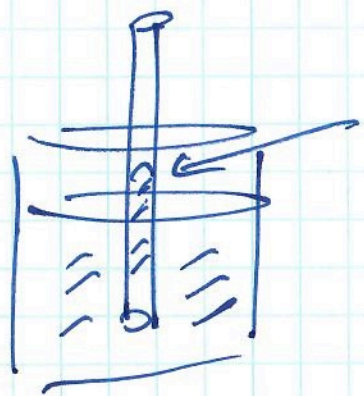
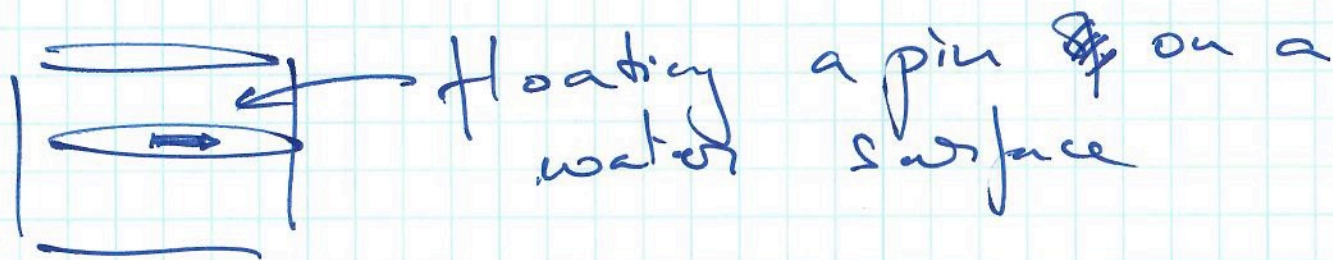
Can you unravel effects of H-bonding, geometry, dipoles, & molecular mass? ⑧



Other consequences of interactions

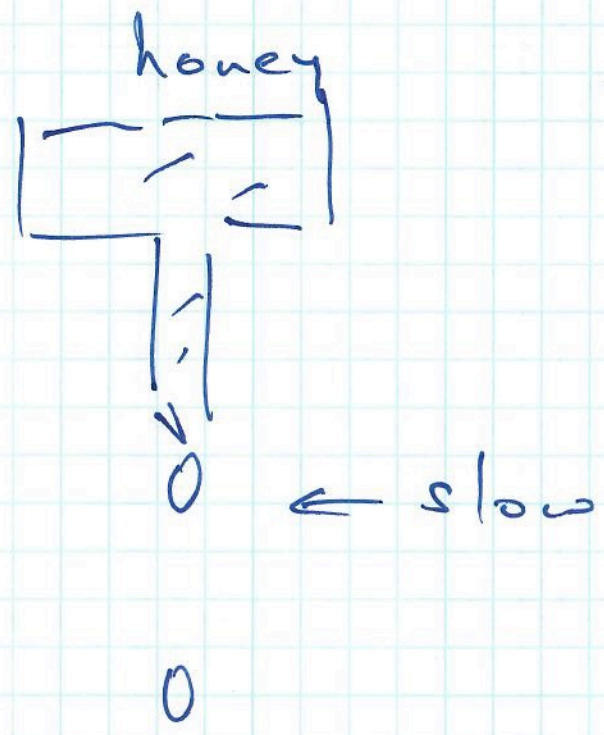
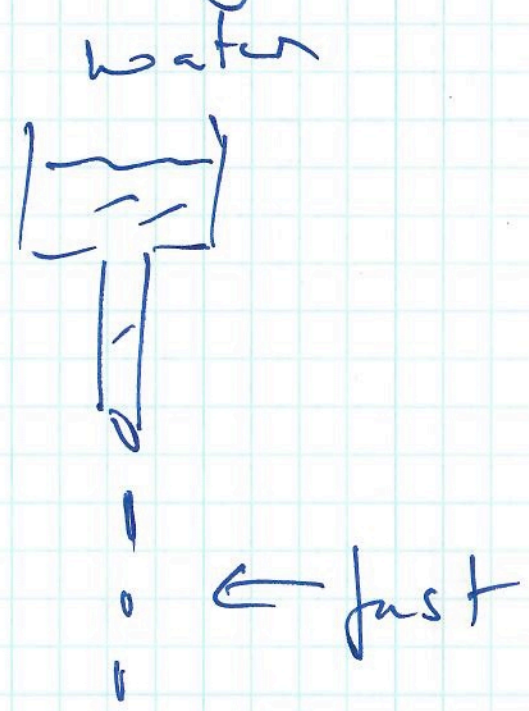
⑧

1. Surface tension: Liquids have molecules that attract each other, but also stick to other surfaces



capillary action: the water rises in a narrow tube (like a drinking straw)

Viscosity : The resistance to flow



We say honey is more viscous than water.