

[TP] Which of the following has dipole-dipole IMFs.

6% 1. $BFCl_2$, whose shape is trigonal-planar, like that of BF_3
29% 2. SCl_2, which is a bent molecule, like H_2O
15% 3. NH_2Cl, whose shape is trigonal-pyramidal, like that of NH_3
11% 4. OCS, which is a linear molecule, like CO_2
38% 5. All of the above
1% 6. None of the above

150103

157 of 191 1 0

BOSTON UNIVERSITY

1

Lecture 12 CH131 Fall 2020

Tuesday, October 27, 2020

- Intermolecular forces (IMF): H-bond, dipole-dipole, London
- IMFs determine relative boiling points
- Practice: Boiling points and enthalpy of vaporization

Next lecture: Vapor pressure: Liquid-vapor equilibrium; Vapor pressure and boiling point; Phase diagrams; Ch11: Solutions

BOSTON UNIVERSITY

2

Dipole-dipole attraction

Molecules must be "polar"

What makes a molecule polar is unequal sharing of electron clouds.

Sharing tendency is proportional to electronegativity difference.

The greater the difference of electronegativities,
the more unequal the sharing,
the more polar the shared electron cloud.

BOSTON UNIVERSITY 6

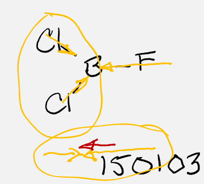
6

[TP] Which of the following has dipole-dipole IMFs.

16% 1. $BFCl_2$, whose shape is trigonal-planar, like that of BF_3
12% 2. SCl_2, which is a bent molecule, like H_2O
1% 3. NH_2Cl, whose shape is trigonal-pyramidal, like that of NH_3
1% 4. OCS, which is a linear molecule, like CO_2
70% 5. All of the above
0% 6. None of the above

is polar

① shape
② bond dipoles
③ polar?
④



164 of 191 7 0

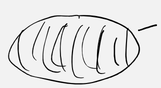
BOSTON UNIVERSITY

7

Instantaneous dipoles → London forces

When one atom encounters another closely, the electrical repulsion between the electron clouds is similar to mismatched (off-resonance) interaction of light and matter.

The result is the electron clouds of all atoms always quiver slightly.



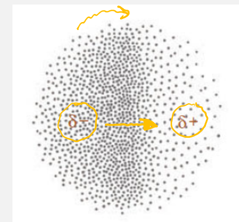
BOSTON UNIVERSITY 9

9

Lecture 12 CH131 Fall 2020 Copyright © 2020 Dan Dill dan@bu.edu

Instantaneous dipoles → London forces

This quivering means that electron clouds are momentarily lopsided, with the result that atom have momentary electrical dipoles.



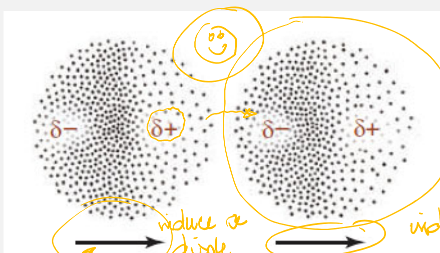
BOSTON UNIVERSITY 10

10

Lecture 12 CH131 Fall 2020 Copyright © 2020 Dan Dill dan@bu.edu

Instantaneous dipoles → London forces

Should another atom pass nearby, the momentary dipole will induce a dipole in the neighboring atom.



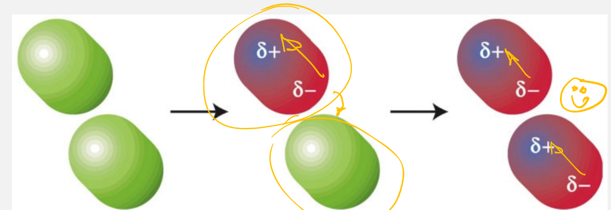
BOSTON UNIVERSITY 11

11

Lecture 12 CH131 Fall 2020 Copyright © 2020 Dan Dill dan@bu.edu

Instantaneous dipoles → London forces

The net result is that electron clouds on neighboring atoms (and molecules) attract one another, due to the London force.



BOSTON UNIVERSITY 12

12

Relative boiling points

Boiling means particles overcome attraction to their neighbors and escape the liquid surface.

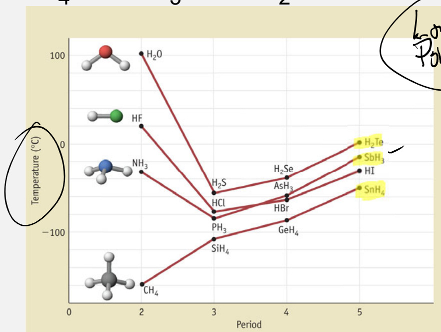
Relative boiling points reflect relative strength of intermolecular forces ...

- London (dispersion)
- Dipole-dipole interaction
- Hydrogen bonding

BOSTON UNIVERSITY 13

13

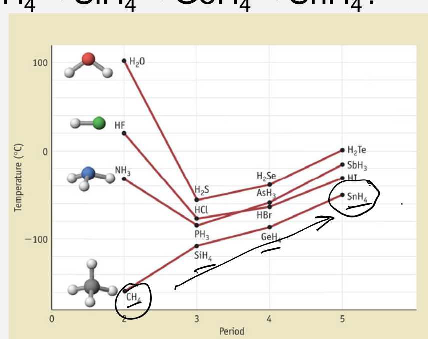
Why is $SnH_4 < SbH_3 < TeH_2$?



BOSTON UNIVERSITY 15

15

Why is $CH_4 < SiH_4 < GeH_4 < SnH_4$?



BOSTON UNIVERSITY 16

16

[TP] The correct order of polarity of HBr, HCl and HI is (least to most) ...

5% 1. HBr < HCl < HI
21% 2. HBr < HI < HCl
33% 3. HCl < HBr < HI
7% 4. HCl < HI < HBr
6% 5. HI < HCl < HBr
29% 6. HI < HBr < HCl

161 of 191 0

BOSTON UNIVERSITY 17

17

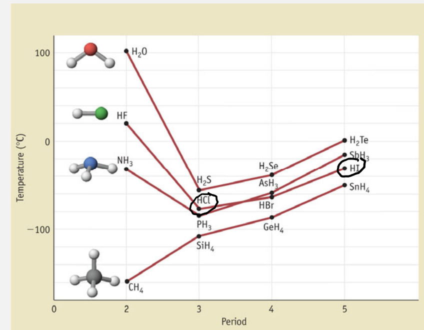
[TP]] The correct order of boiling point of HBr, HCl and HI is (lowest to highest) …

- 0% 1. HBr < HCl < HI
- 0% 2. HBr < HI < HCl
- 0% 3. HCl < HBr < HI
- 0% 4. HCl < HI < HBr
- 0% 5. HI < HCl < HBr
- 0% 6. HI < HBr < HCl

0 of 191

18

Why is HCl < HBr < HI?



greatest London

H : I

H : Br

H : Cl most polar

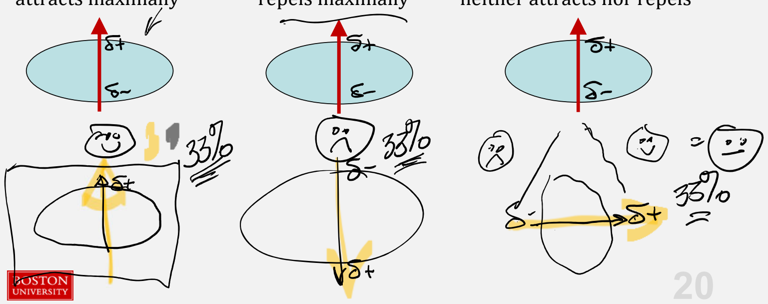
19

Permanent dipoles

Sketch a second molecule arranged so that it …

close to b.p // dipole-dipole interaction will be about 0.

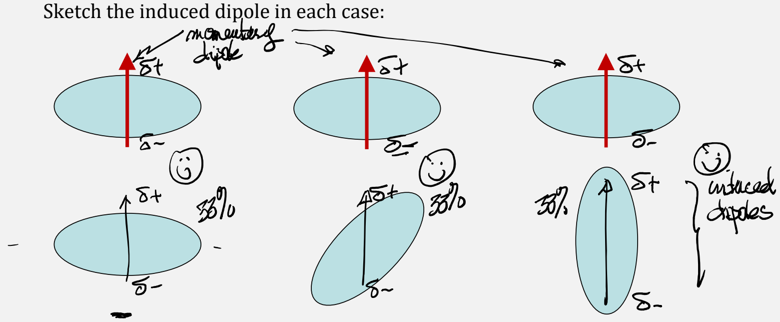
attracts maximally | repels maximally | neither attracts nor repels



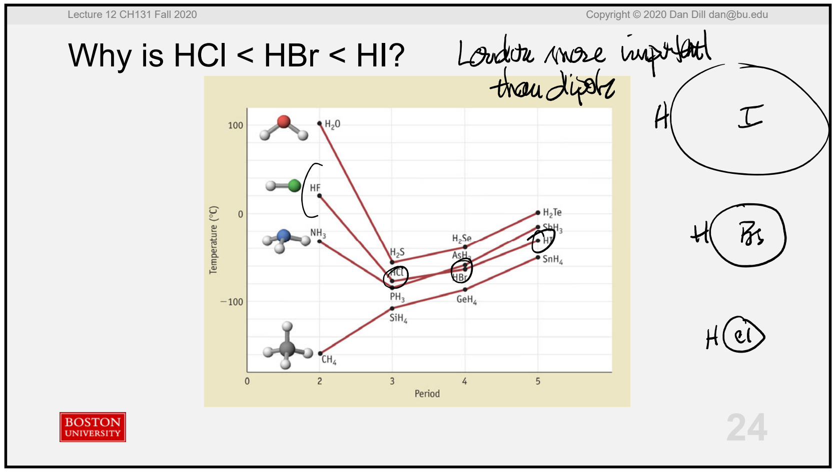
20

Induced dipoles

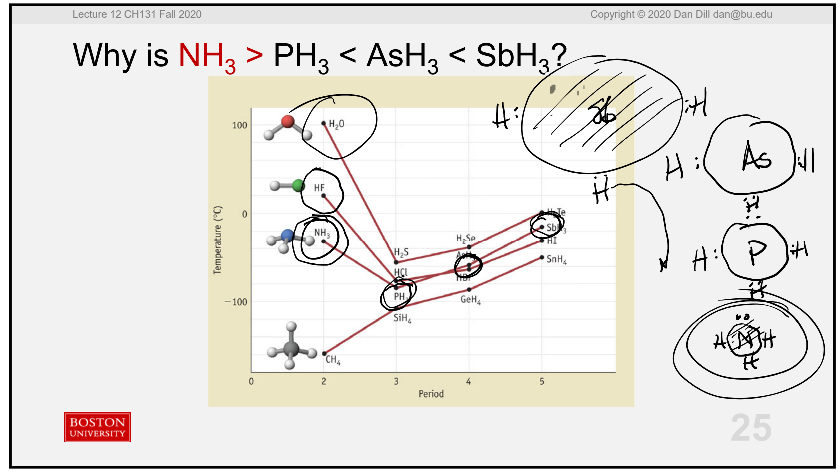
Sketch the induced dipole in each case:



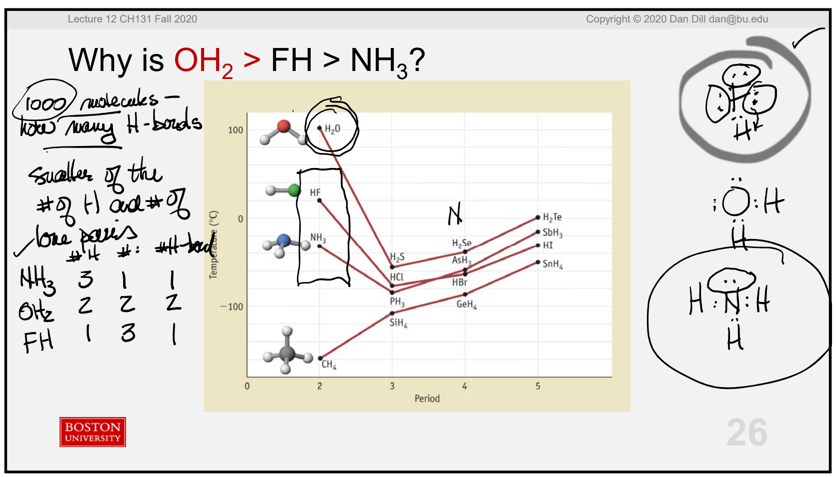
22


Lecture 12 CH131 Fall 2020
Copyright © 2020 Dan Dill dan@bu.edu
Why is HCl < HBr < HI?
London more important than dipole
Temperature (°C)
Period
H_2O
HF
NH_3
CH_4
H_2S
HCl
PH_3
SiH_4
H_2Se
AsH_3
HBr
GeH_4
H_2Te
SbH_3
HI
SnH_4
BOSTON UNIVERSITY
24

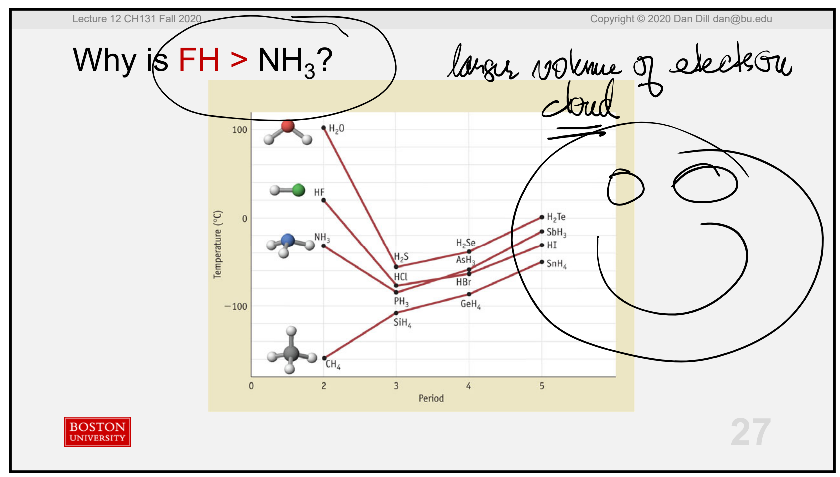
24


Lecture 12 CH131 Fall 2020
Copyright © 2020 Dan Dill dan@bu.edu
Why is NH_3 > PH_3 < AsH_3 < SbH_3?
Temperature (°C)
Period
BOSTON UNIVERSITY
25

25


Lecture 12 CH131 Fall 2020
Copyright © 2020 Dan Dill dan@bu.edu
Why is OH_2 > FH > NH_3?
1000 molecules – how many H-bonds
smaller of the # of H and # of lone pairs
Temperature (°C)
Period
BOSTON UNIVERSITY
26

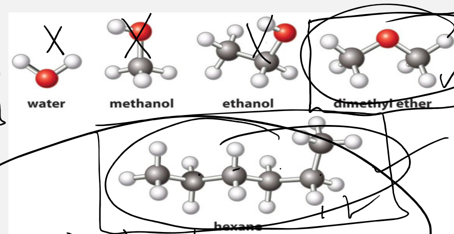
26


Lecture 12 CH131 Fall 2020
Copyright © 2020 Dan Dill dan@bu.edu
Why is FH > NH_3?
larger volume of electron cloud
Temperature (°C)
Period
BOSTON UNIVERSITY
27

27

[TP] Identify the compound with the smallest energy of vaporization (kJ/mol).

13% 1. water
13% 2. ethanol
39% 3. dimethyl ether
34% 4. hexane



163 of 191

28

[TP] The correct order of boiling point of CH_3OH, CH_4, and S=C=O (lowest to highest) is …

1% 1. $CH_3OH < CH_4 < S=C=O$
22% 2. $S=C=O < CH_4 < CH_3OH$
75% 3. $CH_4 < S=C=O < CH_3OH$
2% 4. $CH_4 < CH_3OH < S=C=O$
0% 5. some other order

165 of 191

30