IMF, vapor pressure, & boiling point

- review:
  - relative strength of IMF:

    H-bond IMF > dipole dipole IMF > London IMF

- vapor pressure (VP):
  - pressure of vapor
  - vapor = gas ← due to evaporation
  - evaporation = liquid → gas
  - evaporation involves overcoming IMF between liquid molecules

- basis / rationale : relative vapor pressure (or volatility = ease to evaporate)

  ↑ volatility = ↑ VP ← ↑ gas molecules ← easier to evaporate ← ↓ IMF

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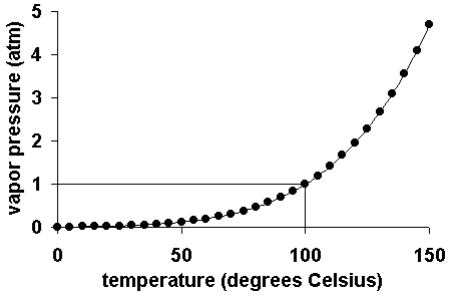
relate VP and temperature

- ↑ temperature → ↑ evaporation → ↑ gas molecules → ↑ VP
- that is, VP is an increasing function of temperature



source: https://www.chem.purdue.edu/gchelp/liquids/vpress.html

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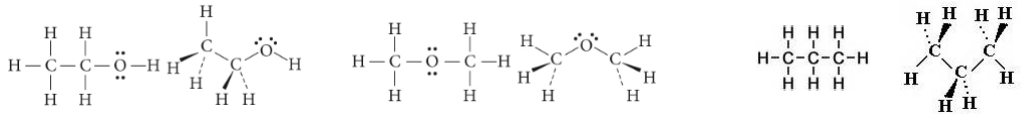
rationalize / basis: relative VP

What's the relative VP for C_2H_5OH, CH_3OCH_3, C_3H_8 ? basis / rationale ?



source: https://12uchem.files.wordpress.com/2017/03/5-vsepr-homework-answers.pdf ; http://propanehikagin.blogspot.com/2017/06/propane-lewis-structure.html

- Identify type of IMF
  - C_2H_5OH = polar cpd → H-bond IMF (+ London IMF)
  - CH_3OCH_3 = polar cpd → dipole dipole IMF (+ London IMF)
  - C_3H_8 = nonpolar cpd → London IMF

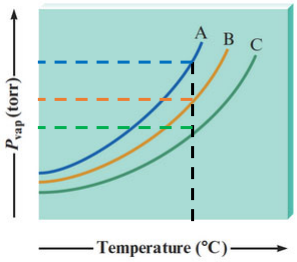
- as relative strength of IMF (assuming similar polarizability):
  H-bond IMF > dipole-dipole IMF > London IMF ,
  predict relative strength of IMF: C_2H_5OH > CH_3OCH_3 > C_3H_8 ; (i.e. strong → weak), so
  predict relative VP: C_2H_5OH < CH_3OCH_3 < C_3H_8 ; (i.e. lowest → highest)

3

3

experimental data – confirm predictions

	VP	source
C_2H_5OH	6 kPa	https://en.wikipedia.org/wiki/Ethanol
CH_3OCH_3	400 kPa	https://en.wikipedia.org/wiki/Diethyl_ether_(data_page)
C_3H_8	850 kPa	https://en.wikipedia.org/wiki/Propane



A: C_3H_8
B: CH_3OCH_3
C: C_2H_5OH

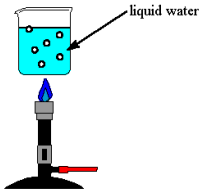
source: https://www.clutchprep.com/chemistry/practice-problems/86564/consider-the-following-vapor-pressure-versus-temperature-plot-for-three-differen

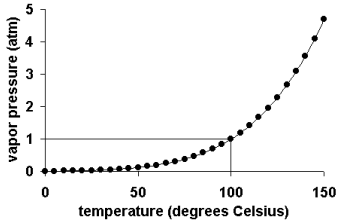
4

4

boiling point

- is the temperature, where the liquid boils
- as boiling: liquid → gas & there's "bubbles"
- so it's temperature, where $P_{atm} = P_{bubble} = VP$





source: https://www.chem.purdue.edu/gchelp/liquids/boil.html

- basis / rationale: relative boiling point
  ↑ boiling point = harder to boil ← harder to separate liquid molecules ← ↑ IMF

5

5

rationalize / basis: relative boiling point

What's the relative boiling for C_2H_5OH, CH_3OCH_3, C_3H_8 ? basis / rationale ?

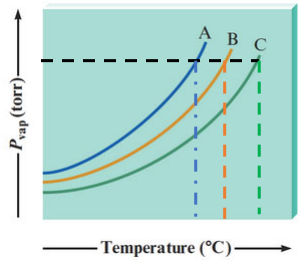
1. Identify type of IMF
   - C_2H_5OH = polar cpd → H-bond IMF
   - CH_3OCH_3 = polar cpd → dipole dipole IMF
   - C_3H_8 = nonpolar cpd → London IMF
2. as relative strength of IMF (assume similar polarizability):
   H-bond IMF > dipole-dipole IMF > London IMF ,
   predict relative strength of IMF: $C_2H_5OH > CH_3OCH_3 > C_3H_8$; (i.e. strong → weak), so
   predict relative boiling point: $C_2H_5OH > CH_3OCH_3 > C_3H_8$

6

6

experimental data – confirm predictions

	VP	boiling point	source
C_2H_5OH	6 kPa	78 C	https://en.wikipedia.org/wiki/Ethanol
CH_3OCH_3	400 kPa	- 24 C	https://en.wikipedia.org/wiki/Diethyl_ether_(data_page)
C_3H_8	850 kPa	- 42 C	https://en.wikipedia.org/wiki/Propane



A: C_3H_8
B: CH_3OCH_3
C: C_2H_5OH

source: https://www.clutchprep.com/chemistry/practice-problems/86564/consider-the-following-vapor-pressure-versus-temperature-plot-for-three-differen

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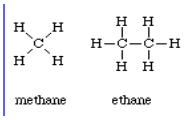
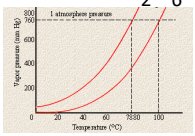
7

still another example

recall: increase polarizability → increase strength of London IMF.

What is the relative boiling point and VP of C_2H_6 versus CH_4 ? basis / rationale ?





(ignore numeric values on graph)

source: https://s1.lite.msu.edu/res/msu/botonl/b_online///library/newton/Chy251_253/Lectures/LewisStructures/LewisStructures.html
https://archives.library.illinois.edu/erec/University%20Archives/1505050/Rogers/Text10/Tx103/tx103.html

based on the Lewis structure, VSEPR, and evaluating the molecule's dipole moment, both compounds are nonpolar, so have only London IMF.

as polarizability: ethane > methane → London IMF: ethane > methane → . . .
→ boiling point: ethane > methane , while VP: ethane < methane.

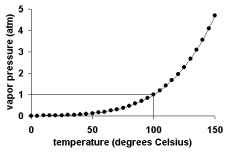
8

8

some applications

rationale / basis:

- at high elevation relative to sea level, there's lower atmospheric pressure, so there's a lower boiling point,



so takes longer time to cook.

- in a pressure cooker, there's higher "atmospheric pressure", so there's a higher boiling point, so takes shorter time to cook.

9

9