

[TP] Which of the following are associated with intramolecular forces (forces within a molecule)?

13% 1. Fog forms on a cold morning
13% 2. Wet clothes are hung out to dry
13% 3. Ice melts
13% 4. 1 and 2
13% 5. 1 and 3
13% 6. 2 and 3
13% 7. All of the above
13% 8. None of the above

Response Counter 10

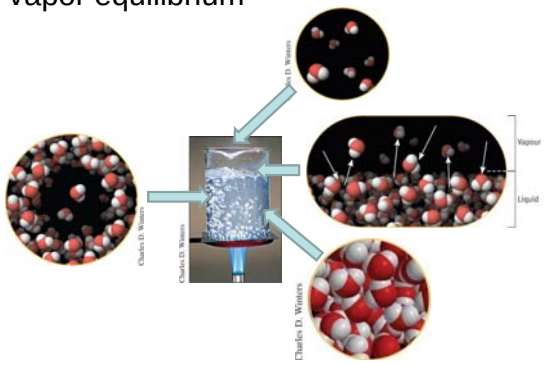
Lecture 13 CH101 A1 (MWF 9 am)

Friday, October 7, 2016

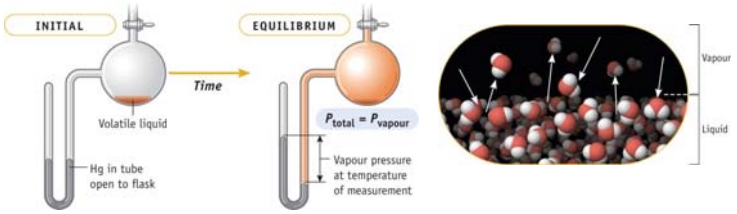
- Complete: Vapor pressure and boiling
- Intermolecular forces

Next lecture: Hydrogen bonding; dipole-dipole interaction (polarity); dispersion interaction; relative boiling points

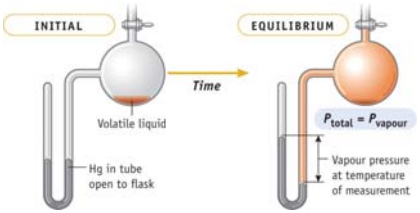
Liquid-vapor equilibrium



Equilibrium vapor pressure



Equilibrium vapor pressure



Low temperature
⟶ Few particles in vapor
⟶ Low equilibrium vapor pressure

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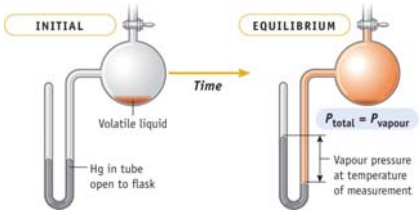
Equilibrium vapor pressure



Higher temperature
⟶ More particles in vapor
⟶ Higher equilibrium vapor pressure

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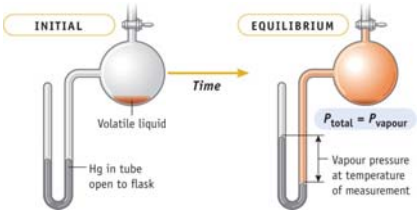
Equilibrium vapor pressure



Normal boiling temperature
⟶ Maximum particles in vapor
⟶ 1 atm equilibrium vapor pressure

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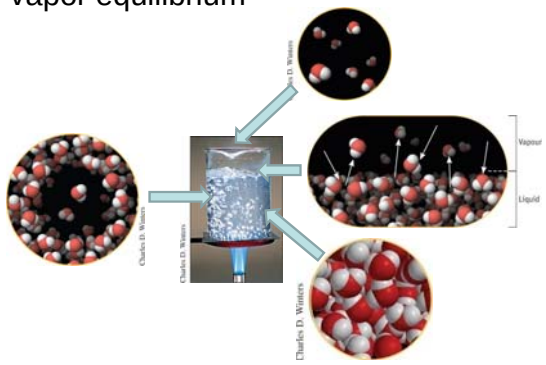
Liquid-vapor equilibrium



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Vapor pressure and boiling point

The normal boiling point is the temperature at which bubbles form at 1 atm.

Can we make bubbles (and so "boil") at a lower temperature?

Let's see …

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[TP] The order of normal boiling points is (lowest to highest) …

Substance	Vapor pressure at 25 °C, kPa	Normal (1 atm) boiling point °C
Acetone, $CH_3C(O)CH_3$	30.8	
Diethyl ether, $(CH_3CH_2)_2O$	71.7	
Ethanol, CH_3CH_2OH	7.87	
Water, H_2O	3.17	100

20% 1. diethyl ether < acetone < ethanol
20% 2. ethanol < acetone < diethyl ether
20% 3. acetone < diethyl ether < ethanol
20% 4. ethanol < diethyl ether < acetone
20% 5. something else

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Vapor pressure and boiling point

The normal boiling point is the temperature at which bubbles form at 1 atm.

What do you predict for relative normal boiling points of these substances?

Substance	Vapor pressure at 25 °C, kPa	Normal (1 atm) boiling point °C
Acetone, $CH_3C(O)CH_3$	3: 30.8	3: 56
Diethyl ether, $(CH_3CH_2)_2O$	4: 71.7	4: 35
Ethanol, CH_3CH_2OH	2: 7.87	2: 78
Water, H_2O	1: 3.17	1. 100

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Relative normal boiling point, T_b

The normal boiling point is the temperature at which bubbles form at 1 atm.

Substance	T_b
Water (H_2O)	100 °C
Ammonia (NH_3)	−33.3 °C
Hydrogen chloride (HCl)	−84.8 °C
Methane (CH_4)	−161.5 °C
Nitrogen (N_2)	−195.8 °C

What do you predict for relative vapor pressures of these substances at −200 °C?

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[Quiz] The substance with the lowest vapor pressure substances at −200 °C is …

25% 1. CH_4
25% 2. NH_3
25% 3. HCl
25% 4. N_2

Substance	T_b
Water (H_2O)	100 °C
Ammonia (NH_3)	−33.3 °C
Hydrogen chloride (HCl)	−84.8 °C
Methane (CH_4)	−161.5 °C
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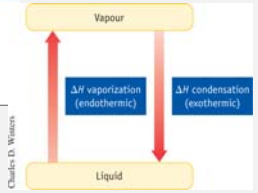
Enthalpy change of vaporization, $\Delta_{vap}H$

Substance	$\Delta_{vap}H$ (kJ mol^{-1})
Water (H_2O)	40.7
Ammonia (NH_3)	23.3
Hydrogen chloride (HCl)	16.2
Methane (CH_4)	8.2
Nitrogen (N_2)	5.6



$H_2O(l) \rightleftharpoons H_2O(g)$, $\Delta_{vap}H = 40.7$ kJ/mol at 100 °C
$NH_3(l) \rightleftharpoons NH_3(g)$, $\Delta_{vap}H = 23.3$ kJ/mol at −78 °C
$N_2(l) \rightleftharpoons N_2(g)$, $\Delta_{vap}H = 5.6$ kJ/mol at −196 °C
etc.

[TP] Which of the following is correct about water?

20% 1. The low enthalpy of vaporization results in a low vapor pressure at room temperature
20% 2. The high enthalpy of vaporization results in a low vapor pressure at room temperature
20% 3. The low enthalpy of vaporization results in a high vapor pressure at room temperature
20% 4. The high enthalpy of vaporization results in a high vapor pressure at room temperature
20% 5. There is no simple relationship between vapor pressure and enthalpy of vaporization

Intramolecular and intermolecular forces

Intermolecular forces are forces of attraction between molecules

Chemical changes are related to breaking and formation of covalent bonds due to intramolecular forces within molecules.

Physical changes are governed by intermolecular forces

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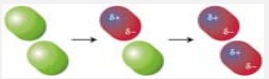
Intermolecular forces: stickiness!

A molecules attract one another, because of the attraction of opposite electrical charges.

Most specific and strongest is "hydrogen bonding": X—H · · · Y

More common and intermediate strength is "dipole-dipole attraction":

Always present and weakest is "temporary dipole attraction" ("dispersion interaction"):



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