

Lecture 15 CH101 A1 (MWF 9:05 am) Fall 2018

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[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



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## Lecture 15 CH101 A1 (MWF 9:05 am)

Wednesday, October 10, 2018

For today ...

- Postscript: Vapor pressure and boiling
- Intermolecular forces
- Hydrogen bonding

Next lecture: Polarity; dipole-dipole vs. temporary dipole (dispersion); Putting it all together: Relative boiling points; Practice: Intermolecular forces; Dissolving ionic solids; solubility rules

Memorize: solubility guidelines fig 6.28, p 181

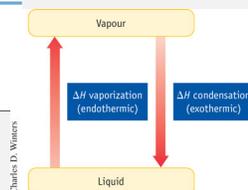


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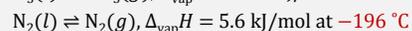
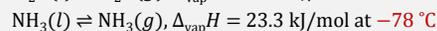
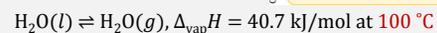
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Enthalpy change of vaporization,  $\Delta_{\text{vap}}H$ 

Substance	$\Delta_{\text{vap}}H$ (kJ mol <sup>-1</sup> )
Water (H <sub>2</sub> O)	40.7
Ammonia (NH <sub>3</sub> )	23.3
Hydrogen chloride (HCl)	16.2
Methane (CH <sub>4</sub> )	8.2
Nitrogen (N <sub>2</sub> )	5.6



Charles D. Waters



etc.



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## 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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[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

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Response Counter 10 6

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## Intermolecular forces: stickiness!

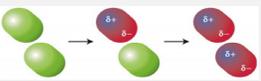
A molecules attract one another, because of the attraction of opposite electrical charges.

Most specific and **strongest** is "**hydrogen bonding**":  $X-H \cdots Y$

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



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



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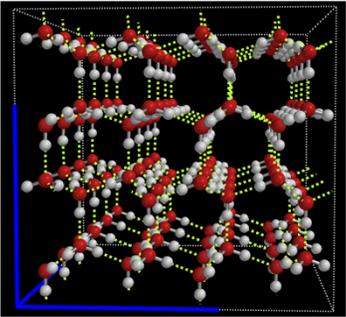
## Hydrogen bonding

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### Ice and water

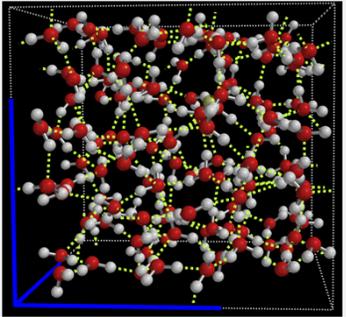


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### Ice and water



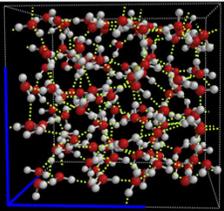
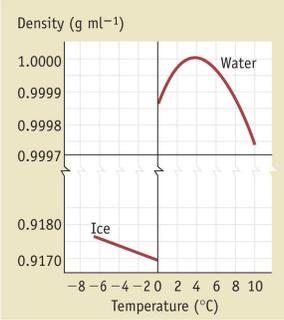
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### Effect of $T$ on water density

Why does the density **rise** from 0 °C to 4 °C?  
 Why does the density **fall** from 4 °C to higher temperatures?

Phase	Temperature (°C)	Density (g ml <sup>-1</sup> )
Ice	-8	0.9170
	-4	0.9175
	-2	0.9178
Water	0	0.9998
	2	0.9999
	4	1.0000
	6	0.9999
	8	0.9997
	10	0.9995

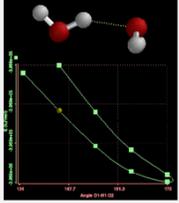
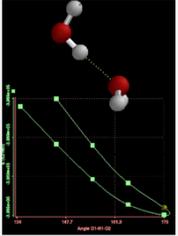
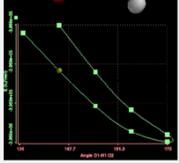
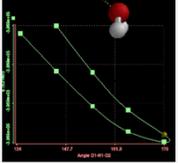
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### Hydrogen bond angle is 180°

N—H — — :N—	O—H — — :N—	F—H — — :N—
N—H — — :O—	O—H — — :O—	F—H — — :O—
N—H — — :F—	O—H — — :F—	F—H — — :F—

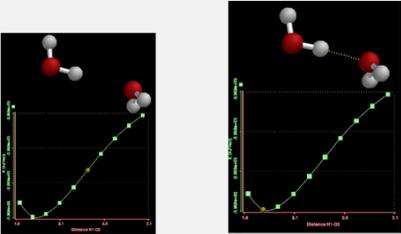
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### Hydrogen bonds are longer than typical bonds

N—H - - - :N—	O—H - - - :N—	F—H - - - :N—
N—H - - - :O—	O—H - - - :O—	F—H - - - :O—
N—H - - - :F—	O—H - - - :F—	F—H - - - :F—



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### Which of the following cannot form H bonds?

- Ammonia,  $\text{NH}_3$
- Methanol,  $\text{CH}_3\text{OH}$
- Ethanol,  $\text{CH}_3\text{CH}_2\text{OH}$
- Dimethyl ether,  $\text{CH}_3\text{OCH}_3$

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[Quiz] Which of the following **cannot** form hydrogen bonds with themselves?

0% 1. Ammonia,  $\text{NH}_3$

0% 2. Methanol,  $\text{CH}_3\text{OH}$

0% 3. Ethanol,  $\text{CH}_3\text{CH}_2\text{OH}$

0% 4. Dimethyl ether,  $\text{CH}_3\text{OCH}_3$

0% 5. 1 and 3

0% 6. 1 and 4

0% 7. 2 and 4

0% 8. All of the above can form hydrogen bonds with themselves

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