[TP] A bubble in a pot of boiling water contains...

17% 1. Only $O_2(g)$ and $H_2(g)$
17% 2. Only $H_2O(g)$
17% 3. Only air
17% 4. $H_2O(g)$ and air
17% 5. All of the above equally
17% 6. None of the above

BOSTON UNIVERSITY

Lecture 12 CH101 A1 (MWF 9 am)

Wednesday, October 5, 2016

- Hydrogen bonding in ice and water
- Heat versus temperature
- Heat capacity
- Vapor pressure and boiling

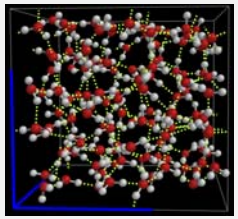
Next lecture: Intermolecular forces: Hydrogen bonding; dipole-dipole interaction (polarity); temporary dipole attraction (dispersion); relative boiling points

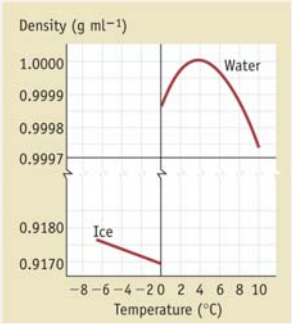
BOSTON UNIVERSITY

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?





BOSTON UNIVERSITY

Heat versus temperature

We use qualitative terms to describe these phenomena...

"It's hot in here!"
"That fire is giving off a lot of heat!"
"I had a temperature, so I felt awful."
"The water's temperature is too hot."

Is our skin ...

a heat sensor or ...
a temperature sensor (thermometer)?
Let's see ...

BOSTON UNIVERSITY

Heat versus temperature

Conclusion: Skin is sensitive to ...

energy transfer rather than temperature

Heating is energy transfer to an object

Cooling is energy transfer from an object

Temperature is a measure energy stored as internal motion.

BOSTON UNIVERSITY 14

Specific heat capacity

Moving hand from cold water (0 °C) to warm water (20 °C), sensation was "hot"

Moving hand from hot water (40 °C) to warm water (20 °C), sensation was "cold"

How to express results in terms of temperature?

Answer: "heat" ΔH = constant × ($T_{final} - T_{initial}$) = constant × ΔT

Constant = mass × specific heat capacity

BOSTON UNIVERSITY 15

Specific heat capacity

ΔH = constant × ($T_{final} - T_{initial}$) = constant × ΔT

constant = mass × specific heat capacity

$\Delta H = m\, c\, \Delta T$

Substance	c (J K^{-1} g^{-1})
Water, $H_2O(\ell)$	4.18
Ethanol, $C_2H_5OH(\ell)$	2.44
Diethyl ether, $C_2H_5OC_2H_5(\ell)$	2.37
Hexane, $C_6H_{14}(\ell)$	2.27
Acetone, $CH_3COCH_3(\ell)$	2.17
Carbon disulfide, $CS_2(\ell)$	1.00
Bromine, $Br_2(\ell)$	0.47

BOSTON UNIVERSITY 16

[TP] A bubble in a pot of boiling water contains...

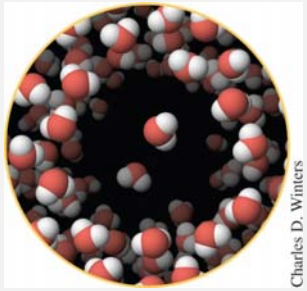
17% 1. Only $O_2(g)$ and $H_2(g)$
17% 2. Only $H_2O(g)$
17% 3. Only air
17% 4. $H_2O(g)$ and air
17% 5. All of the above equally
17% 6. None of the above

BOSTON UNIVERSITY 19

Boiling: Fig 6.7, p 164

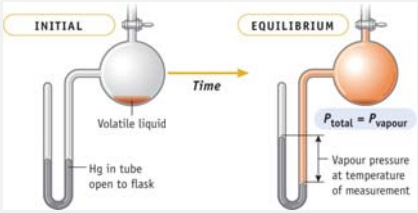
Boiling means "bubbles"

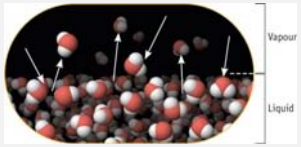
Bubbles are pure vapor of the liquid



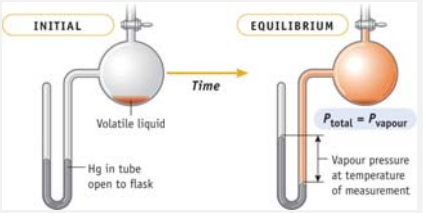
Liquid-vapor equilibrium

Equilibrium vapor pressure





Equilibrium vapor pressure



Substance	Equilibrium Vapour Pressure (kPa)
Water, $H_2O(\ell)$	3.17
Ethanol, $C_2H_5OH(\ell)$	7.87
Hexane, $C_6H_{14}(\ell)$	20.2
Bromine, $Br_2(\ell)$	28.7
Acetone, $CH_3COCH_3(\ell)$	30.8
Carbon disulfide, $CS_2(\ell)$	48.2
Diethyl ether, $C_2H_5OC_2H_5(\ell)$	71.7

1 Pa = force/area = 1 kg m/s^2 / m^2 = 1 kg m^{-1} s^{-2}

1 bar = 100 kPa (exactly)

1 atm = 101.325 kPa (exactly)

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, $CH_3C(O)CH_3$	30.8	
Diethyl ether, $(CH_3CH_2)_2O$	71.7	
Ethanol, CH_3CH_2OH	7.87	
Water, H_2O	3.17	100

[Group quiz] The order of normal boiling points is ...

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

Response Counter 10

