Al-Farabi Kazakh National University

Applied Problems of Mechanics and Energetics

WEEK 8. Latent and sensible heat

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Latent and sensible heat

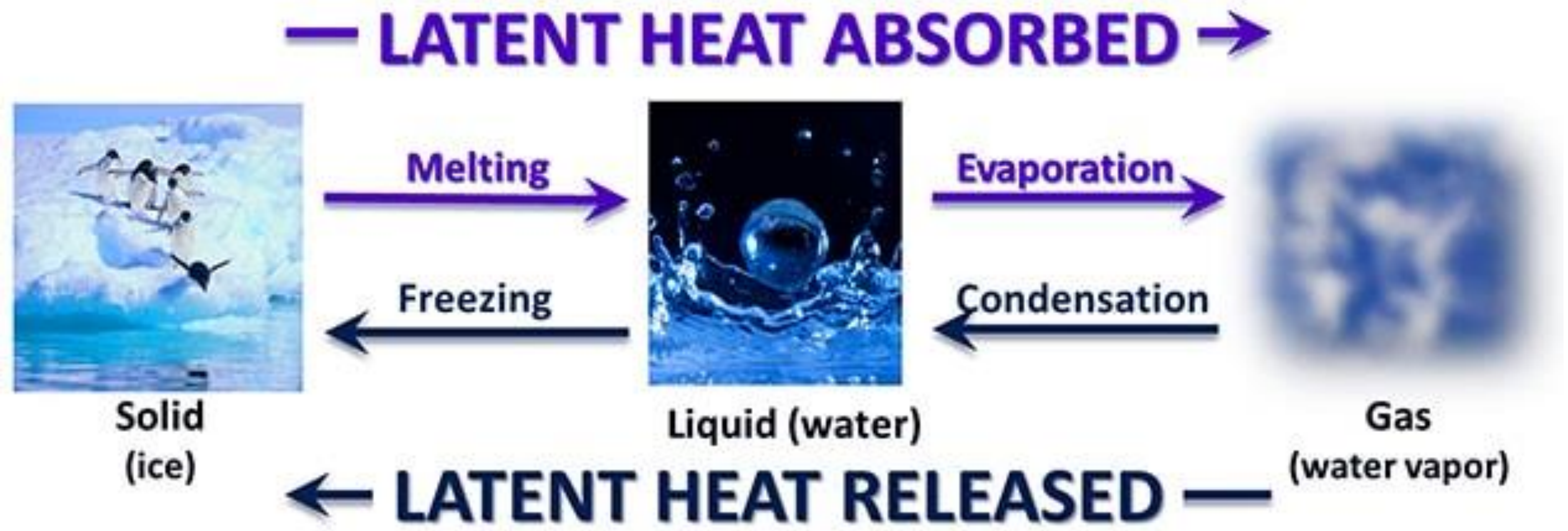
Latent heat is related to changes in phase between liquids, gases, and solids.

Sensible heat is related to changes in temperature of a gas or object with no change in phase.

Latent heat

Latent heat is energy released or absorbed, by a body or a thermodynamic system, during a constant-temperature process, usually a phase transition process.

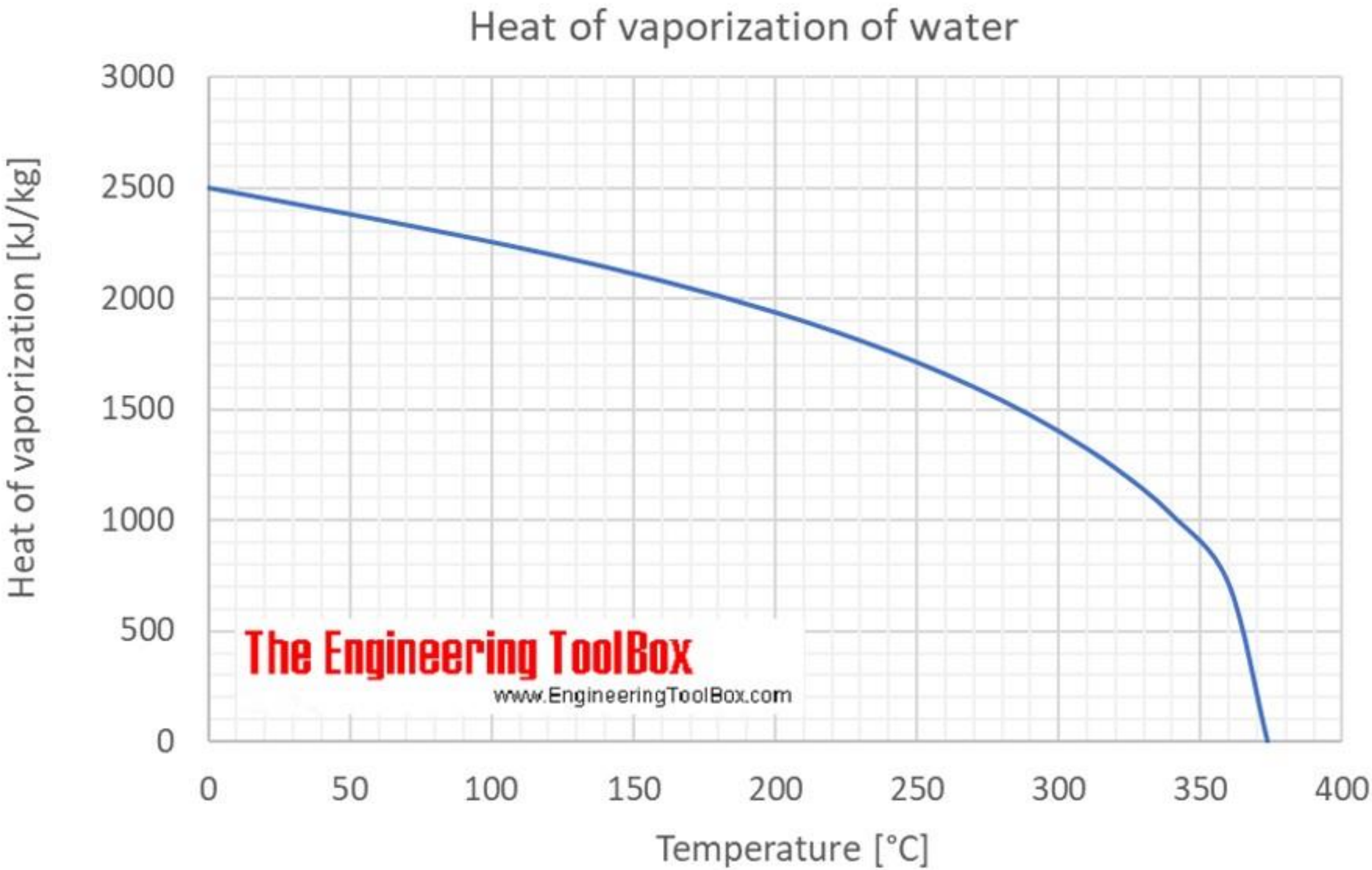
Latent heat can be understood as energy in hidden form which is supplied or extracted to change the state of a substance without changing its temperature.



Heat of vaporization as a function of pressure

The **(latent) heat of vaporization** (ΔH_{vap}) also known as the enthalpy of vaporization or evaporation, is the amount of energy (enthalpy) that must be added to a liquid substance, **to transform a given quantity of the substance into a gas**.

The enthalpy of vaporization is a function of the pressure at which that transformation takes place. The heat of vaporization diminishes with increasing temperature and it vanishes completely at a certain point called the critical temperature (Critical temperature for water: 373.946 °C or 705.103 °F, Critical pressure: 220.6 bar = 22.06 MPa = 3200 psi).



Heat of vaporization of water
Heat of vaporization [kJ/kg]
3000
2500
2000
1500
1000
500
0
0
50
100
150
200
250
300
350
400
Temperature [°C]
The Engineering ToolBox
www.EngineeringToolBox.com

Latent Heat Formula

For information
1 Cal = 4184 **J**

$$Q = mL_f \quad \text{or} \quad Q = mL_v$$

Q = thermal energy [J]
m = mass [kg]
L = heat of fusion or vaporization [J/kg]
(also known as specific latent heat)

Example:
L_f (the latent heat of fusion) for water is 80 cal/g.

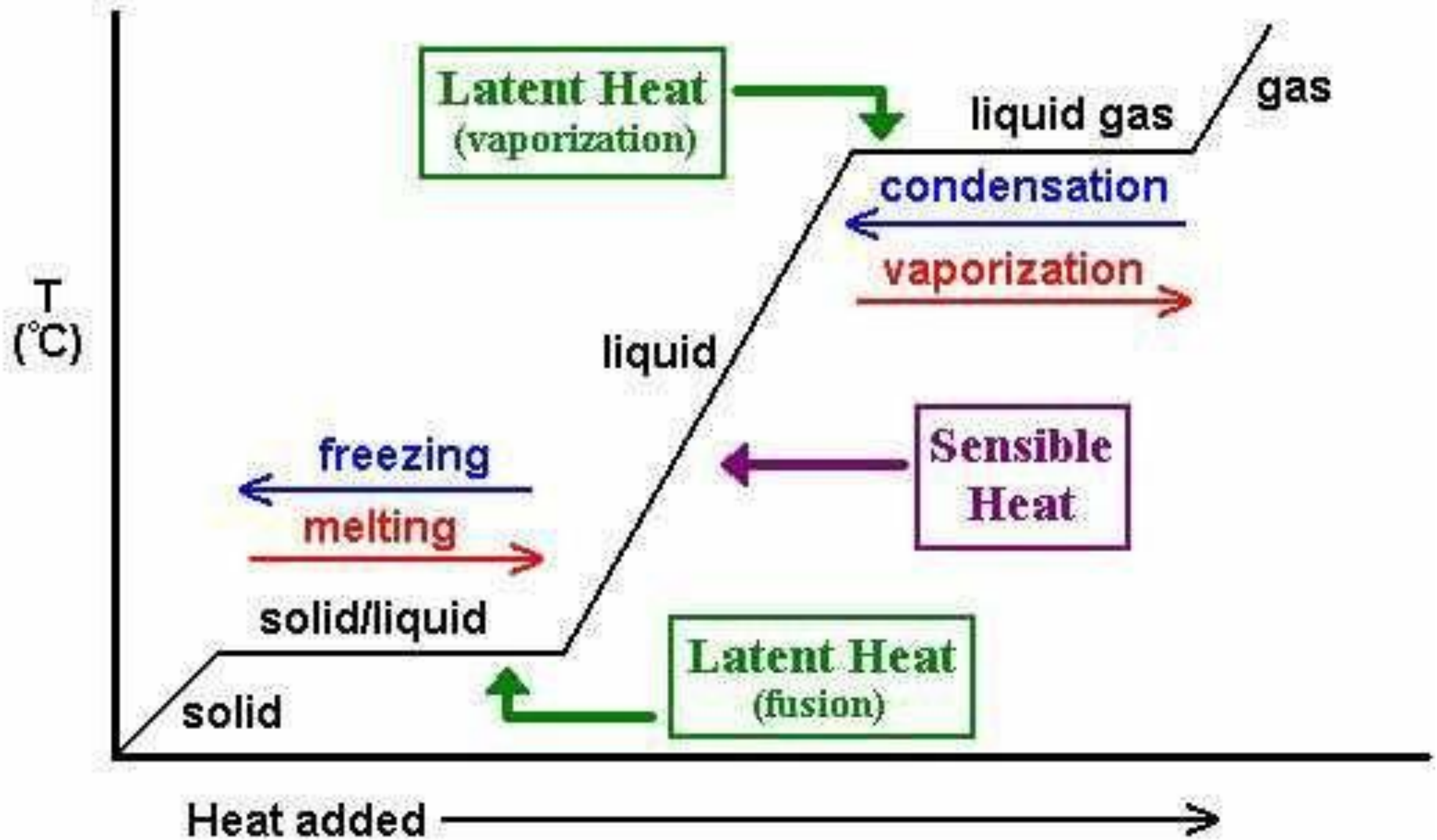
Ice melts at 0°C. 50 grams of ice at 0°C will not become liquid until additional heat is added. The amount of heat needed is:

$$Q = mL_f = 50(80) = 4000 \text{ cal}$$

In other words, it takes 4000 calories of heat to turn 40 grams of ice at zero degrees C into 40 grams of water at zero degrees C.

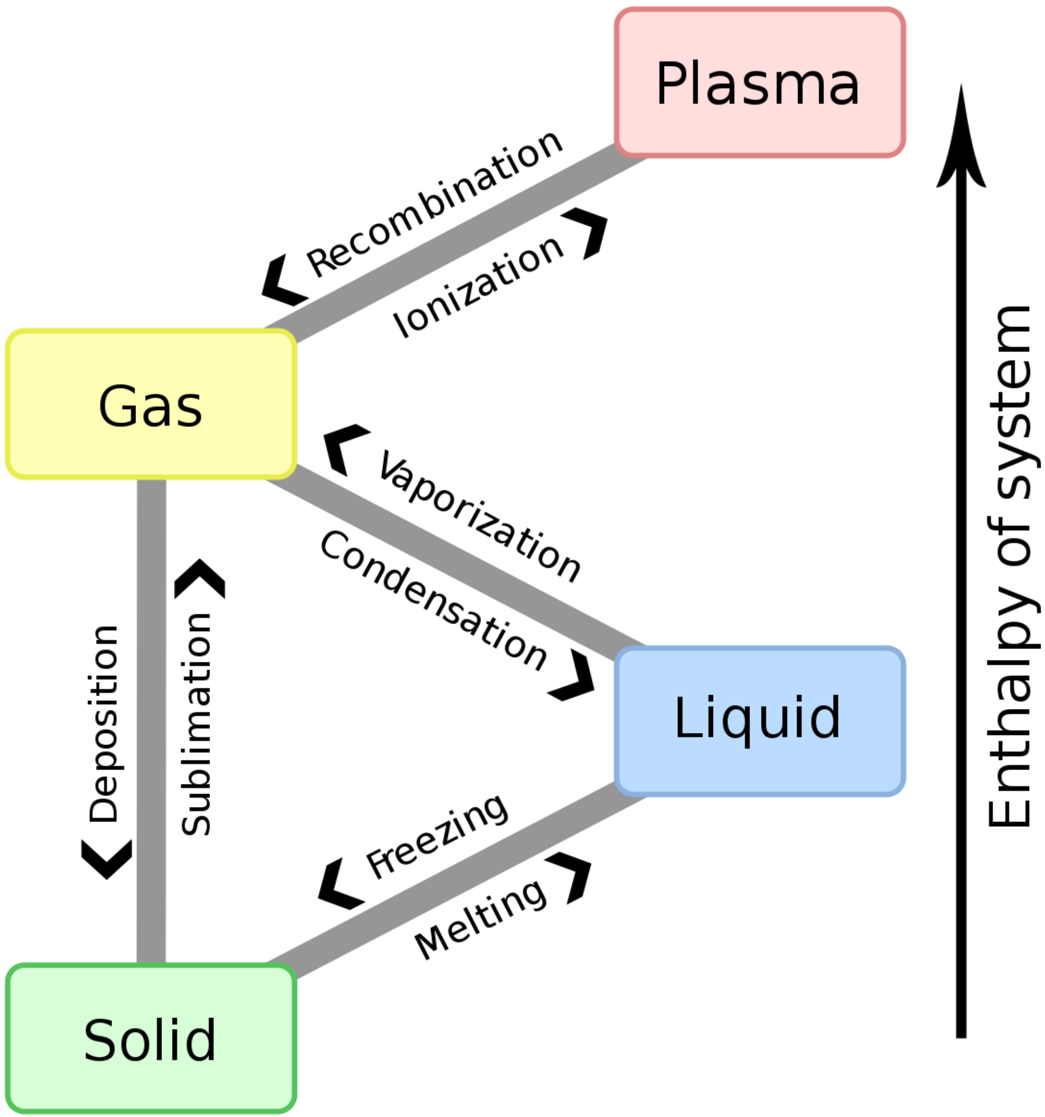
Latent Heats of Fusion and Vaporization

Substance	Melting Point (°C)	Latent Heat of Fusion (J/kg)	Boiling Point (°C)	Latent Heat of Vaporization (J/kg)
Helium	−269.65	5.23×10^3	−268.93	2.09×10^4
Oxygen	−218.79	1.38×10^4	−182.97	2.13×10^5
Nitrogen	−209.97	2.55×10^4	−195.81	2.01×10^5
Ethyl alcohol	−114	1.04×10^5	78	8.54×10^5
Water	0.00	3.33×10^5	100.00	2.26×10^6
Sulfur	119	3.81×10^4	444.60	3.26×10^5
Lead	327.3	2.45×10^4	1 750	8.70×10^5
Aluminum	660	3.97×10^5	2 450	1.14×10^7
Silver	960.80	8.82×10^4	2 193	2.33×10^6
Gold	1 063.00	6.44×10^4	2 660	1.58×10^6
Copper	1 083	1.34×10^5	1 187	5.06×10^6



T
(°C)
Latent Heat
(vaporization)
liquid gas
gas
condensation
vaporization
liquid
freezing
melting
Sensible
Heat
solid/liquid
Latent Heat
(fusion)
solid
Heat added

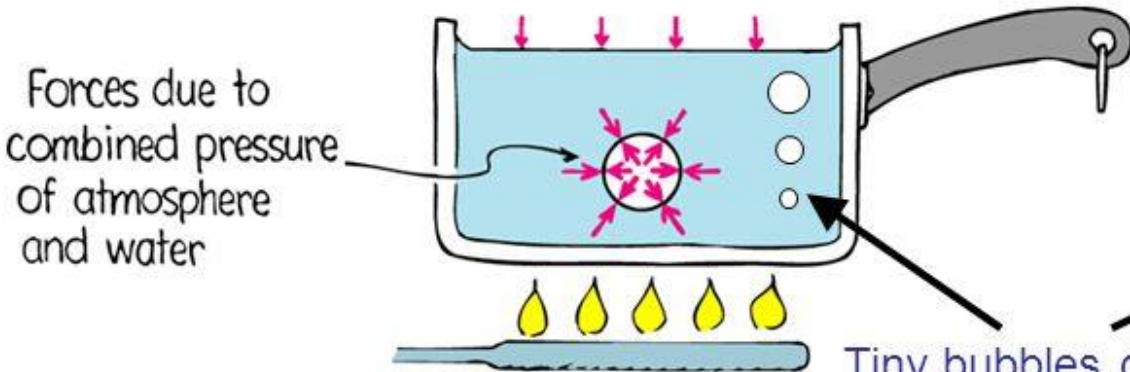
Phase Changes Between States of Matter



Boiling

When the temperature of a liquid is high enough that evaporation occurs everywhere, not just the surface, then the liquid boils.

The temperature required depends on the pressure; lower the pressure, the lower the boiling temperature (boiling point).

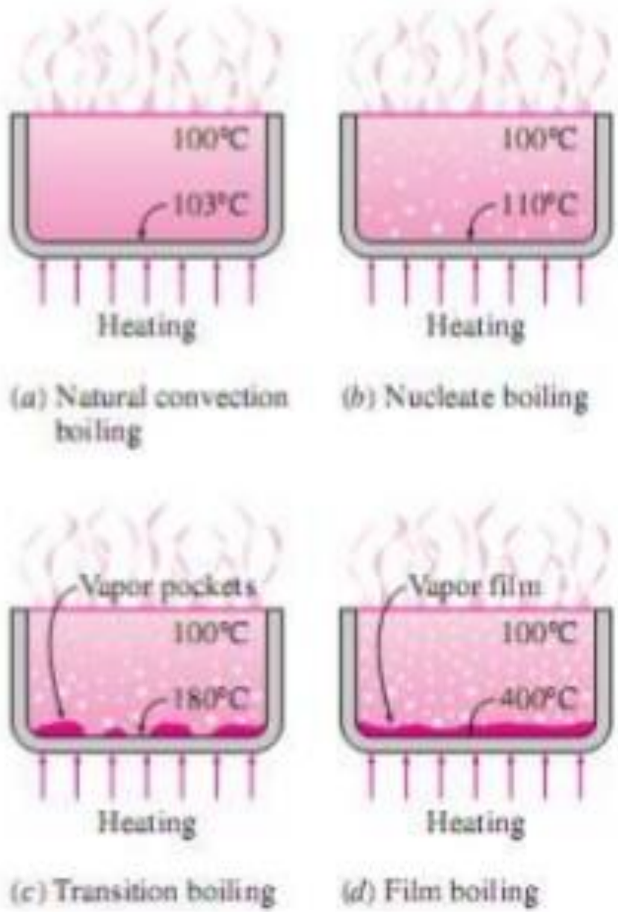


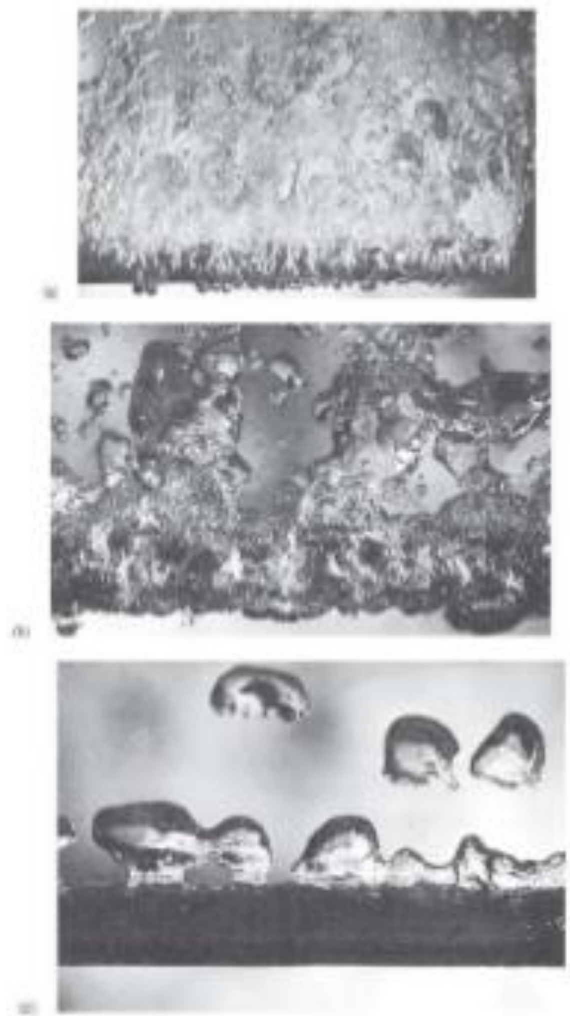
Tiny bubbles grow due to evaporation at their surface

Зависимость температуры кипения воды от давления

P (атм)	T ^{o}C		P (атм)	T ^{o}C
0.01	6.698		1.5	110.79
0.02	17.20		2.0	119.62
0.04	28.64		2.5	126.79
0.1	45.45		3.0	132.88
0.2	59.67		4.0	142.92
0.3	68.68		5.0	151.11
0.4	75.42		6.0	158.08
0.5	80.86		7.0	164.17
0.6	85.45		8.0	169.61
0.7	89.45		9.0	174.53
0.8	92.99		10.0	179.04
0.9	96.18		20.0	211.38
1.0	99.09		25.0	222.90
1.033	**100.0**		50.0	262.70
			100.0	309.53

Different boiling regimes in pool boiling



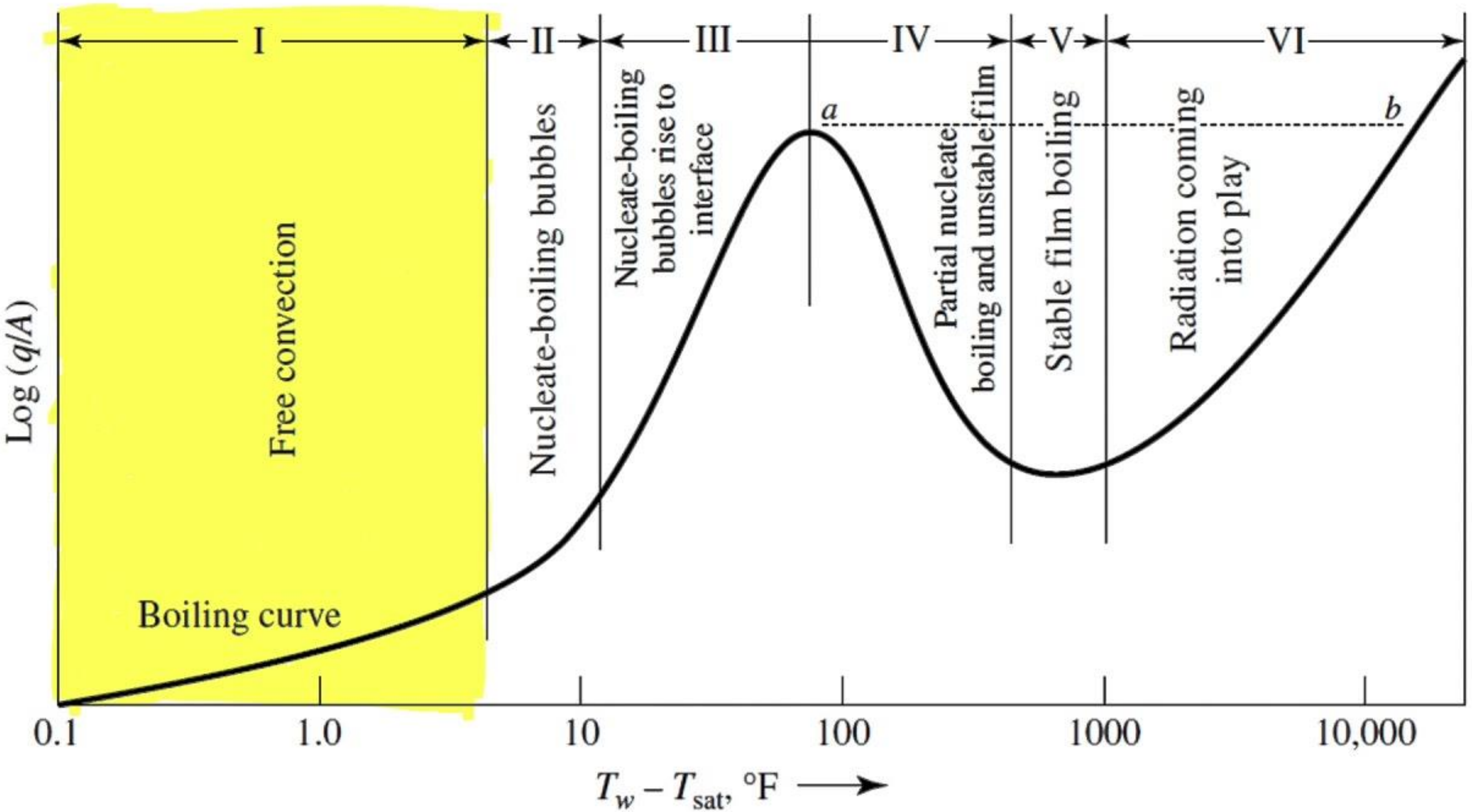


Nucleate boiling

Transition boiling

Film boiling

The 6 regimes of boiling



Critical heat flux. Leidenfrost point.