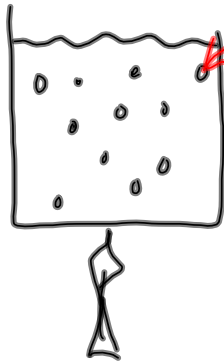# Vapour Pressure in the bubble

before the liquid
boils, there are
bubbles filled with
vapour.

pressure inside the
bubbles => vapour
pressure.

During boiling, the pressure
must be greater than or equal
to the pressure of the liquid.

The pressure of the liquid where the bubbles are is due to:

- the pressure of the atmosphere
- the pressure due to the liquid.
- the pressure due to the surface tension

If the atmospheric pressure is reduced, then the pressure
needed to form the vapour in the bubble is less => the
temperature of the liquid when it begins to boil is less.

A decrease in atmospheric pressure, depth of liquid,
or surface tension will reduce the boiling point for a
given liquid.

Evaporation

Evaporation is the process whereby some particles with above average kinetic energy are able to overcome the cohesive forces holding the liquid together and so escape from the surface.
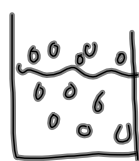
— occurs at the surface

- if below the boiling point, the mean kinetic energy is not enough for the particles to break free ..... some particles are faster and have more KE than the mean & can escape the surface.
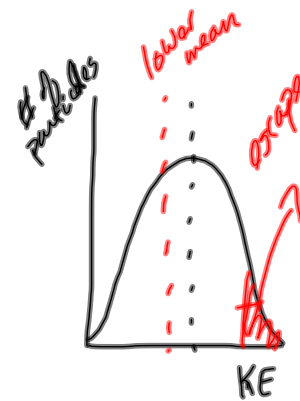
- the remaining particles with have a lower mean kinetic energy

(∴ a lower temperature)

- evaporation causes cooling!

Rate of evaporation:

- a greater surface area will increase the evaporation rate.

- if the liquid is at a hotter temperature, then the rate of evaporation will be greater.

- air flow over the surface will increase evaporation

moves escaped particles away from the surface so that there will be less collisions near the surface.

During a phase change → no change in temperature

melting/freezing → no change in temperature

boiling/condensation → no change in temperature

The bonding potential energy of the particles is changing while their random kinetic energy remains the same. The temperature ONLY depends on the random kinetic energy. So the temperature remains constant.

Evaporation → the potential energy (bonding) of the particles increases, but the random kinetic energy is decreased.

→ no heat is added

increase in PE has to come from the decrease in KE.

Boiling

bubbles of water vapour form throughout the liquid.

- change of state (vapourization to form bubbles) occurs throughout the liquid.

- a rapid process

- the mean KE of the particles is sufficient to break cohesive bonds to form a gas

- heat is required → energy added increases the potential energy of the particles but not the mean random kinetic energy (temp stays the same)

Evaporation

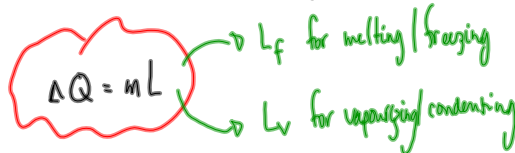higher energy particles break free from the surface; lower energy particles remain.

- change of state occurs ONLY at the surface of the liquid.

- a slow process (compared to boiling)

- the mean KE of the particles is insufficient to break free, but some have energy greater than the mean and break free.

- heat is not required → the temperature of the liquid is reduced since the slower partic! remain. (the increase in potenti energy came from the decrease in kinetic energy)
                    mean random.

(cooling effect)

Specific Latent Heat (L)

L_f — the specific latent heat of fusion. (solid $\rightleftarrows$ liq)

L_v — the specific latent heat of vapourisation (liq $\rightleftarrows$ gas)

units: $J \, kg^{-1}$

water/ice : $L_f = 334 \; J \, kg^{-1}$
              $L_v = 2260 \; J \, kg^{-1}$

$$\Delta Q = mL$$
→ L_f for melting / freezing
→ L_v for vapourising / condensing

Why does a burn from steam at 100°C cause more injury that a burn from boiling water at 100°C ?

water → heat from the water going into your body until cooled to an equilibrium temp

steam → heat from the steam condensing + the heat from water now 100°C going into your body. until cooled to an equilibrium temp.

Example
An immersion heater can supply heat at a rate of 5.2×10² W $5.2 \times 10^2 \; J/s$
Calculate the time (in minutes) it will take to completely
evaporate 1.25×10^{-1} kg of water initially at 21°C
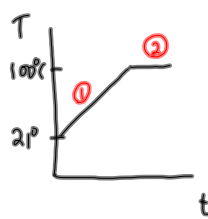
① Heat the water from 21°C to 100°C

$\Delta Q = mc \Delta T$
$\Delta Q = (1.25 \times 10^{-1} kg)(4.2 \times 10^3 J \, kg^{-1} \, °C^{-1})(79°C)$
$\Delta Q = 41475 J$

② Vapourization @ 100°C

$\Delta Q = m L_v$
$\Delta Q = (1.25 \times 10^{-1} kg)(2260 \; J \, kg^{-1})$
$\Delta Q = 282.5 J$

```
  41475 J
    282.5 J
 _____
  41757.5 J
```
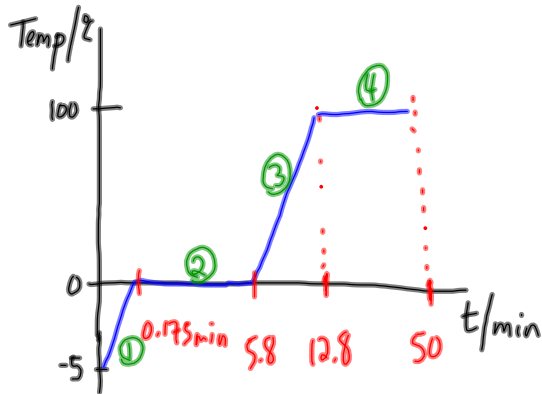
$$P = \frac{W}{\Delta t}$$

$$\Delta t = \frac{W}{P}$$

$$\Delta t = \frac{41757.5 J}{5.2 \times 10^2 \; J \, s^{-1}}$$

$$\Delta t = 80 s$$

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Example

- 100W heater is placed in $\overset{(exactly)}{0.1 \text{ kg}}$ of ice at $\overset{(exactly)}{-5°c}$
  heated until it turns to water, boils + turns completely to Vapour
- Using the data, calculate the critical points, in minutes, on
  the time axis for this process.

$$C_{ice} = 2.10 \times 10^3 \text{ J kg}^{-1} K^{-1}$$

$$C_{water} = 4.18 \times 10^3 \text{ J kg}^{-1} K^{-1}$$

$$L_f = 3.34 \times 10^5 \text{ J kg}^{-1}$$

$$L_v = 2.25 \times 10^6 \text{ J kg}^{-1}$$

① Heating ice from $-5°c$ to $0°c$:

$$\Delta Q = m C_{ice} \Delta T$$

$$\Delta Q = (0.1 \text{ kg})(2.10 \times 10^3 \text{ J kg}^{-1} °c^{-1})(0 - (-5°c))$$

$$\Delta Q = 1050 \text{ J}$$

$$P = \frac{\Delta Q}{\Delta t}$$

$$\Delta t = \frac{\Delta Q}{P}$$

$$\Delta t = \frac{1050 \text{ J}}{100 \text{ J s}^{-1}}$$

$$\boxed{\Delta t = 10.5 \text{ s}}$$

$$\frac{10.5 s}{60 s} = 0.175 \text{ min}$$

② melting the ice (phase change) $\Delta Q = m L_f$