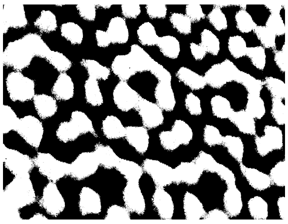
KINETIC THEORY AND THERMODYNAMICS

1. Basic ideas

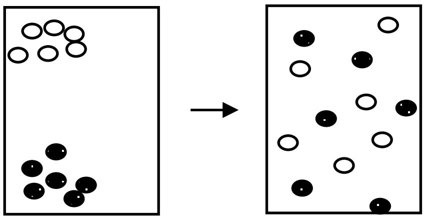
Kinetic theory – based on experiments, which proved that

a) matter contains particles and quite a lot of space between them
b) these particles always move
c) if the particles are very close to each other, they repel and if they are further apart, they attract

ad a) atoms (10^{-10}m) observed by electron microscopes, scanning tunnelling microscopes...



a)



b)

ad b) diffusion – particles of two or more substances mix because of their random chaotic motion

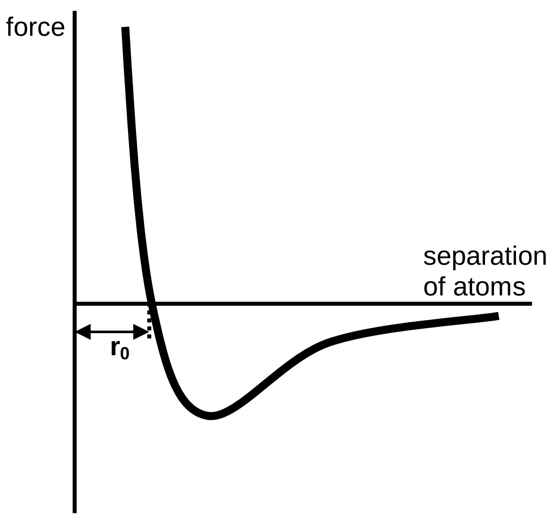
Brownian motion (1827 Robert Brown) – pollen grains suspended in a liquid exhibit a „jerky“ motion

http://phet.colorado.edu/simulations/sims.php?sim=Gas_Properties

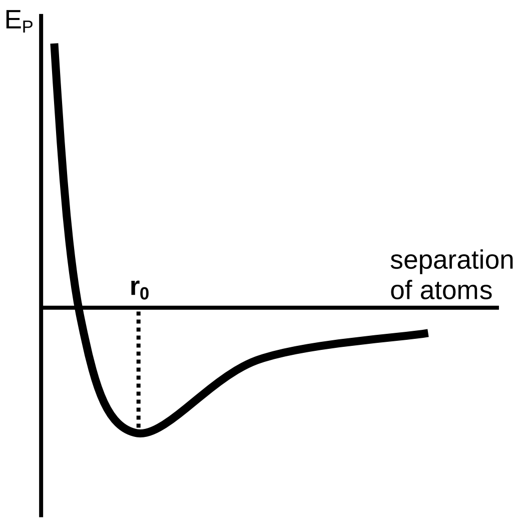
http://galileo.phys.virginia.edu/classes/109N/more_stuff/Applets/brownian/brownian.html

ad c) stretching and compressing materials (metals ...)

force-separation graph



potential energy-separation graph



r_0 ... equilibrium separation

Questions:

1. Find information about the ways how atoms and molecules can be “seen”.
2. What did Brownian motion prove?
3. Describe the force-separation graph. What does it represent?

2. Interatomic bonds

Use the materials provided to fill in the following table:
work out how each of the bonds is formed, which types of atom can it affect, what are the properties of the substances having this bond (mechanical, electrical, melting point etc.) and give some examples.

bond	covalent	ionic	metallic	van der Waals
example				
describe the bond				
properties of the substances				

Questions:

4. Describe the ionic, covalent, metallic and van der Waals bond. Mention its mechanical and electrical properties. Find typical representatives.

3. Models of substances in different states of matter

Use different resources to find information about a typical solid liquid and gas. Compare their internal kinetic and potential energies, distance between the particles and their type of motion.

	solid	liquid	gas
internal kinetic energy - motion of particles			
internal potential energy - strength of bonds			
other important data			

Questions:

5. Describe a typical solid, liquid and gas using the idea of internal kinetic and potential energy.

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4. Heat and temperature

- **Thermal equilibrium** (Prévost 1792)

If the amount of heat absorbed by an object from its surroundings during a certain time interval equals the heat released by the object during the same time, the object is in thermal equilibrium with its surroundings and they have the same temperature.

- **Temperature scales**

Celsius scale: freezing point – 0 °C, boiling point – 100 °C

Kelvin scale (thermodynamic scale):

no negative values, 0 K = -273.15 °C ... absolute zero

$\{\Delta T\} = \{\Delta t\}$ ... temperature change in K is the same as in °C

273.15 K =	°C	-150 °C =	K
600 K =	°C	0 °C =	K
5 000 K =	°C	20 °C =	K

Fahrenheit scale

$\{\vartheta\} = (\frac{9}{5}\{t\} + 32)$ $\{t\} = \frac{5}{9}(\{\vartheta\} - 32)$

32 °F =	°C	37 °C =	°F
212 °F =	°C	-150 °C =	°F

- **Temperature measurement**

Temperature change is converted into changes of other quantities

a) $\Delta t \rightarrow \Delta V$

Mercury (ethanol)-in-glass thermometer – the substance used must have a big ....

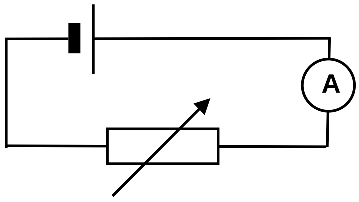
so that ....of the medium rises easily when the temperature.....................

Bimetallic thermometer – two metals sealed together bend when heated because the two metals

have different.. This is used in.........................

choose: rises, thermometers and kettles, linear expansivity, volume expansivity, volume *b)* $\Delta t \rightarrow \Delta R$ (changes in electric current are measured)

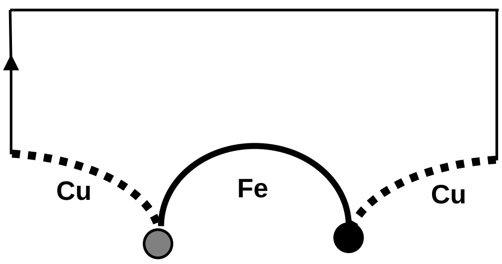
Platinum resistance thermometer (metal - t↑⇒ R↑)



Thermistor thermometer (semiconductor - t↑⇒ R↓)

c) $\Delta t \rightarrow$ *current produced*

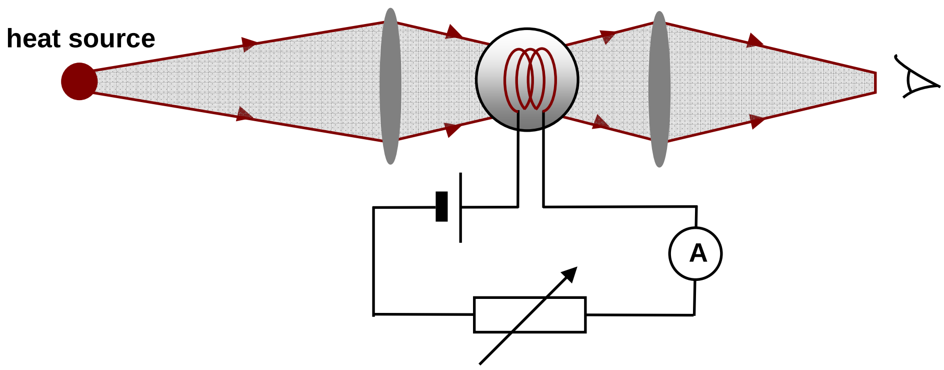
Thermocouple thermometer – Cu-Fe-Cu, 2 junctions, one heated – very small current flows ⇒ source of electric current



d) comparison of colours – non-contact method for extreme temperatures

Optical pyrometer (has to be calibrated, for one substance)

http://www.pyrometer.com/



Thermovision – different „colour“ for each temperature of the object, observed by a special „camera“

http://www.nationalinfrared.com/x20/shop/pshow.php?SKU=IR-595

Questions:

6. The calculations connected with calorimetric equation you have done in previous years were done in degrees Celsius. Does it mean that the results were wrong? Explain.
7. Describe the methods of temperature measurement. What are they based on?
8. Ethanol can be used instead of mercury in thermometers. What is the property of ethanol that makes it suitable for this use?
9. What are the properties of the two metals used in bimetallic thermometer?
10. Why does the resistance of a metal increase /semiconductor decrease/ with the rising temperature?
11. Why do we need non-contact methods of temperature measurement?
12. What is the advantage of a thermocouple?

5. Isolated system and quantities that describe it

The object or substance can be at a different state of matter, its particles can be arranged in different structures – for example carbon in graphite and diamond. So the object can be in a different **state.** Such a system is called a **thermodynamic system**. Gas in a closed container, water and its vapour in a flask are examples of a system. A thermodynamic system can be determined by physical quantities that describe its state. The basic ones are **pressure, volume, temperature, mass**, number of moles, number of particles etc.

isolated system – does not exchange particles or energy (heat, work) with its surroundings
closed system – does not exchange particles with its surroundings
open system – can exchange both particles and energy with its surroundings
adiabatically isolated system – no heat exchange with its surroundings

We describe processes, in which the thermodynamic system changes from one "initial" state into another "final" state.

When outer conditions stay constant, any thermodynamic system will gradually get into equilibrium with its surroundings.

Questions:

13. Give the basic macroscopic physical quantities that are used to describe a thermodynamic system.
14. Describe the differences between an isolated, closed and adiabatically isolated system. Give examples from everyday life.