



**EXERCISE
32**

DETERMINATION OF STEFAN-BOLTZMANN CONSTANT

Measurement instruction

1. List of equipment,

- | | |
|-----------------------|--|
| 1) Power generator, | 6) Experimental set with two bodies:
black body and non-black body, |
| 2) Voltmeter, | 7) Thermos, |
| 3) Ammeter, | 8) Thermocouple, |
| 4) Temperature meter, | |
| 5) Electric wires, | |

2. Scope,

A determination of the Stefan-Boltzmann constant. Equal temperature and Equal power methods are examined (the equality concerns two bodies).

3. Measurement setup,

An experimental set with two bodies (black & non-black), with a switch and electric sockets.

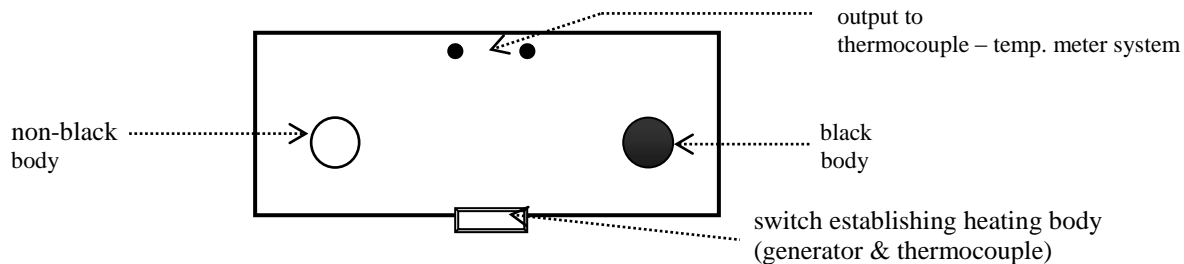


Fig 1. A scheme of the measurement setup (a view from the top).

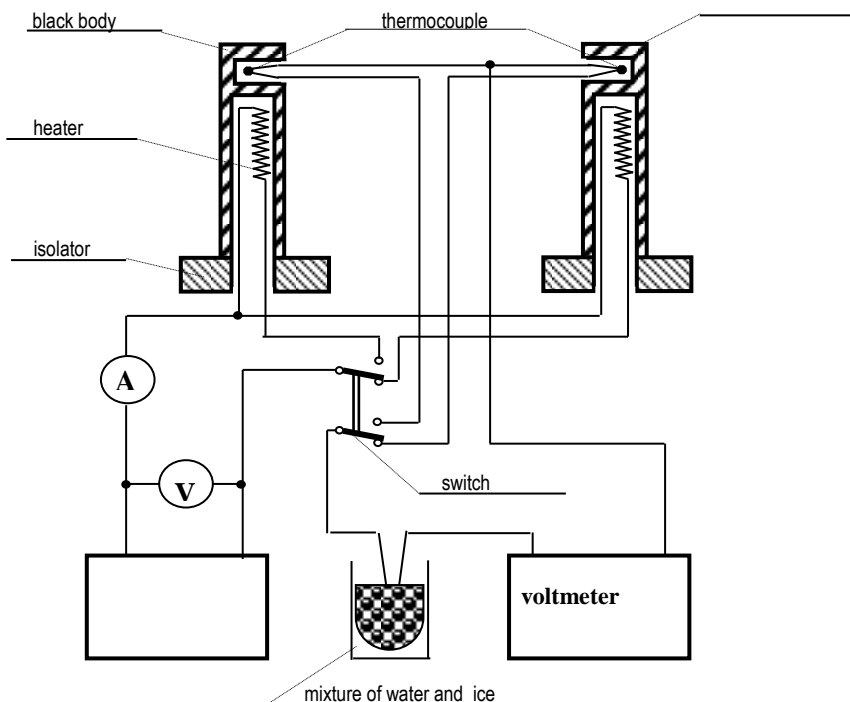


Fig. 2. A detailed wiring diagram.

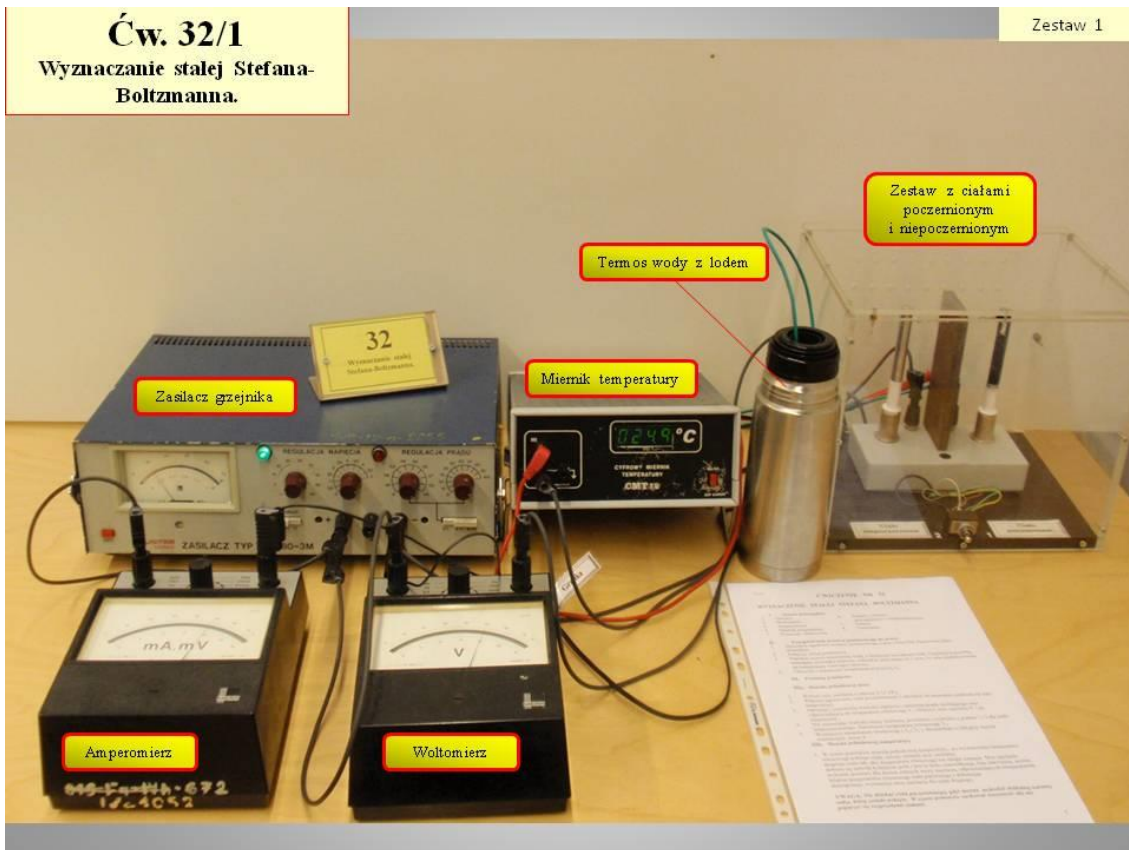


Fig.3. A picture of the measurement setup.

4. Measurement procedure,

- 1) Compare equipment with the list provided in the first section. Write down types of meters available in the laboratory (for your measurement setup).
- 2) Prepare your measurement setup in agreement with all attached figures.
- 3) Fill up the thermos with a mixture of water and ice. Place one end of the thermocouple in this mixture. Wait for about 2 – 3 minutes (this allows a reference temperature to stabilize within the thermos).
- 4) Write down a room temperature, T_0 .

An equal power method (the equality concerns two bodies),

- 1) Make sure that the power supplied to the measurement circuit is approximately 5-15 [W].
- 2) Turn on a heating of a black body and wait until its temperature, T_c , has established.
- 3) Write down a voltage drop, a current in the measurement circuit, together with a temperature in the equilibrium, T_c . Calculate the power in your circuit and its uncertainty.
- 4) Turn on a heating of a non-black body (use the switch). Repeat steps from two previous points. Do not change the supplied power.
- 5) Determine temperatures of both bodies (T_c and T_n) for different values of a power, P (always the same for non-black and black elements).

An equal temperature method,

- 1) Select the power supplied to the measurement circuit. Establish a temperature of a black body, T_c .

- 2) Change the power in the measurement circuit so that a temperature of a non-black body, T_n , equals to the recently-established temperature of a black body, T_c . This can be a time-consuming process.
- 3) It is possible to measure a temperature of a non-black body for two different powers, and then extrapolate the power, P , corresponding to the temperature of interest, $T_n = T_c$.

5. Report

- 1) Determine the Stefan-Boltzmann constant from measurement results (obtained during experiments conducted in equal powers, as well as in equal temperatures). Assume that the total surface of each body is $S = 2,74 \cdot 10^{-3} [\text{m}^2]$, $\Delta S/S = 2$.
- 2) Establish an uncertainty for every σ (for a single setup – constant power in the case of an equal power method, and a constant temperature in the case of an equal temperature method).
- 3) Compare results. Comment on the precision of measurements.
- 4) Prepare an average of all σ . Compare the latter value with a the Stefan-Boltzmann constant available in literature.

6. Additional remarks,

WARNING: The set with two bodies has to remain inside a plexiglass cover during experiments. This protects a thin layer of soot located on a surface of a black body and hands from burns. This plexiglass cover heats up during measurements. It is important to take this into account while preparing a report.

7. Exemplary tables,

Table 1. Exemplary table for a determination of the Stefan-Boltzmann constant (Protocol).

no	T_0 [°C]	U [V]	I [mA]	P [W]	T_c [°C]	T_n [°C]
1						
2						
3						
⋮						
n						

Table 2. Exemplary table for a determination of the Stefan-Boltzmann constant (Report).

no	T_0 [°C]	U [V]	I [A]	P [W]	T_c [°C]	T_n [°C]	$\sigma \left[\frac{\text{W}}{\text{m}^2 \text{K}^4} \right]$
1							
2							
3							
⋮							
n							
\bar{X}							
ΔX							
$u(X)$							
$u_c(X)$							