EXERCISE 20a	THERMOCOUPLE SCALING AND WATER SOLIDIFICATION TEMPERATURE DETERMINATION

Measurement procedure

1. List of equipment

1) Heater
2) Thermometer
3) Voltmeter
4) Pot with water
5) Thermos with mixture of ice and water
6) Thermocouple
7) Pot for mixture of ice and water with salt
8) Glass bottle for water/ice
9) Timer
10) Syringe

2. Goals

1) Thermocouple scaling and determination of the thermocouple thermoelectric coefficient.
2) Water solidification temperature determination.

3. Measurement setup

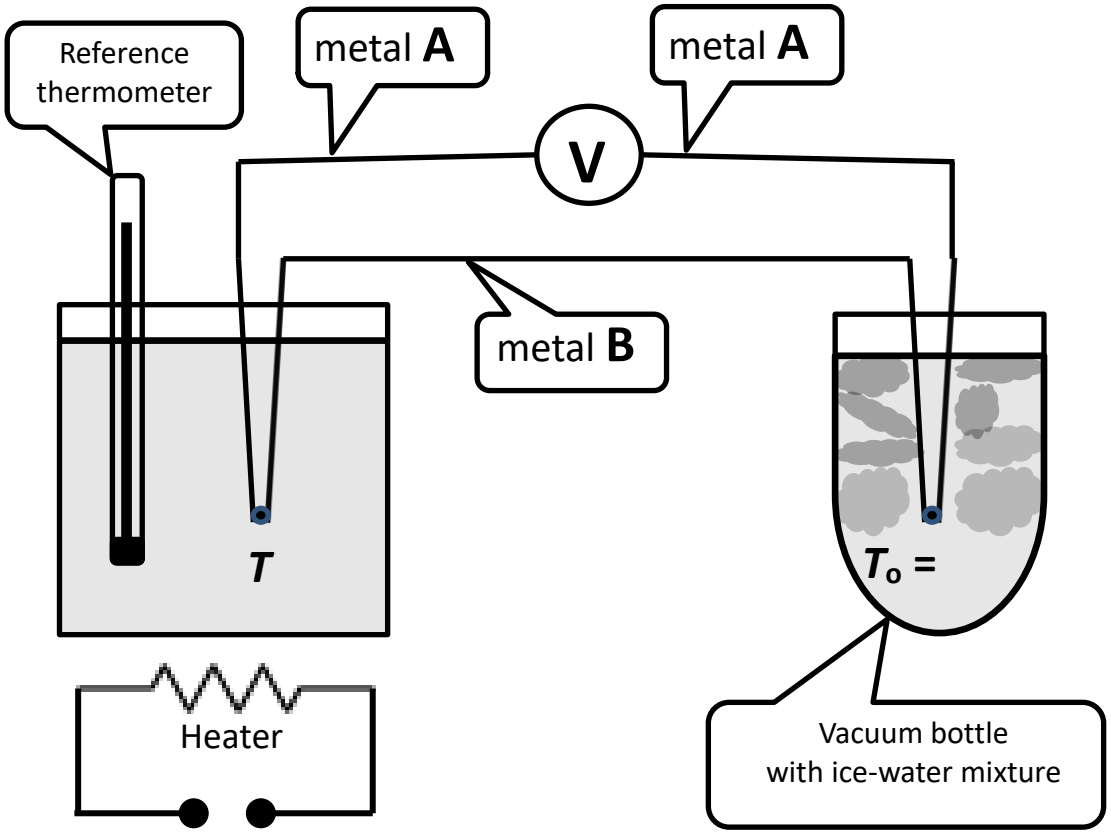

Fig. 1. Thermocouple scaling setup diagram.

Fig. 2. Experimental setup.

4. Measurements plan

4.1. Thermocouple scaling, i.e. determination of $U = f(T)$ dependence – how thermocouple thermoelectric voltage U depends on the temperature of one of the contacts T while the second thermocouple contact is kept at constant (reference) temperature $T_o = 0°C$.

a) Fill the vacuum bottle with ice with water mixture.
b) Fill the pot with water up to approximately 2 cm below its edge. Cover the pot with a lid and put it on the heater.
c) Insert one thermocouple contact into the vacuum bottle and the second one, through the hole in the lid, into the pot (confirm if it is immersed in water).
d) Turn on the thermometer and insert it into the pot through the second hole in the lid.
e) Connect the thermocouple to the voltmeter (see Fig. 1.) and switch it on.
f) Switch on the heater.
g) Measure the voltage temperature dependence from 24 to 60°C with a 2°C step.
h) After finishing the measurements, turn off the heater. **Do not pour out the water before it cools down!**

4.2. Water solidification temperature determination

a) Fill the thermal vessel 1/3 with cold water, add a flat spoon of salt and wait for it to dissolve (stir). Fill the vessel up to 2/3 with ice from the freezer (from room 51).
b) Draw up about 5 ml of warm tap water into the syringe. Pour the water into the glass bottle. Close the vessel with a stopper.
c) Take the junction of the thermocouple out of the pot lid and place it in a pan with warm water so that the thermocouple is immersed in the water but not touching the pan.
d) Gently attach the dish to the tripod and immerse it in a solution of ice, water and salt.
e) Start the stopwatch and during the water cooling process (approx. 25 minutes), note the time and thermoelectric voltage every 20 seconds.

5. Analysis of results

5.1. Thermocouple scaling and determination of the thermoelectric coefficient α

1. Plot the voltage temperature dependence $U = f(T)$.
2. Mark uncertainties on the graph for a few chosen points.
3. Determine the thermocouple thermoelectric coefficient α and its uncertainty using linear regression method (the plotted dependence has a form $U = \alpha \cdot T$).

5.2. Water solidification temperature determination

1. Plot the voltage time dependence in the cooling process $U = f(t)$.
2. Following the teacher recommendation, choose one of the methods below to determine the alloy solidification voltage U_k.

Method 1

Determine the voltage U_k and its uncertainty from the graph as illustrated in Fig. 3.

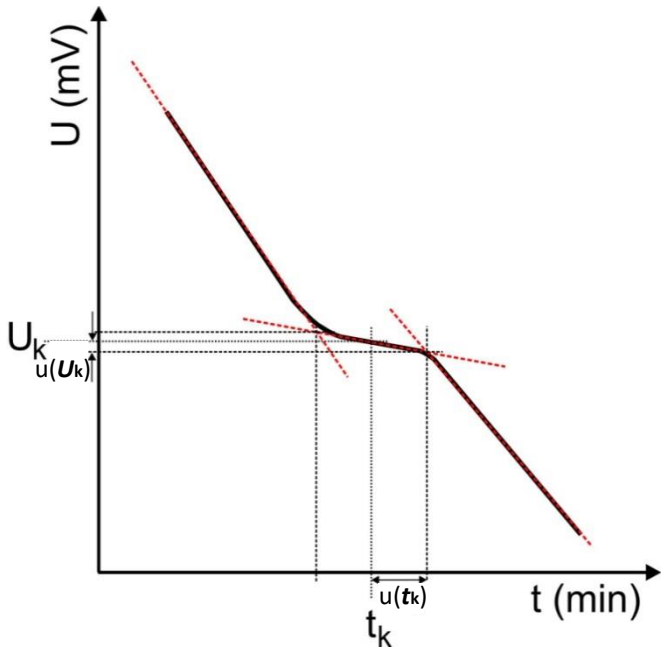

Fig. 3. Determination of the voltage U_k and its uncertainty.

Method 2

Calculate the voltage U_k as an arithmetic mean of voltage values in the range of plateau. Its uncertainty calculate as a standard uncertainty of these voltage values, where the instrument uncertainty corresponds to the mean uncertainty of the voltmeter in the range of plateau.

3. Determine the water solidification temperature T_K and its uncertainty according to the formula:

$$T_K = \frac{U_K}{\alpha}. \qquad (1)$$

6. Suggested measurement tables

6.1. Thermocouple scaling

no.	T [°C]	$u(T)$ [°C]	U [mV]	$u(U)$ [mV]	α [mV/°C]	$u(\alpha)$ [mV/°C]
1						
2						
3						
…	…	…	…	…		

6.2. Water solidification temperature determination

no.	t [s]	$u(t)$ [s]	U [mV]	$u(U)$ [mV]	U_K [mV]	$u(U_K)$ [mV]	T_K [°C]	$u(T_K)$ [°C]
1								
2								
3								
…	…		…	…				