INTERNAL ENERGY AND ELECTRICAL WORK

EXPERIMENT PROCEDURE

- **Measure the temperature of aluminium and copper calorimeters as a function of the electrical work done.**
- **Check that the change in temperature is proportional to the electrical work and verify the first law of thermodynamics.**
- **Determine the specific heat capacities of copper and aluminium.**

OBJECTIVE

Increase internal energy by means of electrical work.

SUMMARY

This experiment investigates how the internal energy of copper and aluminium calorimeters can be increased by electrical work. As long as the aggregate state does not change and no chemical reactions occur, it is possible to determine the increase in internal energy from the rise in temperature to which it is proportional. In order to prevent heat being transferred from the calorimeters to their surroundings, the series of measurements should start at a temperature somewhat below the ambient temperature and finish at a temperature only slightly above that of the surroundings.

REQUIRED APPARATUS

Quantity	Description	Number
1	Copper Calorimeter	**1002659**
1	Alumiunium calorimeter	**1017897**
1	Temperature sensor	**1017898**
1	Pair of adapter cables with 4 mm safety plugs/2 mm plugs	**1017899**
1	Pair of Safety Experimental Leads, 75cm, red/blue	**1017718**
1	Digital Multimeter P1035	**1002781**
1	DC Power Supply 0 – 20 V, 0 – 5 A (230 V, 50/60 Hz)	**1003312 or**
	DC Power Supply 0 – 20 V, 0 – 5 A (115 V, 50/60 Hz)	**1003311**

GENERAL PRINCIPLES

The internal energy of a system can be increased not only by mechanical work but also by electrical work. In both cases, the temperature of the system rises in linear proportion to the work done, as long as there is no change in the aggregate state and no chemical reactions occur.

This experiment investigates how the internal energy of copper and aluminium calorimeters is increased by electrical work. This is proportional to the applied voltage U, the current I which flows and the time the measurement is made t:

(1) $$\Delta W_E(t) = U \cdot I \cdot t$$

This electrical work causes the temperature of the calorimeter to rise from an initial value T_0 to a final value T_n. Therefore the internal energy rises by the following amount:

(2) $$\Delta E(t) = m \cdot c \cdot (T(t) - T_0)$$

m: mass of calorimeter
c: specific heat capacity of material

In order to minimise transfer of heat to the surroundings as far as possible, the calorimeter is initially cooled down to a start temperature of T_0 before any measurements are made. This should be only slightly lower than the ambient temperature. Measurement is halted when a final temperature T_n is attained, which is equally as far above the ambient temperature as the initial temperature was below it.

Under such conditions, the change in internal energy should be equal to the work done, meaning that the following applies:

(3) $$\Delta E(t) = \Delta W_E(t)$$

EVALUATION

An NTC temperature sensor is used to measure the temperature T by measuring its resistance, which depends on the temperature. The following applies

$$T = \frac{217}{R^{0.13}} - 151$$

The temperatures measured in this way are plotted against the electrical work. The heat capacity of the calorimeters can be determined from the slope of straight lines in the graphs and as long as their mass is known, it is then possible to calculate the specific heat capacity.

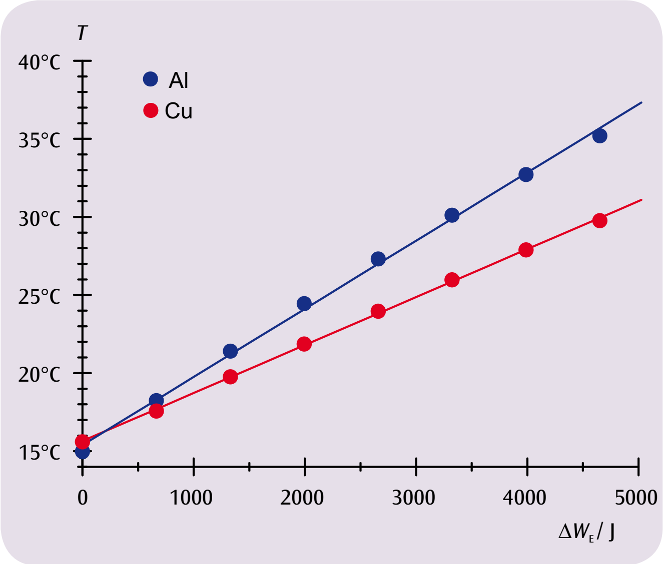

Fig. 1: Calorimeter temperature as a function of electrical work

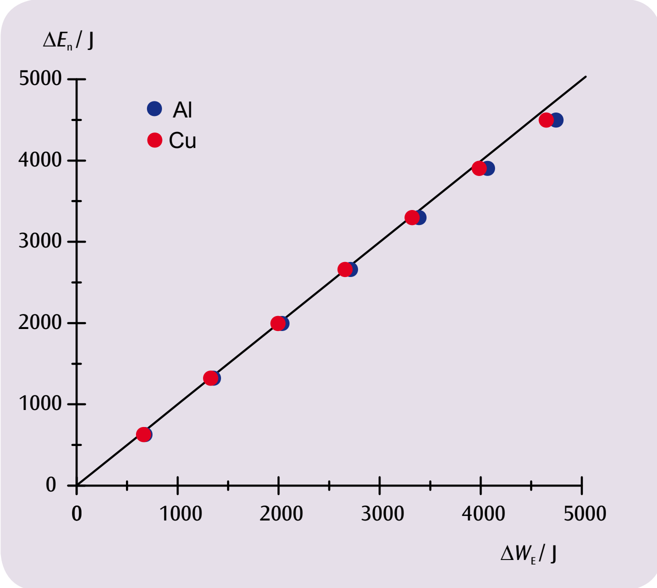

Fig. 2: Change in internal energy as a function of electrical work done