A model of a lead accumulator is to be used to demonstrate how electrical energy can be chemically stored for later use.

Equipment

Physics demonstration board, with frame	02150.00	1
Connector, straight, DB	09401.01	1
Connector, angled, DB	09401.02	4
Connector, T-shaped, DB	09401.03	1
Connector, interrupted, DB	09401.04	4
Junction, DB	09401.10	2
Switch on/off, DB	09402.01	1
Reverse switch, DB	09402.02	1
Clamp on fixing magnet	02151.01	1
Motor, 2 V	11031.00	1
Disc for motor, 2 V	11031.01	1
Support plate with holder, DB	09471.00	1
Pneumatic trough, 100 x 50 x 120 mm	06620.00	1
Plate electrode holder	06618.00	2
Lead electrode 76 mm x 40 mm	45215.00	2
Connecting cable, 25 cm, red	07360.01	1
Connecting cable, 25 cm, blue	07360.04	1
Connecting cable, 50 cm, red	07361.01	1
Connecting cable, 50 cm, blue	07361.04	1
Connecting cable, 100 cm, red	07363.01	3
Connecting cable, 100 cm, blue	07363.04	3
Power supply, universal	13500.93	1
Analog demonstration multimeter ADM 2	13820.00	2
Electr. symbols f. demo-board	02154.03	1
Sulphuric acid, 10%, tech. gr., 1000 ml	31828.70	1
Spoon with spatula end, 18 cm, plastic	38833.00	1
Sandpaper, medium, 1 from	01605.02	(1)
Distilled water		
Absorbent cloth or paper		

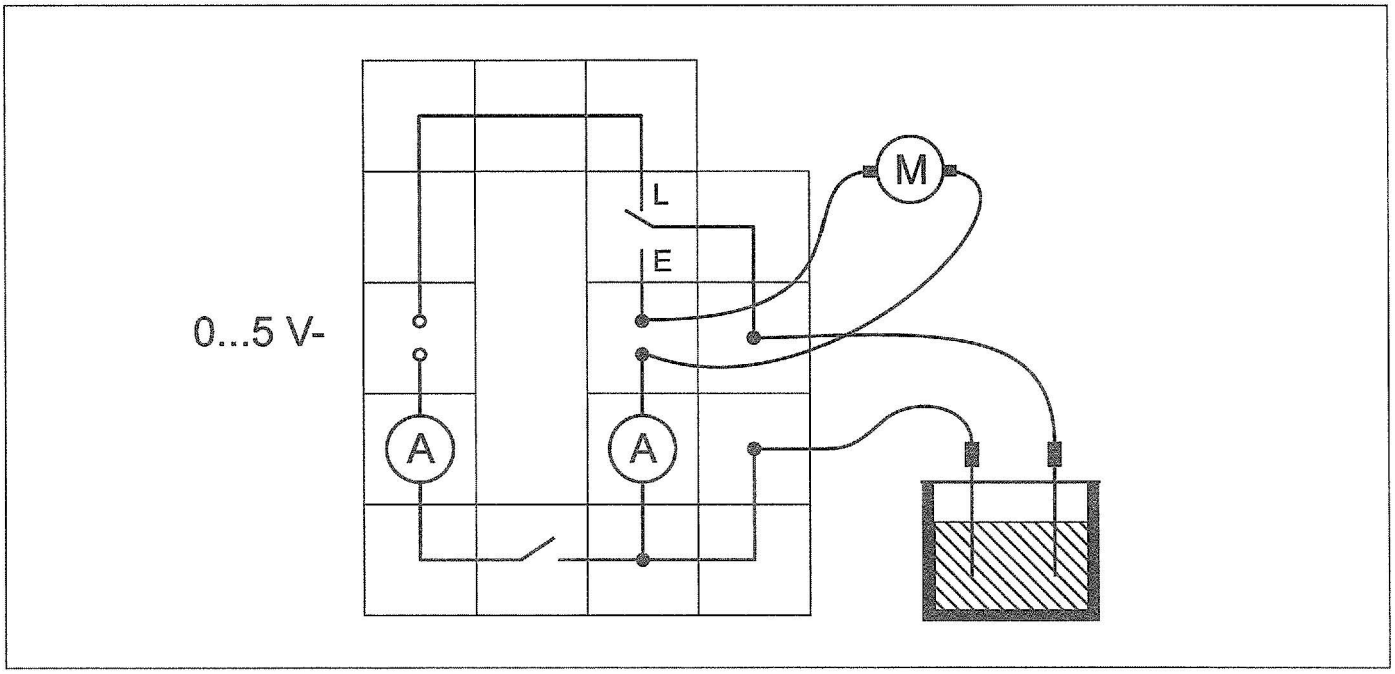
Safety Precautions

R: 36/38/61-62-E20/22-33
S: 26/53-37-45
Dilute sulphuric acid is highly corrosive to skin, eyes and mucous membranes. Aerosols irritate the respiratory organs. Lead is a hazard to health. Carry out cleaning of the lead electrodes in a fume cupboard if possible! Wear protective gloves! Wash hands at the end of the experiment.
Wear eye protection!

Set-up and Procedure

— Half-fill the cleaned glass trough with distilled water, add about 50 ml of sulphuric acid and stir
— Dip the lead electrodes, thoroughly cleaned with sandpaper and held in the holders, in the solution and set up the experiment as shown in Fig. 1
— Set the measurement range 300 mA- for the charging current, and the measurement range 100 mA- for the discharging current
— Switch on the power supply, close the switch, then turn the reverse switch to position L (load)
— Adjust the charging current to about 200 mA and load the cell for about 20 seconds
— Interrupt the charging process using the on/off switch; disconnect the charging current measuring instrument from the building block, set the 3 V- measurement range and measure the voltage directly across the lead electrodes; note the measured value (1)

Fig. 1



— Fit the measuring instrument with 300 mA- measurement range back in the position it had when the experiment was started
— Turn the reverse switch to position E (discharge) and so close the discharging circuit; observe the running time of the motor and the direction of the discharging current; note the direction of the discharging current (2)
— Turn the reverse switch to L, repeat the charging and discharging process; again observe the running time of the motor; compare it with that previously observed (3)
— Repeat the charging process once again, open the switch, take the electrodes out of the solution, rinse them with water and describe the changes in the electrode surfaces (4)

Waste Disposal

Dilute remainders of acids with water, neutralize them (pH 6-8) and flush then to drain.

Pour solutions containing heavy metal ions or salts into an appropriately labelled container and subject them to proper disposal.

Observations and Measurement Results

(1) U = 1.9 V
(2) The discharging current flows in the opposite direction to the charging current
(3) The running time of the motor is longer than that previously noted
(4) The lead plate that was connected to the positive pole of the charging current source, the anode, has become blackish-brown in colour, the surface of the cathode looks like clean lead.

Evaluation

A lead accumulator consists in its simplest form of an aqueous solution of sulphuric acid, with two electrodes in the form of lead plates protruding into it. When electrical direct current is passed through this arrangement, which is called a cell, then electrical energy is stored and the cell is so brought to a condition in which it can supply electricity.

Charging and discharging currents flow in opposite directions The voltage of a charged cell is about 2 V.

The ability of the accumulator cell to store electrical charge, i.e. electrical energy, and again release it, is the result of the chemical reactions that take place during charging and discharging:

Prior to application of a voltage, H_2SO_4 is already dissociated, and the two lead electrodes become coated with lead sulphate ($PbSO_4$).

The cathode accepts electrons. Its surface is reduced to pure lead:

$$PbSO_4 \rightarrow Pb^{2+} + SO_4^{2-}$$
$$Pb^{2+} + 2e^- \rightarrow Pb$$

$$PbSO_4 + 2e^- \rightarrow Pb + SO_4^{2-}$$

The anode releases electrons and binds oxygen. Lead oxide is formed from lead sulphate on its surface:

$$PbSO_4 \rightarrow Pb^{2+} + SO_4^{2-}$$
$$Pb^{2+} \rightarrow Pb^{4+} + 2e^-$$
$$Pb^{4+} + 2H_2O \rightarrow PbO_2 + 4H^+$$

$$PbSO_4 + 2H_2O \rightarrow PbO_2 + 4H^+ + SO_4^{2-} + 2e^-$$

During discharging, the chemical processes are reversed. The anode accepts electrons and the cathode releases exactly the same number of electrons.

Remarks

From observation (3) it follows that the capacity of the lead accumulator increases when it is successively charged and discharged several times. This process is called forming the accumulator.

The capacity of an accumulator is measured in Ah (ampere hours).