H28354 **S-Range Digital Joulemeter** **NFU552**

Purpose

The Joulemeter measures electrical energy directly in joules, and power in watts. It has a clear, digital display which is most valuable for class demonstrations.
It can be used to measure the energy supplied to calorimeter heaters, and the power input to motors and output from dynamos, to calculate their efficiencies.
It can measure the energy stored in a capacitor, and show that is does not depend on the discharge current. It can demonstrate the maximum power transfer when impedances are matched, and that no power is dissipated in a wholly reactive load. It can be used with a cathode ray oscilloscope to show how average and peak power dissipation varies with the phase angle between current and voltage.

The instrument has four internal shunts to give maximum current ranges of 0.7mA, 7mA, 0.7A and 7A, with a maximum input of 15V for a.c. The voltage maximum for d.c. is 20V, with corresponding maximum currents of 1mA, 10mA, 1A and 10A. This means that the maximum input power is doubled when the current is direct. A three-position JOULES switch applies multipliers of x1, x10 and x100 to the four ranges.

Ratings

Input voltage	0 to 15 a.c (20V d.c)
Input resistance	1MΩ
Input frequency	d.c or 50 to 1000Hz a.c
Max load current	0.7mA, 7mA, 0.7A and 7A

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Warnings

For your safety, this product should be used in accordance with these instructions, otherwise the protection provided may be impaired.

EMC
This equipment is Class A according to the EMC standard EN 55011 and is intended for use in a non-domestic environment only.

Do not open or remove covers or panels. Repairs and service may only be carried out by our repair agent, otherwise the warranty may be void.

Use only the 3-core mains cable supplied with the unit. If the mains cable is replaced, the rating of the replacement must be the same or better than the original.

The unit must be earthed at all times. The unit is earthed/grounded through the 3-core mains lead, so no additional earth connection is required.

Always position the power supply so that it can be disconnected from the mains, if an emergency arises.

This unit is intended for use in DRY conditions. Avoid spillage of water and other liquids on to the unit. If spillage occurs, disconnect the mains supply.

There is no specific requirement for insulation of external circuits as they cannot become hazardous live, as a result of connection to this unit. Limit the length of any connecting leads to 3 metres.

Features
- Determine specific heat capacity of metal
- Measure the enthalpy changes of reactions taking place in a solution
- Investigation the efficiency of energy conversion
- Meter output sockets for display of watts

Theory
The power taken by the load is determined by sampling the potential difference across it, and the current through it. These readings are then multiplied together in a four-quadrant analogue multiplier. The sign of the readings is taken into account so, for example, if one is positive and the other negative, their product will be negative.

The product is then integrated, since watts x seconds = joules, and displayed on the digital readout.
The 100uA sockets provide an output current of maximum value 100uA when the power output on a given range is half maximum. The connection of a 100uA meter with a 1kΩ movement to this output will therefore give a direct reading of power.

Depending on which shunt is used, the ranges will be 0-l0mW, 0-100mW, 0-10W and 0-100W. The ability to investigate the power output waveforms at these sockets is a particularly powerful function of the instrument.

Power indication
If the power consumption of the load is steady, then the power indicated by the microammeter, multiplied by the time the joulemeter was counting, should agree almost exactly with the digital display. See the SPECIFICATION for the interpretation of the microammeter display.

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Precautions
- The instrument will safely stand an input voltage of ±100V.

- When high currents are being drawn, care should be taken that the correct external load sockets are being used. Otherwise the internal shunt resistors might burn out. If in doubt, use the highest current range first, and then work down.
- If the peak inputs of 20V and 1mA, 10mA, 1A and 10A are exceeded, the readings obtained will be too low. To avoid the current rating being exceeded, the load current should be measured or calculated from the load resistance.
- For example, if a heating coil is being run from 20V d.c. supply, the 10A maximum current will be exceeded if its resistance is less than 2Ω. Were the only available coil to have a resistance of, say, 10, then the voltage would have to be reduced to 10V. If a 2Ω coil were used with an a.c. supply, the maximum voltage would be 14V r.m.s., because the peak values would be 20V and 10A.
- The COUNT ZERO control should rarely require adjustment. If the instrument is set on the most sensitive x1 JOULES range, and still counts with no input, then it should be left on for half an hour before making the adjustment. This ensures the temperature of the instrument is stable.
- The control should now be very slowly turned anti-clockwise until the joulemeter just stops counting. If the instrument does not keep counting down to an input of 2V a.c. with a load designed to be 12V and 50W (e.g. an immersion heater), the control should be turned slightly clockwise. Care should be taken not to overshoot and cause a zero input count.

GENERAL OPERATING PROCEDURE

- Determine by measurement or calculation the approximate current to be drawn by the external load. Plug one of the load's leads into the yellow socket marked EXTERNAL LOAD. Plug the other load lead into the appropriate blue socket. For example, if the expected current is 3mA, then plug the lead into the blue socket marked 7mA. If in any doubt, start by trying the 7A socket and work down through the more sensitive ranges.
- Connect the leads from the power supply to the sockets marked INPUT. Do not switch the power supply on yet. If a d.c. supply is being used, connect the earthed, or more negative lead, to the black socket marked with the earth symbol. Connect the other lead to the blue socket of the INPUT. If a battery is being used, do not make the final connection to the battery yet.
- Anticipate the total energy transfer during the experiment, and consider what sensitivity is required. Set the JOULES switch. In the x1 setting, the right-hand digit of the display will be counting in the unit written above the blue external load socket in use. For instance, if the 0.7A socket is in use, this digit will count tenths of a joule - a reading of 1524 is thus 152.4J. In the x10 setting, the right-hand digit will count in units ten times that written above the socket. In the x100 setting, the units will be one hundred times that written. So, for instance, a reading of 6948 with the 0.7A socket would mean 69,480J.
- If a simultaneous display of power is required, then a 100uA, 1kΩ meter should be connected to the red and black sockets marked METER. Take care to connect the lead correctly.
- Switch on the joulemeter and zero the display by pressing the red button marked RESET.
- Switch on the power supply. If power is being dissipated in the load, the display should now start to count. It may be reset at any time, as required.

Experiment 1
Purpose
To determine the specific heat capacity of a metal

Requirements
Power supply unit, 12V a.c.
Immersion heater, 12V 50W
Aluminium block calorimeter Thermometer (-10°C to +110°C x1°C)

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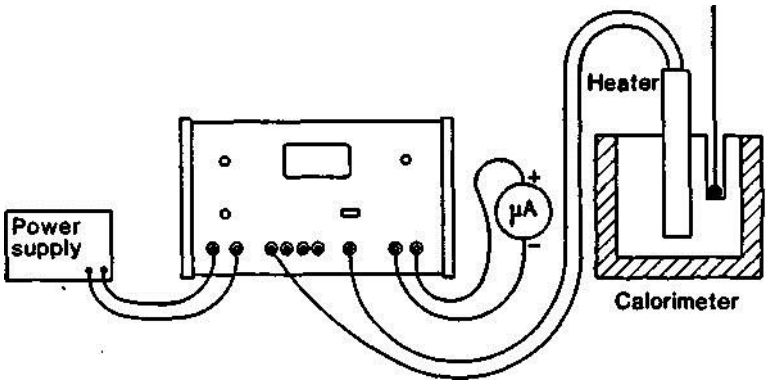
Microammeter (-20uA to +100uA, 1kΩ)
4mm plug leads
Lagging for the calorimeter, e.g. felt or expanded polystyrene



Operating procedure and theory

- Connect the circuit shown, using the 12V a.c. supply.
- Switch on the heater and, once the temperature of the block has risen a couple of degrees, reset the joulemeter.
- When the temperature of the block has risen by about 20°C, read the thermometer again and read the joulemeter.
- Measure the mass of the block of metal.
- The energy required to heat a 1kg block of the metal by 1°C (assuming no losses), is called "the specific heat capacity" (SHC) of the metal. Its units are J kg-1 °C-1

$$SHC = \frac{E}{m \times t}$$

Where E is the electrical energy supplied to the heater, m is the mass of the metal block in kg and t is the temperature rise

The delay in starting the joule counter is to avoid including the heat capacity of the heater. Choosing a temperature rise is a compromise between having a large rise and a consequently small percentage error in the difference between the readings, and having the larger heat losses resulting from a high final temperature of the block. The great advantage of the digital display directly in joules, when teaching SHC, is that pupils need not be confused by the power calculations that are necessary when using older techniques involving voltmeters and ammeters.

Further ideas
A similar technique can be used to measure the SHC of a liquid. The heater should be put in a well lagged beaker of the liquid instead of the metal block. The liquid should be stirred throughout the experiment.

Experiment 2 Purpose
To measure the enthalpy changes of reactions between liquids or reactions taking place in solution.

Requirements
Power supply unit

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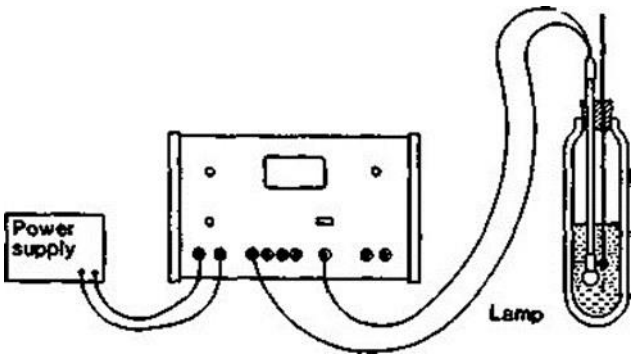
Electrical compensation calorimeter (12V 24W lamp inside an insulated container) Thermometer -5°C to +105°C x 0.1°C
4mm plug leads



Operating procedure and theory

- Connect the circuit shown, using the 12V a.c. supply. Allow the carefully measured samples of the reactants to reach room temperature.
- Ensure that the total volume of reacting liquid will not come up to the neck of the light bulb.
- Pour the reactants into the flask, insert the stopper, lamp and thermometer, and measure the temperature change caused by the reaction. Once the temperature is steady, switch on the power supply until the heat from the lamp causes the same temperature change as that measured above.
- In the case of endothermic reactions, this will mean returning the temperature of the liquid to its original value. Since energy losses from the flask are small, the fact that the electrical energy was supplied to the liquid at a different temperature from the chemical energy, does not greatly affect the result. The energy measured by the joulemeter is the same as the enthalpy change during the reaction. No complications arise as a result of the heat capacities of the flask, lamp and thermometer because these absorb the same energy whether chemically or electrically heated. A lamp is used because it is glass and will not be affected by most chemicals, but care must be taken to allow it to cool fully before starting the experiment - it could crack, or at least spoil the results.
- Owing to the energy change being read directly, the experiment is clear, as shown in the example: 0.1dm3 of 0.2M cobalt(II) sulphate solution (0.02 moles) is reacted with a slight excess of powdered zinc (about 2g).

The joulemeter read 1.7kJ after the experiment.
The reaction is exothermic, so:

$$\Delta H = \frac{-1.7\text{kJ}}{0.02\text{ mol}} = -85\text{kJ mol}^{-1}$$

Unless the experiment is conducted under standard conditions, this will not be the standard enthalpy change, ΔH. However, it will be quite a close approximation.

Cleaning

The Digital Joulemeter may be wiped clean using a damp cloth. Be sure to disconnect the unit from the mains before cleaning, and do not use any abrasive cleaners or organic solvents.

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Periodic testing:

Check the mains lead and plugs at both ends for any damage.

Periodically check the earth bonding and insulation, by performing a Portable Appliance Test (**PAT**). Most schools and local authorities have a regular schedule for such testing.

Check that the fuse in the mains plug (5A recommended) and the T50mA PCB mounted fuse are of the correct rating. Please note the PCB mounted fuse is not user replaceable.

Disposal of Waste Electrical and Electronic Equipment (WEEE)

Do not dispose of this product with household waste

- For the proper treatment, recovery and recycling please take this product to an appropriate collection point.
- If you are unsure where this is, contact your Local Authority.
- By disposing of this product correctly you will be providing positive help to the environment.

Warranty, repairs and spare parts:
The Joulemeter is guaranteed for a period of one year from the date of delivery to the customer. This warranty does not apply to defects resulting from the action of a user such as misuse, improper wiring, any operations outside of its specification, improper maintenance or repair, or unauthorized modification.

Our liability is limited to repair or replacement of the product. Any failure during the warranty period should be referred to Customer Services.

In the event of a fault, the power supply should be referred to the Philip Harris recommended repair agent. Please contact Customer Services or techsupport@philipharris.co.uk for advice

Instructions for authorized service technicians:
Ensure that any replaceable mains cord is of the correct rating.
Ensure that all earth conductors and protective earth bonding is maintained after service work.
Please refer to the detailed service procedures, safe servicing and continued safety – contact techsupport@philipharris.co.uk for advice.
For any manufacturer specific parts please refer to our recommended repairer.
Please refer to product specific risks that may affect service personnel, the protective measures and verification of the safe state after repair.

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