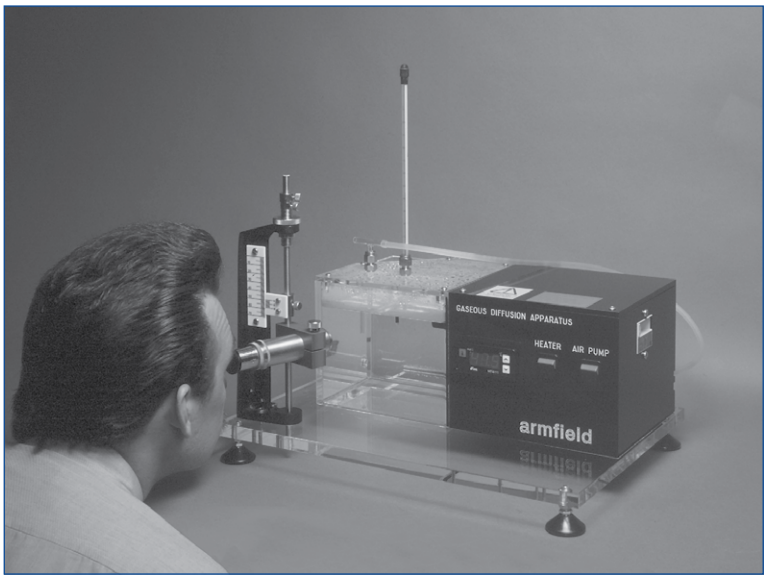
armfield

MASS TRANSFER AND DIFFUSION COEFFICIENTS

CERa/CERb
issue 10



CERa Gaseous Diffusion Coefficients Apparatus

Two separate items of laboratory equipment have been designed to allow measurement of molecular diffusivities and, in so doing, to familiarise students with the basic notions of mass transfer theory. The gaseous diffusivity apparatus (CERa) involves diffusion with bulk flow, whilst the liquid diffusivity apparatus (CERb) relates to an equi-molar counter-diffusion process.

MEASUREMENT AND INSTRUCTIONAL CAPABILITIES

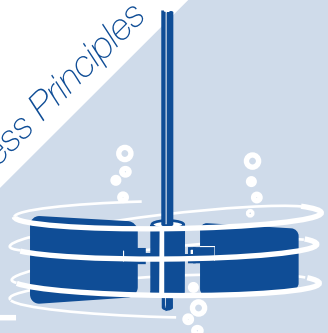
CERa Gaseous Diffusion Coefficient Apparatus

- *direct measurement of mass transfer rates in the absence of convective effects*
- *use of gas laws to calculate concentration differences in terms of partial pressures*
- *use of Fick's Law to measure diffusion coefficients in the presence of a stationary gas*
- *measurement of the effect of temperature on diffusion coefficients*
- *gaining familiarity with the use of laboratory instruments to achieve accurate measurements of data required for industrial process design.*

CERb Liquid Diffusion Coefficient Apparatus

- *accurate measurement of mass transfer rates in the absence of convective effects*
- *use of Fick's Law to deduce diffusion coefficients from measurements of mass transfer rate and concentration difference*
- *simple analysis of a first order unsteady state process*
- *effect of concentration on diffusion coefficients*
- *gaining familiarity with the use of laboratory instruments to achieve accurate measurements of data required for industrial process design*
- *Windows data logging software included*

Basic Process Principles



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CERa Gaseous Diffusion Coefficients Apparatus

DESCRIPTION

The diffusion of a vapour 'A' from a volatile liquid into another gas 'B' can be conveniently studied by confining a small sample of the liquid in a narrow vertical tube, and observing its rate of evaporation into a stream of gas 'B' passed across the top of the tube. Normally, for simple instructional purposes, 'B' is air and 'A' is an organic solvent such as acetone or methyl alcohol.

The apparatus consists essentially of a glass capillary tube placed in a transparent-sided temperature controlled water bath. A horizontal glass tube is fixed to the upper end of the capillary tube and air is blown through this by a small air pump included within the unit. This arrangement allows the maintenance of a partial pressure difference within the capillary tube between the evaporating liquid surface and the flowing air stream. A travelling microscope, with sliding vernier scale, is mounted on a rigid stand alongside the thermostatic bath and is used to measure the rate of fall of the solvent/air meniscus within the capillary.

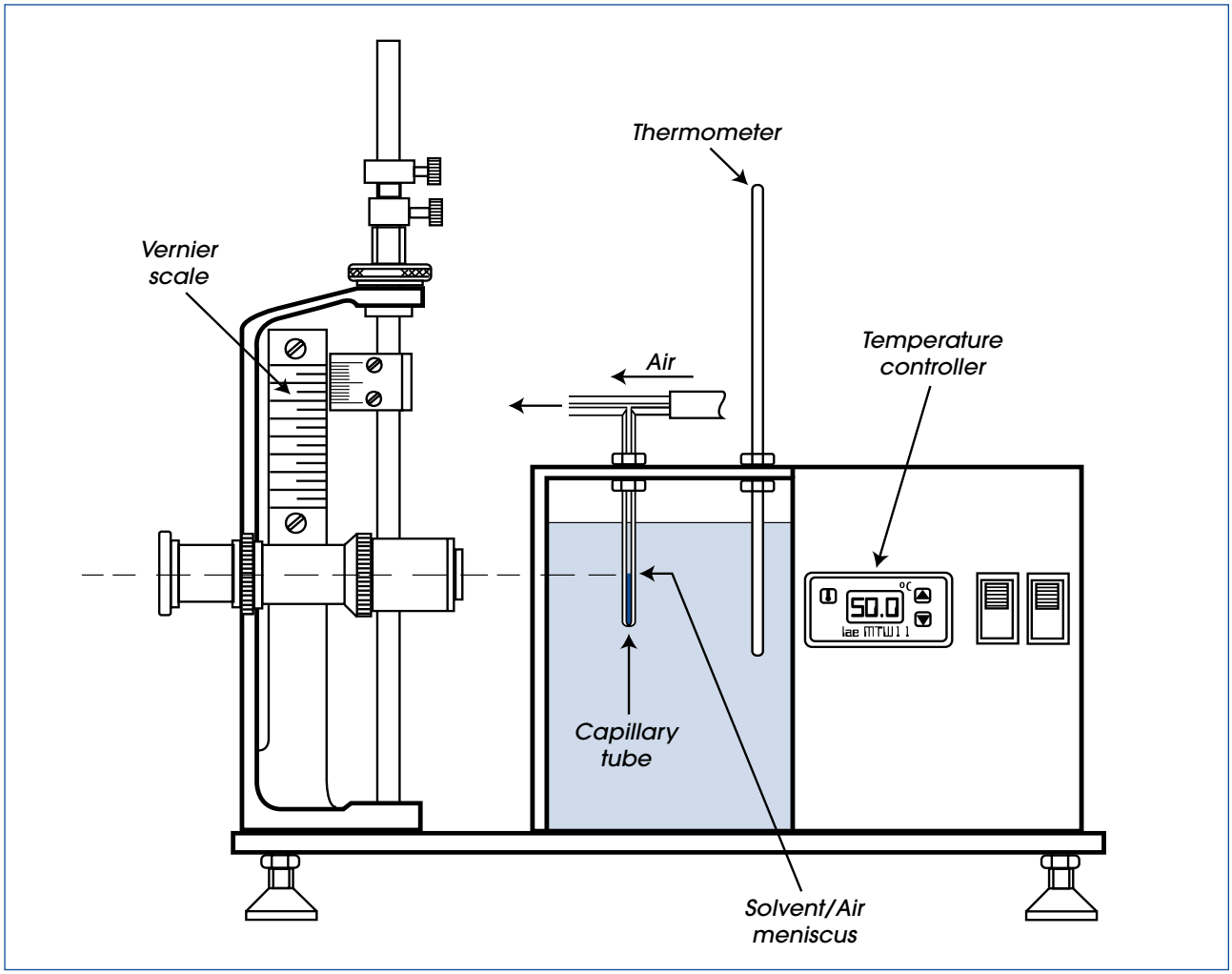
The relation between the measured molar mass transfer rate ('N_A' per unit area), the partial pressure gradient and the diffusion coefficient D is deduced from the one dimensional steady state version of Fick's Law with bulk flow:

$$N_A = -D \frac{[C_A + C_B]}{[C_B]} \frac{dC_A}{dy}$$

where 'C_A' and 'C_B' are the molar concentrations of the vapour 'A' and air 'B' respectively.

TECHNICAL DETAILS

Thermostatic bath:	*capacity 4.0 litres*
Water heater element:	*500 Watts*
Temperature controller:	*range 0 to 60°C, on/off type*
Temperature sensor:	*PTC*
Vernier range:	*0 to 70 x 0.10 resolution (mm)*



CERa Gaseous Diffusion Coefficients Apparatus

CERb Liquid Diffusion Coefficients Apparatus

DESCRIPTION

Armfield has developed a unique diffusion cell which overcomes the traditional problem of slow diffusion rates in liquids requiring long observation times, but without sacrificing accuracy or introducing convective effects. Essentially, the cell consists of a honeycomb of accurately dimensioned capillaries, positioned between two liquids of differing concentration of the solute whose diffusion coefficient is to be determined.

In practice, a small volume of concentrated solution is placed on one side of the honeycomb, whilst the other side consists initially of a large volume of pure solvent (water). As diffusion of the solute occurs, the concentration within the larger volume increases, and is monitored with a conductivity sensor and meter. The mixture is continuously stirred with a magnetic stirrer to ensure uniform concentration within the bulk liquid. Whilst the conductivity sensor may be readily calibrated for any required aqueous system, for introductory studies, dilute solutions of sodium chloride are recommended, for which conductivity data are provided.

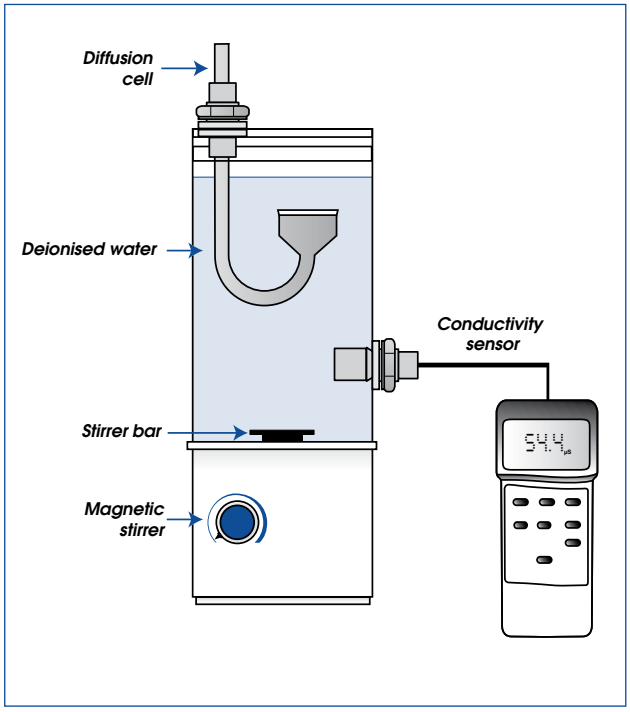
TECHNICAL DETAILS

Diffuser vessel: *capacity 1.0 litre*
Conductivity meter: *3 ranges 199.9µS to19.99mS*
Computer output: *RS232*

RECOMMENDED ACCESSORIES

Stop clock

Cartridge deioniser



CERb: Liquid diffusion coefficients apparatus - equipment set-up

ORDERING SPECIFICATION CERa

- ***Bench mounted apparatus for the determination of diffusion coefficients of a vapour in air, which uses the method of measuring the rate of evaporation of a liquid through a stagnant layer into a flowing air stream, comprising:***
  - ***i) A precision bore capillary tube, which may be filled from a syringe, and at the top of which means are provided to pass air (or an inert gas) stream to remove vapour.***
  - ***ii) An air pump.***
  - ***iii) A travelling microscope with accurate focus adjustment and mounted for vertical axis movement against a Vernier scale having 0.1mm graduations.***
  - ***iv) A thermostatically controlled water bath, in which to place the capillary tube, capable of accurate temperature control within the range ambient to 60 degrees centigrade to ±1 degree centigrade.***
- ***Experimental Capabilities***
  - ➤ ***Direct measurement of mass transfer rates in the absence of convective effects.***
  - ➤ ***Use of gas laws to calculate concentration differences in terms of partial pressures.***
  - ➤ ***Use of Fick's Law to measure diffusion coefficients in the presence of a stationary gas.***
  - ➤ ***Measurement of the effect of temperature on diffusion coefficients.***
  - ➤ ***Gaining familiarity with the use of laboratory instruments to achieve accurate measurements of data required for industrial process design.***

ORDERING SPECIFICATION CERb

- ***Bench mounted apparatus for the determination of diffusion coefficients of components in the liquid phase. The method employs a diffusion cell of capillary tubes so constructed to permit equi-molar counter diffusion between liquids of differing concentration each side of the cell without convective effects being present.***
- ***Concentration changes on one side of the cell with respect to time are measured with the conductivity cell and the meter provided, and a magnetic stirrer keeps the bulk solution well mixed.***
- ***Possible to obtain reproducible and accurate values of diffusivity within a period of 1.5 hours of practical laboratory time.***

- ***Experimental Capabilities***
  - ***Accurate measurement of mass transfer rates in the absence of convective effects.***
  - ***Use of gas laws to calculate concentration differences in terms of partial pressures.***
  - ***Use of Fick's Law to deduce diffusion coefficients from measurement of mass transfer rate and concentration difference.***
  - ***Simple analysis of a first order unsteady state process.***
  - ***Effect of concentration on diffusion coefficients.***
  - ***Gaining familiarity with the use of laboratory instruments to achieve accurate measurements of data required for industrial process design.***
- ***Software is included to allow the temperature and conductivity in the diffusion vessel to be displayed, logged and recorded on a customer supplied PC, using a RS232 interface.***

SERVICES REQUIRED

Electricity supply:
CERa-A: 220-240V/1ph/50Hz
CERa-B: 120V/1ph/60Hz

CERb: Battery operated

OVERALL DIMENSIONS

CERa Gaseous Diffusion Coefficient Apparatus

Height: 355mm
Width: 450mm
Depth: 390mm

CERb Diffusion Apparatus

Height: 310mm
Diameter: 190mm

Conductivity Meter

Height: 130mm
Width: 150mm
Depth: 250mm

SHIPPING SPECIFICATION

CERa: *Volume: 0.20m^3*
Gross Weight: 30kg
CERb: *Volume: 0.10m^3*
Gross Weight: 10kg

COMPLEMENTARY PRODUCTS

CES: Wetted Wall Gas Absorption Column
UOP3BM: Batch Distillation Column
UOP3CC: Computer Interfaced Distillation Column
UOP4MkII: Solid–Liquid Extraction Unit
UOP5: Liquid–Liquid Extraction Unit
UOP7: Gas Absorption Column

REQUIREMENTS

Data logging requires a customer supplied PC, with RS232 Serial interface, running Windows 98 or later.

Armfield Limited
Bridge House West Street Ringwood
Hampshire England BH24 1DY
Tel: +44 (0)1425 478781
Fax: +44 (0)1425 470916
E mail: sales@armfield.co.uk
URL: http://www.armfield.co.uk

USA Office:
Armfield Inc.
436 West Commodore Blvd (#2)
Jackson NJ 08527
Tel: (732) 928-3332
Fax: (732) 928-3542
E mail: info@armfieldinc.com