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Reference: IQ1802100c

Prof. Angiolina Comotti
University of Milano Biocca
Department of Materials Science
Via R. Cozzi 55
20125 Milan, Italy

Application: Gas sorption in MOFs and related porous materials

Proposed Instrument/Model: IGA-001

Local Hiden Representative: Dr Michelle Mercer

Quotation Prepared by: Dr Michelle Mercer

24 July, 2018

Dear Prof. Comotti

Thank you very much for your interest in Hiden Isochema and our IGA series of gravimetric gas and vapour sorption analysers.

Please find enclosed your quotation for an **IGA-001** as requested.

If you would like to discuss your requirements further, or have any specific questions, please do not hesitate to contact our representative in your area, Dr Michelle Mercer, or our headquarters directly.

Yours sincerely,

Mark Roper PhD
Sales and Marketing Director
Hiden Isochema Ltd.

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Prof. Angiolina Comotti
University of Milano Biocca
Department of Materials Science
Via R. Cozzi 55, 20125 Milan, Italy

IGA Series Gas and Vapour Sorption Analysers

The Intelligent Gravimetric Analyser (IGA) can be used to determine both the equilibria and kinetics of gas and vapour sorption by materials at a range of temperatures and pressures.

Different models in the IGA range provide different capabilities:

IGA-001 provides static single component gas sorption measurement at pressures up to 20 bar

IGA-002 adds single component static vapour sorption measurement capability

IGA-003 allows dynamic gas sorption experiments, with up to four flowing gas streams

IGA-100 performs all the functions of the IGA range, including static gas, static vapour and dynamic mixed gas and vapour sorption measurements

IGA-200 is designed specifically for ambient pressure dynamic mixed gas and vapour sorption studies

Each model can be provided with a range of accessories, including low pressure range sensors for high resolution measurement at sub-ambient pressures, a wide range of thermostats allowing operational temperatures between 77 K and 1000 °C, and additional gas and vapour flow streams. All models may also be upgraded retrospectively.

Hiden Isochema's UK headquarters and manufacturing facility

About Hiden Isochema

Hiden Isochema is a world leader in the design and manufacture of sorption instruments for research, development and production applications in surface chemistry and materials science.

We have been producing sorption measurement systems since 1992 when Hiden Analytical first began manufacturing the Intelligent Gravimetric Analyser (IGA). Shortly afterwards, a bench top dynamic vapour sorption analyser, the IGAsorp, was produced using IGA technology, alongside the development of various different upgrades and accessories for IGA systems. Following a decade of continued success, Hiden Isochema was formed as a wholly-owned subsidiary of Hiden Analytical in order to further specialise in the development and manufacture of sorption-specific instrumentation.

Since then, the company has expanded its product range to include unique high pressure manometric (IMI) and gravimetric (**XEMIS**) sorption analysers, climate control (**XCS**), breakthrough (**ABR**) and membrane permeation (**MBR**) systems, and we continue to strengthen our reputation for delivering high quality and versatile instrumentation.

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PROPOSED SYSTEM: IGA-001 Gas Sorption Analyser 50 degC to 500 degC or 77K (LN2) or 87K (Liq Ar) / 10^{-6}mbar to 20 bar

ITEM	DESCRIPTION	PRICE EUROS
IG1-1	IGA-001 System[1,2]	**89445.00**
IG2-2	Enhanced Pressure Rating 20 bar	**6190.00**
IG2-3A	Additional Pressure Range 0-1 bar	**2480.00**
IG2-4B	Turbomolecular Pump Station	**16850.00**
IG3-1	Standard 500 °C Furnace and Controller	**6945.00**
IG3-5	Liquid Nitrogen (BET) Jacket (77K)	**2280.00**
IG2-5	Floor Mounting Frame [1] *Agreed price for the frame*	**2850.00**

System Proposal Price:	**127040.00**
Exceptional discount (37%):	**(-45880.00)**
Packing and Carriage:	**1195.00**
Installation, Commissioning and Essential On-Site Training [3]:	**5740.00**
Total Price:	**€88095.00**

OPTIONS

ITEM	DESCRIPTION	PRICE EUROS
IG2-6	Personal Computer with IGA communications interface	**1890.00**
IG2-3B	Additional Pressure Range 0-2 mbar, 0-10 mbar or 0-100 mbar	**4280.00**
Special	PVC environment jacket for use with recirculating water bath sourced separately: (Special Price – discontinued item)	**1500.00**
IG3-6	Refrigerated Recirculating Bath and Stainless Steel - Environment Jacket	**10495.00**
IG1-AT	Advanced Training Course (data reduction and interpretation) [3]	**P.O.A.**

Please see Technical Specifications following this quotation for full details about each item.

Notes

[1] A floor mounting frame item IG2-5 is required if there is no load bearing wall space to mount the analyser.

[2] A Windows PC with equivalent minimum specifications to item IG2-6 is required for system operation.

[3] Standard installation charge includes essential training covering sample loading, system setup and software tutorial. The optional Advanced Training Course (item IG1-AT) can be tailored to individual requirements, typically including material-specific experiment optimization, data reduction and interpretation. The Advanced Training Course may be offered on-site, at the Hiden Isochema primary manufacturing centre, or elsewhere.

Terms and Conditions

Warranty:	12 months parts and labour, to commence on date of installation In the event that installation is delayed at the customer's request, the warranty period will commence automatically should the delay exceed 6 months.
Prices:	Euros Excludes local taxes and duties DDU [Milan, Italy] Valid 90 days from 24th July 2018.
Delivery:	Typically 12-16 weeks from order
Payment:	40% net 30 days from order 50% net 30 days from delivery 10% net 30 days from acceptance

Mark Roper Ph.D
Sales and Marketing Director
Contract reviewed
For and on behalf of
HIDEN ISOCHEMA LTD

IGA Series Technical Specifications

ITEM	DESCRIPTION
	Section 1.0: The Primary IGA Systems
IG1-1	**IGA-001 Gas Sorption Analyser** The IGA-001 system is designed to study single component gas-solid and gas-liquid interactions and can also provide physical property analyses by gas adsorption experiments. Sorption processes including physisorption, chemisorption, capillary condensation and absorption can be investigated. Densitometry analysis of the sample or gas phase is also provided. The IGA design integrates precise computer-control and measurement of mass change, pressure and temperature to enable fully automatic and reproducible determination of gas adsorption-desorption isotherms and isobars in diverse operating conditions. The system is supplied complete with Windows™ software incorporating the IGA method that exploits the relaxation behaviour, following pressure or temperature changes, to simultaneously evaluate kinetic parameters (diffusivity) and asymptotic uptake. The IGA-001 system features: • Computer-controlled microbalance and independent balance thermostat • Peltier-controlled balance electronics • PTFE coated balance, Kalrez and PTFE seals for enhanced corrosion resistance • Stainless steel vacuum-pressure vessel to ultra-high vacuum standards • Stainless steel (SS316L) 500°C sample reactor • Computer-controlled pressure system to admit and remove gas with precise set-point regulation and ramp control modes • Stainless steel gas-handling system incorporating pressure transducer, pressure relief valve, manual vacuum-pressure isolation valve and ports for pump and gas supply • Temperature control/measurement interface for up to three Pt100 or Type K sensors • Thermostatted steel cabinet secured with anti-vibration wall mounting brackets. • Safety interlock • Process control computer and signal conditioning with custom control software • Serial communications interface • Windows ™ software for fully automatic and semi-automatic operation • Data acquisition and storage of data to hard disk • Data display on-screen in real-time • Environment tables for user experiment set-up (isotherms, TGA etc.) • Real-time trend analysis of mass relaxation • Buoyancy calculator to correct weight change readings • Densitometry calculator • Gas compressibility calculator • Vapour pressure calculator to determine relative pressure • Data export to ASCII format or DDE with Excel ™

ITEM	DESCRIPTION
IG1-1 cont'd	**Specifications** **General** IGA cabinet dimensions: 410 x 410 x 710 (wide) mm Overall space required (typical): 700 (deep) x 2500 (high) x 1500 (wide) mm Colour: Ivory Electrical supply: 110-240Va.c. 50/60Hz Electricity consumption: 500W **Weight** Balance capacity: 1 gram standard (5 grams optional) Corrosion protection: PTFE coating Sample capacity: Balance capacity less weight of hang-down and container (typically less 0.25 grams) Weight range: 0-100 mg (0-200 mg with 5g balance option) Tare: Equivalent to sample capacity Hang-down: Gold chain/tungsten wire Settling time: Adjustable 1-30 seconds Weighing resolution: 0.1 µg (0.2 µg with optional 5g balance) Stability: In an inert atmosphere at room temperature: Long term: +/- 1 µg Short term: +/- 0.1µg, and dependant on sample environment at other pressure/temperature. **Pressure** Leak rate: $<10^{-9}$ mbar l/sec Design pressure: 10 bar standard. (20 bar optional) Design temperature (at pressure): 500°C Pressure transducer ranges: Single range 0-10 bar standard Additional ranges between 0-2 mbar and 0-20 bar are optional (up to three ranges may be selected) Pressure resolution: 1/16000 of range Pressure controller: Set-point regulation/ramp control Minimum control increment: 0.05% of range Accuracy (set-point regulation): +/ -0.02% of range Maximum rate of change of pressure (admittance): Approximately 1% of range / sec Pressure vessel flanges: Conflat-type with copper gasket seals and Swagelok™ or VCR gas ports Pressure vessel certification : ASME Cat.III BS5500

ITEM	DESCRIPTION
IG1-1 cont'd	**Temperature** Temperature sensors: Platinum Resistance Thermometer (Pt100) or Type K Thermocouple (with Cold Junction Compensation). 3 off are standard with the type and measurement range to suit user application. Maximum measurement range: -270 to 1000°C Typical resolution / accuracy: +/- 1°C (Type K) +/- 0.01 to 0.1 °C over temperature range (PRT) Response time: 0.05 second (Type K) 1 second (PRT) Linearisation: Software algorithm Temperature control: Set-point regulation/ramp control (see following sections)
IG1-2	**IGA-002 Vapour Sorption Analyser** The IGA-002 analyser is specifically designed to study water and single component vapour sorption and vapour-solid interactions. The IGA-002 includes all features of the IGA-001 and can also therefore be used additionally as a gas sorption analyser. The system is available in an ultra-high vacuum configuration to enable microporous materials to be studied and degassing/activation can be performed *in situ* by adding an optional furnace (see section 3.0). A selection of pressure sensors enables pressure control at very low vapour pressures. The incorporated anti-condensation system extends the temperature range to 50°C over which the full p/p_o envelope can be measured. The analyser is fully compatible with the accessories described in sections 2.0 and 3.0. Typical sample environment options include the re-circulating refrigerated water bath for precise sample temperature control. The IGA-002 system is identical with the IGA-001 system and further incorporates: • Additional low-pressure sensor (100 mbar or 10 mbar typically) and associated gas-handling • Over-pressure safety relief valve • Pressure-tested liquid adsorbate reservoir • Cabinet door with access to the internal port for connection of the thermostatted adsorbate reservoir • Manual isolation valve and a purge valve for the adsorbate reservoir • Additional heating system for the IGA cabinet • Heating system and jacket for external pipework • Software upgrade incorporating interactive vapour pressure calculator with three models for saturation vapour pressure – temperature • Adjustable temperature control stage to set anti-condensation temperature • Safety interlock

ITEM	DESCRIPTION
	IGA-003 Dynamic Sorption Analyser The IGA-003 system is specifically designed for experimental applications where it is necessary to have a flow of gas past the sample including thermal analysis experiments and multiple gas studies. The IGA-003 includes all features of the IGA-001 and can also therefore be used additionally as a gas sorption analyser (see item IG1-1). In this arrangement it is possible to have up to four gas streams mixed prior to entry into the IGA system so that a defined gas mixture composition is delivered at the sample position. The gas flow system is designed for operation at pressures to 20 bar maximum, or to the specified working pressure of the IGA system, to enable input of multiple gas streams to the IGA reactor vessel under pressure control. The IGA-003 system is identical to that detailed above for the IGA-001 system but further incorporates: • Multiple gas inlet system • Adjustable total flow rates to 500ml/min • Independent automated control of each stream • Display as % composition or flow rate • Switchable panel meter read-out • Safety interlock • Gas feed and gas handling to the reactor vessel • Gas handling to switch between IGA-001and IGA-003 modes • IGA flow (expansion) interface • Integrated IGASwin dynamic sorption upgrade • Automatic gas species flow rate conversion • Non-return valves fitted to each stream **Flow Specifications** Mass flow control type: Thermal Full scale range: From 3ml/min to 500ml/min Accuracy: +/-1% full scale including linearity Repeatability: 0.25% rate Control range: 50 to 1 Gas connector: 1/8” Swagelok™ **Please Note:** The inlet system is offered in 2 stream, 3 stream and 4 stream versions. Two stream and three stream versions may be retrospectively upgraded.
IG1-3A	**Two Stream IGA-003 System**
IG1-3B	**Three stream IGA-003 System**
IG1-3C	**Four Stream IGA-003 System**

ITEM	DESCRIPTION
	Section 1.1: Dynamic Sorption Options The items in this section are options that require a dynamic sorption IGA model and include vapour mixture generation and the CATLAB microreactor. Appropriate IGA models for these options are IGA-003 and IGA-100.
IG1-3-1	**Humidity Control Module** A humidity control module can be substituted for the normal IGA sample reactor tube to provide a controlled humidified gas flow to the sample position. The gas feed for the humidifier connects to the first two outputs of the IGA-003 multiple gas inlet system. The humidifier consists of a chamber that incorporates a sample reactor, integral vapour reservoir and relative humidity sensor. The output from the sensor is interfaced to the IGA system, which varies the flow in either the wet or dry flow streams accordingly to maintain constant humidity at the sample position. All of the components are incorporated within a jacket for accurate temperature control by a recirculating water bath. Includes software upgrade for RH set point and ramp-cycle operations together with dynamic vapour sorption isotherms and conformance test (OQ) method. Sensor: Capacitance polymer film type Measurement range: 0% (determined by gas supply) to 100% Measurement accuracy: +/- 1% Regulation accuracy: +/-0.1% Minimum Control Increment: 2% Operating pressure: Atmospheric Gas supply requirement: Typically dry N_2 or air Maximum temperature: 80°C Minimum temperature: 5°C **Please Note:** The refrigerated water bath is required additionally (see Item IG3.6).

ITEM	DESCRIPTION
IG1-3-2	**Single Stage Humidity Generator Module** A stainless steel (SS316) pressurised generator operated in conjunction with an independent remote-controlled refrigerated recirculating water bath. The generator is mounted to the bath lid with an 1/8" Swagelok™ port gas port, manual bypass valve, refill port and PTFE seals. Includes anti-condensation protection to 50°C of the vapour generator and the delivery connections with a heated exhaust transfer pipe complete with controller. This module uses a single stream (typically helium or nitrogen) of the IGA-003 interface for vapour generation but which can be bypassed when the vapour generator is not in use to release this stream for other duties. Supplied complete with salt solution conformance test kit for in situ calibration checks of the relative humidity generator. This unit can also be used for with species other than water under guidance from Hiden Isochema. Wetted parts: SS316 and PTFE Anti-condensation protection: 50°C Maximum flow rate: Equivalent to IGA-003 specifications Fluid capacity: 150ml Maximum gas pressure: 10 bars %RH conformance accuracy: +/- 1% RH using salts supplied
IG1-3-3	**ABR Automated Breakthrough Reactor** A substitute reactor designed to allow determination of breakthrough curves using IGA dynamic sorption gas supply and sample environment systems. • Unique reactor design allowing integration with IGA pressure/flow control system • SS 316 stainless steel construction with VCR pressure fittings. • Total flow rate variable up to 500 ml/min. • Gas sampling connection port for operation with Dynamic Sampling Mass Spectrometer systems • Optional anti-condensation protection for operation with Item IG1-3-4 Bed length: 50 mm Bed internal diameter: 7.1 mm Volume of bed: Nominally ~2 cm^3 as standard (other volumes available by request) Operational temperature range: Typically 0 to 500 °C Thermostatting of bed: Equivalent to IGA sample environment option IG3-7 (see section 3.0) Operational pressure range: Vacuum to 20 bar (depending on IGA pressure configuration) Flow rate: Variable, controlled by IGA gas delivery system (maximum 500 ml/min). **Please note:** Operation of the ABR is mutually exclusive with operation of the IGA in gravimetric mode.

ITEM	DESCRIPTION
	Section 1.2: Integrated IGA systems These integrated systems are advanced models to suit the broadest range of experimental applications involving both single component gases and vapours together with dynamic operating modes for gas mixtures (IGA-100) or gas/vapour mixtures (IGA-200).
	IGA-100 Integrated Sorption Analyser Combines all features and applications of our IGA-001, IGA-002 and IGA-003 instruments in one analyser to provide the most versatile and powerful option either for different analyses using the same sample or to extend the scope of your experiments. Specifications and features are identical with the items IG1-1, IG1-2 and IG1-3 described above.
IG1-100A	**Two Stream IGA-100 System**
IG1-100B	**Three stream IGA-100 System**
IG1-100C	**Four Stream IGA-100 System**
IG1-200	**IGA-200 Dynamic Mixed Gas and Vapour Sorption Analyser** An integrated gravimetric analyser (as IGA-100) supplied complete with the required accessories for dynamic mixed gas and vapour sorption analysis as described in Hiden Isochema application note 113. This package includes items IG1-3.3, IG3-7 and IG4-1 and also includes the isothermal software upgrade for sequential vapour exposure and thermal desorption analyses.

ITEM	DESCRIPTION
	Section 2.0: General Upgrades / Options / Accessories The following items are available for all IGA models.
IG2-1	**Enhanced Capacity Microbalance** Balance capacity 5g in place of the standard 1g balance. See item IG1-1 for specifications.
IG2-2	**Enhanced Pressure Rating** Vessel and gas handling for system operation to 20 bar in place of standard 10 bar operation. Includes a 20 bar pressure transducer in place of the standard transducer of the core system.
	Additional Pressure Ranges One range is included in the IGA system (section 1.0). Up to two additional operating pressure ranges (incorporating transducer, signal conditioning, gas-handling and software) may be selected. Additional ranges are used to increase the control accuracy and measurement within the selected range.
IG2-3A	Additional piezo-resistive strain gauge transducer Pressure range available 0-1 bar
IG2-3B	Additional capacitance manometer Pressure ranges available 0-2 mbar or 0-10 mbar or 0-100 mbar
	Vacuum Stations The IGA requires an appropriate pump for de-pressurization (exhaust control) and outgassing. The high vacuum station is required for gas-adsorption studies of materials with affinity for water and generally for low-pressure studies. Vacuum systems are offered to two levels of vacuum. Both systems are mounted in a compact module 500mm x 500mm x 450mm high.
IG2-4A	**Rotary Pump Station - Please Note:** This pump is NOT COMPATIBLE with pure oxygen For operation to 10^{-2} mbar, comprising: • Two-stage rotary pump • Flexible stainless steel foreline bellows for connection to the IGA gas handling • Foreline vapour trap • Vacuum manifold • Pirani gauge for pressure measurement and vacuum confirmation • Safety overpressure relief valve • Swagelok™ vent connection port • Adjustable height trolley table

ITEM	DESCRIPTION
IG2-4B	**High Vacuum Turbo Molecular Pump Station** For the operation to 10^{-8} mbar, comprising: • 60 l/sec wide-range turbomolecular drag pump set and controller • Dry diaphragm foreline pump • Ultra high vacuum (UHV) manifold • Combined Penning/Pirani gauge for UHV and foreline pressure measurement • Flexible stainless steel bellows for connection to the IGA gas handling system • Safety overpressure relief valve • Swagelok™ vent connection port • Interface with IGA system for automatic control of pump start and stop • Adjustable height trolley table **Please Note:** Corrosion-resistant pumping stations are offered for aggressive gas applications and are quoted against confirmation of gas type.
IG2-5	**Floor Mounting Frame** The IGA systems (see section 1.0) are supplied for wall mounting on solid load-bearing walls. The floor-mounting frame is an alternative where wall space is restricted or the wall construction is unsuitable. The frame measures 1800mm high x 1050 mm wide x 580 mm deep and system layout drawings can be provided on request to assess laboratory space requirements. • Rigid 75mm steel box section • Floor fixing feet for vibration isolation • IEC electrical breakout • Expansion or chemical bolt fixings • IGA system mounting brackets
IG2-6	**Personal Computer with IGA Communications Interface** PC compatible with HIsorp software, installed, tested and ready for use. The PC is supplied to the following minimum specification: • i5 Pentium Class Processor (3000 MHz) • 4 GB RAM • 500 GB hard disc • 2 to 4 USB ports (depending on **IMI** model) • Monitor • Keyboard and mouse • CD-ROM drive • Microsoft Windows™ 10 professional 64 bit(Win 7 or 8 available on request) Also includes HIsorp installation key

ITEM	DESCRIPTION
	Section 3.0: Sample Environment Equipment A range of sample environment options are offered to suit different user applications. Prices includes lab-stand (where appropriate), sensors and safety systems to suit the selected user option(s). All options are supplied with temperature controller where appropriate.
IG3-1	**Standard 500°C Furnace and Controller** Laboratory furnace for sample outgassing up to 500°C and set-point regulation between 40°C and 500°C**.** Supplied with nested loop PD controller for feedback with IGA Pt100 sample temperature sensor (see IG1-1) and temperature sentry. Maximum ramp rate (warming): 3°C/min Minimum ramp rate: 0.05°C/min Cooling time (to ambient): 3-5 hours Minimum temperature set point: 40°C (dependent on lab ambient) Temperature set time (typical): 1 hour Regulation accuracy: +/- 0.1-1°C Maximum Electrical Power: 0.5kW Over-temperature sentry: Type K Ramp rate control is used to inhibit heating/cooling when appropriate. The actual thermal profile may not be linear through each individual ramp stage.
IG3-2	**Standard 1000°C Furnace and Controller** Laboratory furnace for sample outgassing up to 1000°C and set-point regulation between 40°C and 1000°C**.** Supplied with nested loop PD controller for feedback with IGA Type K sample temperature sensor (see IG1-1) and temperature sentry. Also includes: • Substitute Klein flange quartz reactor assembly • Conflat to Klein flange adapter • Quartz sample container • Over-pressure safety relief valve and vent port • Faraday cage Maximum ramp rate (warming): 5°C/min Minimum ramp rate: 0.05°C/min Cooling time (to ambient): 3-5 hours Minimum temperature set point: 40°C (dependent on lab ambient) Temperature set time (typical): 1 hour Regulation accuracy: +/- 0.1-1°C Maximum Electrical Power: 1kW Over-temperature sentry: Type K Ramp rate control is used to inhibit heating/cooling when appropriate. The actual thermal profile may not be linear through each individual ramp stage.

ITEM	DESCRIPTION
IG3-3	**Low Thermal Mass Linear Ramp 500°C Furnace and Controller** An air-cooled radiant furnace for sample outgassing up to 500°C, linear ramp control for temperature programmed analyses and set-point regulation (isotherm determination) between 40 and 500°C**.** Supplied with nested loop PD controller for feedback with IGA Pt100 sample temperature sensor (see IG1-1) and temperature sentry. Maximum ramp rate: 20°C/min Minimum ramp rate: 0.05°C/min Cooling time (to ambient): 30mins Minimum temperature set point: 40°C (dependent on lab ambient) Regulation accuracy: +/- 0.1-1°C Maximum Electrical Power: 0.5kW Over-temperature sentry: Type K Air cooling: Automatic
IG3-4	**Low Thermal Mass Linear Ramp 1000°C Furnace and Controller** An air-cooled radiant furnace for sample outgassing up to 1000°C, linear ramp control for temperature programmed analyses and set-point regulation (isotherm determination) between 40 and 1000°C**.** Supplied with nested loop PD controller for feedback with Type K sample temperature sensor (see IG1-1) and temperature sentry. **Please Note:** This furnace is not designed for prolonged operation above 800 °C. • Substitute Klein flange quartz reactor assembly • Conflat to Klein flange adapter • Quartz sample container • Over-pressure safety relief valve and vent port • Faraday cage Maximum ramp rate: 20°C/min Minimum ramp rate: 0.05°C/min Cooling time (to ambient): 30mins Minimum temperature set point: 40°C (dependent on lab ambient) Regulation accuracy: +/- 0.1-1°C Maximum Electrical Power: 1kW Over-temperature sentry: Type K Air cooling: Automatic
IG3-5	**Liquid Nitrogen (BET) Jacket** A manually filled dewar flask with lab-stand and insulated stainless steel lid incorporating LN_2 refill and vent ports that adapts to the IGA reactor and BET upgrade (BET surface area calculation and graph plot). LN_2 capacity is 5 litres for maximum analysis time of 12 hours

ITEM	DESCRIPTION
IG3-6	**Refrigerated Recirculating Bath** Remote-controlled refrigerated recirculating bath with thermo-regulator including an environment jacket to allow the thermostatting fluid to be pumped around the sample reactor in the range 0°C to 80°C Supplied with nested loop software PD control for feedback with the IGA sample temperature sensor (see IG1-1) and includes over-temperature sentry. Typical regulation accuracy: +/- 0.05°C Settling time: 30-60minutes Bath capacity: 5 litres Bath fluid: Water / Ethylene Glycol Electrical power: 2kW Maximum pump pressure: 300 mbar
IG3-7	**Degas Heater Reactor with Integral Refrigerated Recirculating Water Bath** A stainless steel reactor and lab-stand with low thermal mass heater and nested loop PID control using the sample temperature sensor. The item offers combined controls with equivalent specifications to IG3-3 and item IG3-6 and includes the remote-controlled refrigerated bath with hose connections, degas heater with ramp/set point controller and the control software upgrade. This software upgrade provides automatic switching between degas functions and the water bath thermostat. The reactor can be used in conjunction with any IGA model and includes a basal gas coupling port beneath a diffuser for use with dynamic sorption systems. Maximum pressure: Equivalent to IGA system Maximum (degas) temperature: 500°C Leak rate: $<10^{-9}$ mbar l/sec Maximum ramp rate: 50°C/min Minimum ramp rate: 0.05°C/min Cooling time (to ambient): 30mins Regulation accuracy: +/- 0.1-1°C Maximum electrical power: 0.5kW (heater only) Over-temperature sentry: Type K (see also specifications IG3-6 for bath control mode) **Please Note:** This item is not compatible with option IG3-11.

ITEM	DESCRIPTION
IG3-8	**Cryofurnace** A detachable furnace with integral heater and cooling controls. Supplied complete with liquid nitrogen dewar on a roller base and two stage cryopumping system. Also includes a 2 metre detachable flexible insulated hose, 2 metre outlet hose and gas flow meter. The system is designed for set-point regulation by nested loop PID control using the IGA sample temperature sensor. This item requires a supply of liquid nitrogen. This item can be used in conjunction with any IGA model. Maximum pressure: Equivalent to IGA system Leak rate: <10-9 mbar l/sec Minimum set-point temperature: -150°C * Maximum set-point temperature: 500°C Cooling time: 60 mins to base temperature Set-point regulation accuracy: +/-0.05 to +/-1°C (depending on operating temperature) LN_2 dewar capacity: 50 litres Cooling control: Remote controlled on/off with manual throttle LN_2 consumption: 1-5 litre/hour (depending on operating conditions) *Lower temperature performance is possible depending on the IGA pressure/species.
IG3-9	**Sample Loader** Our unique sample loader enables air sensitive samples to be transferred to the gravimetric analyser in a controlled environment (e.g. dry nitrogen or argon). The loader can be purged with inert gas automatically using the IGA controls or by manual gas feed. The sample, which is housed in a vacuum-tight cartridge, is then attached using an integral manipulator. The system monitors pressure and flow (optional depending on IGA model) throughout the loading process to ensure reproducible conditions. The optional mass spectrometer can also be used to determine trace impurity concentrations. This item can be used in conjunction with any IGA model with the stainless steel tube reactor. It is not compatible with sample environment item IG3-7.
IG3-10	**Actuated Sample Environment Manipulator Arm** An electronically actuated manipulator arm to replace standard lab-stands and allow simple, rapid exchange of sample environment accessories. The sample environment manipulator arm features quick release locating pins, a motion limiter and personnel safety interlocks. This item is compatible with all sample environment options in section 3.0 and also the humidity control module (item IG1-3-2).

ITEM	DESCRIPTION
IG3-11	**Enhanced Temperature Rating at Pressure** An alternative sample reactor manufactured from Inconel® 625 designed for applications where temperatures above 500 °C are required in combination with pressures above ambient. Requires item IG3-2 or IG3-4 for temperature control. The reactor is supplied with a DN-35-CF flange to allow direct interchange with the standard reactor. Specifications equivalent to standard IGA system with extensions as below: Design pressure: 20 bar Design temperature (at pressure): 800 °C **Please note:** Operation is mutually exclusive with operation of items IG3-7, IG3-8 and IG3-9.
	Section 4.0: Gas Analysis Systems Close-coupled downstream analysis of the IGA gas composition expands the range of experiments to include TGA-MS and evolved gas analysis. A Dynamic Sampling Mass Spectrometer system (DSMS type HPR-20) with Hiden's high performance Quartz Inlet Capillary (QIC) is offered for gas analysis from IGA systems. A choice of mass spectrometer gauges and inlets are available to suit user applications. The DSMS system is directly interfaced with the IGASwin applications software to enable simultaneous data acquisition. Each DSMS is supplied on a mobile cart and may be rapidly decoupled from the IGA and released for use when not required for IGA measurements. Each system incorporates: • UHV 60 l/sec turbomolecular pump set • UHV vacuum manifold • High vacuum gauge • 2m heated capillary • Heated direct source inlet • Two stage rotary bypass pump (or oil-free scroll pump with Item IM5-5) • IGA interface • IGA-DSMS software upgrade
IG4-1	**Integrated DSMS with QIC Inlet** Inlet pressure range: 100 mbar – 2 bar Detector type: Single Filter Dual Faraday/Electron Multiplier Detection mass range: 1-200 AMU Typical detector sensitivity: 100 ppb, subject to spectral interference Typical response time: < 300 msec

ITEM	DESCRIPTION
IG4-2	**Integrated DSMS with QIC Inlet and Triple Mass Filter** Inlet pressure range: 100 mbar – 2 bar Detector type: Triple Filter Dual Faraday/Electron Multiplier Detection mass range: 1-300 AMU (or customer specified) Typical detector sensitivity: 5 ppb, subject to spectral interference Typical response time: < 300 msec
IG4-3	**Enhanced QIC Inlet Upgrade** Optional upgrade for Items IG4-1 or IG4-2 to allow sampling from 10 bars for moderate pressure studies without affecting system performance.
IG4-4	**High Pressure Inlet Upgrade** Optional upgrade for Items IG4-1 or IG4-2 replacing the QIC inlet to allow sampling from experiments at higher pressures. A typical (20 bar) inlet exhibits the following characteristics: Inlet pressure range: 100 mbar – 20 bar Typical response time: < 1000 msec Hiden Isochema is able to offer DSMS sampling inlets optimized to suit your application at pressures up to 200 bars. Please contact your local Hiden Isochema representative for further information.
IG4-5	**DSMS Oil-Free Pump Upgrade** Upgrades dual rotary pumps on DSMS system to a single oil-free scroll pump, preventing the possibility of sample contamination by back-streamed oil vapour.

Prof. Angiolina Comotti
University of Milano Biocca
Department of Materials Science
Via R. Cozzi 55, 20125 Milan, Italy

IGA Series Complete Price List

ITEM	DESCRIPTION	PRICE EUROS
	Section 1.0: Primary IGA Systems	
IG1-1	IGA-001 System	**89445.00**
IG1-2	IGA-002 System	**105025.00**
IG1-3A	IGA-003 Two Stream System	**117490.00**
IG1-3B	IGA-003 Three Stream System	**121910.00**
IG1-3C	IGA-003 Four Stream System	**126445.00**
	Section 1.1: Dynamic Sorption Options	
IG1-3-1	Humidity Control Module	**13840.00**
IG1-3-2	Single Stage Humidity Generator Module	**13855.00**
IG1-3-3	ABR Automated Breakthrough Reactor	**P.O.A.**
	Section 1.2: Integrated IGA systems	
IG1-100A	IGA-100 Two Stream System	**133070.00**
IG1-100B	IGA-100 Three Stream System	**137485.00**
IG1-100C	IGA-100 Four Stream System	**142025.00**
IG1-200	IGA-200 System	**P.O.A.**
	Section 2.0: General Options / Accessories	
IG2-1	Enhanced Balance Capacity 5 g	**3850.00**
IG2-2	Enhanced Pressure Rating 20 bar	**6190.00**
IG2-3A	Additional Pressure Range 0-1 bar	**2480.00**
IG2-3B	Additional Pressure Range 0-2 mbar, 0-10 mbar or 0-100 mbar	**4280.00**
IG2-4A	Rotary Pump Station	**7240.00**
IG2-4B	Turbomolecular Pump Station	**16850.00**
IG2-4C	Turbomolecular Pump Station with Enhanced Chemical Resistance	**P.O.A.**
IG2-5	Floor Mounting Frame	**4350.00**
IG2-6	Personal Computer with IGA communications interface	**1890.00**

Installation, training and delivery additional

ITEM PRICES continued

ITEM	DESCRIPTION	PRICE EUROS
	Section 3.0: Sample Environment Equipment	
IG3-1	Standard 500 °C Furnace and Controller	**6945.00**
IG3-2	Standard 1000 °C Furnace and Controller	**10725.00**
IG3-3	Low Thermal Mass Linear Ramp 500 °C Furnace and Controller	**9290.00**
IG3-4	Low Thermal Mass Linear Ramp 1000 °C Furnace and Controller	**14555.00**
IG3-5	Liquid Nitrogen (BET) Jacket	**2280.00**
IG3-6	Refrigerated Recirculating Bath and Environment Jacket	**10495.00**
IG3-7	Degas Heater Reactor	**22050.00**
IG3-8	Cryofurnace	**25035.00**
IG3-9	Sample Loader for Air- and Moisture- Sensitive Samples	**8680.00**
IG3-10	Actuated Sample Environment Manipulator Arm	**4440.00**
IG3-11	Enhanced Temperature Rating at Pressure	**11530.00**
	Section 4.0: Gas Analysis Systems	
IG4-1	Integrated DSMS with QIC Inlet 1-200 AMU	**53350.00**
IG4-2	Integrated DSMS with QIC Inlet and Triple Mass Filter	**59630.00**
IG4-4	High Pressure Inlet Upgrade (20 bar)	**P.O.A.**
IG4-5	DSMS Oil-Free Pump Upgrade	**10700.00**

Installation, training and delivery additional