Smart Q TECHNOLOGY

Gas Pressure Sensors

Differential Gas Pressure

(Product No. 3141)

Number of pressure ports: 2

- ±200 kPa (Resolution: 0.1 kPa)
- ±30 psi (Resolution: 0.02 psi)

Differential Gas Pressure

(Product No. 3139)

Number of pressure ports: 2

- ±10 kPa (Resolution: 0.01 kPa)
- ±1.5 psi (Resolution: 0.001 psi)

Absolute Gas, Barometric Pressure or Altitude

(Product No. 3210)

Number of pressure ports: 1

- 0 to 110 kPa Absolute (Resolution: 0.1 kPa)
- 85 to 110 kPa Absolute (Resolution: 0.1 kPa)
- 0 to 33 inHg (Resolution: 0.01 inHg)
- Altitude -500 to 12,000 m (Resolution: 4 m)

Absolute Gas Pressure

(Product No. 3142)

Number of pressure ports: 1

- 0 to 700 kPa Absolute (Resolution: 0.3 kPa)
- 0 to 100 psi (Resolution: 0.1 psi)

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Introduction

Pressure is defined as force per unit area and can be measured using a wide range of units. The standard SI unit of pressure is the pascal (Pa). Alternative measures are inches of mercury and pounds per square inch.

The *Smart Q* Gas Pressure Sensors are equipped with a micro controller that greatly improves the accuracy, precision and consistency of readings. They are supplied calibrated and the stored calibration is automatically loaded when the Pressure Sensor is connected.

The sensing element in the *Smart Q* Gas Pressure Sensors is a diaphragm that flexes as the pressure changes. The sensor's electronics has temperature compensation to minimise the effect of ambient temperature changes on data.

There are 4 Gas Pressure Sensors with ranges designed specifically to suit experimental conditions.

1. The *Smart Q* Differential Gas Pressure Sensor (*Product No. 3141*) has two ports and gives an output relative to the difference of pressure between the two ports. It can be used to measure differential pressure in either kPascals or pounds per square inch.

   If the second port is left open to the atmosphere then pressure is measured relative to atmospheric pressure.

2. The *Smart Q* Differential Gas Pressure Sensor *(Product No. 3139)* is similar to 3141 but with a much more sensitive range. This makes it suitable for investigations that require measurement of small pressure changes with high resolution e.g. as in many Biology investigations. It can be used to measure differential pressure in either kPascals or pounds per square inch.

3. The *Smart Q* Absolute Gas Pressure, Barometric Pressure or Altitude Sensor *(Product No. 3210)* can be used to measure either absolute pressure in kPascals, or inches of mercury or altitude in meters above sea level.

4. The *Smart Q* Absolute Gas Pressure Sensor *(Product No. 3142)* is similar to 3210 but has a wider pressure range – equivalent to 7 atm. It can be used to measure absolute pressure in either kPascals or pounds per square inch.

The Differential Gas Pressure Sensors

(Product No. 3141)

- ±200 kPa
- ±30 psi

(Product No. 3139)

- ±10 kPa
- ±1.5 psi

The *Smart Q* Differential Gas Pressure Sensors have two ports available to allow for the application of pressure to either side of the diaphragm. These sensors measure the **difference** between the pressures applied to these ports.

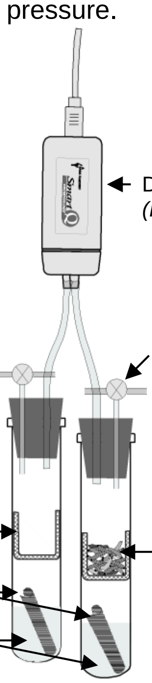
P1 – P2 = Differential Pressure

If both ports are left open to the atmosphere, the effect of atmospheric pressure will equal each other out and the difference between the ports will be zero.

If only one port is used, and the unused port is left open to the atmosphere, the Sensor will measure pressures above or below atmospheric pressure i.e. gauge pressure.

If the Sensor shows a reading of 25 kPa (gauge), that is 25 kPa above atmospheric pressure. Since atmospheric pressure is approx. 101.3 kPa, the equivalent atmospheric pressure reading would be 25 + 101.3 = 126.3 kPa (absolute).

Investigations that would traditionally use a manometer can utilise the Differential Sensors. One port is connected to the 'living' chamber that holds the organisms. The other port is connected to a 'non living' chamber which acts as a thermo barometer. CO_2 given off by the respiring organisms is absorbed by the potassium hydroxide resulting in a change of pressure.



Investigating the uptake of oxygen by maggots

The maximum pressure that these sensors can tolerate without permanent damage is: -
Product No. 3141 = maximum pressure between ports P1 to P2 = ***400 kPa*** *or* ***58 psi***
Product No. 3139 = maximum pressure between ports P1 to P2 = ***75 kPa*** *or* ***10 psi***

Absolute Gas Pressure, Barometric Pressure, or Altitude Sensor

(Product No. 3210)
- 0 to 110 kPa
- 85 to 110 kPa
- 0 to 33 inHg
- Altitude -500 to 12,000 m

This Pressure Sensor is used to measure **absolute** pressure - the actual gas pressure at the port with respect to zero. The pressure is measured against a built-in internal vacuum reference. The Sensor then produces an output voltage that varies with absolute pressure.

If the port is left open to the atmosphere, the Sensor will display the value for atmospheric pressure (pressure caused by the downward force of the Earth's gravity pressing the air down on the Earth). The average pressure exerted at sea level by the atmosphere in Britain is 101.325 kPa (1 atmosphere).

Some equivalent values for 1 atmosphere (atm) are = 101.325 kPa = 760 mm of Hg = 29.92 in.of Hg (at 0^oC) = 14.70 psi = 1013 millibar

This Sensor can be used to measure **Barometric Pressure** for weather studies. As the Earth spins some of the Earths atmosphere swirls into eddies. These areas can have pressure above or below the average. Energy from water vapour condensing in colder air and from convection currents can increase these effects as they move through the atmosphere changing our weather. To show the pattern of pressure changes, all the places on the map that have equal air pressure are joined by lines called isobars. Isobars have their pressure marked in millibars (mB) or inches of mercury (in.of Hg).

The conversion from kPA to mBar is simply to multiply by 10.

Conversion 1 kPascal = 10 millibar = 0.14504 psi.

1,000 millibars = 1 bar = 100,000 Newtons acting on a square meter.

1 millibar = 0.02953 inches of mercury.

1 hectoPascal = 1 millibar.

Note: *The value for Barometric pressure reported by airports and weather stations is usually given for the pressure at sea level i.e. pressure after it has been adjusted to its equivalent at sea level. The value obtained by this Sensor will be the pressure at its current location.*

This Sensor can also display values for **Altitude**. No matter what weather systems are doing, the air's pressure decreases with height. The Altitude scale has been calibrated to measure height rather than pressure. The conversion of pressure to altitude assumes 1 atmosphere (101.325 kPa) of pressure at sea level so the Sensor will give a **relative** rather than an absolute value of altitude.

Note: *To give an exact height, the barometric pressure at sea level (for that location) would be required (this may not be 101.325 kPa). For example: the Sensor may display that the altitude at sea level is 100 m instead of zero, due to atmospheric pressure being 1001 mBar not 1013. If the altitude for the starting level is known, values can be adjusted using the Pre or Post-log Functions in the* ***EASY****SENSE software.*

The maximum pressure that this sensor can tolerate without permanent damage is: -
400 kPa *or* ***118 inHg***

Absolute Gas Pressure

(Product No. 3142)
- 0 to 700 kPa
- 0 to 100 psi

This *Smart Q* Gas Pressure Sensor will measure **absolute** pressure - the actual air pressure at the port with respect to zero. The pressure is measured against a built-in internal vacuum reference. The Sensor then produces an output voltage that varies with absolute pressure.

An absolute pressure reading of 150 kPa may be described as a gauge pressure of 150 -101.3 = 48.7 kPa (gauge), that is 48.7 kPa above atmospheric pressure.

The maximum pressure that this Sensor can tolerate without permanent damage is:- ***700 kPa*** *or* ***100 psi.***

Connecting

- Push one end of the sensor cable (supplied with the **EASY**SENSE unit) into the hooded socket on the Gas Pressure sensor with the locating arrow on the cable facing upwards.
- Connect the other end of the sensor cable to an input socket on the **EASY**SENSE unit.
- The **EASY**SENSE unit will detect that the Gas Pressure sensor is connected and display values using the currently selected range.

To set the range

With some **EASY**SENSE units it is possible to set the range from the unit. Please refer to the **EASY**SENSE unit's user manual.

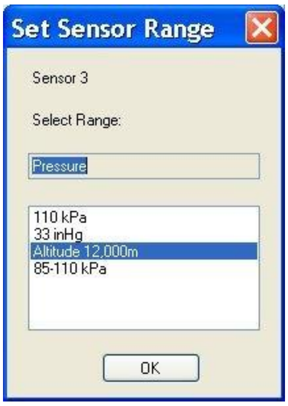
To alter the range in the EasySense software:

1. Select **EasyLog** from the Home screen.
2. Select the **New** recording wizard icon. 

3. Click on the sensor's name.
4. A set sensor range window will open. Select the required range, then OK.
5. Select Finish to exit the wizard.

Or

1. From the Home screen select **Sensor Config** from the Settings menu.
2. Select the Pressure sensor from the list and click on the **Change Range** button.
3. The current range will be highlighted. Select the required range and click on OK.
4. Close Sensor Config.



The range setting will be retained until changed by the user. To alter the currently selected range.

Practical information

The sensor element has automatic internal temperature compensation from 0˚C to 50˚C.

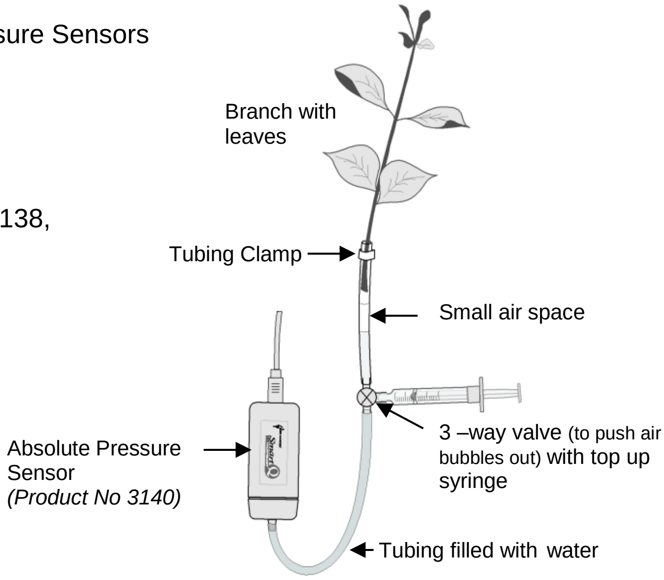
Maximum Operating Temperature: -40˚C to 85˚C.
Maximum Storage Temperature: -55˚C to 125˚C.
Humidity: 0 to 100% RH.

The external diameters of the ports on the Pressure Sensors are tapered from 4.0 to 4.3 mm.

Use with PVC or Silicon tubing: **3.0** to **3.5 mm** internal diameter

A Gas Pressure Accessory Pack, Product No. 3138, is available which contains a selection of tubing elements and valves which allow gas tight connections to the Gas Pressure sensor.
They are:

- 1 x 1 m PVC tube (3 mm bore x 1 mm wall thickness),
- 1 x 1 m of nylon pneumatic tube (4 mm O.D x 2.5 mm I.D),
- 4 x large pipette tips,
- 4 x small pipette tips,
- 1 x straight push fit connector,
- 1 x Tee piece push fit connector,
- 2 x 3-way valves (stop cocks) and
- 1 x 20 ml Syringe



Rate of plant transpiration

Only use these Sensors to measure non-corrosive/non-ionic media such as air or dry gases.

These Sensors are **not suitable** for use with flammable gases.

The vapour pressure of liquids can be monitored but do **not** allow liquid to enter the Sensor.

Protect from the weather – keep the Sensor dry.

The container used with the Pressure Sensor must be suitable for the task and able to sustain the pressure. The type of container selected will depend on the investigation.

A non-flexible airtight container like a syringe could be used for quantitative investigations e.g. pressure vs. volume.

Gas contained in a system under pressure will try to find a way out. The longer the investigation lasts the more dominant the effect of any leaks will become - try to complete the investigation as quickly as it allows.

Units of Measurement

Pressure can be measured using a wide range of units. The standard SI unit of pressure is the pascal (Pa).

InHg (USA) and mBar (UK) are used for weather measurements only. The conversion from kPa to mBar is simply to multiply by 10.

Equivalent values for 1 atmosphere (atm) are = 101.325 kPa = 760 mm Hg = 29.92 in. of Hg (at 0^{o}C) = 14.70 psi = 1013 millibar.

Conversion 1kPascal = 10 millibar = 0.14504 psi. 1 Pascal = 1 Newton per square meter (1 N/m^2).

Best sensor recommendations

The ‘best’ sensor will depend on the way an investigation is conducted. The recommendations and values quoted are based on our experience in using these Sensors.

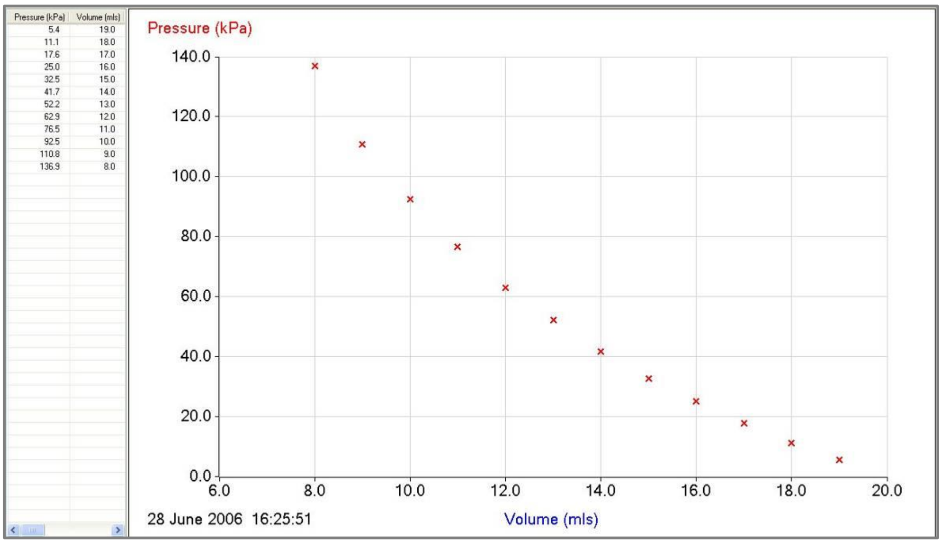
✓✓✓ Best, ✓✓ Next Best, ✓ Tolerable, ✘ Not recommended (results will likely be outside of this Sensor’s range or the resolution is not good enough).

Investigation	Differential *No. 3139* ±10 kPa. (Res. 0.01 kPa)	Differential *No. 3141* ±200 kPa. (Res. 0.1 kPa)	Absolute *No. 3210* *No. 3140* 0 – 110 kPa (Res. 0.1 kPa)	Absolute *No. 3142* 0 – 700 kPa (Res. 0.3 kPa)
Boyle’s law (Pressure vs. volume) e.g. 20 ml syringe = approx. 200 kPa movement (Abs. 100 + 200 = 300 kPa, Diff. 0 + 200 = 200 kPa)	✘	✓✓✓ A pre or post log function can be used to add atmospheric value to the result	✘	✓✓✓
Gay-Lussac’s law (Pressure vs. absolute temperature) e.g. approx. 10 - 30 kPa movement	✘	✓✓✓ A pre or post log function can be used to add atmospheric value to the result	✓✓	✓✓
Rates of chemical reaction e.g. 5 - 20 kPa movement (depends on quantity of chemicals)	✓✓✓ (If small quantities of chemical are used)	✓✓✓	✓	✓
Production of gases in an enclosed atmosphere e.g. O_2 - photosynthesis of an aquatic plant approx. 10 kPa movement	✓✓✓	✓✓	✓✓	✓
Rate of Respiration e.g. Germinating seeds approx. 10 kPa movement	✓✓✓	✓✓	✓✓	✓
Yeast Fermentation e.g. Carbon dioxide production approx. 10 kPa movement	✓✓✓	✓✓	✓✓	✓
Rate of Transpiration e.g. Plant on a windy or sunny day approx. 10 kPa movement	✓✓✓	✓✓	✓✓	✓
Chest expansion e.g. With Breathing Rate belt - Product No. 3190 approx. 3 kPa movement	✓✓✓	✘	✘	✘
Bursting a Balloon e.g. Abs. 100 – 140 kPa, Diff. 0 – 40 kPa	✘	✓✓✓	✘	✓✓
Depth gauge (lower the end of pvc tube into water e.g. 15 cm depth = 1.5 kPa approx.)	✓✓✓	✓✓	✓	✓
Changes in air pressure e.g. Weather studies approx. 95 to 105 kPa	✘	✘	✓✓✓	✓✓
Altitude investigations	✘	✘	✓✓✓	✘

Investigations

Boyle’s Law (Pressure vs. Volume)

- Connect a short piece (approx. 2 cm) of PVC tubing to the nozzle of a 20 ml syringe.
- Move the syringe piston to the required volume mark e.g. 20 mls before connecting to the Pressure Sensor.
- Push the tubing onto the Pressure Sensor port marked P1.
- Start the **EASY**SENSE software and select **Snapshot** from the **Home** screen.
- Select **Pre-Log Function** from the **Tools** menu. Select **Preset** function, with **General** from the first drop-down list and then **Asks for Value** from the second list. Next. Type in Volume as the name, enter the units to be used e.g. mls and alter the maximum value to 20. Finish.
- From the **Options** icon, select **X-Axis** and select **Channel**. OK. If necessary, click below the graph area so that ‘Volume’ is displayed on the x-axis.
- Click on the **Start** icon to begin. Click in the graph area to record the pressure and then enter a value of 20 into the dialogue box.
- Push the syringe plunger in to decrease the volume by a regular amount e.g. every 1 ml, click in the graph area to record the pressure and enter the volume value.
- Repeat the above until either the value reaches near the top of the sensors range or it becomes too difficult to push.

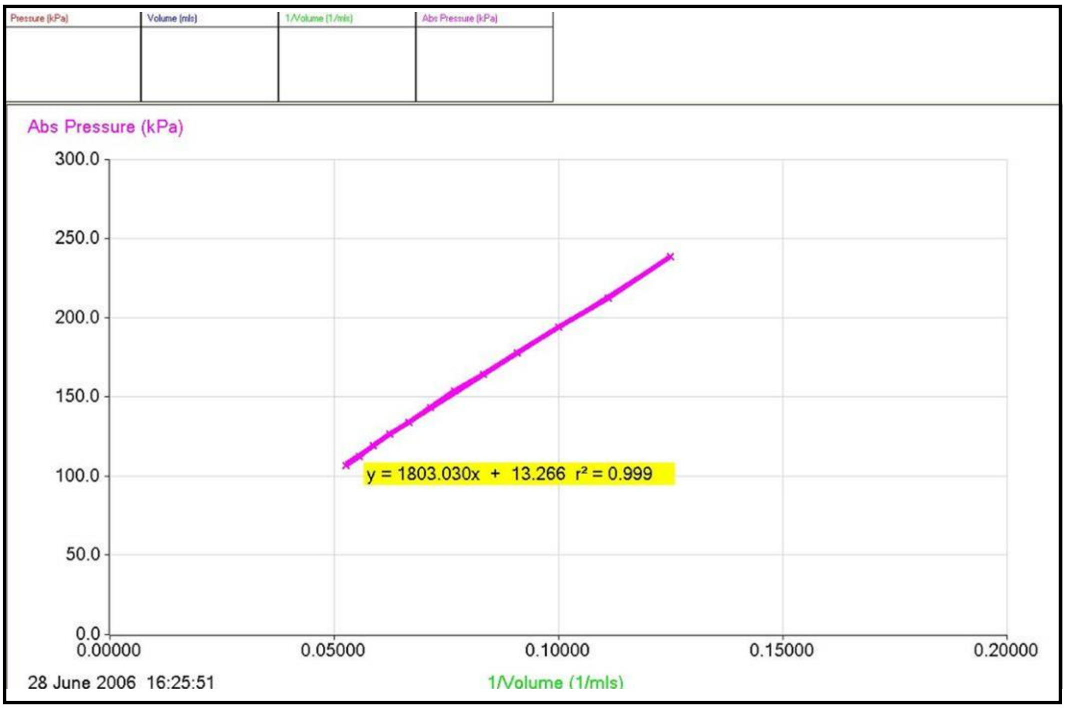


Pressure (kPa)	Volume (mls)
5.4	19.0
11.1	18.0
17.6	17.0
25.0	16.0
32.5	15.0
41.7	14.0
52.2	13.0
62.9	12.0
76.5	11.0
92.5	10.0
110.8	9.0
136.9	8.0

Graph shown with the min and max limits reduced by using Sensor Settings (Options), with Graph Type set to x point style.

- Select **Post-log function** from the **Tools** menu. Select **Formula** and **a/x + c** from the drop-down menu, Next. Select **Volume** as the channel, Next. Rename as **1/Volume**, 1/mls as the units, the number of decimal places as **5**, with a maximum value of **0.2**, a = 1 and c = 0, Finish. Click below the graph area to display 1/Volume.
- If the Differential Pressure sensor was used, select **Post-log function** from the **Tools** menu. Select **Pre-set function, General** and then **Add a constant** from the drop-down menus, Next. Select **Pressure** as the channel, Next. Rename as **Abs Pressure**, with a maximum value of **300**, and the number to add as 101.3, Finish. Click to the left of the graph area to display Abs Pressure.

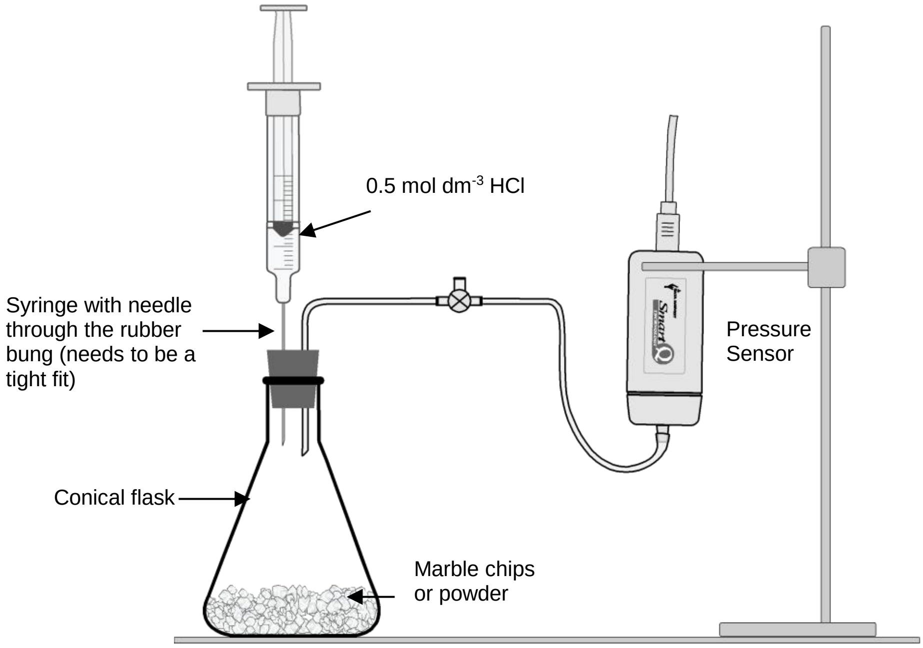
Typical results: -



Graph Type set to line graph, shown with automatic Best Fit (Tools) applied

Rate of Reaction between marble chips and hydrochloric acid

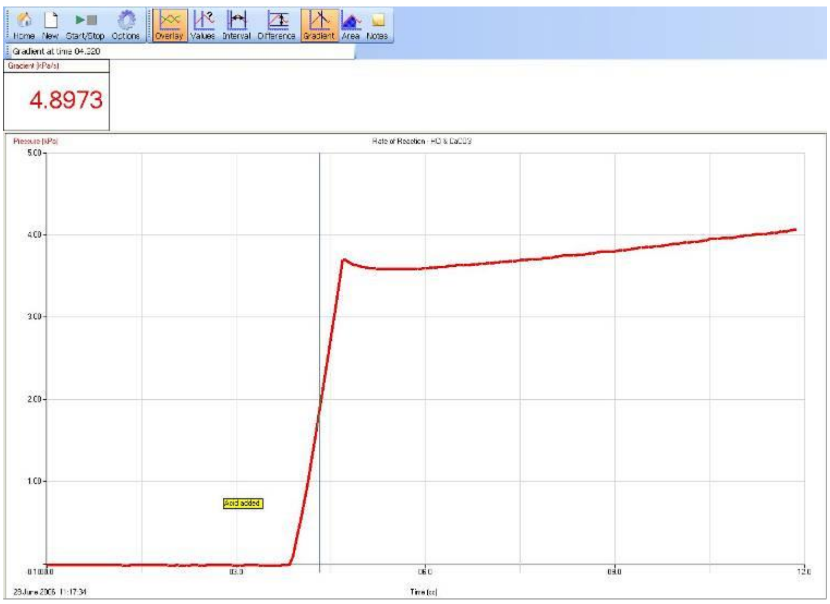
The rate of a chemical reaction can be affected by concentration of reacting chemicals, temperature, particle size and catalysts. The progress of the reaction between calcium carbonate and hydrochloric acid can be monitored by the evolution of carbon dioxide, $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$. The carbon dioxide produced will cause a pressure increase in a sealed container.



- Assemble the apparatus as shown. The quantity of marble chips will depend upon the size of the flask i.e. in a 250 ml flask use 5 g of large marble chips.
- The two chemicals need to be kept separate until you are ready to start logging. Place the rubber bung in the flask without the syringe attached (to release any pressure). Draw up 10 cm^3 of 0.5 mol dm^{-3} hydrochloric acid into the syringe and fix to the PVC tube.
- Start the **EASY**SENSE software and select **EasyLog** from the Home screen.
- Click on the **Start** icon to begin logging and add the hydrochloric acid from the syringe to the flask.

  Note: *Keep gentle pressure on the bung and the plunger of the syringe to prevent them from lifting.*

- Use **Gradient** to find the rate of reaction from the slope of the graph.



Graph shown with the min and max limits reduced by using Sensor Settings (Options).

Limited warranty

For information about the terms of the product warranty, see the Data Harvest website at: https://data-harvest.co.uk/warranty.

Note: Data Harvest products are designed for **educational** use and are not intended for use in industrial, medical or commercial applications.

WEEE (**W**aste **E**lectrical and **E**lectronic **E**quipment) Legislation

Data Harvest Group Ltd is fully compliant with WEEE legislation and is pleased to provide a disposal service for any of our products when their life expires. Simply return them to us clearly identified as 'life expired' and we will dispose of them for you.