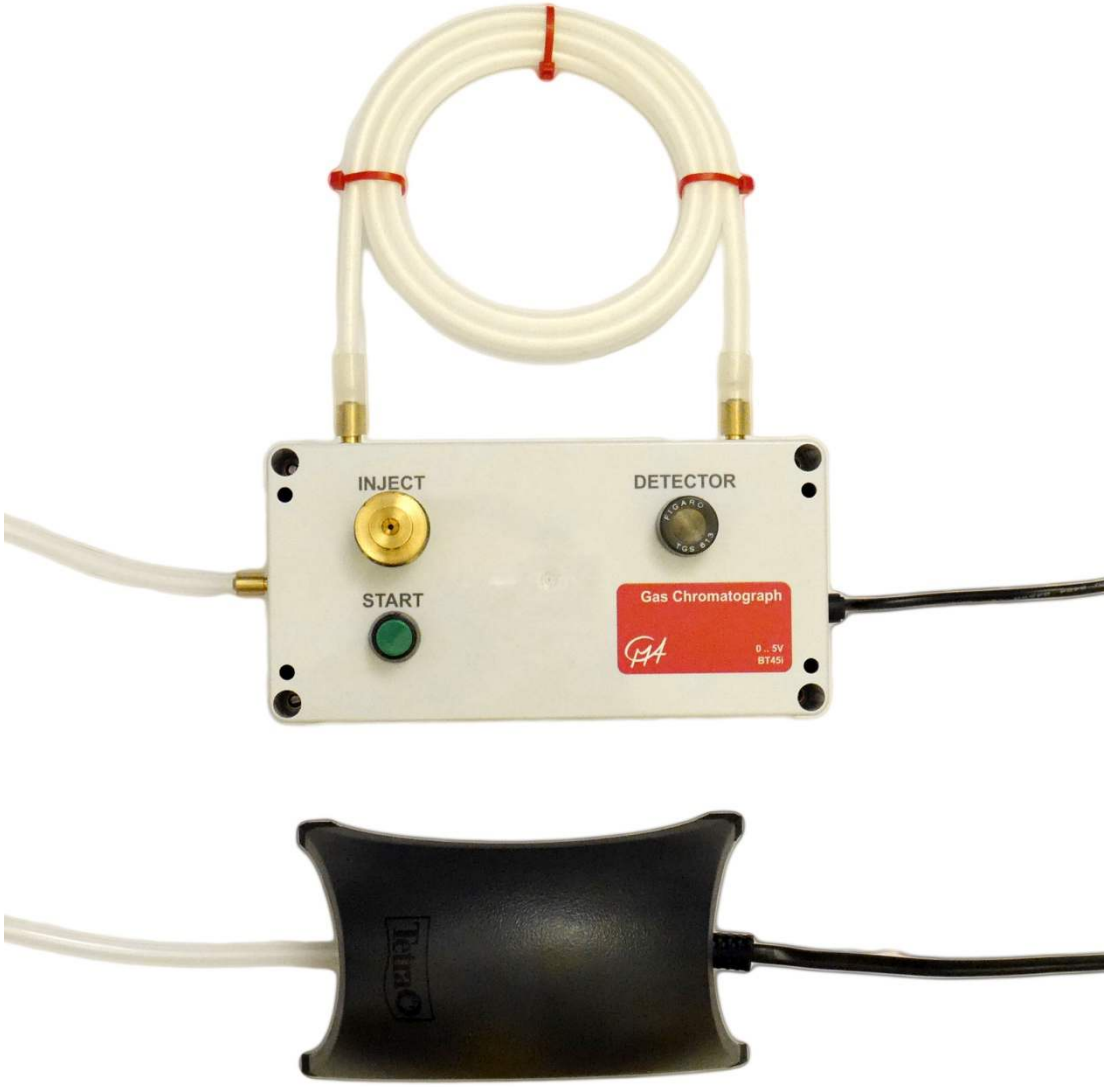
GAS CHROMATOGRAPH BT45i

USER'S GUIDE



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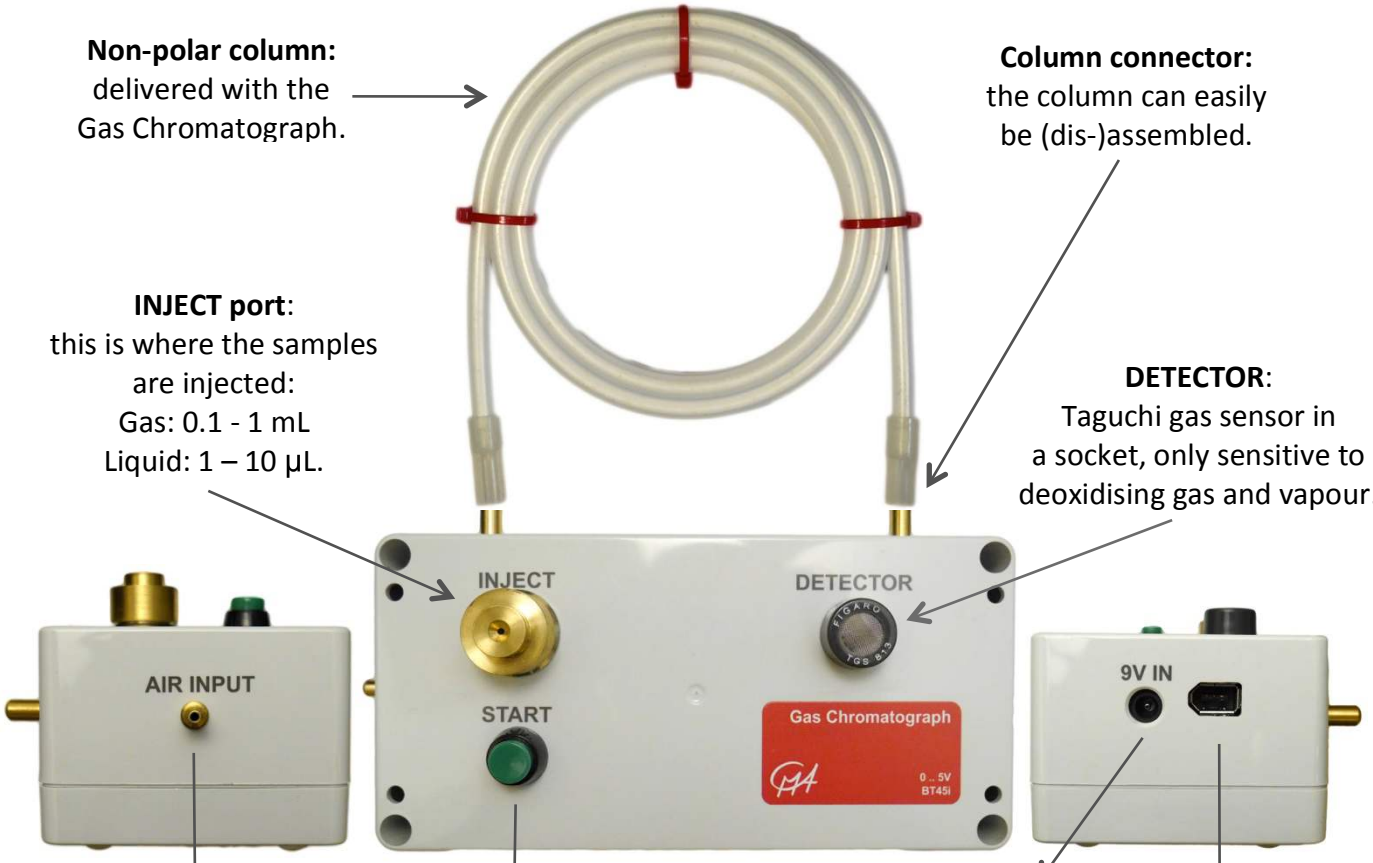
Short description

The Gas Chromatograph BT45i (later called GC) is a low cost gas chromatograph, intended for educational use. It is designed to separate mixtures of gases or volatile liquids and identify components of the mixtures by their specific retention times. The GC operates at room temperature, eliminating long warming up periods.

The CMA GC BT45i is delivered with:

- non-polar column,
- air pump,
- 9V power adapter,
- 3 syringes (1 mL volume) with 3 short needles (0.5 × 16 mm),
- 2 spare septa (a third septum is placed below the injection port),
- 40-cm long PVC tubing,
- disposable cigarette lighter.



The GC BT45i can be directly connected to analog BT inputs of CMA interfaces. The sensor cable BT - IEEE1394 needed to connect the sensor to an interface is not supplied with the sensor and has to be purchased separately (Order Code BTsc_1).

⚠ Caution:

- Operating the GC implies working with combustibles. Keep in mind the general safety measures on handling combustible gases and liquid.
- Use eye protection. Protect your arms and hands by wearing a long-sleeve lab coat and gloves.
- Never inject more than 10 µL of liquid. Injecting too much fluid can cause permanent damage of the column.
- Place the needle back into its protective cap immediately after use.

Overview of GC elements

The GC consists of a number of components.

1. Gas carrier

An air pump serves as a carrier gas source. The carrier gas is therefore air. The pump is connected to the air inlet via a plastic tube delivered with GC. This air inlet is internally connected to the injection chamber, which is located under the injection port.

2. Injection of samples

A sample is injected in the injection port. When using the metal injection needle, insert the needle into the INJECT port and pierce through the septum (not-visible, silicone rubber disc located inside the injection port). The syringe must then be quickly emptied and at the same time the measurement should be started.

Injecting gas samples

Many sources of gas can be sampled without using the needle.

Then replace the needle; press the needle of the filled syringe perpendicularly into the hole at the top of the injection port and quickly empty the syringe.

The sample's volume depends on the type of column and the composition of the gas sample. The ideal volume for a certain sample can be obtained experimentally. A good starting-point could be 0.2 mL (for cigarette lighter gas with the non-polar column).

Injecting liquid samples

For the injection of liquid samples a micro syringe **must** be used. A standard type micro syringe has a typical needle length of 50 mm. Such needles **must not be** inserted in the injection port **deeper than 16 mm** to avoid damage to both the needle and the internal injection port.

Preferably inject only volatile samples, as pure as possible.

Injecting liquid samples may pollute the injection port with non-volatile components. The injection port will need to be cleaned regularly with pure ethanol.

Use of the syringe

- Handle your micro syringe with care. A bent needle or piston makes the syringe useless.
- Never use needles bigger than Ø 0.5 × 16 mm.
- Connect the needle to the syringe by pressing it on with the protective cap. Remove the protective cap only shortly before injecting the sample. The needle

can be removed from the syringe by turning the protective cap and pulling at the same time.

The injection septum

The injection septum consists of a silicone rubber disc and has a lifetime of 50 to 100 injections. If the septum is worn out, it may start leaking. You may notice an increase in retention times and smaller peak surface area's due to loss of sample.

You can replace the septum with the supplied spare types. Unscrew the injection port cap, replace the septum and screw the cap back on by hand.

3. Column

The column consists of a rolled up piece of plastic hose filled with small granules. The injected sample flows into the column together with the carrier gas. In the column, the substances from the sample will constantly condense on the grains, causing them to stop moving and evaporate again so that they are passed through the column with the carrier gas. Substances with a low boiling point that easily evaporate will pass through the column relatively faster because they are more often gaseous. The time that a substance needs to go through the column is the retention time of that substance.

The end of the column is attached to a connector that is internally connected to an outflow opening where it can be detected by the gas sensor.

A non-polar column, needed for most experiments, is delivered with the GC BT45i.

A polar column and a short (fast) non-polar column are not supplied and can be purchased separately.

4. Detection

The GC's detection system is based upon a Taguchi type gas sensor TGS813. The sensor is fitted in a socket for good visibility and can easily be taken out for replacement. The sensor can be plugged in two possible ways; the symmetrical pin layout permits both ways. The sensor's ventilation grid should not be obstructed.

The sensing element of the gas sensor is a tin dioxide (SnO_2) semiconductor material. The gas sensor is only sensitive to combustible gasses and vapours such as hydrogen, alkanes, alkenes, alcohols, etc. These vapours will be oxidised by the oxygen, which is permanently adsorbed at the sensor's surface. Contact with deoxidising gasses generates a small electric current. The signal from the detector is measured via the sensor output.

5. The START Button

The START button allows to remotely start the measurement by using the Coach software. Pressing the button generates a voltage signal of circa 4.5 V at the sensor output. The START button will only work when the appropriate trigger conditions in the software have been set.

Measuring with GC sensor in the Coach software

1. Set-up your GC.
   - Connect the column to the two column connectors on top of the GC.
   - Connect the air pump to the air input of the GC by using the provided PVC tubing.
   - Plug the air pump to an outlet.
   - Plug the round plug of the 9 V power supply into the 9V-port of the GC and plug it

into the outlet.

- Your GC is now ready for use. Typically the GC is used horizontally on the table to make injection easier. For a better view during classroom demonstrations it can be placed vertically.

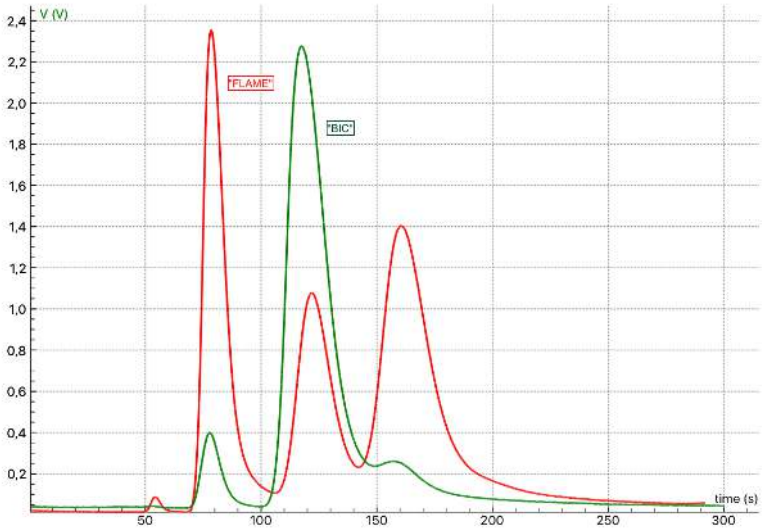
2. Setup your measurement in the Coach software.
   - Connect the GC with your interface. Use the sensor cable (not delivered with the GC) and connect the GC sensor output with an analog input of your interface.
   - The GC has a memory chip (EEPROM) with information about the sensor: its name, measured quantity, unit and calibration. By default this information is used and the sensor measures voltage between 0 .. 5V. When your GC is properly connected to an interface then it is automatically recognized in the Coach software and the measured values are shown on the icon displayed on the screen panel in Coach. If your GC is not automatically detected by an interface you have to manually set it up by selecting it from the Coach Sensor Library.
   - The GC's gas sensor produces a minimum output of about 0.15 V when nothing is detected. To set this "base signal" to 0 V you have to shift this signal. Right-click the GC icon on the interface panel in Coach and select the option **Set to Zero**.
   - To use the START button you have to select appropriate trigger conditions. Set the **trigger level to 4 V** and the **trigger direction to up**.
   - Set the proper measurement time, this time interval depends on the expected retention times of the sample to be investigated e.g. measurement time of 350 seconds is appropriate for investigating cigarette-lighter gas. The sampling rate of 5 measurements per second is sufficient.
3. Perform your measurement.
   - Fill the syringe with a sample (see details given under '2. Injection of samples').
   - Start your measurement in Coach. Remember to enable triggering with the conditions given above. Then the data collection will start automatically when the START button on the GC is pressed.
   - Inject the sample and at the same moment press the START button. For the best synchronisation the person who injects the sample should do this. The START button is positioned close to the injection port for easy access.
   - Determine the retention times from your chromatogram.

The table below displays retention times with the non-polar column. The retention times can vary due to differences in temperature, gas-flow (pump pressure) and packing density. The empty fields in the table can be used to note corrected values.

Substance	Retention time (s)			
hydrogen	44.5			
methane	46.4			
ethene	50.0			
ethane	52.5			
propene	65.6			
propane	68.5			
methylpropane	95.1			

1-butene	105			
n-butane	119			
2,2-dimethylpropane	138			
2-methylbutane	207			
1-pentene	219			
methylmethanoate	223			
n-pentane	257			
2,2-dimethylbutane	383			
ethylmethanoate	440			
methylethanoate	450			
2,3-dimethylbutane	455			
2-methylpentane	506			
3-methylpentane	562			
1-hexene	583			
n-hexane	680			
ethylethanoate	899			
benzene	968			
2,2-dimethylpentane	970			
2,3-dimethylpentane	970			
3-ethylpentane	1567			
n-heptane	1900			
methylbenzene	3080			
n-octane	5470			

The image shows examples of chromatograms of gases used in two different cigarette lighters of brand "FLAME" and "BIC". In both cases 0.2 mL of gas was injected. The measured retention times can be read from the chromatogram and compared with the reference table to see which substances are in the gas mixture. From the height of the peaks one can see how much of that substance is present.



Note: If your GC has not been used for a longer period of time it is advisable to 'burn in' the sensor for 24 hours prior to use. The air pump does not need to be connected. Just power the GC with its power adapter. Burning in the sensor improves the sensor's reproducibility and sensitivity.

Suggested experiments

The GC BT45i is very well suited for the demonstration of the principles of gas chromatography. Its simple construction and room temperature operation will require only short preparation times. It can be used in a variety of experiments:

- **Cigarette lighter gas:** Gas from a cigarette lighter contains propane, methylpropane and butane. Small amounts of ethane and pentane are also often detected. Various brands contain different compositions. By comparing the chromatograms of two different lighters, the qualitative as well as the quantitative aspects of gas chromatography can be discussed.
- **Natural gas:** The first peak in the chromatogram obtained from natural gas is from methane. Other components such as propane and butane can also be detected. Natural gas contains about 14% nitrogen. The detection sensor **is not** sensitive to nitrogen gas.
- **Natural oil:** The lightest components of crude oil can be found dissolved in the oil, but also in the vapour above the oil in a barrel. The vapour above the oil can be investigated using the GC BT45i. Oil from another site contains the same gasses in a different relative abundance. During the distillation of crude oil, gas samples can be taken from the condenser at different temperatures.
- **White spirit:** An investigation of white spirit shows that white spirit consists of more than just methanol and ethanol. A polar column is needed for the investigation of polar components such as alcohols.
- **Biogas:** Gas from a ditch or from a (self-made) biogas installation can be investigated.
- **Hydrogen:** Hydrogen can very easily be obtained in a pure form (electrolysis or the reaction of a metal with an acid). Hydrogen has a very short retention time. This makes hydrogen very suitable for measuring the detectors properties. Since hydrogen is hardly adsorbed by the stationary phase of the column, it can be used to determine the flow of the carrier-gas. The retention time of hydrogen is almost equal to the carrier gas retention time.
- **Aerosol propelling agent:** CFC propelling gas has been used in aerosol cans for a long time. Since 1989 they are banned because they are hazardous to the environment. What kind of propelling agents are used today in a can of deodorant spray?
- **Investigating the detector:** The detectors sensitivity to hydrogen can be investigated. What is the minimum amount of hydrogen that can be detected?
- **Calibrating the detector:** If the surface-area of a peak in the chromatogram is a measure for the amount of a certain component, and the carrier gas flow is constant, then the vertical axis of the chromatogram can theoretically be calibrated in mole per second. Is this also true in practice? Is the calibration the same for different components?
- **Forensic investigation:** Use the GC to determine the source of a given sample of petrol. Record chromatograms of different brands of petrol (not diesel) and compare the results with the sample chromatogram. A much faster method is to compare a gaseous sample with different brands of cigarette lighters.
- **Methanol in white wine:** White wine often contains small amounts of poisonous methanol. With a polar column methanol can be detected. First the wine should be distilled. To prevent non-volatile components to reach the column the distillate should be injected.

Check the Teaching Resources provided on the CMA website (https://cma-science.nl) to find the ready-to-go lessons for the Gas Chromatograph BT45i.

Technical Specifications

Sensor kind	Analog, generates an output voltage between 0 and 5 V
Measuring range	0 .. 5 V
Resolution using *12- bits 5V AD converter*	1.25 mV
Gas detector	TGS813 gas sensor Optional TGS822 sensor can be used which is slightly more sensitive to alcohol vapours (www.figarosensor.com)
Carried Gas	Air
Carrier Gas Pressure	150 mbar
Supply Voltage	9 V (external mains adapter included)
Current	170 mA
Start button	+4.5 V pulse
Operating temperature	20°C - 50°C
Non-polar column: *Suitable for separation of gaseous and volatile liquid non-polar samples*	red wire wraps dimensions: Ø 4 × 1500 mm stationary phase: silicon oil 15% support: chromosorb W 60 - 80
Injection septum	a silicone rubber disc, Ø 12 × 2 mm (three included)
Injection syringe	1 mL volume (three included)
Injection needle	Ø 0.5 × 16 mm maximum (three included)
PVC tubing	4 × 6 × 400 mm
Connection	IEEE1394 connector for BT-IEEE1394 sensor cable. Sensor cable not delivered with the sensor.

Note: A polar column and a short (fast) non-polar column **are not supplied** and can be purchased separately.

Warranty:

The Gas Chromatograph BT45i is warranted to be free from defects in materials and workmanship for a period of 24 months from the date of purchase provided that it has been used under normal laboratory conditions. This warranty does not apply if the sensor has been damaged by accident or misuse.

Note: *This product is to be used for educational purposes only. It is not appropriate for industrial, medical, research or commercial applications.*

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