Chemistry
Laws of gases

C11 - Determination of n: quantity of matter in a gas

Theoretical notes and objectives

The law of perfect gases shows that the pressure P of a gas, the volume V, the quantity of matter n and the absolute temperature T are related by the equation:

$P V = n R T$

Where $n = \frac{PV}{RT}$

The relation between the temperature t expressed in °C and the absolute temperature T is written as:

$T = 273.15 + t$

The reaction studied here is written as:

$HCO_3^- + H_3O^+ \text{ ------> } CO_2 + 2\ H_2O$

An excess of nitric acid shall be used to make sure that the reaction is completed.

Aim of the experiment:
Study the law linking the pressure P and the volume V, the quantity of matter n and the absolute temperature T.
Obtain an estimate of the quantity of matter n.

Material

VTT console	ref 477000
VTT pressure sensor	ref 472010
VTT thermometer sensor	ref 472004
500mL glass flask	ref 713621
Stopper for the flask	ref 253082
Beaker (25 mL) - pack of 10	ref 713502
Pipette (10 mL)	ref 713047
Dropper bulb	ref 703172
Round wash bottles (pack of 6)	ref 723208
Distilled water (1L)	ref 107340
Nitric acid 62% *	ref 106012
Sodium bicarbonate 250g	ref 107270
Balance	ref:701276
Generis 5+ software	ref 000720

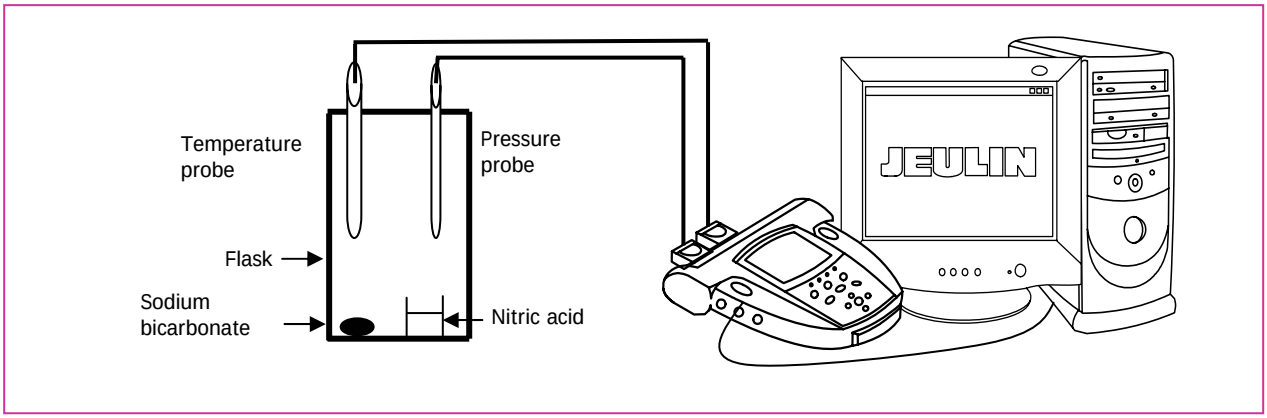
* Be careful, dangerous product. Handle with care.

Experimental procedure

Weight about 2g of sodium bicarbonate and place it in the flask.
Prepare 10 mL of nitric acid at 6 mol/L and place it in a small beaker.

Close the flask, placing the two probes of temperature and pressure connected to the VTT interface.

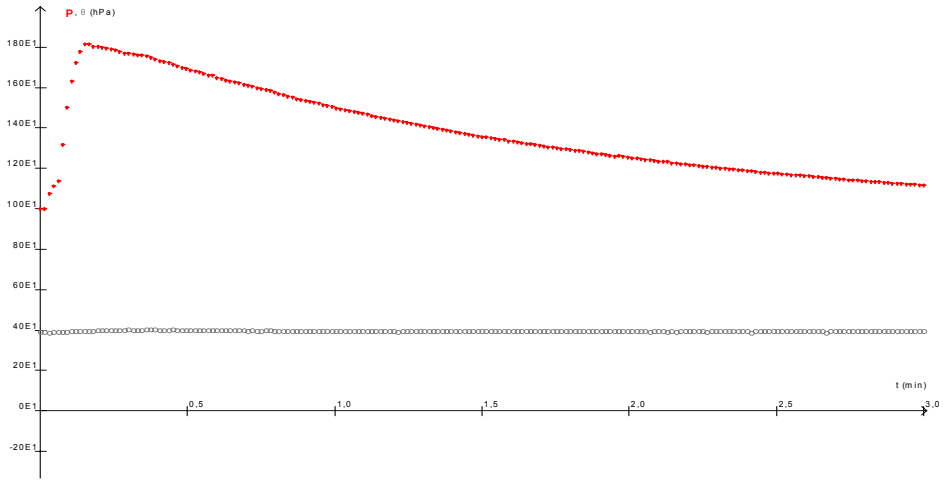
Setting the apparatus



Settings required before the experiment

Work to be done	How to do it?
Connect the VTT interface to the computer. Calibration of sensors.	Refer to the sensors' instruction manuals.
Launch Generis	Start, Programmes, Science Studio, Generis 5+
Put the adapters in ordinate. Give a name to the magnitude.	
Pressure sensor in channel /.	Drag-drop the **pressure sensor**  on one of the channels in ordinate and name the magnitude P.
Temperature sensor in channel //.	Drag-drop the **temperature sensor**  on one of the channels in ordinate and name the magnitude θ. (use the F12 key for the Greek alphabet). Unit: °C
Time in abscissa. Duration: 180 s	Drag-drop the **icon time**  in abscissa. Name the magnitude t. Duration: 180 s
Start the acquisition: Tilt the flask pouring the nitric acid on the bicarbonate. The reaction is over when there are no more gas bubbles. Observe the increase in temperature and pressure	Click on 
Save the file corresponding to this graph P = f (V) under the name **Determination of n.lab.**	Go to File, Save as… Select the directory folder and give the name **Determination of n.**

Results obtained



Analysis of results

Work to be done	How to do it?
Magnify the curves: use the automatic scales	Click on the icon 
Using the relative pointer, determine the increase in pressure and the rise in temperature.	Right click on the graph and select **Pointer.** Click on the first summit and without dropping go to the next summit. The value of increase in pressure can be read in the caption bar.
	Change the axis for reading the second value: icon 
Save the work completed	**Click on the icon**  **or Menu File, Save.**

Interpretation of results

Note the increase of pressure and the rise in temperature.
Explain the increase of pressure.
Calculate the number of moles of bicarbonate used knowing the pressure of CO_2 gas, its temperature and the volume of calorimeter: 500mL
Calculate the number of moles of bicarbonate used based on the weight indicated when starting (4g).
Compare the two results. Explain the difference between the two results.

Drafting of report

Work to be done	How to do it
Click on the tab Report	
Enter the title	Click on the icon  and define a rectangle Enter the title
Insert the graph P(t) and θ(t): a single graph	Open the dialog box  and click on the curves to be inserted P(t) and θ(t). Define a rectangle containing the curves.
Answer the questions asked.	Click on the icon  and define a rectangle for the answers.
Go to Print preview and if required, modify the elements of the report.	Click on the icon 

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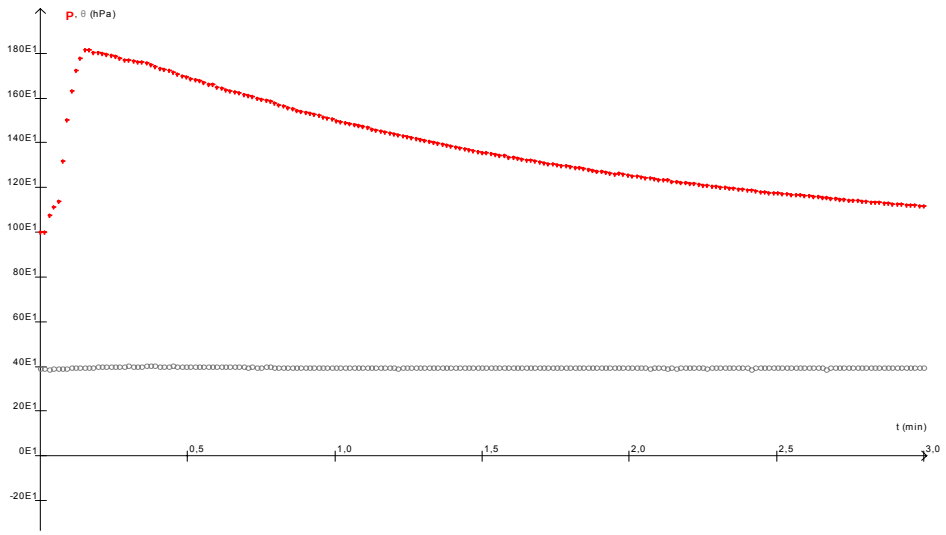
Determination of n: quantity of matter in a gas – Correction sheet



Increase of the pressure: ΔP = 816 hPa =81600 Pa
Rise in the temperature: Δt = 0.75°C. Final temperature t = 24°C.
The increase of pressure is linked to the release of gaseous carbon dioxide in the flask.
Number of moles of bicarbonate used:

$$n = \frac{PV}{RT} = \frac{82000.0{,}0005}{8.32.297} = 0.017 = 1.7.10^{-2} \text{ mol}$$

Number of moles of $NaHCO_3$ used (weighing):
n =1.90 / 84.01 = $2.26.10^{-2}$ mol
For obtaining more precise results, a sealed calorimeter should be used.