IDEAL GAS LAW - INTRO TO MATHCAD©

by

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STUDENT INSTRUCTIONS

Welcome to MATHCAD! This program is a combination text editor and calculator. It could be used to write lab reports, lecture notes, etc. as any text editor can do, but it can also do calculations and even derive formulas which most text editors cannot do.

MATHCAD documents in this course come in sections (Some of the comments in this document are specific instructions for the St. Olaf students. Students at other campuses should follow the instructions of their own instructor.). The sections are::

1. A written set of instructions for a calculation (such as this one) with a filename ending in ...ins.mcd These instruction files are stored on the disk in case you need to print one out. It is a good idea to print this document so that you can use it while you are working with the executable worksheet for this assignment.

2. The actual calculations are done in a ...run file. The instructions in the gasins.mcd file are to help you perform the tasks in the file named gasrun.mcd.

3. If your calculations require tabulated data, these are often stored in .....PRN files.

So now let's get started. Find a computer with MATHCAD 6.0 available. On the program screen you should find an icon for Mathsoft app. With the mouse move the cursor to this icon and click on it. A new screen should appear and you then click on the MATHCAD PLUS 6.0 icon to start the program. A screen labeled Mathcad PLUS should appear with buttons at the top and an empty workspace. In Windows 95 the MATHCAD icon should take you directly to the work screen; follow the instructions of your instructor on how to start Mathcad on the computers in your laboratory. In the upper right corner click on the button to increase the screen size (the square in Windows 95).

At this point press the open file button (second from the left in the long row). Next select the disk drive (**c** for hard disk, **a** for floppy) where the MATHCAD programs documents are stored. Then locate and click on the icon for gasrun.mcd. You can double-click on this icon, or click once on it and then click on the 'open' button and the document should appear. At this point click on the 'Edit' menu and on 'Regions' and then on 'View Regions.' You will note that each mathematical expression is in its own region, and that the sections of text are in their own regions.

EXERCISE 1 (very easy)

You should note values of T, P, and V are given for a gas at what used to be called standard pressure and temperature. What units should be supplied to each of these quantities? Note the symbol := which appears in these expressions. This is the 'assign value' type of symbol - the values of the expressions on the right are assigned to the variables on the left. Press the F9 function key. This should cause the document to calculate values. Record the value for R. What are its units?

EXERCISE 2

Now we wish to calculate R in different units. Change the pressure to 101325 (in pascals) and the volume should correspond to m^3. 1 $m^3 = 10^3$ liters. To change a number place the cursor on the number. You may see a vertical line (called the insertion point) in among the numbers. You can eliminate characters to the left and right of the insertion point by pressing 'Backspace' or 'Delete.' Another way to eliminate a number is to get the insertion point into the number and then press the 'up-arrow' key. This should enclose the number inside a blue box. Press 'Delete' and the number should go away to be replaced by a rectangle with one corner chopped off called the placeholder. Now type the new number. Press F9 to recalculate. What are the units of T, P, and V? What are the value and units for R?

Subscripts

In the computational document we note the equation $V_i=RT/P_i$. For a given temperature T=300 K we wish to calculate values of V corresponding to a range of values for P. By typing i:=0..30 (Type a colon ':' to get the := symbol and type a semicolon ';' to get the ...) we choose to calculate values of P at 31 points. This is done on the next line where to get a subscript we typed '[' then the subscript immediately after the P, we then pressed the up arrow key to select the whole quantity rather than just the subscript. This means that we will have P values from 1 to 4 at intervals of 0.1. Next we calculate V_i for each value of P_i using the same technique for the subscript. Type P= and V= to see the arrays. Now we plot a graph of V vs. P. Do one or two calculations by hand with your calculator to check your work.

EXERCISE 3

Here you can test your understanding. Modify the computational document to calculate V for 21 temperatures from 200 to 400 K at a pressure of 1.00 atmosphere. Adjust the quantities on the graph to get the desired plot. You do the adjusting by clicking on the graph and then clicking on the axis label. Now you can change the label.

In the next part of the document you will see a 3-D plot where V is shown as a surface that is a function of P and T. Information about the 3D plot is included in the run document.

Next let's learn how to do simple symbolic operations with Mathcad. Go to page 3 of the **run** document.

Symbolic Operations

Solve for variable: Note the expression in the computational document 'PV=nRT'. (The type of equal sign in this expression, in bold, is the logical equal and to get it you type 'cntr ='.) To solve for V click on V and then press the up-arrow key and hopefully you will enclose V in a little blue box. It is now "selected." Then click on 'Symbolic', then 'solve for variable'. The answer will appear below the original equation.

To make this into an equation you need to select it and put it on the clipboard. Holding the left mouse button down move the cursor toward the expression. When you get close enough a dotted line will surround the expression. Click on cut (scissors) and the expression will disappear to the clipboard. Then type 'Vcntr=' and then click on the paste button (8th from the left) and the expression will reappear.

Differentiate on Variable

Move the cursor down the page to an empty space and press either the 'paste' button or type 'cntr v'. The expression for V will then appear. Click on T and use up-arrow to select it. Then on the 'Symbolic' menu select 'Differentiate on Variable' and the derivative will appear below.

EXERCISE 4

Go back to the expression for V and find the derivative with respect to P.

EXERCISE 5

Enter into the worksheet the equation PV=wRT/MP where w is the weight of the gas in grams and M is the molecular weight in grams/mole. Use the symbolic facility to solve for the molecular weight M. Find the derivative with respect to T. If the temperature of a gas sample should be 5 K too high calculate how far off the molecular weight will be.

Units

Note the illustration for units in the computational document. Units are considered quantities multiplied by the number. To enter 10 Kg you type '10' then * then press 'cntr u'. Usually you can find the units you are looking for in the right-hand column. Select the unit kg and then click on 'insert'.

EXERCISE 6

The root mean square velocity of a molecule is given by

$$\text{vel} := \sqrt{\frac{3 \cdot R \cdot T}{M}}$$

Set up the constants with their units and calculate the root mean square velocity for O_2. Hint: the square root sign is on the arithmetic pallet (the button that looks like a calculator). The values of constants with their units are: R=8.314 joule/(K*mole), T=300 K, and M=0.032 kg/mole.