EUROPEAN UNION SCIENCE OLYMPIAD

EUSO

BRUSSELS 2006

Test 2

Country……………………………

Team: **A** **B**
(circle)

Name : ……………………………………

Name : ……………………………………

Name : ……………………………………

TEST 2

THIS TEST IS MADE OF TWO DIFFERENT ACTIVITIES:

- **MEASUREMENT OF CO_2 PRODUCTION DURING RESPIRATION (activity 1)**
- **CALCULATION OF A CHICKEN'S VOLUME USING BOYLE'S LAW (activity 2)**

Caution: Wear protection goggles all time during manipulation

If you have any spit of the solutions on your body rinse thoroughly under running water

You are given 3 explanation sheets, including the answer sheets,

2 of them to work with. The third one should contain your final answers.

Put this one in the envelop (Answer sheet) . Join your graph(s) to this answer sheet.

Only this third answer sheet will be marked.

Activity 1 carries 50 marks

Activity 2 carries 50 marks (task A: 35 ; task B : 15)

Activity 1

MEASURE OF CO_2 PRODUCTION DURING RESPIRATION

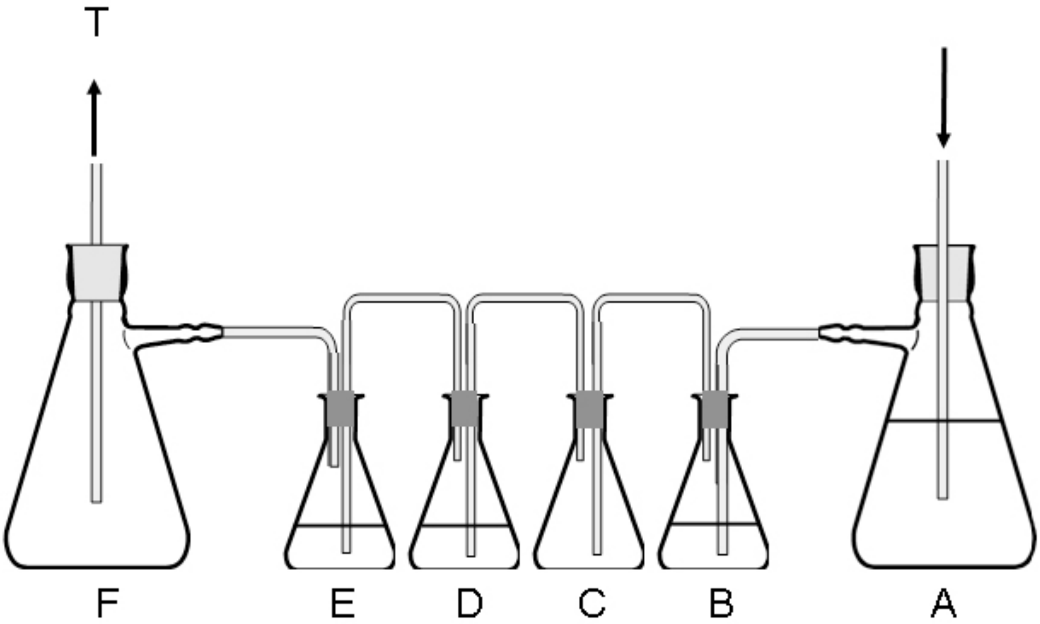
The production of CO_2 during respiration of soya shoots will be measured with a very simple device. The device allows you to flow CO_2free air over the plant shoots and to recover the CO_2 produced by respiration.

Caution: wear protection goggles all time during manipulation. If you have any spit of the solutions on your hands rinse thoughoutly under running water.

A. Material

1. A suction flask (labelled A), of a content of approximately 1 liter, half-filled with glass beads and potassium hydroxide solution 20 mass%. The flask is sealed with a stopper glass tubing and a side exit: (see drawing)
2. Four erlenmeyer flasks labelled B to E (content 250 mL), each with a two-hole stopper glass tubing: one for bubbling and one exhaust tube.
3. One suction flask labelled F (identical to vial A)
4. Soya shoots in a beaker
5. A solution of barium hydroxide ($Ba(OH)_2$), approximately 0,11 % to be titrated precisely only once later on.
6. A solution of oxalic acid prepared by dissolving 3.81g of $(COOH)_2.2H_2O$ per liter of solution.
7. Two burettes of 50 mL (one for barium hydroxide; one for oxalic acid) and two glass funnels.
8. An erlenmeyer labelled G for the titration of the barium hydroxide solution.
9. A clock
10. A dropper with phenolphtalein solution
11. Magnetic stirrer and magnetic bar
12. Balance
13. Parafilm
14. A plastic wash bottle with demineralised water
15. 1 beaker of 250 mL
16. Filter paper

Schema of assembly



B. Method

1. Using the piece of filter paper weigh the amount of soya shoots - approximately 40 g - very precisely (precision: 1/100 g) and indicate the result in the corresponding box of table of experimental results under heading C.

2. Assemble the apparatus as follows.
Remark: in order to avoid any leakage, stoppers and tubing’s have to be wrapped with parafilm.

a) Fill erlenmeyer C with the soya shoots. Don’t pack them: air should be able to flow through easily.
b) Measure and pour 200 mL of the barium hydroxide solution in each erlenmeyer labelled B, D, and E (measurement should be made with one of the burettes - needs four refills using the glass funnel).
c) Align the erlenmeyers in the order indicated on the scheme **(assembly has to be checked by an assistant before connecting the vacuum; connecting the vacuum ought to be made in the presence of an assistant).**
d) Fit tightly the ramp of stoppers to the erlenmeyers and suction bottles as indicated on the scheme.

Connect the suction bottle F to the vacuum source. With the vacuum tap adjust the aspiration in order to obtain a bubble rate of about 1 bubble/sec in suction bottle A.

3. Let the device run for one and a half hour.

4. During this time proceed to the titration of the initial solution of barium hydroxide:

- fill a buret with the oxalic acid solution
- with a second buret pour 200 mL of barium hydroxide in erlenmeyer G.
- add a few drops of phenolphtalein in erlenmeyer G
- neutralise by dropping in oxalic acid into the barium hydroxide solution until decoloration.
- note the volume of oxalic acid used and indicate it in the appropriate box V_0 in table of experimental results under heading C.

5. Turn off the aspiration and disconnect the vacuum source. Observe the content of erlenmeyers B, D and E (**call the assistant to check the assembly at this point before moving to next step).**

6. Unplug erlenmeyers D and E and titrate in each of them the remaining barium hydroxide following the same procedure as in step 4. Note the volume of oxalic acid used and indicate them in the appropriate boxes V_D and V_E in table of experimental results under heading C.

C. Experimental results

Mass of the soya shoots	V_0	V_D	V_E

D. Equations

1.Write the equations of the chemical reactions, if any, in each of A to E.

A…………………………………………………………..

B…………………………………………………………..

C…………………………………………………………..

D…………………………………………………………..

E…………………………………………………………..

2. Write the equation of the chemical reaction during titration.

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E. Calculations

1. Calculate the mass of CO_2 produced per g of fresh material in one hour. (3 significant digits)

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2. Calculate the corresponding volume of CO_2 at 20.0°C under standard atmospheric pressure per g of fresh material in one hour. Express your results in SI units. (3 significant digits)

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Activity 2

CALCULATION OF A CHICKEN'S VOLUME USING BOYLE'S LAW

Theory and description of the situation

Boyle's Law indicates that for an amount of gas at a constant temperature, the pressure and the volume are inversely proportional:
$p.V$ = constant or $p_1.V_1 = p_2.V_2$ (Boyle's law)

This law is applied in the bio industry to determine the volume of chickens. A chicken is placed in a barrel that's filled with air and closed by a piston. The volume is recorded and the pressure of the air in the barrel is measured. By moving a little bit the piston the air volume decreases and the pressure increases. Again volume and pressure are registered.
The volume of the chicken is calculated with these data, making use of Boyle's law.

In the experiment you are simulating this procedure with a syringe (barrel with piston) and a little red object (chicken), assuming Boyle's law can be applied.

When applying Boyle's law, another problem arises, so you'll have to solve this first. As you see in the illustration (see appendix), the volume read out on the scale of the syringe is not the correct complete volume of the air. The tube and the sensor as well contain an amount of air that's not negligible and we call this volume the internal volume (V_i). You have to find this internal volume first.
To check the accuracy of your result, verify Boyle's law, using the corrected volume .

Procedure and tasks

Equipment

ruler, graph paper, pencil, eraser
little object (red)
syringe 20 mL
plastic tube
gas pressure sensor (0 - 210 kPa)
CBL2 (interface) and Ti 84 Plus (calculator) on a holder, connected with a link cable
(*photographs in appendix).*

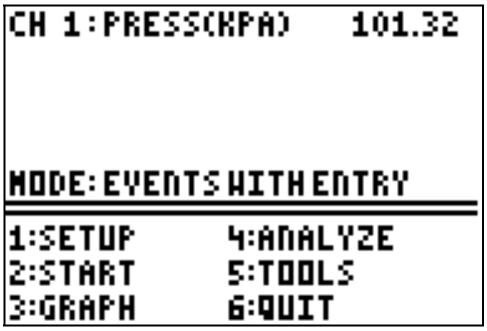
Task A: Finding the internal volume at a constant temperature

1. Plug the sensor into channel 1 (CH1) of the CBL2 (check if the CBL2 is connected to the TI-84 Plus). Take 10 mL air in the syringe, then connect one side (A) of the tube to the syringe (tighten but not too strong). Verify the connection is airtight. Tighten the other side(B) of the tube into the sensor (not too strong)
   Now you have a fixed amount of gas (air) during the experiment

   ask an assistant to verify the assembly

autograph / comment by assistant:

2. Switch on the TI-84 Plus (calculator) and press the [APPS] button and select option “4:DATAMATE” to start the application. A few seconds later appears the screen below. *(if not → ask an assistant to help you setup the application)*

   Verify the following:
   a. CH1: PRESS (KPA)
      Initially the pressure equals the atmospheric pressure.

   b. MODE : EVENTS WITH ENTRY
      (if not → ask an assistant to setup the application)

   The equipment is ready to start measuring

3. Choose option “2 : START” (a little orange LED blinks on top of the CBL2)

   You need at least 10 measurements. Don’ t make any measurement out of the range of the sensor (0 – 200 kPa)

4.

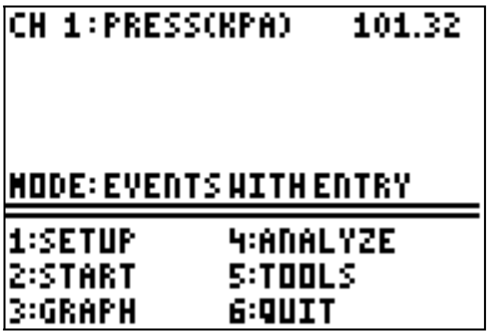
a. pull the piston to 15 mL or more
b. hold the position of the piston in the syringe fixed
c. press [ENTER] to collect the data of the sensor (now the pressure is collected
d. enter (in mL) the volume indicated on the scale of the syringe and press [ENTER] to continue
e. the next measurement (pressure) is indicated and will change as you change the volume in the syringe. Place the piston onto another volume and hold it fixed!
f. press [ENTER] to collect the data of the sensor (now the pressure is collected
g. enter (in mL) the volume indicated on the scale of the syringe and press [ENTER] to continue (the previous entered value is indicated below on the screen)
h. remark dots appearing on the screen (constructing a graph)
i. repeat e. f. g.
   You need at least 10 measurements. Don’ t make any measurement out of the range of the sensor (0 – 200 kPa)
j. press [STO] to stop

k. reflect on the graph on the screen:

   which quantity is on the x-axis? __________.   unit ____________.

   which quantity is on the y-axis? __________.   unit ____________.

l. press [ENTER] to return to the following screen



m. press [6] to quit

n. the next screen shows where the data are stored
“EVENTS IN L1” means you’ll find the entered volumes in the list L1
“CH1 IN L2” means you’ll find the data collected from the sensor in the list L2 (if the sensor is plugged in channel 1)
o. press [ENTER] to quit the application

Now you can use the TI-84 Plus as a calculator.

5. press [STAT] and choose option “1:EDIT” to see the data in lists L1 and L2.
Copy the data in a table.

6. reflect on a graphical method to find the internal volume (V_i) (of the sensor and the tube) and give equations in your explanation.

7. make a new list in your table using the TI-84 plus
   a. in the screen showing the lists, select L3 (move the cursor to L3 on top of the table) and press [ENTER]
   b. at the bottom you can type a formula (L3= . . . .); if you need data from list L1 or list L2, type [2ND] [1] or [2ND] [2]
   c. add a column in your table of part 5 (see above) and record these data

CALL AN ASSISTANT TO STORE THE DATA IN A COMPUTER

Autograph of the assistant

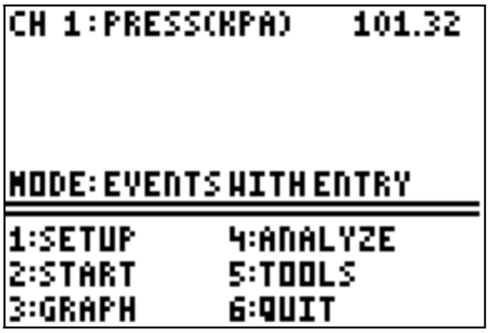
8. draw the graph on graph-paper and indicate using an arrow where you determine the internal volume. (*you can ask for more paper if needed)*
9. result (1 decimal place): the internal volume (in mL):

V_i =

Task B: Finding the volume of the red object (simulates the chicken) at a constant temperature

1. loosen the tube and pull the piston out.
2. put the object in the syringe and close the syringe with the piston (position of the piston: between 10 mL and 20 mL on the scale of the syringe)
3. tighten the tube again, you can start the experiment

4. Press the [APPS] button and select option “4:DataMate” to start the application. A few seconds later appears the screen below. (if not → ask an assistant to help you setup the application)



Now you can choose your procedure.

* **EITHER**
You only read the pressure indicated on top of the screen(right) and record them below (you don’t have to press 2 to start).
*** OR**
you start the procedure as described in task A part 3. The new data will be stored in lists L1 and L2 (previous data in L1 and L2 will be overwritten, but in the other lists there are still data from the previous experiment).

- Make the measurements.
Don’t make any measurement out of the range of the sensor (0 – 200 kPa).

- Write the measurements in a table.
- Find the volume of the red object as accurately as possible.

5. Explain how you calculate the volume of the object.
Write down the mathematical equations in several steps.

6. Result (1 decimal place): the volume (in mL):

$V_x =$