Romanian Master of Physics 2013

Experimental Problem No. 1 – Porosity (10 points)

I. Footprints on beach sand

Write in the appropriate box in the answer sheet the letter corresponding to the answer you think is correct.

When running on a sandy beach, water saturated, immediately after a wave the area around the foot:

(a) Remains almost unchanged.

(b) Becomes wetter.

(c) Becomes drier.

Briefly justify your choice.

II. Metallic Sponges

Porous metallic powders are used to produce catalysts, gas storage etc. They are assemblies of particles crossed by canals, with a sponge-like structure. In the Figure 1 is shown a portion of a spherical particle – part of the powder - crossed by pores and surrounded by other particles. The spheres forming a porous powder are crossed by networks of pores as shown in Figure 2. The sketch of pores in Figure 2 is not "at scale".
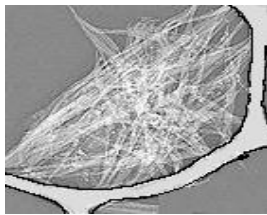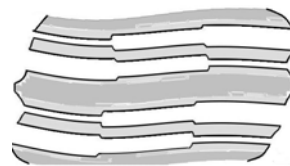
Figure 1

Figure 2

Through optical microscopy is established that the spherical particles of a metallic powder have the radius $R = 200\,\mu m$ and that the larger pores observed on the surface of a spherical particle of this powder have the diameter $d_1 = 10\,\mu m$. Pores can be modeled as a sequence of cylinders with different radii and lengths. Both ends of a pore penetrate the surface of particle so that "clogged" pores do not exist. In the following, consider that the temperature of the system remains constant.

$\mathcal{A}.$ In a syringe of $10\,cm^3$ is inserted metallic powder with the volume of $V = 6\,cm^3$. The mass of powder introduced into the syringe is $m_p = 1,2\,g$. The syringe needle hole is closed and the air from the syringe is compressed. The relationship between volume of syringe (delimited by the piston) and pressure in the syringe during the compression is described by the data in Table 1.

Task No. 1

1.a. Briefly describe a method allowing determining the density of solid material which was used to produce porous metallic powder. The method will use the provided data and an appropriate graphical representation.

1.b. Calculate the density of solid material used to produce porous metal powder.

Table 1

Nr. crt.	Volume (cm^3)	Pressure ($N \cdot m^{-2}$)
1	10	$1{,}000 \times 10^5$
2	9	$1{,}116 \times 10^5$
3	8	$1{,}263 \times 10^5$
4	7	$1{,}455 \times 10^5$
5	6	$1{,}714 \times 10^5$

B. In the syringe - whose needle hole was closed – is inserted the volume $V = 6{,}00\,cm^3$ of porous powder and a volume $v_\ell = 4{,}00\,cm^3$ of liquid that does not wet porous material. At first, the liquid does not penetrate into porous powder composed of spheres - "sponge", similar in size and porosity, crossed by canals of the kind shown in Figure 2. In the absence of compression, the air occupies the places between the particles and also the channels of different diameter in the spheres. Volumes of these channels are denoted by $v_I, v_{II}, \ldots$ in descending order of their diameters (denoted respectively $d_I, d_{II}, \ldots$). During the solving the problem, use the following notations:

Notation	Physical measure
v_m	The volume of solid material in the sphere
v_a	Initial air volume between the spheres
v_I	The volume of pores of largest diameter
v_{II}	The volume of pores having the second diameter as length
…	
v_s	The volume of spheres (solid material and channels)
V	The total volume of porous powder
v_ℓ	The volume of liquid

The plunge compresses slowly the liquid. As consequence the liquid starts to penetrate into porous material, removing air. Pressure dependence of the volume under the piston is illustrated in Figure 3, and numerical data on compression are written in Table 2.
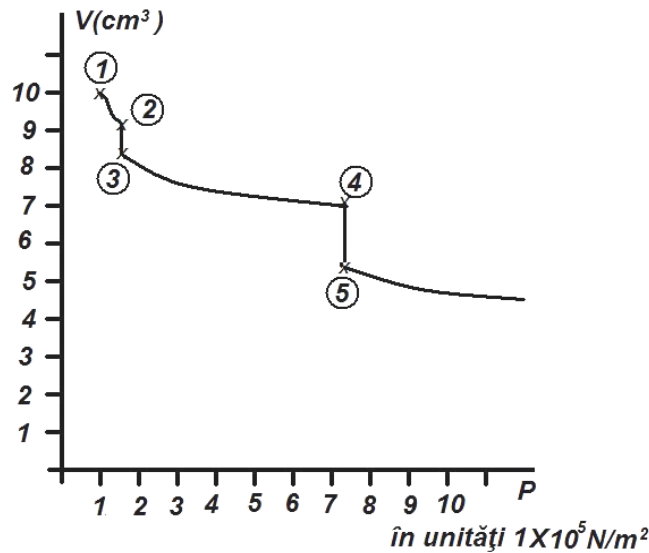

Figure 3

Table 1

	①	②	③	④	⑤
$P(N \cdot m^{-2})$	$1{,}0 \cdot 10^5$	$1{,}6 \cdot 10^5$	$1{,}6 \cdot 10^5$	$8{,}0 \cdot 10^5$	$8{,}0 \cdot 10^5$
$V\left(cm^3\right)$	10,00	9,16	8,74	7,07	5,11

Task No. 2

2.a. Briefly describe phenomena that occur inside the syringe during the pressing of the plunger.

2.b. Specify how many types of pores are in the metallic powder particles inside the syringe. Justify your answer.

2.c. Determine the volume occupied by particles of metallic powder.

2.d. Determine the total volume for each type of pores.

2.e. Determine the pore surface area in particles of metallic powder inside the syringe.

2.f. Estimate the number of particles in the volume of studied porous material.

2.g . Estimate the total length of each pore type existing in a particle.

2.h. Estimate the total number of channels in a particle of porous metallic dust into the syringe.

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Delia DAVIDESCU, PhD
Adrian DAFINEI, PhD

ANSWER SHEET

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Write the letter corresponding to the answer you think is correct.

Briefly justify your choice.   1,00p

II. Metallic Sponges

Task No. 1

1.a.   Briefly describe a method allowing determining the density of solid material which was used to produce porous metallic powder. The method will use the provided data and an appropriate graphical representation.   1,00p

1.b.   Calculate the density of solid material used to produce porous metal powder.   1,00p

Task No. 2

2.a. Briefly describe phenomena that occur inside the syringe during the pressing of the plunger.   1,00p

2.b. Specify how many types of pores are in the metallic powder particles inside the syringe. Justify your answer.   0,50p

2.c. Determine the volume occupied by particles of metallic powder.   1,50p

2.d.   Determine the total volume for each type of pores.   0,50p

2.e. Determine the pore surface area in particles of metallic powder inside the syringe.   1,50p

2.f.   Estimate the number of particles in the volume of studied porous material.   0,50p

2.g.   Estimate the total length of each pore type existing in a particle.   0,50p

2.h.   Estimate the total number of channels in a particle of porous metallic dust into the syringe.   1,00p