ASSIGNMENT – PARTICLE SIZES & DISTRIBUTIONS

1.a	*NOTE: For this type of questions, we expect rather short answers in words – it is not necessary to start complicated calculations.* Assume you have to design a process where cuboid particles are used as catalysts for a chemical reaction – during that process they are neither destroyed nor do they agglomerate. Which property is important? Why? Explain in a few words the concept of the equivalent spherical diameter. Assume you have to design a process where the non-spherical particles are transported via a rapid pneumatic transport line. Which equivalent spherical diameter would you use for them? Why? Name four different particle-size analysers and discuss which one measures which equivalent diameter.	6
1.b	Cost Estimate for Sieving: (Prices: Sieve-Preparation+Cleaning (50 Euro), Sieving per hour (70 Euro), Product Price per kilogram (19 Euro), Batch Mass: In: 250kg – Out: 240kg (desired material, value 25 Euro per kilogram + Waste (too large particles): 0 Euro/kg) – Sieving Efficiency (=mass going through/mass-in) for the above batch: 10min: 50%, 20min: 80%, 30min: 88%, 40min: 92%, 50min: 93%, 60min: 94%, 120min. 95%, 240min. 96%. Decide how long each batch should best be sieved.	4
2.	It is difficult to define the geometrical quantities for an irregularly shaped particle. One quantity is obtained from comparison with a spherical particle. Imagine a cylindrical particle with diameter 3 mm and height 1.0 mm. Calculate the equivalent volume diameter, the equivalent surface diameter, and the equivalent sieve diameter. Give the equations (3pts.) and the numbers (3pts.)	6
3.a	Given below is a size distribution of a sample of powder with a density of 2600 kg/m^3. The numbers is that what you get from your measurement. How do you check if the distribution is normalized? If not normalize. Determine and write down the cumulative undersize distribution Q_u. What is the size with 50 per-cent of the particles smaller/larger, x_{50} ? Why is the size range increasing with increasing size ? Determine the modal values. Explain graphically.	6

x (µm)	2	4	6	8	10	15	20	25	30	35	40	50	60	70
q(x)	0.01	0.03	0.06	0.12	0.15	0.11	0.05	0.01	0.10	0.12	0.09	0.03	0.01	0
$q_0(x)$														
Q_u														

3.b	Assuming that all particles in the sample are spherical, estimate the specific surface area of the sample in m^2/kg. Derive and write down the formula (2pts) and insert the numbers – use only the two modal values to save time (2pts).	4

see the additional page on Fractals

Fractals and the Fractal Dimension (additional for fun homework worth 6 additional points)

Some fractals can be constructed by down-sizing the original object and by replicating it a certain number of times.

For the so-called Koch curve the procedure is:

level 0 | down-sized | replicated 4 times

1) down-size the line by a factor 1/3
2) replicate it 4 times and combine those
3) repeat this for every new line
4) and again …

For the three-dimensional equivalent object, at each stage, a triangular face is replaced by six down-scaled copies of itself:

1. Here, the scale factor is ½ since the side of a new triangle is one-half of the original – however, the surface is ¼. Which scale factor has to be used?

2. Compute the fractal dimensions of the Koch curve and of the Koch triangle:

   The dimension of a self-similar object is calculated as **log (*N*) / log (1/*r*)**,
   where at any stage ***N*** is the number of scaled copies and ***r*** is the scale of that copy.

   1. What is the scale factor in going from one stage to the next?
   2. How many down-scaled copies are made?
   3. What is the fractal dimension of the completed Koch Tetrahedron?

3. Check your results for plausibility and apply the calculation to the special case of an object with fractal dimension d=2. What does this mean?

4. Calculate the fractal dimension for the Koch curve by measuring the length of level 4 or higher with rulers of length 1, 1/3, 1/9, 1/27, …
   Plot the measured length (log-log-plot) against the length of the ruler and read off the slope. What is the meaning of the slope?

5. Can you apply the same principle to the Koch Triangle, or another fractal of your choice?