Group 1
Size and Scale for 1st Year Students

Critical Concepts (Build Nano Intuition)

- Dimensional analysis
- Units
- Powers of 10
- Examples above and below 1 μm
- Estimate size
- Relative size
- Dimensionality
- Metric prefixes
- Geometric formulas

Explicit statement of critical concept

Students will learn how to apply notions of size / scale and dimensionality to predict, explain, compare and/or calculate nanoscale properties and phenomena.

Learning outcomes

- Give examples of objects with different sizes.
  - ◊ Estimate powers of 10.
- Predict / compare / explain results or properties based on calculations.
- Identify implications of differences in surface area to volume ratios and differences in dimensionality.
  - ◊ Estimate number of number of particles from measurements of volume or area.

Evidence for the claim of having learned relative size and dimensionality

Give examples of objects with different sizes

- A correct ranking of five objects that have a range of size of at least five orders of magnitude, all of which are smaller than the resolution of the naked eye.

- A classification of five objects, none of which can be seen with the naked eye, that correctly differentiates between those that occur on the nanoscale and those that occur on the microscale. (This classification may require calculations, such as determining the length of a carbon nanotube that would enable it to be classified as an object visible with a low-resolution light microscope.)

Evidence for the claim of having learned relative size and dimensionality

Predict/compare/explain results or properties based on calculations

- An explanation of why ASA 400 black and white film consists of traditional crystals of AgBr with a tetrahedral morphology attached to a polymer base, whereas ASA 1600 film requires the creation of AgBr crystals that are thin plates that have a hexagonal crystal morphology.
- A prediction of the relative reactivity of gold nano-particles of different size and crystal morphology. The prediction would need to capture the effect of differences in the relative amounts of gold atoms on the surface versus the bulk in the particles.

Evidence for the claim of having learned relative size and dimensionality

Predict/compare/explain results or properties based on calculations.

- An explanation why light that shines off a CD with a particular granularity has many colors, whereas light that reflects off a silver mirror does not that has the following characteristics: an approximate wavelength for the visible spectrum; that they have captured the implications of the spacing of the dots on the CD; and that the diffraction that gives rise to multiple wavelengths is the result of similarities between the scale of the wavelength of the visible light and the surface granularity.

Evidence for the claim of having learned relative size and dimensionality

Estimate number of particles from projects involving volume or area.

- Construct a model in two dimensions (and then three dimensions) that shows clusters of particles. Determine the ratio of the number of surface particles to the total number of particles as an estimate of the surface area to volume ratio. Predict the effect of increasing the size of the clusters used to build the model.

Assessment

Assessment Task(s)

1. Rank objects by size
    - Go into lab and measure sizes of objects (AFM/STM/SEM)
    - Look up sizes in references (e.g., web)
    - Provide actual examples of each type of material
    - Discuss physical or chemical properties of a sample of a given material as the cluster size shrinks (like the melting point of clusters of gold clusters, the solubility of a given compound at different sizes)

Assessment

Assessment Task(s)

2. Predict/explain/compare results based on calculations

- Construct a graph of reactivity vs. size for a catalyst (e.g. Pt oxidation catalyst) and explain graph features.
- Look at AgBr(s) crystal grains in different ISO films using AFM or SEM, compare results to film's sensitivity to light.
- CD experiment using AFM; possibly compare "standard" DVD vs. blu-ray DVD. Alternatively, this could be a lecture demo/practical or homework.

Assessment

Assessment Task(s)

3. Estimate number of particles from projects involving volume or area.

- Construct a model using appropriate computer modeling software or a physical model in two dimensions (and then three) that shows clusters of particles. Determine the ratio of the number of surface particles to the total number of particles as an estimate of the surface area to volume ratio. Predict the effect of increasing the size of the clusters used to build the model.
- Cut starting object in repeated steps to measure changes in volume and surface area.