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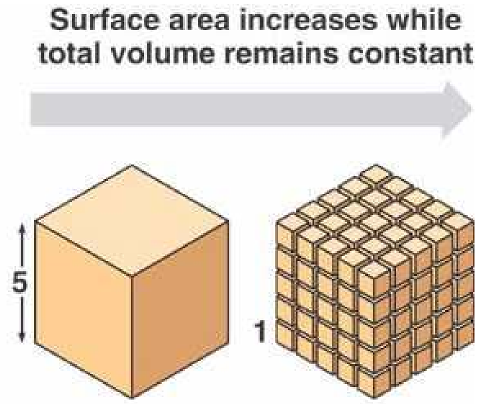
CHAPTER 5: SURFACE AREA TO VOLUME RATIOS IN NANOSCIENCE



Total surface area (height × width × number of sides × number of boxes)	6	150	750
Total volume (height × width × length × number of boxes)	1	125	125
Surface-to-volume ratio (surface area / volume)	6	1.2	6

SA/V Diagram

INTRODUCTION

he main focus of this chapter is the interesting change in **properties** of materials due to increased **surface area to volume ratio**. **Reactions** take place at the surface of a chemical or material; the greater the surface for the same volume, the greater the **reactivity**. The link to nanotechnology is that as particles get smaller; their surface area to volume ratio increases dramatically. Imagine a cube of sugar, reacting with water as the water dissolves the outside of the sugar. Now imagine the same cube of sugar cut into many little pieces. Each cut makes new outer surfaces for the water to dissolve. For smaller particles of sugar, the same volume of sugar now has much more surface area. A particle with a high surface area has a greater number of reaction sites than a particle with low surface area, and thus, results in higher **chemical** reactivity.

Nanoparticles are special and interesting because their chemical and physical properties are different from their macro counterparts. The sugar example is interesting if you want to make tea sweet faster (use granules instead of cubes), but serves little real application. One prime example of surface area to volume ratio at the nanoscale is gold as a nanoparticle. At the macroscale, gold is an **inert element**, meaning it does not react with many chemicals, whereas at the nanoscale, gold nanoparticles become extremely reactive and can be used as **catalysts** to speed up reactions.

This increased reactivity for surface area to volume ratio is widely taken advantage of in nature, one biological example being the body's digestive system. Within the small intestine, there are millions of folds and subfolds that increase the surface area of the inner lining of the digestive tract. These folds allow more nutrients and chemicals to be absorbed at the same time, greatly increasing our body's efficiency and the rate at which we digest food.

The main goal in the surface area to volume ratio chapter is to engage students in a variety of activities to teach this surface area to volume ratio concept. Each type of activity has a different purpose whether to teach, analyze, or review surface area to volume ratio. After teaching the basics of the concept, students will analyze and apply these basics to invoke critical thinking. Review of the material helps them retain and use the information for future courses.

These activities use common day materials and examples that the students should be familiar with. The ideas gained from these commonplace examples should be applied to other applications to develop the student's understanding about nanotechnology.

SA/V GOALS

By the end of this chapter, students should be able to:

RECALL BASIC CONCEPTS OF SURFACE AREA, VOLUME AND RATIOS

Correctly calculate the surface area, volume, and SA/V of an object with given dimensions.

Recognize that SA/V is not a constant value.

Recognize that the shape changing acts of “flattening” and “drawing out” increase the SA/V of an object.

Recognize that as an object of a particular shape gets smaller (lower volume) without changing shape, the SA/V increases.

UNDERSTAND THE RELATION OF SA/V RATIO TO CHEMICAL REACTIVITY

As particles get smaller, their surface area to volume ratio gets larger. With more surface area for the same volume, these small particles react much faster because more surface area provides more reaction sites for the same volume, leading to more chemical reactivity. Students will come to learn several factors which dictate surface area, such as roughness of the surface and the size of the object.

RELATE ROUGHNESS TO A HIGHER SA/V RATIO AND HOW NATURE USES THIS

One important application of SA/V ratio is roughness, as surfaces that are significantly rougher at the microscale and nanoscale have more surface area while taking up the same approximate volume. Students will also learn about how nature takes advantage of this SA/V ratio increase in natural phenomena such as the small intestine, lungs, and root hairs, in order to operate efficiently.