

BUILDING BUCKYBALLS FROM SCRATCH

Introduction to Euler's rule

Leonhard Euler was a mathematician born in Basel, Switzerland in the early 1700's. One of the simplest relationships he discovered was the relationship between the faces, vertices (corners), and shared edges of a closed polyhedron. Using the two figures shown below, a pyramid and a cube, fill in the accompanying table and determine a consistent mathematical relationship between the edges of each face and the total number of faces, corners, and edges of a closed polyhedron.

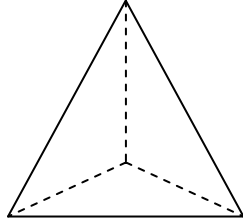


figure 1

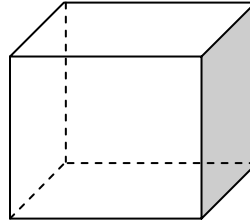


figure 2

figure	face edges (n)	faces (F)	corners (C)	total edges (E)
1				
2				

Relationship between F and C from the table above:

Relationship between C and E from the table above:

Relationship between n, F, and E from the table above:

Building C₆₀

1. Buckminsterfullerene is another example of a closed polyhedron and is subject to all of the same relationships that you created above. Using these mathematical equations, determine the number of faces and edges found in one molecule of a buckyball assuming that you will be starting out with 60 vertices (the carbon atoms).

figure	faces (F)	corners (C)	edges (E)
buckminsterfullerene		60	

2. Using the number of F, C, and E's found in step (1) for one molecule of buckminsterfullerene, is it possible to create this structure using only hexagons? Only pentagons? Explain your answer and show all work.

3. Hopefully you have now proven that buckminsterfullerene cannot be created from only one type of polygon. Buckyballs actually contain a mixture of both hexagons and pentagons in a fixed ratio. Calculate the number of hexagons and pentagons that would be needed to create one buckyball. Show all calculations. (Hint: the number of hexagons and pentagons must equal the total number of faces)

4. You are now ready to build your buckyball model. Start by making a pentagonal carbon ring using the trigonal planar carbon atoms. To each side of the pentagon, add a hexagon so that they share only one common edge as seen in the picture. Construct one more of these structures so that you have a set of two and put one of them aside. You have just created the "top" and "bottom" of your buckyball and have already accounted for two pentagons and ten hexagons, don't lose count.



5. You will now finish your model of the buckyball as you connect the top and bottom using one simple rule: no two pentagons may share a corner or edge (no touching!). Remember to keep track of the number of hexagons and pentagons you are creating and stay within the limits you set for yourself in step (3). You should now use this model along with your representations of diamond, graphite, and CNTs while investigating the physical properties of each allotrope in the next section and answering the attached questions at the end of the lab.