The background features a dark blue gradient with faint, overlapping circular patterns and a scale-like structure on the left side. The scale has numerical markings from 40 to 260 in increments of 10. The main title is centered in large, white, bold, sans-serif font.

EXPLORE CHEMISTRY WITH CHEMTUBE -3D

DR. YOGENDRA KUMAR KOTHARI
SENIOR LECTURER IN CHEMISTRY,
GOVT. EXCELLENCE HIGHER SECONDARY SCHOOL, MADHAVNAGAR,
UJJAIN (M.P)

DR. YOGENDRA KUMAR KOTHARI



<https://www.youtube.com/c/YogendraKothari>



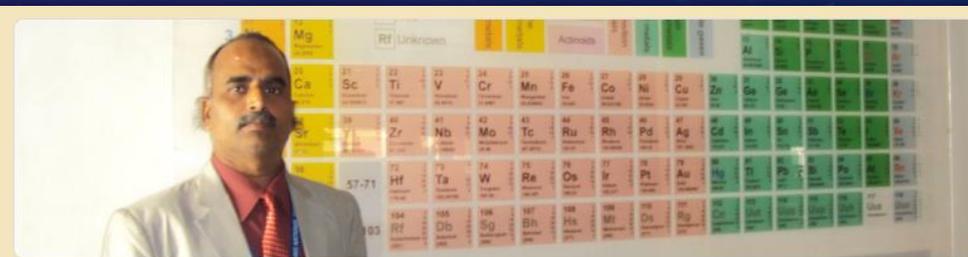
<https://scientific-knowledge-and-life.blogspot.com>

Online Chemistry Test and Science Quiz series

INNOVATIVE SCIENCE TEACHER AWARDEE – 2001

NATIONAL AWARDEE TEACHER – 2008

**BEST CHEMISTRY TEACHER AWARD BY TATA
CHEMICALS - 2016**



Online Chemistry Test No.12 - Class XI - Chemical Bonding & Molecular Structure with Dr. Yogendra Kothari

This is an online chemistry test on Environmental chemistry for Class XI students

Brief history of ChemTube3D

ChemTube3D.com has been available to the public as an Open Educational Resource since January 2008. In the period up to June 2019 there had been 4.8 million visitors to the site from 216 different countries. The most active University networks in the year to June 2019 (a measure of usage on campus within those institutions) were the following in decreasing order: Oxford, Cambridge, Manchester, Liverpool, Irvine, Washington, Texas Austin, Emory, Minnesota, UCLA.



Professor Nick Greeves MA PhD NTF SFHEA

Director of Teaching & Learning

Chemistry



+44 (0)151 794 3506



Ngreeves@liverpool.ac.uk



<http://www.chemtube3d.com>



About **Research** Publications Teaching Professional Activities

About

Personal Statement

Nick is a Cambridge graduate, obtaining his PhD there in 1986 for work on the stereoselective Horner-Wittig reaction with Stuart Warren. He then held a Harkness Fellowship at the University of Wisconsin-Madison and at Stanford University, California, with Barry Trost and a Research Fellowship at Cambridge University before joining Liverpool in 1989 where he was promoted to Professor in 2015. He was selected for a HEA National Teaching Fellowship in 2009 and SFHEA in 2014. Nick is married with two children and lives in Formby. His interests include Macs, music (iPhone), photography (iPhone), and social media. He is saving up for the next version of Apple Watch.

Co-author of the bestselling (100,000 copies) textbook [Organic Chemistry](#) now in 2nd edition

Creator of [ChemTube3D](#) read more about the project on [Kudos](#)

ChemTube 3D in Chemistry Teaching

ChemTube3D is an **Open Educational Resource (OER)** that contains interactive 3D chemistry animations and structures, with supporting information, for students studying some of the most important topics in advanced school chemistry and university chemistry courses



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Project

ChemTube3D: An Internationally Renowned Open Educational Resource

University of Liverpool Faculty of Science and Engineering

Project DOI: 10.26303/skjjx-ts11

Source: <https://chemtube3d.com/>

Navigate to : <https://chemtube3d.com/>

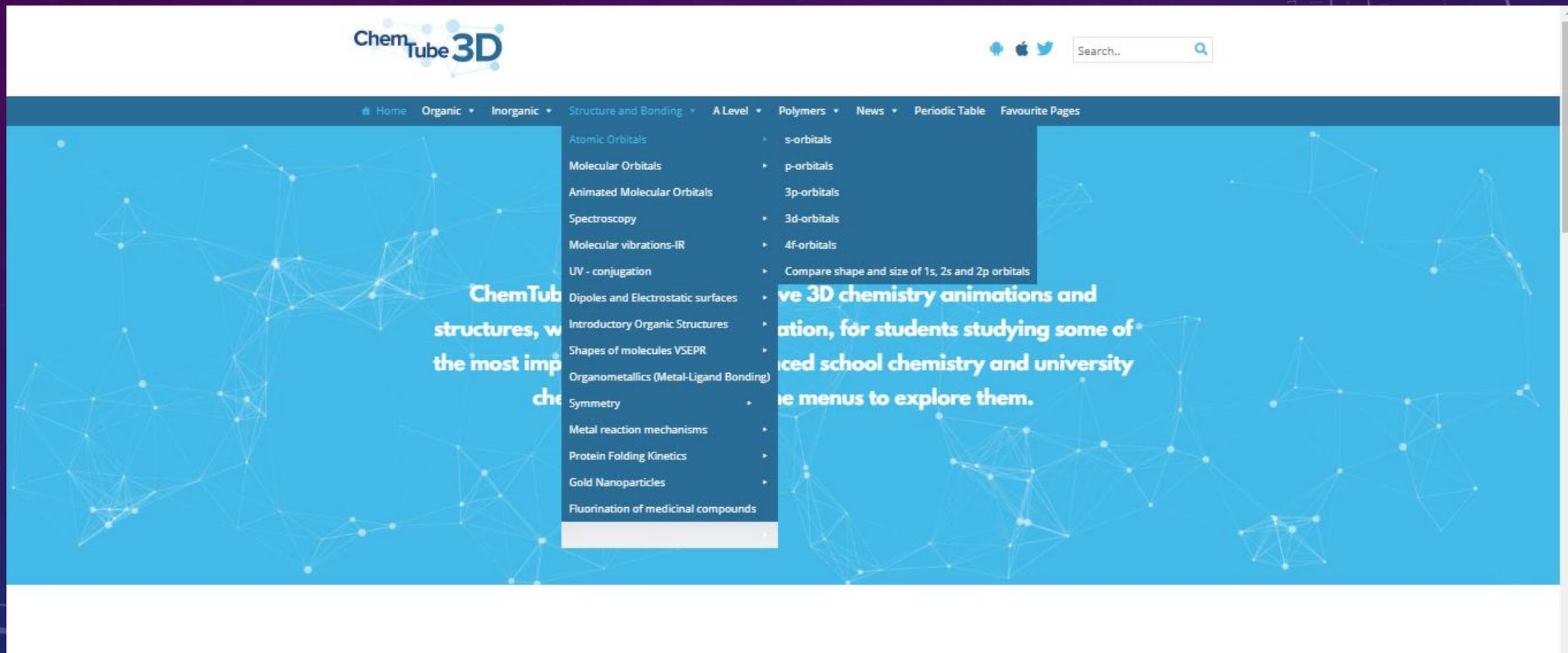
A search bar with a light gray border and a magnifying glass icon on the right side.

[Home](#) [Organic](#) [Inorganic](#) [Structure and Bonding](#) [A Level](#) [Polymers](#) [News](#) [Periodic Table](#) [Favourite Pages](#)

ChemTube3D contains interactive 3D chemistry animations and structures, with supporting information, for students studying some of the most important topics in advanced school chemistry and university chemistry courses. Use the menus to explore them.

EXPLAINING SHAPE OF ORBITALS USING CHEMTUBE 3D TOOLS

Click on "Structure and Bonding" => Atomic Orbitals

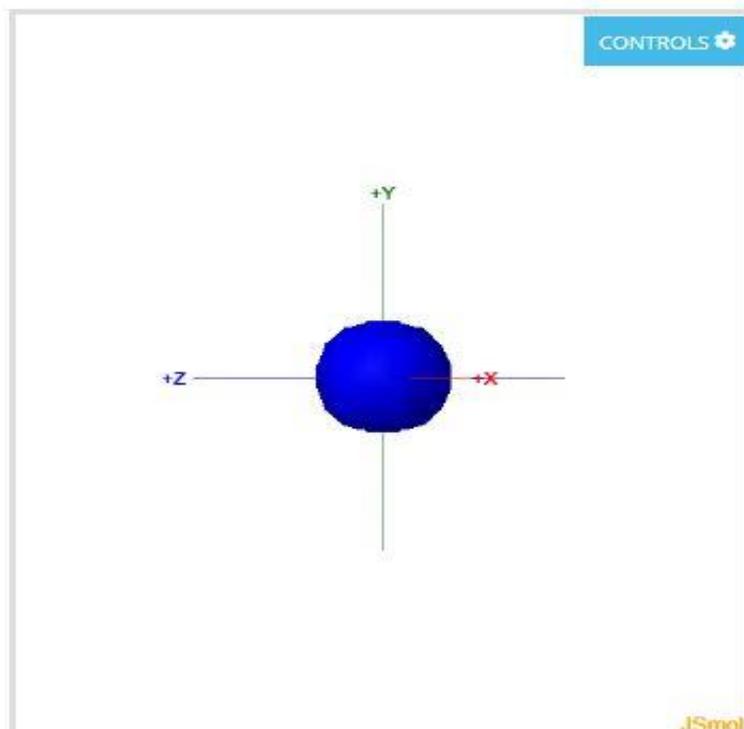


The screenshot shows the ChemTube 3D website interface. At the top left is the logo "ChemTube 3D". To the right are social media icons for YouTube, Apple, and Twitter, followed by a search bar with the text "Search..". Below the header is a navigation menu with the following items: Home, Organic, Inorganic, Structure and Bonding (which is expanded), A Level, Polymers, News, Periodic Table, and Favourite Pages. The expanded "Structure and Bonding" menu lists the following sub-items: Atomic Orbitals, Molecular Orbitals, Animated Molecular Orbitals, Spectroscopy, Molecular vibrations-IR, UV - conjugation, Dipoles and Electrostatic surfaces, Introductory Organic Structures, Shapes of molecules VSEPR, Organometallics (Metal-Ligand Bonding), Symmetry, Metal reaction mechanisms, Protein Folding Kinetics, Gold Nanoparticles, and Fluorination of medicinal compounds. The "Atomic Orbitals" sub-item is highlighted. To the right of the menu, a large blue banner contains the text: "ChemTube 3D chemistry animations and... for students studying some of... school chemistry and university... the menus to explore them."

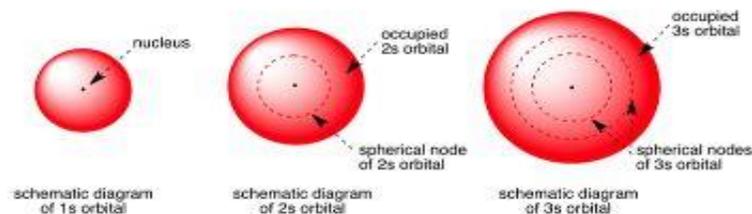
SHAPE OF S ORBITALS

Click on "Structure and Bonding" => Atomic Orbitals => s-orbitals

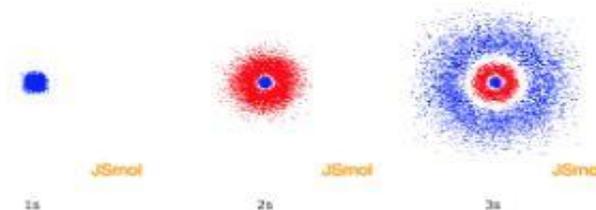
Shape of s-orbitals in 3D



An illustration of the shape of the 1s, 2s and 3s orbitals



Probability distribution of an electron in s orbitals - slice



Exploring "Controls" => Various options

ChemTube 3D

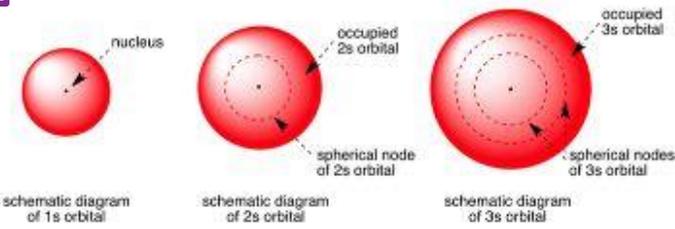
Home Organic Inorganic Structure and Bonding A Level Polymers News Periodic Table Favourite Pages

Home / Structure and Bonding / Atomic Orbitals / Shape of s-orbitals in 3D

Shape of s-orbitals in 3D

CONTROLS

An illustration of the shape of the 1s, 2s and 3s orbitals

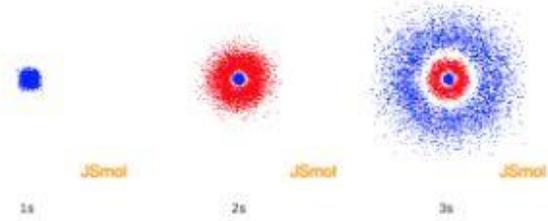


schematic diagram of 1s orbital

schematic diagram of 2s orbital

schematic diagram of 3s orbital

Probability distribution of an electron in s orbitals - slice



1s 2s 3s

Animation controls:

- Play once
- Play back and forth
- Loop animation
- Stop animation
- Frame 1 Next Prev

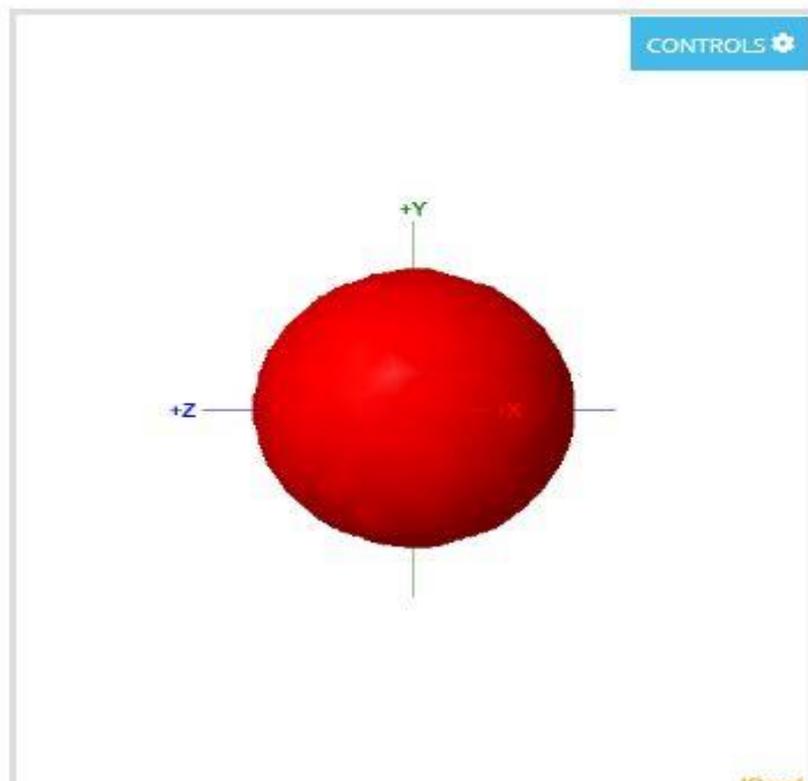
Display controls:

- Spacefill Ball & Stick Sticks
- Spin Zoom
- Show/hide H Antialias

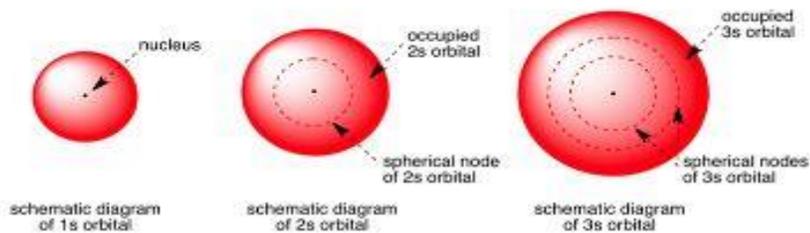
Show All Symmetry Elements

SHAPE OF 2S ORBITALS

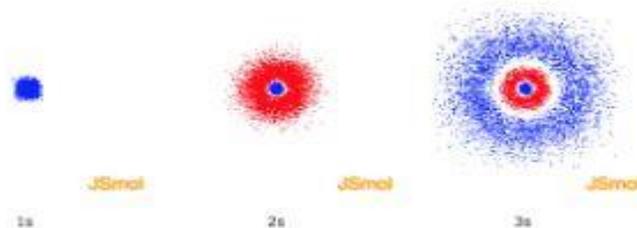
Shape of s-orbitals in 3D



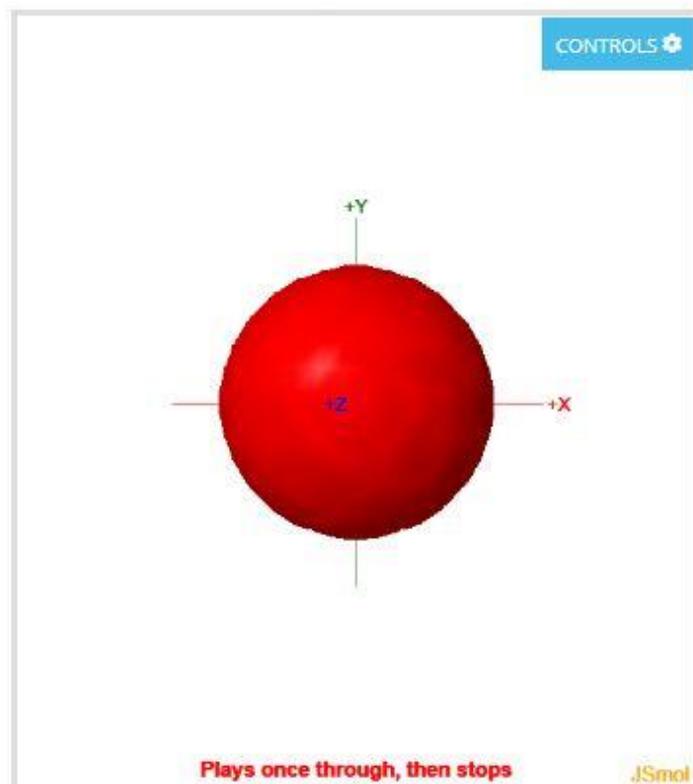
An illustration of the shape of the 1s, 2s and 3s orbitals



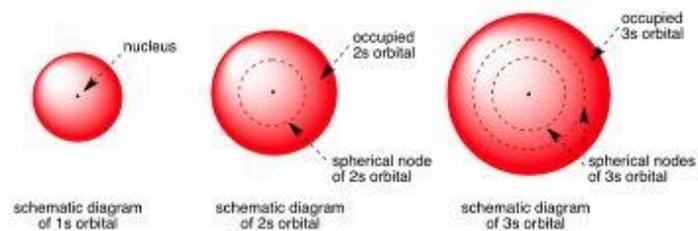
Probability distribution of an electron in s orbitals - slice



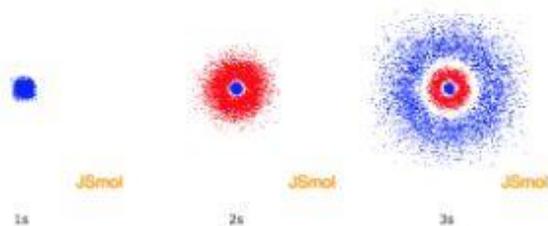
Shape of s-orbitals in 3D



An illustration of the shape of the 1s, 2s and 3s orbitals



Probability distribution of an electron in s orbitals - slice



Animation controls:

Play once

Play back and forth

Loop animation

Stop animation

Frame 1 Next Prev

Display controls:

Spacefill Ball & Stick Sticks

 Spin Zoom Show/hide H Antialias[Show All Symmetry Elements](#)

Exploring "Controls" => Hit "Spin"

ChemTube 3D

Home Organic Inorganic Structure and Bonding A Level Polymers News Periodic Table Favourite Pages

Home / Structure and Bonding / Atomic Orbitals / Shape of s-orbitals in 3D

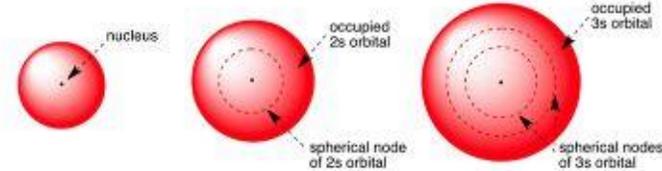
Shape of s-orbitals in 3D

CONTROLS



Plays once through, then stops JSmol

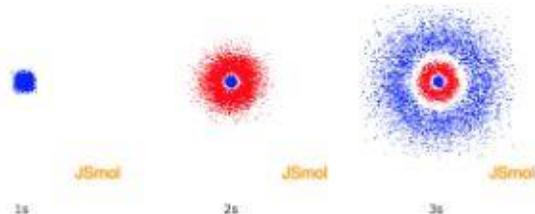
An illustration of the shape of the 1s, 2s and 3s orbitals



nucleus
occupied 2s orbital
occupied 3s orbital
spherical node of 2s orbital
spherical nodes of 3s orbital

schematic diagram of 1s orbital
schematic diagram of 2s orbital
schematic diagram of 3s orbital

Probability distribution of an electron in s orbitals - slice



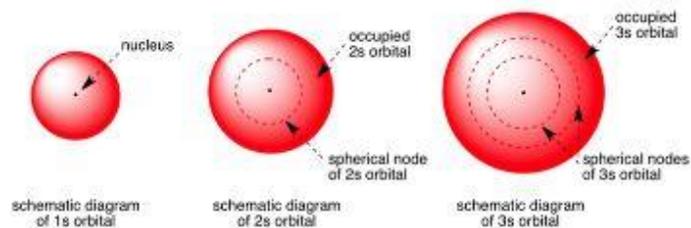
1s JSmol 2s JSmol 3s JSmol

Animation controls:
Play once
Play back and forth
Loop animation
Stop animation
Frame 1 Next Prev
Display controls:
Spacefill Ball & Stick Sticks
Spin Zoom
Show/hide H Antialias
Show All Symmetry Elements

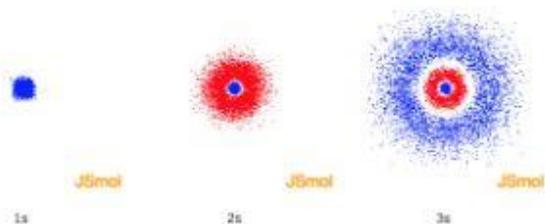
Shape of s-orbitals in 3D



An illustration of the shape of the 1s, 2s and 3s orbitals



Probability distribution of an electron in s orbitals - slice



Animation controls:

Play once

Play back and forth

Loop animation

Stop animation

Frame 1 Next Prev

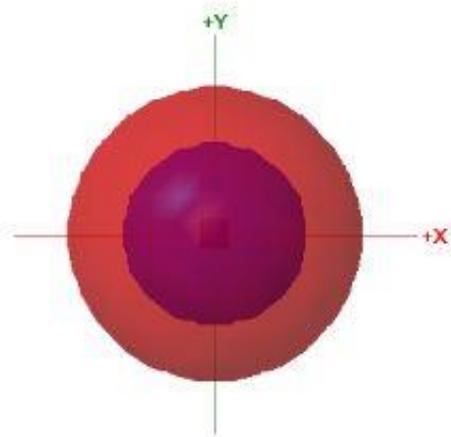
Display controls:

Spacefill Ball & Stick Sticks

 Spin Zoom Show/hide H Antialias[Show All Symmetry Elements](#)

RELATIVE SIZE OF 1S, 2S ORBITALS

Atomic Orbitals - shape and relative size of 1s, 2s and 2p orbitals



CONTROLS ⚙️

An illustration of the shape and relative size of 1s, 2s and 2p orbitals

- 1s orbital
- 2s orbital
- 3s orbital
- 2p_x orbital
- 2p_y orbital
- 2p_z orbital

Click the check boxes to show and hide the atomic orbitals

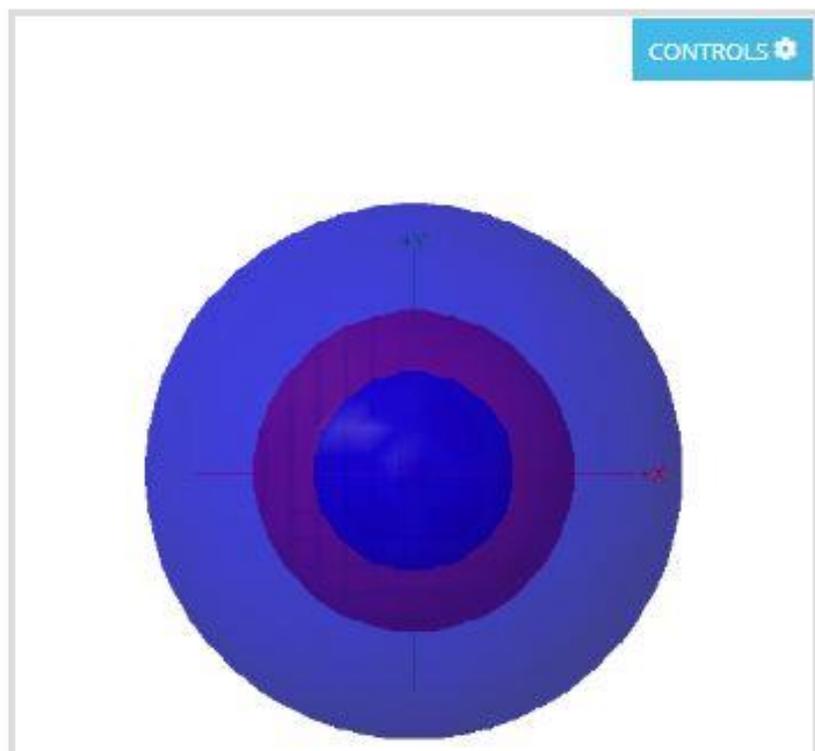
Explore other atomic orbitals

[s-orbitals](#) | [p-orbitals](#) | [d-orbitals](#)

★★★★★ 4.5(50)

RELATIVE SIZE OF 1S, 2S AND 3S ORBITALS

Atomic Orbitals - shape and relative size of 1s, 2s and 2p orbitals



An illustration of the shape and relative size of 1s, 2s and 2p orbitals

- 1s orbital
- 2s orbital
- 3s orbital
- 2p_x orbital
- 2p_y orbital
- 2p_z orbital

Click the check boxes to show and hide the atomic orbitals

Explore other atomic orbitals

[s-orbitals](#) | [p-orbitals](#) | [d-orbitals](#)

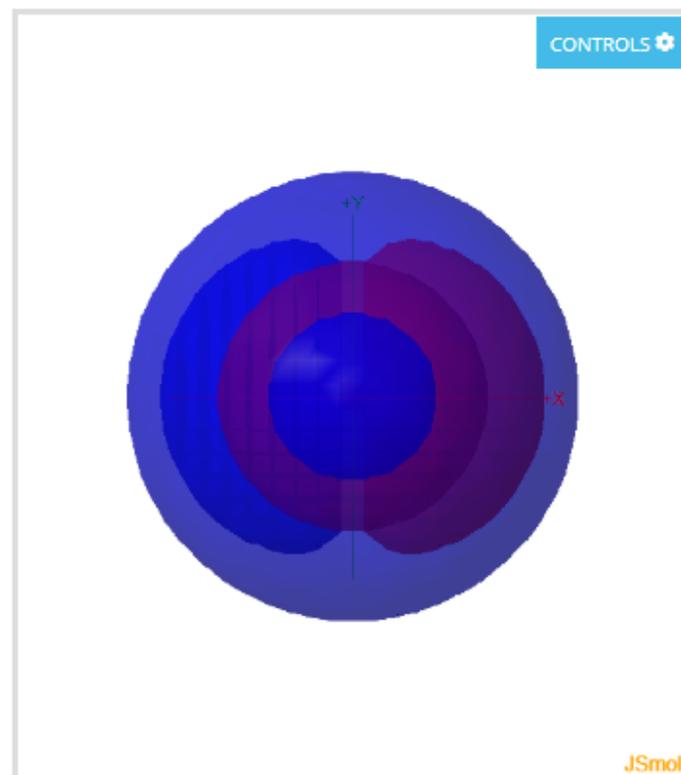
★★★★★ 4.5(50)

RELATIVE SIZE OF 1S, 2S, 3S and 2P ORBITALS

Select four checkboxes (1s, 2s, 3s, 2p) orbitals

[Home](#) / [Structure and Bonding](#) / [Atomic Orbitals](#) / Atomic Orbitals – shape and relative size of 1s, 2s and 2p orbitals

Atomic Orbitals – shape and relative size of 1s, 2s and 2p orbitals



An illustration of the shape and relative size of 1s, 2s and 2p orbitals

- 1s orbital
- 2s orbital
- 3s orbital
- 2p_x orbital
- 2p_y orbital
- 2p_z orbital

Click the check boxes to show and hide the atomic orbitals

Explore other atomic orbitals
[s-orbitals](#) | [p-orbitals](#) | [d-orbitals](#)

★★★★★ 4.5(52)

How useful was this page?

Click on a star to rate it!



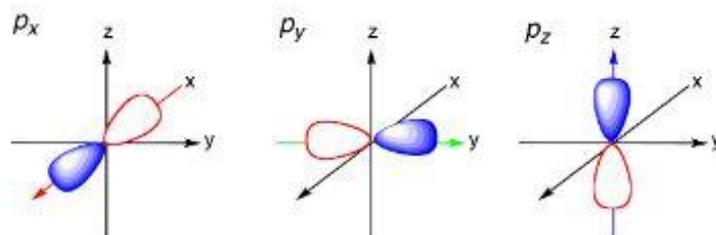
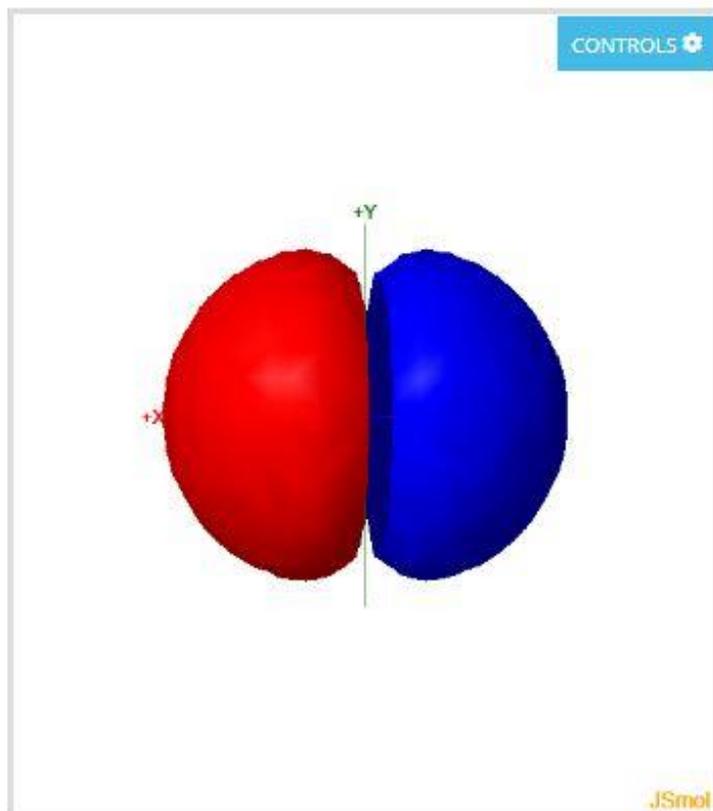
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SHAPE OF P- ORBITALS

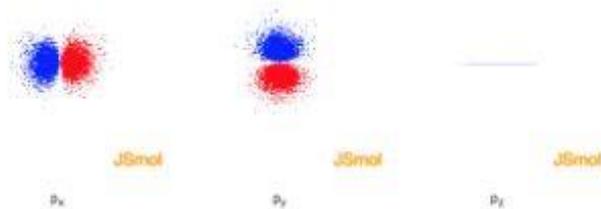
Home / Structure and Bonding / Atomic Orbitals / Shape of p-orbitals in 3D

Shape of p-orbitals in 3D



The three p orbitals are aligned along perpendicular axes

Probability distribution of an electron in 2p orbitals - slice



Click the images to see the various views

The p sub shell can hold a maximum of six electrons as there are three orbitals within this sub shell. The three p orbitals are at right angles to each other and have a lobed shape. The size of the p orbitals also increases as the energy level or shell increases.

X CLOSE

Animation controls:

Play once

Play back and forth

Loop animation

Stop animation

Frame 1 Next Prev

Display controls:

Spacefill Ball & Stick Sticks

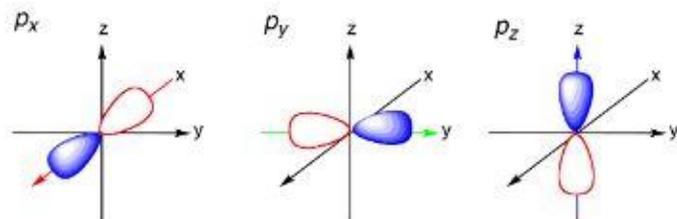
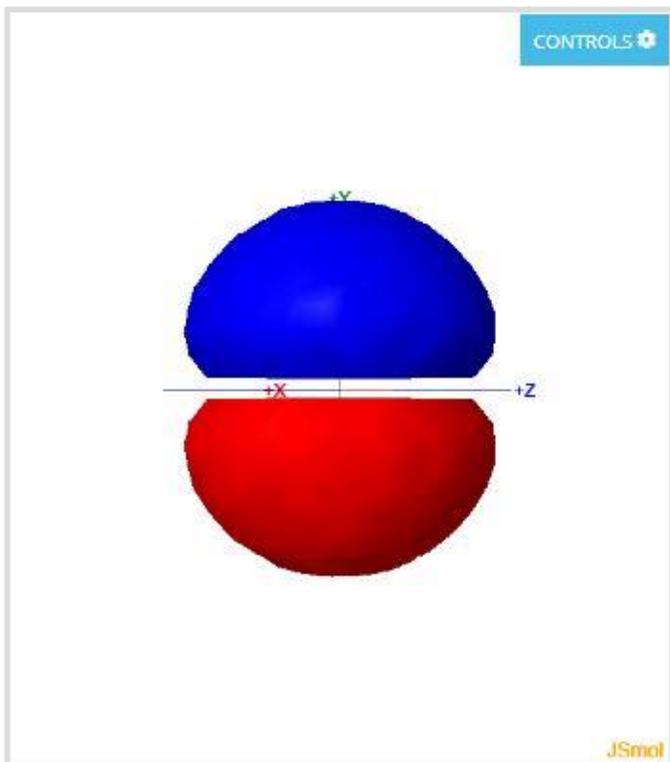


Spin Zoom

Show/hide H Antialias

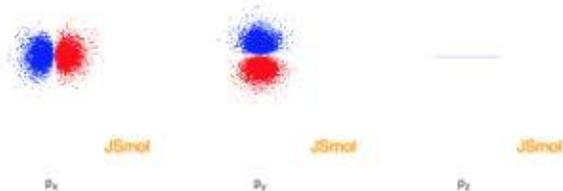
Show All Symmetry Elements

Shape of p-orbitals in 3D



The three p orbitals are aligned along perpendicular axes

Probability distribution of an electron in 2p orbitals - slice



Click the images to see the various views

The p sub shell can hold a maximum of six electrons as there are three orbitals within this sub shell. The three p orbitals are at right angles to each other and have a lobed shape. The size of the p orbitals also increases as the energy level or shell increases.

Animation controls:

Play once

Play back and forth

Loop animation

Stop animation

Frame 1 Next Prev

Display controls:

Spacefill Ball & Stick Sticks

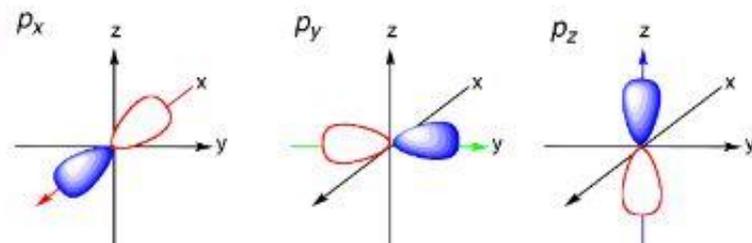
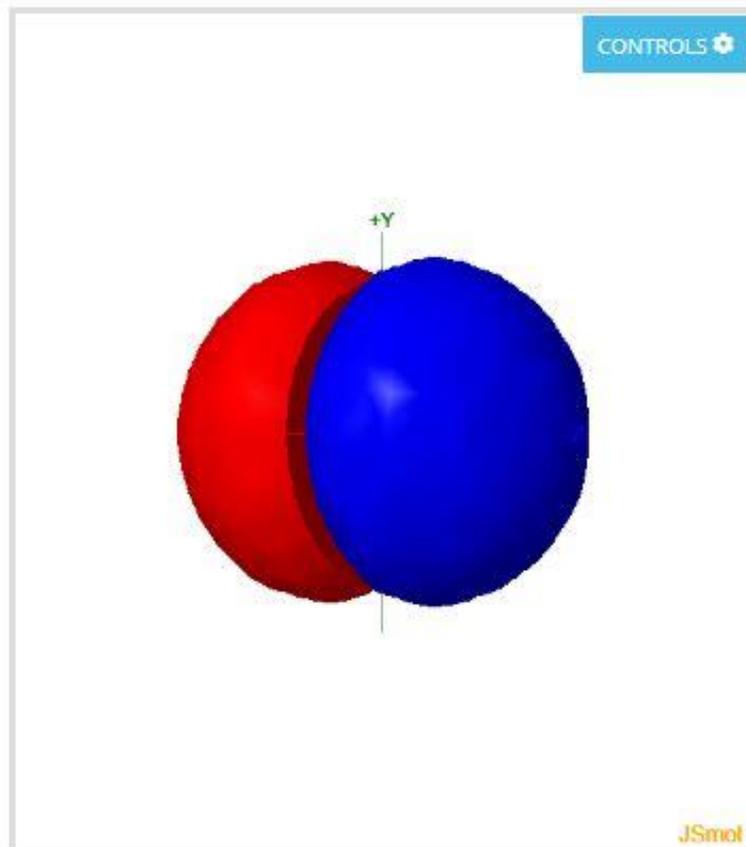


Spin Zoom

Show/hide H Antialias

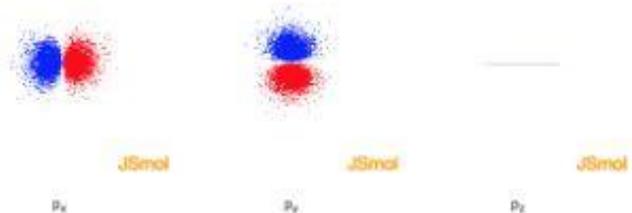
Show All Symmetry Elements

Shape of p-orbitals in 3D



The three p orbitals are aligned along perpendicular axes

Probability distribution of an electron in 2p orbitals - slice



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The p sub shell can hold a maximum of six electrons as there are three orbitals within this sub shell. The three p orbitals are at right angles to each other and have a lobed shape. The size of the p orbitals also increases as the energy level or shell increases.

Animation controls:

Play once ▶

Play back and forth ↺

Loop animation ↻

Stop animation ■

Frame 1 ⏪ Next ⏩ Prev ⏪

Display controls:

Spacefill Ball & Stick Sticks



Spin Zoom

Show/hide H Antialias

Show All Symmetry Elements

DISTRIBUTION OF ELECTRONS IN S ORBITALS

Click on "Probability distribution of an electron" (Red and Blue section)

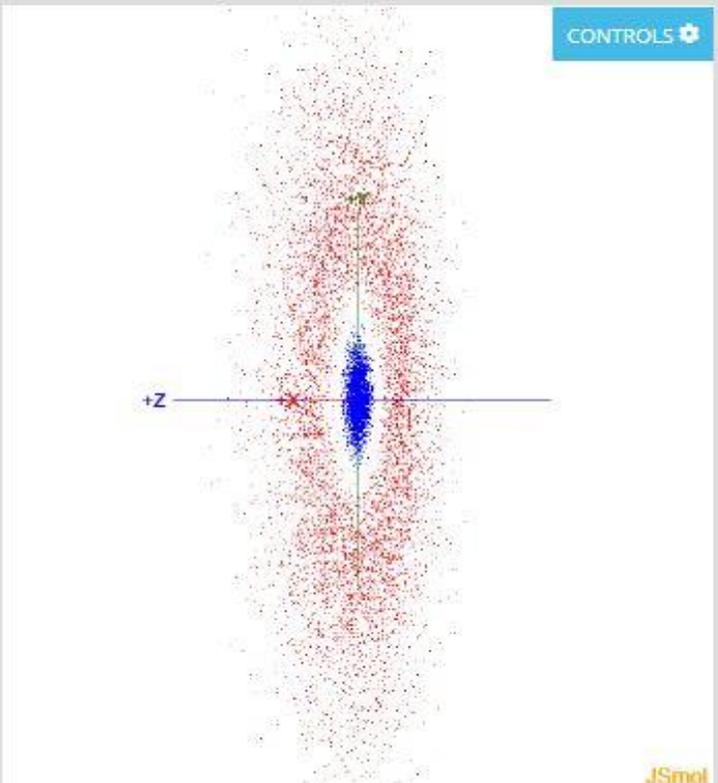
ChemTube 3D

Home Organic Inorganic Structure and Bonding A Level Polymers News Periodic Table Favourite Pages

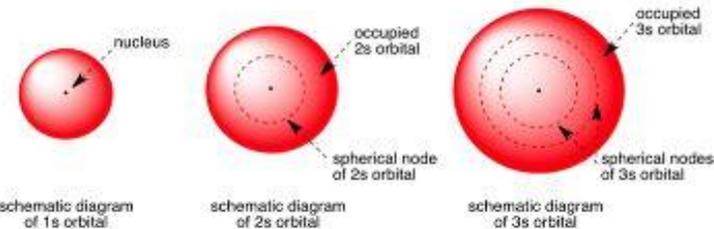
Home / Structure and Bonding / Atomic Orbitals / Shape of s-orbitals in 3D

Shape of s-orbitals in 3D

CONTROLS

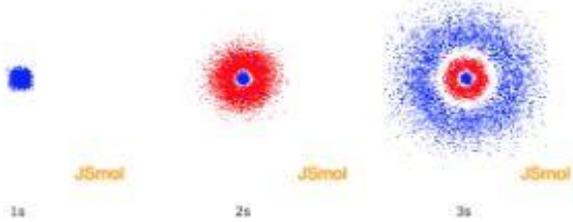


An illustration of the shape of the 1s, 2s and 3s orbitals



schematic diagram of 1s orbital schematic diagram of 2s orbital schematic diagram of 3s orbital

Probability distribution of an electron in s orbitals - slice



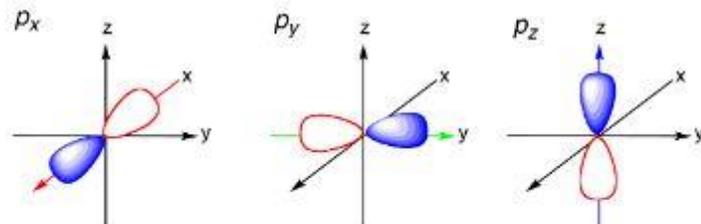
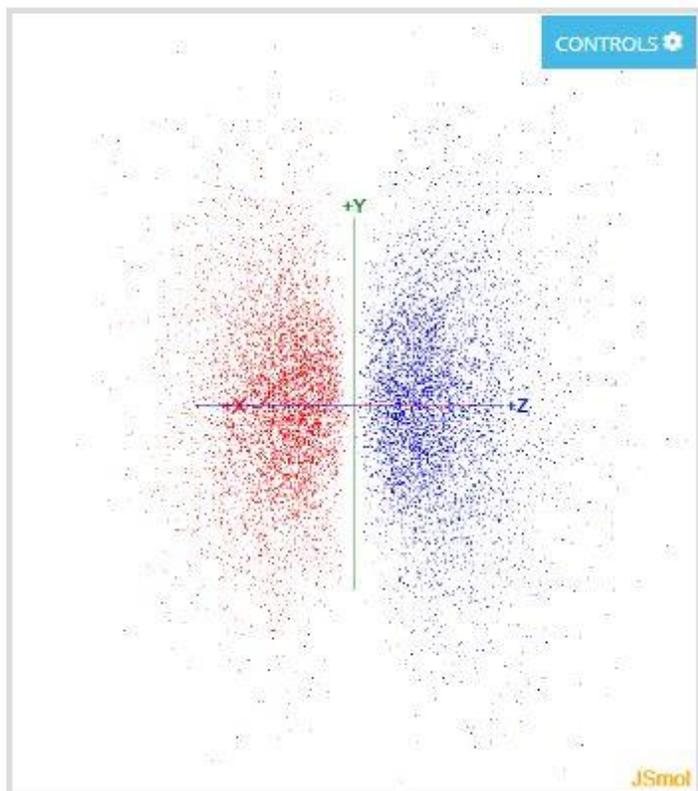
1s 2s 3s

JSmol JSmol JSmol

DISTRIBUTION OF ELECTRONS IN P ORBITALS

Home / Structure and Bonding / Atomic Orbitals / Shape of p-orbitals in 3D

Shape of p-orbitals in 3D



The three p orbitals are aligned along perpendicular axes

Probability distribution of an electron in 2p orbitals - slice



Click the images to see the various views

The p sub shell can hold a maximum of six electrons as there are three orbitals within this sub shell. The three p orbitals are at right angles to each other and have a lobed shape. The size of the p orbitals also increases as the energy level or shell increases.

Animation controls:

Play once 

Play back and forth 

Loop animation 

Stop animation 

Frame 1  Next  Prev 

Display controls:

Spacefill  Ball & Stick  Sticks 



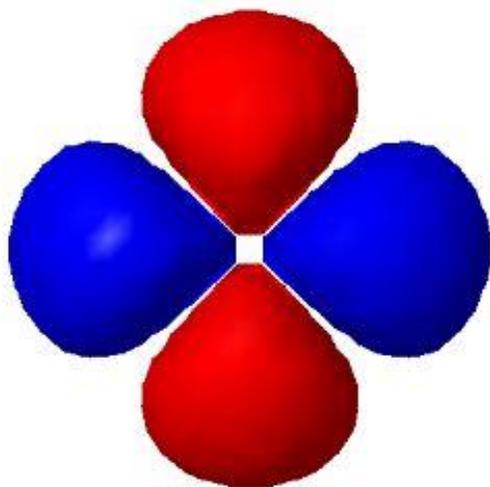
Spin Zoom

Show/hide H Antialias

Show All Symmetry Elements 

SHAPE OF d - ORBITALS

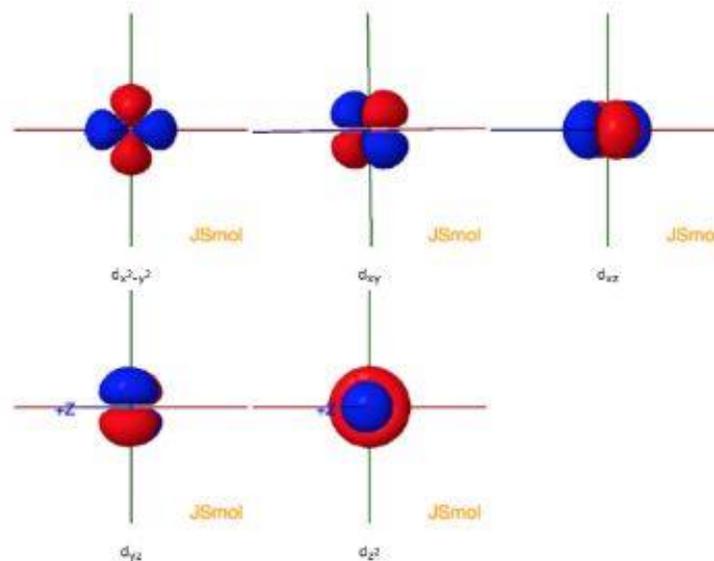
Shapes of the 3d orbitals in 3D



CONTROLS

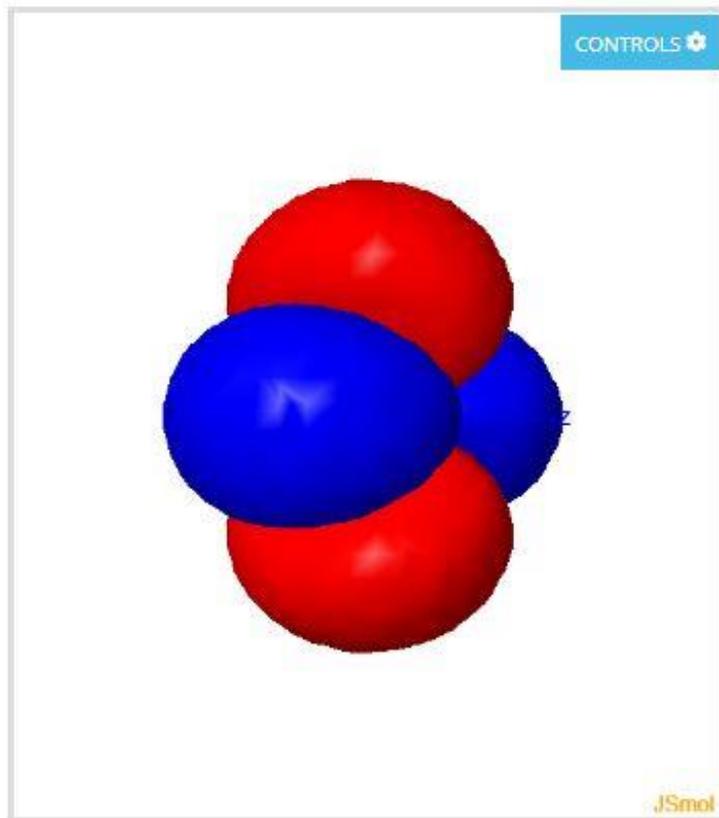
JSmol

An illustration of the shape of the 3d orbitals

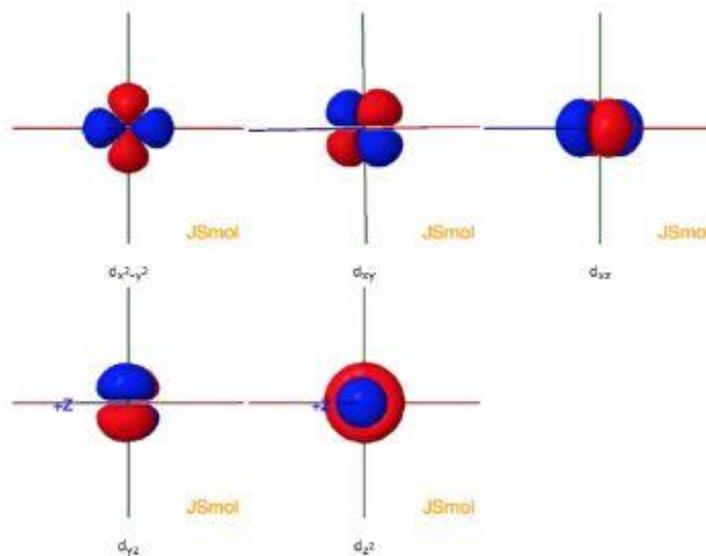


Click the images to see the various 3d orbitals

Shapes of the 3d orbitals in 3D



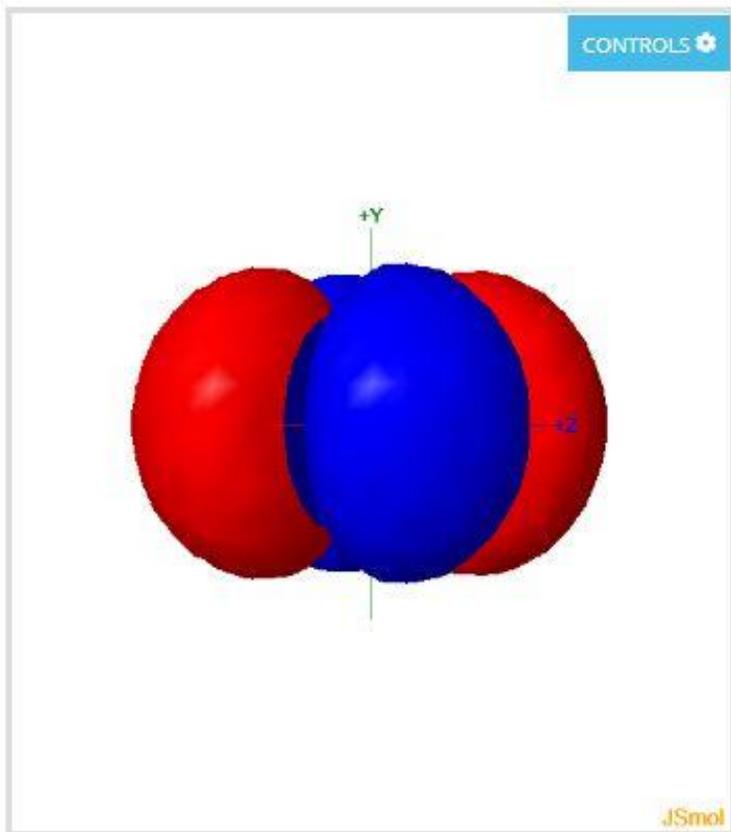
An illustration of the shape of the 3d orbitals



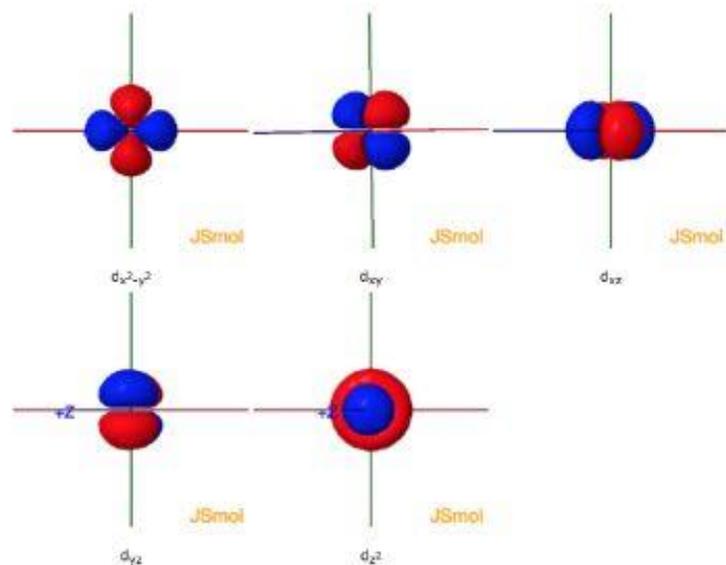
Click the images to see the various 3d orbitals

There are a total of five d orbitals and each orbital can hold two electrons. The transition metal series is defined by the progressive filling of the 3d orbitals. These five orbitals have the following m_l values:

Shapes of the 3d orbitals in 3D



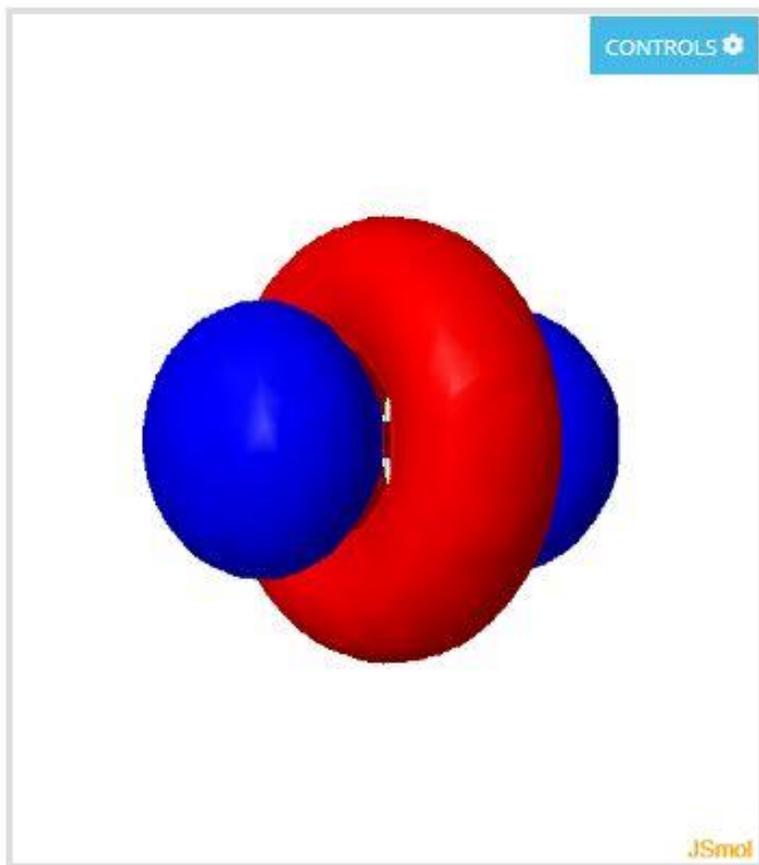
An illustration of the shape of the 3d orbitals



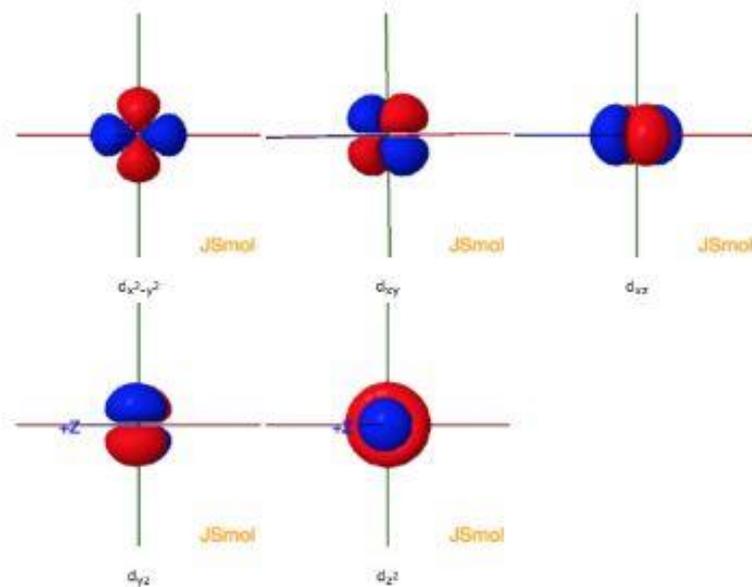
Click the images to see the various 3d orbitals

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Shapes of the 3d orbitals in 3D



An illustration of the shape of the 3d orbitals



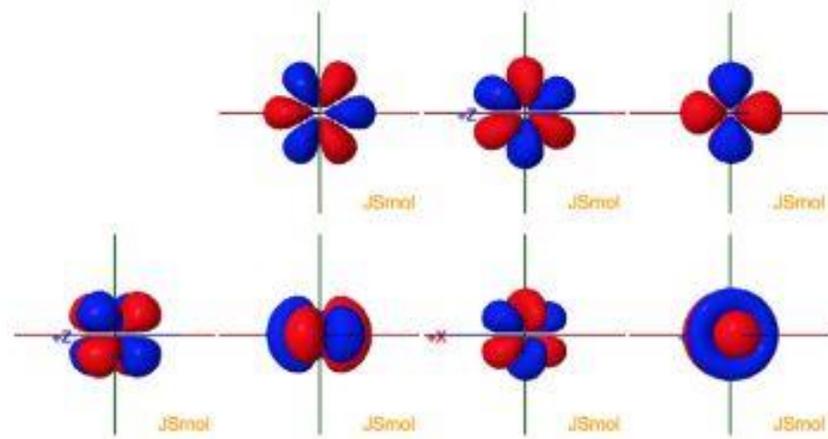
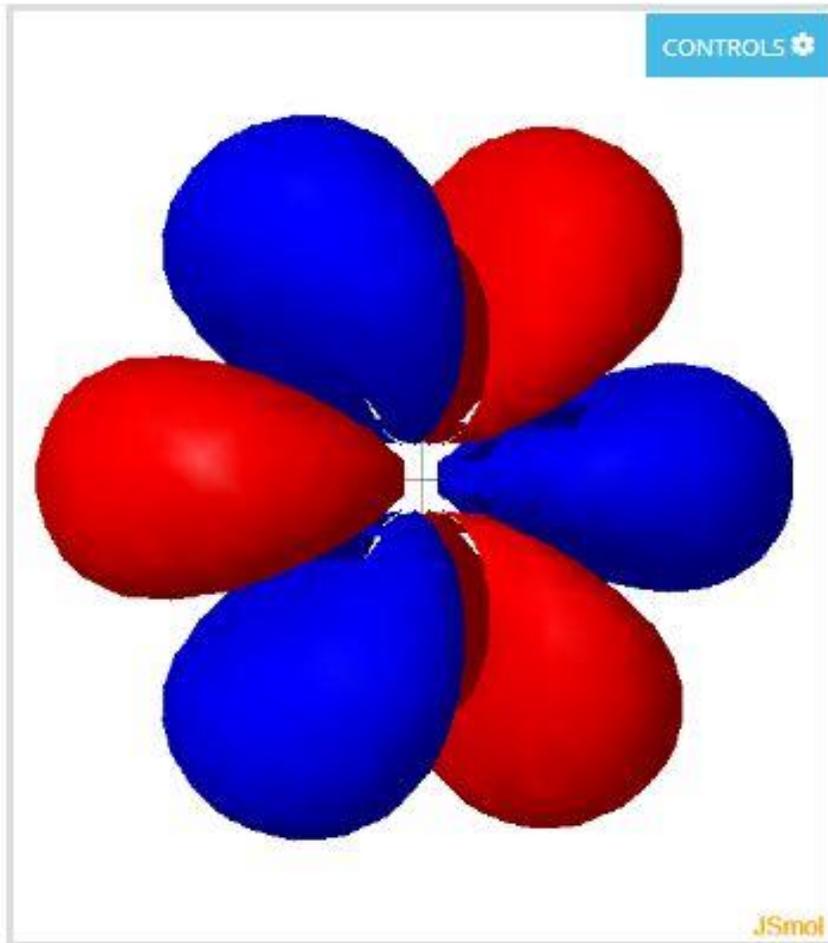
Click the images to see the various 3d orbitals

There are a total of five d orbitals and each orbital can hold two electrons. The transition metal series is defined by the progressive filling of the 3d orbitals. These five orbitals have the following m_l values:

SHAPE OF f - ORBITALS

[Home](#) / [Structure and Bonding](#) / [Atomic Orbitals](#) / [Shapes of the 4f orbitals in 3D](#)

Shapes of the 4f orbitals in 3D



Click the images to see the various 4f orbitals

The lanthanide series is defined by the progressive filling of the 4f orbitals.

These seven orbitals have the following m_l values:

$$m_l = 0, \pm 1, \pm 2,$$

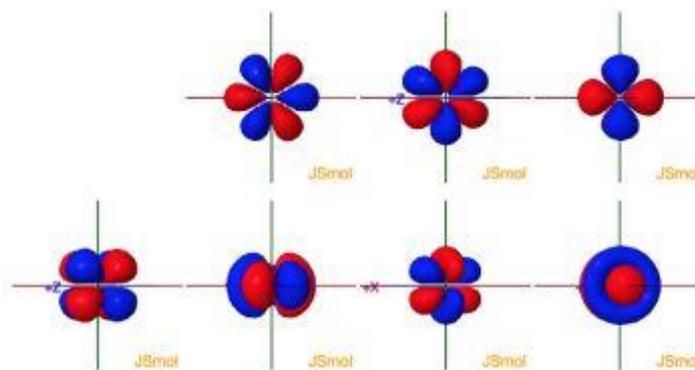
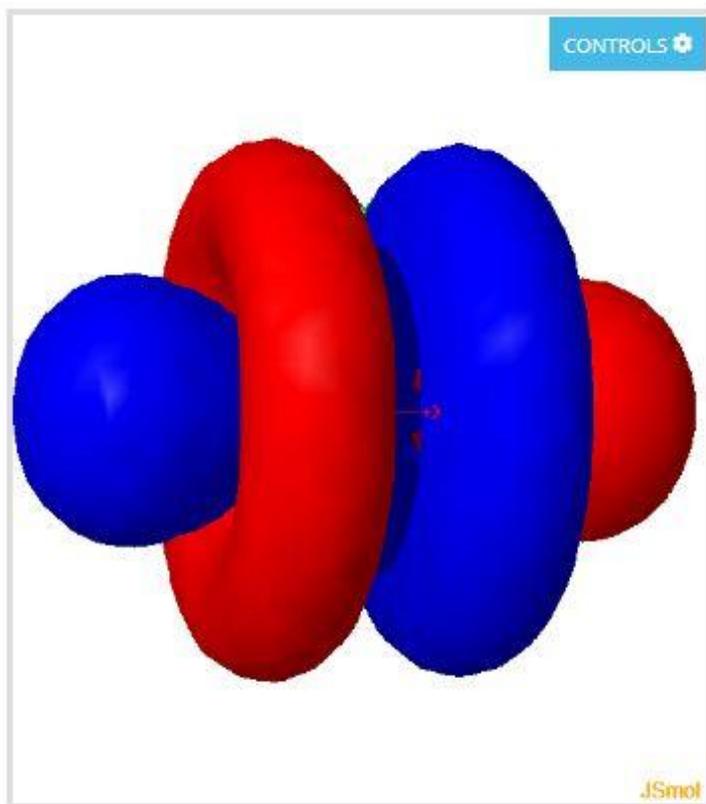
$$\pm 3$$

$m_l = 0$ are real, all the others are complex and so linear combinations must be

taken to obtain

real orbitals.

Shapes of the 4f orbitals in 3D



Click the images to see the various 4f orbitals

The lanthanide series is defined by the progressive filling of the 4f orbitals.

These seven orbitals have the following m_l values:

$m_l = 0, \pm 1, \pm 2,$

± 3

$m_l = 0$ are real, all the others are complex and so linear combinations must be taken to obtain real orbitals.

General set

These are produced by simply taking linear

EXPLAINING GEOMETRY OF MOLECULES USING CHEMTUBE 3D

Click on "A-Level"



Search..



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- Atomic Orbitals ▶
- Organic Reaction Mechanisms
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- Proton NMR Introduction ▶
- Shapes of molecules VSEPR
- Polymers A Level ▶

ChemTube3D contains interactive 3D chemistry animations and structures, with supporting information, for students studying some of the most important topics in advanced school chemistry and university chemistry courses. Use the menus to explore them.

Hover over "Shapes of molecules VSEPR", and it will show various molecules (Water, Ammonia etc.)



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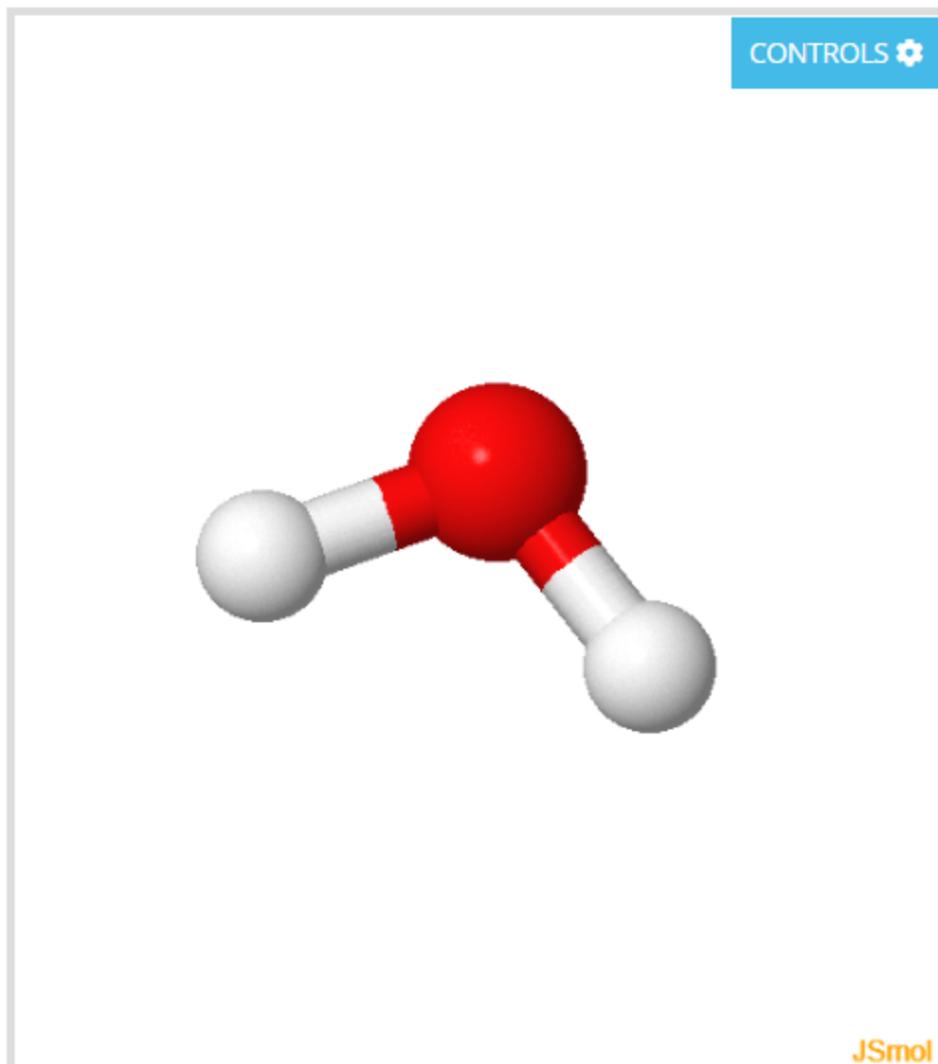
- H₂O Water
- NH₃ Ammonia
- CH₄ Methane
- SF₆ Sulfur Hexafluoride
- SF₄ Sulfur Tetrafluoride
- PF₅ Phosphorus Pentafluoride
- ClF₃ Chlorine Trifluoride

ChemTube3D contains interactive 3D chemical structures, with supporting information, for the most important topics in advanced school chemistry courses. Use the menus to explore some of the topics and see some of the resources available at the University of York.

GEOMETRY OF WATER (H₂O)

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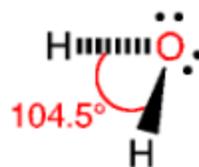
VSEPR H₂O Water



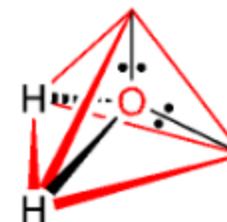
Valence Shell Electron Pair Repulsion

H₂O Water

 View Live



The H-O-H bond angle is
104.5°



The red lines outline a **tetrahedron**
Black lines show the
electron pairs

Water has 4 regions of electron density around the central oxygen atom (2 bonds and 2 lone pairs). These are arranged in a tetrahedral shape. The resulting molecular shape is bent with an H-O-H angle of 104.5°.

Click the structures to load the molecules

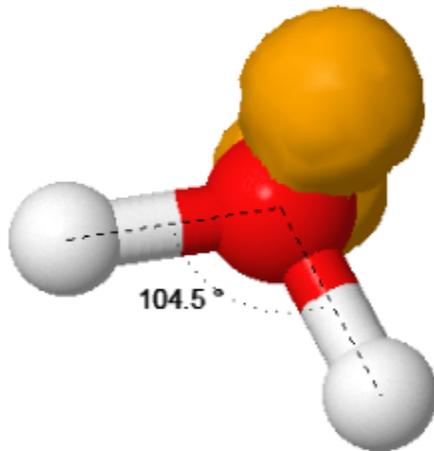
Related structures [H₂O](#) | [NH₃](#) | [CH₄](#) | [PF₅](#) | [SF₄](#) | [ClF₃](#) | [SF₆](#) | [XeF₄](#)

JSmol

Click on "H-O-H" bond angle is 104.5 degree (First structure)

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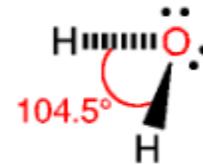
VSEPR H₂O Water



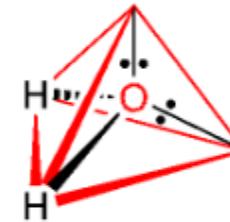
Valence Shell Electron Pair Repulsion

H₂O Water

 View Live



The H-O-H bond angle is
104.5°



The red lines outline a **tetrahedron**
Black lines show the
electron pairs

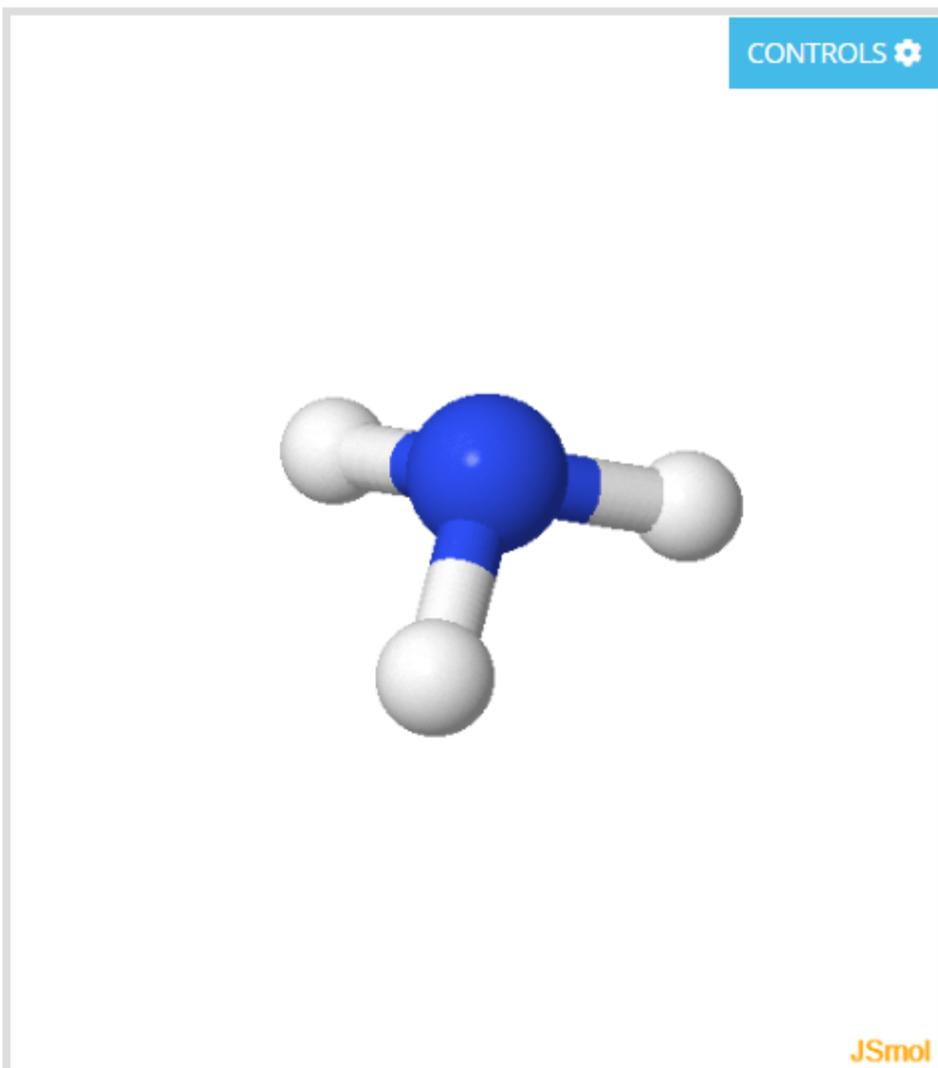
Water has 4 regions of electron density around the central oxygen atom (2 bonds and 2 lone pairs). These are arranged in a tetrahedral shape. The resulting molecular shape is bent with an H-O-H angle of 104.5°.

Click the structures to load the molecules

GEOMETRY OF AMMONIA

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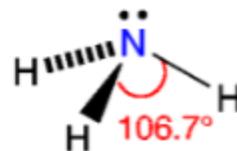
VSEPR NH₃ Ammonia



Valence Shell Electron Pair Repulsion

NH₃ Ammonia

 View Live



The H–N–H bond angle is
106.7°



The red lines outline a
tetrahedron
Black lines show the
electron pairs

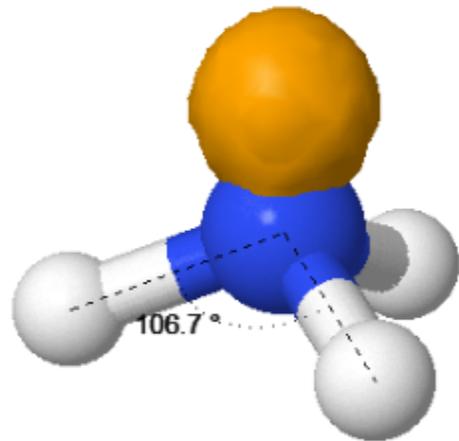
Ammonia has 4 regions of electron density around the central nitrogen atom (3 bonds and one lone pair). These are arranged in a tetrahedral shape. The resulting molecular shape is trigonal pyramidal with H-N-H angles of 106.7°.

Click the structures to load the molecules

Click on "H-N-H" bond angle is 106.7 degree (First structure)

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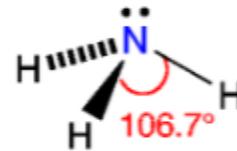
VSEPR NH₃ Ammonia



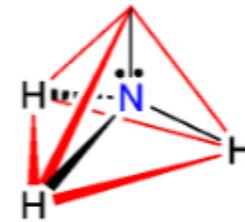
Valence Shell Electron Pair Repulsion

NH₃ Ammonia

 View Live



The H-N-H bond angle is
106.7°



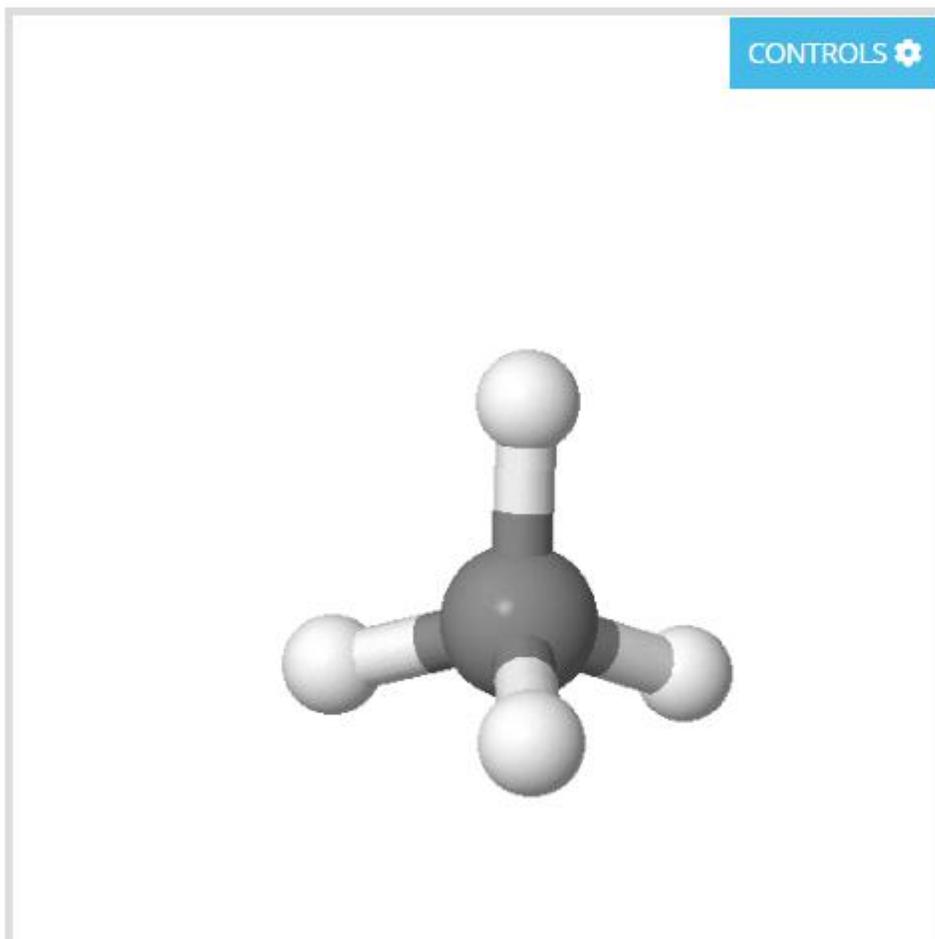
The red lines outline a
tetrahedron
Black lines show the
electron pairs

Ammonia has 4 regions of electron density around the central nitrogen atom (3 bonds and one lone pair). These are arranged in a tetrahedral shape. The resulting molecular shape is trigonal pyramidal with H-N-H angles of 106.7°.

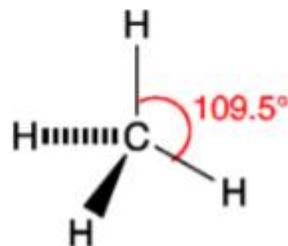
GEOMETRY OF METHANE

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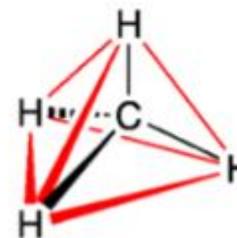
VSEPR CH₄ Methane



Valence Shell Electron Pair Repulsion



The H-C-H bond angle is
109.5°



The red lines outline a
tetrahedron
Black lines show the
covalent bonds

Methane has 4 regions of electron density around the central carbon atom (4 bonds, no lone pairs). The resulting shape is a regular tetrahedron with H-C-H angles of 109.5°.

Click the structures to load the molecules

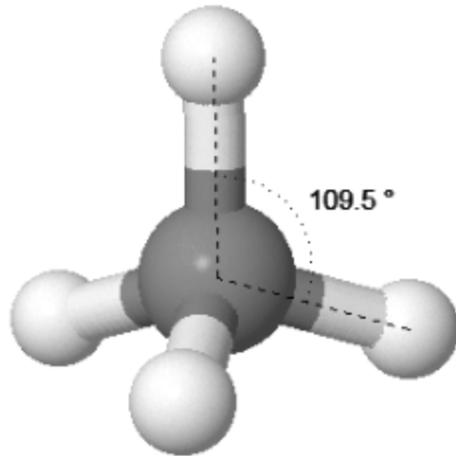
Related structures [H₂O](#) | [NH₃](#) | [CH₄](#) | [PF₅](#) | [SF₄](#) | [ClF₃](#) | [SF₆](#) | [XeF₄](#)

Click on "H-C-H" bond angle is 109.5 degree (First structure)

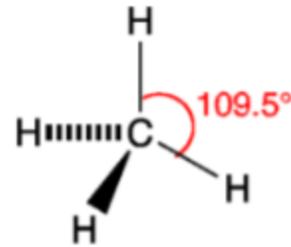
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VSEPR CH₄ Methane

CONTROLS ⚙



Valence Shell Electron Pair Repulsion



The H-C-H bond angle is
109.5°



The red lines outline a
tetrahedron
Black lines show the
covalent bonds

Methane has 4 regions of electron density around the central carbon atom (4 bonds, no lone pairs). The resulting shape is a regular tetrahedron with H-C-H angles of 109.5°.

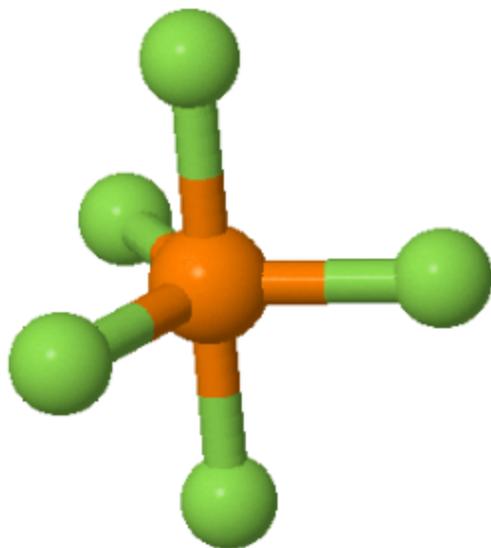
Click the structures to load the molecules

Related structures [H₂O](#) | [NH₃](#) | [CH₄](#) | [PF₅](#) | [SF₄](#) | [ClF₃](#) | [SF₆](#) | [XeF₄](#)

GEOMETRY OF PHOSPHOROUS PENTAFLUORIDE

[Home](#) / [A Level](#) / [Shapes of molecules VSEPR](#) / [VSEPR PF5 Phosphorus Pentafluoride](#)

VSEPR PF₅ Phosphorus Pentafluoride

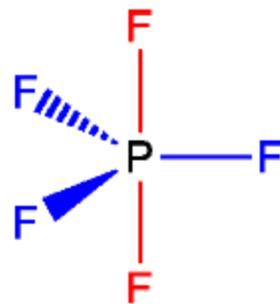


CONTROLS ⚙

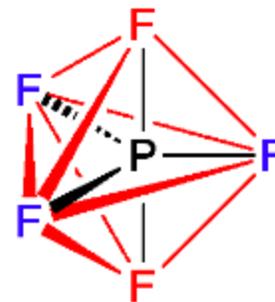
Valence Shell Electron Pair Repulsion

PF₅ Phosphorus Pentafluoride

 View Live



Axial F atoms are in a different environment to the **equatorial** F atoms

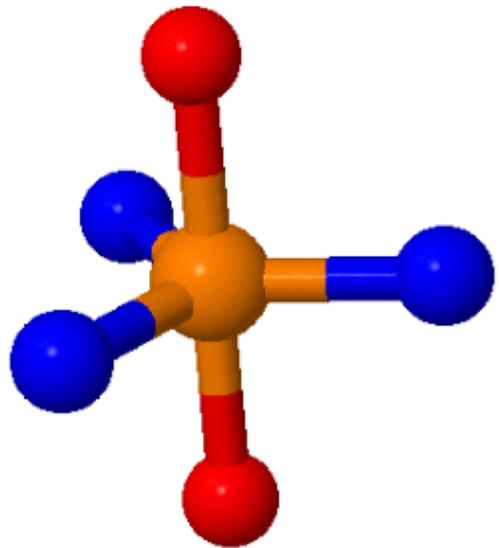


The red lines outline a **trigonal bipyramid**. Black lines show the covalent bonds

Click on PCL5 structure (first image) to the simulation

[Home](#) / [A Level](#) / [Shapes of molecules VSEPR](#) / [VSEPR PF5 Phosphorus Pentafluoride](#)

VSEPR PF₅ Phosphorus Pentafluoride

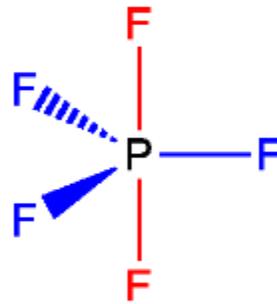


CONTROLS ⚙

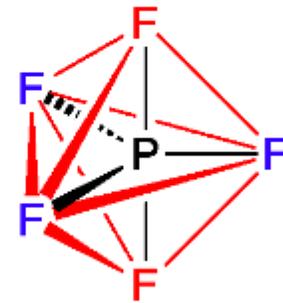
Valence Shell Electron Pair Repulsion

PF₅ Phosphorus Pentafluoride

 View Live



Axial F atoms are in a different environment to the **equatorial** F atoms



The red lines outline a **trigonal bipyramid**. Black lines show the covalent bonds

ACKNOWLEDGEMENTS

I would like to express sincere gratitude to **chemtube-3D Open Source Tools** for effective simulations which are useful for teachers and students

I would also like to sincerely thank **CIET – NCERT** for providing such platform

THANKS

