

# Atomic radii of the elements (data page)

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The **atomic radius** of a chemical element is the distance from the centre of the nucleus to the outermost shell of the electron. Since the boundary is not a well-defined physical entity, there are various non-equivalent definitions of atomic radius. Depending on the definition, the term may apply only to isolated atoms, or also to atoms in condensed matter, covalently bound in molecules, or in ionized and excited states; and its value may be obtained through experimental measurements, or computed from theoretical models. Under some definitions, the value of the radius may depend on the atom's state and context.<sup>[1]</sup>

Atomic radii vary in a predictable and explicable manner across the periodic table. For instance, the radii generally decrease rightward along each period (row) of the table, from the alkali metals to the noble gases; and increase down each group (column). The radius increases sharply between the noble gas at the end of each period and the alkali metal at the beginning of the next period. These trends of the atomic radii (and of various other chemical and physical properties of the elements) can be explained by the electron shell theory of the atom; they provided important evidence for the development and confirmation of quantum theory.

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## Atomic radii

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**Note:** All measurements given are in picometers (pm). For more recent data on covalent radii see Covalent radius.

atomic number	symbol	name	empirical †	Calculated	van der Waals	Covalent (single bond)	Covalent (triple bond)	Metallic
1	H	hydrogen	25	53	120	38	no data	
2	He	helium	120	31	140	32	no data	
3	Li	lithium	145	167	182	134	no data	152
4	Be	beryllium	105	112	153 <sup>a</sup>	90	85	112
5	B	boron	85	87	192 <sup>a</sup>	82	73	
6	C	carbon	70	67	170	77	60	
7	N	nitrogen	65	56	155	75	54	
8	O	oxygen	60	48	152	73	53	
9	F	fluorine	50	42	147	71	53	
10	Ne	neon	160	38	154	69	no data	
11	Na	sodium	180	190	227	154	no data	186
12	Mg	magnesium	150	145	173	130	127	160
13	Al	aluminium	125	118	184 <sup>a</sup>	118	111	143
14	Si	silicon	110	111	210	111	102	
15	P	phosphorus	100	98	180	106	94	
16	S	sulfur	100	88	180	102	95	
17	Cl	chlorine	100	79	175	99	93	
18	Ar	argon	71	71	188	97	96	
19	K	potassium	220	243	275	196	no data	227
20	Ca	calcium	180	194	231 <sup>a</sup>	174	133	197
21	Sc	scandium	160	184	211 <sup>a</sup>	144	114	162 <sup>b</sup>
22	Ti	titanium	140	176	no data	136	108	147
23	V	vanadium	135	171	no data	125	106	134 <sup>b</sup>
24	Cr	chromium	140	166	no data	127	103	128 <sup>b</sup>
25	Mn	manganese	140	161	no data	139	103	127 <sup>b</sup>
26	Fe	iron	140	156	no data	125	102	126 <sup>b</sup>
27	Co	cobalt	135	152	no data	126	96	125 <sup>b</sup>
28	Ni	nickel	135	149	163	121	101	124 <sup>b</sup>
29	Cu	copper	135	145	140	138	120	128 <sup>b</sup>
30	Zn	zinc	135	142	139	131	no data	134 <sup>b</sup>
31	Ga	gallium	130	136	187	126	121	135 <sup>c</sup>
32	Ge	germanium	125	125	211 <sup>a</sup>	122	114	

33	As	<u>arsenic</u>	<u>115</u>	<u>114</u>	<u>185</u>	<u>119</u>	<u>106</u>	
34	Se	<u>selenium</u>	<u>115</u>	<u>103</u>	<u>190</u>	<u>116</u>	<u>107</u>	
35	Br	<u>bromine</u>	<u>115</u>	<u>94</u>	<u>185</u>	<u>114</u>	<u>110</u>	
36	Kr	<u>krypton</u>	no data	<u>88</u>	<u>202</u>	<u>110</u>	<u>108</u>	
37	Rb	<u>rubidium</u>	<u>235</u>	<u>265</u>	<u>303</u> <sup>a</sup>	<u>211</u>	no data	<u>248</u>
38	Sr	<u>strontium</u>	<u>200</u>	<u>219</u>	<u>249</u> <sup>a</sup>	<u>192</u>	<u>139</u>	<u>215</u>
39	Y	<u>yttrium</u>	<u>180</u>	<u>212</u>	no data	<u>162</u>	<u>124</u>	<u>180</u> <sup>b</sup>
40	Zr	<u>zirconium</u>	<u>155</u>	<u>206</u>	no data	<u>148</u>	<u>121</u>	<u>160</u>
41	Nb	<u>niobium</u>	<u>145</u>	<u>198</u>	no data	<u>137</u>	<u>116</u>	<u>146</u> <sup>b</sup>
42	Mo	<u>molybdenum</u>	<u>145</u>	<u>190</u>	no data	<u>145</u>	<u>113</u>	<u>139</u> <sup>b</sup>
43	Tc	<u>technetium</u>	<u>135</u>	<u>183</u>	no data	<u>156</u>	<u>110</u>	<u>136</u> <sup>b</sup>
44	Ru	<u>ruthenium</u>	<u>130</u>	<u>178</u>	no data	<u>126</u>	<u>103</u>	<u>134</u> <sup>b</sup>
45	Rh	<u>rhodium</u>	<u>135</u>	<u>173</u>	no data	<u>135</u>	<u>106</u>	<u>134</u> <sup>b</sup>
46	Pd	<u>palladium</u>	<u>140</u>	<u>169</u>	<u>163</u>	<u>131</u>	<u>112</u>	<u>137</u> <sup>b</sup>
47	Ag	<u>silver</u>	<u>160</u>	<u>165</u>	<u>172</u>	<u>153</u>	<u>137</u>	<u>144</u> <sup>b</sup>
48	Cd	<u>cadmium</u>	<u>155</u>	<u>161</u>	<u>158</u>	<u>148</u>	no data	<u>151</u> <sup>b</sup>
49	In	<u>indium</u>	<u>155</u>	<u>156</u>	<u>193</u>	<u>144</u>	<u>146</u>	<u>167</u>
50	Sn	<u>tin</u>	<u>145</u>	<u>145</u>	<u>217</u>	<u>141</u>	<u>132</u>	
51	Sb	<u>antimony</u>	<u>145</u>	<u>133</u>	<u>206</u> <sup>a</sup>	<u>138</u>	<u>127</u>	
52	Te	<u>tellurium</u>	<u>140</u>	<u>123</u>	<u>206</u>	<u>135</u>	<u>121</u>	
53	I	<u>iodine</u>	<u>140</u>	<u>115</u>	<u>198</u>	<u>133</u>	<u>125</u>	
54	Xe	<u>xenon</u>	no data	<u>108</u>	<u>216</u>	<u>130</u>	<u>122</u>	
55	Cs	<u>caesium</u>	<u>260</u>	<u>298</u>	<u>343</u> <sup>a</sup>	<u>225</u>	no data	<u>265</u>
56	Ba	<u>barium</u>	<u>215</u>	<u>253</u>	<u>268</u> <sup>a</sup>	<u>198</u>	<u>149</u>	<u>222</u>
57	La	<u>lanthanum</u>	<u>195</u>	<u>195</u>	no data	<u>169</u>	<u>139</u>	<u>187</u> <sup>b</sup>
58	Ce	<u>cerium</u>	<u>185</u>	<u>158</u>	no data	no data	<u>131</u>	<u>181.8</u> <sup>c</sup>
59	Pr	<u>praseodymium</u>	<u>185</u>	<u>247</u>	no data	no data	<u>128</u>	<u>182.4</u> <sup>c</sup>
60	Nd	<u>neodymium</u>	<u>185</u>	<u>206</u>	no data	no data	no data	<u>181.4</u> <sup>c</sup>
61	Pm	<u>promethium</u>	<u>185</u>	<u>205</u>	no data	no data	no data	<u>183.4</u> <sup>c</sup>
62	Sm	<u>samarium</u>	<u>185</u>	<u>238</u>	no data	no data	no data	<u>180.4</u> <sup>c</sup>

63	Eu	<u>europium</u>	<u>185</u>	<u>231</u>	no data	no data	no data	<u>180.4</u> <sup>c</sup> <u>  </u>
64	Gd	<u>gadolinium</u>	<u>180</u>	<u>233</u>	no data	no data	<u>132</u>	<u>180.4</u> <sup>c</sup> <u>  </u>
65	Tb	<u>terbium</u>	<u>175</u>	<u>225</u>	no data	no data	no data	<u>177.3</u> <sup>c</sup> <u>  </u>
66	Dy	<u>dysprosium</u>	<u>175</u>	<u>228</u>	no data	no data	no data	<u>178.1</u> <sup>c</sup> <u>  </u>
67	Ho	<u>holmium</u>	<u>175</u>	<u>226</u>	no data	no data	no data	<u>176.2</u> <sup>c</sup> <u>  </u>
68	Er	<u>erbium</u>	<u>175</u>	<u>226</u>	no data	no data	no data	<u>176.1</u> <sup>c</sup> <u>  </u>
69	Tm	<u>thulium</u>	<u>175</u>	<u>222</u>	no data	no data	no data	<u>175.9</u> <sup>c</sup> <u>  </u>
70	Yb	<u>ytterbium</u>	<u>175</u>	<u>222</u>	no data	no data	no data	<u>176</u> <sup>c</sup> <u>  </u>
71	Lu	<u>lutetium</u>	<u>175</u>	<u>217</u>	no data	<u>160</u>	<u>131</u>	<u>173.8</u> <sup>c</sup> <u>  </u>
72	Hf	<u>hafnium</u>	<u>155</u>	<u>208</u>	no data	<u>150</u>	<u>122</u>	<u>159</u>
73	Ta	<u>tantalum</u>	<u>145</u>	<u>200</u>	no data	<u>138</u>	<u>119</u>	<u>146</u> <sup>b</sup> <u>  </u>
74	W	<u>tungsten</u>	<u>135</u>	<u>193</u>	no data	<u>146</u>	<u>115</u>	<u>139</u> <sup>b</sup> <u>  </u>
75	Re	<u>rhenium</u>	<u>135</u>	<u>188</u>	no data	<u>159</u>	<u>110</u>	<u>137</u> <sup>b</sup> <u>  </u>
76	Os	<u>osmium</u>	<u>130</u>	<u>185</u>	no data	<u>128</u>	<u>109</u>	<u>135</u> <sup>b</sup> <u>  </u>
77	Ir	<u>iridium</u>	<u>135</u>	<u>180</u>	no data	<u>137</u>	<u>107</u>	<u>135.5</u> <sup>b</sup> <u>  </u>
78	Pt	<u>platinum</u>	<u>135</u>	<u>177</u>	<u>175</u>	<u>128</u>	<u>110</u>	<u>138.5</u> <sup>b</sup> <u>  </u>
79	Au	<u>gold</u>	<u>135</u>	<u>174</u>	<u>166</u>	<u>144</u>	<u>123</u>	<u>144</u> <sup>b</sup> <u>  </u>
80	Hg	<u>mercury</u>	<u>150</u>	<u>171</u>	<u>155</u>	<u>149</u>	no data	<u>151</u> <sup>b</sup> <u>  </u>
81	Tl	<u>thallium</u>	<u>190</u>	<u>156</u>	<u>196</u>	<u>148</u>	<u>150</u>	<u>170</u>
82	Pb	<u>lead</u>	<u>180</u>	<u>154</u>	<u>202</u>	<u>147</u>	<u>137</u>	
83	Bi	<u>bismuth</u>	<u>160</u>	<u>143</u>	<u>207</u> <sup>a</sup> <u>  </u>	<u>146</u>	<u>135</u>	
84	Po	<u>polonium</u>	<u>190</u>	<u>135</u>	<u>197</u> <sup>a</sup> <u>  </u>	no data	<u>129</u>	
85	At	<u>astatine</u>	no data	<u>127</u>	<u>202</u> <sup>a</sup> <u>  </u>	no data	<u>138</u>	
86	Rn	<u>radon</u>	no data	<u>120</u>	<u>220</u> <sup>a</sup> <u>  </u>	<u>145</u>	<u>133</u>	
87	Fr	<u>francium</u>	no data	no data	<u>348</u> <sup>a</sup> <u>  </u>	no data	no data	no data
88	Ra	<u>radium</u>	<u>215</u>	no data	<u>283</u> <sup>a</sup> <u>  </u>	no data	<u>159</u>	no data
89	Ac	<u>actinium</u>	<u>195</u>	no data	no data	no data	<u>140</u>	
90	Th	<u>thorium</u>	<u>180</u>	no data	no data	no data	<u>136</u>	<u>179</u> <sup>b</sup> <u>  </u>

91	Pa	<u>protactinium</u>	<u>180</u>	no data	no data	no data	<u>129</u>	<u>163</u> <sup>d</sup>
92	U	<u>uranium</u>	<u>175</u>	no data	<u>186</u>	no data	<u>118</u>	<u>156</u> <sup>e</sup>
93	Np	<u>neptunium</u>	<u>175</u>	no data	no data	no data	<u>116</u>	<u>155</u> <sup>e</sup>
94	Pu	<u>plutonium</u>	<u>175</u>	no data	no data	no data	no data	<u>159</u> <sup>e</sup>
95	Am	<u>americium</u>	<u>175</u>	no data	no data	no data	no data	<u>173</u> <sup>b</sup>
96	Cm	<u>curium</u>	no data	no data	no data	no data	no data	<u>174</u> <sup>b</sup>
97	Bk	<u>berkelium</u>	no data	no data	no data	no data	no data	<u>170</u> <sup>b</sup>
98	Cf	<u>californium</u>	no data	no data	no data	no data	no data	<u>186</u> +/- <u>2</u> <sup>b</sup>
99	Es	<u>einsteinium</u>	no data	no data	no data	no data	no data	<u>186</u> +/- <u>2</u> <sup>b</sup>
100	Fm	<u>fermium</u>	no data	no data	no data	no data	no data	no data
101	Md	<u>mendelevium</u>	no data	no data	no data	no data	no data	no data
102	No	<u>nobelium</u>	no data	no data	no data	no data	no data	no data
103	Lr	<u>lawrencium</u>	no data	no data	no data	no data	no data	no data
104	Rf	<u>rutherfordium</u>	no data	no data	no data	no data	<u>131</u>	no data
105	Db	<u>dubnium</u>	no data	no data	no data	no data	<u>126</u>	no data
106	Sg	<u>seaborgium</u>	no data	no data	no data	no data	<u>121</u>	no data
107	Bh	<u>bohrium</u>	no data	no data	no data	no data	<u>119</u>	no data
108	Hs	<u>hassium</u>	no data	no data	no data	no data	<u>118</u>	no data
109	Mt	<u>meitnerium</u>	no data	no data	no data	no data	<u>113</u>	no data
110	Ds	<u>darmstadtium</u>	no data	no data	no data	no data	<u>112</u>	no data
111	Rg	<u>roentgenium</u>	no data	no data	no data	no data	<u>118</u>	no data
112	Cn	<u>copernicium</u>	no data	no data	no data	no data	<u>130</u>	no data
113	Nh	<u>nihonium</u>	no data	no data	no data	no data	no data	no data
114	Fl	<u>flerovium</u>	no data	no data	no data	no data	no data	no data
115	Mc	<u>moscovium</u>	no data	no data	no	no data	no data	no data

					data			
116	Lv	<u>livermorium</u>	no data	no data	no data	no data	no data	no data
117	Ts	<u>tennessine</u>	no data	no data	no data	no data	no data	no data
118	Og	<u>oganesson</u>	no data	no data	no data	no data	no data	no data

## See also

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- Atomic radius
- Covalent radius (Single-, double- and triple-bond radii, up to the superheavy elements.)
- Ionic radius

## Notes

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- The radius of an atom is not a uniquely defined property and depends on the definition. Data derived from other sources with different assumptions cannot be compared.
- † to an accuracy of about 5 pm
- (a) These radii are taken from M. Mantina, A.C. Chamberlin, R. Valero, C.J. Cramer, and D.G. Truhlar, *J. Phys. Chem.* 2009, **113**, 5806.
- (b) 12 coordinate
- (c) gallium has an anomalous crystal structure
- (d) 10 coordinate
- (e) uranium, neptunium and plutonium have irregular structures

## References

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1. Cotton, F. A.; Wilkinson, G. (1988). *Advanced Inorganic Chemistry* (5th ed.). Wiley. p. 1385. ISBN 978-0-471-84997-1.

Data is as quoted at <http://www.webelements.com/> from these sources:

### Atomic radius (empirical)

- J.C. Slater (1964). "Atomic Radii in Crystals". *J. Chem. Phys.* **41**: 3199. Bibcode:1964JChPh..41.3199S (<https://ui.adsabs.harvard.edu/abs/1964JChPh..41.3199S>). doi:10.1063/1.1725697 (<https://doi.org/10.1063%2F1.1725697>).

### Atomic radius (calculated)

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### Van der Waals radius

- A. Bondi (1964). "van der Waals Volumes and Radii". *J. Phys. Chem.* **68**: 441. doi:10.1021/j100785a001 (<https://doi.org/10.1021%2Fj100785a001>).
- M. Mantina; A.C. Chamberlin; R. Valero; C.J. Cramer; D.G. Truhlar (2009). "Consistent van der Waals Radii for the Whole Main Group" (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3658832>). *J. Phys. Chem. A.* **113** (19): 5806–12. Bibcode:2009JPCA..113.5806M (<https://ui.adsabs.harvard.edu/abs/2009JPCA..113.5806M>). doi:10.1021/jp8111556 (<https://doi.org/10.1021%2Fjp8111556>). PMC 3658832 (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3658832>). PMID 19382751 (<https://pubmed.ncbi.nlm.nih.gov/19382751>).

## Covalent radii (single bond)

More recent data can be found in [Covalent radius](#). The above values are based on

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- L.E. Sutton, ed. (1965). "Supplement 1956–1959, Special publication No. 18". *Table of interatomic distances and configuration in molecules and ions*. London, UK: Chemical Society.
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## Triple-bond covalent radii

- S. Riedel; P.Pyykkö, M. Patzschke; Patzschke, M (2005). "Triple-Bond Covalent Radii". *Chem. Eur. J.* **11** (12): 3511–3520. doi:10.1002/chem.200401299 (<https://doi.org/10.1002%2Fchem.200401299>). PMID 15832398 (<https://pubmed.ncbi.nlm.nih.gov/15832398>). Mean-square deviation 3pm.
- Triple-Bond Covalent Radii Table online (<http://www.psichem.de/triple-bond/index.htm>)

## Metallic radius

[Greenwood, Norman N.; Earnshaw, Alan \(1997\). \*Chemistry of the Elements\* \(2nd ed.\). Butterworth-Heinemann. ISBN 978-0-08-037941-8.](#)

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