

## 2 Properties

**Cobalt** Co – A silvery metal having a close packed hexagonal crystal structure.

### a) Atomic Structure

Cobalt is a transition metal, appearing between iron and nickel in the first long period of the periodic table. It is a group VIII metal with a configuration  $3d^7 4s^2$ , total electrons.

$$1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^2 = 27 \text{ Atomic Number}$$

$$\text{Atomic Mass} = 58.99 \text{ (59) } 27 \text{ Protons, } 32 \text{ Neutrons}$$

The structure accounts for the variable valency of cobalt with  $\text{Co}^{2+}$  being the obvious one with the two 4s electrons removed. Cobalt ions  $\text{Co}^{3+}$  occur by electron addition and  $\text{Co}^{+1}$  occurs in a few complex salts.

### b) Physical Constants

Density:	8.85 g/cm <sup>3</sup>
Melting Point:	1493°C (2719°F)
Boiling Point:	3100°C (5612°F)
Coeff. of Linear Expansion:	10 <sup>-6</sup> per °C      20-100° = 12.5 100-200° = 13.6
Coeff. of Volume Expansion:	10-6 per °C      100°C = 35.6
Transition Temp. CPH to FCC:	~421°C
Electrical Resistivity:	6.24 μΩ cm
Curie Point:	1121°C

### Cobalt Characteristics

Symbol:	Co	Atomic Weight:	58.933
Atomic Number:	27	Valencies:	2 + 3
Electron Structure:	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^2$		

### Allotropic Transformation Data (Transition ~ 421°C)

	Hexagonal		Face Centred Cube
Atoms/Cell	4		6
Lattice parameter	2.5071A	Room Temp.	3.5441A
Density	8.85 g/cc	Room Temp.	8.80 g/cc
Linear Coeff. of expansion	12.5 x 10 <sup>-6</sup> /°C	Room Temp.	14.2 x 10 <sup>-6</sup> /°C
Transformation Temperature		421°C	
Lattice at transformation	2.541A	421°C	
Heat of transformation		1 cal/gr	
Volume expansion		0.36% approx.	
Free Energy Charge	500J/mol (hex → fcc)		(fcc → hex) 360J/mol
Latent Heat of Fusion		61.75 cal/g	
Electrical Resistivity at 20°C		6.24 microhm/cm	
Temperature Coefficient 0-100°C		0.00604°C	
Std Elctrode Potential at 25°C		Eo Co/Co <sup>++</sup> = -0.277	
Curie Temperature		1121°C	
Saturation Induction		17900 Gauss (1.79T)	

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Residual Magnetisation	4900 Gauss (0.49T)
Coercive Force	8.9 Oersted (707 A/m)
Initial Permeability $\mu$	68
Maximum Permeability $\mu_m$	245
Modulus of Elasticity (room)	$2.1 \times 10^6$ kg/cm <sup>2</sup>
Shear Modulus	$0.78 \times 10^6$ kg/cm <sup>2</sup>
Latent Heat of Vaporisation	1550 cal/g
Electrochemical Equivalent (2)	0.305 mg/coulomb
Hardness of Electrodeposited Cobalt	270-310 N/mm <sup>2</sup>
Vapour Pressure	$1 \times 10^{-6}$ atm at 1477°C

### 3 Main Uses of Cobalt

<b>Metallurgical</b>	-	Superalloys
	-	Wear Resistant Coatings
	-	High Speed Steels
	-	Prosthetics
	-	Low Expansion Alloys
	-	Steels
	-	Corrosion Resistant Alloys
	-	Spring Alloys
<b>Magnetic Alloys</b>	-	Alnico's
	-	Rare Earths
	-	Soft Magnetic Materials
<b>Chemicals</b>	-	Catalysts
	-	Adhesives – Cobalt Soaps
	-	Specialist Chemicals: Driers, Pigments, Colours
	-	Electroplating
	-	Agriculture and Medicine
	-	Electro-Magnetic Recording
<b>Cemented Carbides Bonded Diamonds</b>		
<b>Electronics</b>	-	Recording Material
	-	Matched Expansion Alloys
	-	Leads
<b>Ceramics &amp; Enamels</b>	-	Colours in glass, enamels, pottery and china