Group 11 / IB; Copper Group

- The elements copper, silver and gold form the group 11 or the copper group. Copper compounds are relatively abundant and elemental copper can also be found. Silver and gold are rare.
  - Elemental gold and copper started the technical age of metals or, to be more precise, the "Age of cold working of elemental metals". Copper was used for tools, gold and silver for displaying wealth and power; cf. this picture.
- All element of this group are rather soft metals. Remarkable is the color of these elements, While most other metals are "silvery" like the silver here, copper is reddish-brown and gold has a yellow sheen. That is related to tricky details of the electronic behavior.
  - Silver has the highest specific electric conductivity not only of all elements but of all materials (except super-conductors at low temperatures).

Basics

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- *Table of Basic Data*

Name *(German)*	***Copper*** ***Kupfer***	***Silver*****Silber**	**Gold** *Gold*
Atomic number	29	47	79
Atomic mass [u]	63,55	107,89	196,97
Melting point [K]	1356,6	1235,08	1337,58
Melting point [^{o}C]	1083,6	962,08	1064,58
Melting point [^{o}F]	1982.5	1765.4	1948.2
Boiling point [K]	2868	2485	3213
Density [g/cm^{3}]	8,92	10,49	19,32
Ionization energy [eV]	7,726	7,576	9,225
Electro-negativitiy	1,8	1,4	1,4
Atomic radius [pm]	127,8	144,4	144,2
Ionic radius [pm]	72	113	91
Oxidation numbers	4, 3, 2, 1	3, 2, 1	5, 3, 2, 1
lattice typ **Transformation temp. [^{o}C]**	fcc -	fcc -	fcc -
Lattice constant [Å] **(a or c)**	2,86	4,08	4,07
Young's - Modul us [GPa]	123	79	78,7
Therm. expansion coefficient α **[10^{-6}K^{-1}]**	16,5	18,7	14,2

- In case of doubt all numbers are for room temperatures
- fcc = face centered cubic; lattice const. = a
  bcc = body centered cubic
  sc = simple cubic
  hp = simple hexagonal

hcp = hexagonal close packed; lattice constants a and c.
op = simple orthorhombic, monoclinic, triclinic
tp = simple tetragonal
dia = diamond structure
r = trigonal or rhomboedral trigonal