

## CHEMICAL CONSTITUENTS OF HUMAN BLOOD

This table lists typical concentrations of some of the chemical constituents of human blood. The table covers elements and compounds of relatively low molecular weight. References 1 and 4 give extensive information on enzymes, hormones, vitamins, and other blood constituents.

The values given for the normal range refer to healthy adults who have not been exposed to unusual environmental agents. In keeping with IUPAC practice, all values refer to a volume of one liter, and thus are stated in units of g/L, mg/L, µg/L or mmol/L. Many clinical test results, especially in the United States, are reported on a deciliter (dL) rather than a liter basis; thus the values in this table should be divided by 10 to place them on a dL basis. The symbols S (for serum), P (plasma), and WB (whole blood) in the second column indicate the nature of the blood sample to which the values apply. In some cases only a single mean value has been reported, rather than a range; these are given in italics.

The total volume of blood in a 100 kg (220 lb) adult is 7.5 L for a male and 6.7 L for a female. The corresponding volume of plasma is 4.4 L and 4.3 L, respectively (Reference 1).

Values from Reference 1 are so-called "reference values" against which clinical tests of blood chemistry are compared. In these cases the "normal range" is understood to include about 95% of the population. The remaining 5% may show values outside the normal range without necessarily implying a medical problem. Note that these reference values may vary slightly from one testing laboratory to another, depending on the detailed test procedure.

Accurate measurements on trace elements are very difficult to make, and wide variations can be found in the literature. Preferred measurement methods are discussed in References 2 and 6. Values

for the trace elements can also vary from one country to another, depending on dietary or environmental factors. Thus cadmium levels tend to be higher in Japan because of the prevalence of sea-food in the diet, and lead levels are higher in regions where lead additives are still used in gasoline. Variations with gender, age, geography, and occurrence of diseases are reviewed in Reference 6.

The Critical Values column gives levels that deviate far enough from the normal range to suggest a probable medical issue. Such values from Reference 3 are the Biological Exposure Indexes (BEI) that are specified by the American Council of Government Industrial Hygienists (ACGIH) as danger signals for the levels of pollutants in the workplace.

## References

1. Wallach, J., *Interpretation of Diagnostic Tests, Eight Edition*, Wolters Kluwer, Philadelphia, 2007.
2. IUPAC Commission on Toxicology, "Sample Collection Guidelines for Trace Elements in Blood and Urine," *Pure & Appl. Chem.*, 67, 1575, 1995.
3. *2008 TLV's and BEI's*, American Conference of Governmental Industrial Hygienists, 1330 Kemper Meadow Drive, Cincinnati, OH 45240-1634, 2008 ([www.acgih.org](http://www.acgih.org)).
4. Altman, P. L., and Dittmer, D. S., Eds., *Biology Data Book, Second Edition, Vol. III*, Federation of American Societies for Experimental Biology, Bethesda, MD, 1974.
5. Bowen, H. J. M., *Trace Elements in Biochemistry*, Academic Press, New York, 1966.
6. Versieck, J., and Cornelis, R., *Trace Elements in Human Plasma or Serum*, CRC Press, Boca Raton, FL, 1989.

Component	Unit	Normal Range		Critical Values	Ref.
		Low	High		
<i>Inorganic</i>					
Aluminum	S µg/L	1	10	>60	6,2
Ammonia	P µg/L	190	600	>700	1
Antimony	S,P µg/L		<i>1</i>		6
Arsenic	S µg/L	0.5	5		6,2
Barium	S,P µg/L		79		4,5
Beryllium	S,P µg/L		<4		4,5
Bicarbonate (HCO <sub>3</sub> <sup>-</sup> )	WB mmol/L	22	28	<10 or >40	1
Bromine	S,P mg/L	2	11		6,4
Cadmium	S µg/L	0.1	1	>5	6,2,3
Calcium, total	S mg/L	90	105	<65 or >140	1
Calcium ion (Ca <sup>++</sup> )	WB mg/L	30	45		1
Carbon dioxide	P mmol/L	21	30	<11 or >40	1
Carbon monoxide*	WB %CO-Hb	0	5%	30%	1
Cesium	S,P µg/L	0.5	2.0		6
Chloride (Cl <sup>-</sup> )	S mmol/L	98	106	<80 or >115	1
Chromium	S µg/L	0.1	0.4		6,2
Cobalt	S µg/L	0.05	0.35	>1	6,2,3
Copper	S mg/L	0.7	1.4		1,2,6
Fluorine	S,P µg/L	33	236		6
Hydrogen ion (H <sup>+</sup> )	WB pH	7.38	7.44	<7.10 or >7.59	1
Iodine (total)	S,P µg/L	59	76		4
Iron	S mg/L	0.5	1.7		1
Lead	S µg/L	5	100	>300	1,3,6

Component		Unit	Normal Range		Critical Values	Ref.
			Low	High		
Lithium	S,P	µg/L		8		6
Magnesium	S	mg/L	18	30	<10 or >47	1
Manganese	S	µg/L	0.3	1.0		6,2
Mercury	S	µg/L	0.5	3	>15	2,3
Molybdenum	S,P	µg/L	0.3	1.3		6
Nickel	S	µg/L	0.1	1.3		6,2
Oxygen (arterial)	WB	% saturation	96%	100%		1
Oxygen (venous)	WB	% saturation	60%	85%		1
Phosphorus (inorganic)	S	mg/L	30	45	<11	1
Potassium	S	mmol/L	3.5	5.0	<2.8 or >6.2	1
		mg/L	137	196		
Rubidium	S,P	µg/L	100	300		6
Selenium	S,P	µg/L	40	160		2,6
Silver	S,P	µg/L		1		6
Sodium	S	mmol/L	135	145	<120 or >160	1
		g/L	3.11	3.34		
Strontium	S,P	µg/L		57		4,5
Sulfur (total)	S,P	mg/L		780		4
Tellurium	S,P	µg/L		30		4,5
Titanium	S,P	µg/L		33		4,5
Tin	S,P	µg/L		1		4,5
Vanadium	S,P	µg/L	0.02	1.0		6
Zinc	S,P	mg/L	0.5	1.2		6,2,4
Zirconium	S,P	µg/L		400		4,5
<i>Organic</i>						
Acetoacetate ion	P	mg/L		<10		1
Acetone	S,P	mg/L	3	20		1
Alanine	S,P	mg/L	30	37		4
Arginine	S,P	mg/L	12	19		4
Asparagine	S,P	mg/L	5.4	6.5		4
Cholesterol, total	P	mg/L	1000	2000**	>2400	1,4
HDL Cholesterol	P	mg/L	400	600		1
LDL Cholesterol	P	mg/L	0	1000	>1900	1
Citrulline	S,P	mg/L	2.1	9.7		4
Creatine	S,P	mg/L	2.8	6.2		4
Creatinine	S	mg/L	5	15	>50	1
Fructose	WB	mg/L	5	50		4
Glucosamine	S,P	mg/L	760	1110		4
Glucose (fasting)	S	mg/L	600	1000	<450 or >1300	1
Glutamic acid	S,P	mg/L	4.3	11.5		4
Glutamine	S,P	mg/L	61	102		4
Glycine	S,P	mg/L	13.4	17.3		4
Histidine	S,P	mg/L	7.9	14.8		4
Homocysteine	P	mg/L	0.54	1.62		1
Isoleucine	S,P	mg/L	6.9	12.8		4
Lactate (venous)	P	mg/L	50	150		1
Leucine	S,P	mg/L	14	23		4
Lysine	S,P	mg/L	25	30		4
Methionine	S,P	mg/L	3.3	4.3		4
Ornithine	S,P	mg/L	6.2	8.0		4
Phenylalanine	S,P	mg/L	5.8	14.0		1
Proline	S,P	mg/L	20	33		4
Serine	S,P	mg/L	10.1	12.5		4

Component		Unit	Normal Range		Critical Values	Ref.
			Low	High		
Taurine	S,P	mg/L	4.1	8.2		4
Threonine	S,P	mg/L	12	17		4
Triglyceride	S	mg/L	250	1750		1
Tyrosine	S,P	mg/L	8.1	14.5		4
Urea	S	mmol/L	3.5	7.0	<0.7 or >28	1
Urea nitrogen (BUN)	S	mg/L (of N)	100	200	<20 or >800	1
Uric acid (males)	S	mg/L	25	80		1
Uric acid (females)	S	mg/L	13	60		1
Valine	S,P	mg/L	24	37		4

\* Measured as the percent of hemoglobin bound to CO. Typical value for heavy smokers is 5%–10%. Major symptoms begin around 30%, and respiratory failure sets in at >60%.

\*\* This is the desirable upper limit. Values between 2000 and 2400 mg/L are considered borderline high.