

PHYSICAL CONSTANTS

1 atm = 760 mm Hg = 760 Torr = 101.3 kPa

R = 8.314 J·K⁻¹·mol⁻¹ or 0.08206 L·atm·K⁻¹ mol⁻¹h = 6.626 × 10⁻³⁴ J·sN = 6.023 × 10²³ mol⁻¹e = 1.6021 × 10⁻¹⁹ coulombF = 96,485 C·mol⁻¹ or 96,485 J·V⁻¹·mol⁻¹c = 3.00 × 10⁸ m·s⁻¹R_∞(Rydberg constant) = 1.097373 × 10⁷ m⁻¹R_∞(Rydberg constant converted to Hertz) = 3.28984 × 10¹⁵ HzR_∞(Rydberg constant converted to Joules) = 2.18 × 10⁻¹⁸ J**ACID-BASE INDICATORS AT 25°C**

pH Range	pK _{in}	Acid	Base	Indicator
1.2 - 2.8	1.6	red	yel	Thymol blue
2.9 - 4.0	3.3	red	yel	Methyl yellow
3.1 - 4.4	4.2	red	yel	Methyl orange
3.8 - 5.4	4.7	yel	blu	Bromocresol green
4.2 - 6.2	5.0	red	yel	Methyl red
4.8 - 6.4	6.0	yel	red	Chlorophenol red
6.0 - 7.6	7.1	yel	blu	Bromothymol blue
6.4 - 7.6	7.4	yel	red	Phenol red
7.4 - 9.0	8.3	yel	pur	Cresol purple
8.0 - 9.6	8.9	yel	blu	Thymol blue
8.0 - 9.8	9.7	-	red	Phenolphthalein
9.3 - 10.5	9.9	-	blu	Thymolphthalein

SOLUBILITY PRODUCT CONSTANTS (K_{sp})

AgBr	8 × 10 ⁻¹³	Cu(OH) ₂	2 × 10 ⁻²⁰
Ag ₂ CO ₃	6 × 10 ⁻¹²	CuS	1 × 10 ⁻³⁶
AgCl	1 × 10 ⁻¹⁰	Fe(OH) ₃	1 × 10 ⁻³⁶
Ag ₂ CrO ₄	2 × 10 ⁻¹²	Hg ₂ Br ₂	3 × 10 ⁻²³
Ag[Ag(CN) ₂]	4 × 10 ⁻¹²	Hg ₂ Cl ₂	6 × 10 ⁻¹⁹
AgI	1 × 10 ⁻¹⁶	HgS	1 × 10 ⁻⁵²
Ag ₃ PO ₄	1 × 10 ⁻¹⁹	KClO ₄	2 × 10 ⁻²
Ag ₂ S	1 × 10 ⁻⁵⁰	MgCO ₃	1 × 10 ⁻⁵
AgCNS	1 × 10 ⁻¹²	MgC ₂ O ₄	9 × 10 ⁻⁵
Al(OH) ₃	2 × 10 ⁻³²	MgNH ₄ PO ₄	2 × 10 ⁻¹³
BaCO ₃	5 × 10 ⁻⁹	Mg(OH) ₂	1 × 10 ⁻¹¹
BaCrO ₄	1 × 10 ⁻¹⁰	MnS	1 × 10 ⁻¹⁵
BaC ₂ O ₄	2 × 10 ⁻⁸	PbCrO ₄	2 × 10 ⁻¹⁴
BaSO ₄	1 × 10 ⁻¹⁰	PbS	1 × 10 ⁻²⁸
CaS	1 × 10 ⁻²⁸	PbSO ₄	2 × 10 ⁻⁸
CaCO ₃	5 × 10 ⁻⁹	SrCrO ₄	4 × 10 ⁻⁵
CaF ₂	4 × 10 ⁻¹¹	Zn(OH) ₂	5 × 10 ⁻¹⁸
CaC ₂ O ₄	2 × 10 ⁻⁹	ZnS	1 × 10 ⁻²⁴

ELECTRODE POTENTIALS (E°)

Al ³⁺ + 3e → Al	-1.66	Cu ⁺ + e → Cu	0.52
Zn ²⁺ + 2e → Zn	-0.76	2HgCl ₂ + 2e → Hg ₂ Cl ₂ + 2Cl ⁻	0.63
Fe ²⁺ + 2e → Fe	-0.44	O ₂ + 2H ⁺ + 2e → H ₂ O ₂	0.68
Cd ²⁺ + 2e → Cd	-0.40	Fe ³⁺ + e → Fe ²⁺	0.77
Sn ²⁺ + 2e → Sn	0.14	Hg ₂ ²⁺ + 2e → 2Hg	0.79
Pb ²⁺ + 2e → Pb	-0.13	Ag ⁺ + e → Ag	0.80
2H ⁺ + 2e → H ₂	0.00	Hg ⁺ + e → Hg	0.86
Sn ⁴⁺ + e → Sn ²⁺	0.15	2Hg ²⁺ + 2e → Hg ₂ ²⁺	0.91
Cu ²⁺ + e → Cu ⁺	0.15	O ₂ + 4H ⁺ + 4e → 2H ₂ O	1.23
AgCl + e → Cl ⁻ + Ag	0.22	Cl ₂ + 2e → 2Cl ⁻	1.36
Cu ²⁺ + 2e → Cu	0.34	MnO ₄ ⁻ + 8H ⁺ + 5e → 4H ₂ O + Mn ²⁺	1.50

WATER VAPOUR PRESSURE (mm)

0°C	4.6	15°C	12.8	20°C	17.5
25°C	23.8	30°C	31.8	50°C	92.5

AVERAGE BOND ENERGIES (kJ/mol)

C-H	413	C-C	348	C-N	293	C-O	358
C-F	485	C-Cl	328	C-Br	276	C=C	614
C=O	799	C=N	615	C≡C	839	C≡N	891
H-H	436	H-F	567	H-Cl	431	H-O	463
N-H	391	N-N	163	N=N	418	N≡N	941

ΔH° AND ΔG° OF FORMATION (kJ/mol)

Compound	ΔH ^{of}	ΔG ^{of}
H ₂ (g)	217.9	203.4
F ₂ (g)	80.0	61.9
Cl ₂ (g)	121.7	105.7
O ₂ (g)	247.5	230.1
HF ₂ (g)	-269	-271
HCl ₂ (g)	-92.3	-95.3
HBr ₂ (g)	-36.2	-53.2
HI ₂ (g)	25.9	1.30
H ₂ O ₂ (g)	-241.8	-228.6
H ₂ O(l)	-285.9	-236.8
CO ₂ (g)	-110.5	-137.2
CO ₂ (g)	-393.5	-394.4
SO ₂ (g)	-296.9	-300.4
SO ₃ (g)	-395.2	-370.4
NO ₂ (g)	90.4	86.7
NO ₂ (g)	33.8	51.8
N ₂ O ₄ (g)	9.66	98.28
NH ₃ (g)	-46.2	-16.7
PCl ₃ (g)	-288.1	-269.5
PCl ₅ (g)	-377.2	-306.9
CH ₄ (g)	-74.8	-50.8
CH ₃ OH(l)	-238.6	-166.2
C ₂ H ₅ OH(l)	-277.7	-174.8
C ₆ H ₆ (l)	49.0	124.5

IONIZATION CONSTANTS - BASES (K_b)

Acetate ion	5.3 × 10 ⁻¹⁰	Methylamine	4.4 × 10 ⁻⁴
Aminopyridine	5.0 × 10 ⁻⁸	Phosphate ion	2.5 × 10 ⁻²
Ammonia	1.8 × 10 ⁻⁵	Pyridine	1.7 × 10 ⁻⁹
Aniline	4.3 × 10 ⁻¹⁰	Triethylamine	6.4 × 10 ⁻⁵
Hydrazine	1.3 × 10 ⁻⁶	Urea	1.5 × 10 ⁻¹⁴
Hydroxylamine	1.1 × 10 ⁻⁸	Dimethylamine	6.4 × 10 ⁻⁴

IONIZATION CONSTANTS - ACIDS (K_a)

Acetic	1.8 × 10 ⁻⁵	H ₂ S	K ₁	9 × 10 ⁻⁸	
Arsenic	K ₁	5.6 × 10 ⁻³	K ₂	1 × 10 ⁻¹⁵	
Benzoic	6.5 × 10 ⁻⁵	Oxalic	K ₁	5.9 × 10 ⁻²	
Boric	K ₁	5.8 × 10 ⁻¹⁰	K ₂	6.4 × 10 ⁻⁵	
Carbonic	K ₁	4.3 × 10 ⁻⁷	Phenol	1.3 × 10 ⁻¹⁰	
	K ₂	5.6 × 10 ⁻¹¹	Phosphoric	K ₁	7.5 × 10 ⁻³
Chromic	K ₂	1 × 10 ⁻⁷	K ₂	6.2 × 10 ⁻⁸	
Citric	K ₁	3.5 × 10 ⁻⁴	K ₃	4.2 × 10 ⁻¹³	
	K ₂	1.7 × 10 ⁻⁵	Succinic	K ₁	7 × 10 ⁻⁵
	K ₃	4.0 × 10 ⁻⁶	K ₂	2.5 × 10 ⁻⁶	
Formic	1.8 × 10 ⁻⁴	Sulfuric	K ₂	1.2 × 10 ⁻²	
Hydrocyanic	4.9 × 10 ⁻¹⁰	Sulfurous	K ₁	1.7 × 10 ⁻²	
Hydrofluoric	6.8 × 10 ⁻⁴		K ₂	6.4 × 10 ⁻⁸	
CHCl ₂ COOH	5 × 10 ⁻²	CCl ₃ COOH		2 × 10 ⁻¹	