DEPARTMENT OF CHEMISTRY

UNIVERSITY OF SWAZILAND

C304 **ANALYTICAL CHEMISTRY I I**

JULY 2014 SUPPLEMENTARY EXAMINATION

Time Allowed: Three (3) Hours

Instructions:

1. **This examination has six (6) questions and one (1) data sheet. The total number of pages is five (5), including this page.**

2. **Answer any four (4) questions fully; diagrams should be clear, large and properly labeled. Marks will be deducted for improper units and lack of procedural steps in calculations.**

3. **Each question is worth 25 marks.**

Special Requirements

1. **Data sheet.**

2. **Graph paper.**

YOU ARE NOT SUPPOSED TO OPEN THIS PAPER UNTIL PERMISSION TO DO SO HAS BEEN GIVEN BY THE CHIEF INVIGILATOR.

QUESTION 1 [25]

a) State Beer's Law as applied to spectroscopy, and explain all terms appearing in it. [2]

b) i) What is meant by "stray light" in spectroscopy? [1]

ii) Use equations to explain why stray light leads to negative deviations from Beer's Law [3]

iii) How is stray light eliminated in spectroscopy? [1]

c) Draw a schematic diagram of a Ge(Li) detector, and use diagrams to show how the voltage measured is directly related to intensity of uv-visible radiation in a spectrometer. [4]

d) Draw and label a vacuum phototube and explain how it works. [3]

e) A typical GC instrument has several standard components and accessories.

(i) What is the role of the nitrogen gas cylinder normally associated with a gas chromatograph? [2]

(iii)What is the role of the filter cartridge normally associated with a gas chromatograph? [3]

(iii)Use a diagram to show how a soap bubble flow meter works. [3]

(iv) Explain why columns are installed in an oven in GC but not in LC [3]

QUESTION 2 [25]

a) Use diagrams to explain why atomic spectra appear as lines, whereas molecular spectra appear as bands [4]

b) Draw and label the "PMT", explain how it works, and explain its advantage over other detectors used in uv-visible spectrometers. [4]

c) The mobile phase is a critical component in chromatography.

i) List and discuss any two (2) desirable properties of a mobile phase in gas chromatography. [2]

ii) Use equations to explain how silanol groups are deactivated in chromatography [4]

d) i) Use equations to explain what is meant by Reverse Phase Bonded Phase Chromatography [4]

ii) Discuss the main advantage that bonded phase chromatography has over non-bonded phase chromatography [2]

iii) Use diagrams to show how a flow through uv-detector works for HPLC [5]

Question 3 [25]

a) Nebulization in atomic spectroscopy is considered inefficient.

i) What is meant by nebulization? [1]

ii) Use diagrams to explain how a cross flow nebulizer works. [3]

iii) Why is nebulization using the nebulizer in a (ii) above inefficient? [2]

b) A major breakthrough in atomic absorption spectrophotometry since the invention of the hollow cathode lamp was graphite furnace AA.

(i) What is the major structural difference between flame AA and graphite furnace AA? Use diagrams to support your answer [3]

(ii) Identify the physical stages involved in a furnace program and describe the processes that occur during each stage. At what stage is the signal sampled, and why? [4]

(iii) Outline three (3) advantages of graphite furnace AA over flame AA [3]

c) The solid support is an important component of an HPLC instrument.

i) What is the function of the solid support in HPLC? [2]

ii) Describe the solid support Chromosorb P -AW in HPLC [3]

iii) List and describe two desirable properties of a solid support in HPLC [4]

Question 4 [25]

a) Prisms are used as monochromators in spectroscopy.

i) Draw the prism [1]

ii) Use equations to explain how the prism works [3]

iii) Draw and label the Bunsen arrangement of optical components in a spectrometer [3]

b) Gratings have a very good resolving power in spectroscopy.

i) Physically how does a grating look like [2]

ii) Use equations to explain how a grating works [3]

iii) Calculate the second order resolving power of a grating which is 5cm long with 1180 lines per mm [3]

c) Chromatography is a very useful technique for the determination of alcohols in a sample.

i) Explain how ethanol and methanol interact with OV-17 stationary phase in GC to effect to their separation [3]

ii) Use equations to explain how benzoic acid can be detected in an electron capture detector (ECD) after derivatization [3]

iii) Use diagrams to explain how an ECD works [4]

Question 5 [25]

a) Inductively Coupled Plasma (ICP) Optical Emission Spectroscopy is the most widely used atomic spectroscopy today.

i) What is the operational definition of the inductively coupled plasma [2]

ii) Draw the ICP torch and label its components [4]

iii) Use a diagram to explain why it is possible to measure up to 35 elements simultaneously using ICP [3]

b) i) In liquid chromatography, two solvent reservoirs are usually used. Explain the reason for this. [2]

ii) In gas chromatography, dual columns are often used simultaneously. Explain the reason for this. [2]

c) One of the applications of GC is the separation of benzene from its mixture with cyclohexane, followed by quantification of the benzene.

(i) In GC, what is meant by lateral diffusion? [3]

(ii) State the equation that relates resistance to mass transfer in the mobile phase to linear velocity [3]

iv) In GC, what is meant by resistance to mass transfer in the stationary phase? [3]

(iv) State the equation that relates resistance to mass flow in the stationary phase to linear velocity [3]

Question 6 [25]

a) Of the many applications of UV-visible spectroscopy, the determination of mixtures is of considerable interest. Use equations to explain how is this achieved [4]

b) The Nernst Glower is a useful source of radiation in infrared spectroscopy.

i) Describe the Nernst Glower as used in IR spectroscopy. [1]

ii) Which of the molecules oxygen and hydrogen chloride is IR active and why? [2]

iii) Why is it not possible to carry out quantitative analyses on dispersive IR? [2]

c) Nebulization is a very wasteful approach to atomization.

i) What does the term "nebulization" mean? [1]

ii) Use diagrams to explain how nebulization is carried out in atomic spectroscopy. [3]

iii) Use your answer in (a) ii above to explain why nebulization is considered inefficient. [2]

d) Bandbroadening is important for peak resolution in HPLC.

i) Use a drawing to explain the importance of linear velocity on HETP [3]

ii) On this drawing, indicate the optimum linear velocity [2]

iii) Use diagrams to explain the phenomenon of "race track effect", how it affects bandbroadening, and how it is eliminated. [5]

11. ACID-BASE INDICATORS AT 25°C

Indicator	pH range	pKin	Acid	Base
hymol blue	1.2 – 2.8	1.6	red	yellow
Iethyl yellow	2.9 – 4.0	3.3	red	yellow
Iethyl orange	3.1 – 4.4	4.2	red	yellow
romocresol green	3.8 – 5.4	4.7	yellow	blue
Iethyl red	4.2 – 6.2	5.0	red	yellow
hlorophenol red	4.8 – 6.4	6.0	yellow	red
romothymol blue	6.0 – 7.6	7.1	yellow	blue
henol red	6.4 – 8.0	7.4	yellow	red
resol purple	7.4 – 9.0	8.3	yellow	purple
hymol blue	8.0 – 9.6	8.9	yellow	blue
henolphthalein	8.0 – 9.8	9.7	colorless	red
hymolphthalein	9.3 – 10.5	9.9	colorless	blue

14. DATA REJECTION—Q TABLE

n	Q_{90}	n	Q_{90}	n	Q_{90}
3	0.94	6	0.56	9	0.44
4	0.76	7	0.51	10	0.41
5	0.64	8	0.47		

15. Bond Enthalpies

kJ mol⁻¹ at 25°C (i.e. Bond Energies)

Single	O	N	C	S	F	Cl
H	463	391	413	368	563	432
C	358	305	346	272	489	328
N	222	163	MISC.		275	192

S—S	251	H—H	436	C=C	615	
S—F	327	N≡N	946	C≡C	812	
S—Cl	271	N=O	607	C=O	749	

19. t TABLE

D.F.	t_{50}	t_{90}	t_{95}	t_{99}
1	1.0	6.3	13	64
2	0.82	2.9	4.3	9.9
3	0.76	2.35	3.2	5.8
4	0.74	2.13	2.8	4.6
5	0.73	2.02	2.57	4.0
6	0.72	1.94	2.45	3.7
7	0.71	1.90	2.36	3.5
8	0.71	1.86	2.31	3.36
9	0.70	1.83	2.26	3.25
10	0.70	1.81	2.23	3.17
20	0.69	1.72	2.09	2.84
30	0.68	1.70	2.04	2.75
∞	0.67	1.64	1.96	2.58

12. ELECTRODE POTENTIALS, $\mathcal{E}°$

$Na^+ + e \rightleftarrows Na$	− 2.713
$Mg^{++} + 2e \leftrightarrows Mg$	− 2.37
$Al^{+++} + 3e \leftrightarrows Al$	− 1.66
$Zn^{++} + 2e \leftrightarrows Zn$	− 0.763
$Fe^{++} + 2e \leftrightarrows Fe$	− 0.44
$Cd^{++} + 2e \leftrightarrows Cd$	− 0.403
$Cr^{+++} + e \leftrightarrows Cr^{++}$	− 0.38
$Tl^+ + e \rightleftarrows Tl$	− 0.336
$V^{+++} + e \rightleftarrows V^{++}$	− 0.255
$Sn^{++} + 2e \leftrightarrows Sn$	− 0.14
$Pb^{++} + 2e \leftrightarrows Pb$	− 0.126
$H^+ + 2e \leftrightarrows H_2$	0.000
$S_4O_6^= + 2e \leftrightarrows 2S_2O_3^=$	0.09
$TiO^{++} + 2H^+ + e \leftrightarrows Ti^{+++} + H_2O$	0.10
$S + 2H^+ + 2e \leftrightarrows H_2S$	0.14
$Sn^{+4} + 2e \leftrightarrows Sn^{++}$	0.14
$Cu^{++} + e \leftrightarrows Cu^+$	0.17
$SO_4^= + 4H^+ + 2e \leftrightarrows H_2O + H_2SO_3$	0.17
$AgCl + e \leftrightarrows Cl^- + Ag$	0.222
Saturated calomel	(0.244)
$Hg_2Cl_2 + 2e \leftrightarrows 2Cl^- + 2Hg$	0.268
$Bi^{+++} + 3e \leftrightarrows Bi$	0.293
$UO_2^{++} + 4H^+ + 2e \leftrightarrows U^{+4} + 2H_2O$	0.33
$VO^{++} + 2H^+ + e \leftrightarrows V^{+++} + H_2O$	0.34
$Cu^{++} + 2e \leftrightarrows Cu$	0.34
$Fe(CN)_6^{-3} + e \leftrightarrows Fe(CN)_6^{-4}$	0.355
$Cu^+ + e \leftrightarrows Cu$	0.52
$I_3^- + 2e \rightleftarrows 3I^-$	0.545
$H_3AsO_4 + 2H^+ + 2e \rightleftarrows H_3AsO_3 + H_2O$	0.56
$I_2 + 2e \rightleftarrows 2I^-$	0.621
$2HgCl_2 + 2e \rightleftarrows Hg_2Cl_2 + 2Cl^-$	0.63
$O_2 + 2H^+ + 2e \rightleftarrows H_2O_2$	0.69
Quinone + $2H^+ + 2e \rightleftarrows$ Hydroquinone	0.70
$Fe^{+++} + e \rightleftarrows Fe^{++}$	0.771
$Hg_2^{++} + 2e \rightleftarrows 2Hg$	0.792
$Ag^+ + e \leftrightarrows Ag$	0.799
$Hg^{++} + 2e \leftrightarrows Hg$	0.851
$2Hg^{++} + 2e \leftrightarrows Hg_2^{++}$	0.907
$NO_3^- + 3H^+ + 2e \leftrightarrows HNO_2 + H_2O$	0.94
$HNO_2 + H^+ + e \leftrightarrows NO + H_2O$	0.98
$VO_2^+ + 2H^+ + e \leftrightarrows VO^{++} + H_2O$	0.999
$Br_2 + 2e \leftrightarrows 2Br^-$	1.08
$2IO_3^- + 12H^+ + 10e \leftrightarrows 6H_2O + I_2$	1.19
$O_2 + 4H^+ + 4e \leftrightarrows 2H_2O$	1.229
$MnO_2 + 4H^+ + 2e \leftrightarrows Mn^{++} + 2H_2O$	1.23
$Cr_2O_7^= + 14H^+ + 6e \leftrightarrows 7H_2O + 2Cr^{+++}$	1.33
$Cl_2 + 2e \leftrightarrows 2Cl^-$	1.358
$2BrO_3^- + 12H^+ + 10e \leftrightarrows 6H_2O + Br_2$	1.50
$MnO_4^- + 8H^+ + 5e \leftrightarrows 4H_2O + Mn^{++}$	1.51
$Ce^{+4} + e \leftrightarrows Ce^{+3}$	1.61

13. MEAN ACTIVITY COEFFICIENTS

M	KCl	Na_2SO_4	$ZnSO_4$
0.001	0.965	0.89	0.70
0.01	0.901	0.72	0.39
0.1	0.769	0.45	0.15
1.0	0.606	0.20	0.045

16. HEATS OF FORMATION

$\Delta H°$ in kJ mol⁻¹ at 25°C

All ions in H_2O solution except as noted

All Elements = 0

H_g	218	H^+	0.0	H_2O_g	−242
O_g	249	Na^+	−240	H_2O_l	−286
C_g	717	Ag^+	106	CO_g	−111
N_g	473	NH_4^+	−133	CO_{2g}	−394
F_g	79	OH^-	−230	NH_{3g}	−46
Cl_g	122	F^-	−333	NO_g	90
Br_g	112	Cl^-	−167	NO_{2g}	33
I_g	107	Br^-	−122	N_2O_{4g}	9
S_g	279	I^-	−55	SO_{2g}	−297
P_g	315	$S^=$	33	SO_{3g}	−396
Na_g	107	$SO_4^=$	−909	H_2S_g	−21
K_g	88	$CO_3^=$	−677	NaF_s	−574
Na^+_g	609	HF_g	−271	$NaCl_s$	−411
K^+_g	514	HCl_g	−92	KF_s	−567
F^-_g	−255	HBr_g	−36	KCL_s	−437
Cl^-_g	−233	HI_g	26	$AgCl_s$	−127
CH_{4g}	−75	HCN_g	135	$AgBr_s$	−100
C_2H_{2g}	227	PH_{3g}	5	PCl_{3g}	−287
C_2H_{4g}	52	C_6H_{6l}	49	PCl_{5g}	−375
C_2H_{6g}	−85	CH_3OH_l	−238		
C_3H_{8g}	−105	$C_2H_5OH_g$	−235		
nC_4H_{10g}	−127	$C_2H_5OH_l$	−278		
nC_8H_{18g}	−209	$COCl_{2g}$	−219		
CCl_{4l}	−135	CH_3Cl_g	−81		

17. ABS. ENTROPY S°

J mol⁻¹ K⁻¹ at 25°C

H_{2g}	131	P_{4wh}	164	SF_{6g}	292
N_{2g}	192	HF_g	174	NO_g	211
O_{2g}	205	HCl_g	187	NO_{2g}	240
Cl_{2g}	223	H_2O_g	189	N_2O_{4g}	304
F_{2g}	203	CO_g	198	NH_{3g}	192
Cgra	5.7	CO_{2g}	214	PCl_{3g}	312
S_{8r}	254	SO_{2g}	248	PCl_{5g}	365
CH_{4g}	186	SO_{3g}	256	BF_{3g}	254
C_2H_{6g}	229	CH_3OH_l	127		
C_3H_{8g}	270	$C_2H_5OH_g$	283		
C_2H_{2g}	201	$C_2H_5OH_l$	161		
C_2H_{4g}	219	$(CH_3)_2O_g$	266		
C_6H_{6g}	269	CH_3COOH_g	282		

18. $\Delta G°$ FORMATION

kJ mol⁻¹ at 25°C

H_g	203	HF_g	−273	H_2O_g	−229
F_g	62	HCl_g	−95	H_2O_l	−237
Cl_g	106	HBr_g	−54	SO_{2g}	−300
O_g	232	HI_g	1.7	SO_{3g}	−371
NO_g	87	NH_{3g}	−16	PCl_{3g}	−268
NO_{2g}	51	CO_g	−137	PCl_{5g}	−305
N_2O_{4g}	98	CO_{2g}	−394	CH_{4g}	−51
C_2H_{4g}	68	C_2H_{2g}	209	C_2H_{6g}	−33
C_6H_{6l}	125	CH_3OH_l	−162		
CCl_{4l}	−65	$C_2H_5OH_l$	−175		
BF_{3g}	−1120	$CHCl_{3g}$	−70		
SF_{6g}	−1105	CH_3COOH_g	−374		
NH_4Cl_g	−203	$(CH_3)_2O_g$	−113		

20. CONC. ACIDS AND BASES

	M.W.	Density	Wt. %	Molarity
Acetic	60.05	1.05	99.5	17.4
H_2SO_4	98.07	1.83	94	17.6
HF	20.01	1.14	45	25.7
HCl	36.46	1.19	38	12.4
HBr	80.91	1.52	48	9.0
HNO_3	63.01	1.41	69	15.4
$HClO_4$	100.46	1.67	70	11.6
H_3PO_4	98.00	1.69	85	14.7
NaOH	40.00	1.53	50	19.1
NH_3	17.03	0.90	28	14.8

21. DENSITIES (g cm⁻³)

Water at			
0°C	0.9168	Air (70 cm)	0.0011
10°	0.9997	Glass	2.7
20°	0.9982	Na_2CO_3	2.5
22°	0.9978	NaCl	2.2
24°	0.9973	$BaSO_4$	4.5
26°	0.9968	AgCl	5.6
28°	0.9963	Aluminum	2.7
30°	0.9956	Iron	7.9
90°	0.9653	Brass	8.4
100°	0.0006	Mercury	13.6
		Platinum	21.4

22. MOBILITIES ($m^2V^{-1}s^{-1} \times 10^9$)

Li^+	39	H_3O^+	350	$\frac{1}{2}Ba^{++}$	6
Na^+	50	NH_4^+	73	$\frac{1}{3}La^{+3}$	7
K^+	74	Ag^+	62	$\frac{1}{2}SO_4^=$	8
Cl^-	76	OH^-	198	$\frac{1}{3}PO_4^{-3}$	8
Br^-	78	I^-	77	NO_3^-	7

23. WATER V.P. (torr)

0°C	4.6	25°	23
15°	12.8	30°	31
20°	17.5	50°	92

24. MISCELLANEOUS

Std. dev. = $\sqrt{\Sigma (X_i - \bar{X})^2/(n-1)}$

Conf. limits = $\bar{X} \pm ts/\sqrt{n}$

$E = E° - (0.0592/n)\log([Red]/[Ox])$

$\log I_o/I_t = abc = A = \log 1/T$

$\log N_T = \log N_0 - 0.301T/T_{\frac{1}{2}}$

$x = (-b \pm \sqrt{b^2 - 4ac})/2a$

$n\lambda = 2d \sin\theta$

$2.303 \log_{10} a = \log_e a$

$h = 6.626 \times 10^{-34}$ J s

$e = 1.602 \times 10^{-19}$ C

$N_A = 6.022 \times 10^{23}$ mol⁻¹

$F = 96487$ C

$g = 9.807$ m s⁻²

$c = 2.998 \times 10^8$ m s⁻¹

1 amu = 1.661×10^{-27} kg

R = 1.987 cals mol⁻¹ K⁻¹

= 0.08206 litre atm mol⁻¹ K⁻¹

= 8.314 J mol⁻¹ K⁻¹

= 8.314 kPa dm³ mol⁻¹ K⁻¹

0 °C = 273.15 K

1 eV = 1.602×10^{-19} J

1 cal = 4.1840 J

760 torr = 101.3 kPa

CHEMISTRY DATA SHEET

1. PERIODIC CHART OF THE ELEMENTS

1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18
1 H 1.00794																	2 He 4.00260
3 Li 6.941	4 Be 9.01218											5 B 10.81	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.99840	10 Ne 20.179
11 Na 22.98977	12 Mg 24.305											13 Al 26.98154	14 Si 28.0855	15 P 30.97376	16 S 32.06	17 Cl 35.453	18 Ar 39.948
19 K 39.0983	20 Ca 40.08	21 Sc 44.9559	22 Ti 47.88	23 V 50.9415	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.69	29 Cu 63.546	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.9059	40 Zr 91.22	41 Nb 92.9064	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.9055	46 Pd 106.42	47 Ag 107.8682	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.9045	54 Xe 131.29
55 Cs 132.9055	56 Ba 137.33	57 ★ La 138.9055	72 Hf 178.49	73 Ta 180.9479	74 W 183.85	75 Re 186.207	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.9665	80 Hg 200.59	81 Tl 204.383	82 Pb 207.2	83 Bi 208.9804	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.0254	89 ▲ Ac 227.0278	104 Unq (261)	105 Unp (262)	106 Unh (263)	107 Uns (262)	108 Uno (265)	109 Une (266)									

A value in brackets denotes the mass number of the longest lived or best known isotope.

★ Lanthanide series	58 Ce 140.12	59 Pr 140.9077	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.9254	66 Dy 162.50	67 Ho 164.9304	68 Er 167.26	69 Tm 168.9342	70 Yb 173.04	71 Lu 174.967
▲ Actinide series	90 Th 232.0381	91 Pa 231.0359	92 U 238.0289	93 Np 237.0482	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)

2. IONIZATION CONSTANTS (K_A) FOR WEAK ACIDS

Acetic		1.9×10^{-5}
2-Amino-pyridinium Ion		2×10^{-7}
Ammonium Ion		5.6×10^{-10}
Anilinium Ion		2.3×10^{-5}
Arsenic	K_1	5.6×10^{-3}
Benzoic		6.7×10^{-5}
Boric	K_1	5×10^{-10}
Carbonic	K_1	4.3×10^{-7}
	K_2	5.6×10^{-11}
Chloroacetic		1.5×10^{-3}
Chromic	K_2	3.2×10^{-7}
Citric	K_1	8.7×10^{-4}
	K_2	1.8×10^{-5}
	K_3	4×10^{-6}
Dichloroacetic		5×10^{-2}
EDTA	K_1	7×10^{-3}
	K_2	2×10^{-3}
	K_3	7×10^{-7}
	K_4	6×10^{-11}
Formic		2×10^{-4}
α-D(+)-Glucose		5.2×10^{-13}
Glycinium Ion	K_1	4.6×10^{-3}
	K_2	2.5×10^{-10}
Hydrazinium Ion		5.9×10^{-9}
Hydrocyanic		7×10^{-10}
Hydrofluoric		7×10^{-4}
Hydroxyl-ammonium Ion		9.1×10^{-7}
Hypochlorous		3.7×10^{-8}
H_2S	K_1	9×10^{-8}
	K_2	1×10^{-15}
Imidazolium Ion		1.1×10^{-7}
Lactic		1.4×10^{-4}
Methylammonium Ion		2.7×10^{-11}
Monoethanol-ammonium Ion		3×10^{-10}
Nicotinium Ion		9.6×10^{-9}
Oxalic	K_1	6×10^{-2}
	K_2	6×10^{-5}
Phenol		1.3×10^{-10}
Phthalic	K_2	4×10^{-6}
Phosphoric	K_1	7.5×10^{-3}
	K_2	6.2×10^{-8}
	K_3	4.7×10^{-13}
Phosphorous	K_1	1.0×10^{-2}
	K_2	2.6×10^{-7}
Pyridinium Ion		1×10^{-5}
Succinic	K_1	7×10^{-5}
	K_2	2.5×10^{-6}
Sulfuric	K_2	1.2×10^{-2}
Sulfurous	K_1	2×10^{-2}
	K_2	6×10^{-8}
Trimethyl-ammonium Ion		1.6×10^{-10}
Uric		1.3×10^{-4}
Water, K_w, 24°C		1.0×10^{-14}

3. SOLUBILITY PRODUCT CONSTANTS

AgBr	4×10^{-13}	BaC_2O_4	2×10^{-8}	$KClO_4$	2×10^{-2}
Ag_2CO_3	6×10^{-12}	$BaSO_4$	1×10^{-10}	$MgCO_3$	1×10^{-5}
AgCl	1×10^{-10}	$CaCO_3$	5×10^{-9}	MgC_2O_4	9×10^{-5}
Ag_2CrO_4	2×10^{-12}	CaF_2	4×10^{-11}	$MgNH_4PO_4$	2×10^{-13}
$Ag[Ag(CN)_2]$	4×10^{-12}	CaC_2O_4	2×10^{-9}	$Mg(OH)_2$	1×10^{-11}
AgI	1×10^{-16}	CdS	1×10^{-28}	MnS	1×10^{-15}
Ag_3PO_4	1×10^{-19}	$Cu(OH)_2$	2×10^{-20}	$PbCrO_4$	2×10^{-14}
Ag_2S	1×10^{-50}	CuS	1×10^{-36}	PbS	1×10^{-28}
AgCNS	1×10^{-12}	$Fe(OH)_3$	1×10^{-36}	$PbSO_4$	2×10^{-8}
$Al(OH)_3$	2×10^{-32}	Hg_2Br_2	3×10^{-23}	$SrCrO_4$	4×10^{-5}
$BaCO_3$	5×10^{-9}	Hg_2Cl_2	6×10^{-19}	$Zn(OH)_2$	3.6×10^{-16}
$BaCrO_4$	1×10^{-10}	HgS	1×10^{-52}	ZnS	1×10^{-24}

4. NET STABILITY CONSTANTS

$Ag(CN)_2^-$	5×10^{20}
$Ag(NH_3)_2^+$	1.6×10^{7}
$Ag(S_2O_3)_2^{-3}$	4.7×10^{13}
$Al(OH)_4^-$	1.0×10^{33}
Ca(EDTA)=	1.0×10^{11}
$Cd(CN)_4$=	8.3×10^{17}
$Cd(NH_3)_4^{++}$	5.5×10^{6}
$Co(NH_3)_6^{+3}$	2×10^{35}
$Cr(OH)_4^-$	4×10^{28}
$Cu(CN)_4^{-3}$	1×10^{23}
$Cu(NH_3)_4^{++}$	1.2×10^{11}
$Fe(CN)_6^{-3}$	4.0×10^{43}
$Fe(CN)_6^{-4}$	2.5×10^{35}
$Fe(SCN)^{++}$	1.0×10^{3}
$HgCl_4$=	1.3×10^{15}
$Hg(CN)_4$=	8.3×10^{38}
$Hg(SCN)_4$=	5.0×10^{20}
HgI_4=	6.3×10^{29}
Mg(EDTA)=	1.3×10^{9}
$Ni(NH_3)_4^{++}$	4.7×10^{7}
$Pb(OH)_3^-$	7.9×10^{13}
$Zn(CN)_4$=	4.2×10^{16}
$Zn(NH_3)_4^{++}$	7.8×10^{8}
$Zn(OH)_4$=	6.3×10^{14}

5. FIRST IONIZATION ENERGIES, e.v.

1A	2A											3A	4A	5A	6A	7A	2
5.4	9.3											8.3	11	15	14	17	22
5.1	7.6	3B	4B	5B	6B	7B		8B		1B	2B	6.0	8.1	11	10	13	16
4.3	6.1	6.6	6.8	6.7	6.8	7.4	7.9	7.9	7.6	7.7	9.4	6.0	8.1	10	9.8	12	14
4.2	5.7	6.6	7.0	6.8	7.2		7.5	7.7	8.3	7.6	9.0	5.8	7.3	8.6	9.0	10	12
3.9	5.2	5.0 6.9	5.5	6	6.0	7.9	8.7	9.2	9.0	9.2	10	6.1	7.4	8			11

6. ELECTRONEGATIVITIES, Pauling

1A	2A											3A	4A	5A	6A	7A	
1.0	1.5											2.0	2.5	3.0	3.5	4.0	
0.9	1.2	3B	4B	5B	6B	7B		8B		1B	2B	1.5	1.8	2.1	2.5	3.0	
0.8	1.0	1.3	1.5	1.6	1.6	1.5	1.8	1.8	1.8	1.9	1.6	1.8	1.8	2.0	2.4	2.8	
0.8	1.0	1.2	1.4	1.6	1.8	1.9	2.2	2.2	2.2	1.9	1.7	1.7	1.8	1.9	2.1	2.5	
0.7	0.9	1.1	1.3	1.5	1.7	1.9	2.2	2.2	2.2	2.4	1.9	1.8	1.8	1.9	2.0	2.2	

7. ATOMIC RADII picometers

1A	2A											3A	4A	5A	6A	7A	32
155	112											98	91	92	73	71	69
190	160	3B	4B	5B	6B	7B		8B		1B	2B	143	132	128	127	99	97
235	197	162	147	134	130	135	126	125	124	128	138	141	137	139	140	114	110
248	215	178	160	146	139	136	134	134	137	144	154	166	162	159	160	133	130
267	222	187	167	149	141	137	135	136	139	146	157	171	175	170	176		145

8. IONIC RADII pm

Li^+	60	Sr^{+2}	113	S^{-2}	184
Na^+	95	Ba^{+2}	135	Se^{-2}	198
K^+	133	B^{+3}	20	Te^{-2}	221
Rb^+	148	Al^{+3}	50	F^-	136
Be^{+2}	31	N^{+3}	171	Cl^-	181
Mg^{+2}	65	P^{+3}	212	Br^-	195
Ca^{+2}	99	O^{-2}	140	I^-	216

9. LATTICE ENERGIES

(All negative) kJ/mol

	F	Cl	Br	I
Li	1030	840	781	718
Na	914	770	728	681
K	812	701	671	632
Rb	780	682	654	617
Cs	744	630	613	585

10. HALF LIVES

H^3	12.3 years	K^{40}	1.28×10^9y	I^{131}	8.1 days
F^{20}	11.4 secs	Ca^{45}	165 days	Cs^{137}	30 years
C^{14}	5730 years	Fe^{59}	45 days	Au^{198}	2.69 days
Na^{24}	15.0 hours	Co^{60}	5.26 y	Ra^{226}	1620 yrs.
P^{32}	14.3 days	Br^{82}	35.5 hours	U^{235}	7.1×10^8y
S^{35}	88 days	Sr^{90}	28 years	U^{238}	4.51×10^9y
Cl^{36}	3.1×10^5y	I^{129}	1.7×10^7y	Pu^{230}	24,400 y

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