UNIVERSITY OF SWAZILAND
SUPPLEMENTARY EXAMINATION 2007-08

TITLE OF PAPER	:	Organic Chemistry
COURSE NUMBER	:	C303
TIME	:	Three Hours
INSTRUCTIONS	:	Answer any **FOUR** questions.
	Each question	carries **25** marks.

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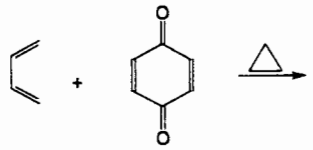
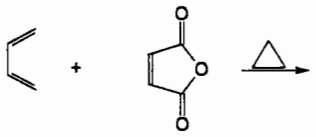
(v) 

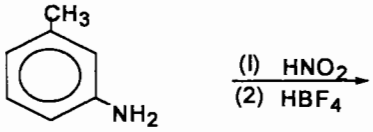
(vi) 

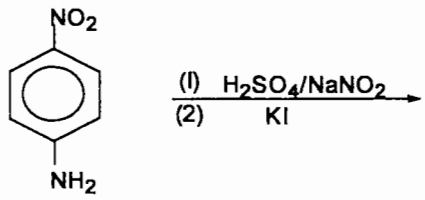
(b) What is meant by the term "disrotatory motion" in electrocyclic reactions? Illustrate your answer with any diene. (4)

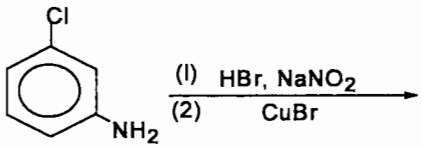
(c) Why is thermal cycloaddition of ethene difficult? (3)

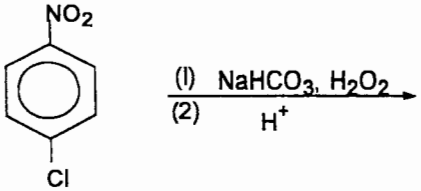
QUESTION 4

(a) Write the structure of the product of each step of the following: (16)

(i) 

(ii) 

(iii) 

(iv) 

(b) Write all steps involved in the mechanism of nucleophilic aromatic substitution involving Meisenheimer complex. What is the effect of electron-withdrawing groups on the substitution? (9)

QUESTION 5

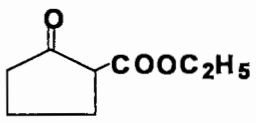
Write down the likely steps in the following transformations:

(a) $CH_3COCH_3 + Br_2 / H^+ \rightarrow CH_3COCH_2Br$ (4)

(b) $CH_3CHO + OH^- \rightarrow CH_3CH(OH)CH_2CHO$ (3)

(c) $CH_3CH_2\ CH_2\ CH_2OH \rightarrow CH_3CH_2\ CH_2\ CH_2CH(C_2H_5)CH_2OH$ (7)

(d) $CH_3COO\ C_2H_5 \rightarrow CH_3COCH_2COO\ C_2H_5$ (6)

(e) $C_2H_5OOC(CH_2)_4COO\ C_2H_5 \longrightarrow$ 

(5)

QUESTION 6

(a) (i) Write the three isomeric ethers with the molecular formula $C_4H_{10}O$ and name them.

(ii) State how many signals will arise in the ^{13}C nmr spectrum of each named compound. (12)

(b) (i) How many ions would you expect in the mass spectrum of 2-hexene by β-fragmentation?

(ii) What are the masses of the ions in (i) above? (6)

(c) Predict the structure of a compound with molecular formula C_7H_8O that has ^1H nmr signals at $\delta = 7.3$, 4.4 and 3.7 ppm with relative intensities of 7:2.9:1.4 respectively. (7)

DEPARTMENT OF CHEMISTRY

UNIVERSITY OF SWAZILAND

C304 **INSTRUMENTAL ANALYSIS**

JULY 2008 SUPPLEMENTARY EXAMINATION

Time Allowed: **Three (3) Hours**

Instructions:

1. **This examination has six (6) questions and two (2) data sheets. The total number of pages is six (6) 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 sheets.**
2. **Graph paper.**

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QUESTION 1 [25]

a. i) Use diagrams to explain what is meant by resistance to mass transfer in the stagnent mobile phase. [3]

ii) State the HETP equation for resistance to mass transfer in the stagnent mobile phase, and explain all terms appearing in it. [4]

iii) For each of any four (4) of these terms above, explain how it influences bandbroadening in practical terms. [4]

b. With regards to liquid chromatography,

i) What does the acronym "HPLC" stand for? [1]
ii) Describe three (3) ways of degassing solvents in HPLC. [3]
iii) Explain why two solvent reservoirs are used instead of one in HPLC. [2]
iv) Give two (2) reasons for using a pre-column in HPLC. [2]
v) State one advantage and one disadvantage of using microparticle packings in HPLC. [2]

c. Use diagrams to explain how a "flow-through" ultraviolet detector works in HPLC. [4]

QUESTION 2 [25]

a. In the table below,

Spectral Region	Energy (J)	Type of Transition	Wavelength (nm)	Frequency (sec^{-1})	Wavenumber (cm^{-1})	Energy (eV)
gamma rays		A		$>10^{20}$		
x-ray		B				120
uv-visible	F	C	700	H		I
infra-red		D			4,000	
micro-wave			G	10^{8}	J	

i. State A, B, C, D [4]

ii. Calculate F, G, H, I, J [5]

b. On a single plot, draw the blackbody radiation profiles of sources heated at 500K and at 2000K. [2]

c. Explain why the 500K plot in (b) above is the ideal one for use as an IR source, and explain its implication on resolution. [2]

d. Draw and label the "Bunsen" arrangement of optical components in a spectrometer. [5]

e. Explain how a single wavelength is practically selected in the spectrometer in (d) above. [3]

f. Explain how the silt width affects resolution in infra-red spectroscopy. [4]

QUESTION 3 [25]

a. For each of the five (5) desirable properties of a solid support for gas chromatography,

i) Discuss the property desired [5]
ii) Explain how each property relates to the Van Deemper equation [5]

b. Describe the solid support "Chromosorb T". [2]

c. In GC, the column is kept in an oven, whereas in LC, the column is kept at ambient temperature. Explain why this is so. [2]

d. Use diagrams and equations to explain how a flame ionization detector works. List three (3) compounds that can not be detected by this method and explain why. [5]

e. Use diagrams and equations to explain how an electron capture detector works. List three (3) compounds that can not be detected by this method and explain why. [6]

QUESTION 4 [25]

a. What does the acronym "ICP-OES" stand for? [1]

b. Give operational definitions of:

i) a plasma [2]
ii) an inductively coupled plasma [2]

c. The ICP is normally referred to as a "non-chemical" flame. Explain the meaning and significance of this. [2]

d. Draw the ICP torch and label all its components. [4]

e. Analytical ICP operates under a range of experimental parameters. Give the optimum range for the following:

iii) radio frequency of coil in MHz [1]
iv) operating power in kW [1]
v) main argon gas flow in mL/min [1]
vi) auxiliary gas flow in mL/min [1]

f. List and describe three (3) disadvantages of graphite furnace AAS when compared to flame AAS. [3]

g. Explain why at low frequencies the plasma shape in ICP-OES assembles a "teardrop", whereas at high frequencies the plasma resembles a "doughnut". [2]

h. In the ICP, "calibration curves cover almost 5 orders of magnitude". Explain the meaning and significance of this phrase. [2]

i. Use diagrams to explain why ICP-OES can make the simultaneous determination of up to 35 elements possible. [3]

QUESTION 5 [25]

a. In the following table:

Wavelength	Colour absorbed	Colour observed
380-420	Violet	A
470-500	D	Red
620-680	Red	C
680-780	B	Green

Complete the table by stating A, B, C, D [4]

b. State Bragg's Law and draw the Czerny-Turner arrangement of opticals in a spectrometer. [4]

c. With the aid of a large diagram, explain how the "barrier layer cell" detector works in spectroscopy. [3]

d. What is meant by a "resonance line" in atomic spectroscopy? [1]

i) Explain why atomic spectra appear as lines when compared to molecular spectra. [2]

ii) The 228.8nm cadmium line corresponds to a $^1S_1 \longrightarrow {}^1S_0$ transition. Would emission or absorption be chosen for its analysis at 2250^{0}C flame operating temperatures? Explain why. [3]

e. For each of the following interferences in flame atomic absorption spectroscopy, describe the interference and explain how it is eliminated.

i) spectral [3]
ii) physical [3]

f. List and describe two (2) disadvantages of graphite furnace atomic absorption spectroscopy over flame methods. [2]

QUESTION 6 [25]

b. i) What is meant by "chromophore" in uv-visible spectroscopy? [1]

ii) State the difference between a "bathochromic" and "hypsochromic" shift in uv-visible spectroscopy. [2]

c. Explain how the following cause deviations in Beer's Law

i) slit width [2]
ii) pH [2]
iii) temperature [2]

d. Explain why IR spectroscopy is performed almost exclusively using double beam instruments. [3]

e. Use diagrams to explain how a "circular cage" photomultiplier tube works. [4]

f. Use diagrams to explain how the Molar Ratio method is used to determine the stoichiometry of the Fe- bipyridine complex, given that bipyridine does not absorb at the wavelength of analysis at 522 nm. [3]

g. Explain how uv-visible spectroscopy can be used to simultaneously measure more than one component in a mixture. [3]

h. Use equations to explain why components in a spectrometer are kept in a darkened compartment. [3]

ACID-BASE INDICATORS AT 25°C

Indicator	pH range	pKin	Acid	Base
Thymol blue	1.2 – 2.8	1.6	red	yellow
Methyl yellow	2.9 – 4.0	3.3	red	yellow
Methyl orange	3.1 – 4.4	4.2	red	yellow
Bromocresol green	3.8 – 5.4	4.7	yellow	blue
Methyl red	4.2 – 6.2	5.0	red	yellow
Chlorophenol red	4.8 – 6.4	6.0	yellow	red
Bromothymol blue	6.0 – 7.6	7.1	yellow	blue
Phenol red	6.4 – 8.0	7.4	yellow	red
Cresol purple	7.4 – 9.0	8.3	yellow	purple
Thymol blue	8.0 – 9.6	8.9	yellow	blue
Phenolphthalein	8.0 – 9.8	9.7	colorless	red
Thymolphthalein	9.3 – 10.5	9.9	colorless	blue

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	

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

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
$2H^+ + 2e \leftrightarrows H_2$	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

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	$P_{4\,wh}$	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

20. CONC. ACIDS AND BAS

	M.W.	Density	Wt. %	Mol it
Acetic	60.05	1.05	99.5	1
H_2SO_4	98.07	1.83	94	1
HF	20.01	1.14	45	2
HCl	36.46	1.19	38	1
HBr	80.91	1.52	48	
HNO_3	63.01	1.41	69	1
$HClO_4$	100.46	1.67	70	1
H_3PO_4	98.00	1.69	85	1
NaOH	40.00	1.53	50	1
NH_3	17.03	0.90	28	1

21. DENSITIES (g cm⁻³)

Water at		Air (70 cm)	0.0
0°C	0.9168	Glass	2.7
10°	0.9997	Na_2CO_3	2.5
20°	0.9982	NaCl	2.2
22°	0.9978	$BaSO_4$	4.5
24°	0.9973	AgCl	5.6
26°	0.9968	Aluminum	2.7
28°	0.9963	Iron	7.9
30°	0.9956	Brass	8.4
90°	0.9653	Mercury	13.6
100°	0.0006	Platinum	21.4

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

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

23. WATER V.P. (torr)

0°C	4.6	25°	
15°	12.8	30°	
20°	17.5	50°	

24. MISCELLANEOUS

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

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

$E = E° - (0.0592/n)\log([Red]/[Ox])$

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

$\log N_T = \log N_0 - 0.301T/T_1$

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

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

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

$h = 6.626 \times 10^{-34}$ 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 $= 1.661 \times 10^{-27}$ 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 $= 1.602 \times 10^{-19}$ J

1 cal $= 4.1840$ J

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}		Hypochlorous		3.7×10^{-8}	
2-Amino-pyridinium Ion		2×10^{-7}		H_2S	K_1	9×10^{-8}	
Ammonium Ion		5.6×10^{-10}			K_2	1×10^{-15}	
Anilinium Ion		2.3×10^{-5}		Imidazolium Ion		1.1×10^{-7}	
Arsenic	K_1	5.6×10^{-3}		Lactic		1.4×10^{-4}	
Benzoic		6.7×10^{-5}		Methylammonium Ion		2.7×10^{-11}	
Boric	K_1	5×10^{-10}		Monoethanol-ammonium Ion		3×10^{-10}	
Carbonic	K_1	4.3×10^{-7}		Nicotinium Ion		9.6×10^{-12}	
	K_2	5.6×10^{-11}		Oxalic	K_1	6×10^{-2}	
Chloroacetic		1.5×10^{-3}			K_2	6×10^{-5}	
Chromic	K_2	3.2×10^{-7}		Phenol		1.3×10^{-10}	
Citric	K_1	8.7×10^{-4}		Phthalic	K_2	4×10^{-6}	
	K_2	1.8×10^{-5}		Phosphoric	K_1	7.5×10^{-3}	
	K_3	4×10^{-6}			K_2	6.2×10^{-8}	
Dichloroacetic		5×10^{-2}			K_3	4.7×10^{-13}	
EDTA	K_1	7×10^{-3}		Phosphorous	K_1	1.0×10^{-2}	
	K_2	2×10^{-3}			K_2	2.6×10^{-7}	
	K_3	7×10^{-7}		Pyridinium Ion		1×10^{-5}	
	K_4	6×10^{-11}		Succinic	K_1	7×10^{-5}	
Formic		2×10^{-4}			K_2	2.5×10^{-6}	
α-D(+)-Glucose		5.2×10^{-13}		Sulfuric	K_2	1.2×10^{-2}	
Glycinium Ion	K_1	4.6×10^{-3}		Sulfurous	K_1	2×10^{-2}	
	K_2	2.5×10^{-10}			K_2	6×10^{-8}	
Hydrazinium Ion		5.9×10^{-9}		Trimethyl-ammonium Ion		1.6×10^{-10}	
Hydrocyanic		7×10^{-10}		Uric		1.3×10^{-4}	
Hydrofluoric		7×10^{-4}					
Hydroxyl-ammonium Ion		9.1×10^{-7}		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 STABILIT CONSTANTS

$Ag(CN)_2^-$	5×10
$Ag(NH_3)_2^+$	1.6×10
$Ag(S_2O_3)_2^{-3}$	4.7×10
$Al(OH)_4^-$	1.0×10
$Ca(EDTA) =$	1.0×10
$Cd(CN)_4 =$	8.3×10
$Cd(NH_3)_4^{++}$	5.5×10
$Co(NH_3)_6^{+3}$	2×10
$Cr(OH)_4^-$	4×10
$Cu(CN)_4^{-3}$	1×10
$Cu(NH_3)_4^{++}$	1.2×10
$Fe(CN)_6^{-3}$	4.0×10
$Fe(CN)_6^{-4}$	2.5×10
$Fe(SCN)^{++}$	1.0×10
$HgCl_4 =$	1.3×10
$Hg(CN)_4 =$	8.3×10
$Hg(SCN)_4 =$	5.0×10
$HgI_4 =$	6.3×10
$Mg(EDTA) =$	1.3×10
$Ni(NH_3)_4^{++}$	4.7×10
$Pb(OH)_3^-$	7.9×10
$Zn(CN)_4 =$	4.2×10
$Zn(NH_3)_4^{++}$	7.8×10
$Zn(OH)_4 =$	6.3×10

5. FIRST IONIZATION ENERGIES, e.v.

1A	2A											3A	4A	5A	6A	7A
5.4	9.3							14				8.3	11	15	14	17
5.1	7.6	3B	4B	5B	6B	7B		8B		1B	2B	6.0	8.1	11	10	13
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
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
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		

6. ELECTRONEGATIVITIES, Pauling

1A	2A							2.1				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	1.4	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							37				3A	4A	5A	6A	7A
155	112											98	91	92	73	71
190	160	3B	4B	5B	6B	7B		8B		1B	2B	143	132	128	127	99
235	197	162	147	134	130	135	126	125	124	128	138	141	137	139	140	114
248	215	178	160	146	139	136	134	134	137	144	154	166	162	159	180	133
267	222	187	167	149	141	137	135	136	139	146	157	171	175	170	176	

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 ENERGIE

(All negative) kJ/n

	F	Cl	Br	
Li	1030	840	781	7
Na	914	770	728	6
K	812	701	671	6
Rb	780	682	654	6
Cs	744	630	613	5

10. HALF LIVES

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

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Electrode Potentials, $E^\ominus$

$H^+ + e^- \rightleftharpoons \frac{1}{2}H_2$ $E^\ominus = 0.000V$

$Ca^{2+} + 2e \rightleftharpoons Ca(s)$ $E^\ominus = -0.246V$

$\quad - \rightleftharpoons Ag(s) + Cl^-$ $E^\ominus = -0.023V$

$Cu^{2+} + 2e^- \rightleftharpoons Cu(s)$ $E^\ominus = +0.34$