

UNIVERSITY OF SWAZILAND

FINAL EXAMINATIONS

ACADEMIC YEAR 2011/2012

TITLE OF PAPER:	INORGANIC CHEMISTRY
COURSE NUMBER:	C301
TIME ALLOWED:	THREE (3) HOURS
INSTRUCTIONS:	THERE ARE SIX (6) QUESTIONS. ANSWER ANY FOUR (4) QUESTIONS. EACH QUESTION IS WORTH 25 MARKS.

THE FOLLOWING HAVE BEEN PROVIDED WITH THIS EXAMINATION PAPER:

- ❖ **Periodic Table of the Elements**
- ❖ **Table of Universal Constants**
- ❖ **Tanabe-Sugano diagrams for octahedral complexes**
- ❖ **Character tables for C_{2v} and D_{3h} point groups**
- ❖ **Decision Tree (Flow chart) for point groups**

PLEASE DO NOT OPEN THIS PAPER UNTIL AUTHORISED TO DO SO BY THE CHIEF INVIGILATOR.

“Marks will be awarded for method, clearly labelled diagrams, organization and presentation of thoughts in clear and concise language”

Question One

- a) Give the IUPAC name for each of the following:
- i) $\text{K}_5[\text{Mo}(\text{CN})_7]$
 - ii) $[\text{Cr}(\text{NH}_3)_6][\text{Cr}(\text{CN})_6]$
 - iii) $[\text{Co}(\text{OH}_2)_6](\text{ClO}_4)_2$
- [6]
- b) Give the formula of each of the following:
- i) Sodium pentacyanonitrosylferrate(II) dihydrate
 - ii) Potassium pentachloronitridoosmate(IV)
 - iii) Tetraammineaquacobalt(III)- μ -cyanobromotetracyanocobaltate(III)
- [6]
- c) Briefly discuss the observed trends in the stability of oxidation states across the periods from left to right and down the groups. Use examples to illustrate your answer.
- [6]
- d) What is the *chelate effect*? Give two ways of explaining how the chelate effect leads to greater stability of complexes.
- [7]

Question Two

- a) Sketch the structures of all possible isomers that may arise from the following complexes:
- i) $[\text{Ni}(\text{SCH}_2\text{CH}_2\text{NH}_2)_2]$, square planar
 - ii) $[\text{Co}(\text{en})_3]^{3+}$
- [6]
- b) For each of the following complexes, give the oxidation state of the metal and its d^N configuration.
- i) $[\text{Mn}(\text{CN})_6]^{4-}$
 - ii) $[\text{Cr}(\text{acac})_3]$
- [4]
- c) What is the "hole formalism"? Give two examples to illustrate your answer.
- [4]
- d) State the following rules:
- i) The spin selection rule
 - ii) The La Porte selection rule
- [3]

- e) Explain the origins of LMCT and MLCT absorptions in the electronic spectra of d-block metal complexes. Give two examples (one for each type) to illustrate your answer.

[8]

Question Three

- a) For each of the complexes given below, determine the oxidation number and electron configuration, d^N , of the transition metal ion.

- i) $\text{Mg}[\text{MoO}_4]$
ii) $[\text{Fe}(\text{CO})_4]^{2-}$

[6]

- b) Give two types of minerals in which titanium, Ti, is found. Your answer should include the chemical formula of the chemical species present. Give a brief outline of one method that is used to extract the metal from its ore (i.e., from one of the minerals in which it is found).

[8]

- c) A student in the year 1895 prepared three chromium compounds all of which corresponded to the same formula of $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$. When each of the compounds is dissolved in water, the number of Cl^- ions released are as indicated below:

Complex :colour	Cl^- ions in solution per Formula Unit
A: Violet	3
B: Light green	2
C: Dark green	1

- i) Write the formulas of these compounds
ii) Suggest a method for confirming the number of Cl^- ions in the outer coordination sphere per formula unit of each complex.

[11]

Question Four

- a) For each of the following pairs of species, indicate which member of the pair is more acidic. Explain each of your answers.
- i) TiO_2 or CrO_2 ii) CrO_3 or WO_3 iii) FeO or Fe_2O_3 [6]
- b) In order to separate gold from solid impurities, the ore is treated with a sodium cyanide (NaCN) solution in the presence of air to dissolve the gold by forming a soluble complex.
- i) Write a balanced chemical equation that depicts the formation of the complex.
- ii) Give the geometry of the complex [6]
- c) Predict the *spin-only* magnetic moment of each of the following octahedral complexes. In each case use a suitable CF (d-orbital) splitting diagram to illustrate how the spin quantum number (S) is obtained.
- i) $[\text{Fe}(\text{CN})_6]^{3-}$
- iii) $[\text{FeF}_6]^{3-}$ [7]
- d) Assume that the trans effect increases in the order $\text{NH}_3 < \text{Cl}^- < \text{NO}_2^- < \text{PR}_3$. Suggest the structures of the products arising from the reactions of $[\text{PtCl}_4]^{2-}$ with the ligands given below. In each case the structures of the products and sequences of reactions should be clearly shown.
- i) Two equivalents of NH_3
- ii) One equivalent of PEt_3 followed by one equivalent of NO_2^- . [6]

Question Five

- a) Consider formation constants for the following reactions (at 298K):

Reaction No.	Reaction Equation	Formation Constant
1.	$\text{Ag}^+ + 2\text{NH}_3 \rightleftharpoons [\text{Ag}(\text{NH}_3)_2]^+$	1.5×10^7
2.	$\text{Ag}^+ + 2\text{CN}^- \rightleftharpoons [\text{Ag}(\text{CN})_2]^-$	1.0×10^{21}
3.	$[\text{Ag}(\text{NH}_3)_2]^+ + 2\text{CN}^- \rightleftharpoons [\text{Ag}(\text{CN})_2]^- + 2\text{NH}_3$	K_3

- i) Calculate the equilibrium constant (K_3) for the third reaction in the table above
- ii) Comment on the relative sizes of the equilibrium constants [5]

- b) Overall stability constants for $[\text{Au}(\text{CN})_2]^-$ and $[\text{Pd}(\text{CN})_4]^{2-}$ are $\log\beta_2=39$ and $\log\beta_4=62.3$, respectively. Write reaction equations that describe the processes to which these constants refer. Then write the expressions to define β_2 and β_4 (in terms of concentrations of appropriate species). [6]
- c) Predict whether the equilibrium for the following reactions is expected to lie more on the right hand side or more on the left hand side. Explain each of your answers.
- $\text{CdI}_2 + \text{CaF}_2 \rightleftharpoons \text{CdF}_2 + \text{CaI}_2$
 - $[\text{CuI}_4]^{2-} + [\text{CuCl}_4]^{3-} \rightleftharpoons [\text{CuCl}_4]^{2-} + [\text{CuI}_4]^{3-}$
 - $\text{CH}_3\text{Hg}^+ + \text{HCN} \rightleftharpoons \text{CH}_3\text{HgCN} + \text{H}^+$
- [6]
- d) Electronic spectra of Ni(II) complex ions, $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{Ni}(\text{en})_3]^{2+}$, together with their molar absorptivity values, are given in the table below.

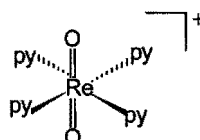
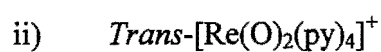
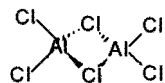
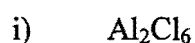
Transitions	Complexes and absorption peak positions (cm^{-1}) and molar absorptivities (in brackets)	
	$[\text{Ni}(\text{OH}_2)_6]^{2+}$	$[\text{Ni}(\text{en})_3]^{2+}$
$\Gamma_2 \leftarrow \Gamma_1$	9000 ($\epsilon \approx 2$)	11000 ($\epsilon \approx 7$)
$\Gamma_3 \leftarrow \Gamma_1$	14000 ($\epsilon \approx 2$)	18000 ($\epsilon \approx 5$)
$\Gamma_4 \leftarrow \Gamma_1$	25000 ($\epsilon \approx 5$)	30000 ($\epsilon \approx 9.5$)

- Use a d^8 Tanabe-Sugano diagram to identify the terms Γ_1 , Γ_2 , Γ_3 , and Γ_4 , and assign the transitions to the absorption bands
- Comment on the differences in peak positions of $[\text{Ni}(\text{OH}_2)_6]^{2+}$ versus those of $[\text{Ni}(\text{en})_3]^{2+}$
- Comment on the differences in peak intensities of $[\text{Ni}(\text{OH}_2)_6]^{2+}$ versus those of $[\text{Ni}(\text{en})_3]^{2+}$

[8]

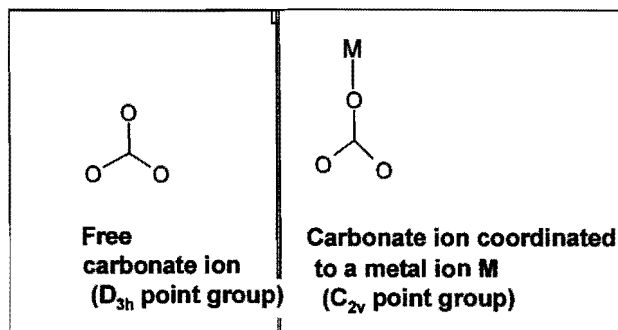
Question Six

- a) With the help of the flow-chart which is provided, determine the point group for each of the following:



- b) [7]
The carbonate ion, CO_3^{2-} , can serve as a ligand. When it does so, the symmetry is lowered from D_{3h} (for the uncoordinated ion), to C_{2v} (for the monodentate ligand or bidentate ligand). Thus infrared spectroscopy makes it possible to distinguish coordinated carbonate from uncoordinated carbonate. Using internal coordinates, r_i , determine the symmetries and number of C-O stretching IR active and Raman active bands for

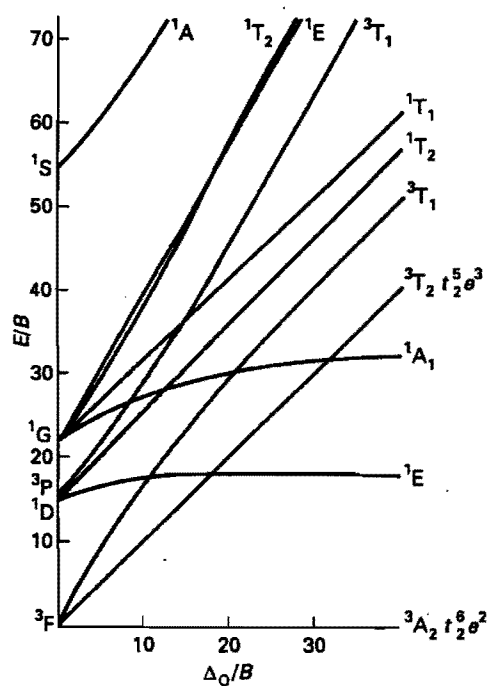
- i) Uncoordinated carbonate
ii) Monodentate carbonate, $\text{M}-\text{O}-\text{CO}_2$, where M= metal center



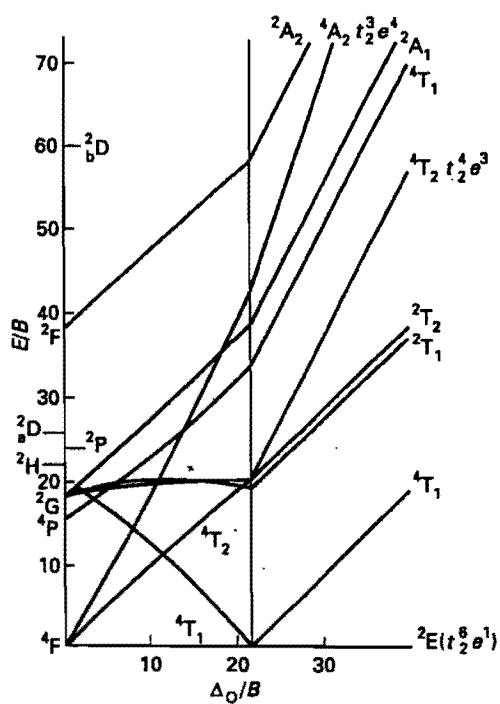
[18]

																1 H 1.008												18/VIII 2 He 4.003	
		1		2												13/III	14/IV	15/V	16/VI	17/VII									
		3	4											5	6	7	8	9	10										
		Li 6.941	Be 9.012											B 10.81	C 12.01	N 14.01	O 16.00	F 19.00	Ne 20.18										
		11	12											13	14	15	16	17	18										
		Na 22.99	Mg 24.30											Al 26.98	Si 28.09	P 30.97	S 32.07	Cl 35.45	Ar 39.95										
Period	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18													
	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36											
	K 39.10	Ca 40.08	Sc 44.96	Ti 47.87	V 50.94	Cr 52.00	Mn 54.94	Fe 55.85	Co 58.93	Ni 58.69	Cu 63.55	Zn 65.39	Ga 69.72	Ge 72.61	As 74.92	Se 78.96	Br 79.90	Kr 83.80											
	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54											
	Rb 85.47	Sr 87.62	Y 88.91	Zr 91.22	Nb 92.91	Mo 95.94	Tc 98.91	Ru 101.1	Rh 102.9	Pd 106.4	Ag 107.9	Cd 112.4	In 114.8	Sn 118.7	Sb 121.8	Te 127.6	I 126.9	Xe 131.3											
55	56	La-Lu	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86												
Cs 132.9	Ba 137.3		Hf 178.5	Ta 180.9	W 183.8	Re 186.2	Os 190.2	Ir 192.2	Pt 195.1	Au 197.0	Hg 200.6	Tl 204.4	Pb 207.2	Bi 209.0	Po 210.0	At 210.0	Rn 222.0												
87	88	Ac-Lr	104	105	106	107	108	109																					
Fr 223.0	Ra 226.0		Unq	Unp	Unh	Uns	Uno	Une																					
s block		d block										p block																	
		Lanthanides Actinides																											
		57	58	59	60	61	62	63	64	65	66	67	68	69	70	71													
		La 138.9	Ce 140.1	Pr 140.9	Nd 146.2	Pm 144.9	Sm 150.4	Eu 152.0	Gd 157.2	Tb 158.9	Dy 162.5	Ho 164.9	Er 167.3	Tm 168.9	Yb 173.0	Lu 175.0													
		89	90	91	92	93	94	95	96	97	98	99	100	101	102	103													
		Ac 227.0	Th 232.0	Pa 231.0	U 238.0	Np 237.0	Pu 239.1	Am 241.1	Cm 244.1	Bk 249.1	Cf 252.1	Es 252.1	Fm 257.1	Md 258.1	No 259.1	Lr 262.1													
		f block																											

7. d^8 with $C = 4.709B$.



6. d' with $C = 4.633B$



Useful relations

At 298.15 K, $RT = 2.4790 \text{ kJ mol}^{-1}$ and $RT/F = 25.693 \text{ mV}$
1 atm = 101.325 kPa = 760 Torr (exactly)
1 bar = 10^5 Pa
1 eV = $1.602\,18 \times 10^{-19} \text{ J} = 96.485 \text{ kJ mol}^{-1} = 8065.5 \text{ cm}^{-1}$
1 $\text{cm}^{-1} = 1.986 \times 10^{-23} \text{ J} = 11.96 \text{ J mol}^{-1} = 0.1240 \text{ meV}$
1 cal = 4.184 J (exactly)
1 D (debye) = $3.335\,64 \times 10^{-30} \text{ C m}$
1 T = 10^4 G
1 Å (ångström) = 100 pm
1 M = 1 mol dm⁻³

General data and fundamental constants

Quantity	Symbol	Value
* Speed of light	c	$2.997\,925 \times 10^8 \text{ m s}^{-1}$
* Elementary charge	e	$1.602\,177 \times 10^{-19} \text{ C}$
Faraday constant	$F = eN_A$	$9.6485 \times 10^4 \text{ C mol}^{-1}$
Boltzmann constant	k	$1.380\,66 \times 10^{-23} \text{ J K}^{-1}$ $8.6174 \times 10^{-5} \text{ eV K}^{-1}$
* Gas constant	$R = kN_A$	$8.314\,51 \text{ J K}^{-1} \text{ mol}^{-1}$ $8.205\,78 \times 10^{-2} \text{ dm}^3 \text{ atm K}^{-1} \text{ mol}^{-1}$
* Planck constant	h $\hbar = h/2\pi$	$6.626\,08 \times 10^{-34} \text{ J s}$ $1.054\,57 \times 10^{-34} \text{ J s}$
* Avogadro constant	N_A	$6.022\,14 \times 10^{23} \text{ mol}^{-1}$
Atomic mass unit	u	$1.660\,54 \times 10^{-27} \text{ kg}$
* Mass of electron	m_e	$9.109\,39 \times 10^{-31} \text{ kg}$
* Vacuum permittivity	ϵ_0 $4\pi\epsilon_0$	$8.854\,19 \times 10^{-12} \text{ J}^{-1} \text{ C}^2 \text{ m}^{-1}$ $1.112\,65 \times 10^{-10} \text{ J}^{-1} \text{ C}^2 \text{ m}^{-1}$
Bohr magneton	$\mu_B = e\hbar/2m_e$	$9.274\,02 \times 10^{-24} \text{ J T}^{-1}$
* Bohr radius	$a_0 = 4\pi\epsilon_0\hbar^2/m_e e^2$	$5.291\,77 \times 10^{-11} \text{ m}$
* Rydberg constant	$R_\infty = m_e e^4 / 8\hbar^3 c \epsilon_0^2$	$1.097\,37 \times 10^5 \text{ cm}^{-1} = 1.09737 \times 10^7 \text{ m}^{-1}$

Prefixes

f	p	n	μ	m	c	d	k	M	G
femto 10 ⁻¹⁵	pico 10 ⁻¹²	nano 10 ⁻⁹	micro 10 ⁻⁶	milli 10 ⁻³	centi 10 ⁻²	deci 10 ⁻¹	kilo 10 ³	mega 10 ⁶	giga 10 ⁹

C301: CHARACTER TABLES

APPENDICES

4. The C_{nv} Groups

* C_{2v}	E	C_2	$\sigma_v(xz)$	$\sigma_v'(yz)$		
A_1	1	1	1	1	z	x^2, y^2, z^2
A_2	1	1	-1	-1	R_z	xy
B_1	1	-1	1	-1	x, R_y	xz
B_2	1	-1	-1	1	y, R_x	yz

C_{3v}	E	$2C_3$	$3\sigma_v$		
A_1	1	1	1	z	$x^2 + y^2, z^2$
A_2	1	1	-1	R_z	
E	2	-1	0	$(x, y)(R_x, R_y)$	$(x^2 - y^2, xy)(xz, yz)$

C_{4v}	E	$2C_4$	C_2	$2\sigma_v$	$2\sigma_d$		
A_1	1	1	1	1	1	z	$x^2 + y^2, z^2$
A_2	1	1	1	-1	-1	R_z	
B_1	1	-1	1	1	-1		$x^2 - y^2$
B_2	1	-1	1	-1	1		xy
E	2	0	-2	0	0	$(x, y)(R_x, R_y)$	(xz, yz)

6 APPENDICES

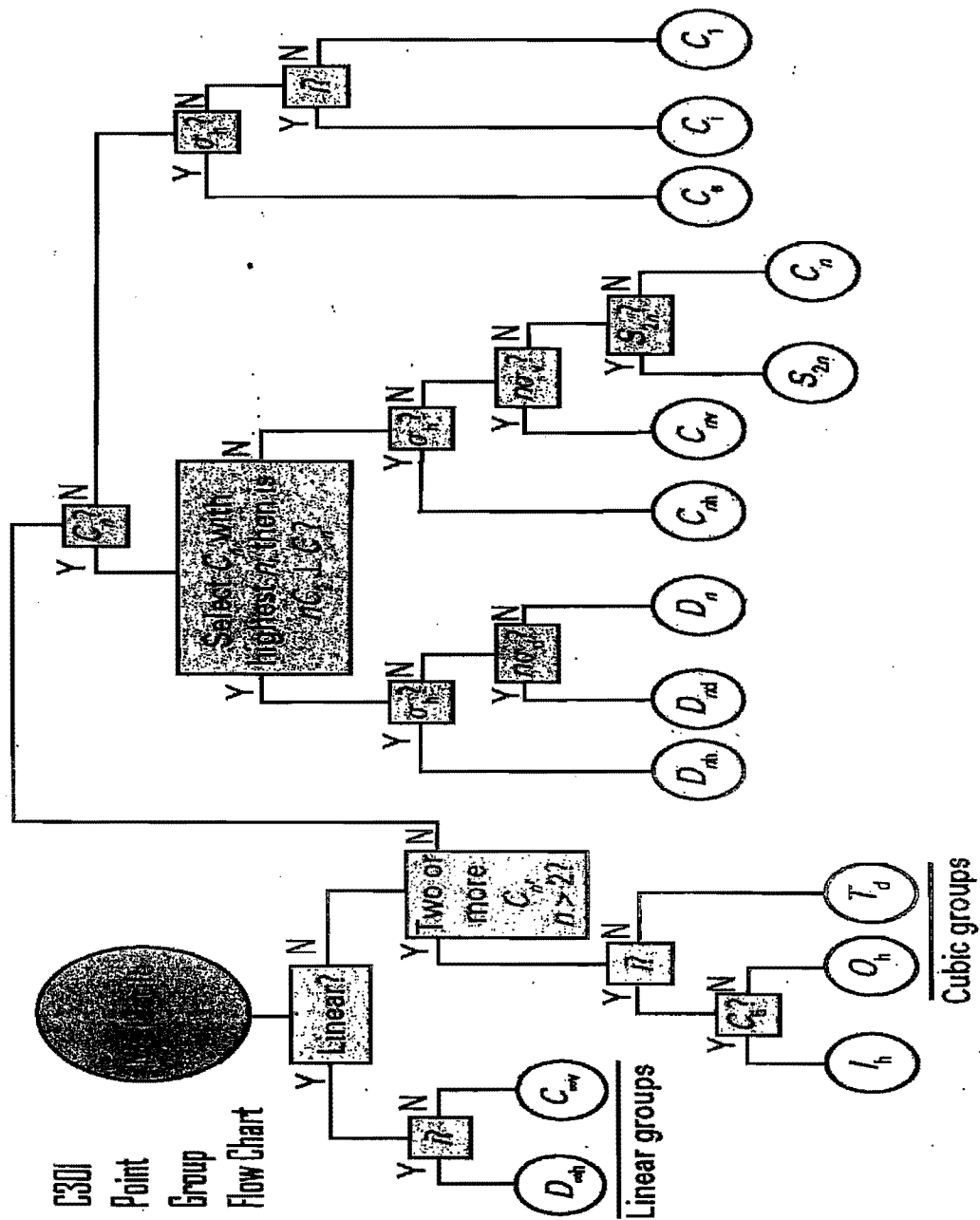
6. The D_{nh} Groups

D_{2h}	E	$C_2(z)$	$C_2(y)$	$C_2(x)$	i	$\sigma(xy)$	$\sigma(xz)$	$\sigma(yz)$		
A_g	1	1	1	1	1	1	1	1		x^2, y^2, z^2
B_{1g}	1	1	-1	-1	1	1	-1	-1	R_z	xy
B_{2g}	1	-1	1	-1	1	-1	1	-1	R_y	xz
B_{3g}	1	-1	-1	1	1	-1	-1	1	R_x	yz
A_u	1	1	1	1	-1	-1	-1	-1		
B_{1u}	1	1	-1	-1	-1	-1	1	1	z	
B_{2u}	1	-1	1	-1	-1	1	-1	1	y	
B_{3u}	1	-1	-1	1	-1	1	1	-1	x	

* D_{3h}	E	$2C_3$	$3C_2$	σ_h	$2S_6$	$3\sigma_v$		
A_1'	1	1	1	1	1	1		$x^2 + y^2, z^2$
A_2'	1	1	-1	1	1	-1	R_z	
E'	2	-1	0	2	-1	0	(x, y)	$(x^2 - y^2, xy)$
A_1''	1	1	1	-1	-1	-1		
A_2''	1	1	-1	-1	-1	1	z	
E''	2	-1	0	-2	1	0	(R_x, R_y)	(xz, yz)

D_{4h}	E	$2C_4$	C_2	$2C_2'$	$2C_2''$	i	$2S_4$	σ_h	$2\sigma_v$	$2\sigma_d$		
A_{1g}	1	1	1	1	1	1	1	1	1	1		$x^2 + y^2, z^2$
A_{2g}	1	1	1	-1	-1	1	1	1	-1	-1	R_z	
B_{1g}	1	-1	1	1	-1	1	-1	1	1	-1		$x^2 - y^2$
B_{2g}	1	-1	1	-1	1	1	-1	1	-1	1		xy
E_g	2	0	-2	0	0	2	0	-2	0	0	(R_x, R_y)	(xz, yz)
A_{1u}	1	1	1	1	1	-1	-1	-1	-1	-1		
A_{2u}	1	1	1	-1	-1	-1	-1	-1	1	1	z	
B_{1u}	1	-1	1	1	-1	-1	1	-1	-1	1		
B_{2u}	1	-1	1	-1	1	-1	1	-1	1	-1		
E_u	2	0	-2	0	0	-2	0	2	0	0	(x, y)	

C301
 Point
 Group
 Flow Chart



Statistical tables

The following tables are presented for the convenience of the reader, and for use with the simple statistical tests, examples and exercises in this book. They are presented in a format that is compatible with the needs of analytical chemists: the significance level $P = 0.05$ has been used in most cases, and it has been assumed that the number of measurements available is fairly small. Most of these abbreviated tables have been taken, with permission, from *Elementary Statistics Tables* by Henry R. Neave, published by Routledge (Tables A.2–A.4, A.7, A.8, A.11–A.14). The reader requiring statistical data corresponding to significance levels and/or numbers of measurements not covered in the tables is referred to these sources.

Table A.1 $F(z)$, the standard normal cumulative distribution function

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
–3.4	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005
–3.3	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0007
–3.2	0.0007	0.0007	0.0007	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009
–3.1	0.0010	0.0010	0.0010	0.0011	0.0011	0.0011	0.0012	0.0012	0.0013	0.0013
–3.0	0.0013	0.0014	0.0014	0.0015	0.0015	0.0016	0.0016	0.0017	0.0018	0.0018
–2.9	0.0019	0.0019	0.0020	0.0021	0.0021	0.0022	0.0023	0.0023	0.0024	0.0025
–2.8	0.0026	0.0026	0.0027	0.0028	0.0029	0.0030	0.0031	0.0032	0.0033	0.0034
–2.7	0.0035	0.0036	0.0037	0.0038	0.0039	0.0040	0.0041	0.0043	0.0044	0.0045
–2.6	0.0047	0.0048	0.0049	0.0051	0.0052	0.0054	0.0055	0.0057	0.0059	0.0060
–2.5	0.0062	0.0064	0.0066	0.0068	0.0069	0.0071	0.0073	0.0075	0.0078	0.0080
–2.4	0.0082	0.0084	0.0087	0.0089	0.0091	0.0094	0.0096	0.0099	0.0102	0.0104
–2.3	0.0107	0.0110	0.0113	0.0116	0.0119	0.0122	0.0125	0.0129	0.0132	0.0136
–2.2	0.0139	0.0143	0.0146	0.0150	0.0154	0.0158	0.0162	0.0166	0.0170	0.0174
–2.1	0.0179	0.0183	0.0188	0.0192	0.0197	0.0202	0.0207	0.0212	0.0217	0.0222
–2.0	0.0228	0.0233	0.0239	0.0244	0.0250	0.0256	0.0262	0.0268	0.0274	0.0281

Table A.1 Continued

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
–1.9	0.0287	0.0294	0.0301	0.0307	0.0314	0.0322	0.0329	0.0336	0.0344	0.0351
–1.8	0.0359	0.0367	0.0375	0.0384	0.0392	0.0401	0.0409	0.0418	0.0427	0.0436
–1.7	0.0446	0.0455	0.0465	0.0475	0.0485	0.0495	0.0505	0.0516	0.0526	0.0537
–1.6	0.0548	0.0559	0.0571	0.0582	0.0594	0.0606	0.0618	0.0630	0.0643	0.0655
–1.5	0.0668	0.0681	0.0694	0.0708	0.0721	0.0735	0.0749	0.0764	0.0778	0.0793
–1.4	0.0808	0.0823	0.0838	0.0853	0.0869	0.0885	0.0901	0.0918	0.0934	0.0951
–1.3	0.0968	0.0985	0.1003	0.1020	0.1038	0.1056	0.1075	0.1093	0.1112	0.1131
–1.2	0.1151	0.1170	0.1190	0.1210	0.1230	0.1251	0.1271	0.1292	0.1314	0.1335
–1.1	0.1357	0.1379	0.1401	0.1423	0.1446	0.1469	0.1492	0.1515	0.1539	0.1562
–1.0	0.1587	0.1611	0.1635	0.1660	0.1685	0.1711	0.1736	0.1762	0.1788	0.1814
–0.9	0.1841	0.1867	0.1894	0.1922	0.1949	0.1977	0.2005	0.2033	0.2061	0.2090
–0.8	0.2119	0.2148	0.2177	0.2206	0.2236	0.2266	0.2296	0.2327	0.2358	0.2389
–0.7	0.2420	0.2451	0.2483	0.2514	0.2546	0.2578	0.2611	0.2643	0.2676	0.2709
–0.6	0.2743	0.2776	0.2810	0.2843	0.2877	0.2912	0.2946	0.2981	0.3015	0.3050
–0.5	0.3085	0.3121	0.3156	0.3192	0.3228	0.3264	0.3300	0.3336	0.3372	0.3409
–0.4	0.3446	0.3483	0.3520	0.3557	0.3594	0.3632	0.3669	0.3707	0.3745	0.3783
–0.3	0.3821	0.3859	0.3897	0.3936	0.3974	0.4013	0.4052	0.4090	0.4129	0.4168
–0.2	0.4207	0.4247	0.4286	0.4325	0.4364	0.4404	0.4443	0.4483	0.4522	0.4562
–0.1	0.4602	0.4641	0.4681	0.4721	0.4761	0.4801	0.4840	0.4880	0.4920	0.4960
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6965	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817

Table A.1 Continued

<i>z</i>	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998

Table A.2 The *t*-distribution

Value of <i>t</i> for a confidence interval of	90%	95%	98%	99%
Critical value of $ t $ for <i>P</i> values of number of degrees of freedom	0.10	0.05	0.02	0.01
1	6.31	12.71	31.82	63.66
2	2.92	4.30	6.96	9.92
3	2.35	3.18	4.54	5.84
4	2.13	2.78	3.75	4.60
5	2.02	2.57	3.36	4.03
6	1.94	2.45	3.14	3.71
7	1.89	2.36	3.00	3.50
8	1.86	2.31	2.90	3.36
9	1.83	2.26	2.82	3.25
10	1.81	2.23	2.76	3.17
12	1.78	2.18	2.68	3.05
14	1.76	2.14	2.62	2.98
16	1.75	2.12	2.58	2.92
18	1.73	2.10	2.55	2.88
20	1.72	2.09	2.53	2.85
30	1.70	2.04	2.46	2.75
50	1.68	2.01	2.40	2.68
∞	1.64	1.96	2.33	2.58

The critical values of $|t|$ are appropriate for a two-tailed test. For a one-tailed test the value is taken from the column for twice the desired *P*-value, e.g. for a one-tailed test, $P = 0.05$, 5 degrees of freedom, the critical value is read from the $P = 0.10$ column and is equal to 2.02.

Table A.3 Critical values of *F* for a one-tailed test ($P = 0.05$)

v_2	v_1														
	1	2	3	4	5	6	7	8	9	10	12	15	20	25	30
1	161.4	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5	241.9	243.9	245.5	247.5	249.0	250.0
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40	19.41	19.43	19.44	19.45	19.46
3	10.13	9.552	9.277	9.117	9.013	8.941	8.887	8.845	8.812	8.786	8.745	8.703	8.661	8.620	8.580
4	7.709	6.944	6.591	6.388	6.256	6.163	6.094	6.041	5.999	5.964	5.912	5.858	5.804	5.751	5.698
5	6.608	5.786	5.409	5.192	5.050	4.950	4.876	4.818	4.772	4.735	4.678	4.619	4.561	4.504	4.447
6	5.987	5.143	4.757	4.534	4.387	4.284	4.207	4.147	4.099	4.060	4.000	3.938	3.877	3.817	3.757
7	5.591	4.737	4.347	4.120	3.972	3.866	3.787	3.726	3.677	3.637	3.575	3.511	3.451	3.391	3.331
8	5.318	4.459	4.066	3.838	3.687	3.581	3.500	3.438	3.388	3.347	3.284	3.218	3.158	3.098	3.038
9	5.117	4.256	3.863	3.633	3.482	3.374	3.293	3.230	3.179	3.137	3.073	3.006	2.946	2.886	2.826
10	4.965	4.103	3.708	3.478	3.326	3.217	3.135	3.072	3.020	2.978	2.913	2.845	2.785	2.725	2.665
11	4.844	3.982	3.587	3.357	3.204	3.095	3.012	2.948	2.896	2.854	2.788	2.719	2.659	2.599	2.539
12	4.747	3.885	3.490	3.259	3.106	2.996	2.913	2.849	2.796	2.753	2.687	2.617	2.557	2.497	2.437
13	4.667	3.806	3.411	3.179	3.025	2.915	2.832	2.767	2.714	2.671	2.604	2.533	2.473	2.413	2.353
14	4.600	3.739	3.344	3.112	2.958	2.848	2.764	2.699	2.646	2.602	2.534	2.463	2.403	2.343	2.283
15	4.543	3.682	3.287	3.056	2.901	2.790	2.707	2.641	2.588	2.544	2.475	2.403	2.343	2.283	2.223
16	4.494	3.634	3.239	3.007	2.852	2.741	2.657	2.591	2.538	2.494	2.425	2.352	2.292	2.232	2.172
17	4.451	3.592	3.197	2.965	2.810	2.699	2.614	2.548	2.494	2.450	2.381	2.308	2.248	2.188	2.128
18	4.414	3.555	3.160	2.928	2.773	2.661	2.577	2.510	2.456	2.412	2.342	2.269	2.209	2.149	2.089
19	4.381	3.522	3.127	2.895	2.740	2.628	2.544	2.477	2.423	2.378	2.308	2.234	2.174	2.114	2.054
20	4.351	3.493	3.098	2.866	2.711	2.599	2.514	2.447	2.393	2.348	2.278	2.203	2.143	2.083	2.023

v_1 = number of degrees of freedom of the numerator and v_2 = number of degrees of freedom of denominator.

ble A.4 Critical values of F for a two-tailed test ($P = 0.05$)

v_1													
1	2	3	4	5	6	7	8	9	10	12	15	20	
647.8	799.5	864.2	899.6	921.8	937.1	948.2	956.7	963.3	968.6	976.7	984.9	993.1	
38.51	39.00	39.17	39.25	39.30	39.33	39.36	39.37	39.39	39.40	39.41	39.43	39.45	
17.44	16.04	15.44	15.10	14.88	14.73	14.62	14.54	14.47	14.42	14.34	14.25	14.17	
12.22	10.65	9.979	9.605	9.364	9.197	9.074	8.980	8.905	8.844	8.751	8.657	8.560	
10.01	8.434	7.764	7.388	7.146	6.978	6.853	6.757	6.681	6.619	6.525	6.428	6.329	
8.813	7.260	6.599	6.227	5.988	5.820	5.695	5.600	5.523	5.461	5.366	5.269	5.168	
8.073	6.542	5.890	5.523	5.285	5.119	4.995	4.899	4.823	4.761	4.666	4.568	4.467	
7.571	6.059	5.416	5.053	4.817	4.652	4.529	4.433	4.357	4.295	4.200	4.101	3.999	
7.209	5.715	5.078	4.718	4.484	4.320	4.197	4.102	4.026	3.964	3.868	3.769	3.667	
6.937	5.456	4.826	4.468	4.236	4.072	3.950	3.855	3.779	3.717	3.621	3.522	3.419	
6.724	5.256	4.630	4.275	4.044	3.881	3.759	3.664	3.588	3.526	3.430	3.330	3.226	
6.554	5.096	4.474	4.121	3.891	3.728	3.607	3.512	3.436	3.374	3.277	3.177	3.073	
6.414	4.965	4.347	3.996	3.767	3.604	3.483	3.388	3.312	3.250	3.153	3.053	2.948	
6.298	4.857	4.242	3.892	3.663	3.501	3.380	3.285	3.209	3.147	3.050	2.949	2.844	
6.200	4.765	4.153	3.804	3.576	3.415	3.293	3.199	3.123	3.060	2.963	2.862	2.756	
6.115	4.687	4.077	3.729	3.502	3.341	3.219	3.125	3.049	2.986	2.889	2.788	2.681	
6.042	4.619	4.011	3.665	3.438	3.277	3.156	3.061	2.985	2.922	2.825	2.723	2.616	
5.978	4.560	3.954	3.608	3.382	3.221	3.100	3.005	2.929	2.866	2.769	2.667	2.559	
5.922	4.508	3.903	3.559	3.333	3.172	3.051	2.956	2.880	2.817	2.720	2.617	2.509	
5.871	4.461	3.859	3.515	3.289	3.128	3.007	2.913	2.837	2.774	2.676	2.573	2.464	

number of degrees of freedom of the numerator and v_2 = number of degrees of freedom of the denominator.

Table A.5 Critical values of Q ($P = 0.05$) for a two-sided test

Sample size	Critical value
4	0.831
5	0.717
6	0.621
7	0.570

Taken from King, E. P. 1958. *J. Am. Statist. Assoc.*, 48: 531.

Table A.6 Critical values of G ($P = 0.05$) for a two-sided test

Sample size	Critical value
3	1.155
4	1.481
5	1.715
6	1.887
7	2.020
8	2.126
9	2.215
10	2.290

Taken from *Outliers in Statistical Data*, Vic Barnett and Toby Lewis, 2nd Edition, 1984, John Wiley & Sons Limited.

Table A.7 Critical values of X^2 ($P = 0.05$)

Number of degrees of freedom	Critical value
1	3.84
2	5.99
3	7.81
4	9.49
5	11.07
6	12.59
7	14.07
8	15.51
9	16.92
10	18.31

Table A.13 The Spearman rank correlation coefficient. Critical values for ρ at $P = 0.05$

n	One-tailed test	Two-tailed test
5	0.900	1.000
6	0.829	0.886
7	0.714	0.786
8	0.643	0.738
9	0.600	0.700
10	0.564	0.649
11	0.536	0.618
12	0.504	0.587
13	0.483	0.560
14	0.464	0.538
15	0.446	0.521
16	0.429	0.503
17	0.414	0.488
18	0.401	0.472
19	0.391	0.460
20	0.380	0.447

Table A.14 The Kolmogorov test. Critical two-tailed values for a specified distribution, and for unspecified normal distributions, at $P = 0.05$

n	Specified distributions	Unspecified normal distributions
3	0.708	0.376
4	0.624	0.375
5	0.563	0.343
6	0.519	0.323
7	0.483	0.304
8	0.454	0.288
9	0.430	0.274
10	0.409	0.262
11	0.391	0.251
12	0.375	0.242
13	0.361	0.234
14	0.349	0.226
15	0.338	0.219
16	0.327	0.213
17	0.318	0.207
18	0.309	0.202
19	0.301	0.197
20	0.294	0.192

The appropriate value is compared with the maximum difference between the experimental and theoretical cumulative frequency curves, as described in the text.

Table A.15 Critical values for C ($P = 0.05$) for $n = 2$

k	Critical value
3	0.967
4	0.906
5	0.841
6	0.781
7	0.727
8	0.680
9	0.638
10	0.602

TABLE B Critical values of Student's *t*-distribution

$\nu \backslash \alpha$	0.9	0.5	0.4	0.2	0.1	0.05	0.02	0.01	0.001	$\alpha \backslash \nu$
1	.158	1.000	1.376	3.078	6.314	12.706	31.821	63.657	636.619	1
2	.142	.816	1.061	1.886	2.920	4.303	6.965	9.925	31.598	2
3	.137	.765	.978	1.638	2.353	3.182	4.541	5.841	12.924	3
4	.134	.741	.941	1.533	2.132	2.776	3.747	4.604	8.610	4
5	.132	.727	.920	1.476	2.015	2.571	3.365	4.032	6.869	5
6	.131	.718	.906	1.440	1.943	2.447	3.143	3.707	5.959	6
7	.130	.711	.896	1.415	1.895	2.365	2.998	3.499	5.408	7
8	.130	.706	.889	1.397	1.860	2.306	2.896	3.355	5.041	8
9	.129	.703	.883	1.383	1.833	2.262	2.821	3.250	4.781	9
10	.129	.700	.879	1.372	1.812	2.228	2.764	3.169	4.587	10
11	.129	.697	.876	1.363	1.796	2.201	2.718	3.106	4.437	11
12	.128	.695	.873	1.356	1.782	2.179	2.681	3.055	4.318	12
13	.128	.694	.870	1.350	1.771	2.160	2.650	3.012	4.221	13
14	.128	.692	.868	1.345	1.761	2.145	2.624	2.977	4.140	14
15	.128	.691	.866	1.341	1.753	2.131	2.602	2.947	4.073	15
16	.128	.690	.865	1.337	1.746	2.120	2.583	2.921	4.015	16
17	.128	.689	.863	1.333	1.740	2.110	2.567	2.898	3.965	17
18	.127	.688	.862	1.330	1.734	2.101	2.552	2.878	3.922	18
19	.127	.688	.861	1.328	1.729	2.093	2.539	2.861	3.883	19
20	.127	.687	.860	1.325	1.725	2.086	2.528	2.845	3.850	20
21	.127	.686	.859	1.323	1.721	2.080	2.518	2.831	3.819	21
22	.127	.686	.858	1.321	1.717	2.074	2.508	2.819	3.792	22
23	.127	.685	.858	1.319	1.714	2.069	2.500	2.807	3.767	23
24	.127	.685	.857	1.318	1.711	2.064	2.492	2.797	3.745	24
25	.127	.684	.856	1.316	1.708	2.060	2.485	2.787	3.725	25
26	.127	.684	.856	1.315	1.706	2.056	2.479	2.779	3.707	26
27	.127	.684	.855	1.314	1.703	2.052	2.473	2.771	3.690	27
28	.127	.683	.855	1.313	1.701	2.048	2.467	2.763	3.674	28
29	.127	.683	.854	1.311	1.699	2.045	2.462	2.756	3.659	29
30	.127	.683	.854	1.310	1.697	2.042	2.457	2.750	3.646	30
40	.126	.681	.851	1.303	1.684	2.021	2.423	2.704	3.551	40
60	.126	.679	.848	1.296	1.671	2.000	2.390	2.660	3.460	60
120	.126	.677	.845	1.289	1.658	1.980	2.358	2.617	3.373	120
∞	.126	.674	.842	1.282	1.645	1.960	2.326	2.576	3.291	∞

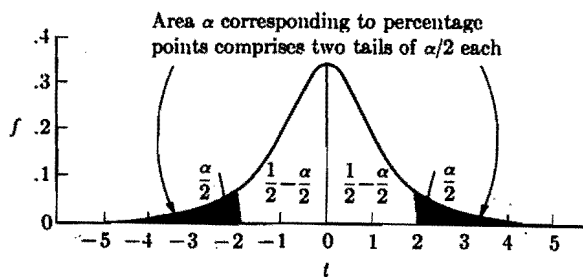


TABLE D Critical values of the chi-square distribution

$\nu \backslash \alpha$	.995	.975	.9	.5	.1	.05	.025	.01	.005	.001	$\alpha \backslash \nu$
1	0.000	0.000	0.016	0.455	2.706	3.841	5.024	6.635	7.879	10.828	1
2	0.010	0.051	0.211	1.386	4.605	5.991	7.378	9.210	10.597	13.816	2
3	0.072	0.216	0.584	2.366	6.251	7.815	9.348	11.345	12.838	16.266	3
4	0.207	0.484	1.064	3.357	7.779	9.488	11.143	13.277	14.860	18.467	4
5	0.412	0.831	1.610	4.351	9.236	11.070	12.832	15.086	16.750	20.515	5
6	0.676	1.237	2.204	5.348	10.645	12.592	14.449	16.812	18.548	22.458	6
7	0.989	1.690	2.833	6.346	12.017	14.067	16.013	18.475	20.278	24.322	7
8	1.344	2.180	3.490	7.344	13.362	15.507	17.535	20.090	21.955	26.124	8
9	1.735	2.700	4.168	8.343	14.684	16.919	19.023	21.666	23.589	27.877	9
10	2.156	3.247	4.865	9.342	15.987	18.307	20.483	23.209	25.188	29.588	10
11	2.603	3.816	5.578	10.341	17.275	19.675	21.920	24.725	26.757	31.264	11
12	3.074	4.404	6.304	11.340	18.549	21.026	23.337	26.217	28.300	32.910	12
13	3.565	5.009	7.042	12.340	19.812	22.362	24.736	27.688	29.819	34.528	13
14	4.075	5.629	7.790	13.339	21.064	23.685	26.119	29.141	31.319	36.123	14
15	4.601	6.262	8.547	14.339	22.307	24.996	27.488	30.578	32.801	37.697	15
16	5.142	6.908	9.312	15.338	23.542	26.296	28.845	32.000	34.267	39.252	16
17	5.697	7.564	10.085	16.338	24.769	27.587	30.191	33.409	35.718	40.790	17
18	6.265	8.231	10.865	17.338	25.989	28.869	31.526	34.805	37.156	42.312	18
19	6.844	8.907	11.651	18.338	27.204	30.144	32.852	36.191	38.582	43.820	19
20	7.434	9.591	12.443	19.337	28.412	31.410	34.170	37.566	39.997	45.315	20
21	8.034	10.283	13.240	20.337	29.615	32.670	35.479	38.932	41.401	46.797	21
22	8.643	10.982	14.042	21.337	30.813	33.924	36.781	40.289	42.796	48.268	22
23	9.260	11.688	14.848	22.337	32.007	35.172	38.076	41.638	44.181	49.728	23
24	9.886	12.401	15.659	23.337	33.196	36.415	39.364	42.980	45.558	51.179	24
25	10.520	13.120	16.473	24.337	34.382	37.652	40.646	44.314	46.928	52.620	25
26	11.160	13.844	17.292	25.336	35.563	38.885	41.923	45.642	48.290	54.052	26
27	11.808	14.573	18.114	26.336	36.741	40.113	43.194	46.963	49.645	55.476	27
28	12.461	15.308	18.939	27.336	37.916	41.337	44.461	48.278	50.993	56.892	28
29	13.121	16.047	19.768	28.336	39.088	42.557	45.722	49.588	52.336	58.301	29
30	13.787	16.791	20.599	29.336	40.256	43.773	46.979	50.892	53.672	59.703	30
31	14.458	17.539	21.434	30.336	41.422	44.985	48.232	52.191	55.003	61.098	31
32	15.134	18.291	22.271	31.336	42.585	46.194	49.480	53.486	56.329	62.487	32
33	15.815	19.047	23.110	32.336	43.745	47.400	50.725	54.776	57.649	63.870	33
34	16.501	19.806	23.952	33.336	44.903	48.602	51.966	56.061	58.964	65.247	34
35	17.192	20.569	24.797	34.336	46.059	49.802	53.203	57.342	60.275	66.619	35
36	17.887	21.336	25.643	35.336	47.212	50.998	54.437	58.619	61.582	67.985	36
37	18.586	22.106	26.492	36.335	48.363	52.192	55.668	59.892	62.884	69.346	37
38	19.289	22.878	27.343	37.335	49.513	53.384	56.896	61.162	64.182	70.703	38
39	19.996	23.654	28.196	38.335	50.660	54.572	58.120	62.428	65.476	72.055	39
40	20.707	24.433	29.051	39.335	51.805	55.758	59.342	63.691	66.766	73.402	40
41	21.421	25.215	29.907	40.335	52.949	56.942	60.561	64.950	68.053	74.745	41
42	22.138	25.999	30.765	41.335	54.090	58.124	61.777	66.206	69.336	76.084	42
43	22.859	26.785	31.625	42.335	55.230	59.304	62.990	67.459	70.616	77.419	43
44	23.584	27.575	32.487	43.335	56.369	60.481	64.202	68.710	71.893	78.750	44
45	24.311	28.366	33.350	44.335	57.505	61.656	65.410	69.957	73.166	80.077	45
46	25.042	29.160	34.215	45.335	58.641	62.830	66.617	71.201	74.437	81.400	46
47	25.775	29.956	35.081	46.335	59.774	64.001	67.821	72.443	75.704	82.720	47
48	26.511	30.755	35.949	47.335	60.907	65.171	69.023	73.683	76.969	84.037	48
49	27.249	31.555	36.818	48.335	62.038	66.339	70.222	74.919	78.231	85.351	49
50	27.991	32.357	37.689	49.335	63.167	67.505	71.420	76.154	79.490	86.661	50

TABLE D Criti

$\nu \backslash \alpha$	.995	.975
51	28.735	33.162
52	29.481	33.968
53	30.230	34.776
54	30.981	35.586
55	31.735	36.398
56	32.490	37.212
57	33.248	38.027
58	34.008	38.844
59	34.770	39.662
60	35.534	40.482
61	36.300	41.303
62	37.068	42.126
63	37.838	42.950
64	38.610	43.776
65	39.383	44.603
66	40.158	45.431
67	40.935	46.261
68	41.713	47.092
69	42.494	47.924
70	43.275	48.758
71	44.058	49.592
72	44.843	50.428
73	45.629	51.265
74	46.417	52.103
75	47.206	52.942
76	47.997	53.782
77	48.788	54.623
78	49.582	55.466
79	50.376	56.309
80	51.172	57.153
81	51.969	57.998
82	52.767	58.845
83	53.567	59.692
84	54.368	60.540
85	55.170	61.389
86	55.973	62.239
87	56.777	63.089
88	57.582	63.941
89	58.389	64.793
90	59.196	65.647
91	60.005	66.501
92	60.815	67.356
93	61.625	68.211
94	62.437	69.068
95	63.250	69.925
96	64.063	70.783
97	64.878	71.642
98	65.694	72.501
99	66.510	73.361
100	67.328	74.222

oution

TABLE D Critical values of the chi-square distribution (continued)

1	.005	.001	α/ν	ν/α	.995	.975	.9	.5	.1	.05	.025	.01	.005	.001	α/ν
35	7.879	10.828	1	51	28.735	33.162	38.560	50.335	64.295	68.669	72.616	77.386	80.747	87.968	51
10	10.597	13.816	2	52	29.481	33.968	39.433	51.335	65.422	69.832	73.810	78.616	82.001	89.272	52
45	12.838	16.266	3	53	30.230	34.776	40.308	52.335	66.548	70.993	75.002	79.843	83.253	90.573	53
77	14.860	18.467	4	54	30.981	35.586	41.183	53.335	67.673	72.153	76.192	81.069	84.502	91.872	54
86	16.750	20.515	5	55	31.735	36.398	42.060	54.335	68.796	73.311	77.380	82.292	85.749	93.168	55
12	18.548	22.458	6	56	32.490	37.212	42.937	55.335	69.918	74.468	78.567	83.513	86.994	94.460	56
75	20.278	24.322	7	57	33.248	38.027	43.816	56.335	71.040	75.624	79.752	84.733	88.237	95.751	57
90	21.955	26.124	8	58	34.008	38.844	44.696	57.335	72.160	76.778	80.936	85.950	89.477	97.039	58
66	23.589	27.877	9	59	34.770	39.662	45.577	58.335	73.279	77.931	82.117	87.166	90.715	98.324	59
09	25.188	29.588	10	60	35.534	40.482	46.459	59.335	74.397	79.082	83.298	88.379	91.952	99.607	60
25	26.757	31.264	11	61	36.300	41.303	47.342	60.335	75.514	80.232	84.476	89.591	93.186	100.888	61
17	28.300	32.910	12	62	37.068	42.126	48.226	61.335	76.630	81.381	85.654	90.802	94.419	102.166	62
88	29.819	34.528	13	63	37.838	42.950	49.111	62.335	77.745	82.529	86.830	92.010	95.649	103.442	63
41	31.319	36.123	14	64	38.610	43.776	49.996	63.335	78.860	83.675	88.004	93.217	96.878	104.716	64
78	32.801	37.697	15	65	39.383	44.603	50.883	64.335	79.973	84.821	89.177	94.422	98.105	105.988	65
30	34.267	39.252	16	66	40.158	45.431	51.770	65.335	81.085	85.965	90.349	95.626	99.331	107.258	66
09	35.718	40.790	17	67	40.935	46.261	52.659	66.335	82.197	87.108	91.519	96.828	100.55	108.526	67
35	37.156	42.312	18	68	41.713	47.092	53.548	67.334	83.308	88.250	92.689	98.028	101.78	109.791	68
71	38.582	43.820	19	69	42.494	47.924	54.438	68.334	84.418	89.391	93.856	99.228	103.00	111.055	69
56	39.997	45.315	20	70	43.275	48.758	55.329	69.334	85.527	90.531	95.023	100.43	104.21	112.317	70
32	41.401	46.797	21	71	44.058	49.592	56.221	70.334	86.635	91.670	96.189	101.62	105.43	113.577	71
39	42.796	48.268	22	72	44.843	50.428	57.113	71.334	87.743	92.808	97.353	102.82	106.65	114.835	72
18	44.181	49.728	23	73	45.629	51.265	58.006	72.334	88.850	93.945	98.516	104.01	107.86	116.092	73
30	45.558	51.179	24	74	46.417	52.103	58.900	73.334	89.956	95.081	99.678	105.20	109.07	117.346	74
14	46.928	52.620	25	75	47.206	52.942	59.795	74.334	91.061	96.217	100.84	106.39	110.29	118.599	75
12	48.290	54.052	26	76	47.997	53.782	60.690	75.334	92.166	97.351	102.00	107.58	111.50	119.850	76
33	49.645	55.476	27	77	48.788	54.623	61.586	76.334	93.270	98.484	103.16	108.77	112.70	121.100	77
18	50.993	56.892	28	78	49.582	55.466	62.483	77.334	94.373	99.617	104.32	109.96	113.91	122.348	78
38	52.336	58.301	29	79	50.376	56.309	63.380	78.334	95.476	100.75	105.47	111.14	115.12	123.594	79
22	53.672	59.703	30	80	51.172	57.153	64.278	79.334	96.578	101.88	106.63	112.33	116.32	124.839	80
31	55.003	61.098	31	81	51.969	57.998	65.176	80.334	97.680	103.01	107.78	113.51	117.52	126.082	81
36	56.329	62.487	32	82	52.767	58.845	66.076	81.334	98.780	104.14	108.94	114.69	118.73	127.324	82
16	57.649	63.870	33	83	53.567	59.692	66.976	82.334	99.880	105.27	110.09	115.88	119.93	128.565	83
51	58.964	65.247	34	84	54.368	60.540	67.876	83.334	100.98	106.39	111.24	117.06	121.13	129.804	84
12	60.275	66.619	35	85	55.170	61.389	68.777	84.334	102.08	107.52	112.39	118.24	122.32	131.041	85
19	61.582	67.985	36	86	55.973	62.239	69.679	85.334	103.18	108.65	113.54	119.41	123.52	132.277	86
22	62.884	69.346	37	87	56.777	63.089	70.581	86.334	104.28	109.77	114.69	120.59	124.72	133.512	87
52	64.182	70.703	38	88	57.582	63.941	71.484	87.334	105.37	110.90	115.84	121.77	125.91	134.745	88
38	65.476	72.055	39	89	58.389	64.793	72.387	88.334	106.47	112.02	116.99	122.94	127.11	135.978	89
31	66.766	73.402	40	90	59.196	65.647	73.291	89.334	107.56	113.15	118.14	124.12	128.30	137.208	90
50	68.053	74.745	41	91	60.005	66.501	74.196	90.334	108.66	114.27	119.28	125.29	129.49	138.438	91
36	69.336	76.084	42	92	60.815	67.356	75.101	91.334	109.76	115.39	120.43	126.46	130.68	139.666	92
59	70.616	77.419	43	93	61.625	68.211	76.006	92.334	110.85	116.51	121.57	127.63	131.87	140.893	93
10	71.893	78.750	44	94	62.437	69.068	76.912	93.334	111.94	117.63	122.72	128.80	133.06	142.119	94
17	73.166	80.077	45	95	63.250	69.925	77.818	94.334	113.04	118.75	123.86	129.97	134.25	143.344	95
31	74.437	81.400	46	96	64.063	70.783	78.725	95.334	114.13	119.87	125.00	131.14	135.43	144.567	96
13	75.704	82.720	47	97	64.878	71.642	79.633	96.334	115.22	120.99	126.14	132.31	136.62	145.789	97
13	76.969	84.037	48	98	65.694	72.501	80.541	97.334	116.32	122.11	127.28	133.48	137.80	147.010	98
9	78.231	85.351	49	99	66.510	73.361	81.449	98.334	117.41	123.23	128.42	134.64	138.99	148.230	99
14	79.490	86.661	50	100	67.328	74.222	82.358	99.334	118.50	124.34	129.56	135.81	140.17	149.449	100

TABLE X Critical values of the δ -corrected one-sample Kolmogorov-Smirnov statistic

n	δ	α				
		0.2	0.1	0.05	0.02	0.01
3	0.0	.35477	.41811	.46702	.53456	.57900
	0.5	.39814	.46938	.54093	.61789	.66234
	1.0	.53584	.63160	.70760	.78456	.82900
4	0.0	.33435	.39075	.44641	.50495	.54210
	0.5	.36765	.44022	.49894	.56387	.60924
	1.0	.46154	.53829	.60468	.68377	.73409
5	0.0	.31556	.37359	.42174	.47692	.51576
	0.5	.34698	.40945	.46328	.52718	.56853
	1.0	.41172	.48153	.54273	.61133	.65692
6	0.0	.30244	.35522	.40045	.45440	.48988
	0.5	.32704	.38466	.43593	.49407	.53327
	1.0	.37706	.44074	.49569	.55969	.60287
7	0.0	.28991	.33905	.38294	.43337	.46761
	0.5	.31005	.36464	.41200	.46701	.50438
	1.0	.35066	.40892	.46010	.51968	.55970
8	0.0	.27828	.32538	.36697	.41522	.44819
	0.5	.29581	.34712	.39177	.44404	.47929
	1.0	.32925	.38365	.43160	.48732	.52519
9	0.0	.26794	.31325	.35277	.39922	.43071
	0.5	.28355	.33191	.37446	.42404	.45776
	1.0	.31157	.36287	.40794	.46067	.49652
10	0.0	.25884	.30221	.34022	.38481	.41517
	0.5	.27260	.31866	.35925	.40662	.43893
	1.0	.29668	.34525	.38798	.43809	.47220
11	0.0	.25071	.29227	.32894	.37187	.40122
	0.5	.26284	.30697	.34577	.39125	.42225
	1.0	.28388	.33008	.37084	.41864	.45127
12	0.0	.24325	.28330	.31869	.36019	.38856
	0.5	.25410	.29648	.33376	.37751	.40738
	1.0	.27269	.31686	.35588	.40167	.43298
13	0.0	.23639	.27515	.30935	.34954	.37703
	0.5	.24624	.28703	.32297	.36516	.39401
	1.0	.26279	.30520	.34265	.38668	.41680
14	0.0	.23010	.26767	.30081	.33980	.36649
	0.5	.23909	.27846	.31319	.35398	.38190
	1.0	.25395	.29478	.33086	.37331	.40238
15	0.0	.22430	.26077	.29296	.33083	.35679
	0.5	.23255	.27064	.30426	.34379	.37087
	1.0	.24600	.28541	.32026	.36128	.38940
16	0.0	.21895	.25439	.28570	.32256	.34784
	0.5	.22653	.26347	.29608	.33446	.36076
	1.0	.23879	.27692	.31065	.35039	.37764
17	0.0	.21397	.24847	.27897	.31489	.33953
	0.5	.22098	.25686	.28855	.32586	.35145
	1.0	.23221	.26918	.30189	.34045	.36691
18	0.0	.20933	.24296	.27270	.30775	.33181
	0.5	.21582	.25073	.28158	.31792	.34284
	1.0	.22617	.26208	.29386	.33134	.35707
19	0.0	.20498	.23781	.26685	.30108	.32459
	0.5	.21103	.24504	.27511	.31054	.33485
	1.0	.22060	.25553	.28646	.32295	.34801
20	0.0	.20089	.23298	.26137	.29484	.31784
	0.5	.20656	.23973	.26908	.30366	.32741
	1.0	.21544	.24947	.27961	.31518	.33962
21	0.0	.19705	.22844	.25622	.28898	.31149
	0.5	.20236	.23477	.26343	.29723	.32045
	1.0	.21064	.24384	.27325	.30796	.33182

TABLE X

n	δ
22	0.0
	0.5
	1.0
23	0.0
	0.5
	1.0
24	0.0
	0.5
	1.0
25	0.0
	0.5
	1.0
26	0.0
	0.5
	1.0
27	0.0
	0.5
	1.0
28	0.0
	0.5
	1.0
29	0.0
	0.5
	1.0
30	0.0
	0.5
	1.0
31	0.0
	0.5
	1.0
32	0.0
	0.5
	1.0
33	0.0
	0.5
	1.0
34	0.0
	0.5
	1.0
35	0.0
	0.5
	1.0
36	0.0
	0.5
	1.0
37	0.0
	0.5
	1.0
38	0.0
	0.5
	1.0
39	0.0
	0.5
	1.0
40	0.0
	0.5
	1.0

ected one-
ov statistic

TABLE X Critical values of the δ -corrected one-sample Kolmogorov-Smirnov statistic (continued)

α		α						
0.02	0.01	n	δ	0.2	0.1	0.05	0.02	0.01
.1456	.57900	22	0.0	.19343	.22416	.25136	.28346	.30552
.1789	.66234		0.5	.19843	.23011	.25814	.29121	.31393
.1456	.82900		1.0	.20616	.23859	.26732	.30123	.32456
.1495	.54210	23	0.0	.19001	.22012	.24679	.27825	.29989
.1387	.60924		0.5	.19472	.22572	.25317	.28554	.30780
.1377	.73409		1.0	.20197	.23367	.26176	.29494	.31776
.1692	.51576	24	0.0	.18677	.21630	.24245	.27333	.29456
.1718	.56853		0.5	.19121	.22159	.24847	.28021	.30202
.133	.65692		1.0	.19804	.22906	.25656	.28904	.31138
.1440	.48988	25	0.0	.18370	.21268	.23835	.26866	.28951
.1407	.53327		0.5	.18790	.21768	.24404	.27516	.29657
.1969	.60287		1.0	.19433	.22472	.25166	.28349	.30539
.1337	.46761	26	0.0	.18077	.20924	.23445	.26423	.28472
.1701	.50438		0.5	.18476	.21397	.23984	.27039	.29140
.1968	.55970		1.0	.19084	.22063	.24704	.27825	.29973
.1522	.44819	27	0.0	.17799	.20596	.23074	.26001	.28016
.1404	.47929		0.5	.18178	.21046	.23586	.26586	.28650
.1732	.52519		1.0	.18753	.21676	.24267	.27330	.29439
.1922	.43071	28	0.0	.17533	.20283	.22721	.25600	.27582
.1404	.45776		0.5	.17894	.20712	.23208	.26156	.28185
.1067	.49652		1.0	.18440	.21309	.23853	.26861	.28933
.1481	.41517	29	0.0	.17280	.19985	.22383	.25217	.27168
.1662	.43893		0.5	.17624	.20393	.22847	.25747	.27742
.1809	.47220		1.0	.18142	.20961	.23461	.26417	.28452
.1187	.40122	30	0.0	.17037	.19700	.22061	.24851	.26772
.1125	.42225		0.5	.17365	.20090	.22504	.25356	.27320
.1864	.45127		1.0	.17859	.20630	.23088	.25994	.27996
.1019	.38856	31	0.0	.16805	.19427	.21752	.24501	.26393
.1751	.40738		0.5	.17119	.19800	.22176	.24983	.26917
.1167	.43298		1.0	.17589	.20314	.22732	.25591	.27561
.1954	.37703	32	0.0	.16582	.19166	.21457	.24165	.26030
.1516	.39401		0.5	.16882	.19522	.21862	.24627	.26531
.1668	.41680		1.0	.17332	.20014	.22393	.25207	.27146
.1980	.36649	33	0.0	.16368	.18915	.21173	.23843	.25683
.1398	.38190		0.5	.16656	.19256	.21561	.24286	.26162
.1331	.40238		1.0	.17086	.19726	.22069	.24840	.26750
.1083	.35679	34	0.0	.16162	.18674	.20901	.23534	.25348
.1379	.37087		0.5	.16439	.19001	.21273	.23958	.25808
.1128	.38940		1.0	.16850	.19451	.21759	.24490	.26371
.1256	.34784	35	0.0	.15964	.18442	.20639	.23237	.25027
.1446	.36076		0.5	.16230	.18756	.20996	.23644	.25469
.1039	.37764		1.0	.16625	.19188	.21462	.24154	.26008
.1489	.33953	36	0.0	.15774	.18218	.20387	.22951	.24718
.1586	.35145		0.5	.16029	.18521	.20730	.23343	.25143
.1045	.36691		1.0	.16408	.18935	.21178	.23831	.25660
.1775	.33181	37	0.0	.15590	.18003	.20144	.22676	.24421
.1792	.34284		0.5	.15836	.18294	.20474	.23052	.24829
.1134	.35707		1.0	.16200	.18692	.20904	.23522	.25326
.1108	.32459	38	0.0	.15413	.17796	.19910	.22410	.24134
.1054	.33485		0.5	.15650	.18076	.20228	.22773	.24527
.1295	.34801		1.0	.16000	.18459	.20642	.23225	.25005
.1484	.31784	39	0.0	.15242	.17595	.19684	.22154	.23857
.1366	.32741		0.5	.15471	.17866	.19991	.22504	.24236
.1518	.33962		1.0	.15808	.18234	.20389	.22938	.24696
.1898	.31149	40	0.0	.15076	.17402	.19465	.21907	.23589
.1723	.32045		0.5	.15297	.17663	.19762	.22244	.23955
.1796	.33182		1.0	.15622	.18018	.20145	.22663	.24399