Pearson

Pearson Edexcel Level 3 Advanced Level GCE in Chemistry (9CH0)

Data Booklet

Issue 2
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Physical constants

Avogadro constant (L)	6.02×10^{23} mol^{-1}
Elementary charge (e)	1.60×10^{-19} C
Gas constant (R)	8.31 J mol^{-1} K^{-1}
Molar volume of a gas at room temperature and pressure (r.t.p.):	24 dm^3 mol^{-1}
Ionic product of water (K_w)	1.00×10^{-14} mol^2 dm^{-6}

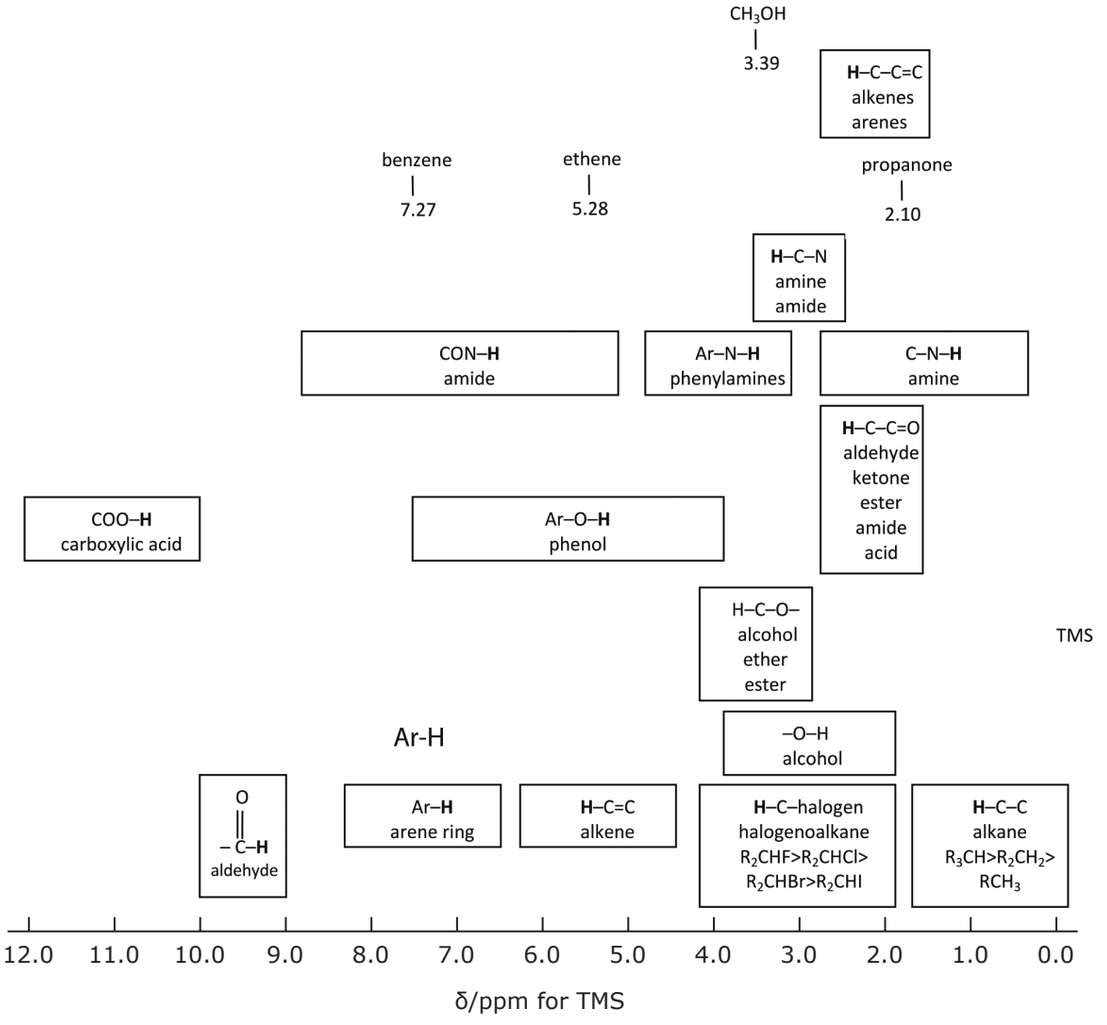
1 dm^3 = 1000 cm^3 = 0.001 m^3

Infrared spectroscopy

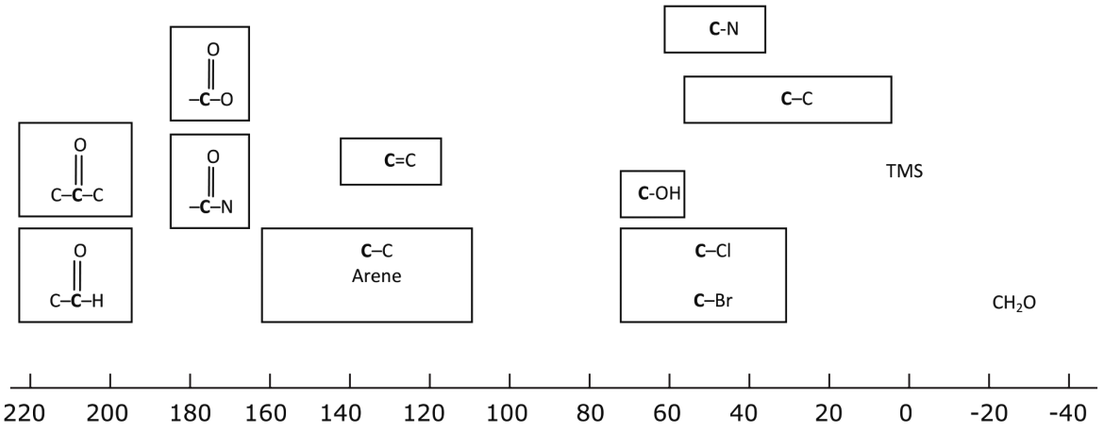
Correlation of infrared absorption wavenumbers with molecular structure

Group	Wavenumber range/cm^{-1}
C-H stretching vibrations	
Alkane	2962-2853
Alkene	3095-3010
Alkyne	3300
Arene	3030
Aldehyde	2900-2820 and 2775-2700
C-H bending vibrations	
Alkane	1485-1365
Arene 5 adjacent hydrogen atoms	750 and 700
4 adjacent hydrogen atoms	750
3 adjacent hydrogen atoms	780
2 adjacent hydrogen atoms	830
1 isolated hydrogen atom	880
N-H stretching vibrations	
Amine	3500-3300
Amide	3500-3140
O-H stretching vibrations	
Alcohols and phenols	3750-3200
Carboxylic acids	3300-2500
C=C stretching vibrations	
Isolated alkene	1669-1645
Arene	1600, 1580, 1500, 1450
C=O stretching vibrations	
Aldehydes, saturated alkyl	1740-1720
Ketones, alkyl	1720-1700
Ketones, aryl	1700-1680
Carboxylic acids, alkyl	1725-1700
Carboxylic acids, aryl	1700-1680
Carboxylic acid, anhydrides	1850-1800 and 1790-1740
Acyl halides, chlorides	1795
Acyl halides, bromides	1810
Esters, saturated	1750-1735
Amides	1700-1630
Triple bond stretching vibrations	
C≡N	2260-2215
C≡C	2260-2100

^{1}H nuclear magnetic resonance chemical shifts relative to tetramethylsilane (TMS)



^{13}C nuclear magnetic resonance chemical shifts relative to tetramethylsilane (TMS)



Pauling electronegativities

Pauling electronegativity index

							H										He
							2·1										
Li	Be											B	C	N	O	F	Ne
1·0	1·5											2·0	2·5	3·0	3·5	4·0	
Na	Mg											Al	Si	P	S	Cl	Ar
0·9	1·2											1·5	1·9	2·1	2·5	3·0	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
0·8	1·0	1·3	1·5	1·6	1·6	1·5	1·8	1·8	1·8	1·9	1·6	1·6	2·0	2·0	2·4	2·8	
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
0·8	1·0	1·2	1·3	1·6	2·1	1·9	2·2	2·2	2·2	1·9	1·6	1·7	1·9	1·9	2·1	2·5	
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
0·7	0·9	1·1	1·3	1·5	2·3	1·9	2·2	2·2	2·2	2·5	2·0	1·6	1·8	1·9	2·0	2·2	

Indicators

		p*K*in (at 298 K)	***acid***	**pH range**	***alkaline***
1	Thymol blue (acid)	1.7	red	1.2–2.8	yellow
2	Screened methyl orange	3.7	purple	3.2–4.2	green
3	Methyl orange	3.7	red	3.2–4.4	yellow
4	Bromophenol blue	4.0	yellow	2.8–4.6	blue
5	Bromocresol green	4.7	yellow	3.8–5.4	blue
6	Methyl red	5.1	red	4.2–6.3	yellow
7	Litmus		red	5.0–8.0	blue
8	Bromothymol blue	7.0	yellow	6.0–7.6	blue
9	Phenol red	7.9	yellow	6.8–8.4	red
10	Phenolphthalein (in ethanol)	9.3	colourless	8.2–10.0	red

Standard electrode potentials

$E^{\ominus}$ Standard electrode potential of aqueous system at 298 K, that is, standard emf of electrochemical cell in the hydrogen half-cell forms the left-hand side electrode system.

	Right-hand electrode system	$E^{\ominus}$/V
1	$Na^+ + e^- \rightleftharpoons Na$	−2.71
2	$Mg^{2+} + 2e^- \rightleftharpoons Mg$	−2.37
3	$Al^{3+} + 3e^- \rightleftharpoons Al$	−1.66
4	$V^{2+} + 2e^- \rightleftharpoons V$	−1.18
5	$Zn^{2+} + 2e^- \rightleftharpoons Zn$	−0.76
6	$Cr^{3+} + 3e^- \rightleftharpoons Cr$	−0.74
7	$Fe^{2+} + 2e^- \rightleftharpoons Fe$	−0.44
8	$Cr^{3+} + e^- \rightleftharpoons Cr^{2+}$	−0.41
9	$V^{3+} + e^- \rightleftharpoons V^{2+}$	−0.26
10	$Ni^{2+} + 2e^- \rightleftharpoons Ni$	−0.25
11	$H^+ + e^- \rightleftharpoons ½H_2$	0.00
12	$S_4O_6^{2-} + 2e^- \rightleftharpoons 2S_2O_3^{2-}$	+0.09
13	$Cu^{2+} + e^- \rightleftharpoons Cu^+$	+0.15
14	$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+0.34
15	$VO^{2+} + 2H^+ + e^- \rightleftharpoons V^{3+} + H_2O$	+0.34
16	$O_2 + 2H_2O + 4e^- \rightleftharpoons 4OH^-$	+0.40
17	$S_2O_3^{2-} + 6H^+ + 4e^- \rightleftharpoons 2S + 3H_2O$	+0.47
18	$Cu^+ + e^- \rightleftharpoons Cu$	+0.52
19	$I_2 + 2e^- \rightleftharpoons 2I^-$	+0.54
20	$O_2 + 2H^+ + 2e^- \rightleftharpoons H_2O_2$	+0.68
21	$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	+0.77
22	$Ag^+ + e^- \rightleftharpoons Ag$	+0.80
23	$NO_3^- + 2H^+ + e^- \rightleftharpoons NO_2 + H_2O$	+0.80
24	$ClO^- + H_2O + 2e^- \rightleftharpoons Cl^- + 2OH^-$	+0.89
25	$VO_2^+ + 2H^+ + e^- \rightleftharpoons VO^{2+} + H_2O$	+1.00
26	$Br_2 + 2e^- \rightleftharpoons 2Br^-$	+1.09
27	$O_2 + 4H^+ + 4e^- \rightleftharpoons 2H_2O$	+1.23
28	$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	+1.33
29	$Cl_2 + 2e^- \rightleftharpoons 2Cl^-$	+1.36
30	$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$	+1.51
31	$H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O$	+1.77

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass **atomic symbol** name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103