



Trial Examination 2010

VCE Chemistry Unit 4

Written Examination

Data Booklet

Directions to students

This data booklet is provided for your reference.

Any writing, jottings, notes or drawings you make on this data booklet will **not** be considered in the marking.

You may keep this data booklet.

1. Periodic Table of the elements

atomic number		symbol of element		relative atomic mass		name of element	
1	H	1.0	hydrogen	79	Au	197.0	gold
2	He	4.0	helium	80	Hg	200.6	mercury
3	Li	6.9	lithium	81	Tl	204.4	thallium
4	Be	9.0	beryllium	82	Pb	207.2	lead
5	B	10.8	boron	83	Bi	209.0	bismuth
6	C	12.0	carbon	84	Po	(209)	polonium
7	N	14.0	nitrogen	85	At	(210)	astatine
8	O	16.0	oxygen	86	Rn	(222)	radon
9	F	19.0	fluorine	87	Fr	(223)	francium
10	Ne	20.2	neon	88	Ra	(226)	radium
11	Na	23.0	sodium	89	Ac	(227)	actinium
12	Mg	24.3	magnesium	90	Th	232.0	thorium
13	Al	27.0	aluminium	91	Pa	231.0	protactinium
14	Si	28.1	silicon	92	U	238.0	uranium
15	P	31.0	phosphorus	93	Np	237.1	neptunium
16	S	32.1	sulfur	94	Pu	(244)	plutonium
17	Cl	35.5	chlorine	95	Am	(243)	americium
18	Ar	39.9	argon	96	Cm	(251)	curium
19	K	39.1	potassium	97	Bk	(247)	berkelium
20	Ca	40.1	calcium	98	Cf	(251)	californium
21	Sc	44.9	scandium	99	Es	(252)	einsteinium
22	Ti	47.9	titanium	100	Fm	(257)	fermium
23	V	50.9	vanadium	101	Md	(258)	mendelevium
24	Cr	52.0	chromium	102	No	(259)	nobelium
25	Mn	54.9	manganese	103	Lr	(260)	lawrencium
26	Fe	55.8	iron	104	Rf	(261)	rutherfordium
27	Co	58.9	cobalt	105	Db	(262)	dubnium
28	Ni	58.7	nickel	106	Sg	(263)	seaborgium
29	Cu	63.5	copper	107	Bh	(264)	bohrium
30	Zn	65.4	zinc	108	Hs	(265)	hassium
31	Ga	69.7	gallium	109	Mt	(268)	meitnerium
32	Ge	72.6	germanium	110	Ds	(271)	darmstadtium
33	As	74.9	arsenic	111	Rg	(272)	roentgenium
34	Se	79.0	selenium	112	Uub		unubium
35	Br	79.9	bromine	113			
36	Kr	83.8	krypton	114	Uuq		ununquadium
37	Rb	85.5	rubidium	115			
38	Sr	87.6	strontium	116	Uuh		ununhexium
39	Y	88.9	yttrium	117			
40	Zr	91.2	zirconium	118	Uuo		ununoctium
41	Nb	92.9	niobium				
42	Mo	95.9	molybdenum				
43	Tc	98.1	technetium				
44	Ru	101.1	ruthenium				
45	Rh	102.9	rhodium				
46	Pd	106.4	palladium				
47	Ag	107.9	silver				
48	Cd	112.4	cadmium				
49	In	114.8	indium				
50	Sn	118.7	tin				
51	Sb	121.8	antimony				
52	Te	127.6	tellurium				
53	I	126.9	iodine				
54	Xe	131.3	xenon				
55	Cs	132.9	caesium				
56	Ba	137.3	barium				
57	La	138.9	lanthanum				
58	Ce	140.1	cerium				
59	Pr	140.9	praseodymium				
60	Nd	144.2	neodymium				
61	Pm	(145)	promethium				
62	Sm	150.3	samarium				
63	Eu	152.0	europlium				
64	Gd	157.2	gadolinium				
65	Tb	158.9	terbium				
66	Dy	162.5	dysprosium				
67	Ho	164.9	holmium				
68	Er	167.3	erbium				
69	Tm	168.9	thulium				
70	Yb	173.0	ytterbium				
71	Lu	175.0	lutetium				
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2. The electrochemical series

	E° in volt
$\text{F}_2(\text{g}) + 2\text{e}^- \rightleftharpoons 2\text{F}^-(\text{aq})$	+2.87
$\text{H}_2\text{O}_2(\text{aq}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}(\text{l})$	+1.77
$\text{Au}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{Au}(\text{s})$	+1.68
$\text{Cl}_2(\text{g}) + 2\text{e}^- \rightleftharpoons 2\text{Cl}^-(\text{aq})$	+1.36
$\text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}(\text{l})$	+1.23
$\text{Br}_2(\text{l}) + 2\text{e}^- \rightleftharpoons 2\text{Br}^-(\text{aq})$	+1.09
$\text{Ag}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{Ag}(\text{s})$	+0.80
$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightleftharpoons \text{Fe}^{2+}(\text{aq})$	+0.77
$\text{O}_2(\text{g}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{H}_2\text{O}_2(\text{aq})$	+0.68
$\text{I}_2(\text{s}) + 2\text{e}^- \rightleftharpoons 2\text{I}^-(\text{aq})$	+0.54
$\text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + 4\text{e}^- \rightleftharpoons 4\text{OH}^-(\text{aq})$	+0.40
$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Cu}(\text{s})$	+0.34
$\text{Sn}^{4+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Sn}^{2+}(\text{aq})$	+0.15
$\text{S}(\text{s}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{H}_2\text{S}(\text{g})$	+0.14
$2\text{H}^+(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{H}_2(\text{g})$	0.00
$\text{Pb}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Pb}(\text{s})$	-0.13
$\text{Sn}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Sn}(\text{s})$	-0.14
$\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Ni}(\text{s})$	-0.23
$\text{Co}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Co}(\text{s})$	-0.28
$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Fe}(\text{s})$	-0.44
$\text{Zn}^{2+} + 2\text{e}^- \rightleftharpoons \text{Zn}(\text{s})$	-0.76
$2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightleftharpoons \text{H}_2(\text{g}) + 2\text{OH}^-$	-0.83
$\text{Mn}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Mn}(\text{s})$	-1.03
$\text{Al}^{3+}(\text{aq}) + 3\text{e}^- \rightleftharpoons \text{Al}(\text{s})$	-1.67
$\text{Mg}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Mg}(\text{s})$	-2.34
$\text{Na}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{Na}(\text{s})$	-2.71
$\text{Ca}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Ca}(\text{s})$	-2.87
$\text{K}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{K}(\text{s})$	-2.93
$\text{Li}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{Li}(\text{s})$	-3.02

3. Physical constants

Avogadro's constant (N_A) = $6.02 \times 10^{23} \text{ mol}^{-1}$

Charge on one electron = $-1.60 \times 10^{-19} \text{ C}$

Faraday constant (F) = $96\,500 \text{ C mol}^{-1}$

Gas constant (R) = $8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

Ionic product for water (K_W) = $1.00 \times 10^{-14} \text{ mol}^2 \text{ L}^{-2}$ at 298 K (self ionisation constant)

Molar volume (V_m) of an ideal gas at 273 K, 101.3 kPa (STP) = 22.4 L mol^{-1}

Molar volume (V_m) of an ideal gas at 298 K, 101.3 kPa (SLC) = 24.5 L mol^{-1}

Specific heat capacity (c) of water = $4.18 \text{ J g}^{-1} \text{ K}^{-1}$

Density (d) of water at 25°C = 1.00 g mL^{-1}

1 atm = 101.3 kPa = 760 mmHg

0°C = 273 K

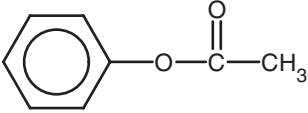
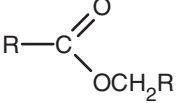
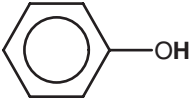
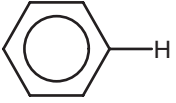
4. SI prefixes, their symbols and values

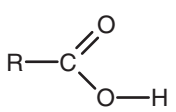
SI prefix	Symbol	Value
giga	G	10^9
mega	M	10^6
kilo	k	10^3
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

5. ¹H NMR data

Typical proton shift values relative to TMS = 0.

These can differ slightly in different solvents. Where more than one proton environment is shown in the formula, the shift refers to the ones in bold letters.

Type of proton	Chemical shift (ppm)
R-CH_3 $\text{R-CH}_2\text{-R}$ RCH=CH-CH_3 $\text{R}_3\text{-CH}$ $\text{CH}_3\text{-C(=O)OR}$ or $\text{CH}_3\text{-C(=O)NHR}$	0.9 1.3 1.7 2.0 2.0
R-C(=O)CH_3 $\text{R-CH}_2\text{-X}$ (X = F, Cl, Br or I) $\text{R-CH}_2\text{-OH}$ $\text{R-C(=O)NHCH}_2\text{R}$	2.1 3–4 3.6 3.2
R-O-CH_3 or $\text{R-O-CH}_2\text{R}$   R-O-H R-NH_2 RHC=CH_2  	3.3 4.1 4.1 1–6 (varies considerably under different conditions) 1–5 4.6–6.0 7.0 7.3
$\text{R-C(=O)NHCH}_2\text{R}$	8.1
R-C(=O)H	9–10

Type of proton	Chemical shift (ppm)
	11.5

6. ^{13}C NMR data

Type of carbon	Chemical shift (ppm)
R-CH ₃	8–25
R-CH ₂ -R	20–45
R ₃ -CH	40–60
R ₄ -C	36–45
R-CH ₂ -X	15–80
RC-NH ₂	35–70
R-CH ₂ -OH	50–90
RC≡CR	75–95
RC=CR	110–150
RCOOH	160–185

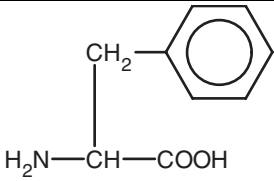
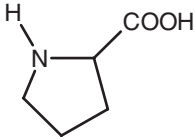
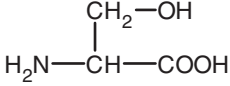
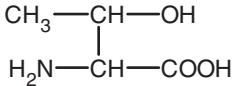
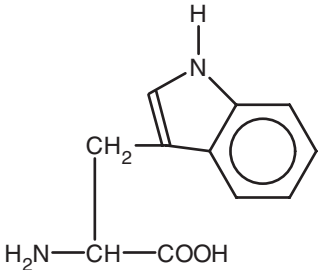
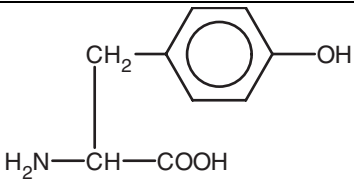
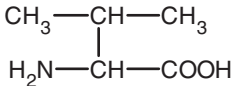
7. Infrared absorption data

Characteristic range for infrared absorption.

Bond	Wave number (cm ⁻¹)
C-Cl	700–800
C-C	750–1100
C-O	1000–1300
C=C	1610–1680
C=O	1670–1750
O-H (acids)	2500–3300
C-H	2850–3300
O-H (alcohols)	3200–3550
N-H (primary amines)	3350–3500

8. 2-amino acids (α -amino acids)

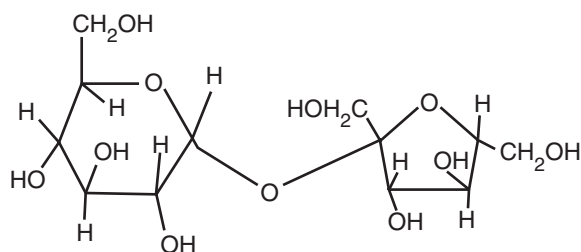
Name	Symbol	Structure
alanine	Ala	$\begin{array}{c} \text{CH}_3 \\ \\ \text{H}_2\text{N}-\text{CH}-\text{COOH} \end{array}$
arginine	Arg	$\begin{array}{c} \text{CH}_2-\text{CH}_2-\text{CH}_2-\text{NH}-\text{C}(\text{NH})=\text{NH}_2 \\ \\ \text{H}_2\text{N}-\text{CH}-\text{COOH} \end{array}$
asparagine	Asn	$\begin{array}{c} \text{O} \\ \\ \text{CH}_2-\text{C}-\text{NH}_2 \\ \\ \text{H}_2\text{N}-\text{CH}-\text{COOH} \end{array}$
aspartic acid	Asp	$\begin{array}{c} \text{CH}_2-\text{COOH} \\ \\ \text{H}_2\text{N}-\text{CH}-\text{COOH} \end{array}$
cysteine	Cys	$\begin{array}{c} \text{CH}_2-\text{SH} \\ \\ \text{H}_2\text{N}-\text{CH}-\text{COOH} \end{array}$
glutamine	Gln	$\begin{array}{c} \text{O} \\ \\ \text{CH}_2-\text{CH}_2-\text{C}-\text{NH}_2 \\ \\ \text{H}_2\text{N}-\text{CH}-\text{COOH} \end{array}$
glutamic acid	Glu	$\begin{array}{c} \text{CH}_2-\text{CH}_2-\text{COOH} \\ \\ \text{H}_2\text{N}-\text{CH}-\text{COOH} \end{array}$
glycine	Gly	$\text{H}_2\text{N}-\text{CH}_2-\text{COOH}$
histidine	His	$\begin{array}{c} \text{N} \\ // \quad \backslash \\ \text{CH}_2 \quad \text{N}-\text{H} \\ \\ \text{H}_2\text{N}-\text{CH}-\text{COOH} \end{array}$
isoleucine	Ile	$\begin{array}{c} \text{CH}_3-\text{CH}-\text{CH}_2-\text{CH}_3 \\ \\ \text{H}_2\text{N}-\text{CH}-\text{COOH} \end{array}$
leucine	Leu	$\begin{array}{c} \text{CH}_3-\text{CH}-\text{CH}_3 \\ \\ \text{CH}_2 \\ \\ \text{H}_2\text{N}-\text{CH}-\text{COOH} \end{array}$
lysine	Lys	$\begin{array}{c} \text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{NH}_2 \\ \\ \text{H}_2\text{N}-\text{CH}-\text{COOH} \end{array}$
methionine	Met	$\begin{array}{c} \text{CH}_2-\text{CH}_2-\text{S}-\text{CH}_3 \\ \\ \text{H}_2\text{N}-\text{CH}-\text{COOH} \end{array}$

Name	Symbol	Structure
phenylalanine	Phe	 $\begin{array}{c} \text{CH}_2 - \text{C}_6\text{H}_5 \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$
proline	Pro	 $\begin{array}{c} \text{H} \\ \\ \text{N} \\ \\ \text{COOH} \end{array}$
serine	Ser	 $\begin{array}{c} \text{CH}_2 - \text{OH} \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$
threonine	Thr	 $\begin{array}{c} \text{CH}_3 - \text{CH} - \text{OH} \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$
tryptophan	Trp	 $\begin{array}{c} \text{CH}_2 - \text{Indole} \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$
tyrosine	Tyr	 $\begin{array}{c} \text{CH}_2 - \text{C}_6\text{H}_4 - \text{OH} \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$
valine	Val	 $\begin{array}{c} \text{CH}_3 - \text{CH} - \text{CH}_3 \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$

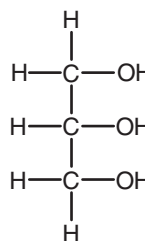
9. Formulas of some fatty acids

Name	Formula
lauric	$C_{11}H_{23}COOH$
myristic	$C_{13}H_{27}COOH$
palmitic	$C_{15}H_{31}COOH$
palmitoleic	$C_{15}H_{29}COOH$
stearic	$C_{17}H_{35}COOH$
oleic	$C_{17}H_{33}COOH$
linoleic	$C_{17}H_{31}COOH$
linolenic	$C_{17}H_{29}COOH$
arachidic	$C_{19}H_{39}COOH$
arachidonic	$C_{19}H_{31}COOH$

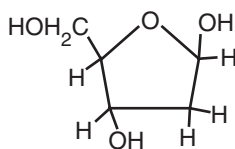
10. Structural formulas of some important biomolecules



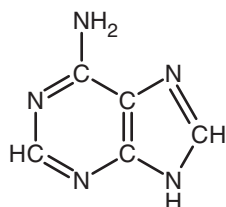
sucrose



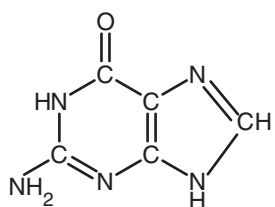
glycerol



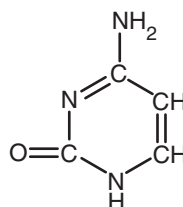
deoxyribose



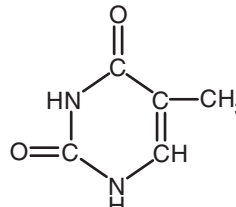
adenine



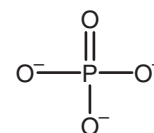
guanine



cytosine



thymine



phosphate

11. Acid–base indicators

Name	pH range	Colour change		K_a
		Acid	Base	
thymol blue	1.2–2.8	red	yellow	2×10^{-2}
methyl orange	3.1–4.4	red	yellow	2×10^{-4}
bromophenol blue	3.0–4.6	yellow	blue	6×10^{-5}
methyl red	4.2–6.3	red	yellow	8×10^{-6}
bromothymol blue	6.0–7.6	yellow	blue	1×10^{-7}
phenol red	6.8–8.4	yellow	red	1×10^{-8}
phenolphthalein	8.3–10.0	colourless	red	5×10^{-10}

12. Acidity constants, K_a , of some weak acids

Name	Formula	K_a
ammonium ion	NH_4^+	5.6×10^{-10}
benzoic	$\text{C}_6\text{H}_5\text{COOH}$	6.4×10^{-5}
boric	H_3BO_3	5.8×10^{-10}
ethanoic	CH_3COOH	1.7×10^{-5}
hydrocyanic	HCN	6.3×10^{-10}
hydrofluoric	HF	7.6×10^{-4}
hypobromous	HOBr	2.4×10^{-9}
hypochlorous	HOCl	2.9×10^{-8}
lactic	$\text{HC}_3\text{H}_5\text{O}_3$	1.4×10^{-4}
methanoic	HCOOH	1.8×10^{-4}
nitrous	HNO_2	7.2×10^{-4}
propanoic	$\text{C}_2\text{H}_5\text{COOH}$	1.3×10^{-5}

13. Values of molar enthalpy of combustions of some common fuels at 298 K and 101.3 kPa

Substance	Formula	State	ΔH_c (kJ mol ⁻¹)
hydrogen	H ₂	g	-286
carbon (graphite)	C	s	-394
methane	CH ₄	g	-889
ethane	C ₂ H ₆	g	-1557
propane	C ₃ H ₈	g	-2217
butane	C ₄ H ₁₀	g	-2874
pentane	C ₅ H ₁₂	l	-3509
hexane	C ₆ H ₁₄	l	-4158
octane	C ₈ H ₁₈	l	-5464
ethene	C ₂ H ₄	g	-1409
methanol	CH ₃ OH	l	-725
ethanol	C ₂ H ₅ OH	l	-1364
1-propanol	CH ₃ CH ₂ CH ₂ OH	l	-2016
2-propanol	CH ₃ CHOHCH ₃	l	-2003
glucose	C ₆ H ₁₂ O ₆	s	-2816

END OF DATA BOOKLET