



Trial Examination 2010

VCE Chemistry Unit 4

Written Examination

Data Booklet

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1. Periodic Table of the elements

1 H 1.0 hydrogen																	2 He 4.0 helium
3 Li 6.9 lithium	4 Be 9.0 beryllium															9 F 19.0 fluorine	10 Ne 20.2 neon
11 Na 23.0 sodium	12 Mg 24.3 magnesium															17 Cl 35.5 chlorine	18 Ar 39.9 argon
19 K 39.1 potassium	20 Ca 40.1 calcium	21 Sc 44.9 scandium	22 Ti 47.9 titanium	23 V 50.9 vanadium	24 Cr 52.0 chromium	25 Mn 54.9 manganese	26 Fe 55.8 iron	27 Co 58.9 cobalt	28 Ni 58.7 nickel	29 Cu 63.5 copper	30 Zn 65.4 zinc	31 Ga 69.7 gallium	32 Ge 72.6 germanium	33 As 74.9 arsenic	34 Se 79.0 selenium	35 Br 79.9 bromine	36 Kr 83.8 krypton
37 Rb 85.5 rubidium	38 Sr 87.6 strontium	39 Y 88.9 yttrium	40 Zr 91.2 zirconium	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	72 Hf 178.5 hafnium	73 Ta 180.9 tantalum	74 W 183.8 tungsten	75 Re 186.2 rhenium	76 Os 190.2 osmium	77 Ir 192.2 iridium	78 Pt 195.1 platinum	79 Au 197.0 gold	80 Hg 200.6 mercury	81 Tl 204.4 thallium	82 Pb 207.2 lead	83 Bi 209.0 bismuth	84 Po (209) polonium	85 At (210) astatine	86 Rn (222) radon
87 Fr (223) francium	88 Ra (226) radium	89 Ac (227) actinium	104 Rf (261) rutherfordium	105 Db (262) dubnium	106 Sg (263) seaborgium	107 Bh (264) bohrium	108 Hs (265) hassium	109 Mt (268) meitnerium	110 Ds (271) darmstadtium	111 Rg (272) roentgenium	112 Uub (272) ununbium	114 Uuq (272) ununquadium	116 Uuh (272) ununhexium	118 Uuo (272) ununoctium			

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 europium	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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90 Th 232.0 thorium	91 Pa 231.0 protactinium	92 U 238.0 uranium	93 Np 237.1 neptunium	94 Pu (244) plutonium	95 Am (243) americium	96 Cm (251) curium	97 Bk (247) berkelium	98 Cf (251) californium	99 Es (252) einsteinium	100 Fm (257) fermium	101 Md (258) mendelevium	102 No (259) nobelium	103 Lr (260) lawrencium
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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

$0^\circ\text{C} = 273 \text{ K}$

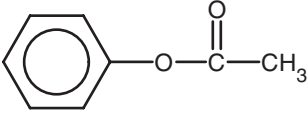
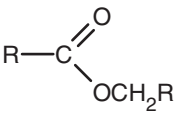
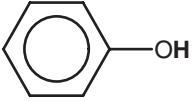
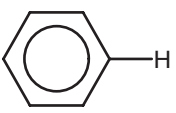
4. SI prefixes, their symbols and values

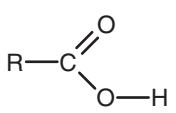
SI prefix	Symbol	Value
giga	G	10^9
mega	M	10^6
kilo	k	10^3
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

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)
$\text{R}-\text{CH}_3$ $\text{R}-\text{CH}_2-\text{R}$ $\text{RCH}=\text{CH}-\text{CH}_3$ R_3-CH $\text{CH}_3-\text{C}(=\text{O})\text{OR}$ or $\text{CH}_3-\text{C}(=\text{O})\text{NHR}$	0.9 1.3 1.7 2.0 2.0
$\text{R}-\text{C}(=\text{O})\text{CH}_3$ $\text{R}-\text{CH}_2-\text{X}$ (X = F, Cl, Br or I) $\text{R}-\text{CH}_2-\text{OH}$ $\text{R}-\text{C}(=\text{O})\text{NHCH}_2\text{R}$	2.1 3–4 3.6 3.2
$\text{R}-\text{O}-\text{CH}_3$ or $\text{R}-\text{O}-\text{CH}_2\text{R}$   $\text{R}-\text{O}-\text{H}$ $\text{R}-\text{NH}_2$ $\text{RHC}=\text{CH}_2$  	3.3 4.1 4.1 1–6 (varies considerably under different conditions) 1–5 4.6–6.0 7.0 7.3
$\text{R}-\text{C}(=\text{O})\text{NHCH}_2\text{R}$	8.1
$\text{R}-\text{C}(=\text{O})\text{H}$	9–10

Type of proton	Chemical shift (ppm)
	11.5

6. ^{13}C NMR data

Type of carbon	Chemical shift (ppm)
$\text{R}-\text{CH}_3$	8–25
$\text{R}-\text{CH}_2-\text{R}$	20–45
R_3-CH	40–60
R_4-C	36–45
$\text{R}-\text{CH}_2-\text{X}$	15–80
$\text{RC}-\text{NH}_2$	35–70
$\text{R}-\text{CH}_2-\text{OH}$	50–90
$\text{RC}\equiv\text{CR}$	75–95
$\text{RC}=\text{CR}$	110–150
RCOOH	160–185

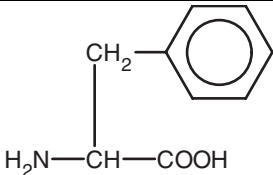
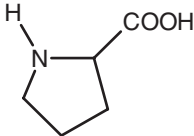
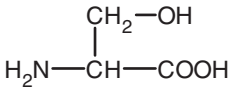
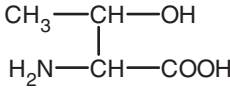
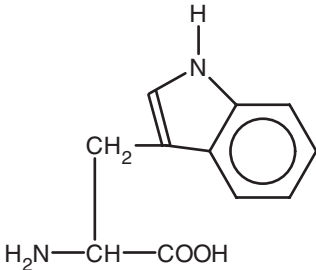
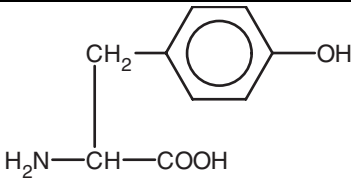
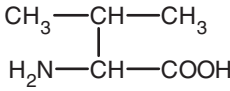
7. Infrared absorption data

Characteristic range for infrared absorption.

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

8. 2-amino acids (α -amino acids)

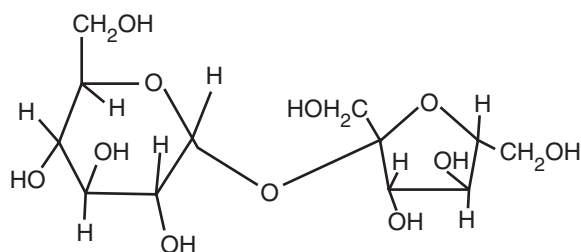
Name	Symbol	Structure
alanine	Ala	$\begin{array}{c} \text{CH}_3 \\ \\ \text{H}_2\text{N}-\text{CH}-\text{COOH} \end{array}$
arginine	Arg	$\begin{array}{c} \text{CH}_2-\text{CH}_2-\text{CH}_2-\text{NH}-\text{C}(=\text{NH})-\text{NH}_2 \\ \\ \text{H}_2\text{N}-\text{CH}-\text{COOH} \end{array}$
asparagine	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	$\begin{array}{c} \text{N} \\ // \quad \backslash \\ \text{CH}_2-\text{C} \quad \text{N}-\text{H} \\ \\ \text{H}_2\text{N}-\text{CH}-\text{COOH} \end{array}$
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	 <chem>N[C@@H](Cc1ccccc1)C(=O)O</chem>
proline	Pro	 <chem>O=C(O)[C@@H]1CCCN1</chem>
serine	Ser	 <chem>N[C@@H](CO)C(=O)O</chem>
threonine	Thr	 <chem>C[C@H](O)[C@@H](N)C(=O)O</chem>
tryptophan	Trp	 <chem>N[C@@H](Cc1c[nH]c2ccccc12)C(=O)O</chem>
tyrosine	Tyr	 <chem>N[C@@H](Cc1ccc(O)cc1)C(=O)O</chem>
valine	Val	 <chem>CC(C)[C@@H](N)C(=O)O</chem>

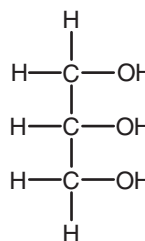
9. Formulas of some fatty acids

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	$C_{19}H_{31}COOH$

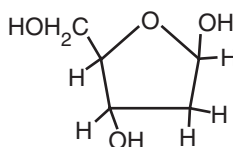
10. Structural formulas of some important biomolecules



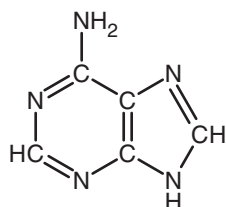
sucrose



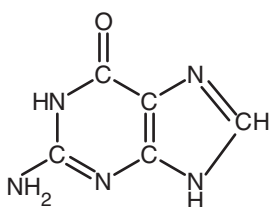
glycerol



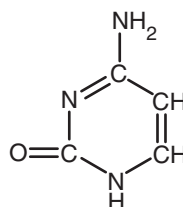
deoxyribose



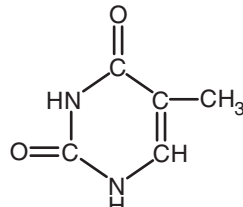
adenine



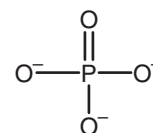
guanine



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