

QCE Chemistry Units 1&2

Paper 1

Student's Name: _____

Teacher's Name: _____

Time allowed

- Perusal time – 10 minutes
- Working time – 90 minutes

General instructions

- Answer all questions in this question and response booklet.
- QCAA-approved calculator permitted.
- Formula and data booklet provided.
- Planning paper will not be marked.

Section 1 (25 marks)

- 25 multiple choice questions

Section 2 (35 marks)

- 7 short response questions

SECTION 1**Instructions**

- Choose the best answer for Questions 1–25.
- This section has 25 questions and is worth 25 marks.
- Use a 2B pencil to fill in the A, B, C or D answer bubble completely.
- If you change your mind or make a mistake, use an eraser to remove your response and fill in the new answer bubble completely.

	A	B	C	D
Example:	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

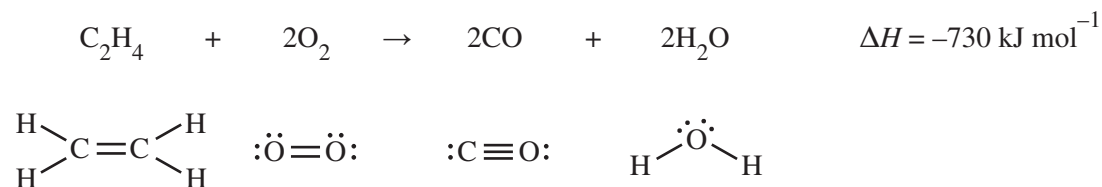
	A	B	C	D
1.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
13.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
14.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
15.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
16.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
17.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
18.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
19.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
20.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
21.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
22.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
23.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
24.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
25.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

SECTION 2**Instructions**

- Write using black or blue pen.
- If you need more space for a response, use the additional pages at the back of this booklet.
 - On the additional pages, write the question number you are responding to.
 - Cancel any incorrect response by ruling a single diagonal line through your work.
 - Write the page number of your alternative/additional response, i.e. See page ...
 - If you do not do this, your original response will be marked.
- This section has seven questions and is worth 35 marks.

QUESTION 26 (5 marks)

Incomplete combustion can result in the formation of carbon monoxide. The reaction below shows the incomplete combustion of ethene.

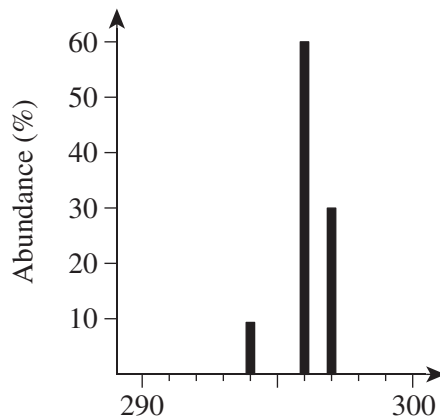


Calculate the bond enthalpy of the $\text{C} \equiv \text{O}$ bond. Show your working.

Bond enthalpy = _____ kJ mol^{-1} (to four significant figures)
--

QUESTION 27 (5 marks)

Mass spectroscopy can be used to provide information about the composition of different elements. The mass spectrum of unknown element X is shown below.



- a) Define the term *isotopes*. [1 mark]

- b) Determine the number of isotopes in the sample of element X. [1 mark]

- c) Calculate the relative atomic mass of element X. Show your working. [3 marks]

Relative atomic mass = _____ amu (to three significant figures)

QUESTION 28 (5 marks)

Bubbles are formed when a strip of magnesium is placed in a solution of hydrochloric acid. The temperature of the reaction mixture also increases.

- a) Describe the reaction by writing a balanced chemical equation. *[2 marks]*

- b) Explain the thermochemical nature of this reaction. *[3 marks]*

QUESTION 29 (5 marks)

The table below shows the subatomic particles in six different chemical species.

Species	Protons	Neutrons	Electrons
A	11	13	11
D	8	8	8
E	19	20	19
G	10	10	10
J	11	12	10
L	17	20	17

- a) Describe species G using nuclear (isotope) notation. *[1 mark]*

- b) Determine the full electron configuration for species E. *[1 mark]*

- c) Identify a species from the table that is charged. *[1 mark]*

- d) Identify two species from the table that have similar chemical properties. *[1 mark]*

- e) Identify two species from the table that will form a covalent bond. *[1 mark]*

QUESTION 30 (6 marks)

Complete the table below by drawing the Lewis (electron dot) structures and identifying the VSEPR shape for each species.

	Hydrogen sulfide H ₂ S	Carbonate ion CO ₃ ²⁻
Lewis structure		
VSEPR shape		

QUESTION 31 (3 marks)

Lead(II) iodide is a bright yellow solid that is insoluble in water.

- a) Identify two solutions that could be combined to produce lead(II) iodide. *[1 mark]*

- b) Describe this reaction using a balanced net ionic equation, including state symbols. *[2 marks]*

QUESTION 32 (6 marks)

Galactose is a carbohydrate that contains, by mass, 40% carbon, 6.7% hydrogen and 53.3% oxygen.

- a) Determine the empirical formula of galactose. Show your working. *[3 marks]*

Empirical formula = _____

- b) The molar mass of galactose is approximately 180 g.
Determine the molecular formula of galactose. Show your working. *[3 marks]*

Molecular formula = _____

END OF PAPER



Trial Examination 2021

Formula and data booklet

QCE Chemistry Units 1&2

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FORMULAS**Processing of data**

$$\text{Absolute uncertainty of the mean } \Delta\bar{x} = \pm \frac{(x_{\max} - x_{\min})}{2}$$

$$\text{Percentage uncertainty (\%)} = \frac{\text{absolute uncertainty}}{\text{measurement}} \times \frac{100}{1}$$

$$\text{Percentage error (\%)} = \left| \frac{\text{measured value} - \text{true value}}{\text{true value}} \right| \times 100$$

Chemical reactions – reactants, products and energy change

$$\Delta H = H_{(\text{products})} - H_{(\text{reactants})}$$

$$\Delta H = \Sigma(\text{bonds broken}) - \Sigma(\text{bonds formed})$$

$$Q = mc\Delta T$$

$$\text{Percentage yield (\%)} = \frac{\text{experimental yield}}{\text{theoretical yield}} \times \frac{100}{1}$$

$$A_r = \frac{(\text{isotopic mass} \times \% \text{ abundance}) + (\text{isotopic mass} \times \% \text{ abundance})}{100}$$

$$\text{Moles } (n) = \frac{\text{number of particles } (N)}{\text{Avogadro's constant } (N_A)}$$

$$\text{Moles} = \frac{\text{mass of substance } (m)}{\text{molar mass } (M)}$$

Intermolecular forces and gas

$$PV = nRT$$

Aqueous solutions and acidity

$$\text{Molarity} = \frac{\text{moles of solute } (n)}{\text{volume of solution } (V)}$$

$$c_1V_1 = c_2V_2$$

PHYSICAL CONSTANTS AND UNIT CONVERSIONS

Physical constants and unit conversions	
Absolute zero	$0 \text{ K} = -273^\circ\text{C}$
Atomic mass unit	$1 \text{ amu} = 1.66 \times 10^{-27} \text{ kg}$
Avogadro's constant	$N_{\text{A}} = 6.02 \times 10^{23} \text{ mol}^{-1}$
Ideal gas constant	$R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$
Molar volume of an ideal gas (at STP)	$2.27 \times 10^{-2} \text{ m}^3 \text{ mol}^{-1} = 22.7 \text{ dm}^3 \text{ mol}^{-1}$
Specific heat capacity of water (at 298 K)	$c_{\text{w}} = 4.18 \text{ J g}^{-1} \text{ K}^{-1}$
Standard temperature and pressure (STP)	273 K and 100 kPa
Volume and capacity conversions	$1 \text{ dm}^3 = 1 \times 10^{-3} \text{ m}^3 = 1 \times 10^3 \text{ cm}^3 = 1 \text{ L}$

LIST OF ELEMENTS

Name	Atomic no.	Symbol
Hydrogen	1	H
Helium	2	He
Lithium	3	Li
Beryllium	4	Be
Boron	5	B
Carbon	6	C
Nitrogen	7	N
Oxygen	8	O
Fluorine	9	F
Neon	10	Ne
Sodium	11	Na
Magnesium	12	Mg
Aluminium	13	Al
Silicon	14	Si
Phosphorus	15	P
Sulfur	16	S
Chlorine	17	Cl
Argon	18	Ar
Potassium	19	K
Calcium	20	Ca
Scandium	21	Sc
Titanium	22	Ti
Vanadium	23	V
Chromium	24	Cr
Manganese	25	Mn
Iron	26	Fe
Cobalt	27	Co
Nickel	28	Ni
Copper	29	Cu
Zinc	30	Zn
Gallium	31	Ga
Germanium	32	Ge
Arsenic	33	As
Selenium	34	Se
Bromine	35	Br

Name	Atomic no.	Symbol
Krypton	36	Kr
Rubidium	37	Rb
Strontium	38	Sr
Yttrium	39	Y
Zirconium	40	Zr
Niobium	41	Nb
Molybdenum	42	Mo
Technetium	43	Tc
Ruthenium	44	Ru
Rhodium	45	Rh
Palladium	46	Pd
Silver	47	Ag
Cadmium	48	Cd
Indium	49	In
Tin	50	Sn
Antimony	51	Sb
Tellurium	52	Te
Iodine	53	I
Xenon	54	Xe
Cesium	55	Cs
Barium	56	Ba
Lanthanum	57	La
Cerium	58	Ce
Praseodymium	59	Pr
Neodymium	60	Nd
Promethium	61	Pm
Samarium	62	Sm
Europium	63	Eu
Gadolinium	64	Gd
Terbium	65	Tb
Dysprosium	66	Dy
Holmium	67	Ho
Erbium	68	Er
Thulium	69	Tm
Ytterbium	70	Yb

LIST OF ELEMENTS (CONTINUED)

Name	Atomic no.	Symbol
Lutetium	71	Lu
Hafnium	72	Hf
Tantalum	73	Ta
Tungsten	74	W
Rhenium	75	Re
Osmium	76	Os
Iridium	77	Ir
Platinum	78	Pt
Gold	79	Au
Mercury	80	Hg
Thallium	81	Tl
Lead	82	Pb
Bismuth	83	Bi
Polonium	84	Po
Astatine	85	At
Radon	86	Rn
Francium	87	Fr
Radium	88	Ra
Actinium	89	Ac
Thorium	90	Th
Protactinium	91	Pa
Uranium	92	U
Neptunium	93	Np
Plutonium	94	Pu

Name	Atomic no.	Symbol
Americium	95	Am
Curium	96	Cm
Berkelium	97	Bk
Californium	98	Cf
Einsteinium	99	Es
Fermium	100	Fm
Mendelevium	101	Md
Nobelium	102	No
Lawrencium	103	Lr
Rutherfordium	104	Rf
Dubnium	105	Db
Seaborgium	106	Sg
Bohrium	107	Bh
Hassium	108	Hs
Meitnerium	109	Mt
Darmstadtium	110	Ds
Roentgenium	111	Rg
Copernicium	112	Cn
Nihonium	113	Nh
Flerovium	114	Fl
Moscovium	115	Mc
Livermorium	116	Lv
Tennessine	117	Ts
Oganesson	118	Og

PERIODIC TABLE OF THE ELEMENTS

		KEY																
		1 atomic number																
		H symbol																
		1.01 relative atomic mass*																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
H 1.01	He 4.00	Li 6.94	Be 9.01	B 10.81	C 12.01	N 14.01	O 16.00	F 19.00	Ne 20.18	Na 22.99	Mg 24.31	Al 26.98	Si 28.09	P 30.97	S 32.06	Cl 35.45	Ar 39.95	
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 65.38	Ga 69.72	Ge 72.63	As 74.92	Se 78.97	Br 79.90	Kr 83.80	
Rb 85.47	Sr 87.62	Y 88.91	Zr 91.22	Nb 92.91	Mo 95.95	Tc (98.91)	Ru 101.07	Rh 102.91	Pd 106.42	Ag 107.87	Cd 112.41	In 114.82	Sn 118.71	Sb 121.76	Te 127.60	I 126.90	Xe 131.29	
Cs 132.91	Ba 137.33	Lanthanoids 57-71	Hf 178.49	Ta 180.95	W 183.84	Re 186.21	Os 190.23	Ir 192.22	Pt 195.08	Au 196.97	Hg 200.59	Tl 204.38	Pb 207.2	Bi 208.98	Po (210.0)	At (210.0)	Rn (222.0)	
Fr (223.0)	Ra (226.1)	Actinoids 89-103	Rf (261.1)	Db (262.1)	Sg (263.1)	Bh (264.1)	Hs (265.1)	Mt (268)	Ds (281)	Rg (272)	Cn (285)	Nh (284)	Fl (289)	Mc (288)	Lv (293)	Ts (294)	Og (294)	
			Lanthanoids															
			57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	
			La 138.91	Ce 140.12	Pr 140.91	Nd 144.24	Pm (146.9)	Sm 150.36	Eu 151.96	Gd 157.25	Tb 158.93	Dy 162.50	Ho 164.93	Er 167.26	Tm 168.93	Yb 173.05	Lu 174.97	
			Actinoids															
			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 (252.1)	Md (258.1)	No (259.1)	Lr (262.1)	

Groups are numbered according to IUPAC convention 1-18.
*Values in brackets are for the isotope with the longest half-life.

ATOMIC AND IONIC RADII OF SELECTED ELEMENTS

		KEY																																																																																	
		atomic number																																																																																	
		symbol																																																																																	
		atomic radius (10^{-12} m)																																																																																	
		charge of ion																																																																																	
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		atomic number																																																																																	
		symbol																																																																																	
		atomic radius (10^{-12} m)																																																																																	
		charge of ion																																																																																	
1	H 1 32 208 (1-)	2	Be 4 99 45 (2+)	3	Li 3 130 76 (1+)	4	Na 11 160 102 (1+)	5	Mg 12 140 72 (2+)	6	K 19 200 138 (1+)	7	Ca 20 174 100 (2+)	8	Rb 37 215 152 (1+)	9	Sr 38 190 118 (2+)	10	Ba 56 206 135 (2+)	11	Sc 21 159 75 (3+)	12	Ti 22 148 86 (2+)	13	V 23 144 79 (2+)	14	Cr 24 130 62 (3+)	15	Mn 25 129 83 (2+)	16	Fe 26 124 78 (2+)	17	Co 27 118 74 (2+)	18	Ni 28 117 69 (2+)	19	Cu 29 122 77 (1+)	20	Zn 30 120 74 (2+)	21	Ga 31 123 62 (3+)	22	Ge 32 120 53 (4+)	23	As 33 120 58 (3+)	24	Se 34 118 188 (2-)	25	Br 35 117 196 (1-)	26	Kr 36 116	27	Y 39 176 90 (3+)	28	Zr 40 164 72 (4+)	29	Nb 41 156 64 (5+)	30	Mo 42 148 65 (4+)	31	Tc 43 138 65 (4+)	32	Ru 44 136 62 (4+)	33	Rh 45 134 67 (3+)	34	Pd 46 130 86 (2+)	35	Ag 47 136 115 (1+)	36	Cd 48 140 95 (2+)	37	In 49 142 80 (3+)	38	Sn 50 140 69 (4+)	39	Sb 51 140 76 (3+)	40	Te 52 137 221 (2-)	41	I 53 136 220 (1-)	42	Xe 54 136

Groups are numbered according to IUPAC convention 1–18.

ELECTRONEGATIVITIES AND FIRST IONISATION ENERGIES OF SELECTED ELEMENTS

1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
H 2.2 1318	Li 1.0 526	Na 0.9 502	Be 1.6 906	K 0.8 425	Ca 1.0 596	Sc 1.4 637	Ti 1.5 664	V 1.6 656	Cr 1.7 659	Mn 1.6 724	Fe 1.8 766	Co 1.9 765	Ni 1.9 743	Cu 1.9 752	Zn 1.7 913	B 2.0 807	Al 1.6 584	Si 1.9 793	P 2.2 1018	S 2.6 1006	Cl 3.2 1257	F 4.0 1687	He 2379	Ga 1.8 585	Ge 2.0 768	As 2.2 953	Se 2.6 947	Br 3.0 1146	Kr 2.9 1357	In 1.8 565	Sn 2.0 715	Sb 2.1 840	Te 2.1 876	I 2.7 1015	Xe 2.6 1177
1 2.2 1318	3 1.0 526	11 0.9 502	4 1.6 906	19 0.8 425	20 1.0 596	21 1.4 637	22 1.5 664	23 1.6 656	24 1.7 659	25 1.6 724	26 1.8 766	27 1.9 765	28 1.9 743	29 1.9 752	30 1.7 913	5 2.0 807	13 1.6 584	14 1.9 793	15 2.2 1018	16 2.6 1006	17 3.2 1257	18 2379	31 1.8 585	32 2.0 768	33 2.2 953	34 2.6 947	35 3.0 1146	36 2.9 1357	49 1.8 565	50 2.0 715	51 2.1 840	52 2.1 876	53 2.7 1015	54 2.6 1177	
1 2.2 1318	3 1.0 526	11 0.9 502	4 1.6 906	19 0.8 425	20 1.0 596	21 1.4 637	22 1.5 664	23 1.6 656	24 1.7 659	25 1.6 724	26 1.8 766	27 1.9 765	28 1.9 743	29 1.9 752	30 1.7 913	5 2.0 807	13 1.6 584	14 1.9 793	15 2.2 1018	16 2.6 1006	17 3.2 1257	18 2379	31 1.8 585	32 2.0 768	33 2.2 953	34 2.6 947	35 3.0 1146	36 2.9 1357	49 1.8 565	50 2.0 715	51 2.1 840	52 2.1 876	53 2.7 1015	54 2.6 1177	

KEY

1	atomic number
H	symbol
2.2	electronegativity
1318	first ionisation enthalpies (kJ mol ⁻¹)

Groups are numbered according to IUPAC convention 1–18.

SOLUBILITY OF SELECTED COMPOUNDS AT 298 K

	bromide	carbonate	chloride	hydroxide	iodide	nitrate	oxide	phosphate	sulfate
aluminium	s	–	s	i	s	s	i	i	s
ammonium	s	s	s	s	s	s	–	s	s
barium	s	i	s	s	s	s	s	i	i
calcium	s	i	s	p	s	s	p	i	p
cobalt(II)	s	i	s	i	s	s	i	i	s
copper(II)	s	–	s	i	i	s	i	i	s
iron(II)	s	i	s	i	s	s	i	i	s
iron(III)	s	–	s	i	s	s	i	i	s
lead(II)	p	i	s	i	i	s	i	i	i
lithium	s	s	s	s	s	s	s	–	s
magnesium	s	i	s	i	s	s	i	p	s
manganese(II)	s	i	s	i	s	s	i	p	s
potassium	s	s	s	s	s	s	s	s	s
silver	i	i	i	i	i	s	i	i	p
sodium	s	s	s	s	s	s	s	s	s
zinc	s	i	s	i	s	s	i	i	s

Key

Abbreviation	Explanation
s	soluble in water (solubility greater than 10 g L ⁻¹)
p	partially soluble in water (solubility between 1 and 10 g L ⁻¹)
i	insoluble in water (solubility less than 1 g L ⁻¹)
–	no data


AVERAGE BOND ENTHALPIES AT 298 K**Single bonds**

	ΔH (kJ mol ⁻¹)								
	H	C	N	O	F	S	Cl	Br	I
H	436								
C	414	346							
N	391	286	158						
O	463	358	214	144					
F	567	492	278	191	159				
S	364	289			327	266			
Cl	431	324	192	206	255	271	242		
Br	366	285		201	249	218	219	193	
I	298	228		201	280		211	178	151

Multiple bonds

Bond	ΔH (kJ mol ⁻¹)
C=C	614
C≡C	839
C=N	615
C≡N	890
C=O	804
N=N	470
N≡N	945
O=O	498

REACTIVITY SERIES OF METALS

Element	Reactivity
K	<p>most reactive</p>  <p>least reactive</p>
Na	
Li	
Ba	
Sr	
Ca	
Mg	
Al	
C*	
Mn	
Zn	
Cr	
Fe	
Cd	
Co	
Ni	
Sn	
Pb	
H ₂ *	
Sb	
Bi	
Cu	
Hg	
Ag	
Au	
Pt	

* Carbon (C) and hydrogen gas (H₂) added for comparison

ACID-BASE INDICATORS

Name	pKa	pH range of colour change	Colour change (acidic to basic)
Methyl orange	3.7	3.1–4.4	red to yellow
Bromophenol blue	4.2	3.0–4.6	yellow to blue
Bromocresol green	4.7	3.8–5.4	yellow to blue
Methyl red	5.1	4.4–6.2	pink to yellow
Bromothymol blue	7.0	6.0–7.6	yellow to blue
Phenol red	7.9	6.8–8.4	yellow to red
Phenolphthalein	9.6	8.3–10.0	colourless to pink

FORMULAS AND CHARGES FOR COMMON POLYATOMIC IONS

Anions		Cations	
acetate (ethanoate)	CH_3COO^- or $\text{C}_2\text{H}_3\text{O}_2^-$	ammonium	NH_4^+
carbonate	CO_3^{2-}	hydronium	H_3O^+
chlorate	ClO_3^-		
chlorite	ClO_2^-		
chromate	CrO_4^{2-}		
citrate	$\text{C}_6\text{H}_5\text{O}_7^{3-}$		
cyanide	CN^-		
dichromate	$\text{Cr}_2\text{O}_7^{2-}$		
dihydrogen phosphate	H_2PO_4^-		
hypochlorite	ClO^-		
hydrogen carbonate	HCO_3^-		
hydrogen sulfate	HSO_4^-		
hydrogen phosphate	HPO_4^{2-}		
hydroxide	OH^-		
nitrate	NO_3^-		
nitrite	NO_2^-		
perchlorate	ClO_4^-		
permanganate	MnO_4^-		
peroxide	O_2^{2-}		
phosphate	PO_4^{3-}		
sulfate	SO_4^{2-}		
sulfite	SO_3^{2-}		
thiosulfate	$\text{S}_2\text{O}_3^{2-}$		

REFERENCES

Aylward, G and Findlay, T 2008, *SI Chemical Data*, 5th ed, John Wiley & Sons, Brisbane.

Haynes, WM (ed) 2016, *CRC Handbook of Chemistry and Physics*, 97th ed, CRC Press, Boca Raton, US.