Neap

Trial Examination 2022

Question and Response Booklet

QCE Chemistry Units 1&2

Paper 2

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.
- Write using black or blue pen.
- QCAA-approved calculator permitted.
- Formula and data booklet provided.
- Planning paper will not be marked.

Section 1 (65 marks)

- 9 short response questions

SECTION 1

Instructions

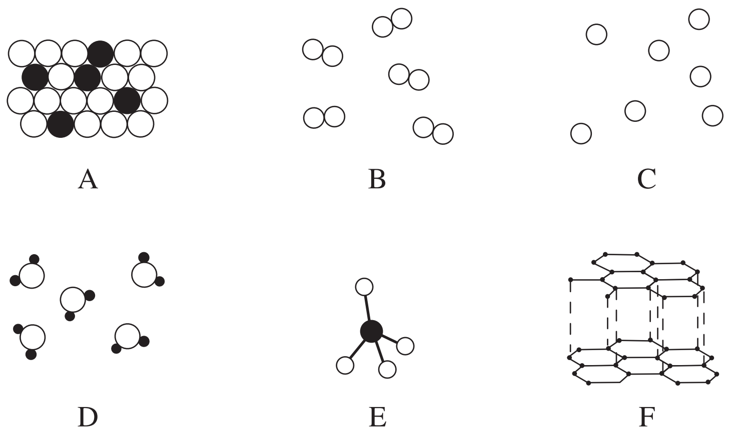
- If you need more space for a response, use the additional pages at the back of this booklet.
  - On the additional pages, write the question number you are responding to.
  - Cancel any incorrect response by ruling a single diagonal line through your work.
  - Write the page number of your alternative/additional response, i.e. See page …
  - If you do not do this, your original response will be marked.

DO NOT WRITE ON THIS PAGE

THIS PAGE WILL NOT BE MARKED

QUESTION 1 (14 marks)

The diagrams A–F represent different types of models of various elements and compounds. Black circles represent different atoms to white circles. White circles do not represent the same atom in different diagrams.



Not to scale

a) Identify which three diagrams (A–F) represent elements. Explain your reasoning. *[2 marks]*

b) Identify the diagram (A–F) that represents a gas containing diatomic molecules and name the gas. Include the molecular formula of the gas in your response. *[2 marks]*

c) Identify the diagram (A–F) that represents a gas containing single atoms. *[1 mark]*

d) Identify the diagram (A–F) that represents graphite. *[1 mark]*

e) Identify the diagrams (A–F) that represent compounds. *[1 mark]*

f) A student thinks that diagrams D and E each represent one of the following.

hydrogen bromide   water   ammonia   methane

Identify diagrams D and E. *[2 marks]*

D ______________________________

E ______________________________

g) i) Draw a Lewis (electron dot) structure of hydrogen bromide. Show the outer shell electrons only. *[1 mark]*

ii) State the type of bonding in hydrogen bromide. *[1 mark]*

Hydrogen bromide dissolves in water to form hydrobromic acid, which is a strong acid.

iii) Define what is meant by a 'strong acid'. *[1 mark]*

iv) Describe a simple chemical test that could be conducted to show that hydrobromic acid is a strong acid. *[1 mark]*

v) Determine the pH value of hydrobromic acid solution. Circle your response. *[1 mark]*

pH 1 pH 4 pH 7 pH 10 pH 14

QUESTION 2 (2 marks)

Biofuels like ethanol are becoming a popular alternative to fossil fuels.

Propose TWO reasons for this.

QUESTION 3 (2 marks)

Identify the states of the stationary and mobile phases of high-performance liquid chromatography.

Stationary phase

Mobile phase

QUESTION 4 (5 marks)

Hydrogen halides are compounds of halogens bonded to hydrogen. The bond polarity of these compounds decreases down the group from hydrogen fluoride to hydrogen iodide.

The boiling points and bond energies of these compounds are shown in the table.

Hydrogen halide	HF	HCl	HBr	HI
Boiling point (°C)	19	–85	–67	–35
H–X bond energy (kJ mol^{-1})	562	431	366	299

a) Define 'bond polarity'. *[1 mark]*

b) i) Explain why the boiling point of hydrogen fluoride is much higher than the other hydrogen halides. *[2 marks]*

ii) Determine the reason for the boiling point trend from hydrogen chloride to hydrogen iodide. *[1 mark]*

c) Are hydrogen halides soluble in water? Justify your response. *[1 mark]*

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QUESTION 5 (10 marks)

Atomic absorption spectroscopy (AAS) is a spectroscopic technique that relies on the absorption of specific wavelengths from a flame to promote electrons within an atom to higher energy levels. It can measure minute traces of metal.

a) Electroplating is used in industry to improve an object's appearance and resistance to corrosion. Cadmium is a toxic metal and is used in electroplating. Water supplies in industrial areas where electroplating is conducted need to be monitored to ensure safe levels of cadmium are maintained. The table shows the absorbance of different cadmium concentrations.

Cadmium concentration (mg L^{-1})	Absorbance
0.00	0.00
1.00	0.04
2.00	0.08
3.00	0.12
4.00	0.16
5.00	0.20
6.00	0.24

i) Use the data in the table to draw a graph of absorbance versus cadmium concentration. *[1 mark]*

ii) Using your graph from 5ai), determine the cadmium concentration in a water sample with an absorbance of 0.180. *[1 mark]*

____

b) A naturally occurring sample of cerium, Ce, contains four isotopes. Data for three of the isotopes is shown in the table.

Isotope	^{136}Ce	^{138}Ce	^{140}Ce	^{142}Ce
Relative isotopic mass	135.91	137.91	139.91	?
Percentage abundance (%)	0.19	0.25	88.45	?

The relative atomic mass of the sample is 140.12.

Use the data to calculate the relative isotopic mass of ^{142}Ce. Show your working. *[3 marks]*

____

____

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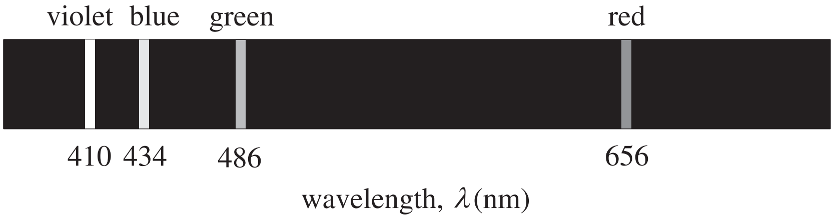
relative isotopic mass = ____________________ (to two decimal places)

c) The emission spectrum of atomic hydrogen in the visible region is known as the Balmer series. An illustration of the series is shown.



Explain why the spectrum appears as a pattern of coloured lines, rather than a continuous spectrum like a rainbow, and identify the transition that produces the green line. *[5 marks]*

QUESTION 6 (11 marks)

The flow chart shows a series of reactions.

$$HCl(aq) \xrightarrow{Mg(s)} \mathbf{A}(aq) + \mathbf{B}(g)$$

$$\downarrow \text{Reagent } \mathbf{X} \text{ (aq)}$$

$$MgCO_3(s) + HNO_3(aq) \longrightarrow \mathbf{C}(aq) + H_2O(l) + \mathbf{D}(g)$$

a) Write the molecular formulas of **A**–**D** and identify reagent **X**. *[5 marks]*

A ______

B ______

C ______

D ______

X ______

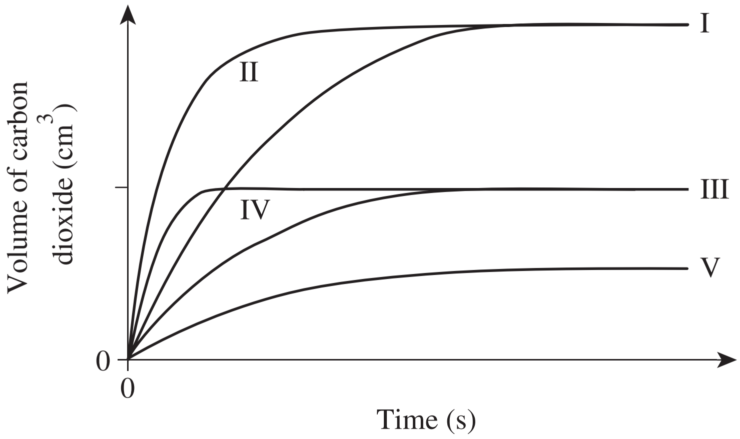
b) i) Write a balanced chemical equation for the reaction between HCl and Mg. *[2 marks]*

ii) Write a net ionic equation for the reaction between HNO_3 and $MgCO_3$. *[2 marks]*

iii) Write a net ionic equation for the reaction between **A** and **X**. *[2 marks]*

QUESTION 7 (8 marks)

A series of experiments was performed to investigate the rate of reaction between calcium carbonate (marble chips) and nitric acid. The data obtained is shown in the graph.



Curve I was produced by the reaction of excess marble chips with 100 cm^3 of 1.0 mol dm^{-3} nitric acid at 20°C.

For each of the following reactions, identify the curve that was produced and explain the factor(s) that were responsible for the difference from curve I.

a) the reaction of 100 cm^3 of 0.5 mol dm^{-3} nitric acid at 20°C with excess marble chips that are the same size *[2 marks]*

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b) the reaction of 50 cm^3 of 1.0 mol dm^{-3} nitric acid at 60°C with excess marble chips that are the same size *[2 marks]*

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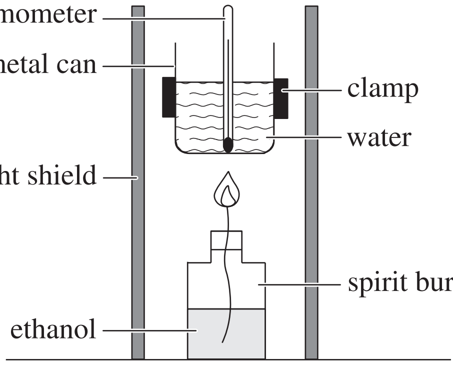
c) the reaction of 50 cm^3 of 0.5 mol dm^{-3} nitric acid at 20°C with excess marble chips that are the same size *[2 marks]*

d) the reaction of 100 cm^3 of 1.0 mol dm^{-3} nitric acid at 20°C with excess powdered marble *[2 marks]*

QUESTION 8 (8 marks)

A student carried out a series of experiments to determine the enthalpy of combustion of ethanol, C_2H_5OH. She used the apparatus shown in the diagram.

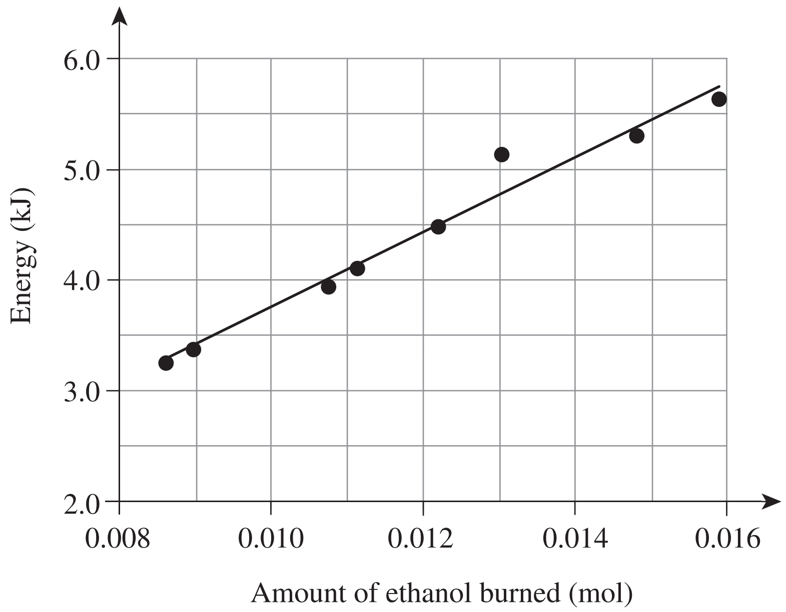


The ethanol in the spirit burner was burned to heat a known mass of water in the metal can. The student recorded the data obtained in the table below.

Experiment number	Mass of ethanol burned (g)	Temperature change (°C)	Mass of water heated (g)	Amount of ethanol burned (mol)	Energy transferred to the water (kJ)
1	0.390	19.5	40.0		
2	0.490	23.6	40.0		
3	0.510	24.5	40.0		
4	0.560	26.9	40.0		
5	0.730	33.6	40.0		
6	0.600	31.1	40.0		
7	0.410	20.3	40.0		
8	0.680	31.7	40.0		

a) Complete the table above. Give your answers correct to three significant figures. *[4 marks]*

The graph shows the energy transferred to the water against the amount of ethanol burned.



b) Identify the experiment that produced the most anomalous result. *[1 mark]*

c) The accepted value for the enthalpy of combustion of ethanol under standard conditions is -1370 kJ mol^{-1}.

Explain why is this value is negative. *[1 mark]*

d) The table shows the masses of ethanol and water used in experiment 1, and the maximum errors in a single reading.

	Mass measured (g)	**Maximum error in a single reading (g)**
Ethanol burned	0.390	0.010
Water heated	40.0	0.10

Calculate the maximum percentage error in the measurement of each mass used in experiment 1. *[1 mark]*

maximum percentage error (ethanol) = ______________________ % (to two decimal places)

maximum percentage error (water) = ______________________ % (to two decimal places)

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e) Another student repeated the same series of experiments under the same conditions. He obtained a value of –612 kJ mol^{-1} for the enthalpy of combustion of ethanol, which is different to the accepted value of –1370 kJ mol^{-1}.

Suggest one reason why there is a difference between the student's calculated value and the accepted value. *[1 mark]*

QUESTION 9 (5 marks)

Cassiterite is an ore of tin that contains tin(IV) oxide, SnO_2. The percentage of tin(IV) oxide in cassiterite can be determined by titration with potassium iodide, KI, solution using a suitable indicator. The ionic equation for this reaction is as follows.

$$Sn^{4+}(aq) + 2I^-(aq) \rightarrow Sn^{2+}(aq) + I_2(aq)$$

A 9.00 g sample of cassiterite was reacted with excess hydrochloric acid to produce $Sn^{4+}(aq)$. The mixture was filtered and the filtrate made up to 200 mL with distilled water in a volumetric flask.

A 20.00 mL sample of this solution required 36.70 mL of 0.250 mol L^{-1} potassium iodide for complete reaction.

a) Calculate the amount of I^- used. *[1 mark]*

amount = ____________________ mol (to three significant figures)

b) Calculate the amount of Sn^{4+} in the 20.00 mL solution sample. *[1 mark]*

amount = ____________________ mol (to three significant figures)

c) Calculate the amount of Sn^{4+} in the 200 mL volumetric flask. *[1 mark]*

amount = ____________________ mol (to three significant figures)

d) i) Calculate the mass of tin(IV) oxide in the 9.00 g cassiterite sample. *[1 mark]*

mass = ____________________ g (to three significant figures)

ii) Calculate the percentage of tin(IV) oxide in the 9.00 g cassiterite sample. *[1 mark]*

percentage = ____________________ % (to three significant figures)

END OF PAPER

ADDITIONAL PAGE FOR STUDENT RESPONSES

Write the question number you are responding to.

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Neap

Trial Examination 2022

Formula and Data Booklet

QCE Chemistry Units 1&2

FORMULAS

Processing of data
Absolute uncertainty of the mean $\Delta\bar{x} = \pm\frac{(x_{max} - x_{min})}{2}$
Percentage uncertainty (%) $= \frac{\text{absolute uncertainty}}{\text{measurement}} \times \frac{100}{1}$
Percentrage error (%) $= \left\lvert \frac{\text{measured value} - \text{true value}}{\text{true value}} \right\rvert \times 100$

Chemical reactions – reactants, products and energy change
$\Delta H = H_{(\text{products})} - H_{(\text{reactants})}$
$\Delta H = \Sigma(\text{bonds broken}) - \Sigma(\text{bonds formed})$
$Q = mc\Delta T$
Percentage yield (%) $= \frac{\text{experimental yield}}{\text{theoretical yield}} \times \frac{100}{1}$
$A_r = \frac{(\text{isotopic mass} \times \%\text{ abundance}) + (\text{isotopic mass} \times \%\text{ abundance})}{100}$
Moles $(n) = \frac{\text{number of particles } (N)}{\text{Avogadro's constant } (N_A)}$
Moles $= \frac{\text{mass of substance}(m)}{\text{molar mass}(M)}$

Intermolecular forces and gas
$PV = nRT$

Aqueous solutions and acidity
Molarity $= \frac{\text{moles of solute } (n)}{\text{volume of solution } (V)}$
$c_1V_1 = c_2V_2$

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PHYSICAL CONSTANTS AND UNIT CONVERSIONS

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

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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 H 1.01																	2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.63	33 As 74.92	34 Se 78.97	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.95	43 Tc (98.91)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57–71 Lanthanoids	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (210.0)	85 At (210.0)	86 Rn (222.0)
87 Fr (223.0)	88 Ra (226.1)	89–103 Actinoids	104 Rf (261.1)	105 Db (262.1)	106 Sg (263.1)	107 Bh (264.1)	108 Hs (265.1)	109 Mt (268)	110 Ds (281)	111 Rg (272)	112 Cn (285)	113 Nh (284)	114 Fl (289)	115 Mc (288)	116 Lv (293)	117 Ts (294)	118 Og (294)

Lanthanoids

57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (146.9)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.05	71 Lu 174.97

Actinoids

89 Ac (227.0)	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np (237.0)	94 Pu (239.1)	95 Am (241.1)	96 Cm (244.1)	97 Bk (249.1)	98 Cf (252.1)	99 Es (252.1)	100 Fm (252.1)	101 Md (258.1)	102 No (259.1)	103 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

Li 3 130 76 (1+)	atomic number symbol atomic radius (10^{-12} m) charge of ion

ionic radius (10^{-12} m)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H 1 32 208 (1–)																	He 2 37
Li 3 130 76 (1+)	Be 4 99 45 (2+)											B 5 84 27 (3+)	C 6 75 16 (4+)	N 7 71 146 (3–)	O 8 64 140 (2–)	F 9 60 133 (1–)	Ne 10 62
Na 11 160 102 (1+)	Mg 12 140 72 (2+)											Al 13 124 53 (3+)	Si 14 114 40 (4+)	P 15 109 38 (5+)	S 16 104 184 (2–)	Cl 17 100 181 (1–)	Ar 18 101
K 19 200 138 (1+)	Ca 20 174 100 (2+)	Sc 21 159 75 (3+)	Ti 22 148 86 (2+) 61 (4+)	V 23 144 79 (2+) 54 (5+)	Cr 24 130 62 (3+) 44 (6+)	Mn 25 129 83 (2+) 64 (3+)	Fe 26 124 78 (2+) 64 (3+)	Co 27 118 74 (2+) 61 (3+)	Ni 28 117 69 (2+) 60 (3+)	Cu 29 122 77 (1+) 73 (2+)	Zn 30 120 74 (2+)	Ga 31 123 62 (3+)	Ge 32 120 53 (4+) 272 (4–)	As 33 120 58 (3+) 46 (5+)	Se 34 118 198 (2–)	Br 35 117 196 (1–)	Kr 36 116
Rb 37 215 152 (1+)	Sr 38 190 118 (2+)	Y 39 176 90 (3+)	Zr 40 164 72 (4+)	Nb 41 156 64 (5+)	Mo 42 148 65 (4+)	Tc 43 138 65 (4+)	Ru 44 136 62 (4+)	Rh 45 134 67 (3+)	Pd 46 130 86 (2+)	Ag 47 136 115 (1+)	Cd 48 140 95 (2+)	In 49 142 80 (3+)	Sn 50 140 69 (4+)	Sb 51 140 76 (3+)	Te 52 137 221 (2–)	I 53 136 220 (1–)	Xe 54 136
Cs 55 238 167 (1+)	Ba 56 206 135 (2+)																

Groups are numbered according to IUPAC convention 1–18.

ELECTRONEGATIVITIES AND FIRST IONISATION ENERGIES OF SELECTED ELEMENTS

KEY

H	1
atomic number	1
symbol	H
electronegativity	2.2
first ionisation enthalpies (kJ mol^{-1})	1318

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 2.2 1318																	2 He 2379
3 Li 1.0 526	4 Be 1.6 906											5 B 2.0 807	6 C 2.6 1093	7 N 3.0 1407	8 O 3.4 1320	9 F 4.0 1687	10 Ne 2087
11 Na 0.9 502	12 Mg 1.3 744											13 Al 1.6 584	14 Si 1.9 793	15 P 2.2 1018	16 S 2.6 1006	17 Cl 3.2 1257	18 Ar 1527
19 K 0.8 425	20 Ca 1.0 596	21 Sc 1.4 637	22 Ti 1.5 664	23 V 1.6 656	24 Cr 1.7 659	25 Mn 1.6 724	26 Fe 1.8 766	27 Co 1.9 765	28 Ni 1.9 743	29 Cu 1.9 752	30 Zn 1.7 913	31 Ga 1.8 585	32 Ge 2.0 768	33 As 2.2 953	34 Se 2.6 947	35 Br 3.0 1146	36 Kr 2.9 1357
37 Rb 0.8 409	38 Sr 1.0 556	39 Y 1.2 606	40 Zr 1.3 666	41 Nb 1.6 670	42 Mo 2.2 691	43 Tc 1.9 708	44 Ru 2.2 717	45 Rh 2.3 726	46 Pd 2.2 811	47 Ag 1.9 737	48 Cd 1.7 874	49 In 1.8 565	50 Sn 2.0 715	51 Sb 2.1 840	52 Te 2.1 876	53 I 2.7 1015	54 Xe 2.6 1177
55 Cs 0.8 382	56 Ba 0.9 509																

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	most reactive ↑
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	least reactive

* Carbon (C) and hydrogen gas (H_2) 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	
acetate (ethanoate)	CH_3COO^- or $C_2H_3O_2^-$
carbonate	CO_3^{2-}
chlorate	ClO_3^-
chlorite	ClO_2^-
chromate	CrO_4^{2-}
citrate	$C_6H_5O_7^{3-}$
cyanide	CN^-
dichromate	$Cr_2O_7^{2-}$
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	$S_2O_3^{2-}$

Cations	
ammonium	NH_4^+
hydronium	H_3O^+

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.

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