Neap

Trial Examination 2023

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 (50 marks)

- 8 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 (5 marks)

The table shows the ionic radii, in picometres, of some main group elements. Where an element forms two ions, the ionic radius of the more common ion is shown.

Li^+ 76	Be^{2+} 45	B^{3+} 27	C^{4+} 16	N^{3-} 146	O^{2-} 140	F^- 133
Na^+ 102	Mg^{2+} 72	Al^{3+} 53	Si^{4+} 40	P^{5+} 38	S^{2-} 184	Cl^- 181
K^+ 138	Ca^{2+} 100	Ga^{3+} 62	Ge^{4+} 53	As^{3+} 58	Se^{2-} 198	Br^- 196
Rb^+ 152	Sr^{2+} 118	In^{3+} 80	Sn^{4+} 69	Sb^{3+} 76	Te^{2-} 221	I^- 220
Cs^+ 167	Ba^{2+} 135					

a) Explain the trend in ionic radii down a group in the periodic table. *[2 marks]*

b) Using the period 3 elements shown in the table, explain why anions are larger than cations in the same period. *[3 marks]*

QUESTION 2 (9 marks)

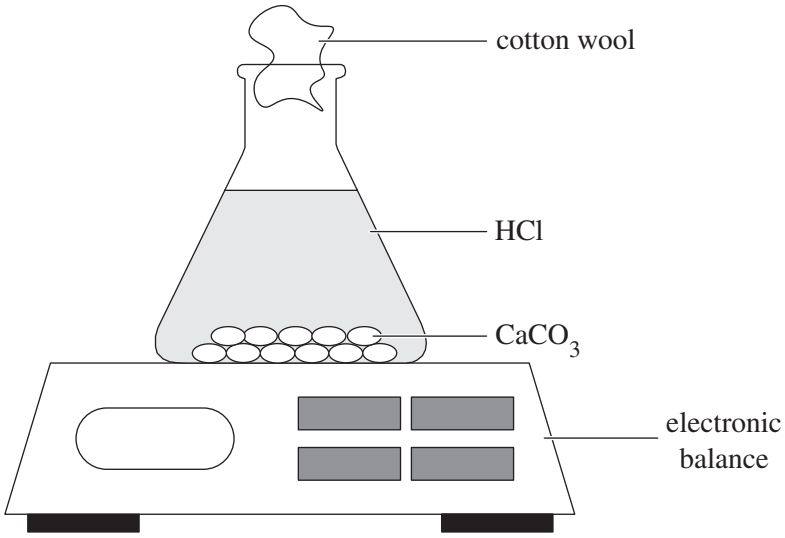
A series of experiments were conducted to investigate the rate of reaction between marble chips ($CaCO_3$) and hydrochloric acid (HCl). The reaction occurred according to the following equation.

$$2HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

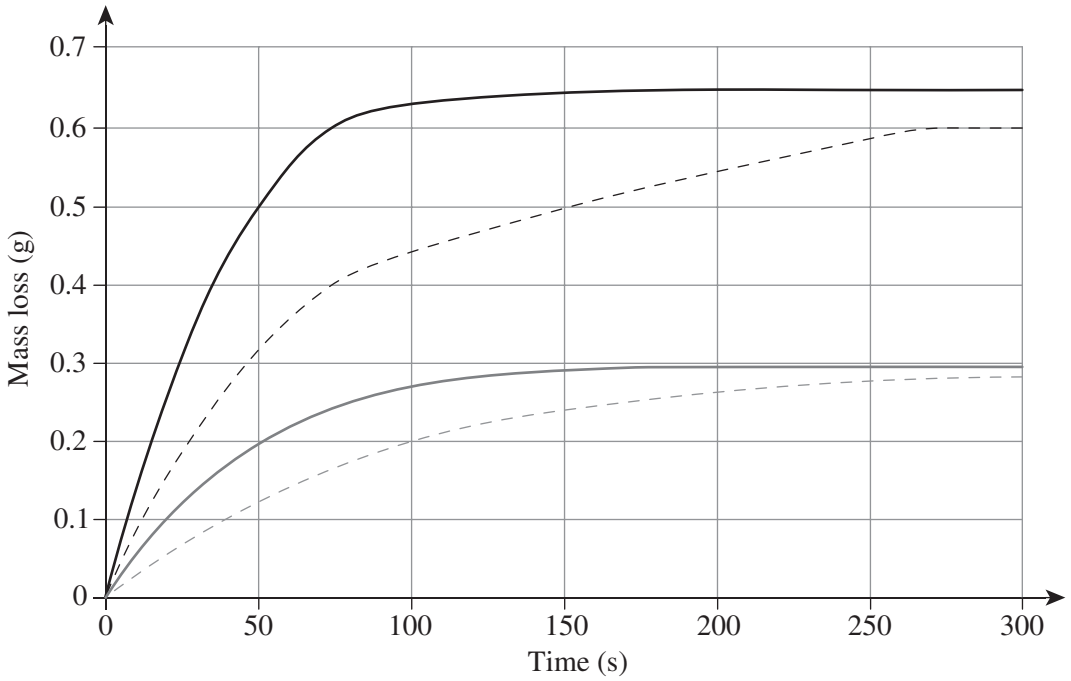
The investigation used two concentrations of the acid and two sizes of marble chips. Four experiments were conducted as follows.

Concentration of HCl (M)	Marble chip size
3.0	large
3.0	small
1.5	large
1.5	small

In each experiment, a flask containing the reactants was placed on an electronic balance. As the reaction proceeded, the mass loss of the flask's contents was recorded. The same mass of chips and volume of acid were used in each experiment. This set-up is shown in the diagram.



The results of the four experiments are shown in the graph.



Key

3.0 M HCl and small chips	3.0 M HCl and large chips
1.5 M HCl and small chips	1.5 M HCl and large chips

a) On the graph, circle the 50-second time period on the curve during which the production of CO_2 is greatest out of all four experiments. *[1 mark]*

b) Using the graph, describe the rate of mass loss in the experiment that used 3.0 M HCl and large marble chips. Refer to two points on the curve. *[2 marks]*

c) Using your knowledge of collision theory and concentration, explain the difference between the results of the two experiments that used small chips. In your response, refer to data in the graph. *[4 marks]*

d) The rates of reaction could have been measured by collecting the CO_2 produced in each experiment and then comparing the volumes collected.

Identify two reasons why this method would have been less reliable. *[2 marks]*

QUESTION 3 (6 marks)

A student performed two experiments, A and B, to test the solubility of various ionic compounds. The table shows the solutions that the student used. All the solutions had a concentration 1.00 M.

Experiment	Solution 1	Solution 2
A	copper sulfate	sodium hydroxide
B	iron(II) chloride	potassium nitrate

a) For each experiment, deduce if a precipitate did or did not form.
Provide a reason for each. *[2 marks]*

Experiment A: _____

_____

Experiment B: _____

_____

b) Write an ionic equation for the reaction where a precipitate formed. *[2 marks]*

_____

_____

c) In a third experiment, the student mixed silver nitrate solution with potassium carbonate. They incorrectly predicted that a precipitate would form.

Propose why a precipitate did not form. *[2 marks]*

_____

_____

_____

_____

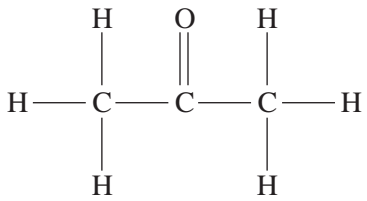
QUESTION 4 (4 marks)

Two experiments were conducted to separate food dyes. Two solvents were used: propan-2-one with water, and ethanol with water. The results of the experiments are shown in the table.

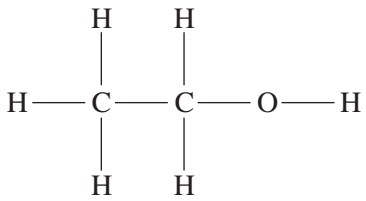
	Experiment 1 (solvent: propan-2-one and water)		**Experiment 2 (solvent: ethanol and water)**	
	Distance travelled in the mobile phase (cm)	**R_f**	**Distance travelled in the mobile phase (cm)**	**R_f**
Solvent front	4.7	–	4.9	–
Green dye	2.9	0.62	4.8	0.98
Red dye	1.3	0.28	3.7	0.76
Yellow dye	4.0	0.85	0.8	0.16
Blue dye	2.9	0.62	2.6	0.53
Purple dye	3.1	0.66	1.4	0.29

The structures of the solvent molecules are shown.

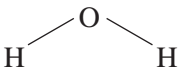
propan-2-one



ethanol



water



a) Which component showed the largest difference between experiment 1 and experiment 2? *[1 mark]*

b) Identify whether propan-2-one or ethanol is more polar. Explain your reasoning. *[2 marks]*

c) Why did the experimenter mix the propan-2-one and ethanol with water? *[1 mark]*

QUESTION 5 (7 marks)

The exothermic reaction of octane burning in oxygen occurs according to the following equation.

$$2C_8H_{18}(g) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(l)$$

The reaction is conducted at 150°C and 111.4575 kPa, and produces 47.0 L of CO_2.

Calculate the mass of C_8H_{18} that is reacted.

Mass = _____ g (to three significant figures)

QUESTION 6 (6 marks)

A polystyrene cup was used in an experiment to measure the enthalpy change (ΔH) of the acid–base reaction shown.

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

In the polystyrene cup, 20.0 mL of water containing 0.034 mol of HCl was added to 20.0 mL of water containing 0.034 mol of NaOH at room temperature. When the reaction was complete, the temperature of the cup's contents was 31.0°C.

The following is assumed.

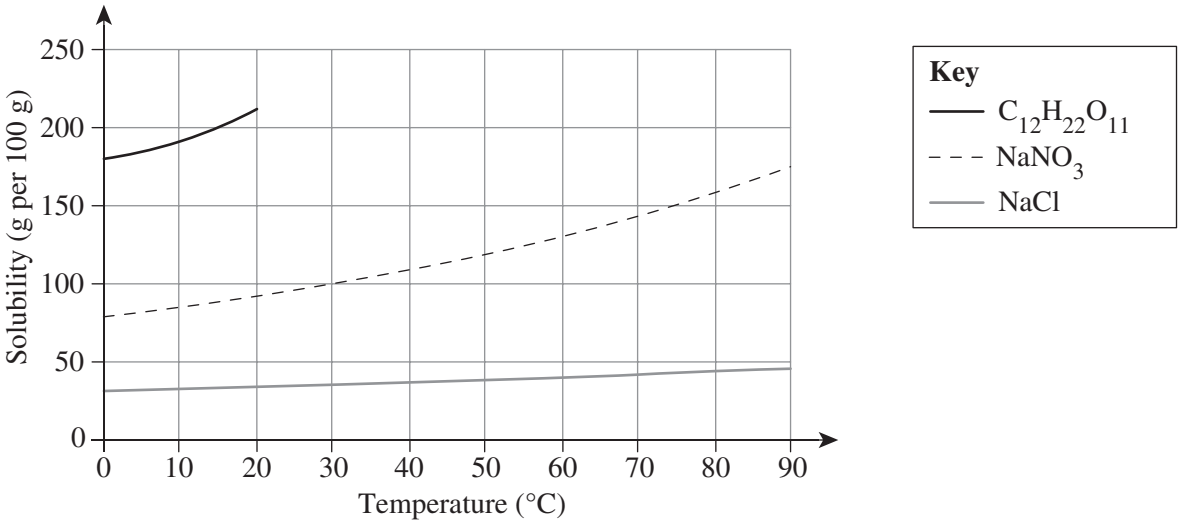
- Room temperature is 25.0°C.
- The density of the solutions was the same as that of water, 1.00 g mL^{-1}.
- The final volume of the cup's contents was equal to the sum of the reacting solutions' volumes.

Calculate the ΔH of the reaction. *[6 marks]*

ΔH = _____ kJ mol^{-1} (to three significant figures)

QUESTION 7 (6 marks)

The graph shows the solubility of three substances – sucrose ($C_{12}H_{22}O_{11}$), sodium nitrate ($NaNO_3$) and salt (NaCl) – in water at various temperatures.



a) Identify the substance that is most soluble in water at room temperature (25°C). *[1 mark]*

b) Describe how the solubility of $NaNO_3$ changes as the temperature increases from 0°C to 90°C. *[1 mark]*

c) Deduce which of the three substances is the most polar. Explain your reasoning. *[2 marks]*

d) Approximately 180 g of $C_{12}H_{22}O_{11}$ will dissolve at 0°C.

At 0°C, 250 g of $C_{12}H_{22}O_{11}$ is added to water.

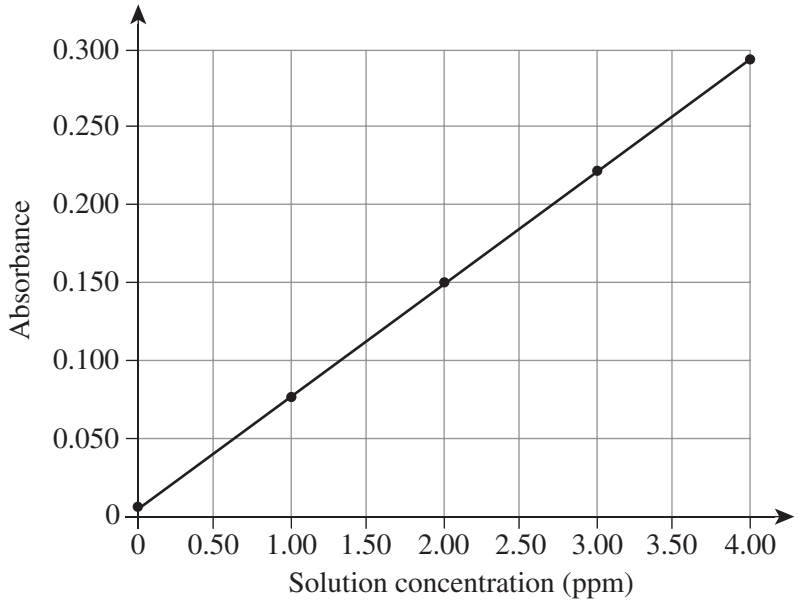
Determine whether the solution is unsaturated, saturated or supersaturated.
Explain your reasoning. *[2 marks]*

QUESTION 8 (7 marks)

A particular brand of energy drink contains iron and has the same density as water, 1.00 g mL^{-1}.

The absorptions of a diluted sample of the drink and several standard solutions containing iron were measured using atomic absorption spectroscopy (AAS). The absorption values recorded are shown in the table and graph.

Solution concentration (ppm)	Absorbance
0.00	0.010
1.00	0.080
2.00	0.150
3.00	0.220
4.00	0.290
sample	0.190



a) State the main advantage of AAS. *[1 mark]*

b) Determine the concentration of iron in the sample. *[1 mark]*

Concentration = _____ ppm (to two decimal places)

c) If a 5.0 mL sample of the drink was taken and then diluted to 50.0 mL, determine the concentration of iron in the undiluted sample. *[1 mark]*

Concentration = _____ ppm (to two decimal places)

d) The drink is sold in cans that have a volume of 200 mL.
Calculate the mass of iron in one can of the drink. *[2 marks]*

Mass = _____ g (to two decimal places)

e) The recommended dietary intake (RDI) of iron for men aged 19 years and over is 8.00 mg per day.
Calculate the percentage of this RDI that one can of the drink contains. *[2 marks]*

Percentage = _____% (to two decimal places)

END OF PAPER

ADDITIONAL PAGE FOR STUDENT RESPONSES

Write the question number you are responding to.

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Write the question number you are responding to.

Neap

Trial Examination 2023

Formula and Data Booklet

QCE Chemistry Units 1&2

FORMULAS

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

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

Intermolecular forces and gas
$PV = nRT$

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

PHYSICAL CONSTANTS AND UNIT CONVERSIONS

Physical constants and unit conversions	
Absolute zero	$0\ \text{K} = -273°\text{C}$
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
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

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 H 1.01 — atomic number; symbol; 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																	18
H 1 32 208 (1–)												13	14	15	16	17	**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+)	3	4	5	6	7	8	9	10	11	12	**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 2.2 1318	atomic number symbol electronegativity first ionisation enthalpies (kJ mol^{-1})

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

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