

Relevant literature and resources for the Basic Chemistry test

Admission to the Master's in Conservation and Restoration of Cultural Heritage

You will complete a basic chemistry test as part of the admissions procedure for the MSc program in Conservation and Restoration of Cultural Heritage. If you have limited background in chemistry, it is useful to study literature on chemistry principles to prepare for this test. The literature in the list below covers the same topics as those taught in the minor programme in Conservation and Restoration at the University of Amsterdam. We suggest specific sections of the following two sources:

ATKINS | *Chemical principles – the quest for insight*, Peter Atkins, Loretta Jones, Leroy Laverman, 6th edition (2013), W.H. Freeman and company, New York.

C:AF | *Chemistry: Atoms first*, Paul Flowers, Edward J. Neth, William R. Robinson Klaus Theopold, Richard Langley, 2nd edition (2023), OpenStax. CC BY v4.0. (ONLINE)
<https://openstax.org/details/books/chemistry-atoms-first-2e>

ATKINS generally goes deeper into the chemistry topics than necessary to complete the test successfully, and it has a broader scope. The book can be expensive to purchase, but it may be possible to find an affordable second-hand copy (it is not the most recent version), borrow it from a library, or find an online version. **C:AF** is freely available online as a webpage, or it can be downloaded. Besides being a free resource, it is written in a slightly different style that suits some people better.

You can choose yourself which of these sources (or both) you would like to use for self-study. In addition to these two sources, there are many other good online resources covering the topics in this course. For instance, you could search for key concepts that you struggle with at Khan Academy (<https://en.khanacademy.org/science>) which provides excellent chemistry videos, text explanations and exercises at various educational levels for free.

After the list of relevant literature on the next page, you can also find several useful resources and tables for use while making the Basic Chemistry online test.

Topic 1: Atomic Structure

ATKINS | Fundamentals B1, B2 (not example B1), B3, Sections 2.3, 2.5, 2.6

C:AF | Sections 2.3, 3.1 (only 'Waves'), 3.3 (only 'Understanding Quantum Theory of Electrons in Atoms'), 3.4 (until Figure 3.29)

Topic 2: The Periodic Table and Chemical Bonding

ATKINS | Fundamentals B4, C. Sections 2.7, 3.1, 3.2, 3.5, 3.12, 4.4, 4.5 (only p122) C:AF | Sections 3.5 (until Example 3.12), 3.6, 3.7 (until Example 3.16), 4.1, 4.2, 5.1 (until Example 5.1)

Topic 3: The Structure of Molecules

ATKINS | Sections 3.6, 3.7, 3.8, 3.9 (only radicals, no biradicals) C:AF | Sections 2.4, 4.4, 4.5

Topic 4: The Shape of Molecules and Ionic Compounds

ATKINS | Sections 4.1–4.3 (only the linear, trigonal planar and tetrahedral electron-pair geometries, and the corresponding molecular shapes), 6.9, Fundamentals D1, D2. C:AF | Sections 4.6, 3.7 (starting at Example 3.16),

Topic 5: Organic Molecules and Functional Groups

ATKINS | Fundamentals C2, D5, Section 19.1, 19.2, 19.3, 19.5 (until 'elimination reactions'), 19.7, 20.2–20.8 (only recognition of most important functional groups and properties)
C:AF | Chapter 21

Topic 6: Polarity and Intermolecular Interactions

ATKINS | Sections 3.12, 6.1, 6.3, 6.4, 6.5, 10.9

C:AF | Sections 10.1, 11.1, 11.3 (only 'Solutions of Liquids in Liquids'), 11.5 (only 'Preparation of Colloidal Systems' and 'Soaps and Detergents')

Topic 7: Chemical Calculations

ATKINS | Fundamentals A1, E, H, L1, L2 C:AF | Sections 6.1, 1.5, 1.6, 7.1 and 7.3.

Topic 8: Salts and Solubility

ATKINS | Fundamentals G1, G3, G4

C:AF | Sections 7.2 (Precipitation Reactions and Solubility Rules), 11.1, 11.3, 13.1, 15.1 (until example 15.6), 6.3 and 6.4 Appendix J (for reference)

Topic 9: Acids and Bases

ATKINS | Fundamentals, and Section 12.1–12.8 (skip 12.2), 12.10, 12.13

C:AF | Sections 7.2 (Acid-Base Reactions), 14.1–14.6, Appendix H, I (for reference), 13.2 (for enthusiasts only)

Topic 10: Redox Reactions

ATKINS | Fundamentals K

C:AF | Sections 16.1, 16.2 (until Cell Notation), 16.3, 16.6, Appendix L (for reference)

PERIODIC TABLE OF THE ELEMENTS

GROUP	1	2	FAMILIES										13	14	15	16	17	18					
	IA	IIA	IIIB		IVB		VB		VIB		VIIB		VIII		IB	IIB		IIIA	IVA	VA	VIA	VIIA	VIIIA
1	1 1.0079 1s ¹ H HYDROGEN																	2 4.0026 1s ² He HELIUM					
2	3 6.941(2) [He] 2s ¹ Li LITHIUM	4 9.0122 [He] 2s ² Be BERYLLIUM																5 10.811 [He] 2s ² 2p ¹ B BORON	6 12.011 [He] 2s ² 2p ² C CARBON	7 14.007 [He] 2s ² 2p ³ N NITROGEN	8 15.999 [He] 2s ² 2p ⁴ O OXYGEN	9 18.998 [He] 2s ² 2p ⁵ F FLUORINE	10 20.180 [He] 2s ² 2p ⁶ Ne NEON
3	11 22.990 [Ne] 3s ¹ Na SODIUM	12 24.305 [Ne] 3s ² Mg MAGNESIUM																13 26.982 [Ne] 3s ² 3p ¹ Al ALUMINUM	14 28.086 [Ne] 3s ² 3p ² Si SILICON	15 30.974 [Ne] 3s ² 3p ³ P PHOSPHORUS	16 32.065 [Ne] 3s ² 3p ⁴ S SULFUR	17 35.453 [Ne] 3s ² 3p ⁵ Cl CHLORINE	18 39.948 [Ne] 3s ² 3p ⁶ Ar ARGON
4	19 39.098 [Ar] 4s ¹ K POTASSIUM	20 40.078 [Ar] 4s ² Ca CALCIUM	21 44.956 [Ar] 3d ¹ 4s ² Sc SCANDIUM	22 47.867 [Ar] 3d ² 4s ² Ti TITANIUM	23 50.942 [Ar] 3d ³ 4s ² V VANADIUM	24 51.996 [Ar] 3d ⁴ 4s ¹ Cr CHROMIUM	25 54.938 [Ar] 3d ⁵ 4s ¹ Mn MANGANESE	26 55.845 [Ar] 3d ⁶ 4s ² Fe IRON	27 58.933 [Ar] 3d ⁷ 4s ² Co COBALT	28 58.693 [Ar] 3d ⁸ 4s ² Ni NICKEL	29 63.546 [Ar] 3d ¹⁰ 4s ¹ Cu COPPER	30 65.409 [Ar] 3d ¹⁰ 4s ² Zn ZINC	31 69.723 [Ar] 3d ¹⁰ 4s ² 4p ¹ Ga GALLIUM	32 72.64(1) [Ar] 3d ¹⁰ 4s ² 4p ² Ge GERMANIUM	33 74.922 [Ar] 3d ¹⁰ 4s ² 4p ³ As ARSENIC	34 78.96(3) [Ar] 3d ¹⁰ 4s ² 4p ⁴ Se SELENIUM	35 79.904 [Ar] 3d ¹⁰ 4s ² 4p ⁵ Br BROMINE	36 83.798 [Ar] 3d ¹⁰ 4s ² 4p ⁶ Kr KRYPTON					
5	37 85.468 [Kr] 5s ¹ Rb RUBIDIUM	38 87.62(1) [Kr] 5s ² Sr STRONTIUM	39 88.906 [Kr] 4d ¹ 5s ² Y YTTRIUM	40 91.224 [Kr] 4d ² 5s ² Zr ZIRCONIUM	41 92.906 [Kr] 4d ⁴ 5s ¹ Nb NIOBIUM	42 95.94(2) [Kr] 4d ⁵ 5s ¹ Mo MOLYBDENUM	43 (98) [Kr] 4d ⁵ 5s ¹ Tc TECHNETIUM	44 101.07(2) [Kr] 4d ⁷ 5s ¹ Ru RUTHENIUM	45 102.906 [Kr] 4d ⁸ 5s ¹ Rh RHODIUM	46 106.42(1) [Kr] 4d ¹⁰ Pd PALLADIUM	47 107.868 [Kr] 4d ¹⁰ 5s ¹ Ag SILVER	48 112.411 [Kr] 4d ¹⁰ 5s ² Cd CADMIUM	49 114.818 [Kr] 4d ¹⁰ 5s ² 5p ¹ In INDIUM	50 118.710 [Kr] 4d ¹⁰ 5s ² 5p ² Sn TIN	51 121.760 [Kr] 4d ¹⁰ 5s ² 5p ³ Sb ANTIMONY	52 127.60(3) [Kr] 4d ¹⁰ 5s ² 5p ⁴ Te TELLURIUM	53 126.904 [Kr] 4d ¹⁰ 5s ² 5p ⁵ I IODINE	54 131.293 [Kr] 4d ¹⁰ 5s ² 5p ⁶ Xe XENON					
6	55 132.905 [Xe] 6s ¹ Cs CESIUM	56 137.327 [Xe] 6s ² Ba BARIUM	57-71 Lanthanides	72 178.49(2) [Xe] 4f ¹⁴ 5d ² 6s ² Hf HAFNIUM	73 180.947 [Xe] 4f ¹⁴ 5d ³ 6s ² Ta TANTALUM	74 183.84(1) [Xe] 4f ¹⁴ 5d ⁴ 6s ² W TUNGSTEN	75 186.207 [Xe] 4f ¹⁴ 5d ⁵ 6s ² Re RHENIUM	76 190.23(3) [Xe] 4f ¹⁴ 5d ⁶ 6s ² Os OSMIUM	77 192.217 [Xe] 4f ¹⁴ 5d ⁷ 6s ² Ir IRIDIUM	78 195.084 [Xe] 4f ¹⁴ 5d ⁹ 6s ¹ Pt PLATINUM	79 196.967 [Xe] 4f ¹⁴ 5d ¹⁰ 6s ¹ Au GOLD	80 200.59(2) [Xe] 4f ¹⁴ 5d ¹⁰ 6s ² Hg MERCURY	81 204.383 [Xe] 4f ¹⁴ 5d ¹⁰ 6s ² 6p ¹ Tl THALLIUM	82 207.2(1) [Xe] 4f ¹⁴ 5d ¹⁰ 6s ² 6p ² Pb LEAD	83 208.980 [Xe] 4f ¹⁴ 5d ¹⁰ 6s ² 6p ³ Bi BISMUTH	84 (209) [Xe] 4f ¹⁴ 5d ¹⁰ 6s ² 6p ⁴ Po POLONIUM	85 (210) [Xe] 4f ¹⁴ 5d ¹⁰ 6s ² 6p ⁵ At ASTATINE	86 (222) [Xe] 4f ¹⁴ 5d ¹⁰ 6s ² 6p ⁶ Rn RADON					
7	87 (223) [Rn] 7s ¹ Fr FRANCIUM	88 (226) [Rn] 7s ² Ra RADIUM	89-103 Actinides	104 (261) Rf RUTHERFORDIUM	105 (262) Db DUBNIUM	106 (266) Sg SEABORGIUM	107 (264) Bh BOHRIUM	108 (277) Hs HASSIUM	109 (268) Mt MEITNERIUM	110 (281) Ds DARMSTADIUM	111 (272) Rg ROENTGENIUM	112 (285) Cn COPERNICIUM	113 (284) Uut UNUNTRIUM	114 (289) Uuq UNUNQUADIUM	115 (288) Uup UNUNPENTIUM	116 (292) Uuh UNUNHEXIUM	117 Uus* UNUNSEPTIUM	118 (294) Uuo UNUNOCTIUM					

Diagram showing the structure of a periodic table element cell for Platinum (Pt):

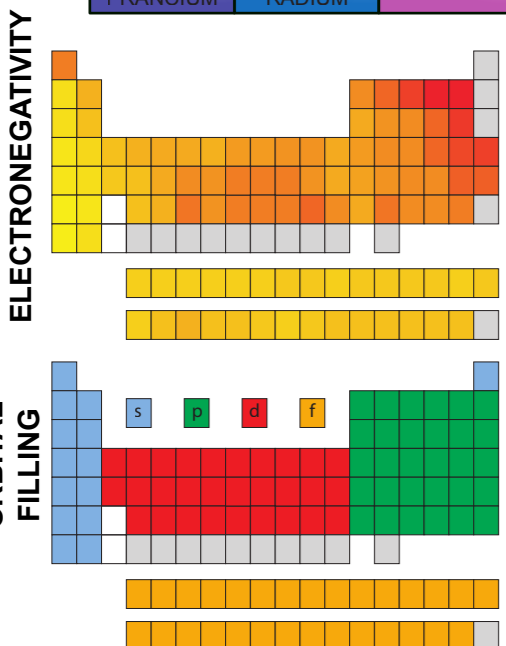
- ATOMIC NUMBER: 78
- RELATIVE ATOMIC MASS (g.mol⁻¹): 195.084
- ELECTRON CONFIGURATION⁽³⁾: [Xe] 4f¹⁴ 5d⁹ 6s¹
- ATOMIC SYMBOL: Pt
- ELEMENT NAME: PLATINUM

FAMILY Legend:

- Metal (Blue)
- Alkaline metals (Purple)
- Alkaline earth metals (Light Blue)
- Transition metals (Dark Blue)
- Lanthanides (Pink)
- Actinides (Light Purple)
- Metalloids (Red)
- Chalcogens (Light Green)
- Halogens (Green)
- Noble gases (Light Green)

Physical State (25°C, 1 atm):

- Ne - gas
- Hg - liquid
- Fe - solid
- Tc - Man-made



LANTHANIDES

57 138.905 [Xe] 5d ¹ 6s ² La LANTHANUM	58 140.116 [Xe] 4f ¹ 5d ¹ 6s ² Ce CERIUM	59 140.908 [Xe] 4f ³ 6s ² Pr PRASEODYMIUM	60 144.242 [Xe] 4f ⁴ 6s ² Nd NEODYMIUM	61 (145) [Xe] 4f ⁵ 6s ² Pm PROMETHIUM	62 150.36(2) [Xe] 4f ⁶ 6s ² Sm SAMARIUM	63 151.964 [Xe] 4f ⁷ 6s ² Eu EUROPIUM	64 157.25(3) [Xe] 4f ⁷ 5d ¹ 6s ² Gd GADOLINIUM	65 158.925 [Xe] 4f ⁹ 6s ² Tb TERBIUM	66 162.500 [Xe] 4f ¹⁰ 6s ² Dy DYSPROSIUM	67 164.930 [Xe] 4f ¹¹ 6s ² Ho HOLMIUM	68 167.259 [Xe] 4f ¹² 6s ² Er ERBIUM	69 168.934 [Xe] 4f ¹³ 6s ² Tm THULIUM	70 173.04(3) [Xe] 4f ¹⁴ 6s ² Yb YTTERBIUM	71 174.967 [Xe] 4f ¹⁴ 5d ¹ 6s ² Lu LUTETIUM
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ACTINIDES

89 (227) [Rn] 6d ¹ 7s ² Ac ACTINIUM	90 232.038 [Rn] 6d ² 7s ² Th THORIUM	91 231.036 [Rn] 5f ² 6d ¹ 7s ² Pa PROTACTINIUM	92 238.029 [Rn] 5f ³ 6d ¹ 7s ² U URANIUM	93 (237) [Rn] 5f ⁴ 6d ¹ 7s ² Np NEPTUNIUM	94 (244) [Rn] 5f ⁶ 7s ² Pu PLUTONIUM	95 (243) [Rn] 5f ⁷ 7s ² Am AMERICIUM	96 (247) [Rn] 5f ⁷ 6d ¹ 7s ² Cm CURIUM	97 (247) [Rn] 5f ⁹ 7s ² Bk BERKELIUM	98 (251) [Rn] 5f ¹⁰ 7s ² Cf CALIFORNIUM	99 (252) [Rn] 5f ¹¹ 7s ² Es EINSTEINIUM	100 (257) [Rn] 5f ¹² 7s ² Fm FERMIUM	101 (258) [Rn] 5f ¹³ 7s ² Md MENDELEVIUM	102 (259) [Rn] 5f ¹⁴ 7s ² No NOBELIUM	103 (262) Lr LAWRENCIUM
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(1) Pure & Applied Chemistry, Vol. 78, No. 11, pp. 2051-2066 (2006) <http://www.iupac.org/publications/pac/2006/pdf/7811x2051.pdf>

(2) The relative atomic mass is given with five significant digits. For items that do not have a stable radionuclide, the value in parentheses indicates the mass number of the isotope of the element with the longest half-life. However, the three elements Th, Pa and Pu which have a characteristic terrestrial isotopic composition, an atomic weight is indicated.

(3) The electronic configurations for which there is doubt are not given.

Solubility Table Common Ionic Compounds

	Group 1				Group 2			Transition Metals					
	NH ₄ ⁺	Li ⁺	Na ⁺	K ⁺	Mg ²⁺	Ca ²⁺	Ba ²⁺	Al ³⁺	Fe ³⁺	Cu ²⁺	Ag ⁺	Zn ²⁺	Pb ²⁺
F ⁻	sol	sol	sol	sol	insol	insol	sl sol	sol	sl sol	sol	sol	sol	insol
Cl ⁻	sol	sol	sol	sol	sol	sol	sol	sol	sol	sol	insol	sol	sol
Br ⁻	sol	sol	sol	sol	sol	sol	sol	sol	sol	sol	insol	sol	sl sol
I ⁻	sol	sol	sol	sol	sol	sol	sol	sol			insol	sol	insol
OH ⁻	sol	sol	sol	sol	insol	sl sol	sol	insol	insol	insol		insol	insol
S ²⁻	sol	sol	sol	sol		sl sol	sol		insol	insol	insol	insol	insol
SO ₄ ²⁻	sol	sol	sol	sol	sol	sl sol	insol	sol	sol	sol	sl sol	sol	insol
CO ₃ ²⁻	sol	sol	sol	sol	insol	insol	insol			sl sol	insol	insol	insol
NO ₃ ⁻	sol	sol	sol	sol	sol	sol	sol	sol	sol	sol	sol	sol	sol
PO ₄ ³⁻	sol	insol	sol	sol	insol	insol	insol	insol	insol	insol	insol	insol	insol
CrO ₄ ²⁻	sol	sol	sol	sol	sol	sol	insol		insol	insol	insol	insol	insol
CH ₃ CO ₂ ⁻	sol	sol	sol	sol	sol	sol	sol	sl sol	sol	sol	sol	sol	sol

sol — soluble >1g/100 mL

sl sol — slightly soluble (0.1 to 1) g/100 mL

insol — insoluble <0.1g/100 mL

(blank) — not enough solubility data available to be determined

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List of formula, names and charges for common polyatomic ions

Formula	Name
NO_3^-	nitrate
NO_2^-	nitrite
CrO_4^{2-}	chromate
$\text{Cr}_2\text{O}_7^{2-}$	dichromate
CN^-	cyanide
MnO_4^-	permanganate
OH^-	hydroxide
CO_3^{2-}	carbonate
SO_4^{2-}	sulfate
SO_3^{2-}	sulfite
$\text{C}_2\text{O}_4^{2-}$	oxalate
PO_4^{3-}	phosphate
PO_3^{3-}	phosphite
ClO_4^-	perchlorate
ClO_3^-	chlorate
ClO_2^-	chlorite
ClO^-	hypochlorite
IO_4^-	periodate
IO_3^-	iodate
IO^-	hypoiodite
BrO_3^-	bromate
BrO^-	hypobromite
HCO_3^-	hydrogen carbonate (bicarbonate)
HSO_4^-	hydrogen sulfate (bisulfate)
HSO_3^-	hydrogen sulfite (bisulfite)
HC_2O_4^-	hydrogen oxalate (binoxalate)
HPO_4^{2-}	hydrogen phosphate
H_2PO_4^-	dihydrogen phosphate
$\text{S}_2\text{O}_3^{2-}$	thiosulfate
AsO_4^{3-}	arsenate
SeO_4^{2-}	selenate
SiO_3^{2-}	silicate
HS^-	hydrogen sulfide
BO_3^{3-}	borate
$\text{B}_4\text{O}_7^{2-}$	tetraborate
SCN^-	thiocyanate
CH_3COO^-	acetate
NH_4^+	ammonium

Electronegativity values of the elements (Pauling scale)

H 2.1																	He
Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0	Ne
Na 0.9	Mg 1.2											Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0	Ar
K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.8	Ni 1.8	Cu 1.9	Zn 1.6	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8	Kr 3.0
Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.8	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.7	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5	Xe 2.6
Cs 0.7	Ba 0.9	La 1.1	Hf 1.3	Ta 1.5	W 1.7	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Tl 1.8	Pb 1.8	Bi 1.9	Po 2.0	At 2.2	Rn 2.4
Fr 0.7	Ra 0.7	Ac 1.1															
Ce 1.1	Pr 1.1	Nd 1.1	Pm 1.1	Sm 1.1	Eu 1.1	Gd 1.1	Tb 1.1	Dy 1.1	Ho 1.1	Er 1.1	Tm 1.1	Yb 1.1	Lu 1.2				
Th 1.3	Pa 1.5	U 1.7	Np 1.3	Pu 1.3	Am 1.3	Cm 1.3	Bk 1.3	Cf 1.3	Es 1.3	Fm 1.3	Md 1.3	No 1.3	Lr				