Appendix 6: Mathematical skills and exemplifications

In order to be able to develop their skills, knowledge and understanding in chemistry, students need to have been taught, and to have acquired competence in, the appropriate areas of mathematics relevant to the subject as indicated in the table on the following pages[1].

The assessment of quantitative skills will include at least 20% Level 2 or above mathematical skills. These skills will be applied in the context of chemistry.

All mathematical content will be assessed within the lifetime of the qualifications.

The following tables illustrate where these mathematical skills may be developed and could be assessed. Those shown in bold type would only be tested in the full International Advanced Level course.

This list of examples is not exhaustive. These skills could be developed in other areas of specification content.

[1] The information in this appendix has been taken directly from the document *GCE AS and A level regulatory requirements for biology, chemistry, physics and psychology* published by the Department for Education (April 2014).

	Mathematical skills	Exemplification of mathematical skill in the context of A Level Chemistry (assessment is not limited to the examples given below)
(i)	**B.0 – arithmetic and numerical computation**	
B.0.0	Recognise and make use of appropriate units in calculation	Candidates may be tested on their ability to: • convert between units, e.g. cm^3 to dm^3 as part of volumetric calculations • **give units for an equilibrium constant or a rate constant** • understand that different units are used in similar topic areas, so that conversions may be necessary, e.g. entropy in J mol^{-1} K^{-1} and enthalpy changes in kJ mol^{-1}
B.0.1	Recognise and use expressions in decimal and ordinary form	Candidates may be tested on their ability to: • use an appropriate number of decimal places in calculations, e.g. for pH • carry out calculations using numbers in standard and ordinary form, e.g. use of Avogadro constant • understand standard form when applied to areas such as (but not limited to) K_w • convert between numbers in standard and ordinary form • understand that significant figures need retaining when making conversions between standard and ordinary form, e.g. 0.0050 mol dm^{-3} is equivalent to 5.0×10^{-3} mol dm^{-3}
B.0.2	Use ratios, fractions and percentages	Candidates may be tested on their ability to: • calculate percentage yields • calculate the atom economy of a reaction • construct and/or balance equations using ratios
B.0.3	Make estimates of the results of calculations (without using a calculator).	Candidates may be tested on their ability to: • **evaluate the effect of changing experimental parameters on measurable values, e.g. how the value of K_c would change with temperature given different specified conditions**
B.0.4	Use calculators to find and use power, **exponential and logarithmic functions**	Candidates may be tested on their ability to: • carry out calculations using the Avogadro constant • **carry out pH and pK_a calculations** • **make appropriate mathematical approximations in buffer calculations**

	Mathematical skills	Exemplification of mathematical skill in the context of A Level Chemistry (assessment is not limited to the examples given below)
(ii)	**B.1 – handling data**	
B.1.1	Use an appropriate number of significant figures	Candidates may be tested on their ability to: • report calculations to an appropriate number of significant figures given raw data quoted to varying numbers of significant figures • understand that calculated results can only be reported to the limits of the least accurate measurement
B.1.2	Find arithmetic means	Candidates may be tested on their ability to: • calculate weighted means, e.g. calculation of an atomic mass based on supplied isotopic abundances • select appropriate titration data (i.e. identification of outliers) in order to calculate mean titres
B.1.3	Identify uncertainties in measurements and use simple techniques to determine uncertainty when data are combined	Candidates may be tested on their ability to: • determine uncertainty when two burette readings are used to calculate a titre value
(iii)	**B.2 – algebra**	
B.2.1	Understand and use the symbols: =, <, <<, >>, >, $\propto$, ~, equilibrium sign	No exemplification required.
B.2.2	Change the subject of an equation	Candidates may be tested on their ability to: • carry out structured and unstructured mole calculations, **e.g. calculate a rate constant *k* from a rate equation**
B.2.3	Substitute numerical values into algebraic equations using appropriate units for physical quantities	Candidates may be tested on their ability to: • carry out structured and unstructured mole calculations • **carry out rate calculations** • **calculate the value of an equilibrium constant K_C**
B.2.4	Solve algebraic equations	Candidates may be tested on their ability to: • carry out Hess's law calculations • **calculate a rate constant *k* from a rate equation**
B.2.5	**Use logarithms in relation to quantities that range over several orders of magnitude**	**Candidates may be tested on their ability to:** • **carry out pH and pK_a calculations**

	Mathematical skills	Exemplification of mathematical skill in the context of A Level Chemistry (assessment is not limited to the examples given below)
(iv)	**B.3 – graphs**	
B.3.1	Translate information between graphical, numerical and algebraic forms	Candidates may be tested on their ability to: • interpret and analyse spectra • **determine the order of a reaction from a graph** • **derive rate expression from a graph**
B.3.2	Plot two variables from experimental or other data	Candidates may be tested on their ability to: • plot concentration–time graphs from collected or supplied data and draw an appropriate best-fit curve
B.3.3	**Determine the slope and intercept of a linear graph**	Candidates may be tested on their ability to: • **calculate the rate constant of a zero-order reaction by determination of the gradient of a concentration–time graph**
B.3.4	**Calculate rate of change from a graph showing a linear relationship**	Candidates may be tested on their ability to: • **calculate the rate constant of a zero-order reaction by determination of the gradient of a concentration–time graph**
B.3.5	**Draw and use the slope of a tangent to a curve as a measure of rate of change**	Candidates may be tested on their ability to: • **determine the order of a reaction using the initial rates method**
(v)	**B.4 – geometry and trigonometry**	
B.4.1	Appreciate angles and shapes in regular 2D and 3D structures.	Candidates may be tested on their ability to: • predict/identify shapes of and bond angles in molecules with and without a lone pair(s), for example NH_3, CH_4, H_2O etc
B.4.2	Visualise and represent 2D and 3D forms including two-dimensional representations of 3D objects	Candidates may be tested on their ability to: • draw different forms of isomers • **identify chiral centres from a 2D or 3D representation**
B.4.3	Understand the symmetry of 2D and 3D shapes	Candidates may be tested on their ability to: • describe the types of stereoisomerism shown by molecules/complexes • **identify chiral centres from a 2D or 3D representation**