Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
The structure of atoms.	0.2 week	**Students should be able to:** • describe the structure of atoms in terms of protons, neutrons and electrons • recall the relative mass and relative charge of protons, neutrons and electrons.	• Students research how the model of the atom changed over time (examples of key contributions could include the Ancient Greeks, Dalton, Thompson, Rutherford, Bohr, Chadwick) (AO1 - Knowledge and understanding of atomic structure; AO3 - Evaluate how and why atomic structure model developed over time). • Rich question – How can we tell what is inside an atom if we can't see it?		RSC timeline: http://www.rsc.org/chemsoc/timeline RSC: Chemists in a social & historical context: http://www.rsc.org/learn-chemistry/resource/res00001332/the-atom-detectives?cmpid=CMP00002843 RI Christmas Lecture – section on atomic structure http://www.rsc.org/learn-chemistry/resource/res00001119/ri-christmas-lectures-2012-atomic-structure

3.1.1.2 Mass number and isotopes

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
To define atoms and ions in terms of protons, neutrons and electrons. Explain the existence of isotopes. How a TOF mass spectrometer works and some of its simple uses.	0.4 weeks	**Students should be able to:** • define atoms and ions in terms of numbers of protons, neutrons and electrons, as well as atomic number and mass number (including isotopes) • describe how a time of flight mass spectrometer works • identify elements and calculate relative atomic mass from mass spectroscopy data • find the relative formula mass of compounds from mass spectroscopy data.	• Students identify atoms and ions from numbers of protons, neutrons and electrons, and vice versa (AO2 - Apply knowledge and understanding). • Students determine the relative atomic mass of elements using isotope abundance data (this could include data for elements found in meteorites to show some difference) quoting answers to a suitable number of significant figures for data provided (AO2 - Apply knowledge and understanding; MS1.1 - Use an appropriate number of significant figures to find relative masses; MS1.2 - Find arithmetic means to find relative masses. • Students look at the mass spectra of compounds to determine the relative formula mass (AO2 - Apply knowledge and understanding).	• SAM AS Paper 1 (set 1) Q2 • June 2013 Unit 1 Question 1a, 1b, 1c and 1f (QS13.1.01) • January 2012 Unit 1 Question 7a (QW12107) • June 2010 Unit 1 Question 8a (QS10.1.8A)	RSC: Build an atom simulation: http://www.rsc.org/learn-chemistry/resource/res00001433/build-an-atom-simulation-rsc-funded RSC Spectral School: http://www.rsc.org/learn-chemistry/collections/spectroscopy Isotope data: http://www.chem.ualberta.ca/~massspec/atomic_mass_abund.pdf Data on isotopes in meteorites: 'The Elements: Their Origin, Abundance, and Distribution' by P. A. Cox AQA Time of flight mass spectrometry Teachers' Notes and Student guide: http://filestore.aqa.org.uk/resources/chemistry/AQA-7404-7405-TN-MASS-SPECTROMETRY.PDF

					http://filestore.aqa.org.uk/resources/chemistry/AQA-7404-7405-SG-TOFMS.PDF http://filestore.aqa.org.uk/resources/chemistry/AQA-7404-7405-SG-TOFMS-QA.PDF
Extension			Students investigate the use of mass spectroscopy in drug testing athletes (AO3 - Analyse, interpret and evaluate scientific information).		

3.1.1.3 Electron configuration

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Describe the electron structure of atoms and ions.	0.5 weeks	**Students should be able to:** • give the electron structure of atoms and ions up to	• Students write the electron structure of atoms and ions with *Z*=1-36 (AO1 - Demonstrate knowledge and understanding of scientific ideas).	• January 2012 Unit 1 Question 5a and 5b (QW12.01.05)	Orbitron (shows shapes of orbitals):

Define and write equations for ionisation energy. Explain how ionisation energy data provides evidence for electron structure.		Z=36 in terms of s, p and d sub-shells • explain how data from ionisation energies provides evidence for electron structure.	• Students research values of first ionisation energies for elements Z=1–36 and plot them on a graph and then explain trends (AO2 - Apply knowledge and understanding; MS3.2 - Plot two variables from experimental or other data). • Students write explanations for trends in ionisation energies down a group and across a period (AO1 - Demonstrate knowledge and understanding of scientific ideas). • Students determine which Group an element is in using successive ionisation energy data (AO2 - Apply knowledge and understanding).	• June 2013 Unit 1 Question 6b, 6c and 6d (QS13.01.06) • January 2010 Unit 1 Question 2 (QW10.01.02) • June 2009 Unit 1 Question 1a and 1b (QS09.01.01) • January 2002 Unit 1 Question 4d (QW02.01.04)	http://winter.group.shef.ac.uk/orbitron/ Ionisation energy data (1st and successive) http://en.wikipedia.org/wiki/Molar_ionization_energies_of_the_elements

3.1.2 Amount of substance

When chemists measure out an amount of a substance, they use an amount in moles. The mole is a useful quantity because one mole of a substance always contains the same number of entities of the substance. An amount in moles can be measured out by mass in grams, by volume in dm^3 of a solution of known concentration and by volume in dm^3 of a gas.

Prior knowledge:

GCSE Chemistry
- Relative atomic mass, relative molecular mass, relative formula mass (although this is revisited here).
- Writing formulae (elements, common compounds and ionic compounds).
- Balancing equations (although this is revisited here).
- Moles (although this is revisited here).
- Calculations involving Masses (although this is revisited here).
- Concentration of solutions (Separate Science - although this is revisited here).
- Empirical and molecular formulae (although this is revisited here).

3.1.2.1 Relative atomic mass and relative molecular mass

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Relative mass of atoms, elements and compounds.	0.1 week	**Students should be able to:** • define relative atomic mass (A_r) • define relative molecular mass (M_r) • determine relative molecular mass (M_r) of a substance using relative atomic mass (A_r) values.	• The relative mass of different substances is calculated from the formula (AO2 - Apply knowledge and understanding) • The mass of everyday objects could be measured relative to a specific object of known mass (AO2 - Apply knowledge and understanding) • Determine the relative formula mass (M_r) of substances using relative atomic mass values (AO2 - Apply knowledge and understanding)	• Students can calculate M_r given the formula of compounds	Suitable resources can be found at http://www.docbrown.info/ and http://www.chemsheets.co.uk/ (subscription required)
Extension			• Students could research why ^{12}C was chosen as the standard (AO3 - Analyse, interpret and evaluate scientific information).		

3.1.2.2 The mole and Avogadro constant

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Calculations using moles for solids and solutions.	1 week	**Students should be able to carry out calculations:** • using the Avogadro constant • using mass of substance, M_r, and amount in moles • using concentration, volume and amount of substance in a solution.	• Students calculate the mass (in g) of atoms/ions using the masses sub atomic particles, quoting answers to a suitable number of significant figures for data provided (AO2 - Apply knowledge and understanding). • Practical opportunity: Students measure out 1 mole (and other mole quantities) of different substances (eg sucrose, salt, water) (AO2 - Apply knowledge and understanding). • Students practice doing calculations involving Avogadro constant, involving mass, M_r and moles, and involving concentration, volume and amount of substance and quoting the final results to the appropriate number of significant figures for data provided (AO2 - Apply knowledge and understanding; MS1.1 - Use an appropriate number of significant figures to find relative masses). • Students find the concentration of NaCl in intravenous saline (9 g per dm^3), glucose in isotonic sports drinks (17 g in 500 cm^3) and other similar calculations for everyday solutions. (AO2 - Apply knowledge and understanding).	• Calculating the mass (in g) of atoms/ions using the masses sub atomic particles to 5 sf • Calculations linking mass, M_r and moles • Calculations linking volume, moles and concentration • Calculations to determine the mass of a substance needed to produce a set volume of a solution with a pre-determined concentration. • Calculations to determine the concentration of a solution when a set mass is dissolved in a set volume. • Calculations using Avogadro's number to determine the number of particles in a solution or given mass.	Sports drink data from http://www.lucozadesport.com/products/sport/ Many suitable calculations can be found at http://www.docbrown.info/ and http://www.chemsheets.co.uk/ (subscription required)
Extension			Students research how Avogadro determined the value of his constant		

			(AO3 - Analyse, interpret and evaluate scientific information). Required practical 1. Other titration practicals.		

3.1.2.3 The ideal gas equation

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Perform calculations using the ideal gas equation.	0.8 week	**Students should be able to carry out calculations:** • using the ideal gas equation.	• Students will need to rearrange the ideal gas equation, work in appropriate units and quote answers to an appropriate number of significant figures (AO2 - Apply knowledge and understanding; MS0.0 - Recognise and make use of appropriate units in ideal gas calculations MS2.2 - Change the subject of the ideal gas equation; MS2.3 - Substitute numerical values into the ideal gas equation using appropriate units for physical quantities). • Practical Opportunity: Students find the M_r of a volatile liquid (AO2 - Apply knowledge and understanding; MS0.0 - Recognise and make use of appropriate units in ideal gas calculations ; MS2.2 - Change the subject of the ideal gas equation; MS2.3 - Substitute numerical values into the ideal gas equation using appropriate units for physical quantities; PS 3.2 - Process and analyse data; PS 4.1 - Know and understand how to use a wide range of experimental and practical instruments, equipment and techniques). • Students find the mass of argon inside a gas cylinder (23 MPa pressure, 146 × 23 cm dimensions) (AO2 - Apply knowledge and	• June 2006 Unit 1 Question 3 (QS06.1.03) • June 2005 Unit 1 Question 2b (QS05.1.02) • January 2005 Unit 1 Question 2b (QW05.1.02) • January 2004 Unit 1 Question 4a (QW04.1.04)	Finding M_r of butane: http://www.nuffieldfoundation.org/practical-chemistry/determining-relative-molecular-mass-butane Data on gas cylinders: http://www.boconline.co.uk/en/index.html Many suitable calculations can be found at http://www.docbrown.info/ and http://www.chemsheets.co.uk/ (subscription required)

			understanding; MS0.0 - Recognise and make use of appropriate units in ideal gas calculations MS2.2 - Change the subject of the ideal gas equation; MS2.3 - Substitute numerical values into the ideal gas equation using appropriate units for physical quantities). Molar volume of hydrogen practical. • Mr of volatile liquid practical.		
Extension			Students investigate the link between the gas laws and the ideal gas equation; (they could also research how the behaviour of real gases deviates from ideal gas behaviour although this is beyond the specification) (AO3 - Analyse, interpret and evaluate scientific information)		

3.1.2.4 Empirical and molecular formula

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources
Calculate empirical and molecular formulae from data.	0.6 week	**Students should be able to:** • explain the difference between empirical and molecular formulae • carry out calculations: • to find empirical formula from data giving composition by mass or percentage by mass • to find molecular formula from the empirical formula and relative molecular mass.	• Practical Opportunity: Students find the empirical formula of a metal oxide (eg magnesium oxide or copper oxide) (AO2 - Apply knowledge and understanding; PS 3.2 – process & analyse data using appropriate mathematical skills). • Students find empirical formulae (and molecular formulae where relevant) from data (AO2 - Apply knowledge and understanding; MS0.2 - Use ratios, fractions and percentages).	• June 2010 Unit 1 Question 4a (QS10.1.04) • June 2009 Unit 1 Question 2c (QS09.1.02)	Finding empirical formula of copper oxide http://www.nuffieldfoundation.org/practical-chemistry/finding-formula-copper-oxide Many suitable calculations can be found at http://www.docbrown.info/ and http://www.chemsheets.co.uk/ (subscription required)
Extension			Students look at some further information about elemental microanalysis using the RSC resource (this is beyond the specification but relevant) (AO3 - Analyse, interpret and evaluate scientific information)		RSC resource on elemental microanalysis: http://www.nationalstemcentre.org.uk/elibrary/resource/9890/elemental-microanalysis

3.1.2.5 Balanced equations and associated calculations

Learning objective	Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Assessment opportunities	Resources

To write balanced full and ionic equations.
 	
To use equations to calculate masses, percentage yields, atom economies, volumes of gases, concentrations & volumes of solutions.
 	
To understand the importance of processes having a high atom economy for society and industry.
 	
Required practical 1
Make up a volumetric solution and carry out a simple acid–base titration.
	2 weeks	**Students should be able to:**
		• write balanced equations
		• write ionic equations
		• carry out calculations for reactions involving:
		  • masses,
		  • percentage yields,
		  • atom economies,
		  • volumes of gases,
		  • concentrations & volumes of solutions,
		• give economic, ethical and environmental advantages for society and industry of processes with a high atom economy.
			• Students balance equations, including ones where formulae are given and some where they are not (AO2 - Apply knowledge and understanding).
			• Students write ionic equations from given equations (AO2 - Apply knowledge and understanding).
			• Students practise calculations to find masses, percentage yields, atom economies, volumes of gases, concentrations & volumes of solutions (AO2 - Apply knowledge and understanding; MS1.1 - Use an appropriate number of significant figures; MS2.3 - Substitute numerical values into algebraic equations using appropriate units for physical quantities).
			• Practical Opportunity: the yield for the conversion of magnesium to magnesium oxide (AO2 - Apply knowledge and understanding; PS 3.2 - Process and analyse data using appropriate mathematical skills).
			• Practical Opportunity: Students find the M_r of a hydrated salt (eg copper sulfate or magnesium sulfate) by heating to constant mass (AO2 - Apply knowledge and understanding; PS 3.2 - Process and analyse data using appropriate mathematical skills).
				• January 2011 Unit 1 Question 3 (QW11.1.03)
				• June 2010 Unit 1 Question 3 (QS10.1.03)
				• January 2009 Unit 1 Question 5 (QW09.1.05)
				• June 2004 Unit 1 Question 2 (QS04.1.02)
				• January 2004 Unit 1 Question 3 (QW04.1.03)
				• January 2002 Unit 1 Question 7 (QW02.1.07)
				• January 2009 Unit 1 Question 3
					Finding the M_r of a hydrated salt: http://www.nuffieldfoundation.org/practical-chemistry/finding-formula-hydrated-copperii-sulfate
					
					Many suitable calculations and practical activities can be found at http://www.docbrown.info/ and http://www.chemsheets.co.uk/ (subscription required)
					
					Chemistry Review article: Atom Economy (Volume 19, edition 2)

			• Practical Opportunity: Students find the percentage conversion of a Group 2 carbonate to its oxide by heat (AO2 - Apply knowledge and understanding; PS 3.2 - Process and analyse data using appropriate mathematical skills). • **Required practical 1** - Make up a volumetric solution and carry out a simple acid–base titration (AO2 - Apply knowledge and understanding; PS 3.2 - Process and analyse data using appropriate mathematical skills); PS 3.3 - Consider margins of error, accuracy and precision of data; AT d - Use laboratory apparatus for a variety of experimental techniques including titration, using burette and pipette; AT f - Use acid–base indicators in titrations of weak/strong acids with weak/strong alkalis). • Practical Opportunity: Students perform titration to analyse many substances, including many everyday substances : • the concentration of ethanoic acid in vinegar • the mass of calcium carbonate in an indigestion tablet • the M_r of a group 2 hydrogencarbonate • the M_r of succinic acid Analysis of coffee descaler • the mass of aspirin in an aspirin tablet.		

			(AO2 - Apply knowledge and understanding; PS 3.2 - Process and analyse data using appropriate mathematical skills); PS 3.3 - Consider margins of error, accuracy and precision of data; AT d - Use laboratory apparatus for a variety of experimental techniques including titration, using burette and pipette ; AT f - Use acid–base indicators in titrations of weak/strong acids with weak/strong alkalis).		