GCSE Sc Chemistry Guidance Notes

The following is intended to provide some general clarification of some of the statements in the specification and is intended for teachers not candidates. It may be amended from time to time. It is not intended to be exhaustive and more detail is included in some areas where it is felt that greater clarification is required. The material here is an adjunct to the specification and is not intended to replace it. As such some of the statements in the specification are considered to be self explanatory and no further elaboration is included here. The *how science works* statements are given some emphasis but aspects of *how science works* could be incorporated in other areas besides those noted. *How science works* permeates throughout the course and is expected to underpin the whole approach to the subject. The emphasis of the course, therefore, is understanding concepts, appreciating processes and gaining skills.
The following information is written in line with the specification statements and uses the relevant specification reference notation. Neither the specification nor these notes represent a particular order for teaching purposes.

Unit C1

1. ATOMIC STRUCTURE, ELEMENTS AND THE PERIODIC TABLE

(a) The composition of the nucleus will not be assessed in this unit (but may be taught if teachers wish and this principle is true throughout, i.e., the specification lists that which will be assessed but teachers are free to teach more than this if they wish).

(b) The atomic number should be used to obtain the number of electrons and the electronic structure may need to be represented diagrammatically or in the form 2,8,1.

(c) An element contains only one kind of atom and cannot be broken down into simpler substances by chemical methods.

(d) For the first three rows, the number of electrons in the outer shell gives the group number; the number of shells gives the number of the period (or row), i.e. Na 2,8,1 means sodium is in Group 1 and Period (Row) 3.

(e) Mendeleev arranged the elements known at that time in order of increasing relative atomic mass. He found that there were patterns in the properties of certain elements when they were arranged in this way. To make his table work he realised that he needed to leave gaps for elements that had not been discovered at that time. He used his table to predict the properties of some undiscovered elements. When these elements were discovered they had the properties that he had predicted for them.

(f) Metals are good conductors of heat and electricity when solid, are malleable and ductile. The melting point of a metal is related to its position in the Periodic Table and can be quite low (e.g. Group 1 metals).

(g) Candidates should always be able to extract given data from tables, graphs or charts and transfer data from one form to another, e.g. use a table of melting points of Group 1 elements to plot an appropriate graph. The term "trend" is taken to mean the general pattern of change on descending or ascending the group, e.g. "the data shows that the melting points of Group 1 elements decrease as you go down the group".

(h) With oxygen in the air, the pattern is:-

$$\mathbf{4M(s) + O_2(g) \rightarrow 2M_2O(s)}$$

With water, the pattern is:-

$$\mathbf{2M(s) + 2H_2O(l) \rightarrow 2MOH(aq) + H_2(g)}$$

The patterns of similarity include alkali formation, fizzing (bubbling), floating, moving around. The differences include increasing vigour down the group and potassium giving a lilac flame.
Foundation candidates will not be expected to write the symbol equation for the reaction with water but may be required to interpret it.

With Group 7 elements, the pattern is:-

$$\mathbf{2M(s) + X_2(g) \rightarrow 2MX(s)} \text{ where X is a halogen atom}$$

Candidates will be expected to name the products

(i) A more reactive halogen displaces a less reactive one from a solution of one of its compounds.
For example,

$$\mathbf{Cl_2(g) + 2NaBr(aq) \rightarrow 2NaCl(aq) + Br_2(aq)}$$

Candidates should use observations to decide whether a reaction has occurred or not and then produce an order of reactivity. For example, when chlorine is bubbled into colourless sodium bromide solution (or chlorine water is added to sodium bromide solution), a brown coloration is seen. Chlorine is more reactive than bromine.
Adding chlorine water or bromine water to a solution of sodium iodide can be use to indicate that both chlorine and bromine are more reactive than iodine

(j) Candidates should know how to carry out a flame test and recognise sodium by a yellow-orange flame or potassium by a lilac flame.
Silver nitrate solution gives a white precipitate with chloride but a pale yellow precipitate with iodide (there is no need to add nitric acid here, since only chloride and iodide are specified). No equations are needed.

(k) Candidates need to know that scientists collect data by carrying out experiments, examining secondary sources or conducting surveys. Data for the number of decayed, missing or filled teeth (dmft) is collected by surveying school children of various ages. The data is reliable because all school children are surveyed and only absentees on the day are excluded. Comparing data from one fluoridated area with that from one non-fluoridated area may not provide sufficient evidence for a valid conclusion, since other factors may be involved in those areas.
Some people support fluoridation of the water supply because scientific evidence shows that it prevents tooth decay. Others oppose it because they feel it is not right to

force everyone to consume fluoride, particularly since there is evidence that, at high concentrations, it may be harmful to health.
It is important for candidates to realise that science cannot address ethical issues (i.e. science cannot answer questions of the type "Is it right to do this?"), although scientific evidence might inform the debate in some cases.
Evidence for examination can be obtained from www.bfsweb.org

(l) (as spec)

(m)

Element	Use	Property
Chlorine	sterilising drinking water	poisonous
Iodine	antiseptic	poisonous
helium	to fill weather balloons	low density gas
neon	advertising signs	not needed
argon	to fill light bulbs	unreactive

2. COMPOUNDS

(a) (as spec)

(b) (as spec)

(c) (as spec)

(d) (as spec)

(e) Candidates should be able to draw these diagrams from given formulae and vice versa.

(f) The reactions of acids should be used to show that there are patterns in the reactions of compounds:

metal + acid $\rightarrow$ salt + hydrogen

base + acid $\rightarrow$ salt + water

carbonate + acid $\rightarrow$ salt + water + carbon dioxide

The term "base" is here used to mean an oxide or hydroxide of a metal. An alkali is a solution of a base in water. Most bases are insoluble. The reaction between a base and an acid is called neutralisation. An alkali is a solution of a base in water. Indicators can be used to show when neutralisation is complete.

Candidates should be able to name the salt produced from a metal, base or carbonate reacting with dilute hydrochloric or dilute sulphuric acid.

Candidates should know how to test for carbonates, carbon dioxide and hydrogen.

3. USING CHEMICAL REACTIONS TO MAKE NEW MATERIALS

(a) (as spec) Candidates should appreciate that the whole point of chemistry is to make the materials which enhance our lives and/or ensure our survival.

(b) (as spec)

(c) (as spec)

(d) (as spec)

(e) (as spec)

4. RATES OF CHEMICAL CHANGE

(a) This section provides a context for developing quantitative practical skills. 'Planning the collection of reliable data' here refers to controlling variables to ensure a fair test, using a suitable range and intervals for the independent variable and the realisation that repeats and averaging of non-rogue values are necessary. Discussion of these aspects can form part of the evaluation.
Candidates should be able to graph data in an appropriate way and interpret rate graphs.

Candidates should know that in order to react, the reactant particles must collide with each other.

Increasing the concentration means more particles in a given volume (or particles closer together), which gives more collisions in the same time (not just 'more collisions').Candidates may tend to omit 'in the same time' and may find it easier to refer to frequency or chance of collision, for example

- collisions occur more often
- collisions are more likely
- there is a greater chance of collision.

Increasing the temperature gives particles more energy so they move around faster and collide more often (or there are more collisions in the same time or any of the above bullets). At GCSE level, the energy of collision (activation energy etc) aspects are not required.

Increasing the surface area, by crushing or powdering a solid reactant, increases the chance of collision between particles of the solid and particles of the acid (say) since there are many more particles of the solid at the surface.

(b) A catalyst speeds up a reaction but is not used up during the reaction. Different reactions may need different catalysts. Candidates should appreciate the vital economic and environmental importance of developing new catalysts as outlined in the spec - this is related to the growing movement called Green Chemistry.

5. NANOSCIENCE

(a) (as spec)

(b) (as spec)

(c) Essentially, candidates need to know that nano-sized materials may have very different properties from the bulk form (see (b) above). The reasons for this are not fully understood.
The new properties may lead to exciting new uses and products. The potential is enormous and rather than specify particular uses, candidates ought to be aware of two examples of their own (or their teacher's) choice.

However, the new properties may have unpredicted, unwelcome effects on people or the environment. There is concern that nanoparticles may easily spread through the atmosphere or ground-water. They could easily enter the body through the lungs or by passing through the skin.

There are ethical and social issues surrounding the development of nanotechnologies, as there are with all new technological development. These aspects will not be tested on written examination papers unless scientific information is given, from which a candidate may provide an opinion using reasoned argument. This section of the specification provides an opportunity for an Extended Report.

An excellent resource for teachers and candidates is the Jan 2005 issue of the Big Picture magazine available from www.wellcome.ac.uk/bigpicture. Other useful websites include www.azonano.com

6. THE PRODUCTION AND USE OF FUELS

(a) A fraction is a mixture of hydrocarbons. The boiling point of a hydrocarbon increases with increasing molecular mass ('chain length' will do as a simplification here). Crude oil is vaporised by heating and the vapour allowed into a tall column which is hotter at the base and gets cooler as you go further up the column. Fractions containing shorter chain molecules have lower boiling points and condense further up the column and vice versa.

(b) (as spec)

(c) (as spec)

(d) (as spec)

(e) This entails performing a bond energy calculation for reactions where the equation (with structural formulae to show the bonds) is given.

(f) Fossil fuels are mainly hydrocarbons but some sulphur is present. Burning fossil fuels produces:

- CO_2, which is a greenhouse gas and leads to global warming
- SO_2, which undergoes further oxidation to SO_3 in the upper atmosphere, causing acid rain
- NO_2 (at spark plugs in car engines - the nitrogen comes from the air), which causes acid rain

Acid rain kills vegetation and fish in rivers and lakes.

Incomplete combustion of fossil fuels produces:

- CO, which is poisonous and can kill people by joining with haemoglobin in blood, preventing the blood from carrying oxygen
- Soot (unburned carbon), which can clog plant stomata (pores) and cause asthma

Burning fossil fuels has been the main source of energy for the development of the high standard of living of modern industrialised societies. It provides the energy to keep people warm and comfortable. It also provides the energy needed to produce new materials.

(g) Candidates may be asked to comment on the advantages and disadvantages of various proposed solution to the problem of acid rain when information is provided to them.

7. EVOLUTION AND MAINTENANCE OF THE ATMOSPHERE

(a) (as spec)

(b) The explanation most favoured currently is that the atmosphere was originally produced by volcanic outgassing.

The main components of the original atmosphere were carbon dioxide and water vapour together with smaller amounts of other gases such as nitrogen and methane;

The carbon dioxide content has decreased, mainly by large quantities of carbon dioxide being removed into carbonate rocks (limestone),

The oxygen content has increased as a result of the evolution of photosynthesising organisms

An ozone layer developed. The ozone layer filters out harmful ultraviolet radiation from the sun.

(c) Respiration uses up oxygen and makes carbon dioxide.
Combustion uses up oxygen and makes carbon dioxide.
Photosynthesis uses up carbon dioxide and makes oxygen.

(d) Candidates should realise that evidence suggests that the Earth is warming but scientists do not all agree on the cause of this. Many think that it is due mainly to increased levels of carbon dioxide in the atmosphere as a result of the combustion of fossil fuels and deforestation causing imbalance in the carbon cycle.

(e) Candidates may be asked to interpret given data, e.g. in the form of tables of data or graphs , etc. They may be required to evaluate the reliability of the evidence.

(f) Global warming may cause

- drier, hotter summers in some parts of the world leading to drought
- flooding due to increased rainfall in some areas
- rising sea levels
- movement of the conveyor (Gulf Stream), resulting in a much colder climate for Britain.

(g) Candidates may be asked to suggest advantages and disadvantages of proposed solutions to the problem of global warming when information is provided to them.

8. GEOLOGICAL PROCESSES

(a) (as spec)

(b) (as spec)

(c) (as spec)

Useful web-sites include www.jesei.org (The Joint Earth Science Education Initiative) and www.earthscienceeducation.com

C1 Useful Web Sites

Global Warming

http://www.defra.gov.uk/environment/climatechange/schools/

http://www.brighton73.freeserve.co.uk/gw/paleo/paleoclimate.htm

http://www.meto.gov.uk/research/hadleycentre/obsdata/cet.html

http://www.meto.gov.uk/

http://www.wmnet.org.uk/wmnet/15.cfm

Crude Oil

http://www.schoolscience.co.uk/petroleum/index.html

http://www.howstuffworks.com/oil-refining4.htm

http://www.schoolscience.co.uk/content/4/chemistry/petroleum/knowl/4/2index.htm?2home_f2.htm

Fluoridation

http://www.bfsweb.org/

http://www.second-opinions.co.uk/fluorideharm.html\

http://www.southernwater.co.uk/educationAndEnvironment/drinkingWaterQuality/

Periodic Table

http://www.webelements.com/webelements/scholar/index.html

http://www.chemsoc.org/networks/learnnet/periodictable/

http://www.ngfl-cymru.org.uk/vtc/periodic_table/eng/Introduction/default.htm

http://www.chemsoc.org/viselements/pages/history.html

Group 1

http://www.webelements.com/webelements/elements/text/Na/key.html

http://www.chemsoc.org/VISELEMENTS/pages/pertable_fla.htm

http://www.nelsonthornes.com/secondary/science/scinet/scinet/index.htm

Group 7

http://www.webelements.com/webelements/elements/text/Cl/key.html

http://www.chemsoc.org/VISELEMENTS/pages/pertable_fla.htm

http://www.nelsonthornes.com/secondary/science/scinet/scinet/index.htm

Continental Drift

http://www.bbm.me.uk/portsdown/PH_061_History_b.htm

http://www.bbc.co.uk/schools/gcsebitesize/chemistry/changestoearthandatmosphere/1platetectonicsrev3.shtml

http://www.stvincent.ac.uk/Resources/EarthSci/index.html

http://www.enchantedlearning.com/subjects/astronomy/planets/earth/Continents.shtml

http://www.classzone.com/books/earth_science/terc/navigation/visualization.cfm#ch03

http://kids.earth.nasa.gov/archive/pangaea/

http://www.ucmp.berkeley.edu/geology/tectonics.html

http://www.moorlandschool.co.uk/earth/tectonic.htm

http://education.usgs.gov/california/index.html

Nanoscience

http://www.royalsoc.ac.uk/landing.asp?id=1210

http://www.sciencemuseum.org.uk/antenna/nano/index.asp

http://www.wellcome.ac.uk/node5954.html

http://www.mrsec.wisc.edu/Edetc/index.html

http://www.nano.gov/html/edu/eduteach.html

http://europa.eu.int/youth/news/index_1178_en.html

http://www.nano.sussex.ac.uk/

http://www.nanoscience.cam.ac.uk/

http://www.nanophase.com/applications/

http://nanocomputer.org/index.cfm?content=81&Menu=26

http://www.newscientisttech.com/channel/tech/nanotechnology

Unit C2

1. ATOMIC STRUCTURE

(a)-(c) (as spec)

(d) "Atomic number" is the number of protons in an atom. "Mass number" is the sum of the number of protons and neutrons in an atom.

(e) It is expected that candidates will be able to give electron arrangements for the first 20 elements.

2. CHEMICAL BONDING, STRUCTURE AND PROPERTIES

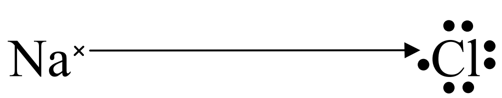
(a)-(c) (as spec)

(d) A metal has atoms (positive ions) that are close together in a regular pattern. These are held together by the outer shell electrons which are free to move between them.
Metals are malleable and ductile because the layers of atoms can slide over each other.
Metals conduct electricity when solid because the outer shell electrons are free to move through the structure.
The melting temperature and physical strength of a metal depend on the strength of the metallic bonding, which depends on the number of outer shell electrons per atom. Aluminium is stronger than sodium because the electrostatic attraction between the ions and free electrons is greater; the Al^{3+} ions are held together by $3e^-$ per ion as opposed to the Na^+ ions which are held together by one e^- per ion.

(e) In a metallic glass, the metal atoms (positive ions) are not in a regular pattern. This makes the material much more brittle but much harder.

(f) When drawing diagrams to show ionic bonding, candidates should use two sets of diagrams to show:

- the situation before electron transfer with an arrow to show how the transfer is to take place, e.g.



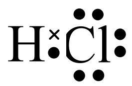
- the situation after the transfer with the charges on the ions, e.g.

Only outer shell electrons need be shown.

(g) For giant ionic structures:

- high melting temperature - strong forces of attraction between oppositely charged ions
- conduct electricity when molten or dissolved - ions are free to move (moving charges constitute an electric current)
- can't conduct electricity when solid - ions not free to move

(h) All outer shell electrons should be shown for each atom (not just the bonding electrons), for example, in hydrogen chloride:



(i) Simple molecular substances have small molecules which have strong covalent bonds holding the atoms together inside the molecule but with weak forces of attraction between one molecule and another. The weak intermolecular forces give low melting and boiling temperatures (many of these substances are gases, low boiling liquids or low melting solids at room temperature).

(j)-(l) (as spec)

(m) No distinction is to be drawn between so-called "metallic" and "semi-conducting" types. Candidates should simply appreciate the analogy with the graphite structure and the potential for conduction of electricity allowing the possibility of tiny electrical circuits.

(n) Candidates will be expected to suggest advantages and disadvantages of new developments when provided with information. At the Foundation level this might well take the form of a question providing information in a "box", followed by suitable questions testing comprehension of the passage. No recall is expected here, other than drawing on knowledge and understanding of previous items in the spec.

3. THE PRODUCTION AND USE OF METALS

(a)-(e) (as spec)

(f) This item implies knowledge and understanding of the electrolytic process and not the purification of bauxite to make alumina. Candidates should be familiar with the electrolytic cell and the processes that go on in it.

(g) The high cost of the process is not simply due to the fact that electricity is used. It is the enormous amount of electrical energy needed (due to the high reactivity of aluminium) that makes the process so costly. A recent article in the Western Mail (Nov 2005) stated that the plant on Anglesey accounts for 10% of Wales' total electrical energy consumption.

(h) (as spec)

(i) A major factor arises from the need for cheap electricity, so proximity to hydroelectric schemes are desirable. Other factors include those usually cited for industrial plants, such as availabilty of workforce and good transport links (including facility for import of the ore / alumina).

(j) Candidates should be familiar with the properties of these metals and should be able to suggest a property that makes the metal suitable for a particular use.

(k) (as spec)

(l) (as spec)

(m) Candidates should be aware of the widespread use of metals and therefore their social and economic importance. They should be aware that metal extraction requires energy and that this has an environmental impact which can be minimised by recycling.

4. CHEMICAL CALCULATIONS

(a)-(d) (as spec)

(e) As well as the usual type of calculation on the Higher Tier, Foundation candidates ought to be able to give the mass of an entity in an equation or word equation if supplied with the masses of <u>all</u> other species present. This is based upon their understanding that no atoms are created or destroyed in a chemical reaction.

(f) Candidates should calculate percentage yield from given data using the relation

$$\textbf{percentage yield} = \frac{\textbf{actual mass of required product}}{\textbf{theoretical maximum mass of required product}} \times \textbf{100\%}$$

(g)-(h) Consider the reaction

$$\mathbf{Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2}$$

The carbon and oxygen atoms are not incorporated into the required product (Fe) and are therefore, waste. The percentage yield (as calculated in (f)) might be 100% but that does not take into account the degree of waste in the process. The Green Chemistry movement recognises that waste (both of material and energy) has economic and environmental disadvantages. Atom economy is a measure of the degree to which atoms of the reactants are incorporated into the useful product.

$$\textbf{atom economy} = \frac{\textbf{theoretical mass of required product}}{\textbf{total mass of reactants used}} \times \textbf{100\%}$$

For the above reaction, **atom economy** $= \dfrac{\mathbf{2 \times 56}}{\mathbf{(112 + 48) + 3(28)}} \times \mathbf{100\%}$

$= 45.9\ \%$

5. AMMONIA AND FERTILISERS

(a) Candidates should understand the term reversible reaction simply as one which "goes both ways". Higher Tier candidates are expected to recall the equation.

(b) No knowledge of le Chatelier's principle is implied here - candidates will be asked to analyse and interpret given data. Note that the atom economy is 100% but that the yield is very low.

(c) No detail of any industrial scale process is implied. Candidates should be able to describe an experiment to make samples of ammonium sulfate or ammonium nitrate.

(d) Candidates should know the advantages and disadvantages of the use of fertilisers and be able to interpret given data.

(e)-(f) (as spec)

6. ALKANES, ALKENES AND POLYMERS

(a) (as spec)

(b) Reference to "spare bonds" is not acceptable to examiners.

(c) Candidates at Higher Tier will be expected to suggest, or complete, equations for the cracking of saturated hydrocarbons.

(d)-(e) (as spec)

(f) Candidates should know that polythene is widely used for packaging, carrier bags, bowls and buckets; PVC is used for window and door frames and guttering; PTFE is used for non-stick cooking utensils. They should know the properties of these polymers that enable them to be used in these ways. They should also be able to suggest which is more suited to any given use, giving a reason (in terms of properties).

(g) Candidates should know the behaviour of thermosets and thermoplastics on heating and relate this to their respective structures.

(h) (as spec)

(i) Candidates should understand that plastics are made from oil which is a finite resource. They should appreciate the advantages of plastic products and weigh these against the problems of litter and waste disposal.

7. SMART MATERIALS

(a) (as spec) – teachers can feel free to embellish the spec here (or anywhere else) for the benefit of their candidates but for assessment purposes the spec lists everything that candidates will be expected to know. The RSC have produced practical work on smart materials.

(b) Candidates should respond to given data to suggest advantages and drawbacks of the use of smart materials.

8. WATER

(a) Candidates should know that insoluble material is removed by filtration and chlorine is used to sterilise the water.

(b) (as spec)

(c) Candidates should know that hardness in water is defined as difficulty in producing a lather with soap and that this is caused by the presence of dissolved calcium and magnesium compounds.

(d) (as spec)

(e) (as spec)

(f) (as spec)

UNIT C3

1. ORGANIC CHEMISTRY

(a)-(b) (as spec)

2. SULPHURIC ACID

(a)-(b) (as spec)

(c) In 1884, A Swedish scientist, called Svante Arrhenius, suggested that solutions of certain compounds conduct electricity because the compounds split up into ions in solution. The ions carry the current. This produces chemical changes at the electrodes. The connection between electricity and chemical reactivity had fallen out of fashion at the time. The importance of his work would not have been recognised at the time were it not for the fact that a professor at Stockholm university appreciated the innovative nature of his ideas.
Acidic solutions contain hydrogen ions, H^+.
In 1923, Johannes Bronsted and Thomas Lowry independently suggested that an acid is a proton (hydrogen ion) donor. This meant that reactions that do not occur in aqueous solution could be considered as acid-base reactions. For example, the reaction between hydrogen chloride gas and ammonia gas to give ammonium chloride.

$$\mathbf{NH_3 + HCl \longrightarrow NH_4^+ + Cl^-}$$

The HCl acts as an acid because it donates a proton to the NH_3, which acts as a base (proton acceptor).

(e)-(f) (as spec)

(g) Candidates should know how sulphuric and ethanoic acids react with metals, bases and carbonates, comparing their rates.

3. CHEMICAL CALCULATIONS

(a)-(e) (as spec)

(f) Foundation candidates should carry out titrations and use the results to say which is the more concentrated of two or more acid (or alkali) solutions.

(g) (as spec)

4. LIMESTONE

(a)-(d) (as spec)

5. INORGANIC QUALITATIVE ANALYSIS

(a)-(b) (as spec)