3 Chemistry in society

(a) Metals

(i) Metallic bonding

118 Metallic bonding is the electrostatic force of attraction between positively charged ions and delocalised electrons.

119 Metallic elements are conductors of electricity because they contain delocalised electrons.

(ii) Reactions of metals

120 Equations, involving formulae, can be written to show the reaction of metals with oxygen, water, and dilute acids:

a) metal + oxygen → metal oxide
b) metal + water → metal hydroxide + hydrogen
c) metal + dilute acid → salt + hydrogen

121 Metals can be arranged in order of reactivity by comparing the rates at which they react.

122 Metals can be used to produce soluble salts. Excess metal is added to the appropriate acid, the mixture is filtered and the filtrate evaporated to dryness.

(iii) Redox

123 Reduction is a gain of electrons by a reactant in any reaction.

124 Oxidation is a loss of electrons by a reactant in any reaction.

125 In a redox reaction, reduction and oxidation take place at the same time.

126 Ion-electron equations can be written for reduction a) and oxidation b) reactions.

127 Ion-electron equations can be combined to produce redox equations.

(iv) Extraction of metals

128 During the extraction of metals, metal ions are reduced forming metal atoms.

129 The method used to extract a metal from its ore depends on the position of the metal in the reactivity series. Equations can be written to show the extraction of metals.

130 Methods used are:

a) ♦ heat alone (for extraction of Ag, Au and Hg)
b) ♦ heating with carbon or carbon monoxide (for extraction of Cu, Pb, Sn, Fe and Zn)
c) ♦ electrolysis (for extraction of more reactive metals including aluminium)

131 Electrolysis is the decomposition of an ionic compound into its elements using electricity.

3 Chemistry in society

132 A d.c. supply must be used if the products of electrolysis are to be identified.

133 Positive ions gain electrons at the negative electrode and negative ions lose electrons at the positive electrode.

(v) Electrochemical cells

134 Electrically conducting solutions containing ions are known as electrolytes.

135 A simple cell can be made by placing two metals in an electrolyte.

136 Another type of cell can be made using two half-cells (metals in solutions of their own ions).

137 An 'ion bridge' (salt bridge) can be used to link the half-cells. Ions can move across the bridge to complete an electrical circuit.

138 Electricity can be produced in cells where at least one of the half-cells does not involve metal atoms/ions. A graphite rod can be used as the electrode in such half-cells.

139 Different pairs of metals produce different voltages. These voltages can be used to arrange the elements into an electrochemical series.

140 The further apart elements are in the electrochemical series, the greater the voltage produced when they are used to make an electrochemical cell.

141 Electrons flow in the external circuit from the species higher in the electrochemical series to the one lower in the electrochemical series.

142 For an electrochemical cell, including those involving non-metals, ion-electron equations can be written for:

- the oxidation reaction
- the reduction reaction
- the overall redox reactions

143 The direction of electron flow can be deduced for electrochemical cells including those involving non-metal electrodes.

(b) Plastics

(i) Addition polymerisation

144 Plastics are examples of materials known as polymers.

145 Polymers are long chain molecules formed by joining together a large number of small molecules called monomers.

3 Chemistry in society

146 Addition polymerisation is the name given to a chemical reaction in which unsaturated monomers are joined, forming a polymer.

147 The names of addition polymers are derived from the name of the monomer used. Note: brackets can be used in polymer names to aid identification of the monomer unit.

(ii) Representation of the structure of monomers and polymers

148 A repeating unit is the shortest section of polymer chain which, if repeated, would yield the complete polymer chain (except for the end-groups).

149 The structure of a polymer can be drawn given either the structure of the monomer or the repeating unit.

150 From the structure of a polymer, the monomer or repeating unit can be drawn.

(c) Fertilisers

(i) Commercial production of fertilisers

151 Growing plants require nutrients, including compounds containing nitrogen, phosphorus or potassium.

152 Fertilisers are substances which restore elements, essential for healthy plant growth, to the soil.

153 Ammonia and nitric acid are important compounds used to produce soluble, nitrogen-containing salts that can be used as fertilisers.

154 Ammonia is a pungent, clear, colourless gas which dissolves in water to produce an alkaline solution.

155 Ammonia solutions react with acids to form soluble salts.

ammonia solution + an acid → an ammonium salt + water

(ii) Haber and Ostwald processes

156 The Haber process is used to produce the ammonia required for fertiliser production.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

157 At low temperatures the forward reaction is too slow to be economical. If the temperature is increased, the rate of reaction increases but, as the temperature increases, the backward reaction becomes more dominant. An iron catalyst is used to increase reaction rate.

158 Ammonia is the starting material for the commercial production of nitric acid.

159 The Ostwald process uses ammonia, oxygen and water to produce nitric acid. A platinum catalyst is used in this process.

3 Chemistry in society

(d) Nuclear chemistry

(i) Radiation

160 Radioactive decay involves changes in the nuclei of atoms. Unstable nuclei (radioisotopes) can become more stable nuclei by giving out alpha, beta or gamma radiation.

161 Alpha particles (α) consist of two protons and two neutrons and carry a double positive charge. They have a range of only a few centimetres in air and are stopped by a piece of paper. Alpha particles will be attracted towards a negatively charged plate.

162 Beta particles (β) are electrons ejected from the nucleus of an atom. They are able to travel over a metre in air but can be stopped by a thin sheet of aluminium. Beta particles will be attracted towards a positively charged plate.

163 Gamma rays (γ) are electromagnetic waves emitted from within the nucleus of an atom. They are able to travel great distances in air. They can be stopped by barriers made of materials such as lead or concrete. Gamma rays are not deflected by an electric field.

(ii) Nuclear equations

164 Balanced nuclear equations can be written using nuclide notation.

165 In nuclear equations:

- an alpha particle can be represented as $^{4}_{2}He$
- a beta particle can be represented as $^{0}_{-1}e$
- a proton can be represented as $^{1}_{1}p$
- a neutron can be represented as $^{1}_{0}n$

166 In the course of any nuclear reaction:

- The sum of the atomic numbers on the left of the reaction arrow is equal to the sum of the atomic numbers on the right of the reaction arrow.
- The sum of the mass numbers on the left of the reaction arrow is equal to the sum of the mass numbers on the right of the reaction arrow.

Candidates do not need to show electrical charges when writing balanced equations representing nuclear reactions.

3 Chemistry in society

(iii) Half-life

167 Half-life is the time for half of the nuclei of a particular isotope to decay.

168 The half-life of an isotope is a constant, unaffected by chemical or physical conditions. Radioactive isotopes can be used to date materials.

169 The half-life of an isotope can be determined from a graph showing a decay curve.

170 Calculations can be performed using the link between the number of half-lives, time and the proportion of a radioisotope remaining.

(iv) Use of radioactive isotopes

171 Radioisotopes have a range of uses in medicine and in industry.

Candidates do not need to be able to name the isotope used in a particular application.

172 Given information on the type of radiation emitted and/or half-lives, the suitability of an isotope for a particular application can be evaluated.

(e) Chemical analysis

(i) Common chemical apparatus

173 Candidates must be familiar with the use(s) of the following types of apparatus:

- conical flask
- beaker
- measuring cylinder
- delivery tube
- dropper
- test tubes/boiling tubes
- funnel
- filter paper
- evaporating basin
- pipette with safety filler
- burette
- thermometer

3 Chemistry in society

(ii) General practical techniques

174 Candidates must be familiar with the following practical techniques:

a) ♦ simple filtration using filter paper and a funnel to separate the residue from the filtrate

b) ♦ use of a balance

c) ♦ methods for the collection of gases including:
   - — collection over water (for relatively insoluble gases)
   - — downward displacement of air (for soluble gases that are less dense than air)
   - — upward displacement of air (for soluble gases that are more dense than air)

d) ♦ methods of heating using Bunsen burners and electric hotplates

e) ♦ preparation of soluble salts by the reaction of acids with metals, metal oxides, metal hydroxides and metal carbonates

f) ♦ preparation of insoluble salts by precipitation

g) ♦ testing the electrical conductivity of solids and solutions

h) ♦ setting up an electrochemical cell using a salt bridge and either metal or carbon electrodes

i) ♦ electrolysis of solutions using a d.c. supply

j) ♦ determination of E_h

(iii) Analytical methods

175 Titration is used to determine, accurately, the volumes of solution required to reach the end-point of a chemical reaction. An indicator is normally used to show when the end-point is reached. Titre volumes within 0·2 cm^3 are considered concordant.

176 Solutions of accurately known concentration are known as standard solutions.

177 Flame tests can identify metals present in a sample.

178 Simple tests can be used to identify oxygen, hydrogen and carbon dioxide gases.

179 Precipitation is the reaction of two solutions to form an insoluble salt called a precipitate.

180 Information on the solubility of compounds can be used to predict when a precipitate will form. The formation of a precipitate can be used to identify the presence of a particular ion.

3 Chemistry in society
(iv) Reporting experimental work
181 Labelled, sectional diagrams can be drawn for common chemical apparatus.
182 Data can be presented in tabular form with appropriate headings and units of measurement.
183 Data can be presented as a bar, line or scatter graph with suitable scale(s) and labels.
184 A line of best fit (straight or curved) can be used to represent the trend observed in experimental data.
185 Average (mean) values can be calculated from data.
186 Given a description of an experimental procedure and/or experimental results, an improvement to the experimental method can be suggested and justified.

Skills, knowledge and understanding included in the course are appropriate to the SCQF level of the course. The SCQF level descriptors give further information on characteristics and expected performance at each SCQF level (www.scqf.org.uk).