



## IB Standards of Chemistry Required

TOPIC	LEARNING OUTCOMES
<b>The particle nature of matter</b>	<ul style="list-style-type: none"><li>• Describe the states of matter and explain their interconversion in terms of the kinetic particle theory</li><li>• Describe and explain diffusion</li><li>• Describe evidence for the movement of particles in gases and liquids (a treatment of Brownian motion is <b>not</b> required)</li><li>• Describe dependence of rate of diffusion on molecular mass (treated qualitatively)</li></ul>
<b>Measurement</b>	<ul style="list-style-type: none"><li>• Name appropriate apparatus for the measurement of time, temperature, mass and volume, including burettes, pipettes and measuring cylinder</li></ul>
<b>Criteria of purity</b>	<ul style="list-style-type: none"><li>• Describe paper chromatography</li><li>• Interpret simple chromatograms</li><li>• Identify substances and assess their purity from melting point and boiling point information</li><li>• Understand the importance of purity in substances in everyday life, e.g. foodstuffs and drugs</li><li>• Interpret simple chromatograms, including the use of <math>R_f</math> values</li><li>• Outline how chromatography techniques can be applied to colourless substances by exposing chromatograms to substances called locating agents (knowledge of specific locating agents is not required)</li></ul>



<b>Methods of purification</b>	<ul style="list-style-type: none"> <li>Describe methods of purification by the use of a suitable solvent, filtration, Crystallisation or distillation (including use of fractionating column).</li> <li>Suggest suitable purification techniques, given information about the substances involved.</li> </ul>
<b>Atomic structure and the Periodic Table</b>	<ul style="list-style-type: none"> <li>State the relative charges and approximate relative masses of protons, neutrons and electrons.</li> <li>Define <i>proton number</i> and <i>nucleon number</i>.</li> <li>Use proton number and the simple structure of atoms to explain the basis of the Periodic Table, with special reference to the elements of proton number 1 to 20</li> <li>Define <i>isotopes</i></li> <li>State the two types of isotopes as being radioactive and non-radioactive</li> <li>State one medical and one industrial use of radioactive isotopes</li> <li>Describe the build-up of electrons in 'shells' and understand the significance of the noble gas electronic structures and of valency electrons</li> </ul>
<b>Bonding: the structure of matter</b>	<ul style="list-style-type: none"> <li>Describe the differences between elements, mixtures and compounds, and between metals and non-metals</li> <li>Describe an alloy, such as brass, as a mixture of a metal with other elements</li> </ul>
<b>Ions and ionic bonds</b>	<ul style="list-style-type: none"> <li>Describe the formation of ions by electron loss or gain</li> <li>Describe the formation of ionic bonds between elements from Groups I and VII</li> </ul>

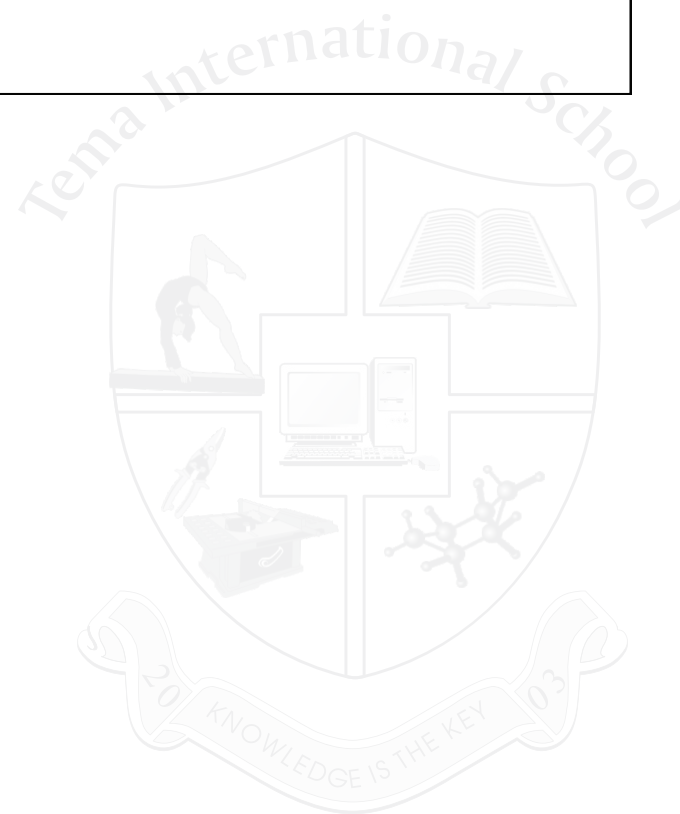


<b>Molecules and covalent bonds</b>	<ul style="list-style-type: none"><li>Describe the formation of single covalent bonds in <math>H_2</math>, <math>Cl_2</math>, <math>H_2O</math>, <math>CH_4</math> and <math>HCl</math> as the sharing of pairs of electrons leading to the noble gas configuration</li><li>Describe the differences in volatility, solubility and electrical conductivity between ionic and covalent compounds</li><li>Describe the formation of ionic bonds between metallic and non-metallic elements</li><li>Describe the lattice structure of ionic compounds as a regular arrangement of alternating positive and negative ions</li></ul>
<b>Macromolecules</b>	<ul style="list-style-type: none"><li>Describe the giant covalent structures of graphite and diamond, and relate their structures to the use of graphite as a lubricant and of diamond in cutting</li><li>Describe the electron arrangement in more complex covalent molecules such as <math>N_2</math>, <math>C_2H_4</math>, <math>CH_3OH</math> and <math>CO_2</math></li><li>Describe the macromolecular structure of silicon(IV) oxide (silicon dioxide)</li></ul>
<b>Metallic bonding</b>	<ul style="list-style-type: none"><li>Describe the similarity in properties between diamond and silicon(IV) oxide, related to their structures</li><li>Describe metallic bonding as a lattice of positive ions in a 'sea of electrons' and use this to describe the electrical conductivity and malleability of metals</li></ul>
	<ul style="list-style-type: none"><li>(Calculations involving reacting masses in simple proportions may be set. Calculations will <b>not</b> involve the mole concept.)</li><li>Determine the formula of an ionic compound from the charges on the ions present</li><li>Construct equations with state symbols, including ionic equations</li><li>Deduce the balanced equation for a chemical reaction, given relevant information</li></ul>



## The mole concept

- Define the *mole* and the *Avogadro constant*
- Use the molar gas volume, taken as  $24 \text{ dm}^3$  at room temperature and pressure
- Calculate stoichiometric reacting masses and volumes of gases and solutions, solution concentrations expressed in  $\text{g/dm}^3$  and  $\text{mol/dm}^3$ . (Calculations involving the idea of limiting reactants may be set. Questions on the gas laws and the conversion of gaseous volumes to different temperatures and pressures will **not** be set.)
- Calculate empirical formulae and molecular formulae
- Calculate % yield and % purity







## Electricity and chemistry

- Describe the electrode products in the electrolysis of:
  - molten lead(II) bromide
  - concentrated hydrochloric acid
  - concentrated aqueous sodium chloride between inert electrodes (platinum or carbon)
- State the general principle that metals or hydrogen are formed at the negative electrode (cathode), and that non-metals (other than hydrogen) are formed at the positive electrode (anode)
- Predict the products of the electrolysis of a specified binary compound in the molten state
- Describe the electroplating of metals
- Name the uses of electroplating
- Describe the reasons for the use of copper and (steel-cored) aluminium in cables, and why plastics and ceramics are used as insulators
- Relate the products of electrolysis to the electrolyte and electrodes used, exemplified by the specific examples in the Core together with aqueous copper(II) sulfate and using copper electrodes (as used in the refining of copper)
- Describe electrolysis in terms of the ions present and reactions at the electrodes in the examples given
- Predict the products of electrolysis of a specified halide in dilute or concentrated aqueous solution
- Describe, in outline, the manufacture of
  - aluminium from pure aluminium oxide in molten cryolite
  - chlorine and sodium hydroxide from concentrated aqueous sodium chloride(Starting materials and essential conditions should be given but not technical details or diagrams.)



<b>CHEMICAL CHANGES</b>	<ul style="list-style-type: none"> <li>Describe the meaning of <i>exothermic</i> and <i>endothermic</i> reactions</li> <li>Describe bond breaking as endothermic and bond forming as exothermic</li> <li>Describe the production of heat energy by burning fuels</li> <li>Describe hydrogen as a fuel</li> <li>Describe radioactive isotopes, such as <math>^{235}\text{U}</math>, as a source of energy</li> <li>Describe the production of electrical energy from simple cells, i.e. two electrodes in an electrolyte.</li> <li>Describe the use of hydrogen as a potential fuel reacting with oxygen to generate electricity in a fuel cell (details of the construction and operation of a fuel cell are <b>not</b> required)</li> </ul>
<b>Chemical reactions</b>	<ul style="list-style-type: none"> <li>Describe the effect of concentration, particle size, catalysts (including enzymes) and temperature on the speeds of reactions</li> <li>Describe a practical method for investigating the speed of a reaction involving gas evolution</li> <li>Describe the application of the above factors to the danger of explosive combustion with fine powders (e.g. flour mills) and gases (e.g. mines)</li> <li>Devise a suitable method for investigating the effect of a given variable on the speed of a reaction</li> <li>Interpret data obtained from experiments concerned with speed of reaction</li> <li>Describe and explain the effects of temperature and concentration in terms of collisions between reacting particles</li> <li>Describe the effect of light on the speed of reactions</li> </ul> <p>Describe the use of silver salts in photography as a process of reduction of silver ions to silver; and photosynthesis as the reaction between carbon dioxide and water in the presence of chlorophyll and sunlight (energy) to produce glucose</p>



<b>REVERSIBLE REACTIONS</b>	<ul style="list-style-type: none"> <li>Describe the idea that some chemical reactions can be reversed by changing the reaction conditions (Limited to the effects of heat on hydrated salts. Concept of equilibrium is <b>not</b> required.)</li> <li>Predict the effect of changing the conditions (temperature and pressure) on other reversible reactions</li> <li>Concept of equilibrium</li> </ul>
<b>REDOX</b>	<ul style="list-style-type: none"> <li>Define <i>oxidation</i> and <i>reduction</i> in terms of oxygen loss/gain. (Oxidation state limited to its use to name ions, e.g. iron(II), iron(III), copper(II), manganate(VII), dichromate(VI).)</li> <li>Define <i>redox</i> in terms of electron transfer</li> <li>Identify redox reactions by changes in oxidation state and by the colour changes involved when using acidified potassium manganate(VII), and potassium iodide. (Recall of equations involving <math>\text{KMnO}_4</math> is <b>not</b> required.)</li> </ul>
<b>The characteristic properties of acids and bases</b>	<ul style="list-style-type: none"> <li>Describe the characteristic properties of acids as reactions with metals, bases, carbonates and effect on litmus</li> <li>Describe the characteristic properties of bases as reactions with acids and with ammonium salts and effect on litmus</li> <li>Describe neutrality and relative acidity and alkalinity in terms of pH (whole numbers only) measured using Universal Indicator paper</li> <li>Describe and explain the importance of controlling acidity in soil</li> <li>Define <i>acids</i> and <i>bases</i> in terms of proton transfer, limited to aqueous solutions</li> <li>Describe the meaning of weak and strong acids and bases</li> </ul>



<b>Types of oxides</b>	<ul style="list-style-type: none"><li>• Classify oxides as either acidic or basic, related to metallic and non-metallic character</li><li>• Further classify other oxides as neutral or amphoteric</li></ul>
<b>Preparation of salts</b>	<ul style="list-style-type: none"><li>• Describe the preparation, separation and purification of salts as examples of some of the techniques specified in section 2.2(b) and the reactions specified in section 8.1</li><li>• Describe the preparation of insoluble salts by precipitation</li><li>• Suggest a method of making a given salt from suitable starting material, given appropriate information</li></ul>
<b>Identification of ions and gases</b>	<ul style="list-style-type: none"><li>• Describe the following tests to identify: <i>aqueous cations:</i> aluminium, ammonium, calcium, copper(II), iron(II), iron(III) and zinc (using aqueous sodium hydroxide and aqueous ammonia as appropriate) (Formulae of complex ions are <b>not</b> required.) <i>anions:</i> carbonate (by reaction with dilute acid and then limewater), chloride (by reaction under acidic conditions with aqueous silver nitrate), iodide (by reaction under acidic conditions with aqueous silver nitrate), nitrate (by reduction with aluminium), sulfate (by reaction under acidic conditions with aqueous barium ions) <i>gases:</i> ammonia (using damp red litmus paper), carbon dioxide (using limewater), chlorine (using damp litmus paper), hydrogen (using lighted splint), oxygen (using a glowing splint).</li></ul>



<b>The periodic table</b>	<p><b>Core</b></p> <ul style="list-style-type: none"> <li>• Describe the Periodic Table as a method of classifying elements and its use to predict properties of elements</li> <li>• Describe the change from metallic to non-metallic character across a period</li> <li>• Describe the relationship between Group number, number of valency electrons and metallic/non-metallic character</li> <li>• Describe lithium, sodium and potassium in Group I as a collection of relatively soft metals showing a trend in melting point, density and reaction with water</li> <li>• Predict the properties of other elements in Group I, given data, where appropriate</li> <li>• Describe chlorine, bromine and iodine in Group VII as a collection of diatomic non-metals showing a trend in colour, and state their reaction with other halide ions</li> <li>• Predict the properties of other elements in Group VII, given data where appropriate</li> <li>• Identify trends in other Groups, given information about the elements concerned</li> <li>• Describe the transition elements as a collection of metals having high densities, high melting points and forming coloured compounds, and which, as elements and compounds, often act as catalysts</li> <li>• Describe the noble gases as being unreactive</li> <li>• Describe the uses of the noble gases in providing an inert atmosphere, i.e. argon in lamps, helium for filling balloons</li> </ul>
<b>Properties of metals</b>	<ul style="list-style-type: none"> <li>• Describe the general physical and chemical properties of metals</li> <li>• Explain why metals are often used in the form of alloys</li> <li>• Identify representations of alloys from diagrams of structure</li> </ul>



<b>Reactivity series</b>	<ul style="list-style-type: none"><li>Place in order of reactivity: potassium, sodium, calcium, magnesium, zinc, iron, (hydrogen) and copper, by reference to the reactions, if any, of the metals with<ul style="list-style-type: none"><li>water or steam</li><li>dilute hydrochloric acid</li></ul>and the reduction of their oxides with carbon</li></ul> <p>Describe the reactivity series as related to the tendency of a metal to form its positive ion, illustrated by its reaction, if any, with</p> <ul style="list-style-type: none"><li>the aqueous ions</li><li>the oxides</li></ul> <p>of the other listed metals</p> <ul style="list-style-type: none"><li>Describe the action of heat on the hydroxides and nitrates of the listed metals</li><li>Account for the apparent unreactivity of aluminium in terms of the oxide layer which adheres to the metal</li><li>Deduce an order of reactivity from a given set of experimental results</li></ul>
<b>Extraction of metals</b>	<ul style="list-style-type: none"><li>Describe the ease in obtaining metals from their ores by relating the elements to the reactivity series</li><li>Name the main ore of aluminium as bauxite</li><li>Describe the essential reactions in the extraction of iron from hematite</li><li>Describe the conversion of iron into steel using basic oxides and oxygen</li><li>Describe in outline, the extraction of zinc from zinc blende</li></ul>



<b>Uses of metals</b>	<ul style="list-style-type: none"><li>• Name the uses of aluminium:<ul style="list-style-type: none"><li>– in the manufacture of aircraft because of its strength and low density</li><li>– in food containers because of its resistance to corrosion</li></ul></li><li>• Describe the idea of changing the properties of iron by the controlled use of additives to form steel alloys</li><li>• Name the uses of mild steel (car bodies and machinery) and stainless steel (chemical plant and cutlery)</li></ul>
<b>Air and water</b>	<ul style="list-style-type: none"><li>• Describe a chemical test for water</li><li>• Describe, in outline, the purification of the water supply in terms of filtration and chlorination</li><li>• Name some of the uses of water in industry and in the home</li><li>• Describe the composition of clean air as being approximately 79% nitrogen, 20% oxygen and the remainder as being a mixture of noble gases, water vapour and carbon dioxide</li><li>• Name the common pollutants in the air as being carbon monoxide, sulfur dioxide, oxides of nitrogen and lead compounds</li><li>• State the source of each of these pollutants:<ul style="list-style-type: none"><li>– carbon monoxide from the incomplete combustion of carbon-containing substances</li><li>– sulfur dioxide from the combustion of fossil fuels which contain sulfur compounds (leading to 'acid rain')</li></ul></li><li>• Oxides of nitrogen from car exhausts</li><li>• State the adverse effect of common pollutants on buildings and on health</li><li>• Describe and explain the presence of oxides of nitrogen in car exhausts and their catalytic removal</li><li>• Describe the separation of oxygen and nitrogen from liquid air by fractional distillation</li></ul>





<b>Sulphur</b>	<ul style="list-style-type: none"><li>• Name some sources of sulfur</li><li>• Name the use of sulfur in the manufacture of sulfuric acid</li><li>• Name the uses of sulfur dioxide as a bleach in the manufacture of wood pulp for paper and as a food preservative (by killing bacteria)</li><li>• Describe the manufacture of sulfuric acid by the Contact process, including essential conditions</li><li>• Describe the properties of dilute sulfuric acid as a typical acid</li></ul>
<b>Carbonates</b>	<ul style="list-style-type: none"><li>• Describe the manufacture of lime (calcium oxide) from calcium carbonate (limestone) in terms of the chemical reactions involved</li><li>• Name some uses of lime and slaked lime as in treating acidic soil and neutralising acidic industrial waste products, e.g. flue gas desulfurisation</li><li>• Name the uses of calcium carbonate in the manufacture of iron and of cement</li></ul>
<b>Names of organic compounds</b>	<ul style="list-style-type: none"><li>• Name and draw the structures of methane, ethane, ethanol, ethanoic acid and the products of the reactions stated in sections 14.4–14.6</li><li>• State the type of compound present, given a chemical name ending in <i>-ane</i>, <i>-ene</i>, <i>-ol</i>, or <i>-oic acid</i>, or a molecular structure</li><li>• Name and draw the structures of the unbranched alkanes, alkenes (not <i>cis-trans</i>), alcohols and acids containing up to four carbon atoms per molecule</li></ul>





<b>Fuels</b>	<p>Name the fuels coal, natural gas and petroleum</p> <ul style="list-style-type: none"> <li>Name methane as the main constituent of natural gas</li> <li>Describe petroleum as a mixture of hydrocarbons and its separation into useful fractions by fractional distillation</li> <li>Name the uses of the fractions as: <ul style="list-style-type: none"> <li>refinery gas for bottled gas for heating and cooking</li> <li>gasoline fraction for fuel (petrol) in cars</li> <li>naphtha fraction for making chemicals</li> <li>kerosene/paraffin fraction for jet fuel</li> <li>diesel oil/gas oil for fuel in diesel engines</li> <li>fuel oil fraction for fuel for ships and home heating systems</li> <li>lubricating fraction for lubricants, waxes and polishes</li> <li>bitumen for making roads</li> </ul> </li> </ul>
<b>Homologous series</b>	<ul style="list-style-type: none"> <li>Describe the concept of homologous series as a 'family' of similar compounds with similar properties due to the presence of the same functional group</li> <li>Describe the general characteristics of an homologous series</li> <li>Describe and identify structural isomerism</li> </ul>
<b>Alkanes</b>	<ul style="list-style-type: none"> <li>Describe the properties of alkanes (exemplified by methane) as being generally unreactive, except in terms of burning</li> <li>Describe the bonding in alkanes</li> <li>Describe substitution reactions of alkanes with chlorine</li> </ul>



<b>Alkenes</b>	<ul style="list-style-type: none"><li>• Describe the manufacture of alkenes and of hydrogen by cracking</li><li>• Distinguish between saturated and unsaturated hydrocarbons<ul style="list-style-type: none"><li>– from molecular structures</li><li>– by reaction with aqueous bromine</li></ul></li><li>• Describe the formation of poly(ethene) as an example of addition polymerisation of monomer units</li><li>• Describe the properties of alkenes in terms of addition reactions with bromine, hydrogen and steam</li></ul>
<b>Alcohols</b>	<ul style="list-style-type: none"><li>• Describe the formation of ethanol by fermentation and by the catalytic addition of steam to ethene</li><li>• Describe the properties of ethanol in terms of burning</li><li>• Name the uses of ethanol as a solvent and as a fuel</li></ul>
<b>Acids</b>	<ul style="list-style-type: none"><li>• Describe the formation of ethanoic acid by the oxidation of ethanol by fermentation and with acidified potassium manganate(VII)</li><li>• Describe ethanoic acid as a typical weak acid</li><li>• Describe the reaction of ethanoic acid with ethanol to give an ester (ethyl ethanoate)</li></ul>
<b>Macromolecules</b>	<ul style="list-style-type: none"><li>• Describe macromolecules in terms of large molecules built up from small units (monomers), different macromolecules having different units and/or different linkages</li></ul>



<b>Synthetic polymers</b>	<ul style="list-style-type: none"> <li>Name some typical uses of plastics and of man-made fibres</li> <li>Describe the pollution problems caused by non-biodegradable plastics</li> <li>Deduce the structure of the polymer product from a given alkene and vice versa</li> <li>Describe the formation of nylon (a polyamide) and <i>Terylene</i> (a polyester) by condensation polymerisation, the structure of nylon being represented as: and the structure of <i>Terylene</i> as: (Details of manufacture and mechanisms of these polymerisations are <b>not</b> required.)</li> </ul>
<b>Natural macromolecules</b>	<ul style="list-style-type: none"> <li>Name proteins, fats and carbohydrates as the main constituents of food</li> <li>Describe proteins as possessing the same (amide) linkages as nylon but with different units</li> <li>Describe the hydrolysis of proteins to amino acids (Structures and names are <b>not</b> required.)</li> <li>Describe fats as esters possessing the same linkage as <i>Terylene</i> but with different units</li> <li>Describe soap as a product of hydrolysis of fats</li> <li>Describe complex carbohydrates in terms of a large number of sugar units, considered as , joined together by condensation polymerisation,</li> <li>Describe the acid hydrolysis of complex carbohydrates (e.g. starch) to give simple sugars</li> <li>Describe the fermentation of simple sugars to produce ethanol (and carbon dioxide) (Candidates will <b>not</b> be expected to give the molecular formulae of sugars.)</li> <li>Describe, in outline, the usefulness of chromatography in separating and identifying the product of hydrolysis of carbohydrates and proteins</li> </ul>