

Curriculum Analysis Taxonomy Chemistry

<i>Topic</i>	<i>2A early concrete</i>	<i>2B late concrete</i>	<i>3A early formal</i>	<i>3B late formal</i>
C.1 Solution	Salt/sugar 'dissolve' in water. Mass of solute (i.e. global idea of amount) is conserved; but volume is not. (For the pre-operational child, the solute simply 'disappears%')	The process is reversible.	The particles intermingle, but stay 'the same', so that each conserves volume, weight, and chemical properties.	Saturation involves an equilibrium situation, with precipitation rate = solution rate.
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C.2 Changes of state/Kinetic theory	A solid 'turns to water', a liquid 'turns to gas') as discrete bits of information.	Ice melts to water, water turns to steam. Each process can go back again on cooling. Heat causes the melting, cooling causes the freezing. A simple kinetic theory picture of molecules close together or far apart, but not applied by translation to reality.	Application of kinetic theory under guidance, to the realisation that all materials might exist as solids, liquids, and gases, depending on the state of their particles. Liquifying means that the particles move around faster so they can change their position. You can measure how much energy is needed to do this with, say, an immersion heater.	Now kinetic theory model will be used deductively e.g. to explain how the particles in steam can be far apart and yet the steam can easily be compressed. Melting and vapourisation are equilibrium processes. Latent heat is the energy required to overcome the potential barrier between liquid and vapour. Different potential barriers in different liquids may be compared by comparing equimolar quantities.

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C.3 Speed of Reaction	The hotter one goes faster. The stronger one goes faster.	The weak one is slowest. If you double the strength, the reaction goes twice as fast. If you raise the temperature by 10°C it goes nearly twice as fast. If you break up the solid, the reaction goes faster because the liquid can get at it more.	It goes faster when you break up the solid because the surface area gets greater. From the graph you can see that the slope is getting less, so the speed is getting less. <i>That</i> part of <i>that</i> graph shows that <i>that reaction</i> is going faster than <i>this</i> . As the concentration falls off, so does the speed.	It measures how fast the reaction is going, so the graph shows speed is proportional to concentration. If you double the concentration, you double the collision rate and so double the speed. If you double the concentration of two reactants, the speed goes up by a factor of 4. Temperature? The particles are going faster and so collide more often. They also collide harder, so more react, so small temperature rise can have high effect on rate. Half-life, growth and decay curves in radio-chemistry. Can set up and conduct investigation into variables that govern, say, rate of decomposition of hydrogen peroxide

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C.4 Elements and Particle Theory	Simplest purification routines, but understood magically, not analytically. No real sense of meaning of element.	Pure substances and purification as learned routines. Element as substance which no one has been able to split into anything simpler. Can order properties of elements under guidance, and so grade 'families of elements.	Atoms have a structure. Some atoms are the same as each other, others are different. Element as a substance of one kind of atom, on a simple model of 'all red beads'. Purity in a similar sense. Knowledge that 100 per cent purity unattainable, without appreciation of the scale or numbers involved. The periodic table as a collection of 'families'; appreciation of simpler examples of two-way gradation of properties.	Measures of purity, limits of purity. Appreciation of the relation between experimental evidence and the various models of the atom. Oil drop experiment for the length of fatty acid molecules. The periodic table as a complex classificatory structure linking properties of elements and compounds to each other, and to their atomic structure. The reasoning involved in grasping Avogadro's hypothesis, and its application to formulae from volumes of reacting gases.

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C.5 Compounds, reactions and their chemical representation	Names used, but only associatively. No content given to a chemical name, thus no representation possible.	Chemical combinations remembered, without general rules being appreciated. Composition of compounds as a kind of mnemonic, e.g. water is made from hydrogen and oxygen, and will produce hydrogen and oxygen. Word equations could be used to indicate a reversible reaction, such as heat on hydrated copper sulphate. But 'copper' in that name is used only as a label, so word equation is only a statement of fact.	Can handle the conservation of elements in an exchange reaction, so for the first time has a model of chemical reaction. Use of balanced chemical equations is possible, provided that plenty of drill is given in learning the rules of the game. The relationship of chemical equations to reactions will be perceived, but do not expect pupils to know how to use them to estimate quantities except by practice in specified situations. May use atomic theory and simple model of atomic structure to account for chemical change.	The functional use of chemical symbols. The Nuffield approach to equations—from the experimental situation, through the nearest idealisation of the facts that fits the measurement, to a balanced equation. Mole concept usable deductively, and pupil can analyse problem to see how to apply translation into moles or molarities and translation back into volumes or masses. Equilibrium, as a dynamic process between reactants and products.

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C.6 Acids and Alkalis	'Acid' as name of substances with certain properties—litmus, attacks metals, sour taste, but only one at a time, the properties are not seen as defining characteristics.	Acids and bases as opposing factions. The pH scale as an interval scale of degrees of acidity. Neutralisation by equal quantities of acid and alkali, if teacher has set up equivalent solutions. If you double quantity of acid, or if you double its concentration you need twice as much alkali. Metal oxides are basic (alkaline), non-metal oxides are acidic.	Reaction of acid with alkali is $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$ Limits to change of pH by dilution alone. Acids are solutions; without water they are not acidic. Conservations during neutralisation: nothing lost, and new product in principle recoverable. $N_1 V_1 = N_2 V_2$ problems, with practice. The reaction between an acid and an alkali, understood in terms of the disturbance of the equilibrium between H^+ and OH^- ions in water.	Use of molar quantities for finding equation of reaction between an acid and an alkali. Can appreciate that there are H^+ ions even in 1.0M sodium hydroxide, and hence has rational understanding of pH scale.

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C.7 Oxidation and reduction	Pure oxygen makes things burn more brightly than air itself.	Carbon can reduce metal-oxides to metal. Oxygen can oxidise a metal. Metals can be placed in a reactivity series by their speed and vigour of burning.	Have a model of a chemical reaction, conserving the elements, so can predict that when carbon or a reactive metal reduces an oxide, carbon dioxide or a metal oxide must be produced. From a set of competition reactions can work out a reactivity series, and from a reactivity series can predict which reductions will succeed. Oxidation is increase of oxygen or other reactive nonmetal.	Can appreciate that there are different theories or models of oxidation/reduction, and can critically compare them. Can use model of reaction even where what they see is paradoxical e.g. magnesium 'burning' in steam—gas produced <i>must</i> be hydrogen. Ready for a valency change or bond-forming account of oxidation.

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C.8		Acids oppose alkalis—each will neutralise the other. Heat often breaks up chemicals. Chemicals often give off heat when they react. See C.2.	A reaction may go further if you add excess of a chemical Not all reactions go all the way. Some reactions are reversible.	Can utilise a dynamic model of molecular or ionic collisions meaning that reaction is always going both ways (to some extent). Hence equilibrium in a 4-component system can be disturbed in both directions by adding excess on the opposite side. Can understand why <i>removing</i> a substance from one side can make equilibrium shift to that side.

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C.9	That one is stronger than this because it's hotter (or brighter).	You can compare them by seeing how much heat is given out, etc. An affinity for oxygen series. If you have to heat it, it must be a weak reaction. If you want more energy you either have to take an element at the top of the series, or take more.	Comparison of energies of reactions by measuring the heat given out (but from equimolar amounts only, if teacher sets it up that way). More energy evolved due to greater attraction of molecules or atoms.	You have to compare like with like, so equimolar quantities necessary. Use of energy level diagrams to answer questions. Comparison of the heats of reactions of chlorides with silver nitrate. Work and heat. Account in terms of molecular rearrangement in relation to kinetic energy of vibration. You can make (some) reactions run backwards by using electrical energy.
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C.10		Names of simple compounds, and their physical properties.	Classification of a few simple families in terms of their common functional group. Absence of the simpler 'rules' of ionic chemistry gives rise to confusion.	Reactions between compounds, and deductive/explanatory model of the properties of compounds in terms of their functional groups and 3D structure. Appreciates that there is a system of possible transformations between different families of compounds and <i>can</i> begin to store knowledge of system.