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**Knowledge Rich Curriculum Plan**

Science – Chemistry

Year 13



| **Science** **Year 13 Chemistry**  | **Unit: Period 3** |  |  |  |
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| **Lesson/Learning Sequence**  | **Intended Knowledge:***Students will know that…* | **Tiered Vocabulary**  | **Prior Knowledge:***In order to know this students, need to already know that…* | **Practical Opportunities** |
| **Lesson:** **Reactions of period 3 elements** | * Students will know that when sodium reacts with water a very exothermic reaction occurs, producing hydrogen and sodium hydroxide (colourless solution)
* Students will know that when magnesium reacts with cold water magnesium hydroxide and hydrogen form: Mg + 2H2O 🡪 Mg(OH)2 + H2
* Students will know that when magnesium reacts with steam magnesium oxide and hydrogen are formed: Mg + H2O 🡪 MgO + 2H2
* Students will know that sodium burns in oxygen with an orange flame to produce a white solid sodium oxide, Na2O
* Students will know that magnesium burns in oxygen with an intense white flame, producing white solid magnesium oxide, MgO
* Students will know that if aluminium is powdered it will burn with oxygen to form a white solid, aluminium oxide (Al2O3)
* Students will know that silicon will burn I oxygen to produce silicon dioxide, SiO2
* Students will know that phosphorous catches fire spontaneously in air with a white flame, producing phosphorous (V) oxide, P­4O10
* Students will know that sulfur burns in air to form sulfur dioxide (SO2) which can be further reacted with oxygen to form sulfur trioxide (SO3)
 |  | * ***Students need to already know that period 3 elements are found in the 3rd row of the periodic table.***
* ***Students need to already know that electronegativity increases across the period, and atomic radius decreases across the period.***
 | Reactions of elements with oxygen and testing pH of the oxides |
| **Lesson:** **Properties of period 3 oxides** | * Students will know that the melting and boiling points for the metallic oxides (Na2O, MgO, Al2O3) are high due to strong attractions between the ions.
* Students will know that silicon dioxide has a high melting point due to its giant covalent structure.
* Students will know that phosphorous oxide, sulfur dioxide/ trioxide are molecular structures
* Students will know that phosphorous oxide has a relatively high melting point due to the large number of atoms increasing the intermolecular forces
* Students will know that when sodium oxide reacts with water, sodium hydroxide is formed. This has a high pH (alkali)
* Students will know that when magnesium oxide reacts with water it forms magnesium hydroxide, which is basic.
* Students will know that aluminium oxide and silicon dioxide doesn’t react readily with water.
* Students will know that when phosphorous (V) oxide reacts with water to form phosphoric acid, which is acidic.
* Students will know how to represent the structure of phosphoric acid.
* Students will know that when sulfur trioxide reacts with water sulfuric acid is produced.
* Students will know that sodium and magnesium oxide react with acids to produce a salt and water.
* Students will know that amphoteric means that it acts as both an acid and an alkali
* Students will know that aluminium oxide reacts with acid to form a salt and water
* Students will know how to represent the reactions of period 3 oxides using equations.
 |  | * ***Students already need to know that period 3 elements form oxides when reacting with oxygen***
* ***Students need to already know the formulae of the period 3 oxides are Na2O, MgO, Al2O3, SiO2, P4O10, SO2 and SO3***
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| **Science****Year 13 Chemistry**  | **Unit: Transition Metals** |  |  |  |
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| **Lesson/Learning Sequence**  | **Intended Knowledge:***Students will know that…* | **Tiered Vocabulary**  | **Prior Knowledge:***In order to know this students, need to already know that…* | **Practical Opportunities** |
| **Lesson:** **Properties of transition metals** | * Students will know that transition metals are metals that have in incomplete d sub-shell when either an atom or an ion, and for this reason zinc doesn’t count as a transition metal.
* Students will know that transition metals form complexes
* Students will know that transition metals form coloured ions
* Students will know that transition metals have variable oxidation states
* Students will know that transition metals can be used as catalysts.
* Students will know that a ligand is a molecule or ion that forms a coordinate bond with a transition metal by donating a pair of electrons.
* Students will know that a complex is a central metal ion/ atom surrounded by ligands
* Students will know that coordination number is the number of coordinate bonds to the central metal atom/ ion.
* Students will know how to represent transition metal complexes.
 | Ligand: a molecule or ion that forms a coordinate bond with a transition metal ion | * ***Students need to already know that transition metals are d-block elements***
* ***Students need to already know that a coordinate bond is a covalent bond where both electrons are provided by one of the atoms/ species***
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| **Lesson:** **Substitution Reactions** | * Students will know that monodentate ligands form one coordinate bond only, and examples include H­2O, NH3 and Cl-
* Students will know that NH3 and H2O are similar sized ligands, which are capable of forming octahedral complexes (coordinate number = 6)
* Students will know that the Cl- ligand is larger than NH3 and H2O, which means that it can only form tetrahedral complexes (coordination number = 4)
* Students will know that exchange between NH3 and H2O ligands involves no change in the coordination number.
* Students will know exchange of the ligand H2O by Cl- can lead to the coordination number changing.
* Students will know that ligands can be bidentate, for example H2NCH2CH2NH­2 and C2O42-.
* Students will know that ligands can be multidentate, for example EDTA4-.
* Students will know that substitution reactions that see the number of products > number of reactants, then entropy increases. This makes the reaction more feasible.
* Students will know that Haem is an iron (II) complex with a multidentate ligand.
* Students will know that oxygen forms a coordinate bond to Fe(II) in haemoglobin, allowing oxygen to be transported in the blood.
* Students will know that carbon monoxide is toxic because it replaces oxygen coordinately bonded to the iron (II)
* Students will know that bidentate and multidentate ligands replace monodentate ligands in the chelating effect
 | Monodentate: forms one coordinate bondBidentate: forms two coordinate bondMultidentate: forms more than two coordinate bond | * ***Students need to already know that ligands are atoms/ molecules that form coordinate bonds with transition metals***
* ***Students will know that entropy is a measure of disorder, and that the more disordered a reaction is the more feasible it is to occur.***
 | Test tube reactions of complexes |
| **Lesson:** **Shapes of Complex Ions** | * Students will know that transition metal ions commonly form octahedral complexes with small ligands.
* Students will know that cis-trans isomerism is a special case of E-Z isomerism, where both groups are the same
* Students will know that octahedral complexes can display cis-trans isomerism with monodentate ligands
* Students will know that octahedral complexes can exhibit optical isomerism with bidentate ligands
* Students will know that transition metal ions commonly form tetrahedral complexes with larger ligands (e.g. Cl-)
* Students will know that square planar complexes can form, and they can display cis trans isomerism
* Students will know that cisplatin (a transition metal ion complex) is used as a cancer drug, and is the cis isomer.
* Students will know that Ag+ can form linear complexes, such as [Ag(NH3)2]+, which is used as Tollens’ reagent.
* Students will know how to draw the shapes of complex ions
* Students will know how to determine whether a complex is exhibiting cis-trans isomerism and optical isomerism
* Students will know how to represent cis-trans and optical isomers.
 |  | * ***Students need to already know that molecular shapes are determined by VSEPR***
* ***Students need to already know how to determine if a molecule would exhibit E-Z isomerism***
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| **Lesson:** **Coloured Ions** | * Students will know that transition metals can be identified by their colour.
* Students will know that colour occurs when some wavelengths of visible light are absorbed and the remaining wavelengths of light are transmitted or reflected.
* Students will know that d electrons move from the ground state to an excited state when light is absorbed.
* Students will know that the energy difference between the ground state and the excited state of the d electrons is given by: ∆E = hν = hc/λ
* Students will know how to use the above equation to calculate energy change, frequency or wavelength
* Students will know that changes in oxidation state, coordination number and ligand can alter the change in energy between the ground state and excited state, which leads to a change in colour.
* Students will know that the absorption of visible light is used in spectroscopy
* Students will know that colorimeters can be used to determine the concentration of coloured ions.
* Students will know how to use colorimetry, including the use of a calibration curve.
 |  | * ***Students need to already know that transition metals are metals where the atom or the ion have incomplete d orbitals***
* ***Students need to already know that transition metals can form coloured ions***
 | Using Calorimetry |
| **Lesson:** **Variable Oxidation States** | * Students will know that vanadium can have 4 main oxidation states: +5, +4, +3, +2
* Students will know that vanadium exists in the +5 oxidation state in the species VO2+
* Students will know that compounds containing vanadium (V) are yellow
* Students will know that vanadium exists in the +4 oxidation state as VO2+.
* Students will know that compounds containing vanadium (IV) are blue in colour
* Students will know that vanadium exists in the +3 oxidation state in the ion V3+.
* Students will know that compounds containing vanadium (III) are green in colour
* Students will know that vanadium exists in the +2 oxidation state in the ion V2+.
* Students will know that compounds containing vanadium (II) are violet in colour
* Students will know that vanadium species in oxidation states IV, III and II are formed by the reduction of VO2+ using zinc in acidic solution.
* Students will know that the redox potential for a transition metal ion changing from higher to a lower oxidation state is influenced by pH and the ligands in the complex.
* Students will know that the reduction of Tollens’ reagent to metallic silver is used to distinguish between aldehydes and ketones
* Students will know that redox titrations can be carried out to determine quantitative properties of ions.
* Students will know how to perform calculations for redox titrations.
 |  | * ***Students need to already that an atom’s oxidation state is equal to the charge its ion would have***
* ***Students need to already know that one of the properties of transition metals is that they have variable oxidation states***
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| **Lesson:** **Catalysts** | * Students will know that heterogeneous means in different states, and homogeneous means in the same state
* Students will know that a heterogeneous catalyst is in a different phase from the reactants and the reaction occurs at active sites on the surface
* Students will know that in heterogeneous catalysis, the reactants adsorb onto the surface of the catalyst, which causes bonds to weaken.
* Students will know that support medium is used to maximise the surface area of a heterogeneous catalyst whilst minimising the cost, such as the honeycomb structure within a catalytic converter
* Students will know that V2O5 acts as a catalyst in the Contact process
* Students will know that the Contact process involves sulfur dioxide being converted into sulfur trioxide, and this reaction is catalysed by V2O5: SO2 + ½ O2 🡪 SO3
* Students will know that this happens through the following stages: SO2 + V2O5 🡪 SO3 + V2O4 V2O4 + ½ O2 🡪 V2O5
* Students will know that Fe is used as a heterogeneous catalyst in the Haber process
* Students will know that heterogeneous catalysts can become poisoned through impurities which block the active site, reducing the efficiency of the catalyst
* Students will know that a homogeneous catalyst is in the same phase as the reactants
* Student sill know that iron ions catalyse the reaction between persulfate ions (S2O82- + 2I- 🡪 2SO42- + I2). This is important as due to the fact the two ions are negative they repel each other, meaning the reaction would be slow
* Students will know that this happens through the following steps: S2O82- + 2Fe2+ 🡪 2SO42- + 2Fe3+
* 2Fe3+ + 2I- 🡪 2Fe2+ + 2I-
* Students will know that autocatalysis involves a reaction being catalysed by one of its products. And example of this is the reaction between potassium manganate and ethanedioic acid
* Students will know that this reaction is very slow at room temperature, but is catalysed by manganese 2 ions
* Students will know that the equation for this reaction is 2MnO4- + 6H+ + 5C2O42- 🡪 2Mn2+ + 8H2O + 10CO­2
 |  | * ***Students need to already know that catalysts are substances that can increase the rate of a chemical reaction without being used up themselves***
* ***Students need to already know that transition metals are used as catalysts***
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| **Science****Year 13 Chemistry**  | **Unit: Reactions of Ions in Aqueous Solution** |  |  |
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| **Lesson/Learning Sequence**  | **Intended Knowledge:***Students will know that…* | **Tiered Vocabulary**  | **Prior Knowledge:***In order to know this students, need to already know that…* |
| **Lesson:** **Reactions of Ions** | * Students will know that in aqueous solution, Fe2 and Cu2+ ions form [M(H2O)6]2+ complexes.
* Students will know that in aqueous solution, Al3+ and Fe3+ ions form [M(H2O)6]3+ complexes
* Students will know that [M(H2O)6]3+ solutions are more acidic than [M(H2O)6]2+ solutions.
* Students will know that 3+ ions are more acidic than 2+ ions because the charge of the ion pulls the electrons In the O-H bonds closer to it, making it easier for a proton to be lost
* Students will know that some metal hydroxides (e.g. Al(OH)3) are amphoteric as they dissolve in both acids and bases.
* Students will know that when hydroxide is added to [Fe(H2O)6]2+ it forms [Fe(H2O)4(OH)2], which is a green precipitate.
* Students will know that when hydroxide is added to [Cu(H2O)6]2+, a blue precipitate forms ([Cu(H2O)4(OH)2])
* Students will know that when hydroxide is added to [Al(H2O)6]3+, a white precipitate first forms ([Al(H2O)3(OH)3]), and when an excess of hydroxide is added this precipitate dissolves and [Al(H2O)2(OH)4]- forms
* Students will know that when hydroxide is added to [Fe(H2O)6]3+, the solution goes from a pale yellow colour to form a dark orange-brown precipitate ([Fe(H2O)3(OH)3]) forms
* Students will know that when ammonia is added to [Fe(H2O)6]2+ it forms [Fe(H2O)4(OH)2], which is a green precipitate.
* Students will know that when ammonia is added to [Cu(H2O)6]2+, a blue precipitate forms ([Cu(H2O)4(OH)2]), and then when an excess of ammonia is added it turns a dark blue solution ([Cu(NH­3)4(H2O)2]2+)
* Students will know that when ammonia is added to [Al(H2O)6]3+, a white precipitate first forms ([Al(H2O)3(OH)3])
* Students will know that when ammonia is added to [Fe(H2O)6]3+, the solution goes from a pale yellow colour to form a dark orange-brown precipitate ([Fe(H2O)3(OH)3]) forms
* Students will know that the M2+ complexes aren’t acidic enough to form carbon dioxide when carbonate is added.
* Students will know that when carbonate is added to [Al(H2O)6]3+, a white precipitate first forms ([Al(H2O)3(OH)3]) and bubbling is seen (as carbon dioxide is released)
* Students will know that when ammonia is added to [Fe(H2O)6]3+, the solution goes from a pale yellow colour to form a dark orange-brown precipitate ([Fe(H2O)3(OH)3]), and carbon dioxide bubbles also form
 |  | * ***Students need to already know that the majority of transition metals will form octahedral complexes with water***
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| **Lesson:** **Required Practical 11** | * Students will know how to carry out simple test-tube reactions to identify metal ions in aqueous solution
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