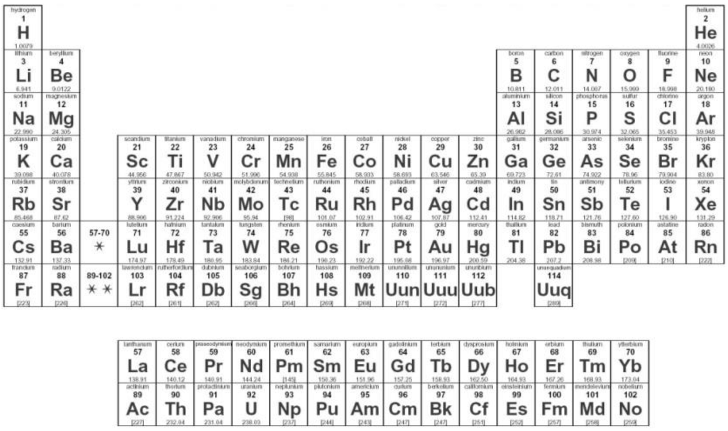
A-level Chemistry

3.2 Inorganic Chemistry

(Y13)



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Lesson Date(s)	Topic	Learning Outcomes From Specification	Key Words & Equations	Notes (Revision tips, exam technique tips, priorities for revision etc.)
	3.2.4 Period 3 elements	The reactions of Na and Mg with water. The trends in the reactions of the elements Na, Mg, Al, Si, P and S with oxygen, limited to the formation of Na_2O, MgO, Al_2O_3, SiO_2, P_4O_{10}, SO_2 and SO_3.		
	3.2.4 Period 3 oxides	The trend in the melting point of the highest oxides of the elements Na–S. The reactions of the oxides of the elements Na–S with water, limited to Na_2O, MgO, Al_2O_3, SiO_2, P_4O_{10}, SO_2 and SO_3, and the pH of the solutions formed. The structures of the acids and the anions formed when P_4O_{10}, SO_2 and SO_3 react with water. Students should be able to: explain the trend in the melting point of the oxides of the elements Na–S in terms of their structure and bonding explain the trends in the reactions of the oxides with water in terms of the type of bonding present in each oxide write equations for the reactions that occur between the oxides of the elements Na–S and given acids and bases.		

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	3.2.5.1 General properties of transition metals	Transition metal characteristics of elements Ti–Cu arise from an incomplete d sub-level in atoms or ions. The characteristic properties include: • complex formation • formation of coloured ions • variable oxidation state • catalytic activity. A ligand is a molecule or ion that forms a co-ordinate bond with a transition metal by donating a pair of electrons. A complex is a central metal atom or ion surrounded by ligands. Co-ordination number is number of co-ordinate bonds to the central metal atom or ion.		

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	3.2.5.2 Substitution reactions	H_2O, NH_3 and Cl^- can act as monodentate ligands. The ligands NH_3 and H_2O are similar in size and are uncharged. Exchange of the ligands NH_3 and H2O occurs without change of co-ordination number (eg Co^{2+} and Cu^{2+}). Substitution may be incomplete (eg the formation of $[Cu(NH_3)4(H_2O)_2]^{2+}$). The Cl^- ligand is larger than the uncharged ligands NH_3 and H_2O. Exchange of the ligand H_2O by Cl^- can involve a change of co-ordination number (eg Co^{2+}, Cu^{2+} and Fe^{3+}). Ligands can be bidentate (eg $H_2NCH_2CH_2NH_2$ and $C_2O_4{}^{2-}$). Ligands can be multidentate (eg $EDTA^{4-}$). Haem is an iron(II) complex with a multidentate ligand. Oxygen forms a co-ordinate bond to Fe(II) in haemoglobin, enabling oxygen to be transported in the blood. Carbon monoxide is toxic because it replaces oxygen co-ordinately bonded to Fe(II) in haemoglobin. Bidentate and multidentate ligands replace monodentate ligands from complexes. This is called the chelate effect. Students should be able to explain the chelate effect, in terms of the balance between the entropy and enthalpy change in these reactions.		

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	3.5.2.3 Shapes of complex ions	Transition metal ions commonly form octahedral complexes with small ligands (eg H_2O and NH_3). Octahedral complexes can display cis–trans isomerism (a special case of E–Z isomerism) with monodentate ligands and optical isomerism with bidentate ligands. Transition metal ions commonly form tetrahedral complexes with larger ligands (eg Cl^-). Square planar complexes are also formed and can display cis–trans isomerism. Cisplatin is the cis isomer. Ag^+ forms the linear complex $[Ag(NH_3)_2]^+$ as used in Tollens' reagent.		

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	3.2.5.4 Formation of coloured ions	Transition metal ions can be identified by their colour. Colour arises when some of the wavelengths of visible light are absorbed and the remaining wavelengths of light are transmitted or reflected. d electrons move from the ground state to an excited state when light is absorbed. The energy difference between the ground state and the excited state of the d electrons is given by: $\Delta E = h\nu = hc/\lambda$ Changes in oxidation state, co-ordination number and ligand alter ΔE and this leads to a change in colour. The absorption of visible light is used in spectroscopy. A simple colorimeter can be used to determine the concentration of coloured ions in solution.		

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	3.2.5.5 Variable oxidation states	Transition elements show variable oxidation states. Vanadium species in oxidation states IV, III and II are formed by the reduction of vanadate(V) ions by zinc in acidic solution. The redox potential for a transition metal ion changing from a higher to a lower oxidation state is influenced by pH and by the ligand. The reduction of $[Ag(NH_3)_2]^+$ (Tollens' reagent) to metallic silver is used to distinguish between aldehydes and ketones. The redox titrations of Fe_2^+ and C_2O_4 2^- with $MnO4^-$ Students should be able to perform calculations for these titrations and similar redox reactions.		

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	3.2.5.6 Catalysts	Transition metals and their compounds can act as heterogeneous and homogeneous catalysts. A heterogeneous catalyst is in a different phase from the reactants and the reaction occurs at active sites on the surface. The use of a support medium to maximise the surface area of a heterogeneous catalyst and minimise the cost. V_2O_5 acts as a heterogeneous catalyst in the Contact process. Fe is used as a heterogeneous catalyst in the Haber process. Heterogeneous catalysts can become poisoned by impurities that block the active sites and consequently have reduced efficiency; this has a cost implication. A homogeneous catalyst is in the same phase as the reactants. When catalysts and reactants are in the same phase, the reaction proceeds through an intermediate species. Students should be able to: explain the importance of variable oxidation states in catalysis explain, with the aid of equations, how V_2O_5 acts as a catalyst in the Contact process explain, with the aid of equations, how Fe^{2+} ions catalyse the reaction between I− and $S_2O_8{}^{2-}$ explain, with the aid of equations, how Mn^{2+} ions autocatalyse the reaction between $C_2O_4{}^{2-}$ and MnO^{4-}		

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	3.2.6 Reactions of ions in aqueous solution	In aqueous solution, the following metal-aqua ions are formed: $[M(H_2O)_6]^{2+}$, limited to M = Fe and Cu $[M(H_2O)_6]^{3+}$, limited to M = Al and Fe The acidity of $[M(H_2O)_6]^{3+}$ is greater than that of $[M(H_2O)_6]^{2+}$ Some metal hydroxides show amphoteric character by dissolving in both acids and bases (eg hydroxides of Al^{3+}). Students should be able to: explain, in terms of the charge/size ratio of the metal ion, why the acidity of $[M(H_2O)_6]^{3+}$ is greater than that of $[M(H_2O)_6]^{2+}$ describe and explain the simple test-tube reactions of: M^{2+}(aq) ions, limited to M = Fe and Cu, and of M^{3+}(aq) ions, limited to M = Al and Fe, with the bases OH^-, NH_3 and $CO_3{}^{2-}$ **Required practical 11** **Carry out simple test-tube reactions to identify transition metal ions in aqueous solution.**		