

MARINA INTERNATIONAL SCHOOL

CHEMISTRY SCHEME OF WORK

FORM 7 - TERM 1

WEEK	TOPIC	TOPIC DETAILS
1.1	Electrons: energy levels, atomic orbitals, ionisation energy, electron affinity	a) explain and use the term electron affinity
1.2	Enthalpy change, ΔH a	a) lattice energy (ΔH negative, i.e. gaseous ions to solid lattice) b) explain, in qualitative terms, the effect of ionic charge and of ionic radius on the numerical magnitude of a lattice energy
1.3	Similarities and trends in the properties of the Group 2 metals, magnesium to barium, and their compounds	a) interpret and explain qualitatively the trend in the thermal stability of the nitrates and carbonates in terms of the charge density of the cation and the polarisability of the large anion b) interpret and explain qualitatively the variation in solubility of the hydroxides and sulfates in terms of relative magnitudes of the enthalpy change of hydration and the corresponding lattice energy
2.1	Hess' Law, including Born-Haber cycles	a) the formation of a simple ionic solid and of its aqueous solution (iv) Born-Haber cycles (including ionisation energy and electron affinity)

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2.2	General physical properties of the first row of transition elements, titanium to copper	<p>a) explain what is meant by a transition element, in terms of d-block elements forming one or more stable ions with incomplete d orbitals</p> <p>b) sketch the shape of a d orbital</p> <p>c) state the electronic configuration of each of the first row transition elements and of their ions</p> <p>d) contrast, qualitatively, the melting points and densities of the transition elements with those of, for example, calcium as a typical s-block element</p> <p>e) describe the tendency of transition elements to have variable oxidation states</p> <p>f) predict from a given electronic configuration, the likely oxidation states of a transition elements</p>
3.1	Entropy change, ΔS	<p>a) explain that entropy is a measure of the 'disorder' of a system, and that a system becomes more stable when its energy is spread out in a more disordered state</p> <p>b) explain the entropy changes that occur:</p> <p>(i) during a change in state e.g. (s) \rightarrow (l); (l) \rightarrow (g); (s) \rightarrow (aq)</p> <p>(ii) during a temperature change</p> <p>(iii) during a reaction in which there is a change in the number of gaseous molecules</p> <p>c) predict whether the entropy change for a given process is positive or negative</p> <p>d) calculate the entropy change for a reaction, ΔS, given the standard entropies, S, of the reactants and products</p>

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3.2	General characteristic chemical properties of the first set of transition elements, titanium to copper	<p>a) describe and explain the reactions of transition elements with ligands to form complexes, including the complexes of copper(II) and cobalt(II) ions with water and ammonia molecules and hydroxide and chloride ions</p> <p>b) (i) define the term ligand as a species that contains a lone pair of electrons that forms a dative covalent bond to a central metal atom/ion including monodentate, bidentate and polydentate ligands (ii) define the term complex as a molecule or ion formed by a central metal atom/ion surrounded by one or more ligands (iii) describe the geometry of transition metal complexes as linear, octahedral, tetrahedral or square planar (iv) state what is meant by co-ordination number and predict the formula and charge of a complex ion, given the metal ion, its charge, the ligand and its co-ordination number</p> <p>c) explain qualitatively that ligand exchange can occur, including the complexes of copper(II) ions with water and ammonia molecules and hydroxide and chloride ions</p> <p>d) describe and explain the use of $\text{Fe}^{3+}/\text{Fe}^{2+}$, $\text{MnO}_4^-/\text{Mn}^{2+}$ and $\text{Cr}_2\text{O}_7^{2-}/\text{Cr}^{3+}$ as examples of redox systems</p> <p>e) predict, using E^\ominus values, the likelihood of redox reactions</p>
4.1	Gibbs free energy change, ΔG	<p>a) define the standard Gibbs free energy change of reaction by means of the equation $\Delta G = \Delta H - T\Delta S$</p> <p>b) calculate ΔG for a reaction using the equation $\Delta G = \Delta H - T\Delta S$</p> <p>c) state whether a reaction or process will be spontaneous/feasible by using the sign of ΔG</p> <p>d) predict the effect of temperature change on the spontaneity/feasibility of a reaction, given standard enthalpy and entropy changes</p>
4.2	Colour of complexes	<p>a) describe the splitting of degenerate d orbitals into two energy levels in octahedral and tetrahedral complexes</p> <p>b) explain the origin of colour in transition element complexes resulting from the absorption of light energy as an electron moves between two non-degenerate d orbitals</p> <p>c) describe, in qualitative terms, the effects of different ligands on absorption, and hence colour, using the complexes of copper(II) ions with water and ammonia molecules and hydroxide and chloride ions as examples</p> <p>d) apply the above ideas of ligands and complexes to other metals, given information</p>

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5.1	Electrolysis	<p>a) state and apply the relationship $F = Le$ between the Faraday constant, the Avogadro constant and the charge on the electron</p> <p>b) predict the identity of the substance liberated during electrolysis from the state of electrolyte (molten or aqueous), position in the redox series (electrode potential) and concentration</p> <p>c) calculate:</p> <p>(i) the quantity of charge passed during electrolysis</p> <p>(ii) the mass and/or volume of substance liberated during electrolysis, including those in the electrolysis of $\text{H}_2\text{SO}_4(\text{aq})$ and of $\text{Na}_2\text{SO}_4(\text{aq})$</p> <p>d) describe the determination of a value of the Avogadro constant by an electrolytic method</p>
5.2	Stereoisomerism in transition element complexes	<p>a) describe the types of stereoisomerism shown by complexes, including those associated with bidentate ligands:</p> <p>(i) cis-trans isomerism, e.g. cis- and trans-platin, $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$</p> <p>(ii) optical isomerism, e.g. $[\text{Ni}(\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2)_3]^{2+}$</p> <p>b) describe the use of cisplatin as an anticancer drug and its action by binding to DNA in cancer cells, preventing cell division</p>
6.1	Standard electrode potentials E^\ominus ; standard cell potentials E^\ominus_{cell} and the Nernst equation	<p>a) define the terms:</p> <p>(i) standard electrode (reduction) potential</p> <p>(ii) standard cell potential</p> <p>b) describe the standard hydrogen electrode</p> <p>c) describe methods used to measure the standard electrode potentials of:</p> <p>(i) metals or non-metals in contact with their ions in aqueous solution</p> <p>(ii) ions of the same element in different oxidation states</p> <p>d) calculate a standard cell potential by combining two standard electrode potentials</p> <p>e) use standard cell potentials to:</p> <p>(i) explain/deduce the direction of electron flow in a simple cell</p> <p>(ii) predict the spontaneity/feasibility of a reaction</p> <p>f) deduce from E^\ominus values the relative reactivity of elements of Group 17 (the halogens) as oxidising agents</p> <p>g) construct redox equations using the relevant half-equations</p> <p>h) predict qualitatively how the value of an electrode potential varies with the concentrations of the aqueous ions</p> <p>i) use the Nernst equation, e.g. $E = E^\ominus + (0.059/z) \log [\text{oxidised species}] / [\text{reduced species}]$ to predict quantitatively how the value of an electrode potential varies with the concentrations of the aqueous ions; examples include $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Cu}(\text{s})$, $\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightleftharpoons \text{Fe}^{2+}(\text{aq})$, $\text{Cl}_2(\text{g}) + 2\text{e}^- \rightleftharpoons 2\text{Cl}^-(\text{aq})$</p>

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6.2	Stability constants, K_{stab}	<p>a) describe and explain ligand exchanges in terms of competing equilibria</p> <p>b) state that the stability constant, K_{stab}, of a complex is the equilibrium constant for the formation of the complex ion in a solvent from its constituent ions or molecules</p> <p>c) deduce and use expressions for the stability constant of a ligand exchange</p> <p>d) explain ligand exchange in terms of K_{stab} and understand that a large K_{stab} is due to the formation of a stable complex ion</p>
7.1	Batteries and fuel cells	a) state the possible advantages of developing other types of cell, e.g. the H_2/O_2 fuel cell and the nickel-metal hydride and lithium-ion rechargeable batteries
7.2	Formulae, functional groups and the naming of organic compounds	a) understand and use systematic nomenclature of simple aromatic molecules with one benzene ring and one or more simple substituents, for example 3-nitrobenzoic acid, 2,4,6-tribromophenol
8.1	Ionic equilibria	<p>a) explain the terms pH, K_a, pK_a and K_w and use them in calculations</p> <p>b) calculate $[H^+ (aq)]$ and pH values for strong and weak acids and strong bases</p> <p>c) explain the choice of suitable indicators for acid-base titrations, given appropriate data</p> <p>d) describe the changes in pH during acid-base titrations and explain these changes in terms of the strengths of the acids and bases</p> <p>e) (i) explain how buffer solutions control Ph (ii) describe and explain the uses of buffer solutions, including the role of HCO_3^- in controlling pH in blood</p> <p>f) calculate the pH of buffer solutions, given appropriate data</p> <p>i) show understanding of, and use, the concept of solubility product, K_{sp}</p> <p>g) calculate K_{sp} from concentrations and vice versa</p> <p>h) show understanding of the common ion effect</p>
8.2	Arenes	<p>a) describe the chemistry of arenes as exemplified by the following reactions of benzene and methylbenzene:</p> <p>(i) substitution reactions with chlorine and with bromine</p> <p>(ii) nitration</p> <p>(iii) Friedel-Crafts alkylation and acylation</p> <p>(iv) complete oxidation of the side-chain to give a benzoic acid</p>

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8.3	Arenes continue	<p>(v) hydrogenation of the benzene ring to form a cyclohexane ring</p> <p>b) (i) describe the mechanism of electrophilic substitution in arenes, as exemplified by the formation of nitrobenzene and bromobenzene</p> <p>(ii) suggest the mechanism of other electrophilic substitution reactions, given data</p> <p>(iii) describe the effect of the delocalisation of electrons in arenes in such reactions</p> <p>c) interpret the difference in reactivity between chlorobenzene and chloroalkanes</p> <p>d) predict whether halogenation will occur in the side-chain or in the aromatic ring in arenes depending on reaction conditions</p> <p>e) apply knowledge relating to position of substitution in the electrophilic substitution of arenes</p>
9.1	Partition coefficients	a) state what is meant by a partition coefficient K_{pc} ; calculate and use a partition coefficient for a system in which the solute is in the same physical state in the two solvents
9.2	Alcohols	vii) formation of esters by acylation with acyl chlorides using ethyl ethanoate and phenyl benzoate as examples
10.1	Simple rate equations, orders of reaction and rate constants	<p>a) explain and use the terms rate equation, order of reaction, rate constant, half-life of a reaction, rate-determining step</p> <p>b) construct and use rate equations of the form $\text{rate} = k[A]^m[B]^n$ (for which m and n are 0, 1 or 2), including:</p> <p>(i) deducing the order of a reaction, or the rate equation for a reaction, from concentration-time graphs or from experimental data relating to the initial rates method and half-life method</p> <p>(ii) interpreting experimental data in graphical form, including concentration-time and rate-concentration graphs</p> <p>(iii) calculating an initial rate using concentration data (integrated forms of rate equations are not required)</p> <p>c) (i) show understanding that the half-life of a first-order reaction is independent of concentration</p> <p>(ii) use the half-life of a first-order reaction in calculations</p> <p>d) calculate the numerical value of a rate constant, for example by using the initial rates or half-life method</p>
10.2	Simple rate equations, orders of reaction and rate constants continue	<p>e) for a multi-step reaction:</p> <p>(i) suggest a reaction mechanism that is consistent with the rate equation and the equation for the overall reaction</p> <p>(ii) predict the order that would result from a given reaction mechanism and vice versa</p> <p>f) devise a suitable experimental technique for studying the rate of a reaction, from given information</p>

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10.3	phenol	<p>a) recall the chemistry of phenol, as exemplified by the following reactions:</p> <ul style="list-style-type: none"> (i) with bases (ii) with sodium (iii) with diazonium salts (iv) nitration of, and bromination of, the aromatic ring <p>b) describe and explain the relative acidities of water, phenol and ethanol</p>
11.1	Effect of temperature: on reaction rates and rate constants and the concept of activation energy	a) explain qualitatively the effect of temperature change on the rate constant and hence the rate of a reaction
11.2	Carboxylic acids	<p>a) acyl chlorides</p> <p>b) recognise that some carboxylic acids can be further oxidised:</p> <ul style="list-style-type: none"> (i) the oxidation of methanoic acid, HCO_2H, with Fehling's and Tollens' reagents (ii) the oxidation of ethanedioic acid, $\text{HO}_2\text{CCO}_2\text{H}$, with warm, acidified manganate(VII) <p>c) explain the relative acidities of carboxylic acids, phenols and alcohols</p> <p>d) use the concept of electronegativity to explain the acidities of chlorine-substituted ethanoic acids</p>
12.1	Homogeneous and heterogeneous catalysts including enzymes	<p>a) outline the different characteristics and modes of action of homogeneous, heterogeneous and enzyme catalysts, including:</p> <ul style="list-style-type: none"> (i) the Haber process (ii) the catalytic removal of oxides of nitrogen from the exhaust gases of car engines (iii) the catalytic role of atmospheric oxides of nitrogen in the oxidation of atmospheric sulfur dioxide (iv) the catalytic role of Fe^{2+} or Fe^{3+} in the $\text{I}^-/\text{S}_2\text{O}_8^{2-}$ reaction <p>(v) the catalytic role of enzymes (including the explanation of specificity using a simple lock and key model but excluding inhibition)</p>
12.2	Acyl chlorides	<p>a) describe the hydrolysis of acyl chlorides</p> <p>b) describe the reactions of acyl chlorides with alcohols, phenols, ammonia and primary amines</p> <p>c) explain the relative ease of hydrolysis of acyl chlorides, alkyl chlorides and aryl chlorides including the condensation (addition-elimination) mechanism for the hydrolysis of acyl chlorides</p>

CHEMISTRY SCHEME OF WORK

FORM 7 - TERM 2

WEEK	TOPIC	TOPIC DETAILS
1.1	Chromatography	a) explain and use the terms R _f value in thin-layer chromatography and retention time in gas / liquid chromatography b) interpret gas/ liquid chromatograms in terms of the percentage composition of a mixture
1.2	Primary amines	a) describe the formation of alkyl amines such as ethylamine (by the reaction of ammonia with halogenoalkanes; the reduction of amides with LiAlH ₄ ; the reduction of nitriles with LiAlH ₄ or H ₂ /Ni) and of phenylamine (by the reduction of nitrobenzene with tin/ concentrated HCl) b) describe and explain the basicity of amines c) explain the relative basicities of ammonia, ethylamine and phenylamine in terms of their structures d) describe the reaction of phenylamine with: (i) aqueous bromine (ii) nitrous acid to give the diazonium salt and phenol e) describe the coupling of benzenediazonium chloride and phenol and the use of similar reactions in the formation of dyes
2.1	Mass spectrometry	a) deduce the molecular mass of an organic molecule from the molecular ion peak in a mass spectrum b) deduce the number of carbon atoms in a compound using the M+1 peak c) deduce the presence of bromine and chlorine atoms in a compound using the M+2 peak d) suggest the identity of molecules formed by simple fragmentation in a given mass spectrum
2.2	Amides	a) describe the formation of amides from the reaction between NH ₃ or RNH ₂ and R'COCl b) recognise that amides are neutral c) (i) describe amide hydrolysis on treatment with aqueous alkali or acid (ii) describe the reduction of amides with LiAlH ₄

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3.1	Carbon-13 NMR spectroscopy	<p>a) analyse a carbon-13 NMR spectrum of a simple molecule to deduce: (i) the different environments of the carbon atoms present (ii) the possible structures for the molecule</p> <p>b) predict the number of peaks in a carbon-13 NMR spectrum for a given molecule</p>
3.2	Amino acids	<p>a) describe the acid/base properties of amino acids and the formation of zwitterions</p> <p>b) describe the formation of peptide bonds between amino acids to give di- and tripeptides</p> <p>c) describe simply the process of electrophoresis and the effect of pH, using peptides and amino acids as examples</p>
4.1	Proton (1 H) NMR spectroscopy	<p>a) analyse and interpret a proton (1 H) NMR spectrum of a simple molecule to deduce: (i) the different types of proton present using chemical shift values (ii) the relative numbers of each type of proton present from relative peak areas (iii) the number of equivalent protons on the carbon atom adjacent to the one to which the given proton is attached from the splitting pattern, using the $n + 1$ rule (iv) the possible structures for the molecule</p> <p>b) predict the chemical shifts and splitting patterns of the protons in a given molecule</p> <p>c) describe the use of tetramethylsilane, TMS, as the standard for chemical shift measurements</p> <p>d) state the need for deuterated solvents, e.g. CDCl_3, when obtaining an NMR spectrum</p> <p>e) describe the identification of O-H and N-H protons by proton exchange using D_2O</p> <p>a) describe the formation of polyesters and polyamides</p> <p>b) describe the characteristics of condensation polymers: (i) in polyesters as exemplified by Terylene (ii) in polyamides as exemplified by polypeptides, proteins, nylon 6, nylon 6,6 and Kevlar</p> <p>c) deduce the repeat unit of a condensation polymer obtained from a given monomer or pair of monomers</p> <p>d) identify the monomer(s) present in a given section of a condensation polymer molecule</p> <p>a) predict the type of polymerisation reaction for a given monomer or pair of monomers</p> <p>b) deduce the type of polymerisation reaction which produces a given section of a polymer molecule</p>

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4.2	Condensation polymerisation	<p>a) describe the formation of polyesters and polyamides</p> <p>b) describe the characteristics of condensation polymers:</p> <p>(i) in polyesters as exemplified by Terylene</p> <p>(ii) in polyamides as exemplified by polypeptides, proteins, nylon 6, nylon 6,6 and Kevlar</p> <p>c) deduce the repeat unit of a condensation polymer obtained from a given monomer or pair of monomers</p> <p>d) identify the monomer(s) present in a given section of a condensation polymer molecule</p>
4.3	Predicting the type of polymerisation	<p>a) predict the type of polymerisation reaction for a given monomer or pair of monomers</p> <p>b) deduce the type of polymerisation reaction which produces a given section of a polymer molecule</p>
5.1	Properties of polymers	<p>a) discuss the properties and structure of polymers based on their methods of formation</p> <p>b) discuss how the presence of side-chains and intermolecular forces affect the properties of polymeric materials (e.g. poly(alkenes), PTFE (Teflon), Kevlar)</p> <p>c) explain the significance of hydrogen bonding in the pairing of bases in DNA in relation to the replication of genetic information</p> <p>d) distinguish between the primary, secondary (α-helix and β-sheet) and tertiary structures of proteins and explain the stabilisation of secondary structure (through hydrogen bonding between C=O and N-H bonds of peptide groups) and tertiary structure (through interactions between R-groups)</p> <p>e) describe how polymers act as:</p> <p>(i) non-solvent based adhesives, e.g. epoxy resins and Super Glues</p> <p>(ii) conducting polymers, e.g. polyacetylene</p>
6.1	Degradable polymers	<p>a) recognise that poly(alkenes) are chemically inert and can therefore be difficult to biodegrade</p> <p>b) recognise that some polymers can be degraded by the action of light</p> <p>c) recognise that polyesters and polyamides are biodegradable by hydrolysis</p> <p>d) describe the hydrolysis of proteins</p>
6.2	Synthesis of chiral drug molecules	<p>a) state that chiral drugs extracted from natural sources often contain only a single optical isomer</p> <p>b) state reasons why the synthetic preparation of drug molecules often requires the production of a single optical isomer, e.g. better therapeutic activity, fewer side effects</p>

WEEK	TOPIC	TOPIC DETAILS
7.1	Synthetic routes	<p>a) for an organic molecule containing several functional groups:</p> <p>(i) identify organic functional groups using the reactions in the syllabus (ii) predict properties and reactions</p> <p>b) devise multi-stage synthetic routes for preparing organic molecules using the reactions in the syllabus</p> <p>c) analyse a given synthetic route in terms of type of reaction and reagents used for each step of it, and possible by-products</p>