**OCR A – A2 Chemistry Checklist**

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| Unit |  |  |
| Module 5: Physical Chemistry and Transition Elements | | |
| 18 | Can you explain and use the terms rate of reaction, order, overall order, rate constant, half-life, rate-determining step. |  |
|  | Can you deduce orders from experimental data? |  |
|  | Can you deduce a rate equation from orders of the form rate = *k*[A]*m*[B]*n*, where *m* and *n* are 0, 1, or 2? |  |
|  | Can you calculate the rate constant, *k*, and related quantities from a rate equation, including determination of units? |  |
|  | Can you deduce the order (0 or 1) with respect to a reactant from the shape of a graph? |  |
|  | Can you calculate reaction rates from the measurements of gradients? |  |
|  | Can you measure constant half-life, *t*1/2, from a concentration time graph? |  |
|  | Can you determine the rate constant, *k*, for a first order reaction from the constant half-life, *t1*/2, using the relationship: *k* = ln 2/*t*1/2? |  |
|  | Can you deduce the order (0, 1, 2) with respect to a reactant from the shape of a graph? |  |
|  | Can you determine the rate constant for a first order reaction from the gradient? |  |
|  | Can you describe the techniques and procedures used to investigate reaction rates by the initial rates method and by continuous monitoring? |  |
|  | Can you predict the rate equation that is consistent with the rate-determining step for a multi-step reaction? |  |
|  | Can you predict possible steps in a reaction mechanism from the rate equation and the balanced equation for the overall reaction of a multi-step reaction? |  |
|  | Can you give a qualitative explanation of the effect of temperature change on the rate of a reaction, and therefore the rate constant? |  |
|  | Can you describe the exponential relationship between the rate constant, k, and temperature, T, given by the Arrhenius equation, k = Ae-Ea/RT |  |
|  | Can you determine *Ea* and *A* graphically using ln *k* = –Ea/*RT* + ln*A* derived from the Arrhenius equation? |  |
| 19 | Can you use the terms mole fraction and partial pressure? |  |
|  | Can you calculate quantities present at equilibrium? |  |
|  | Can you describe the techniques and procedures used to determine quantities present at equilibrium? |  |
|  | Can you write expression for *Kc* and *Kp* for homogeneous and heterogeneous equilibria? |  |
|  | Can you calculate *Kc* and *Kp* or related quantities, including determination of units? |  |
|  | Can you describe the qualitative effect on equilibrium constants of changing temperature for exothermic and endothermic reactions? |  |
|  | Can you described the constancy of equilibrium constants with changes in concentration, pressure, or in the presence of a catalyst? |  |
|  | Can you explain of how an equilibrium constant controls the position of equilibrium on changing concentration, pressure and temperature? |  |
|  | Can you apply the above principles for *K*c, *K*p to other equilibrium constants, where appropriate**?** |  |
| 20 | Can you describe a Brønsted–Lowry acid as a species that donates a proton and a Brønsted–Lowry base as a species that accepts a proton? |  |
|  | Can you use the term *conjugate acid–base pairs*? |  |
|  | Can you describe monobasic, dibasic, and tribasic acids? |  |
|  | Can you describe the role of H+ in the reactions of acids with metals and bases (including carbonates, metal oxides and alkalis), using ionic equations? |  |
|  | Can you describe the acid dissociation constant*, K*a, for the extent of acid dissociation? |  |
|  | Can you describe the relationship between *K*a and p*K*a? |  |
|  | Can you use the expression for pH as:  pH = –log[H+]  [H+] = 10–ph |  |
|  | Can you use the expression for the ionic product of water, *K*w? |  |
|  | Can you calculate pH for strong monobasic acids? |  |
|  | Can you calculate pH for strong bases using *Kw*? |  |
|  | Can you calculate pH, *K*a or related quantities, for a weak monobasic acid using approximations |  |
|  | Can you describe the limitations of using approximations to *K*a related calculations for ‘stronger’ weak acids? |  |
| 21 | Can you describe a buffer solution as a system that minimises pH changes on addition of small amounts of an acid or a base? |  |
|  | Can you describe the formation of a buffer solution from a weak acid and a salt of the weak acid, e.g. CH3COOH/CH3COONa? |  |
|  | Can you describe the formation of a buffer solution from excess of a weak acid and a strong alkali, e.g. excess CH3COOH/NaOH? |  |
|  | Can you explain the role of the conjugate acid–base pair in an acid buffer solution, e.g. CH3COOH/CH3COO–, in the control of pH? |  |
|  | Can you calculate the pH of a buffer solution, from the *K*a value of a weak acid and the equilibrium concentrations of the conjugate acid–base pair; calculations of related quantities? |  |
|  | Can you explain of the control of blood pH by the carbonic acid–hydrogencarbonate buffer system |  |
|  | Can you sketch and interpret the shapes of pH titration curves? |  |
|  | Can you explain the choice of suitable indicators, given the pH range of the indicator, for pH titration curves? |  |
|  | Can you explain indicator colour changes in terms of equilibrium shift between the HA and A– forms of the indicator? |  |
|  | Can you describe the techniques and procedures used when measuring pH with a pH meter? |  |
| 22 | Can you explain the term *lattice enthalpy* (formation of 1 mol of ionic lattice from gaseous ions, ΔLE*H*) and use as a measure of the strength of ionic bonding in a giant ionic lattice |  |
|  | Can you use the lattice enthalpy of a simple ionic solid and the relative energy terms to construct Born–Haber cycles? |  |
|  | Can you use the lattice enthalpy of a simple ionic solid and the relative energy terms to describe related calculations? |  |
|  | Can you explain and use the term enthalpy change of solution? |  |
|  | Can you explain and use the terms enthalpy change of hydration? |  |
|  | Can you use the enthalpy change of solution of a simple ionic solid and relevant energy terms to construct enthalpy cycles? |  |
|  | Can you use the enthalpy change of solution of a simple ionic solid and relevant energy terms to describe related calculations? |  |
|  | Can you give qualitative explanation of the effect of ionic charge and ionic radius on the exothermic value of a lattice enthalpy and enthalpy change of hydration? |  |
|  | Can you explain entropy in terms of the dispersal of energy in a system and how disordered the system is? |  |
|  | Can you explain the difference in magnitude of the entropy of a system of solids, liquids and gases? |  |
|  | Can you explain the difference in magnitude of the entropy of a system for a reaction in which there is a change in the number of gaseous moles? |  |
|  | Can you calculate the entropy change of a system, Δ*S*, and related quantities for a reaction given the entropies of the reactants and the products? |  |
|  | Can you explain that the feasibility of a process depends upon the entropy change and temperature in the system, *T*Δ*S*, and the enthalpy change of the system, Δ*H?* |  |
|  | Can you explain and calculate the free energy change, Δ*G*, as: Δ*G* = Δ*H – T*Δ*S* (the Gibbs’ equation) and that a process is feasible when Δ*G* has a negative value? |  |
|  | Can you describe the limitations of predictions made by Δ*G* about feasibility, in terms of kinetics? |  |
| 23 | Can you explain and use of the terms *oxidising agent* and *reducing agent*? |  |
|  | Can you construct redox equations using half- equations and oxidation numbers? |  |
|  | Can you interpret and predict reactions involving electron transfer? |  |
|  | Can you describe the techniques and procedures used when carrying out redox titrations including those involving Fe2+/MnO4– and I2/S2O32−? |  |
|  | Can you carry out structured and non-structured titration calculations, based on experimental results of redox titrations involving Fe2+/MnO4– and I2/S2O32−? |  |
|  | Can you carry out structured and non-structured titration calculations, based on experimental results of redox titrations involving non-familiar redox systems? |  |
|  | Can you use the term *standard electrode (redox) potential*, *E* o including its measurement using a hydrogen electrode? |  |
|  | Can you describe the techniques and procedures used for the measurement of cell potentials of metals or non-metals in contact with their ions in aqueous solution? |  |
|  | Can you describe the techniques and procedures used for the measurement of cell potentials of ions of the same element in different oxidation states in contact with a Pt electrode? |  |
|  | Can you calculate a standard cell potential by combining two standard electrode potentials? |  |
|  | Can you predict the feasibility of a reaction using standard cell potentials and the limitations of such predictions in terms of kinetics and concentration? |  |
|  | Can you apply principles of electrode potentials to modern storage cells? |  |
|  | Can you explain that a fuel cell uses the energy from the reaction of a fuel with oxygen to create a voltage and the changes that take place at each electrode? |  |
| 24 | Can you describe the electron configuration of atoms and ions of the d-block elements of Period 4 (Sc–Zn), given the atomic number and charge? |  |
|  | Can you describe the elements Ti–Cu as transition elements i.e. d-block elements that have an ion with an incomplete d-sub-shell? |  |
|  | Can you show using examples the formation of coloured ions? |  |
|  | Can you show using examples the existence of more than one oxidation state for each element in its compounds? |  |
|  | Can you show using examples the catalytic behaviour of the elements and their compounds and their importance in the manufacture of chemicals by industry? |  |
|  | Can you explain and use of the term *ligand* in terms of coordinate (dative covalent) bonding to a metal ion or metal, including bidentate ligands? |  |
|  | Can you use the term*s* complex ion and coordination number to show six-fold coordination with an octahedral shape? |  |
|  | Can you use the term*s* complex ion and coordination number to show four-fold coordination with either a planar of tetrahedral shape? |  |
|  | Can you describe *cis–trans* isomerism? |  |
|  | Can you describe optical isomerism? |  |
|  | Can you describe the use of *cis*-platin as an anticancer drug and its action by binding to DNA preventing cell division? |  |
|  | Can you describe ligand substitution reactions and the accompanying colour changes in the formation of [Cu(NH3)4(H2O)2]2+ and [CuCl4]2– from [Cu(H2O)6]2+? |  |
|  | Can you describe ligand substitution reactions and the accompanying colour changes in the formation of [Cr(NH3)6]3+ from [Cr(H2O)6]3+? |  |
|  | Can you explain of the biochemical importance of iron in haemoglobin, including ligand substitution involving O2 and CO? |  |
|  | Can you describe reactions, including ionic equations, and the accompanying colour changes of aqueous Cu2+, Fe2+, Fe3+, Mn2+ and Cr3+ with aqueous sodium hydroxide and aqueous ammonia, including precipitation reactions? |  |
|  | Can you describe reactions, including ionic equations, and the accompanying colour changes of aqueous Cu2+, Fe2+, Fe3+, Mn2+ and Cr3+ with aqueous sodium hydroxide and aqueous ammonia, including complex formation with excess aqueous sodium hydroxide and aqueous ammonia? |  |
|  | Can you recall redox reactions and accompanying colour changes for interconversions between Fe2+ and Fe3+? |  |
|  | Can you recall redox reactions and accompanying colour changes for interconversions between Cr3+ and Cr2O72-? |  |
|  | Can you recall redox reactions and accompanying colour changes for interconversions between Cu+ and Cu2+? |  |
|  | Can you interpret and predict unfamiliar reactions including ligand substitution, precipitation, redox? |  |
| **Module 6: Organic Chemistry and Analysis** | | |
| 25 | Can you describe the comparison of the Kekulé model of benzene with the subsequent delocalised models for benzene in terms of p-orbital overlap forming a delocalised π-system? |  |
|  | Can you describe the experimental evidence for a delocalised, rather than Kekulé, model for benzene in terms of bond lengths, enthalpy change of hydrogenation and resistance to reaction? |  |
|  | Can you use IUPAC rules of nomenclature for systematically naming substituted aromatic compounds? |  |
|  | Can you describe the electrophilic substitution of aromatic compound with concentrated nitric acid in the presence of concentrations sulfuric acid? |  |
|  | Can you describe the electrophilic substitution of aromatic compound with a halogen in the presence of a halogen carrier |  |
|  | Can you describe the electrophilic substitution of aromatic compound with a haloalkane or acyl chloride in the presence of a halogen carrier (Friedel–Crafts reaction) and its importance to synthesis by formation of a C–C bond to an aromatic ring? |  |
|  | Can you describe the mechanism of electrophilic substitution in arenes for nitration and halogenation? |  |
|  | Can you explain the relative resistance to bromination of benzene, compared with alkenes, in terms of the delocalised electron density of the π-system in benzene compared with the localised electron density of the π-bond in alkenes? |  |
|  | Can you interpret unfamiliar electrophilic substitution reactions of aromatic compounds, including prediction of mechanisms? |  |
|  | Can you describe the weak acidity of phenols shown by the neutralisation reaction with NaOH but absence of reaction with carbonates? |  |
|  | Can you describe the electrophilic substitution reactions of phenol with bromine to form 2,4,6-tribromophenol? |  |
|  | Can you describe the electrophilic substitution reactions of phenol with dilute nitric acid to form 2-nitrophenol? |  |
|  | Can you describe the relative ease of electrophilic substitution of phenol compared with benzene, in terms of electron pair donation to the π-system from an oxygen p-orbital in phenol? |  |
|  | Can you explain the 2- and 4-directing effect of electron- donating groups (OH, NH2) and the 3-directing effect of electron-withdrawing groups (NO2) in electrophilic substitution of aromatic compounds? |  |
|  | Can you predict substitution products of aromatic compounds by directing effects and the importance to organic synthesis? |  |
| 26 | Can you describe oxidation of aldehydes using Cr2O72–/H+ (i.e. K2Cr2O7/H2SO4) to form carboxylic acids? |  |
|  | Can you describe nucleophilic addition reactions of carbonyl compounds with NaBH4 to form alcohols? |  |
|  | Can you describe nucleophilic addition reactions of carbonyl compounds with HCN to form hydroxynitriles? |  |
|  | Can you describe the mechanism for nucleophilic addition reactions of aldehydes and ketones with NaBH4 and HCN? |  |
|  | Can you use 2,4-dinitrophenylhydrazine to detect the presence of a carbonyl group in an organic compound? |  |
|  | Can you use 2,4-dinitrophenylhydrazine to identify a carbonyl compound from the melting point of a derivative? |  |
|  | Can you use Tollen’s reagent to detect the presence of an aldehyde group? |  |
|  | Can you use Tollen’s reagent to distinguish between aldehydes and ketones, explained in terms of the oxidation of aldehydes to carboxylic acids with reduction of silver ions to silver? |  |
|  | Can you explain the water solubility of carboxylic acids in terms of hydrogen bonding? |  |
|  | Can you describe reactions in aqueous conditions of carboxylic acids with metals and bases (including carbonates, metal oxides and alkalis)? |  |
|  | Can you describe the esterification of carboxylic acids with alcohols in the presence of an acid catalyst (e.g. concentrated H2SO4)? |  |
|  | Can you describe the esterification of acid anhydrides with alcohols? |  |
|  | Can you describe the hydrolysis of esters in hot aqueous acid to form carboxylic acids and alcohols? |  |
|  | Can you describe the hydrolysis of esters in hot aqueous alkali to form carboxylate salts and alcohols? |  |
|  | Can you describe the formation of acyl chlorides from carboxylic acids using SOCl2? |  |
|  | Can you describe use of acyl chlorides in synthesis in formation of esters, carboxylic acids and primary and secondary amides? |  |
| 27 | Can you describe the basicity of amines in terms of proton acceptance by the nitrogen lone pair and the reactions of amines with dilute acids, e.g. HC*l* (aq), to form salts? |  |
|  | Can you describe the preparation of aliphatic amines by substitution of haloalkanes with excess ethanolic ammonia and amines? |  |
|  | Can you describe the preparation of using tin and concentrated hydrochloric acid? |  |
|  | Can you recall the general formula for an α-amino acid as RCH(NH2)COOH? |  |
|  | Can you recall the reaction of the carboxylic acid group with alkalis and in the formation of esters? |  |
|  | Can you recall the reaction of the amine group with acids? |  |
|  | Can you recall the structures of primary and secondary amino acids? |  |
|  | Can you describe optical isomerism (an example of stereoisomerism, in terms of non- superimposable mirror images about a chiral centre)? |  |
|  | Can you identify chiral centres in a molecule of any organic compound? |  |
|  | Can you describe condensation polymerisation to form polyesters? |  |
|  | Can you describe condensation polymerisation to form polyamides? |  |
|  | Can you describe the acid and base hydrolysis of the ester groups in polyesters? |  |
|  | Can you describe the acid and base hydrolysis of the amide groups in polyamides? |  |
|  | Can you describe the precipitation from addition and condensation polymerisation of the repeat unit from a given monomer? |  |
|  | Can you describe the precipitation from addition and condensation polymerisation of the monomer required for a given section of a polymer molecule? |  |
|  | Can you describe the precipitation from addition and condensation polymerisation of the type of polymerisation? |  |
| 28 | Can you describe the use of C–C bond formation in synthesis to increase the length of a carbon chain? |  |
|  | Can you describe the formation of C-C=N by reaction of haloalkanes with CN– and ethanol, including nucleophilic substitution mechanism? |  |
|  | Can you describe the formation of C-C=N by reaction of carbonyl compounds with HCN, including nucleophilic addition mechanism? |  |
|  | Can you recall the reactions of nitriles by reduction to form amines? |  |
|  | Can you recall the reactions of nitriles by acid hydrolysis to form carboxylic acids? |  |
|  | Can you describe the formation of a substituted aromatic C–C by alkylation (using a haloalkane) and acylation (using an acyl chloride) in the presence of a halogen carrier (Friedel–Crafts reaction)? |  |
|  | Can you describe organic preparation using Quickfit apparatus and distillation and heating under reflux? |  |
|  | Can you describe the purification of an organic solid by filtration under reduced pressure, recrystallization, measurement of melting points? |  |
|  | Can you identify individual functional groups of organic molecules containing several functional groups? |  |
|  | Can you predict properties and reactions of organic molecules containing several functional groups? |  |
|  | Can you describe multi-stage synthetic routes for preparing organic compounds? |  |
| 29 | Can you interpret one-way TLC chromatograms in terms of *R*f values? |  |
|  | Can you interpret gas chromatograms in terms of retention times? |  |
|  | Can you interpret gas chromatograms in terms of the amounts and proportions of the components in a mixture? |  |
|  | Can you recall the test for alkenes by reaction with bromine? |  |
|  | Can you recall the test for haloalkanes by reaction with aqueous silver nitrate in ethanol? |  |
|  | Can you recall the test for phenols by weak acidity but no reaction with  CO32–? |  |
|  | Can you recall the test for carbonyl compounds by reaction with 2,4- DNP |  |
|  | Can you recall the test for aldehydes by reaction with Tollens’ reagent? |  |
|  | Can you recall the test for primary and secondary alcohols and aldehydes by reaction with acidified dichromate? |  |
|  | Can you recall the test for carboxylic acids by reaction with CO32–? |  |
|  | Can you use a carbon-13 NMR to make predictions about the number of carbon environments in a molecule? |  |
|  | Can you use a carbon-13 NMR to make predictions about the different types of carbon environment present, from chemical shift values? |  |
|  | Can you use a carbon-13 NMR to make predictions about possible structures for the molecule? |  |
|  | Can you use a high resolution proton NMR spectrum to make predictions about the number of proton environments in the molecule? |  |
|  | Can you use a high resolution proton NMR spectrum to make predictions about the different types of proton environment present, from chemical shift values? |  |
|  | Can you use a high resolution proton NMR spectrum to make predictions about the relative numbers of each type of proton present from relative peak areas, using integration traces or ratio numbers, when required? |  |
|  | Can you use a high resolution proton NMR spectrum to make predictions about the number of non-equivalent protons adjacent to a given proton from the spin– spin splitting pattern, using the *n* + 1 rule? |  |
|  | Can you use a high resolution proton NMR spectrum to make predictions about possible structures for the molecule? |  |
|  | Can you predict a carbon-13 or proton NMR spectrum for a given molecule? |  |
|  | Can you describe the use of tetramethylsilane, TMS, as the standard for chemical shift measurements? |  |
|  | Can you recall the need for deuterated solvents, e.g. CDC*l* 3, when running an NMR spectrum? |  |
|  | Can you identify O–H and N–H protons by proton exchange using D2O? |  |
|  | Can you deduce the structures of organic compounds from elemental analysis? |  |
|  | Can you deduce the structures of organic compounds from mass spectra? |  |
|  | Can you deduce the structures of organic compounds from IR spectra? |  |
|  | Can you deduce the structures of organic compounds from NMR spectra? |  |