LEAVING CERTIFICATE CHEMISTRY

REVISION CHECKLIST

The Periodic Table and Atomic Structure

Periodic Table:

- ☐ I can name the first 36 elements from their symbols
- ☐ I know the contribution of the Greeks, Boyle, Davy and Mosley to the discovery of elements.
- ☐ I know that the periodic table is designed to show the trends in the physical and chemical properties of elements.
- ☐ I know the contribution of **Dobereiner, Newlands**, Mendeleev and **Mosley** to the development of the periodic table.
- ☐ I can list 4 differences between the modern periodic table and Mendeleev's.
- ☐ I can name groups I, II, VII and VIII on the periodic table and know their characteristic properties

Atomic Structure:

- ☐ I know that all matter is composed of particles which may be atoms, molecules or ions.
- ☐ I know how small atoms are
- ☐ I can state 3 things about Daltons atomic theory
- ☐ **I understand how Crookes worked with vacuum tubes and discovered cathode rays**
- ☐ I know that Thompson discovered the electron by working with cathode rays
- ☐ I can draw Thompson's model of an atom
- ☐ **I know that Thompson calculated the charge : mass ratio of an electron**
- ☐ **I know that the name electron was proposed by George Stoney.**
- ☐ **I know that Milikan calculated the charge on the electron using the oil drop experiment. (details not required)**
- ☐ I can state the law of conservation of mass
- ☐ I know that Rutherford discovered the nucleus using the α-particle scattering experiment (Gold leaf experiment)
- ☐ **I know how Rutherford discovered the proton**
- ☐ **I know how Chadwick discovered the Neutron**
- ☐ I can draw Bohr's model of an atom
- ☐ I can fill in a table of properties of electrons, protons and neutrons (mass, charge, location)
- ☐ I can identify the mass number (A) and the atomic number (Z) of an atom of an element from the periodic table
- ☐ I know what an isotope is **and can calculate relative atomic masses from the abundances of isotopes of given mass number.**
- ☐ I know that the relative atomic mass is based on the mass of a ^{12}C atom.

- ☐ I know that a mass spectrometer is used to determine relative atomic mass
- ☐ **I know that there are 5 processes that occur in a mass spectrometer and can name and explain them. (not including mathematical treatment)**

Electronic Structure of Atoms

- ☐ I know what an energy level is
- ☐ I know why Bohr's model works for the first 20 elements in the periodic table. (no. of electrons in each main energy level)
- ☐ I can classify the first 20 elements in the periodic table on the basis of the number of electrons in their outermost shell
- ☐ **I know what an emission spectrum is**
- ☐ **I know what an absorption spectrum is**
- ☐ **I know that the Balmer series is the visible light section of energy emission**
- ☐ I know that different metals give rise to different coloured flames, eg fireworks, sodium street lights
- ☐ **I know that line spectra give evidence for energy levels and how.**
- ☐ **I know that energy levels have sub levels**
- ☐ **I can state Heisenberg's uncertainty principle.**
- ☐ **I know that electrons have a wave nature.**
- ☐ **I can define Orbital**
- ☐ **I can draw S and P orbitals**
- ☐ **I can state the Aufbau principle**
- ☐ **I can state Hund's Rule**
- ☐ **I can state the Pauli Exclusion principle**
- ☐ **I can draw the full s,p,d electronic configurations of the first 36 elements.**

Trends in the Periodic table:

- ☐ I can define atomic radii
- ☐ I can account for the trends in atomic radii down a group
- ☐ I can account for the trends in atomic radii across a period.
- ☐ **I can define First ionisation energy**
- ☐ **I can account for the trends in ionisation energy down a group**
- ☐ **I can account for the trends in ionisation energy across a period**
- ☐ **I can account for the exceptions to the trends in ionisation energy across a period**
- ☐ **I can define second and successive ionisation energies**
- ☐ **I can explain how successive ionisation energies give evidence for the existence of energy levels.**
- ☐ I can explain how electronic structure influences the chemical properties of an element
- ☐ I can explain in terms of atomic radius, screening effect and nuclear charge, the general trends in properties of elements in groups I and VII.

Radioactivity:

- ☐ I know that Henri Becquerel discovered radioactivity and how.
- ☐ I know that Marie and Pierre Curie worked on Uranium salts to discover polonium and radium
- ☐ I know that radioactivity is all around us
- ☐ I know the nature and penetrating ability of alpha, beta and gamma radiation and I can give one example of each
- ☐ **I know the difference between chemical reactions and nuclear reactions**
- ☐ **I can complete simple nuclear equations for alpha and beta particles.**
- ☐ I know what a radioisotope is
- ☐ I can give three uses of radioisotopes
- ☐ I can define half life
- ☐ I know how half life is used in ^{14}C dating.
- ☐ I can explain the use of ^{60}Co radiation in cancer treatment.

Oxidation and Reduction:

- ☐ I can give three simple examples of oxidation and reduction reactions
- ☐ I can explain the rusting of iron in terms of oxidation
- ☐ I can define oxidation and reduction in terms of loss or gain of electrons
- ☐ I can name three common oxidising agents and three common reducing agents including bleach as both an oxidising and a reducing agent.
- ☐ I can explain how oxidation and reduction is used in the treatment of swimming pool water
- ☐ I can build up an electrochemical series based on how easily metals are oxidised. (displacement reactions)
- ☐ I can use scrap iron to extract copper
- ☐ I can explain the electrolysis of copper sulfate solution with copper electrodes **and give the half equations.**
- ☐ I can explain the electrolysis of acidified water with inert electrodes **and give the half equations.**
- ☐ I can give practical uses of electrolysis such as electroplating, purification of copper and chrome and nickel plating and cutlery.

Oxidation Numbers:

- ☐ **I know 7 rules for assigning oxidation numbers**
- ☐ **I can assign oxidation numbers according to those rules.**
- ☐ **I can work out the oxidation numbers of transition metals in their compounds**
- ☐ **I can define oxidation and reduction in terms of oxidation numbers.**

Chemical Bonding

Chemical compounds:

- ☐ I can construct simple chemical formulas
- ☐ I know why noble gases are so unreactive
- ☐ I can give a use of helium and/or argon related to their unreactivity
- ☐ I can define valency
- ☐ I can predict bonding based on attainment of a stable structure
- ☐ I can state the octet rule and know its limitations.
- ☐ I know the structure and valency of the following anions: hydroxides, carbonates, **nitrates, hydrogencarbonates, sulfites and sulfates**.
- ☐ I know that transition elements have variable valency and can explain why in relation to Cu, Fe, Cr, and Mn.

Ionic Bonding:

- ☐ I know that there are positive and negative ions
- ☐ I can predict the type of ion an atom of an element is likely to form
- ☐ I can define an ionic bond
- ☐ I can represent ionic bonds using dot and cross diagrams
- ☐ I know the structure of a sodium chloride crystal and how ionic bonding is responsible
- ☐ I know the properties of ionic substances such as hardness, melting and boiling points, and the ability to conduct electricity.
- ☐ I can give the uses of two everyday ionic substances.

Covalent Bonding:

- ☐ I can define covalent bonding
- ☐ I know about single double and triple bonds and how they form
- ☐ **I can distinguish between sigma and pi bonding.**
- ☐ I can draw covalent bonds using dot and cross diagrams
- ☐ I know the difference between polar and non-polar bonding
- ☐ I can test for polarity in liquids using a charged plastic rod
- ☐ I can give two examples of polar and non-polar materials in everyday life
- ☐ I know the properties of covalent substances such as hardness, melting and boiling points, and the ability to conduct electricity.

Electronegativity:

- ☐ I can define electronegativity
- ☐ I can explain trends in electronegativity down a group on the periodic table
- ☐ I can explain trends in electronegativity across a period on the periodic table
- ☐ I can use electronegativity differences to predict ionic, polar covalent, or non-polar covalent bonding.

Shapes of Molecules and Intermolecular Forces:

- ☐ I can use the electron pair repulsion theory to explain the shape of molecules of type AB_n for up to 4 pairs of electrons around a central atom. (refer to bond angle)
- ☐ I know the difference between intramolecular bonding and intermolecular forces
- ☐ I can define ven der Waals forces and explain their occurrence
- ☐ I can define dipole-dipole forces and explain their occurrence
- ☐ I can define Hydrogen bonding and explain its occurrence
- ☐ I can explain the effect of intermolecular forces on the boiling forces of a covalent substance and use it to explain differences in boiling points of various substances.

STOICHIOMETRY, FORMULAS and EQUATIONS.

- ☐ **I know how particles move in solids, liquids and gases.**
- ☐ **I can define diffusion and know that NH_3 and HCl diffuse and form a visible solid ammonium chloride. I also know that ink diffuses in water and smoke diffuses in air.**
- ☐ **I can state Boyles law and understand how Boyles air pump works**
- ☐ **I can state Charles's law.**
- ☐ I can state Gay-Lussac's law of combining volumes.
- ☐ I can state avagadro's law
- ☐ **I can state the combined gas law**
- ☐ **I can do simple calculations using the combined gas law including correction of gas volumes to S.T.P. using the units: Pa; cm^3; K)**
- ☐ I can state the assumptions of the kinetic theory of gases.
- ☐ I know what an ideal gas is
- ☐ I know why an gases deviate from ideal gas behaviour
- ☐ I can write the equation of state for an ideal gas
- ☐ I can do calculations using the equation of state for an ideal gas (using the units: Pa; m^3; and K).
- ☐ I can convert cm^3 to m^3.
- ☐ **I can define and express numerically Avogadro's constant**
- ☐ **I can define and write numerically a mole.**
- ☐ **I can define and write numerically Standard Temperature and Pressure (s.t.p.)**
- ☐ **I can define molar volume and find the value on an exam paper**
- ☐ **I can define molar mass**
- ☐ **I can define relative atomic mass**

- ☐ **I can define relative molecular mass M_r)**
- ☐ **I can carry out calculations to find relative molecular mass from relative atomic masses**
- ☐ **I can convert moles into grams, litres and into number of particles.**
- ☐ **I can convert grams and litres into moles**
- ☐ I can convert number of particles into moles
- ☐ I can convert moles to number of atoms of a molecular species
- ☐ I know how a mass spectrometer is used to determine M_r and know about the structure of a mass spectrometer.
- ☐ **I can define an empirical formula**
- ☐ **I can define a molecular formula**
- ☐ **I can carry out calculations of empirical formulas given the % composition by mass**
- ☐ I can calculate empirical formulas given the masses of reactants and products
- ☐ **I can calculate molecular formulas given the empirical formula and the relative molecular mass (e.g. glucose and urea).**
- ☐ **I can define and calculate % composition by mass**
- ☐ **I can define structural formulas and draw simple ones**
- ☐ **I can balance chemical equations**
- ☐ I can balance redox equations (ionic equations only – ignore spectator ions)
- ☐ **I can carry out calculations in g or kg involving masses and volumes based on balanced equations using the mole concept.**
- ☐ I can carry out calculations involving an excess of one reactant
- ☐ I can calculate and define percentage yields

VOLUMETRIC ANALYSIS.

- ☐ **I can write the concentration of solutions in: mol l^{-1} (molarity); g l^{-1}; and in** % (W/V); **% (v/v) (and know its use in wine); and** % (w/w).
- ☐ **I can calculate molarity from concentration in grams per litre and vice versa.**
- ☐ **I can calculate the number of moles from molarity and volume**
- ☐ I can carry out simple calculations using percentage concentrations
- ☐ **I know that colour intensity is a function of concentration.**
- ☐ I can do calculations of the effect of dilution on concentration
- ☐ **I know what a primary standard and a secondary standard is**
- ☐ **I can define acids, bases and salts.**
- ☐ **I can define neutralisation**
- ☐ **I can give two examples of a household acid and two examples of a household base.**
- ☐ **I can give everyday examples of neutralisation such as indigestion tablets and lime in agriculture**

☐ **I know the Arrhenius theory of acids and bases for aqueous solutions**
☐ I know the Bronsted-Lowry theory of acids and bases for aqueous solutions
☐ I can define a conjugate acid-base pair and can identify the conjugate acid and the conjugate base of a range of substances.
☐ **I know what apparatus is used in titrations**
☐ **I can outline correct titrimetric procedure**
☐ **I can solve volumetric problems using the formula method**
☐ I can solve volumetric problems from first principles
☐ I can calculate the relative molecular mass of a compound by titration
☐ I can calculate the amount of water of water of crystallisation in a compound from titration data.
☐ I can do calculations based on acid/base and redox volumetric analysis experiments.

RATES OF REACTION.

☐ **I can define rate of reaction**
☐ **I can plot and interpret a reaction rate graph**
☐ I can distinguish between average and instantaneous rate of reaction
☐ I can calculate the instantaneous rate of reaction from a graph
☐ **I know how and why concentration effects the rate of reaction**
☐ **I know how and why particle size effects the rate of reaction**
☐ **I know why dust explosions occur**
☐ **I know how and why temperature effects the rate of reaction**
☐ **I know how and why catalysts effects the rate of reaction**
☐ **I know that enzymes are catalysts produced by living cells and can give 2 examples**
☐ **I know the nature of the catalysts in catalytic converters**
☐ **I know the reactions that are catalysed in catalytic converters**
☐ **I know the environmental benefits of catalytic converters**
☐ **I know what a catalyst poison is and can give an example**
☐ **I have seen the oxidation of methanol using hot platinum or nichrome as a catalyst**
☐ I know what activation energy is
☐ I know how temperature influences activation energy
☐ I know how to draw a reaction profile diagram
☐ I know the two theories of catalysts: Surface adsorption theory and the intermediate formation theory
☐ I know how catalysis effect the activation energy
☐ **I have seen a demonstration of the oxidation of potassium sodium tartrate by hydrogen peroxide, catalysed by cobalt (II) salts.**

EXPERIMENTS:

VOLUMETRIC ANALYSIS
Summary of all the titrations

THEORY

Mol/L = Moles / Litre = moll^{-1} = M = Molar
gL^{-1} = g/L = grams / Litre
%(W/V) = no of grams / 100cm^3
%(V/V) = No of cm^3 / 100cm^3
%(W/W) = no. of grams / 100 g
ppm = mg/ L

1) Prepare a Standard Solution of Sodium Carbonate

- Use clean, dry spatula to weigh onto clock glass
- Record weight to within 0.01g accurately
- Transfer solid from clock glass to a beaker of 100cm^3 H_2O (deionised).
- Wash all traces of solid from clock glass into beaker using a wash bottle.
- Stir with a glass rod to dissolve
- Pour solution down a glass rod through a funnel into a volumetric flask (this ensures that the least possible amount of the solution gets stuck to the sides)
- Rinse beaker with wash bottle and add washings to volumetric flask as above.
- Make the solution in the volumetric flask up to the line carefully. Use a dropper to fill the last bit. Ensure that the bottom of the meniscus rests on the line.
- Stopper the flask and invert it 20 times. This ensures that the solution is the same concentration throughout.
- Label the flask with the name of the solution, the concentration, the date and your name.

CALCULATIONS

$$\text{Number of moles} = \frac{\text{mass you have}}{\text{Molar mass}}$$

This is the number of moles in 250cm^3.
(X4) = moles / 1000 cm^3 = molarity of the solution (mol/L or M)

2) Correct titration method

- Wash pipette, burette and conical flask with deionised water
- Wash pipette with solution to be used
- Wash burette with solution to be used
- Do not rinse the conical flask with the solution to be used or the volume will be affected

- Pour solutions to be used into separate labelled beakers for pipetting and pouring
- Fill burette using a funnel to above 0. Remove funnel.
- Release solution from the burette into waste beaker so that the bottom of the meniscus rests on the 0 mark. This fills the part of the burette below the tap with the solution so that it is more accurate.
- Pipette 25cm^3 of the other solution into a conical flask
- Add indicator
- Place a white tile below the conical flask so that the colour changes are easier to see.
- Carry out 1 rough titration and 2 or 3 accurate titrations (within 0.1cm^3 of each other)
- Swirl flask continuously
- Stop titrating as soon as there is a complete colour change.

CALCULATIONS

To get the correct titration result, ignore the rough result and average the others.

Solution 1	Solution 2
M_1 = unknown	M_2 = Concentration of known solution
V_1 = volume used (amount in pipette)	V_2 = volume used (amount on burette)
n_1 = no. of moles in balanced eqn.	n_2 = no. of moles in balanced eqn.

$$\frac{M_1V_1}{n_1} = \frac{M_2V_2}{n_2}$$

$$M_1 = \frac{M_2V_2n_1}{V_1n_2}$$

Answer is found in moles / L = M

HCl and Sodium Carbonate – To standardise HCl

- HCl in Burette
- Standard (known conc.) sodium carbonate in pipette
- Indicator is methyl orange (used with strong acids). It is yellow in a base and red in an acid.

4) HCl + NaOH (Sodium Hydroxide) – ordinary level only

- Known concentration of HCl in burette
- Unknown conc. NaOH in pipette/conical flask
- Indicator is methyl orange (used with strong acids). It is yellow in a base and red in an acid.

5) % Ethanoic acid in vinegar – higher level only

- Dilute vinegar (pipette 50cm^3 – 2X25cm^3 into a volumetric flask and make up to 250cm^3). This is a 1:5 dilution. (diluted to save using too much reagent)

- Sodium hydroxide in burette (unusual because bases tend to clog up apparatus – therefore must rinse the burette thoroughly after the experiment. It is done this was because it is easier to see the colour appear than disappear).
- 25cm^3 of diluted vinegar in conical flask / pipette
- Indicator is phenolphthalein (used with weak acids). It is pink in a base and clear in an acid.

CALCULATIONS:
Find Mol/L in flask (as above).
X5 (dilution factor) to find mol/L in original.
Moles/Litre → grams/Litre → %(W/V)

6) % water of crystallisation in hydrated sodium carbonate (washing soda) – higher level only.

- weigh sodium carbonate accurately and make up solution in volumetric flask
- sodium carbonate in conical flask / pipette
- HCl in burette
- Indicator methyl orange (used with strong acids). It is yellow in a base and red in an acid.
- Find mol/L sodium carbonate in flask

CALCULATIONS:

X moles / litre in flask
X/4 moles in 250 cm^3.

You weighed out Z amount of crystals. Of that Y grams were sodium carbonate. The rest was water of crystallisation

Mass water of crystallisation = Z – Y.

$$\% \text{ water of crystalisation} = \frac{Z - Y}{Z} \times 100$$

7) Standardise KmnO$_4$ with ammonium iron (II) Sulfate.

- KMnO$_4$ cannot be weighed out to give a known concentration solution as it may have reduced slightly (it is an oxidising agent). It decomposes in the presence of sunlight
- Can't make a standard solution of iron(II) sulfate as it is not a primary standard because the crystals can be oxidised slightly by the air and the

crystals tend to loose their water of crystallisation when exposed to the air. (efflorescence)
- Make a standard solution of ammonium iron (II) sulfate ($(NH_4)_2SO_4.FeSO_4.6H_2O$). This is a double salt which can be used as a primary standard as it is very stable.
- Do this by first dissolve the ammonium iron (II) sulfate in 20 cm^3 of dilute **sulphuric acid**. This prevents the Fe^{2+} ions reacting with the water (hydrolysis) and changing to Fe^{3+}. Then add $100cm^3$ water.
- Put the potassium permanganate in the burette – read from the top of the meniscus, as the colour of the $KmnO_4$ is so intense making it hard to identify the bottom of the meniscus.
- Ammonium iron (II) sulfate is in the conical flask / pipette.
- Also add **H_2SO_4** to conical flask to supply the H^+ ions for the reaction.
- No indicator is needed. Colourless iron(II)sulfate → pink $KMnO_4$ when all the iron(II) sulfate has been oxidised.
- The first few drops of $KMnO_4$ decolourise slowly but then it speeds up as the Mn^{2+} ions being produced in the reaction are auto catalysts.
- Calculate as normal

8) Amount of Iron in an Iron tablet

- Find the mass of 5 tablets
- Dissolve them in sulphuric acid (stops $Fe^{2+} \rightarrow Fe^{3+}$) and then in water.
- $KMnO_4$ goes in burette
- Iron solution goes in the pipette/conical flask
- Add H_2SO_4 to flask to provide the H^+ ions needed for the reaction
- Read from top of meniscus
- $KmnO_4$ stains the glass so rinse burette well after use.

CALCULATIONS

Find moles/litre in flask
X rel. molecular mass of $FeSO_4$ = g/Litre
÷ 4 = g / 250 cm^3 = g/5 tablets
÷ 5 (or number of tablets) = grams / 1 iron tablet.

$$\% = \frac{\text{mass of iron in 1 tablet}}{\text{mass of 1 tablet}} \times 100$$

9) Standardise Sodium Thiosulfate using iodine.

- Iodine solution cannot be made directly as iodine vaporises (sublimes) and iodine doesn’t dissolve in water.
- To make an iodine solution

$2MnO_4^- + 10\,I^- + 16\,H^+ \rightarrow 2Mn^{2+}\ 5\,I_2 + 8H_2O$

use known volume of standardised $KmnO_4$

KI in excess keeps iodine dissolved in solution

H_2SO_4 in excess provides H^+ for reaction.

- $2MnO_4 : 5\,I_2$
- Iodine reacts with Sodium Thiosulfate

$I_2 + 2S_2O_3^{2-} \rightarrow 2I^{--}\,{}^{+}\,S_4O_6^{2-}$

- $5\,I_2 : 10\,S_2O_3^{2-}$
- $2MnO_4 : 10S_2O_3^{2—}$
- $1MnO_4 : 5\,S_2O_3^{2--}$
- So use 1 and 5 as the n values in the calculation.
- Thiosulfate goes in the burette
- $KMnO_{4\,+}$ KI $_{+}$ H_2SO_4 go in the conical flask. Measure $KmnO_4$ with the pipette.
- Initially no indicator is used. The colour changes from red/brown to pale yellow.
- When the solution is pale yellow add starch indicator which turns the starch blue/black
- It will turn colourless at the end point as there is no more iodine present.

10) (W/V) Hypochlorite in Bleach

- $ClO^- + 2I^- + 2\,H^+ \rightarrow Cl^- + I_2 + H_2O$

hypochlorite

Excess KI ensures that ClO^- is limiting reagent.

H_2SO_4 in excess provides H^+ for reaction. HCl would be oxidized itself and HNO_3 is an oxidizing agent

- This iodine s abov
- $1\,ClO^- : 1\,I_2 : 2\,S_2O_3^{2-}$
- Bleach is diluted 1:10 so that larger volumes can be used – limiting error but reagents are not wasted ($25cm^3 \rightarrow 250cm^3$ volumetric flask)
- Tap water cannot be used to dilute as dissolved chlorine in the water is an oxidising agent and will effect the results.
- Standardised sodium thiosulfate goes in the burette
- Bleach (pipette); KI; and H_2SO_4 go in conical flask.
- Colourless bleach → red/brown when KI and H_2SO_4 are added. → pale yellow as thiosulfate is added. → blue/black when starch indicator is added → colourless at end point.

<u>CALCULATIONS:</u>

Find moles per litre of Hypochlorite.
X molecular mass of NaClO = g/L Hypochlorite
÷ 10 = $g/100cm^3$ hypochlorite
= %(W/V) Hypochlorite in diluted sample
X 10 = % (W/V) in original bleach.

OTHER EXPERIMENTS

1) **Flame tests**
2) **Tests for Anions**
3) **Determination of the relative molecular mass of a volatile liquid**
4) **Redox reactions of group VII elements – halogens as oxidising agents (reactions with bromides, iodides $^{Fe+}$and sulphites. Dissplacement reactions of metals (Zn with Cu^{2+}, Mg with Cu^{2+}.)**
5) **Monitoring the rate of oxygen production from from hydrogen peroxide using manganese dioxide as a catalyst**
6) **Studying the effects on the reaction rate of (i) concentration and (ii) temperature, using thiosulfate solution and hydrochloric acid.**