FP understanding and key concepts

Introduction to foundation chemistry

1. **Measurements**
   - ✓ Accuracy vs precision
   - ✓ Uncertainties in measurements
   - ✓ Random and systematic errors
   - ✓ Significant figure and the scientific notation
   - ✓ Graphing techniques
2. **The atomic structure:**

- ✓ Atoms contain a positively charged dense nucleus composed of protons and neutrons (nucleons).
- ✓ Negatively charged electrons occupy the space outside the nucleus in energy levels.
- ✓ Isotopes are atoms of the same element that have the same atomic number but different number of neutrons.
- ✓ The relative atomic mass of an element (A_r) is the average mass of an atom of the element from all its isotopes compared to one atom of carbon-12
- ✓ Emission spectra are produced when photons are emitted from atoms as excited electrons return to a lower energy level.
- ✓ The line emission spectrum of hydrogen provides evidence for the existence of electrons in discrete energy levels, which converge at higher energies.
- ✓ The main energy level or shell is given an integer number, n, and can hold a maximum number of electrons, $2n^2$.
- ✓ A more detailed model of the atom describes the division of the main energy level into s, p, d and f sub-levels of successively higher energies.
- ✓ Sub-levels contain a fixed number of orbitals, regions of space where there is a high probability of finding an electron.
- ✓ Trends in first ionization energy across periods account for the existence of main energy levels and sub-levels in atoms.
- ✓ Successive ionization energy data for an element give information that shows relations to electron configurations.
- ✓ No more than two electrons can occupy any one orbital, and if two electrons are in the same orbital they must spin in the opposite directions (Pauli Exclusion Principle)
- ✓ If more than one orbital in a sub level is available, electrons occupy different orbitals with parallel spins (Aufbaus Principle)

3. **The periodic table**

- ✓ The periodic table is arranged into four blocks associated with the four sublevels— s, p, d, and f.
- ✓ The periodic table consists of groups (vertical columns) and periods (horizontal rows).
- ✓ The period number (n) is the outer energy level that is occupied by electrons.
- ✓ The number of the principal energy level and the number of the valence electrons in an atom can be deduced from its position on the periodic table.
- ✓ The periodic table shows the positions of metals, non-metals and metalloids
- ✓ Vertical and horizontal trends in the periodic table exist for atomic radius, ionic radius, ionization energy, electron affinity and electronegativity.
- ✓ Electronegativity of an element is a measure of the ability of an atom to attract electrons in a covalent bond.
- ✓ Electron affinity of an atom is the energy change that occurs when one mole of electrons is added to one mole of gaseous atoms.
- ✓ Metals have lower ionization energies and electronegativities than non-metals.
- ✓ Oxides change from basic through amphoteric to acidic across a period.

- ✓ Chemical properties of an element are largely determined by the number of valence electrons in their outer energy level.
- ✓ Group 1 elements are alkali metals; they react vigorously with water to produce hydrogen and metal hydroxide.
- ✓ Group 2 are alkaline earth metals; they are less reactive than group 1.
- ✓ Group 7 or 17 are the halogens. They are diatomic molecules and react with group 1 to form salts (ionic halides). The more reactive halogen displaces the ions of the less reactive halogen from its compounds.
- ✓ Group 8 or 18 are the noble gases. They are colourless, monoatomic and very unreactive due to a stable octet or duplet for He.
- ✓ Oxides of metals are ionic and basic. Oxides of non-metals are covalent and acidic. Aluminium oxide is amphoteric.
- ✓ Alkalis are bases which are soluble in water. They form hydroxide ions in aqueous solution.

4. Chemical bonding and structure

- ✓ Positive ions (cations) form by metals losing valence electrons. (valence is derived from Latin word for strength)
- ✓ Negative ions (anions) form by non-metals gaining electrons.
- ✓ The number of electrons lost or gained is determined by the electron configuration of the atom.
- ✓ The ionic bond is due to electrostatic attraction between oppositely charged ions.
- ✓ Under normal conditions, ionic compounds are usually solids with lattice structures.
- ✓ A covalent bond is formed by the electrostatic attraction between a shared pair of electrons and the positively charged nuclei.
- ✓ Single, double and triple covalent bonds involve one, two and three shared pairs of electrons respectively.
- ✓ Bond length decreases and bond strength increases as the number of shared electrons increases.
- ✓ Bond polarity results from the difference in electronegativities of the bonded atoms.
- ✓ Lewis (electron dot) structures show all the valence electrons in a covalently bonded species.
- ✓ The “octet rule” refers to the tendency of atoms to gain a valence shell with a total of 8 electrons.
- ✓ Some atoms, like Be and B, might form stable compounds with incomplete octets of electrons.
- ✓ Shapes of species are determined by the repulsion of electron pairs according to VSEPR theory.
- ✓ Carbon and silicon form giant covalent/network covalent structures.
- ✓ Intermolecular forces include London (dispersion) forces, dipole-dipole forces and hydrogen bonding.
- ✓ The relative strengths of these interactions are London (dispersion) forces < dipole-dipole forces < hydrogen bonds.
- ✓ A metallic bond is the electrostatic attraction between a lattice of positive ions and delocalized electrons.
- ✓ The strength of a metallic bond depends on the charge of the ions and the radius of the metal ion.
- ✓ Alloys usually contain more than one metal and have enhanced properties
- ✓ Electrical conductivity and malleability in metals is due to free delocalized electrons and atoms being capable of slipping with respect to one another
- ✓ Molecules with polar bonds are not always polar. If symmetrically arranged, the diploes cancel out (CO_2, BF_3, CCl_4). Molecules such as CH_3Cl, NH_3, and $H_2O$are polar.

5. Stoichiometric relationships

- ✓ Atoms of different elements combine in fixed ratios to form compounds, which have different properties from their component elements.
- ✓ Mixtures contain more than one element and/or compound that are not chemically bonded together and so retain their individual properties.
- ✓ Mixtures are either homogeneous or heterogeneous.
- ✓ State symbols (s), (l), (g) and (aq) are used in chemical equations.
- ✓ The mole is a fixed number of particles and refers to the amount, *n*, of substance.
- ✓ Masses of atoms are compared on a scale relative to ^{12} C and are expressed as relative atomic mass (*A*r) and relative formula/molecular mass (*M*r).
- ✓ Molar mass (*M*) has the units g mol^{-1}

- ✓ The empirical formula and molecular formula of a compound give the simplest ratio and the actual number of atoms present in a molecule respectively.
- ✓ Avogadro's law enables the mole ratio of reacting gases to be determined from volumes of the gases.
- ✓ The molar volume of an ideal gas is a constant at specified temperature and pressure.
- ✓ The molar concentration of a solution is determined by the amount of solute and the volume of solution.
- ✓ A standard solution is one of known concentration.

6. Methods of separation

Method	Description	Property
Decantation	Separation of solids from liquids. Sediments settled and liquid can be carefully poured without disturbing	Insoluble substances of different densities
Filtration	Use filter paper and filter funnel to get residue and filtrate from a mixture.	Insoluble solid/ precipitate in a solution.
Evaporation	To heat off the water saturating the solution to produce crystals	Separate solute from the solvent in a solution
Separating funnel	Separating immiscible liquids	Liquid mixture of different densities
Simple distillation	Used to separate homogeneous mixtures	differences in boiling points of substances
Chromatography	Separates components of a mixture based on ability of each component to be drawn across the surface of another material	Separation occurs because various components travel at different rates
Osmosis and dialysis	Uses the concept of diffusion where a semi-permeable membrane only allows water molecules pas through.	Concentration and colloid particle size
Centrifugation	Centrifuges rotate containers of liquids to separate suspended materials with different densities	Suspensions with different densities
Fractional distillation	separating a solution of two or more miscible liquids	different boiling points of the liquids