Unit title: Inorganic Chemistry

Unit code: **R/601/0349**

QCF level: **4**

Credit value: **15**

Aim

This unit covers the foundations of inorganic chemistry relating to structure and bonding, together with the chemistry of important elements and compounds and a review of some major industrial applications.

Unit abstract

The unit provides a comprehensive coverage of basic inorganic chemistry and lays a firm foundation for studying chemistry at higher levels. The unit applies the principles of inorganic chemistry to aspects of structure and bonding and the chemistry of selected elements and compounds. These, together with a survey of important industrial applications, form a firm foundation for employees working in the chemistry field or for learners hoping to gain such employment or progress to higher levels of study.

Learning outcomes

On successful completion of this unit a learner will:

1 Understand the structure of atoms

2 Understand the structure of matter

3 Understand the chemistry of elements and compounds

4 Be able to review the industrial applications of elements and compounds.

Unit content

1 **Understand the structure of atoms**

Historical development: Dalton's work; JJ Thompson and electrons; Robert Millikan and electron charge; Rutherford and Geiger-Marsden's work (α particle deflections)

The spectrum of atomic hydrogen: characteristics of electromagnetic radiation; wavelength; amplitude; frequency; simple calculations using $c = f\lambda$ and Planck's equation; Bohr model; spectral series (Lyman, Balmer); the Rydberg equation (including associated calculations)

The quantum mechanical model: wave particle duality (de Broglie's relation); Heisenberg uncertainty principle; solutions to the Schrödinger equation (qualitative only)

The electronic structure of atoms: electronic configurations (spdf) of elements 1 to 36 (Aufbau); shapes and orientation of s, p and d orbitals; atomic orbitals in terms of principal quantum number, orbital angular momentum quantum number and magnetic quantum number; Pauli exclusion principle in terms of electron quantum numbers; Hund's rule

The Periodic Table and electronic structure: structure of Periodic Table in terms of s block, p block, d block and f block; ionisation energies and trends across periods 2 and 3; ionisation energies and trends down groups; electron affinity (definition and examples)

Atomic radii: covalent, metallic, ionic and Van der Waals radii; trends in radii across periods and down groups

2 **Understand the structure of matter**

Ionic bonding: formation of ionic compounds e.g. Born Haber cycles; properties of ionic compounds; polarisation and covalency; Fajan rules; role of electronegativity difference in determining ionic/covalent bonding

Metallic bonding: metallic bonding using the electron sea model; electrical conductivity; thermal conductivity

Covalent bonding: bond length; bond order; bond enthalpy; bond polarity; polar molecules; dative covalent (coordinate) bonding

Intermolecular forces of attraction: causes, occurrence and relative strengths; dispersion forces; dipole-dipole; hydrogen bonding

Localised bond models of covalent bonding: Lewis concepts (shared electron pairs); valence bond (resonance); hybridisation; valence shell electron pair repulsion (VSEPR) theory; VSEPR and shapes of molecules

Delocalised bond models: molecular orbitals; molecular orbital energy level diagrams; linear combination of atomic orbitals (LCAO) for homonuclear and simple heteronuclear diatomic molecules; bond order and bond strength

Types of structure: formation, structure and typical properties of ionic and metal crystal structures; simple molecular and giant covalent (macromolecular); explanation of properties in terms of bonding and intermolecular forces

3 **Understand the chemistry of elements and compounds**

The third period of the Periodic Table: physical and chemical properties of the elements, oxides, hydrides and chlorides; interpretation of trends in terms of electronic structure and bonding

s block, groups 1 and 2: physical and chemical properties of the elements, oxides, chlorides, carbonates, sulfates and nitrates; anomalous behaviour of lithium and beryllium

p block chemistry: groups 13-16 to cover first two elements only in terms of physical and chemical properties of elements and their compounds with hydrogen, oxygen and chlorine (where appropriate); group 17 (halogens, fluorine to iodine) to include group trends (melting/boiling points, bond energy, oxidation states); anomalous nature of fluorine; formation of halides; reactions with sulfur and phosphorous; oxides; reactions with water; hydrogen halides

The chemistry of hydrogen: the hydrogen (H^+) and hydroxonium ions (H_3O^+); the hydride ion (H^-); reactions of metal hydrides; physical properties and reactions of covalent hydrides

The chemistry of the inert gases (group 18): trends within the group; inability of helium and neon to form compounds; synthesis and properties of xenon fluorides, xenon oxides; dangers of radon gas

d block, transition metals (Sc-Zn): trends in the physical properties of 3d metals; typical properties of transition metal compound to include formation of coloured ions; variable oxidation state; complex formation; anomalous behaviour of scandium and zinc

Experimental work: experimental work involving elements and compounds from the s, p or d block to support earlier content; interpret results in terms of electronic structure and bonding

4 **Be able to review the industrial applications of elements and compounds**

Hydrogen applications: production and applications of hydrogen and its compounds; potential use as fuel; uses of hydrogen isotopes; Haber process; conversion to methanol; industrial acids; s and p block hydrides; hydrogen peroxide

s block applications: industrial use of lithium (lithium greases); production and uses of sodium metal; production and uses of magnesium e.g. alloys; uses of calcium e.g. building materials

p block: production and applications of p block elements and their compounds including aluminium, silicon, nitrogen, sulfur, chlorine and argon

d block: production and applications of transition metals and their alloys including titanium, iron, nickel and copper

Learning outcomes and assessment criteria

Learning outcomes On successful completion of this unit a learner will:	**Assessment criteria for pass** The learner can:
LO1 Understand the structure of atoms	1.1 discuss the historical development of different models of the atom 1.2 explain the hydrogen spectrum using associated equations 1.3 discuss the quantum mechanical model of electron behaviour 1.4 explain the electronic configuration of elements hydrogen through to krypton 1.5 review electron structure in relation to position in Periodic Table 1.6 explain trends in atomic radii
LO2 Understand the structure of matter	2.1 discuss the factors that have led to the current model of ionic bonding 2.2 explain the valence electron model of metallic bonding 2.3 explain the characteristics of covalent bonds and assess the factors that contribute to the magnitude of intermolecular forces of attraction 2.4 explain localised and delocalised models of covalent bonding 2.5 categorise substances according to structure
LO3 Understand the chemistry of elements and compounds	3.1 outline the chemistry associated with period 3 3.2 explain the chemistry of selected elements and compounds of the s, p and d blocks 3.3 review the chemistry of hydrogen 3.4 explain the limited reactivity of selected group 18 elements 3.5 investigate experimentally selected elements and compounds of the s, p and d blocks to confirm their properties, using safe practices
LO4 Be able to review the industrial applications of elements and compounds	4.1 review the industrial applications of hydrogen 4.2 review the industrial applications of selected s, p and d block elements

Guidance

Links

This unit has particular links with the following units within this qualification:

- *Unit reference number Y/601/0353: Physical Chemistry*
- *Unit reference number M/601/0360: Inorganic Chemistry of Crystal Structures and Transition Metal Complexes*
- *Unit reference number F/601/0413: Industrial Chemistry*
- *Unit reference number F/601/0217: Biochemistry of Macromolecules and Metabolic Pathways*

Essential requirements

Delivery

The unit should be delivered using a variety of approaches, for example lectures, demonstrations, and practical work. Delivery must integrate theoretical considerations with practical outcomes, emphasising the industrial importance of reactions and processes.

Assessment

Assessment must confirm learners' ability to categorise and systemise information relating to the chemistry of the elements and their compounds in terms of structural types and according to their position in the periodic table. An understanding of trends, patterns and differences within and across the s, p and d blocks of the periodic table must be demonstrated.

Where appropriate, underlying principles should be supported by practical investigation. There must be evidence of learner ability to access and research information and data and evaluate these in terms of structures, properties and trends.

Resources

Learners will need access to advanced laboratory facilities with appropriate technical support.

Employer engagement and vocational contexts

Where possible, site visits or invited speakers may enhance the content. It is important to integrate as many vocational examples as possible particularly in relation to learning outcomes 2 to 4.

