

Higher National Unit Specification

General information for centres

Unit title: Transition Metal Chemistry

Unit code: DR0E 35

Unit purpose: This Unit is designed to give candidates the underpinning chemistry knowledge and practical skills to describe and explain the chemistry and structural properties of d-metal elements, compounds and complexes together with the ability to apply the concepts of bonding to the spectral and magnetic properties of coordination compounds. The practical element of this Unit will support the theoretical aspects and also further develop candidates practical, analytical and communication skills.

On completion of the Unit the candidate should be able to:

- 1 Describe the chemistry of d-metal elements, compounds and complexes and apply the concepts of bonding to the spectral and magnetic properties of coordination compounds.
- 2 Perform chemical techniques and report and explain the results concisely.

Credit points and level: 1 HN Credit at SCQF level 8: (8 SCQF credit points at SCQF level 8*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

Recommended prior knowledge and skills: Access to this Unit is at the discretion of the centre but it is preferable for candidates to be able to demonstrate a knowledge of inorganic chemistry at SCQF level 7. This may be the result of relevant work experience or might be by the possession of credits for the Units Fundamental concepts of Inorganic Chemistry (DP2N 34) and/or Fundamental Chemistry: Theory and Practice (DH2K 34).

Core skills: There may be opportunities to gather evidence towards the core skills of Communication and Problem solving at Higher level in this Unit although there is no automatic certification of core skills or core skills components.

Context for delivery: If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes.

This Unit is included as part of the core framework for HND Chemistry and is an optional Unit in the framework for HND Applied Sciences but may be also offered as part of other HND national programmes. If this Unit is offered as part of a Group Award it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes.

General information for centres (cont)

Assessment: The assessment for Outcome 1 will take the form of structured questions based on a sample of the knowledge and skills taught. This assessment will take place under closed-book, controlled conditions. A periodic table in an appropriate format should be supplied Outcome 2 will be assessed by means of practical experiments and completion of a laboratory report, checklist and a laboratory diary for the specified number of experiments.

Higher National Unit specification: statement of standards

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The sections of the Unit stating the Outcomes, knowledge and/or skills, and evidence requirements are mandatory.

Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the knowledge and/or skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 1

Describe the chemistry of d-metal elements, compounds and complexes and apply the concepts of bonding to the spectral and magnetic properties of coordination compounds

Knowledge and/or skills

- ◆ IUPAC nomenclature of coordination compounds
- ◆ Isomerism in coordination compounds
- ◆ Use of transition elements in analysis
- ◆ Redox Chemistry of the elements
- ◆ Crystal field and valence bond theories and their applications
- ◆ Electronic spectra
- ◆ Stabilisation of coordination compounds

Evidence requirements

Candidates will need evidence to demonstrate their knowledge and/or skills by showing that they can display competence in a sample of five out of seven of the above list of knowledge and skills on a single occasion. Assessment should be under closed-book controlled conditions and the questions set in the assessment should cover a representative sample of the topics suggested in the support notes. There should be a mixture of short answer, extended response and structured questions in each part of the assessment.

A periodic table in an appropriate format should be supplied to candidates.

Assessment guidelines

Candidates should use models where appropriate (eg isomerism). Where possible candidates should be made aware of the relationship between different topics (eg valence bonding, charge spectra and stabilisation) and encouraged to view the Unit holistically and also to foster links between the various theoretical aspects and the exercises in the practical Outcome

Higher National Unit specification: statement of standards (cont)

Unit title: Transition Metal Chemistry

Outcome 2

Perform chemical techniques and report and explain the results concisely

Knowledge and/or skills

- ◆ Follow instructions to perform a range of chemical experiments
- ◆ Work in a safe manner regarding current health and safety regulations
- ◆ Achieve consistent and accurate results
- ◆ Report the results clearly and concisely
- ◆ Identify sources of experimental errors and estimate size of errors as appropriate

Evidence requirements

Evidence for this Outcome will be provided by the candidate performing at least two practicals from the categories shown in the support notes, or equivalent alternatives. Only 1 of the practical experiments should be used to produce laboratory report.

Candidates should be assessed on their:

- ◆ performance in completing the laboratory work
- ◆ ability to produce satisfactory a laboratory report
- ◆ interpretation/explanation of the theoretical aspects of their experiments as appropriate and their ability to work safely
- ◆ description of risks and the precautions taken to reduce them

A checklist and the record of results and calculations in a laboratory diary should be used to assess performance in the laboratory. This checklist will recognise the need for accuracy and error evaluation in analytical work and place an emphasis on yield and quality of product in any preparative work. Candidates who fail to submit a satisfactory report will be required, after suitable remediation, to submit an additional report for another experiment.

Candidates should have access to the SQA Databook for Higher/Advanced Higher Chemistry when sitting the assessment.

Assessment guidelines

The experiments selected for assessment purposes should cover a range of techniques to provide a guide to the candidates' all round practical ability. It is recommended that one practical experiment should be from category A and the other from B or C as detailed in the support notes. Candidates should be encouraged to view the Unit holistically and also to foster links between the various theoretical aspects and the exercises in the practical Outcome.

The experiments listed in the support notes are for guidance only and appropriate alternatives may be substituted providing that they:

Higher National Unit specification: statement of standards (cont)

Unit title: Transition Metal Chemistry

- (a) are of an equivalent standard in terms of skills development and
- (b) have a direct relationship to a theoretical topic covered in Outcome 1
- (c) can be placed in one of the three categories A, B or C.

Administrative Information

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Superclass category:	RD
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Higher National Unit specification: support notes

Unit title: Transition Metal Chemistry

This part of the Unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours.

Guidance on the content and context for this Unit

This Unit is in the core of the HND chemistry framework and an option within the framework of HND Applied Science and. It may also be suitable for inclusion in other science HNC/HND awards. The aim is to give candidates the underpinning theoretical and practical chemical knowledge to allow them to function as an effective technician or junior manager.

Outcome 1

Candidates should be able to:

- ◆ Use IUPAC nomenclature to convert chemical formulae of complexes into IUPAC names and vice versa.
- ◆ To predict, recognise and name the isomeric possibilities for compounds of the type M_xL_y and construct structural diagrams. This will give the opportunity for students to learn how to construct and use models.
- ◆ Discuss and explain the approaches to use of transition elements in analysis. Use of EDTA. Selection of indicators and the reasons for prescribed pH conditions and calculations in volumetric analysis. Use of precipitating agents (especially organic and organometallic compounds) in gravimetric analysis. Ideal properties of precipitants and calculation of results.
- ◆ Predict the redox chemistry of the transition elements and compounds using Latimer diagrams.
- ◆ Apply crystal field and valence bond theories to explain weak and strong field complexes, inner and outer orbital complexes, magnetic properties, paramagnetism and diamagnetism, high and low spin complexes, calculations of CFSE and spin only moments.
- ◆ Interpret and explain UV spectra of one electron systems in terms of location, absorbance, and shape using the selection rules. Predict and explain using the spectrochemical series, red or violet shifts in location with change of ligand. Explain the processes giving rise to charge spectra in terms of regions of high and low electron density within a complex.
- ◆ Explain and predict the stabilisation of certain ligand/metal complex combinations in terms of regions of high and low electron density within a complex and the subsequent secondary metal/ligand bond types. Candidates should also be able to predict bond types (σ , π) and the stereochemical and valence bond conditions for them to form.

Outcome 2

Candidates should be introduced to at least two practical techniques of which one should be from Category A including:

Higher National Unit specification: support notes (cont)

Unit title: Transition Metal Chemistry

- 1 **Category A.** Volumetric analysis, involving compleximetric titrations should be covered. This should include use of EDTA and selection of suitable indicators and pH conditions.

Possible experiments:

- (a) Analysis of Zinc using EDTA
- (b) Determination of the purity of a nickel salt by back titration using EDTA
- (c) Determination of the total hardness of water using EDTA

- 2 **Category B.** Gravimetric analysis, particularly of transition metals (eg Nickel) which could include organic precipitants.

Possible experiments:

- (a) Determination of nickel using dimethylglyoxime
- (b) Determination of Zinc as ZnO (via $\text{Zn}(\text{CO}_3)_2$)
- (c) Determination of Iron as Fe_2O_3

- 3 **Category C.** Inorganic preparations of transition metal compounds and complexes. It may be possible to get students to run and interpret UV spectra.

Possible experiments:

- (a) Prepare $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ and $[\text{TiCl}_6]^{3-}$ and run the UV spectra. Account for location, shape, absorbance of each and the differences between them.
- (b) Prepare MnCl_2 using HCl and MnCO_3
- (c) Prepare the cis- and trans- isomers of $\text{K}[\text{Cr}(\text{C}_2\text{O}_4)_2(\text{H}_2\text{O})_2]$. Test each isomer for purity (dil. NH_4OH). Give the correct IUPAC names and use structural diagrams to explain the geometric isomerism observed.

A lab diary should be kept and the students should be introduced to Standard Operating Procedures (SOPs). The laboratory report for the assessed practical should be in an appropriate format and include health and safety in regard to risk. Errors/yields should be evaluated as appropriate.

Guidance on the delivery and assessment of this Unit

This Unit is likely to form part of a Group Award, which is primarily designed to prepare candidates for employment in a science related post. The emphasis should be on encouraging the students to think about the practical implications of the theory they study.

Independent study should be encouraged by using candidate-centred, resource based methodologies.

The assessment of Outcome 1 is by a closed-book assessment. This should cover five out of the seven knowledge and skills items.

Higher National Unit specification: support notes (cont)

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In Outcome 2 candidates should be assessed on their ability to perform laboratory work to a required standard. For example titration results should be both accurate and consistent. Gravimetric analysis must give accurate results and any preparative work should produce compounds which are pure and in reasonable quantity with yields and purity being assessed. Practical work may provide an opportunity for students to develop the core skill of working with others. Evaluation of error/yield should be carried out.

Opportunities for developing Core Skills

There are opportunities to develop the Core Skill(s) of Problem Solving and Communication at Higher level in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Open learning

If this Unit is delivered by open or distance learning methods, additional planning resources may be required for candidate support, assessment and quality assurance.

A combination of new and traditional authentication tools may have to be devised for assessment and re-assessment purposes.

For further information and guidance, please see Assessment and Quality Assurance of Open and Distance Learning (SQA, February 2001, publication code A1030).

Candidates with additional support needs

This Unit specification is intended to ensure that there are no artificial barriers to learning or assessment. The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative Outcomes for Units. For information on these, please refer to the SQA document *Guidance on Assessment Arrangements for Candidates with Disabilities and/or Additional Support Needs*, which is available on the SQA website www.sqa.org.uk.

General information for candidates

Unit title: Transition Metal Chemistry

This is a 1 credit SQCF level 8 Unit, intended to be delivered as part of an HNC/HND science qualification. It is likely to be delivered in the second year of an HND programme.

It is designed to give you the basic chemistry knowledge and practical skills you will need to undertake training as a higher-grade technician or junior manager in a wide range of science based industries. The emphasis will be on applying the theoretical knowledge in practical situations.

On completion of this Unit you should be able:

- 1 Describe the chemistry of d-metal elements, compounds and complexes and apply the concepts of bonding to the spectral and magnetic properties of coordination compounds.
- 2 Perform a range of chemical techniques and report and explain the results concisely.

The main components of the Unit are described in more detail below:

Outcome 1

In this Outcome you will cover the following:

- ◆ IUPAC nomenclature of coordination compounds.
- ◆ Isomerism in coordination compounds: Structural, geometric and optical especially in compounds of the type M_xL_y .
- ◆ The use of transition elements in analysis: Uses of complexes in analytical chemistry, gravimetric analysis, requirements for a precipitate to be useful. EDTA as a titrant, chelate effect.
- ◆ Redox Chemistry of the elements: Latimer diagrams and their use to predict redox chemistry.
- ◆ Crystal field and valence bond theories and their applications: Weak and strong field complexes, inner and outer orbital complexes, magnetic properties, paramagnetism and diamagnetism, high and low spin complexes, calculations of CFSE and spin only moments.
- ◆ Electronic spectra: Explanation of UV and charge transfer spectra using the selection rules, application of the rules, characteristics of bands, the spectrochemical series.
- ◆ Charge transfer spectra and the concept of electron rich and electron poor regions of a complex.
- ◆ Stabilisation of coordination compounds: The concepts of high and low oxidation states, electron rich and electron poor regions of a complex, and metal ligand bonding arrangements.

Outcome 2

In this Outcome you will carry out at least two practical techniques from different categories (A, B, C). You will be encouraged to understand the need for accuracy and the underlying principles behind the experiments you undertake. You will learn the following skills:

General information for candidates (cont)

Unit title: Transition Metal Chemistry

How to:

- ◆ follow instructions to perform a range of chemical experiments
- ◆ work in a safe manner regarding current health and safety regulations
- ◆ achieve consistent and accurate results
- ◆ report the results clearly and concisely
- ◆ identify sources of experimental errors and estimate size of errors as appropriate

Assessment

Outcome 1 will be assessed using a single, closed-book assessment.

Outcome 2 will be assessed using at least two of laboratory exercises. You will be required to perform at least two experiments to the required standard and to produce a laboratory report for one. You will be required to keep a laboratory diary. If you fail to submit a satisfactory laboratory report you will be required, after suitable remediation, to submit an additional report for another experiment. A checklist and the record of results and calculations in a laboratory diary will be used to assess your performance in the laboratory. This checklist will recognise the need for accuracy and error evaluation in analytical work and place an emphasis on yield and quality of product in any preparative work.