Unit 53: Extraction and Refining of Metals

Unit code: L/600/0306

QCF Level 3: BTEC Nationals

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit aims to give learners an understanding of the relationship between the processes used in the extraction and refining of metals used in the casting of products.

Unit introduction

In order for metals or alloys to be used in the manufacture of castings or products, the ore needs to be prepared and processed before the metal is extracted. Depending on the type of ore, different extraction processes are used and metals technicians need to understand the chemical reactions that take place. The metal is then refined and impurities are removed.

This unit will enable learners to understand the origins and nature of many of the metals used within the metallurgical industries. The unit aims to provide learners with the knowledge and understanding of the laws of chemical reaction, plus metal production technology relevant to the needs of metals technology technicians.

Learners will be able to appreciate the origin and nature of metallic ores and how these affect the processes used to extract and refine them.

The unit also provides an opportunity for learners to understand the relationship between extraction and refining processes and therefore it will support their understanding of subsequent manufacturing processes covered in other units.

Learning outcomes

On completion of this unit a learner should:

1 Know about the use of ore preparation processes for the ores of common metals

2 Understand the physical chemistry of extraction and refining of metals

3 Understand the techniques used in the extraction of metals

4 Know the processes used in the refining of metals.

Unit content

1 Know about the use of ore preparation processes for the ores of common metals

Types of ore: ores of common metals eg iron, copper, lead, zinc, aluminium, titanium, tin, magnesium; chemical form eg oxides, sulphides, oxy-salt; geographical distribution; factors affecting their economic value

Preparation processes (dressing of ores): comminution, concentration (gravity separation, magnetic separation, froth flotation) and agglomeration processes (sintering) of metals eg iron, copper, lead, zinc, aluminium

2 Understand the physical chemistry of extraction and refining of metals

Laws of chemical reaction: energy changes; entropy; free energy/temperature (Ellingham) diagrams and their limitations; reactions involved in smelting eg slag/metal, combustion, redox reactions

Extraction and refining: chemical reactions involved in the extraction and refining of the common metals eg iron, copper, lead, zinc, aluminium, titanium, tin, magnesium

3 Understand the techniques used in the extraction of metals

Classification of extraction processes: pyrometallurgical eg processes for iron, copper, lead, zinc, tin, titanium; hydrometallurgical eg for copper and zinc; electrometallurgical eg for aluminium and magnesium

Extraction processes: extraction of metals eg iron, copper, aluminium, nickel, zinc, lead and tin; processes (blast furnace, pyrometallurgical and hydrometallurgical extraction, electrolytic reduction)

4 Know the processes used in the refining of metals

Key stages: removal of impurities by preferential oxidation and preferential deposition in electrolysis

Refining processes: eg pyrometallurgical refining of iron (to form steel), lead and nickel, fire refining of blister copper, electrolytic refining of aluminium, copper, nickel, zinc and lead, electric arc steel making

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 describe the chemical form, geographical distribution and factors affecting the value of three ores of common metals	**M1** compare and contrast different processes used when preparing ores for extraction	**D1** evaluate the effectiveness of an ore preparation process
P2 describe ore preparation (dressing) processes for three common metals	**M2** predict the rate and extent of reactions	**D2** use free energy/temperature (Ellingham) diagrams for oxide formation to explain extraction and refining processes.
P3 explain the laws of chemical reaction governing the extraction and refining of metals	**M3** justify the use of different extraction processes when extracting metal from the ore	
P4 predict extraction and refining reactions by using the laws of chemical reaction [IE1, IE4]	**M4** compare and contrast the refining processes for given metals.	
P5 classify extraction processes as pyrometallurgical, hydrometallurgical or electrometallurgical		
P6 explain the extraction processes used for a given metal		
P7 identify the key stages in the refining process of a ferrous and a non-ferrous metal.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key			
	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

It will be useful to adopt a variety of delivery methods in this unit. Some parts would benefit from an investigative approach, particularly those that involve factors affecting the economic value of ores/metals. Information on the origins, nature, cost and availability of metallic ores should be made available and internet access would be advantageous.

The learners' knowledge of chemistry should be developed to a level that will allow the understanding and application of the laws governing extraction and refining of metals.

Note that the use of 'eg' in the unit content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole class teaching: • introduction to unit • describe the ores of common metals, their chemical forms, geographical distribution and factors affecting value • describe the methods and processes for preparing ores. *Group work:* • investigating factors that affect value of metals and their geographical distribution.
Prepare for and carry out **Assignment 1: Ore Preparation Processes** (P1, P2, M1 and D1)
Whole class teaching: • explain the laws of chemical reactions and reactions involved in smelting. Explain their application and the use of free energy diagrams • explain the chemical reactions involved in the extraction and refining of metals. *Industrial visit/workshop demonstration (depending on centre resources):* • view the use of a blast furnace, pyrometallurgical and hydrometallurgical extraction etc for the extraction of metals.
Prepare for and carry out **Assignment 2: Chemical Reactions of Extraction and Refining** (P3, P4, M2 and D2)
Whole class teaching: • explain the classification of pyrometallurgical, hydrometallurgical and electrometallurgical extraction. Describe the processes used for the extraction of metals.
Prepare for and carry out **Assignment 3: Classification of Metal Extraction Processes** (P5, P6 and M3)
Whole class teaching: • identify and describe the key stages in the refining of metals. Describe the refining processes used for a variety of different metals.

Topic and suggested assignments/activities and/assessment
Prepare for and carry out **Assignment 4: Refining Processes for Ferrous and Non-ferrous Metals** (P7, M4)
Feedback, unit evaluation and close.

Assessment

Evidence of the learning outcomes may be collected from well-planned investigative assignments, case studies and unseen tests. A suitable case study would involve learners reviewing suitable preparation, extraction and refining techniques for a given metal.

To achieve a pass, learners must know and understand the techniques used to produce metals from their ores. They must be able to describe ore preparation processes and explain the laws of chemical reaction governing the extraction and refining of metals. They will need to show that they can apply laws of chemical reaction in order to predict extraction and refining reactions, classify extraction processes as pyrometallurgical, hydrometallurgical or electrometallurgical, and explain various processes used in the extraction and refining of metals.

To achieve a merit learners must compare and contrast the processes used in ore preparation and in the refining of metals. They should be able to justify the use of different extraction processes and predict the rate and extent of chemical reactions occurring in both the extraction and refining of metals.

To achieve a distinction learners must evaluate the effectiveness of appropriate ore preparation process in terms of particle size and concentration of metallic species. They must demonstrate the ability to use free energy (Ellingham) diagrams.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1 and D1	Ore Preparation Processes	Metallurgist report on different preparation processes or report on given case study.	Case study or report on industrial visit or visiting speaker.
P3, P4, M2 and D2	Chemical Reactions of Extraction and Refining	Chemist carrying out a survey across different companies on their extraction processes.	Case study or report on industrial visit or visiting speaker.
P5, P6 and M3	Classification of Metal Extraction Processes	Metallurgist report on chemical reactions taking place during the extraction and refining of metals.	Investigation report including practical activities.
P7, M4	Refining Processes for Ferrous and Non-ferrous Metals	Chemist working for a company investigating the purity of ferrous and non-ferrous metals.	Case study or report on industrial visit or visiting speaker.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following unit titles in the Engineering suite:

Level 1	Level 2	Level 3
		Mechanical and Thermal Treatment of Metals
		Structure and Properties of Metals
		Industrial Alloys
		Metallurgical Techniques
		Liquid Metal Casting Processes

Essential resources

Learners will need access to samples of metallic ores and a range of product data (eg comminution machines' input/output size range).

Employer engagement and vocational contexts

There are a range of organisations that may be able help centres engage and involve local employers in the delivery of this unit, for example:

- Work Experience/Workplace learning frameworks – Centre for Education and Industry (CEI, University of Warwick) – www.warwick.ac.uk/wie/cei
- Learning and Skills Network – www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk
- National Education and Business Partnership Network – www.nebpn.org
- Local, regional Business links – www.businesslink.gov.uk
- Work-based learning guidance – www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Higgins R – *Materials for Engineers and Technicians* (Newnes, 2006) ISBN 0750668504

Moore J J – *Chemical Metallurgy* (Butterworth-Heinemann, 1993) ISBN 0750616466

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are ...
Independent enquirers	identifying questions to answer and problems to resolve relating to extraction and refining reactions analysing and evaluating information, judging its relevance and value in relation to extraction and refining of metals.

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are ...
Creative thinkers	generating ideas and exploring possibilities relating to the extraction and refining of metals
Reflective learners	setting goals with success criteria for their development and work
Self-managers	organising time and resources, prioritising actions.

Functional Skills – Level 2

Skill	When learners are ...
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	describing and explaining ore preparation and metals refining processes
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	investigating and researching metals extraction and refining processes
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing and explaining ore preparation and metals refining processes.