City & Guilds Level 2 Diploma in Process Technology

(0610-20/21/22)

Version 2.5 (September 2024)

Qualification Handbook

Qualification at a glance

Subject area	Manufacturing technologies
City & Guilds number	0610-20, 0610-21, 0610-22
Age group approved	16-18, 19+
Entry requirements	n/a
Assessment	Online Multiple Choice, Short-Answer, Assignment, Multiple Choice, Centre Devised
Grading	Pass/Fail
Approvals	Full Approval
Support materials	Assessment pack, assignment version, centre devised guidance
Registration and certification	For last dates see the online catalogue/Walled Garden

Title and level	City & Guilds qualification number	Regulatory reference number	GLH	TQT
City & Guilds Level 2 Diploma in Process Technology (Chemical Processes)	0610-20	600/0820/9	400	540
City & Guilds Level 2 Diploma in Process Technology (Petroleum Operations)	0610-21	600/0820/9	400	540
City & Guilds Level 2 Diploma in Process Technology (Metal Production)	0610-22	600/0820/9	400	540

Version and date	Change detail	Section
1.1 March 2012	QAN	Qualification at a glance
2.0 Sept 2012	Amend RoC	Structure
2.1 July 2016	Tutor guidance on use of calculators in online tests	Assessment
2.2 March 2017	Centre devised guidance	Assessment
2.4 August 2017	Added TQT details	2.4 August 2017
2.5 September 2024	Handbook reviewed. Quality assurance and access statements, test conditions and credit values updated.	Throughout

Contents

Introduction

This document tells you what you need to do to deliver these qualifications:

Area	Description
Who are the qualifications for?	These qualifications are aimed at candidates who • are following Modern Apprenticeship programmes • require evidence towards the underpinning knowledge of an N/SVQ • seeking a technical certificate • wish for career progression within the Process Technology industry Without evidence of formal qualifications, candidates must be able to demonstrate prior adequate knowledge and experience necessary to complete the course.
What do the qualifications cover?	These qualifications are designed to contribute towards the knowledge and understanding for the N/SVQs in Process Technology Level 2, while containing additional skills and knowledge which go beyond the scope of the National Occupational Standards. These awards can be used as a technical certificate within a modern apprenticeship scheme
What opportunities for progression are there?	Career progression within the Process Technology industry

Area	Description
Who did we develop the qualification with?	N/A
Is it part of an apprenticeship framework or initiative?	These diplomas can be used as a technical certificate within a modern apprenticeship scheme.

Structure

To achieve the City & Guilds Level 2 Diploma in Process Technology (Chemical Processes), learners must achieve: a minimum total of 54 credits. This is made up of 24 credits from the Core Mandatory Group, plus 24 credits from the Pathway Mandatory Group, plus a minimum of 6 credits from the Optional Group.

City & Guilds unit number	Unit title	Credit Value
Core Mandatory units:		
Learners must achieve all **4** core mandatory units.		
201	Fundamentals of process science	6
202	Calculations in process industries	6
203	Health, safety and environmental issues in process industries	6
204	Fundamentals of communications and information technology in process industries	6
Pathway Mandatory:		
Learners must achieve all **2** pathway mandatory units.		
205	Fundamentals of process chemistry	12

City & Guilds unit number	Unit title	Credit Value
206	Process plant and process plant services in process industries	12
Optional units:		
Learners must achieve **2** units from the optional units.		
207	Processing solids in process industries	6
208	Processing fluids in process industries	6
209	Principles of laboratory analysis	6
210	Fundamentals of special processes in process industries	6
211	Instrumentation, measurement and control in process industries	6

To achieve the City & Guilds Level 2 Diploma in Process Technology (Petroleum Operations) learners must obtain a minimum total of 54 credits. This is made up of 24 credits from the Core Mandatory Group, plus 24 credits from the Pathway Mandatory Group, plus a minimum of 6 credits from the Optional Group.

City & Guilds unit number	Unit title	Credit Value
Core Mandatory units:		
Learners must achieve all **4** core mandatory units.		
201	Fundamentals of process science	6
202	Calculations in process industries	6
203	Health, safety and environmental issues in process industries	6
204	Fundamentals of communications and information technology in process industries	6
Pathway Mandatory:		
Learners must achieve all **2** pathway mandatory units.		

City & Guilds unit number	Unit title	Credit Value
206	Process plant and process plant services in process industries	12
223	Chemistry for Petroleum Operations	6
224	Fundamentals of petroleum technology	6
Optional units:		
Learners must achieve **2** units from the optional units.		
208	Processing fluids in process industries	6
209	Principles of laboratory analysis	6
210	Fundamentals of special processes in process industries	6
211	Instrumentation, measurement and control in process industries	6

To achieve the City & Guilds Level 2 Diploma in Process Technology (Metal Production) learners must obtain a minimum total of 54 credits. This is made up of 24 credits from the Core Mandatory Group, plus 6 credits from the Pathway Mandatory Group, plus a minimum of 24 credits from the Optional Group.

City & Guilds unit number	Unit title	Credit Value
Core Mandatory units:		
Learners must achieve all **4** core mandatory units.		
201	Fundamentals of process science	6
202	Calculations in process industries	6
203	Health, safety and environmental issues in process industries	6
204	Fundamentals of communications and information technology in process industries	6

City & Guilds unit number	Unit title	Credit Value
Pathway Mandatory:		
Learners must achieve **1** pathway mandatory unit.		
212	Fundamentals of processing metals in process industries	6
Optional units:		
Learners must achieve **4** units (or Unit 206 + 2 other units) from the optional units.		
r206	Process plant and process plant services in process industries	12
211	Instrumentation, measurement and control in process industries	6
215	Fundamentals of primary working in the steel industry	6
219	Fundamentals of metallurgy of iron and steel production	6
222	Non-ferrous metal and alloys	6

Total Qualification Time (TQT)

Total Qualification Time (TQT) is the number of notional hours which represents an estimate of the total amount of time that could reasonably be expected for a learner to demonstrate the achievement of the level of attainment necessary for the award of a qualification.

TQT comprises of the following two elements:

1) the number of hours that an awarding organisation has assigned to a qualification for guided learning
2) an estimate of the number of hours a learner will reasonably be likely to spend in preparation, study or any other form of participation in education or training, including assessment, which takes place as directed by – but, unlike guided learning, not under the immediate guidance or supervision of – a lecturer, supervisor, tutor or other appropriate provider of education or training.

Title and level	GLH	TQT
City & Guilds Level 2 Diploma in Process Technology	400	540

Centre requirements

Approval

Full approval

To offer these qualifications, new centres will need to gain both centre and qualification approval. Please refer to the document **Centre Approval Process: Quality Assurance Standards** for further information.

Centre staff should familiarise themselves with the structure, content and assessment requirements of the qualification before designing a course programme.

Resource requirements

Centre staffing

Staff delivering these qualifications must be able to demonstrate that they meet the following occupational expertise requirements. They should:

- be occupationally competent or technically knowledgeable in the area(s) for which they are delivering training and/or have experience of providing training (this knowledge must be to the same level as the training being delivered)
- have recent relevant experience in the specific area they will be assessing
- have credible experience of providing training.

Continuing professional development (CPD)

Centres are expected to support their staff in ensuring that their knowledge remains current of the occupational area and of best practice in delivery, mentoring, training, assessment and quality assurance, and that it takes account of any national or legislative developments.

Quality assurance

Approved centres must have effective quality assurance systems to ensure optimum delivery and assessment of qualifications. Quality assurance includes initial centre approval, qualification approval and the centre's own internal procedures for monitoring quality. Centres are responsible for internal quality assurance and City & Guilds is responsible for external quality assurance. All external quality assurance processes reflect the minimum requirements for verified and moderated assessments, as detailed in the Centre Assessment Standards Scrutiny (CASS), section H2 of Ofqual's General Conditions. For more information on both CASS and City and Guilds Quality Assurance processes visit: the What is CASS? and Quality Assurance Standards documents on the City & Guilds website.

Standards and rigorous quality assurance are maintained by the use of:

- Internal quality assurance
- City & Guilds external quality assurance.

In order to carry out the quality assurance role, Internal Quality Assurers must

- have appropriate teaching and vocational knowledge and expertise

- have experience in quality management/internal quality assurance
- hold or be working towards an appropriate teaching/training/assessing qualification
- be familiar with the occupation and technical content covered within the qualification.

External quality assurance for the qualification will be provided by City & Guilds EQA process. EQAs are appointed by City & Guilds to approve centres, and to monitor the assessment and internal quality assurance carried out by centres. External quality assurance is carried out to ensure that assessment is valid and reliable, and that there is good assessment practice in centres.

The role of the EQA is to:

- provide advice and support to centre staff
- ensure the quality and consistency in the setting of assessments and marking instruction within and between centres by the use of systematic sampling
- ensure the quality and consistency of assessments and marking/grading within and between centres by the use of systematic sampling
- provide feedback to centres and to City & Guilds.

Learner entry requirements

City & Guilds does not set entry requirements for these qualifications. However, centres must ensure that candidates have the potential and opportunity to gain the qualification successfully.

Age restrictions

These qualifications are approved for learners aged 16 or above.

Access arrangements and reasonable adjustments

City & Guilds has considered the design of these qualifications and their assessments in order to best support accessibility and inclusion for all learners. We understand however that individuals have diverse learning needs and may require reasonable adjustments to fully participate. Reasonable adjustments, such as additional time or alternative formats, may be provided to accommodate learners with disabilities and support fair access to assessment.

Access arrangements are adjustments that allow candidates with disabilities, special educational needs, and temporary injuries to access the assessment and demonstrate their skills and knowledge without changing the demands of the assessment. These arrangements must be made before assessment takes place.

Equality legislation requires City & Guilds to make reasonable adjustments where a disabled person would be at a substantial disadvantage in undertaking an assessment.

It is the responsibility of the centre to ensure at the start of a programme of learning that candidates will be able to access the requirements of the qualification.

Please refer to the Joint Council for Qualifications (JCQ) access arrangements and reasonable adjustments and Access arrangements - when and how applications need to be made to City & Guilds for more information. Both are available on the City & Guilds website.

Delivering the qualification

Initial assessment and induction

An initial assessment of each learner should be made before the start of their programme to identify:

- if the learner has any specific training needs
- support and guidance they may need when working towards their qualification
- any units they have already completed or credit they have accumulated which is relevant to the qualification
- the appropriate type and level of qualification.

We recommend that centres provide an induction programme so the learner fully understands the requirements of the qualification, their responsibilities as a learner and the responsibilities of the centre. This information can be recorded on a learning contract.

Inclusion and diversity

City & Guilds is committed to improving inclusion and diversity within the way we work and how we deliver our purpose which is to help people and organisations develop the skills they need for growth.

More information and guidance to support centres in supporting inclusion and diversity through the delivery of City & Guilds qualifications can be found here:

Inclusion and diversity | City & Guilds (cityandguilds.com)

Sustainability

City & Guilds are committed to net zero. Our ambition is to reduce our carbon emissions by at least 50% before 2030 and develop environmentally responsible operations to achieve net zero by 2040 or sooner if we can. City & Guilds is committed to supporting qualifications that support our customers to consider sustainability and their environmental footprint.

More information and guidance to support centres in developing sustainable practices through the delivery of City & Guilds qualifications can be found here:

Our Pathway to Net Zero | City & Guilds (cityandguilds.com)

Centres should consider their own carbon footprint when delivering this qualification and consider reasonable and practical ways of delivering this qualification with sustainability in mind. This could include:

- reviewing purchasing and procurement processes (such as buying in bulk to reduce the amount of travel time and energy, considering and investing in the use of components that can be reused, instead of the use of disposable or single use consumables)

- reusing components wherever possible
- waste procedures (ensuring that waste is minimised, recycling of components is in place wherever possible)
- minimising water use and considering options for reuse/salvage as part of plumbing activities wherever possible.

Support materials

The following resources are available these qualifications:

Description	How to access
Centre devised guidance	**www.cityandguilds.com**
Assessment pack	**www.cityandguilds.com**
Assignment version	**www.cityandguilds.com**

Assessment

Assessment of the qualifications

This qualification is assessed by a combination of online multiple choice tests marked by City & Guilds, and multiple choice tests, a short answer test, an assignment, and centre devised assessments marked by the centre. These assessments cover practical skills and underpinning knowledge. The table below provides details on the assessment methods for each unit.

Assessment types			
Unit	**Title**	**Assessment method**	**Where to obtain assessment materials**
201	Fundamentals of process science	Online multiple choice	**www.cityandguilds.com**
202	Calculations in process industries	Online multiple choice	**www.cityandguilds.com**
203	Health, safety and environmental issues in process industries	Short answer	**www.cityandguilds.com**
204	Fundamentals of Communications and information technology in process industries	Assignment	**www.cityandguilds.com**
205	Fundamentals of process chemistry	Multiple choice	**www.cityandguilds.com**
206	Process plant and process plant services in process industries	Multiple choice	**www.cityandguilds.com**
207	Processing solids in process industries	Multiple choice	**www.cityandguilds.com**

Assessment types			
208	Processing fluids in process industries	Multiple choice	**www.cityandguilds.com**
209	Principles of laboratory analysis	Centre devised assignment	**www.cityandguilds.com**
210	Fundamentals of Special processes in process industries	Centre devised assignment	**www.cityandguilds.com**
211	Instrumentation, measurement and control in process industries	Multiple choice	**www.cityandguilds.com**
212	Fundamentals of Processing metals in process industries	Multiple choice	**www.cityandguilds.com**
215	Fundamentals of Primary working in the steel industry	Centre devised assignment	**www.cityandguilds.com**
219	Fundamentals of Metallurgy of iron and steel production	Centre devised assignment	**www.cityandguilds.com**
222	Non-ferrous metals and alloys	Centre devised assignment	**www.cityandguilds.com**
223	Chemistry for petroleum operations	Multiple choice	**www.cityandguilds.com**
224	Fundamentals of petroleum technology	Multiple choice	**www.cityandguilds.com**

Assessment strategy

City & Guilds has written the following assessments to use with these qualifications:

- evolve multiple choice tests to be delivered on-screen (201, 202).
- multiple choice tests that can be downloaded from the City & Guilds website (205, 206, 207, 208, 211, 223, 224)
- a short answer test that can be downloaded from the City & Guilds website (203)
- an assignment that can be downloaded from the City & Guilds website (204).

Evolve multiple choice tests are externally set, externally marked exams, scheduled and delivered by the centre under invigilated conditions.

Live assessments downloaded from the City & Guilds website, ie multiple choice tests, short answer test and assignment, are set by City & Guilds and administered by the centre when the candidate is ready. These assessments should be delivered by the centre under supervised conditions.

Assessments are marked by the centre using the marking guide provided in the relevant assessment materials which are available to download from www.cityandguilds.com. All assessment materials must be held securely by centres and not made available to candidates.

Units 209, 210, 215, 219 and 222 require centre-based assessment. For these units, City & Guilds has provided separate guidance for writers to be read in conjunction with the City & Guilds document, entitled Developing centre devised assessments (GM1) Guidance for centre based assessment writers (see section below).

Please find the document **'0610 Centre devised guidance'** on the City & Guilds qualification page for 0610.

All internally marked assessments are subject to internal and external verification.

Centre set and marked assessments

City & Guilds has provided separate guidance for writers of centre-based assessments which are available to download from www.cityandguilds.com and should be read in conjunction with this document.

All internally set and marked assessments are subject to internal and external verification.

Recognition of prior learning (RPL)

Recognition of prior learning means using a person's previous experience or qualifications which have already been achieved to contribute to a new qualification.

RPL is not allowed for this qualification.

Conditions of Use (Assessment Materials)

City & Guilds Assessment Materials are protected by copyright and are supplied only to Approved Centres for use solely for the purpose of summative assessment.

The following conditions, which apply to City & Guilds Assessment Materials, are additional to:

- the Standard Copying Conditions which can be found at Copyright | City & Guilds (cityandguilds.com); and
- (where the City & Guilds Assessment Materials are dated examinations), the JCQ Instructions for Conducting Examinations

The Approved Centre must:

- only use the City & Guilds Assessment Materials in formal, summative assessment leading to the award of credit/a qualification and not for any other purpose (including, but not restricted to, teaching, revision, as practice assessments or for commercial purposes)
- handle and store securely the City & Guilds Assessment Materials in accordance with the following conditions:
    - City & Guilds Assessment Material must be accessible to candidates only during formal assessment as governed by the assessment conditions specified for the qualification.
    - Candidate portfolios may contain assessment results referenced to the assessment taken but should not contain the City & Guilds Assessment Materials (such as assessment tasks or questions or candidates' marked scripts if the tests may be reused (unless otherwise stated)).
    - The Approved Centre must not make public in any format the contents of any City & Guilds Assessment Materials either in part or in full.
    - City & Guilds Assessment Materials must be securely handled and under no circumstances shared with third party organisations or individuals.
- seek permission from City & Guilds via their EQA if they want to convert City & Guilds Assessment Material for storage, retrieval and delivery in electronic form (ie using some form of e-assessment or e-learning system)
- provide access, on request, to City & Guilds to the system(s) on which the Assessment Materials appear.

Invigilation and supervision requirements

The evolve online tests (201, 202) are formal summative assessments and should be treated as such. They are formal examinations that are closed book and must be invigilated. Non-programmable calculators are permitted. Tests should be scheduled at an appropriate time, and only when candidates are ready to demonstrate the knowledge in the units.

The live downloadable assessments (multiple choice tests, short answer test and assignment) are formal summative assessment and must be delivered in supervised conditions. They are closed book unless otherwise specified in the assessment documents. Assessments should be scheduled at an appropriate time, and only when candidates are ready to demonstrate the knowledge and skills in the units.

Candidates should on no account be allowed to take question papers or assessment materials away with them, and copies of assignments, question papers and marking guides should be kept securely by the centre at all times.

Marking, submission of results and certification

Tutors/assessors should mark the assessments using the marking guides and pass marks provided in the relevant assessment materials.

All assessments are graded pass or fail.

When a candidate has been successful, the result should be submitted to City & Guilds via the Walled Garden.

Retention of evidence

In order to fully support candidates, centres are required to retain copies of candidates' assessment records for three years after certification. This may be in electronic format.

Test specifications

The way the knowledge is covered by each test is laid out in the tables below:

.

Permitted materials: Please note that the use of a non-programmable calculator is permitted for the completion of the online multiple-choice tests.

Graded: Pass/Fail

Assessment conditions: Invigilated

Test 1: 0610-201	**Unit 201 Fundamentals of process science Duration: 75 minutes**		
Unit	**Outcome**	**Number of questions**	**Percentage %**
201	1 know the composition and properties of matter	14	27
	2 understand the concepts of force, energy, work and power	18	35
	3 understand the thermal properties of solids, liquids and gases	13	25
	4 know the nature and application of electricity	7	13
	Total	52	100

Permitted materials: Please note that the use of a non-programmable calculator is permitted for the completion of the online multiple choice.

Graded: Pass/Fail

Assessment conditions: Invigilated

Test 2: 0610-202	**Unit 202 Calculations in process industries Duration: 30 minutes**		
Unit	**Outcome**	**Number of questions**	**Percentage %**
201	1 know how to perform simple arithmetic operations	6	27
	2 know how to solve problems involving simple formulae	7	32
	3 know how to interpret graphical data	9	41
	Total	**22**	**100**

Units

Structure of the units

These units each have the following:

- City & Guilds reference number
- title
- level
- guided learning hours (GLH)
- credit value
- unit aim
- assessment type
- learning outcomes, which are comprised of a number of assessment criteria
- range statements
- supporting information
- relationship to NOS/mapping to occupational/apprenticeship standards.

Guidance for delivery of the units

These qualifications comprise/comprises a number of **units**. A unit describes what is expected of a competent person in particular aspects of their job.

Each **unit** is divided into **learning outcomes** which describe in further detail the skills and knowledge that a candidate should possess.

Each **learning outcome** has a set of **assessment criteria** (performance and knowledge and understanding) which specify the desired criteria that must be satisfied before an individual can be said to have performed to the agreed standard.

Range statements define the breadth or scope of a learning outcome and its assessment criteria by setting out the various circumstances in which they are to be applied.

Supporting information provides guidance of the evidence requirement for the unit and specific guidance on delivery and range statements. Centres are advised to review this information carefully before delivering the unit.

Unit 201 Fundamentals of process science

Level:	2
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Assessment type:	Online multiple choice test
Aim:	This unit provides the essential science required for an understanding of the technology used in the process industries.

Learning outcome	**The learner will:**
1. Know the composition and properties of matter	
Assessment criteria	
The learner can: 1.1 describe the three states of matter 1.2 describe the nature of changes in the states of matter 1.3 describe the importance of fixed points, melting point and boiling point 1.4 state the effects of impurities upon the fixed points of substances 1.5 state the effects of changes in pressure upon the fixed points of substances 1.6 describe the terms atom, element, molecule, compound and mixture 1.7 identify the chemical symbols of common elements • aluminium • argon • calcium • carbon • chlorine • helium • hydrogen • iodine • iron • lead • mercury • nitrogen • oxygen • potassium • silicon • sodium • sulphur • tin • uranium • zinc 1.8 describe the structure of atoms	

- electrons
- protons
- neutrons

1.9 state atomic number and relative atomic mass of atoms in relation to atomic structures

1.10 define the terms density and relative density

1.11 perform density and relative density calculations

1.12 define the terms viscosity and viscosity index

1.13 state the SI unit of viscosity

1.14 state the importance of viscosity in relation to the processing and transportation of fluids in industry

Learning outcome	**The learner will:**
2. Understand the concepts of force, energy, work and power	
Assessment criteria	

The learner can:

2.1 identify common forms of energy:

- heat
- electrical
- chemical
- nuclear
- gravitational
- potential
- kinetic

2.2 state the law of conservation of energy

2.3 identify types of energy conversion

2.4 describe energy as the capacity for doing work

2.5 identify the differences between the terms mass and weight

2.6 calculate the work done in moving mass through distances

2.7 calculate the kinetic energy of mass moving at a constant velocity

2.8 calculate the potential energy of mass at heights

2.9 calculate problems involving energies

2.10 define power as energy per unit time

2.11 calculate the power generated in performing work

2.12 define the relationship between absolute, gauge and atmospheric pressure

2.13 calculate pressure due to singular liquid columns

2.14 solve problems involving volumetric flow rates

2.15 describe the importance of laminar and turbulent flows

2.16 use SI unit and quantity symbols

- mass
- force
- energy
- power
- velocity
- acceleration
- pressure
- volumetric flowrate

2.17 use alternative metric units
- litres
- bars
- tonnes

2.18 apply the multiples and sub-multiples of units
- micro
- milli
- centi
- deci
- kilo
- mega.

Learning outcome	**The learner will:**
3. Understand the thermal properties of solids, liquids and gases	
Assessment criteria	

The learner can:

3.1 identify the differences between heat and temperature

3.2 define the terms sensible heat and latent heat

3.3 calculate SI units
- heat
- temperature
- specific latent heat
- specific heat capacity

3.4 convert Celsius and absolute (Kelvin) temperatures

3.5 calculate the heat transferred to or from bodies
- Q = mass x specific heat capacity x temperature change

3.6 use coefficient of expansions to solve problems relating to linear expansions of materials

3.7 describe how heat energy is transferred
- conduction
- convection
- radiation.

3.8 identify the differences between heat conductors and insulators

3.9 state the effects of surface colour on the reflection and absorption of heat

3.10 perform calculations using Boyle's law, Charles' law and the combined gas equation

3.11 define changes of state
- evaporation
- condensation
- sublimation.

3.12 define the terms humidity, relative humidity and dew point

3.13 state the temperature dependence of humidity, relative humidity and dew point

Learning outcome	**The learner will:**
4. Know the nature and application of electricity	

Assessment criteria
The learner can: 4.1 describe electrical conductance in terms of the flow of electrons in solids • conductor • insulator 4.2 describe applications of the conversion of electrical energy • electromagnetic • electrochemical • thermoelectric • piezoelectric • photoelectric • electrostatic 4.3 apply the equations V = IR, P = VI and Q = It using the correct SI quantity and unit symbols 4.4 calculate the total resistance of two resistors in series or parallel 4.5 identify differences between direct and alternating current 4.6 state the purpose of rectifiers, transformers and fuses 4.7 describe precautions necessary to minimise hazards associated with static electricity

Unit 202 Calculations in process industries

Level:	2
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Assessment type:	Online multiple choice test
Aim:	This core unit is designed to give candidates the arithmetic skills required to complete the Level 2 progression award in Process Plant and provide the basis for progression to the Level 3 award

Learning outcome	**The learner will:**
1. Know how to perform simple arithmetic operations	
Assessment criteria	
The learner can: 1.1 identify the numerator and denominator of fractions 1.2 convert between fractions and decimals 1.3 calculate the averages of sets of numbers 1.4 use different types of numbers to perform calculations • percentages • ratio • proportion • fractions • decimals 1.5 evaluate expressions using calculators • addition • subtraction • multiplication • division • squares • square roots. 1.6 identify the order of arithmetic operations	

Learning outcome	The learner will:
2. Know how to solve problems involving simple formulae	
Assessment criteria	
The learner can: 2.1 use algebraic symbols to represent numeric quantities 2.2 perform equations from instructions 2.3 evaluate formulae from data 2.4 perform transposition of formulae 2.5 perform transposition of formulae involving brackets 2.6 use formulae for areas to solve problems • rectangles • triangles • circles • compound 2.7 use formulae for volumes to solve problems • cuboids • cylinders • spheres • compound	

Learning outcome	The learner will:
3. Know how to interpret graphical data	
Assessment criteria	
The learner can: 3.1 calculate relative frequency percentages. 3.2 classify data on pie charts. 3.3 construct tally charts from raw data. 3.4 classify data into class intervals. 3.5 use histograms to represent data 3.6 construct linear graphs from data. 3.7 estimate gradients of straight-line graphs. 3.8 illustrate best-fit straight lines from experimental data 3.9 apply the operations of interpolation and extrapolation to data	

Unit 203 Health, safety and environmental issues in process industries

Level:	2
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Assessment type:	Short Answer
Aim:	High standards of health, safety and environmental care are essential to the success of an organisation. Both individuals (employees) and organisations (employers) benefit from effective and efficient health, safety and environmental management systems. This unit will provide candidates with an awareness of health, safety and environmental issues and some of the important legislation relating to them. The unit also covers the need for effective communication and accurate record keeping.

Learning outcome	**The learner will:**
1. Know the importance of personal health, safety and environmental issues in the workplace and the regulations relating to these matters	
Assessment criteria	
The learner can: 1.1 state the prime objectives of the Health and Safety at Work Act 1974. 1.2 list general employee duties under the Health and Safety at Work Act 1974. 1.3 identify workplace regulations • environmental protection • use of machinery • hazardous substances • electrical equipment • manual handling • portable tools and equipment • lifting equipment • working at height. 1.4 identify organisational procedures applicable to workplace activities. 1.5 state responsibilities in monitoring and maintaining health and safety for individuals 1.6 describe the importance of accident prevention in the workplace. 1.7 describe active and pro-active health and safety management systems in the workplace.	

Learning outcome	**The learner will:**

2. Know on the factors that contribute to the maintenance of standards of health and safety within an organisation

Assessment criteria

The learner can:

2.1 define the terms hazard and risk
2.2 describe importance of hazards and risks in reducing accidents within industrial organisations
2.3 state where hazards might exist in industrial organisations
2.4 state how to assess hazards in industrial organisations
2.5 state the hierarchy of control measures to minimise risks.
2.6 describe how to conduct risk assessments
2.7 state the requirements for the use and storage of equipment and materials.
2.8 state what actions individuals should take in emergency situations
- fire
- toxic gas release
- environmentally harmful spillage
- accident involving fellow employees.

2.9 describe what is meant by Permit To Work systems
2.10 outline why the regulations and procedures controlling Permit to Work systems should not be breached.
2.11 state the differences between hazardous and non-hazardous materials and waste.
2.12 identify types of Personal Protective Equipment (PPE)
2.13 describe manual handling techniques.
2.14 describe the necessity of establishing and maintaining good working relationships with others
2.15 describe how to deal with incidents affecting the health of others
- not to exceeding ones own limitations

2.16 describe the types of fire fighting equipment in the workplace
- fire hose
- portable fire extinguishers
  - carbon dioxide (CO2)
  - foam
  - water
  - dry powder
- fire blankets
- sprinkler systems.

2.17 describe the uses and limitations of fire fighting equipment

Learning outcome	The learner will:
3. Know the importance of accurate communications and records with regard to health, safety and welfare in the workplace	
Assessment criteria	
The learner can: 3.1 state how to communicate clearly and effectively 3.2 distinguish the degrees of urgency. 3.3 state the importance of accuracy when dealing with messages. 3.4 describe the importance of accuracy and legibility in relation to health and safety records. 3.5 describe the importance of accident reporting systems. 3.6 state the importance of respecting and maintaining confidentiality. 3.7 state the purpose of health and safety records and procedures.	

Unit 204 Fundamentals of Communications and information technology in process industries

Level:	2
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Assessment type:	Assignment
Aim:	This core unit is designed to develop candidates' workplace communication skills and enable them to utilise information technology to develop and produce technical documentation. The unit also provides the basis for progression to the Level 3 award in Communications and Information Technology.

Learning outcome	**The learner will:**
1. Be able to interpret and summarise information from technical documentation	
Assessment criteria	
The learner can: 1.1 communicate technically relevant topics. 1.2 identify key points in documents 1.3 identify methods of communicating written information • memorandum • email • letter • technical report. 1.4 interpret information from documents • charts • graphs • diagrams. 1.5 create accurate documents • spelling • punctuation • grammar 1.6 use language in documents that are appropriate to their context and intended audience. 1.7 create logically structured documents 1.8 create documents maintaining relevance of information.	

Learning outcome	**The learner will:**

2. Be able to use standard features of a word-processing package to enhance the appearance and legibility of technical documentation
Assessment criteria
The learner can: 2.1 select fonts and font sizes • body text • headings • sub-headings 2.2 use tabulation and justification to align texts. 2.3 use bullet points and numbering. 2.4 use text boxes and tables to position information. 2.5 apply software spelling and grammar checks to texts.

Learning outcome	**The learner will:**
3. Be able to record, organise and develop information using a spreadsheet package	
Assessment criteria	
The learner can: 3.1 apply row and column headings. 3.2 select formats of cells of spreadsheets. 3.3 apply cell protection. 3.4 use copy and paste functions for cells. 3.5 use link cells functions between worksheets. 3.6 use the mathematical operators in formulae. • + • – • x • ÷ 3.7 illustrate formulae using cell references. 3.8 use add (or 'sum') function for numbers in cells. 3.9 use graphical forms to represent data sets • pie chart • line graph • bar chart.	

Unit 205 Fundamentals of process chemistry

Level:	2
GLH:	It is recommended that 80 hours should be allocated for this unit, although patterns of delivery are likely to vary.
Assessment type:	Multiple Choice
Aim:	This unit provides the essential knowledge required for an understanding of the chemical principles involved in manufacturing processes carried out in the chemical industries.

Learning outcome	**The learner will:**
1. Know the structure of atoms, elements, compounds and chemical symbols that represent them	
Assessment criteria	
The learner can: 1.1 identify differences between particles in relation to relative mass and charge. • electrons • protons • neutrons 1.2 describe structures of atoms in terms of sub-atomic particles. 1.3 identify differences between relative atomic mass and atomic number. 1.4 identify the chemical symbols for common elements. 1.5 identify the differences between elements, compounds and mixtures. 1.6 define the term ion . 1.7 identify differences between ionic and covalent bonding in terms of electron transfer and electron sharing. 1.8 identify the differences between properties of ionic and covalently bonded compounds. 1.9 define the term valency. 1.10 apply the concepts of valency to chemical formulae 1.11 identify the formulae of molecules and ions. 1.12 identify chemical formulae of compounds • oxides • hydroxides • sulphates • chlorides • nitrates • carbonates • sulphides • hydrogen carbonates. 1.13 define the term formula (molar) mass 1.14 calculate formula masses.	

Learning outcome	The learner will:
2. Know fundamental scientific laws to the construction and use of balanced chemical equations	
Assessment criteria	
The learner can: 2.1 identify the differences between chemical and physical changes. 2.2 define the term chemical reaction. 2.3 describe the law of conservation of matter and the law of definite proportion. 2.4 define the term stoichiometric quantity. 2.5 construct balanced chemical equations to represent chemical reactions. 2.6 calculate the masses of reactants and products from balanced chemical equations. 2.7 describe the importance of Avogadro's law. 2.8 identify differences between exothermic and endothermic reactions. 2.9 state the function of catalysts. 2.10 identify the differences between chemical compounds • acid • alkali • base • salt 2.11 identify chemical formulae of common chemical compounds • acid • alkali • base • salt 2.12 construct balanced chemical equations for reactions involving acids • metals • alkalis • bases • carbonates • hydrogen carbonates. 2.13 describe the relationship between pH and acidity/alkalinity. 2.14 define the terms neutralisation and neutral solution. 2.15 state the function of common indicators.	

Learning outcome	The learner will:
3. Understand solutions, solubility and solubility curves	
Assessment criteria	
The learner can:	

3.1 define terms associated with solutions and solubility
- solute
- solvent
- solution
- suspension
- precipitate
- unsaturated solution
- saturated solution
- supersaturated solution.

3.2 define the term solubility and the units used.

3.3 identify factors which affect rates at which solute dissolves in solvents
- particle size
- temperature of solvent
- degree of agitation.

3.4 explain how solubility of solutes varies with temperature of solvents

3.5 interpret solubility curves
- unsaturated solutions
- saturated solutions
- supersaturated solutions.

3.6 calculate concentration of solutions
- molar solutions
- moles per litre
- as a percentage of the solvent (w/w)
- as a percentage of the solution (w/v).

3.7 define the terms crystallisation and water of crystallisation.

3.8 explain conditions under which crystallisation occurs.

3.9 identify substances that cause temporary and permanent hardness in water.

3.10 define differences between efflorescence, deliquescence and anhydrous.

Learning outcome	**The learner will:**
4. Know the application and importance of electrochemical principles	
Assessment criteria	
The learner can: 4.1 describe electrochemical series (reactivity series). 4.2 define the terms anode, cathode and electrolyte. 4.3 describe how simple cells can be constructed. 4.4 identify primary and secondary cells. 4.5 define the terms electrolysis, anion and cation. 4.6 describe common uses of electrolysis • molten sodium chloride • brine • acidified water.	

Learning outcome	**The learner will:**
5. Know the structure, classification and properties of carbon compounds	

Assessment criteria
The learner can: 5.1 identify the differences between inorganic and organic chemicals. 5.2 describe the structure of hydrocarbon compounds • straight chain • branched chain • ring compounds. 5.3 define the term homologous series. 5.4 state the general formulae for alkanes, akenes and alkynes. 5.5 identify the differences between saturated and unsaturated hydrocarbons. 5.6 identify the differences between molecular and structural formulae • first six alkanes • first three alkenes • ethyne. 5.7 define the term alkyl group 5.8 state common types of alkyl group 5.9 define the term functional group. 5.10 describe the classification of organic compounds in terms of their functional groups • alcohols • acids • esters • halides • amines. 5.11 identify general formulae for functional groups. 5.12 identify the differences between aliphatic and aromatic compounds. 5.13 identify aromatic compounds • benzene • methyl benzene (toluene) • dimethylbenzene (xylene). 5.14 identify systematic and common names for common organic compounds.

Unit 206 Process plant and process plant services in process industries

Level:	2
GLH:	It is recommended that 80 hours should be allocated for this unit, although patterns of delivery are likely to vary
Assessment type:	Multiple Choice
Aim:	This unit provides the essential knowledge required for an understanding of the production, distribution and use of essential plant services in the process industries.

Learning outcome	**The learner will:**
1. Know the construction and operation of pipes and equipment	
Assessment criteria	
The learner can: 1.1 identify materials to makes pipes 1.2 state applications of materials • ferrous – carbon, alloy and stainless steels • non-ferrous – copper, nickel, aluminium and their alloys • non-metals – glass, plastics and rubber. 1.3 identify materials used to protect pipework • external protection – painting, bituminous coatings • internal protection – rubber, cement, resin and metal linings. 1.4 identify methods of joining pipes • welding, brazing • flanges and seals, unions and couplings. 1.5 identify common pipe fittings • elbows • T-pieces • reducers. 1.6 identify BS symbols for pipework systems • water (all, cooling, drinking, hydro power, fire extinguisher) • compressed air • steam • drainage • North Sea gas • oil (all, diesel fuel oil, lubrication oil) • acids and alkalis. 1.7 state the principles of construction and operation of pumps and fans • persuasive – centrifugal pumps • positive displacement – reciprocating, diaphragm, rotary and gear pumps	

- other types – mono, peristaltic, rotary and vacuum pumps
- fans – centrifugal and axial.

1.8 identify applications of pumps and fans.

1.9 identify advantages and disadvantages of pumps and fans

1.10 identify pumps and fans for appropriate duties.

1.11 describe principles of construction and operation of valves

- gate, ball, plug, globe, butterfly and needle valves
- pressure reducing, pressure relief and non-return valves.

1.12 identify applications of valve types.

1.13 identify advantages and disadvantages of valve types.

1.14 describe the precautions necessary to minimise the hazards associated with use of pumps and valves

- static electricity – earthing
- cavitation
- valves associated with positive displacement pumps
- hazards due to high pressure – bursting discs.

Learning outcome	**The learner will:**
2. Know the construction, operating principles and uses of heat exchange equipment	
Assessment criteria	

The learner can:

2.1 identify uses of heat exchange equipment

- heating and cooling
- condensation and boiling.

2.2 describe construction, operation and characteristics of heat exchangers

- concentric pipe
- jacketed vessels
- heating coils
- single and multi-pass shell and tube types
- plate and frame types
- air fin types.

2.3 describe how mechanical and thermal efficiencies of heat exchangers are maintained

- expansion joints and bellows
- baffles
- fluid turbulence
- insulation

2.4 state common heat exchange media (thermal fluids)

- water
- steam
- air
- oils
- flue gases.

2.5 describe precautions necessary to minimise hazards associated with heat exchange equipment

- hot surfaces
- thermal fluid leaks

- corrosion
- blocked tubes
- toxic and flammable hazards.

Learning outcome	The learner will:
3. Know impurities in raw water and how they can be removed	
Assessment criteria	
The learner can: 3.1 identify sources of water available to industry • reservoirs, rivers • wells • sea water. 3.2 state impurities found in industrial water • water hardness salts • dissolved gases • un-dissolved solids • bacteria, algae. 3.3 identify the need for water treatment • to prevent scale formation in boilers and heat exchange equipment • to produce potable and pathogen-free water. 3.4 describe methods of water treatment • de-ionisation • de-aeration • filtration • pH control • chemical additions 3.5 identify hazards associated with water treatment and supply • high pressure water • pollution.	

Learning outcome	The learner will:
4. Know the production, distribution and uses of steam	
Assessment criteria	
The learner can: 4.1 describe equipment used for production of steam • shell type boilers • water tube boilers. 4.2 identify the differences between types of steam • wet and dry steam • high pressure and low pressure steam • flash steam. 4.3 state uses of steam in process industries • low pressure steam for heating	

- high pressure steam for power
- steam for steam ejectors.

4.4 describe methods of ensuring efficient distribution and use of steam
- steam traps
- lagging
- pipework expansion loops.

4.5 calculate energy required to produce dry steam at 100 °C and 101 kPa pressure
- sensible heat $Q = c \times m \times (T2 - T1)$
- latent heat $Q = m \times l$

4.6 calculate energy given up when dry steam condenses and cools from 100 °C at 101 kPa
- latent heat $Q = m \times l$
- sensible heat $Q = m \times c \times (T2 - T1)$

4.7 describe heat transfer processes within boiler plant
- conduction through tubes
- natural and forced convection in fluids
- radiation from flames and walls.

4.8 describe the precautions necessary to minimise the hazards associated with production and distribution of steam
- scalds and burns
- static electricity

Learning outcome	**The learner will:**
5. Know the production and uses of air, compressed air and vacuum	
Assessment criteria	

The learner can:

5.1 identify the types of air required in process industries
- purified
- compressed
- atmospheric.

5.2 identify the uses of air
- in pneumatic control systems
- power for pneumatic tools
- cleaning lines and vessels.

5.3 describe the construction and operation of equipment used to produce compressed air
- reciprocating compressors
- centrifugal compressors

5.4 describe precautions necessary to minimise hazards associated with the production and supply of compressed air
- high pressure
- dust/grit contamination

5.5 identify the difference between absolute pressure and gauge pressure

5.6 state uses of vacuum in process industries
- processing heat sensitive materials
- removal of dangerous gases/fumes.

5.7 describe methods of producing vacuum
- reciprocating and rotary vane pumps
- steam ejectors.

5.8 state factors affecting efficient production and distribution of vacuum
- use of traps and filters
- corrosion prevention
- leaks from faulty seals and joints.

5.9 describe precautions necessary to minimise hazards associated with production and distribution of vacuum
- implosion
- leaks.

5.10 use the combined gas equation to solve problems relating to the distribution of compressed air and vacuum

Learning outcome	**The learner will:**
6. Know characteristics and uses of a.c. and d.c. electrical supplies	
Assessment criteria	
The learner can: 6.1 state methods of production of a.c. and d.c. electrical supplies • alternators • dynamos, batteries, rectification. 6.2 state the functions of rectifiers and transformers. 6.3 identify the differences between characteristics and uses of a.c. and d.c. • a.c. for heating and power • d.c. for electrolysis and electroplating. 6.4 identify hazards associated with using electricity • electric shock • burns • sparks • static electricity. 6.5 apply equations to electrical energy problems.	

Unit 207 Processing solids in process industries

Level:	2
GLH:	It is recommended that 40 hours should be allocated for this unit, although patterns of delivery are likely to vary.
Assessment type:	Multiple Choice
Aim:	This unit provides the essential knowledge required for an understanding of the techniques used by industry for the processing of solid materials into intermediate and final products.

Learning outcome	**The learner will:**
1. Know the scientific and technological principles associated with processing of solid materials	
Assessment criteria	
The learner can: 1.1 describe principles of pneumatic and fluidised conveying systems. 1.2 state the purposes of industrial size reduction 1.3 identify forces associated with size reduction • shear • compression • impact • attrition 1.4 identify the differences between batch and continuous processing of solid materials. 1.5 describe the principles for separation of solids from liquids by sedimentation, filtration and centrifuging. 1.6 state the factors which affect the rate of separation of solids from liquids by sedimentation, filtration and centrifuging • viscosity, density and temperature of liquid • particle size and mass of solid • nature of filter medium • pressure and gravitational effects. 1.7 describe the principles of solid and liquid extraction. 1.8 state the factors which affect the rate of solid and liquid extraction • particle size • solvent use • solvent temperature • degree of agitation 1.9 describe the principles of drying solids. 1.10 describe the factors which affect the rate and process of drying solids • humidity • vacuum • temperature.	

Learning outcome	The learner will:
2. Know the construction, operation and application of equipment used in processing of solid materials	
Assessment criteria	
The learner can: 2.1 identify methods of storing solid materials • silos, bins, hoppers • bags • pallet systems. 2.2 describe equipment for transferring solid materials • conveyors • elevators • screws • pneumatic systems • fluidised systems. 2.3 identify the differences between crushing and grinding. 2.4 describe principles of construction and operation of size reduction equipment • jaw crushers • gyratory crushers • roll crushers • hammer mills • ball mills • ultra fine grinders 2.5 state factors affecting product size 2.6 state applications of size reduction equipment 2.7 describe sequencing of size reduction in terms of crushing, grinding and classification. 2.8 describe purposes of particle size classification. 2.9 describe methods of size classification for solid materials • shaking sieves • rotary sieves • vibratory sieves. 2.10 describe methods of producing uniformly sized particles • sintering • pelletising • briquetting 2.11 identify the differences between mixing and blending. 2.12 describe construction and operation of equipment used for mixing and blending of solid materials • kneading types: Z blade • planetary mixers • ribbon mixers • pug mixers • tumbler types 2.13 describe applications of equipment used for mixing and blending of solid materials 2.14 describe principles of construction and operation of equipment used for separation of insoluble solids from liquids	

- batch and continuous sedimentation tanks
- bed filters
- Nutsch filters
- plate and frame filters
- rotary vacuum filters
- leaf filters
- edge filters
- batch and continuous centrifugal filters.

2.15 describe applications of equipment used for separation of insoluble solids from liquids

2.16 describe the factors affecting the choice of equipment used for separation of insoluble solids from liquids

2.17 identify types of filter media and filter aids.

2.18 state purposes of solvent extraction of solids (leaching)

- to extract a soluble solid product
- to purify a solid by extraction of soluble impurities.

2.19 describe principles of construction and operation of solid/liquid extraction equipment

- batch mixer settler units
- counter current units.

2.20 describe applications of solid and liquid extraction equipment

2.21 describe principles of construction and operation of equipment used for drying of solids

- tray and tunnel driers
- pneumatic driers
- rotary driers
- spray driers
- vacuum driers
- freeze driers
- drum driers
- fluidised bed driers

2.22 state common applications of equipment used for drying of solids

Learning outcome	**The learner will:**
3. Know health and safety aspects associated with processing solid materials	
Assessment criteria	

The learner can:

3.1 describe precautions to minimise hazards associated with processing solid materials

- moving machinery
- dusts
- pyrophoric materials
- static electricity

3.2 describe the precautions necessary to minimise the hazards associated with sedimentation, filtration and centrifuging

- mechanical
- vacuum and high pressure

3.3 describe the precautions necessary to minimise the hazards associated with solid/liquid extraction

- flammable solvents

- acids and alkalis
- toxic materials

3.4 describe the precautions necessary to minimise the hazards associated with the drying of solids

- hot and cold surfaces
- static electricity
- dust emissions.

Unit 208 Processing fluids in process industries

Level:	2
GLH:	It is recommended that 40 hours should be allocated for this unit, although patterns of delivery are likely to vary.
Assessment type:	Multiple Choice
Aim:	This unit provides the essential knowledge required for an understanding of the techniques used by industry for the processing of solid materials into intermediate and final products.

Learning outcome	**The learner will:**
1. Understand scientific and technological principles associated with the processing of fluids	
Assessment criteria	
The learner can: 1.1 describe changes of state of materials. 1.2 describe effects of pressure changes on boiling points of liquids. 1.3 state principles of mixing and blending of fluids. 1.4 define the terms solution, suspension and emulsion 1.5 state the purposes of liquid and liquid extraction 1.6 describe the principles of liquid and liquid extraction 1.7 describe terms used in liquid and liquid extraction operations • solute • solvent • solution • extract • raffinate 1.8 state the purposes of gas absorption 1.9 describe the principles of gas absorption. 1.10 identify the differences between chemical and physical absorption. 1.11 describe effects of temperature and pressure changes on gas solubility. 1.12 describe the principles used in the separation of liquids by distillation • simple distillation • fractional distillation • steam distillation • vacuum distillation 1.13 describe effects of changes of pressure on distillation processes. 1.14 define terms used in distillation operations • reflux and reflux ratio • condensate and residue • fractions	

- ancillary equipment.

1.15 describe the importance of turbulence in evaporation operations.

1.16 identify the differences between evaporation and boiling.

1.17 describe effects of changes in pressure on boiling point of liquids.

1.18 state the purposes of evaporation operations

- reduce liquor bulk
- produce concentrated products
- produce supersaturated solutions
- ease fluid handling.

1.19 define terms used in crystallisation operations

- unsaturated solutions
- saturated solutions
- supersaturated solutions

1.20 describe principles of crystallisation operations

- cooling
- evaporation
- seeding.

1.21 identify crystallisation processes from solubility curves.

Learning outcome	**The learner will:**
2. Know the construction, operation and application of equipment used in the processing of fluids	
Assessment criteria	

The learner can:

2.1 state methods of storing liquid materials

- drums
- containers
- cylindrical
- rectangular tanks.

2.2 identify methods of storing gases

- cylinders
- gas holders
- tanks and tank farms
- spheres

2.3 describe construction and operation of equipment used for mixing and blending of liquids

- impellers
- propellers
- paddle mixers
- jet mixers

2.4 describe applications of equipment used for mixing and blending of liquids

2.5 describe construction and operation of equipment used for mixing gases

- baffles
- fans.

2.6 describe applications of equipment used for mixing gases
2.7 identify the differences between batch and continuous mixing processes.
2.8 describe construction and operation of liquid and liquid extraction equipment
- batch mixer settler units
- continuous extraction columns and towers.

2.9 describe applications of liquid and liquid extraction equipment
2.10 state desirable properties of solvents used in liquid and liquid extraction processes.
2.11 state solvents used in extraction processes
2.12 describe the importance of solvent recovery.
2.13 describe construction and operation of equipment used for gas absorption operations
- packed columns
- spray towers
- centrifugal scrubbers.

2.14 describe applications of equipment used for gas absorption operations
2.15 describe construction, operation and application of distillation equipment
- stills
- plate columns
- packed columns.

2.16 describe applications of distillation equipment
2.17 state advantages, disadvantages and applications of distillation equipment
2.18 describe construction and operation of equipment used for evaporation operations
- vertical short tube evaporators
- natural and forced convection evaporators
- climbing film long tube evaporators
- forced circulation evaporators (Oslo)
- multiple effect evaporators.

2.19 describe applications of equipment used for evaporation operations
2.20 state advantages and disadvantages of evaporation equipment
2.21 describe construction and operation of crystallisation equipment
- cooling crystallisers
- evaporative crystallisers
- vacuum crystallisers.

2.22 describe applications of crystallisation equipment
2.23 state advantages and disadvantages of crystallisation equipment

Learning outcome	The learner will:
3. Know the health and safety aspects associated with the processing of fluids	
Assessment criteria	

The learner can:

3.1 describe precautions to minimise hazards associated with storage and handling of liquids and gases
- static electricity
- flammable liquids
- gases above and below atmospheric pressure.

3.2 describe precautions to minimise hazards associated with mixing and blending operations
- mechanical
- static electricity
- flammable, explosive, toxic and acidic materials.

3.3 describe precautions to minimise hazards associated with liquid/liquid extraction operations
- flammable materials
- acids and alkalis
- toxic materials

3.4 describe precautions to minimise hazards associated with gas absorption
- toxic materials
- flammable materials
- environmental contamination

3.5 describe precautions to minimise hazards associated with distillation operations
- toxic, flammable and explosive materials
- flooding and channelling
- corrosion
- pressure and vacuum.

3.6 describe precautions to minimise hazards associated with evaporation equipment
- steam
- pressure and vacuum
- solvent vapours.

3.7 describe precautions to minimise hazards associated with crystallisation equipment
- solvent vapours
- steam usage
- tube blockage
- overloading of agitators

Unit 209 Principles of laboratory analysis

Level:	2
GLH:	It is recommended that 40 hours should be allocated for this unit, although patterns of delivery are likely to vary.
Assessment type:	Centre Devised
Aim:	This unit provides the essential principles for an understanding of the procedures involved in the straightforward laboratory analysis needed to maintain quality in the process industries.

Learning outcome	**The learner will:**
1. Know fundamental items of laboratory equipment	
Assessment criteria	
The learner can: 1.1 identify laboratory equipment • beaker • conical flask • pipette • pipette filler • burette • measuring cylinder • clamp • magnetic stirrer • conductivity meter and probe • pH meter and probe • syringe • volumetric flask • rough balance • analytical balance • filter funnel • filter paper 1.2 state uses of laboratory equipment	

Learning outcome	The learner will:
2. Know terms commonly used in chemical analysis	
Assessment criteria	
The learner can: 2.1 define the terms, solvent, solute and solution. 2.2 define the term concentration • moles of substance • volume of solution. 2.3 state the equivalence of the terms, molar, (M), moles per litre, (mol l-1), (mol/l), moles per cubic decimetre, (mol dm-3), (mol/dm3). 2.4 define percentage concentration in terms of volume and mass. 2.5 define the concentration term grams per litre (g l-1). 2.6 state the equivalence of the terms milligrams per litre (mg l-1) and parts per million (ppm). 2.7 calculate concentration from a number of moles and a volume. 2.8 define the term dilution. 2.9 calculate the concentration of diluted solutions.	

Learning outcome	The learner will:
3. Understand the principles of Acid/Base titration	
Assessment criteria	

The learner can:

3.1 define acid and base in terms of hydrogen ions.
3.2 define pH in terms of hydrogen ion concentration.
3.3 describe the terms acidic, neutral and alkaline
- pH
- relative amount of hydrogen
- relative amount of hydroxide ions

3.4 define weak acid and weak base.
3.5 identify names of common acids and corresponding anions
- hydrochloric/chloride
- sulphuric/hydrogen sulphate and sulphate
- nitric/nitrate
- ethanoic/ethanoate
- hydrofluoric/fluoride
- methanoic/methanoate
- carbonic/hydrogen carbonate and carbonate
- nitrous/nitrite
- sulphurous/hydrogen sulphite and sulphite.

3.6 identify names of common bases
- sodium hydroxide
- potassium hydroxide
- calcium hydroxide
- calcium oxide
- ammonia
- sodium carbonate
- sodium hydrogen carbonate
- calcium carbonate.

3.7 construct word equations for acid reactions
- reactive metals
- metal oxides
- metal carbonates
- alkalis.

3.8 state ratios in balanced symbol equations.
3.9 explain how pH meters are calibrated using standard buffer solutions.
3.10 state properties of primary standards in titrimetric analysis.
3.11 describe roles of standards in standardisation of laboratory acids and alkalis.
3.12 define the terms titre and indicator.
3.13 explain how the concentration of acids or alkalis may be found by titration
- pH meter
- suitable indicator.

Learning outcome	The learner will:
4. Know potential hazards in the use and disposal of laboratory chemicals	
Assessment criteria	
The learner can: 4.1 describe main types of laboratory hazards • flammable • oxidising agent • corrosive • explosive • harmful • toxic • radioactive • biohazard • harmful to the environment • carcinogenic/mutagenic 4.2 describe methods of hazard labelling in laboratories • manufacturers' labels • orange tape 4.3 state where to obtain information about hazards • MDS leaflets • R and S phrases. 4.4 state where to obtain information about appropriate disposal of laboratory waste 4.5 describe common methods of waste disposal in laboratories • run to waste with plenty of water • non-chlorinated waste solvent bottle • chlorinated waste solvent bottle • dedicated waste container (solids/oil/Ag residues etc).	

Learning outcome	The learner will:
5. Know elements of quality systems in a laboratory	
Assessment criteria	
The learner can: 5.1 describe ways in which results can be recorded in laboratories • electronically • graphically • handwritten in a hard-backed book 5.2 describe methods of logging samples • directly on computer • on a job sheet • in a hard-backed book • with information corresponding to the label 5.3 describe information used in labelling samples • date • batch • sub-sample number • person taking the sample • sampling point • conditions (environmental samples) • some property of the sample measured immediately like specific gravity • code denoting whether it is a process or despatch sample	

Unit 210 Fundamentals of Special processes in process industries

Level:	2
GLH:	It is recommended that 40 hours should be allocated for this unit, although patterns of delivery are likely to vary.
Assessment type:	Centre Devised
Aim:	Both the individual and industry will benefit from the individuals involved in operations having an appropriate level of understanding of the relevant processes. This unit is concerned with an individual's responsibilities within their operational role and as part of a team and their awareness of health and safety matters. The unit also details the knowledge required of the raw materials and products of the process and their commercial relevance.

Learning outcome	**The learner will:**
1. Understand personal responsibility within overall process operations	
Assessment criteria	
The learner can: 1.1 describe the company structure. 1.2 explain how roles fit into the organisations 1.3 describe the main responsibilities of roles. 1.4 explain the importance of team-working.	

Learning outcome	**The learner will:**
2. Understand the main unit operations within processes	
Assessment criteria	
The learner can: 2.1 explain the principle of operation of unit operations. 2.2 state the critical operating parameters for processes. 2.3 state where operating procedures are located 2.4 state HSE issues associated with processes.	
Learning outcome	**The learner will:**
3. Know details of raw materials, intermediate and final products	
Assessment criteria	

The learner can: 3.1 state the requirements for safe storage of raw materials and final products. 3.2 describe the procedure(s) to follow in event of spillages. 3.3 state the main use(s) of final products.

Learning outcome	**The learner will:**
4. Know commercial issues of processes	
Assessment criteria	
The learner can: 4.1 identify the major customers for products of processes. 4.2 identify major competitors 4.3 describe factors influencing sales of products	

Unit 211 Instrumentation, measurement and control in process industries

Level:	2
GLH:	It is recommended that 40 hours should be allocated for this unit, although patterns of delivery are likely to vary.
Assessment type:	Multiple Choice
Aim:	This unit provides the candidate with the fundamental operating principles of process plant instrumentation.

Learning outcome	**The learner will:**
1. Know the purpose of instrumentation within industrial process systems and factors that govern its use	
Assessment criteria	
The learner can: 1.1 describe the role of Instrument Technicians 1.2 state the purpose of instrumentation and control 1.3 state the main factors affecting decisions to install instrumentation and control systems • safety • efficiency • cost • operability and maintainability. 1.4 describe instrumentation terminology • accuracy • range • span • sensitivity • live zero • tolerance. 1.5 describe errors found in instruments • zero • span • linearity • hysteresis. 1.6 state the need for instrument calibration • Safe Operation of Plant	

- Quality Control
- Preventative Maintenance.

1.7 state factors that affect the accuracy of instruments
- temperature
- corrosion
- stray magnetic fields
- environment
- maintenance
- vibration.

1.8 describe the essential elements of measurement systems
- input
- transducer/sensor
- amplifier
- display
- output.

Learning outcome	**The learner will:**
2. Know pressure measurements and pressure measuring instruments	
Assessment criteria	

The learner can:

2.1 define the term pressure.

2.2 state the SI unit of pressure.

2.3 convert pressure units
- Pa
- N/m2
- bar
- mbar
- PSI.

2.4 identify types of pressure
- gauge pressure
- atmospheric pressure
- absolute pressure
- differential pressure
- hydrostatic pressure.

2.5 define the term vacuum.

2.6 describe the operation of dead weight testers.

2.7 describe the operating principles, constructional features and operational ranges of pressure instruments
- U tube manometer
- inclined manometer
- single tube manometer

- double tube manometer
- aneroid barometer
- diaphragm gauge
- bellows gauge
- C type Bourdon gauge
- piezo-electric, resistive and capacitive transducers.

2.8 state the common sources of error found in pressure instruments

Learning outcome	**The learner will:**
3. Know temperature measurements and temperature measuring instruments	
Assessment criteria	
The learner can: 3.1 define the terms temperature and heat 3.2 describe the operating principles, constructional features and operational ranges of temperature instruments • expansion types – alcohol and mercury thermometers • liquid in steel and liquid in glass thermometers • solids – bi-metallic type • electrical – platinum resistance, thermocouple types • radiation – infrared optical pyrometer, radiation pyrometer. 3.3 describe hot junction, cold junction and cold junction compensation in thermocouples 3.4 describe the Seebeck Effect. 3.5 describe the Peltier Effect. 3.6 state the common sources of error found in temperature instruments	

Learning outcome	**The learner will:**
4. Know level measurement and operation of level measuring instruments	
Assessment criteria	
The learner can:	

4.1 describe the operating principles, constructional features and operational ranges of common level instruments
- dip stick
- sight glass
- float operated devices
- hydrostatic level measurement using differential pressure transmitter
- purged dip pipe method
- electrical resistance methods
- capacitance probes
- ultrasonic level methods
- buoyancy methods
- radioactive level measurement
- load cells.

4.2 state the main sources of error in level measuring instruments.

4.3 define the terms ullage and outage.

Learning outcome	**The learner will:**
5. Know flow measurement and operation of flow measuring instruments	
Assessment criteria	

The learner can:

5.1 describe laminar flow.

5.2 describe turbulent flow.

5.3 define volumetric flow rate

5.4 define mass flow rate.

5.5 describe the operating principles, applications, constructional features and operational ranges of flow measuring instruments
- positive displacement meters
- differential pressure head devices – venturi, dall tube, orifice plate, pitot tube
- variable area flow meters
- inferential – turbine
- electrical – electromagnetic, vortex, corriollis.

5.6 state the main sources of error in flow measuring instruments.

Learning outcome	The learner will:
6. Know the measurement of viscosity, density and humidity	
Assessment criteria	

The learner can:

6.1 define viscosity.
6.2 define the SI unit of viscosity and its common multiples and sub-multiples.
6.3 describe the operating principles of viscometers
- annular
- Redwood
- Stokes (falling sphere)
- Torsion.

6.4 state applications and sources of error for viscometers
6.5 define absolute humidity, relative humidity, dew point
6.6 define water vapour pressure and saturated water vapour pressure.
6.7 describe the operation of hygrometers
- wet and dry bulb
- hair type
- electrical conductivity
- mirror type
- chemical methods (silica gel).

6.8 define density and relative density
6.9 state the SI unit of density and its common multiples and sub multiples.
6.10 describe Archimedes' principle.
6.11 state how the density of solids can be determined by direct measurement.
6.12 state how the density of liquids is measured
- an SG bottle
- a hygrometer
- continuous gravitometers
- buoyancy transducer.

6.13 describe how the density of gas is measured.
6.14 describe why temperature readings must be taken in conjunction with density readings

Learning outcome	The learner will:
7. Understand instrumentation practice	
Assessment criteria	
The learner can: 7.1 identify orifice plate tapping positions for various flow measurement situations • gas flow measurement • steam measurement • slurry measurement • clean liquids • suspended solids. 7.2 explain the operation and use of orifice plates • concentric • eccentric • segmental 7.3 identify the hazards associated with oxygen measurement • explosion • fire • asphyxiation. 7.4 explain the importance of bursting discs, pressure snubbers, pigtails, lutes and oil filled gauges. 7.5 describe zone classification • Zone 0 • Zone 1 • Zone 2 7.6 describe temperature classifications • T1 • T2 • T3 • T4 • T5 • T6. 7.7 define the term intrinsic safety. 7.8 describe Seal Pot and Condensate Chambers	

Learning outcome	The learner will:
8. Know open and closed loop control systems	
Assessment criteria	
The learner can: 8.1 state the purposes of control systems • to maintain optimum performance at all times during the process by the manipulation of process variables. • to ensure process safety. • to provide data on the parameters of a process. 8.2 describe the essential elements of control systems • detecting element • measuring element • comparing element • motor (control) element • final correcting element 8.3 identify block diagrams of open and closed loop control systems 8.4 state the advantages and disadvantages of manual and automatic control 8.5 describe simple closed loop systems for pressure temperature level and flow control 8.6 describe 3 term control. 8.7 describe on/off (2 step) control.	

Unit 212 Fundamentals of Processing metals in process industries

Level:	2
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Assessment type:	Multiple Choice
Aim:	This mandatory unit provides an introduction to the production of iron, steel, aluminium and copper. It outlines the processes from metal ore to finished product, which may be a raw material for further processing in other manufacturing industries. It should be considered as the minimum educational requirement for those who work in the metal producing and metal using industries.

Learning outcome	The learner will:

1. Know how metals are produced from metal ore
Assessment criteria
The learner can: 1.1 identify metal ores used to produce iron, aluminium and copper • iron: o haematite - red iron ore Fe2O4 o magnetite- magnetic iron ore o limonite - brown iron ore • aluminium: bauxite • copper: low grade sulphide ore. 1.2 state main features of modern iron blast furnaces • water cooled steel structure lined with refractory • mechanism for charging solids at top of furnace • hot air blast and tuyeres for injection of air • metal and slag tapping holes • gas extraction system. 1.3 state main features of aluminium reduction cells • insulated steel case with a carbon cathode lining • anode conductor bar with self baking carbon anode • molten electrolyte with solid alumina crust • molten aluminium with siphon ladle system. 1.4 state processes used for the manufacture of iron, aluminium and copper from their metal ore • iron: reduction of oxide by heat and reducing agent • aluminium: electrolysis of fused salts • copper: beneficiation of low grade ores. 1.5 state main impurities of iron produced from iron ore • carbon • silicon • manganese • sulphur • phosphorus.

Learning outcome	**The learner will:**
2. Know how metals are refined	

Assessment criteria
The learner can: 2.1 describe main features of the process and production units for the manufacture of steel from molten iron • Basic Oxygen Steel making unit • top blown with oxygen and lime • rapid exothermic chemical reactions • raw materials from charging hopper • tilted for tapping removal of slag and temperature measurements. 2.2 describe main features of the process and production units for the manufacture of steel from scrap • Electric Arc Furnace, roof, electrodes, side walls, hearth, oxygen and fuel injectors, forward and backwards tilting • roof removal for charging, melt down, oxidation, sampling, tapping. 2.3 state mechanical properties of high carbon iron 2.4 state mechanical properties of low carbon steel 2.5 describe main types of production units used for refining of aluminium 2.6 state main features of the process for producing copper from ore • preparation of ores • fire refining • electrolytic purification

Learning outcome	The learner will:
3. Know how metal are cast	

Assessment criteria
The learner can: 3.1 state main features of continuous casting processes for steel • ladles to machine • tundish and pouring nozzles • mould shape size and lubrication • cooling zone • exit and straightening • cut to length. 3.2 describe how continuous casting processes are efficient in the bulk production of steel • casting speed • continuous process • elimination or reduction of primary working. 3.3 state main features of ingot casting • mould preparation • casting bays • wide range of shapes • casting temperatures • cover slag.

Learning outcome	The learner will:
4. Know how metals are initially shaped	
Assessment criteria	

The learner can:

4.1 state suitable processing temperatures for primary working metals/alloys
- steel (typically 1100 to 900 □C)
- copper and alloys (typically 900 to 700 □C)
- aluminium and alloys (typically 700 to 600 □C)

4.2 state types of furnace that achieve correct working temperatures for primary working metals
- pusher furnace
- walking beam furnace
- batch pit furnace
- rotary furnace.

4.3 describe main features of operating primary rolling mills
- monitor and track supply from reheat furnace to primary mill
- roll to size and shape according to schedule
- progress to cut to length and cooling racks.

4.4 state profiles produced by primary rolling mills
- square
- round
- slabs
- special profiles:
  - rails
  - girders/joists
  - channels.

4.5 describe the importance for hot working cast metals
- low flow stress
- refinement of cast structure:
  - finer grains
  - lower porosity
- improvement in strength
- improvement in ductility.

Learning outcome	**The learner will:**
5. Know finishing processes for metals	
Assessment criteria	
The learner can:	

5.1 state the main features of finishing hot rolling operations for rod, section and sheet

- rod - supplied with either hot rolled billet or continuous cast billet
- rod - continuous rolling
- rod - discharge into a downcoiler or conveyor system (stelmor)
- section - ability to produce a wide range of shapes
- sheet - multi-stand producing high quality sheet in coils.

5.2 state the main features of cold finishing operations for sheet

- annealing lines with controlled atmosphere
- cleaning system for surfaces before cold work commences
- highly polished work rolls
- repeated operation until required thickness is achieved.

5.3 state the main features of cold finishing operations for wire

- annealing lines with controlled atmosphere
- cleaning system for surfaces before cold work commences
- wire is drawn through multi holed drawing machines.

5.4 state advantages of hot and cold finishing operations

- hot:
  - rapid reduction
  - complex linear shapes achievable
  - refinement of cast structure
- cold:
  - increase in strength
  - close size tolerances possible
  - bright finishes

Learning outcome	**The learner will:**
6. Know the main testing methods for metals	
Assessment criteria	
The learner can: 6.1 identify mechanical tests	

- strength: tensile
- toughness: Charpy
- hardness: Brinell, Vickers.

6.2 describe non-destructive tests used to find surface and sub surface defects in metals

- dye penetrant
- magnetic particle
- eddy current
- ultrasonics (subsurface)
- radiography (subsurface).

Unit 215 Fundamentals of Primary working in the steel industry

Level:	2
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Assessment type:	Centre Devised
Aim:	This unit describes the Primary Working of cast steel. Reheating for hot working is described, followed by details of the Primary Rolling process. Hot forging of steel sections is outlined. The rolling of plate and sheet is described.

Learning outcome	The learner will:

1. Know the types of furnaces used to heat steel for Rolling and Forging operations
Assessment criteria
The learner can: 1.1 list key properties when selecting cold feed stock for hot working processes • section size • section shape • surface condition • chemical analysis. 1.2 describe how cold feed stock is prepared for reheating processes. 1.3 state advantages of using hot feed stock directly from casting processes • increase in thermal efficiency • increase in production rate • reduction in cooling and heating cracks. 1.4 describe how feed stock is tracked during the hot working processes. 1.5 identify main features of furnaces used for rolling and forging operations • pusher • walking beam. 1.6 state the advantages of walking beam furnaces over pusher furnaces • better surface quality • gaps between different specifications • more even heating of billets • furnace flow direction can be reversed. 1.7 describe the term soaking pit. 1.8 describe how carbonaceous fuels burn to produce heat. 1.9 state types of furnace atmospheres that can be produced • carbonaceous fuel • reducing • neutral • oxidising. 1.10 state factors which affect the thermal efficiency of furnaces • insulation • size and operation of doors • burner design. 1.11 describe how the temperature of reheating furnaces is measured and controlled

Learning outcome	**The learner will:**
2. Know the Primary Rolling process	
Assessment criteria	

The learner can:

2.1 identify main features of reversing primary mills
- mill housing
- work rolls
- screw down mechanism
- universal couplings
- manipulators
- input and output roller tables.

2.2 identify main features of continuous mills which produce billet
- roll train
- vertical and horizontal rolls
- twister guides
- crop shear
- run out table.

2.3 state rolling temperature ranges for hot rolling of steel, copper and aluminium.

2.4 describe how scale is removed from the billet before the first pass.

2.5 identify roll pass sequences for production of square sections, angles and channels.

2.6 calculate increases in rolling speed for reductions in area.

2.7 describe cut off mechanisms and surface scarfing.

Learning outcome	The learner will:
3. Know the process for hot forging of steel sections	
Assessment criteria	
The learner can: 3.1 describe the preparation of rolled feedstock for small and medium forgings. 3.2 describe the preparation of ingots for large pressings and forgings. 3.3 describe the heating of steel for forging. 3.4 describe main features of small, medium and heavy forging equipment. 3.5 state forging temperature ranges for carbon steels. 3.6 describe the manipulation of steel during forging. 3.7 state products manufactured by forging. 3.8 state improvements in mechanical properties of components manufactured by forging compared to casting	

Learning outcome	The learner will:
4. Know the operation of hot plate and strip mills	
Assessment criteria	
The learner can: 4.1 state dimensions of starting slabs for production of plates. 4.2 describe the surface preparation of starting slabs for production of plates. 4.3 calculate starting slab sizes in relation to finished plate sizes. 4.4 describe how starting slabs are heated up to rolling temperature. 4.5 describe the layout and operation of rolling mills for plates. 4.6 describe how the edges of plate are prepared to customer specifications. 4.7 identify end uses for hot rolled plates • ships • bridge decks • chemical and nuclear plant • pressure vessels • hazardous waste storage tanks. 4.8 identify main features of hot strip mills. 4.9 state the stages in controlling stock thickness during rolling • sensor • analysis of signal • feedback and adjustment. 4.10 describe why steel strip is cooled after rolling and before coiling. 4.11 identify main features of coilers. 4.12 state applications of hot rolled steel sheet and strip.	

Unit 219 Fundamentals of Metallurgy of iron and steel production

Level:	2
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Assessment type:	Centre Devised
Aim:	This unit explains and describes many of the metallurgical principles involved in the production and processing of iron and steel. It is designed to be suitable for study at level 2 and is further extended at level 3.

Learning outcome	The learner will:
1. Know the metallurgical principles involved in the production of steel from iron ore and from scrap	
Assessment criteria	

The learner can:

1.1 identify production processes for the manufacture of iron and steel
- blast furnace
- direct reduction of iron
- basic oxygen steel making
- electrical arc steel making.

1.2 identify standard methods of testing the quality of metallurgical coke
- carbon content
- ash content
- shatter index
- porosity.

1.3 state the main chemical reactions occurring in blast furnaces
- carbon reacting with oxygen to produce heat
- direct and indirect reduction of iron oxide
- reduction of silicon and manganese oxides
- production of slag.

1.4 state the main chemical reactions in the Basic Oxygen Steel making process
- exothermic reaction between oxygen and carbon, silicon, manganese
- reactions involving lime oxygen and phosphorus.

1.5 state factors which improve thermal efficiency of electric arc melting furnaces
- ultra high power
- fuel injection
- use of electricity and or tonnage oxygen at various stages of the process
- foaming slags and long arc practice.

1.6 state the stages in making steel to specifications
- melt
- boil
- kill
- trim to specification.

Learning outcome	The learner will:

2. Know the chemistry of making plain carbon steels
Assessment criteria
The learner can: 2.1 describe the removal of carbon, silicon, and manganese during the oxidation phase of steel making. 2.2 identify conditions necessary for the removal of phosphorus from steel • highly oxidising • excess of lime • relatively low temperature. 2.3 identify conditions necessary for the removal of sulphur from steel • reducing • excess of lime • relatively high temperature. 2.4 identify the metals often present in steel that cannot be removed during the oxidation phase of steel making • copper • tin • nickel. 2.5 identify conditions which will reduce the free oxygen content of steel • vacuum treatment • argon rinse • addition of de-oxidant: ○ silicon ○ manganese ○ aluminium. 2.6 identify factors involved in achieving close control over the final chemical analysis of steel • rapid chemical analysis • controlled hopper additions • computer control system. 2.7 identify advantages of argon stirring of molten steel prior to casting • uniformity and close control of temperature • uniformity of chemical composition throughout the melt.

Learning outcome	The learner will:
3. Know the process of solidification of metals	
Assessment criteria	
The learner can: 3.1 describe the arrangement of atoms in liquids and solids 3.2 identify the stages in cooling curves for pure metals. 3.3 state the stages in the solidification of metals • creation of a solid nucleus in a liquid • growth of the solid nucleus within the liquid • formation of a solid dendrite • growth of the solid dendrite • solid dendrites meet to form a solid grain. 3.4 describe how fine grained and coarse grained metal structures are formed. 3.5 describe how equi-axed and columnar grains are formed. 3.6 describe production of micro and macro segregation in cast metals. 3.7 describe production of micro and macro porosity in cast metals.	

Unit 222 Non-ferrous metals and alloys

Level:	2
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Assessment type:	Centre Devised
Aim:	This unit provides details about the production, processing, properties and applications of aluminium, copper, and zinc, together with the main alloys based upon these metals. Emphasis is then given to the properties and industrial applications of non-ferrous metals and alloys. This unit provides an introduction to non-ferrous metals and alloys for those who work in the non-ferrous metal producing and non-ferrous metal using industries.

Learning outcome	**The learner will:**
1. Know how aluminium, copper and zinc are produced from ores	
Assessment criteria	
The learner can: 1.1 identify metal ores used to produce aluminium, copper and zinc. 1.2 describe electrolytic extraction of aluminium from bauxite. 1.3 list stages involved in the extraction of copper from lean copper ore. 1.4 describe the production of zinc by blast furnace smelting.	

Learning outcome	**The learner will:**
2. Know how aluminium, copper and zinc are refined	
Assessment criteria	
The learner can: 2.1 describe electrolytic refining of aluminium. 2.2 describe fire-refining and electrolytic refining of copper. 2.3 describe pyrometallurgical refining of zinc.	

Learning outcome	The learner will:
3. Know the processing of non-ferrous metals and alloys	
Assessment criteria	
The learner can: 3.1 identify aluminium based light alloys that are processed by casting into shape • aluminium / 8% to 12% copper • aluminium / 3% copper + 12% zinc • aluminium / 13% silicon • aluminium / 5% magnesium. 3.2 identify aluminium based light alloys that are processed by hot and cold working into shape • aluminium / 4% copper • aluminium / zinc + magnesium + copper. 3.3 identify types of copper based alloys • single phase alpha brasses up to 70% copper / 30% zinc • two phase beta brasses in the region of 60% copper / 40% zinc • high tensile strength brasses • monels • bronzes. 3.4 describe the main features of zinc die casting and titanium forging alloys.	

Learning outcome	The learner will:

4. Understand the main properties of the widely used non-ferrous metals and alloys

Assessment criteria

The learner can:

4.1 compare properties of alloys
- density
- strength
- strength to weight
- cost
- aluminium
- copper
- nickel
- titanium
- iron.

4.2 state typical mechanical properties of non-ferrous metals and alloys
- pure aluminium
- aluminium / 4% copper alloy
- pure copper
- copper based alloys containing:
  - zinc (brasses)
  - tin (bronzes)
  - Beryllium
- pure nickel
- nickel based alloys containing:
  - copper (monel)
  - chromium (inconel)
  - molybdenum (hastelloy)
  - iron (incoloy)
  - cobalt (stellite)
- pure titanium
- titanium alloys containing:
  - aluminium
  - tin (alpha alloys)
  - vanadium and chromium (beta alloys).

4.3 compare common non-ferrous metals and alloys
- corrosion resistance
- electrical conductivity
- service temperature
- density
- resistance to fatigue
- cost
- Aluminium
- Al/4%Cu
- Copper
- Cu/30%Zn
- Nickel
- Titanium

Learning outcome	The learner will:
5. Know the main industrial applications of non-ferrous metals and alloys	
Assessment criteria	
The learner can: 5.1 describe uses of aluminium and its alloys • beverage cans • automotive components • electrical power transmission • aircraft and aerospace components. 5.2 describe uses of copper and its alloys • electrical applications • pumps • valves • plumbing parts • marine applications. 5.3 describe uses of nickel and its alloys • gas turbines • chemical plants • heat exchangers • valves and pumps at high temperatures and or in an aggressive environment. 5.4 describe uses of titanium and its alloys • chemical plant • marine components • medical implants • airframes • aero engine components. 5.5 describe how zinc is used to protect steels from corrosion	

Unit 223 Chemistry for petroleum operations

Level:	2
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Assessment type:	Multiple Choice
Aim:	This unit provides the essential knowledge required for an understanding of the chemical principles involved in manufacturing processes carried out in the petroleum industries.

Learning outcome	The learner will:
1. Know the structure of atoms, elements, compounds and chemical symbols that represent them	
Assessment criteria	

The learner can:

1.1 identify differences between particles in relation to relative mass and charge.
- electrons
- protons
- neutrons

1.2 describe structures of atoms in terms of sub-atomic particles.
1.3 identify differences between relative atomic mass and atomic number.
1.4 identify the chemical symbols for common elements.
1.5 identify the differences between elements, compounds and mixtures.
1.6 define the term ion.
1.7 identify differences between ionic and covalent bonding in terms of electron transfer and electron sharing.
1.8 identify the differences between properties of ionic and covalently bonded compounds.
1.9 define the term valency.
1.10 apply the concepts of valency to chemical formulae
1.11 identify the formulae of molecules and ions.
1.12 identify chemical formulae of compounds
- oxides
- hydroxides
- sulphates
- chlorides
- nitrates
- carbonates
- sulphides
- hydrogen carbonates.

1.13 define the term formula (molar) mass
1.14 calculate formula masses.

Learning outcome	The learner will:
2. Know fundamental scientific laws to the construction and use of balanced chemical equations	
Assessment criteria	

The learner can:

2.1 identify the differences between chemical and physical changes.
2.2 define the term chemical reaction.
2.3 describe the law of conservation of matter and the law of definite proportion.
2.4 define the term stoichiometric quantity.
2.5 construct balanced chemical equations to represent chemical reactions.
2.6 calculate the masses of reactants and products from balanced chemical equations.
2.7 describe the importance of Avogadro's law.
2.8 identify differences between exothermic and endothermic reactions.

2.9 state the function of catalysts.

2.10 identify the differences between chemical compounds

- acid
- alkali
- base
- salt

2.11 identify chemical formulae of common chemical compounds

- acid
- alkali
- base
- salt

2.12 construct balanced chemical equations for reactions involving acids

- metals
- alkalis
- bases
- carbonates
- hydrogen carbonates.

2.13 describe the relationship between pH and acidity/alkalinity.

2.14 define the terms neutralisation and neutral solution.

2.15 state the function of common indicators.

Learning outcome	The learner will:
3. Know the structure, classification and properties of carbon compounds	
Assessment criteria	

The learner can:

3.1 identify the differences between inorganic and organic chemicals.
3.2 describe the structure of hydrocarbon compounds
- straight chain
- branched chain
- ring compounds.

3.3 define the term homologous series.
3.4 state the general formulae for alkanes, akenes and alkynes.
3.5 identify the differences between saturated and unsaturated hydrocarbons.
3.6 identify the differences between molecular and structural formulae
- first six alkanes
- first three alkenes
- ethyne.

3.7 define the term alkyl group
3.8 state common types of alkyl group
3.9 define the term functional group.
3.10 describe the classification of organic compounds in terms of their functional groups
- alcohols
- acids
- esters
- halides
- amines.

3.11 identify general formulae for functional groups.
3.12 identify the differences between aliphatic and aromatic compounds.
3.13 identify aromatic compounds
- benzene
- methyl benzene (toluene)
- dimethylbenzene (xylene).

3.14 identify systematic and common names for common organic compounds

Unit 224 Fundamentals of petroleum technology

Level:	2
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Assessment type:	Multiple Choice
Aim:	This unit provides the essential knowledge required for an understanding of oil exploration, reservoir technology and the production, distribution and processing/refining of crude oil and gas.

Learning outcome	**The learner will:**
1. Know the origins of crude oil and gas and the geological formations that contain them	
Assessment criteria	
The learner can: 1.1 describe the origins of crude oil and gas. 1.2 describe the principal types of geological feature that contain crude oil and gas 1.3 describe how crude oil and gas flow with rock formations. 1.4 describe features relevant to reservoir technology • porosity • temperature, pressure, volume • faulting • viscosity • phases: liquid, gas, emulsion.	

Learning outcome	**The learner will:**
2. Know the principles and methods of oil & gas exploration	
Assessment criteria	
The learner can: 2.1 describe principal methods of exploration • surface geological survey • seismic surveying • magnetometer survey • gravity survey • drilling of test wells. 2.2 compare advantages and disadvantages of exploration on land and sub-sea	

Learning outcome	The learner will:
3. Know the construction, operating principles and uses of oil and gas production and distribution systems both on and off shore	
Assessment criteria	

The learner can:

3.1 describe principal elements of typical well and drilling operations
- drill bit
- drill pipe
- derrick
- casing
- kelly
- drilling mud, biocides
- Christmas tree
- production header/collection point
- instrumentation
- geological analysis
- well completion techniques
- data logging
- well testing
- inhibitor injection
- services/utilities

3.2 describe the construction and principles of operation of principal pieces of surface equipment
- oil-gas separator
- oil-water separator
- test separators
- desalting unit
- flare
- gas scrubbers.

3.3 describe principal types of drilling
- vertical
- directional
- horizontal.

3.4 describe the construction and principles of operation of down hole and nodding donkey pumps

3.5 describe the effects of well pressure on production.

3.6 describe principal components of cross country and sub-sea pipeline systems
- pipe design and support
- pigs and pigging stations
- pumping/compression stations
- storage.

3.7 describe principal features of oil and gas tanker ships
- single hull
- double hull
- holds
- refrigerated storage
- pressurised storage.

3.8 identify hazards associated with production operations
- reservoir pressure; blowouts
- pollution

- flammable materials
- toxicity of materials
- difficulty of evacuation to and from remote areas
- helicopter ditching and sea survival techniques
- corrosion

Learning outcome	**The learner will:**
4. Know the key functions of refineries, associated processing units, their key products and uses	
Assessment criteria	
The learner can: 4.1 describe the construction, key features and operations of refineries • reception of crude • electrostatic desalting • atmospheric distillation • vacuum distillation • desulphurisation • catalytic conversion • alkylation • isomerisation • tankage/storage • blending operations • export of products. 4.2 describe the composition, appearance and uses of refinery feeds and products • naphtha • kerosine • gasoline • gas oil • fuel oil • lubricating oil • bitumen • LPG • LNG • crude oils – light/medium/heavy and sweet/sour.	

Appendix 1 Relationships to other qualifications

Functional Skills

Literacy, language, numeracy and ICT skills development

City & Guilds offer a range of qualifications which are intended to support learners as they seek to improve their literacy and numeracy skills. Visit the City & Guilds website for more information. http://www.cityandguilds.com

Appendix 2 Sources of general information

The following documents contain essential information for centres delivering City & Guilds qualifications. They should be referred to in conjunction with this handbook. To download the documents and to find other useful documents, go to the **Centre document library** on **www.cityandguilds.com** or click on the links below:

Centre Handbook: Quality Assurance Standards

This document is for all approved centres and provides guidance to support their delivery of our qualifications. It includes information on:

- centre quality assurance criteria and monitoring activities
- administration and assessment systems
- centre-facing support teams at City & Guilds/ILM
- centre quality assurance roles and responsibilities.

The Centre Handbook should be used to ensure compliance with the terms and conditions of the centre contract.

Centre Assessment: Quality Assurance Standards

This document sets out the minimum common quality assurance requirements for our regulated and non-regulated qualifications that feature centre-assessed components. Specific guidance will also be included in relevant qualification handbooks and/or assessment documentation.

It incorporates our expectations for centre internal quality assurance and the external quality assurance methods we use to ensure that assessment standards are met and upheld. It also details the range of sanctions that may be put in place when centres do not comply with our requirements or actions that will be taken to align centre marking/assessment to required standards. Additionally, it provides detailed guidance on the secure and valid administration of centre assessments.

Access arrangements: When and how applications need to be made to City & Guilds provides full details of the arrangements that may be made to facilitate access to assessments and qualifications for candidates who are eligible for adjustments in assessment.

The **Centre document library** also contains useful information on such things as:

- conducting examinations
- registering learners
- appeals and malpractice.

Useful contacts

Please visit the **Contact us** section of the City & Guilds website.

City & Guilds

For over 140 years, we have worked with people, organisations and economies to help them identify and develop the skills they need to thrive. We understand the life-changing link between skills development, social mobility, prosperity and success. Everything we do is focused on developing and delivering high-quality training, qualifications, assessments and credentials that lead to jobs and meet the changing needs of industry.

We partner with our customers to deliver work-based learning programmes that build competency to support better prospects for people, organisations and wider society. We create flexible learning pathways that support lifelong employability because we believe that people deserve the opportunity to (re)train and (re)learn again and again – gaining new skills at every stage of life, regardless of where they start.

The City & Guilds community of brands includes Gen2, ILM, Intertrain, Kineo and The Oxford Group.

Copyright

City & Guilds reviews its Qualifications on a regular basis to ensure they remain current, relevant, and meet industry and learner needs.

This Qualification Handbook however may contain references to historic information, such as former organisations, obsolete frameworks, codes or standards, or retired units and qualifications. This information is included for reference purposes only.

Published by City & Guilds, a registered charity established to promote education and training.

City & Guilds of London Institute
Giltspur House
5–6 Giltspur Street
London
EC1A 9DE

cityandguildsgroup.com