Higher National Unit specification

General information for centres

Unit title: Physics Principles: Heat and Thermodynamics

Unit code: F43H 34

Unit purpose: This Unit is designed to provide candidates with a practical introduction to, and understanding of the Physics Principles of Heat and Thermodynamics.

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

1 Apply the concepts of temperature and heat to determine thermal expansion parameters.
2 Apply temperature difference to heat transfer processes.
3 Apply the First Law of Thermodynamics to physical systems.
4 Apply the kinetic theory of gases to explain the properties of gases.

Credit points and level: 1 HN credit at SCQF level 7: (8 SCQF credit points at SCQF level 7*)

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

Recommended prior knowledge and skills: Access to this Unit will be at the discretion of the centre. It is recommended that candidates have some prior skills in mathematics and physics at SCQF level 6, or equivalent.

Core Skills: There are opportunities to develop the Core Skill of *Numeracy* and the components Critical Thinking at SCQF level 6 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

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

Assessment: The assessments for Outcomes 1, 2, 3 and 4 could be taken by the candidates at the completion of each Outcome. The assessments should be taken under supervised conditions. The practical elements of Outcomes 1 and 3 could be completed at any time during the delivery of these Outcomes when the candidate could apply much of the theory learned during this period. The assessment papers for each Outcome could be composed of an appropriate balance of short answer, restricted response and structured questions.

Higher National Unit specification: statement of standards

Unit title: Physics Principles: Heat and Thermodynamics

Unit code: F43H 34

The sections of the Unit stating the Outcomes, Knowledge and/or Skills, and Evidence Requirements are mandatory.

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

Outcome 1

Apply the concepts of temperature and heat to determine thermal expansion parameters

Knowledge and/or Skills

- Thermal equilibrium, temperature
- Empirical temperature scales (Fahrenheit, Celsius, Kelvin)
- Zero'th Law of Thermodynamics
- Thermometric Properties
- Thermal expansion
- Mechanical Stress, strain, Young's Modulus
- Health and safety regulations
- Experimental uncertainties

Evidence Requirements

Evidence for this Outcome will be provided on a sample basis with candidates being required to provide evidence for three of the first six Knowledge and/or Skills items. Assessment must be carried out under supervised conditions.

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- define the terms thermal equilibrium and temperature.
- illustrate, both diagramatically and by providing definitions, the Zero'th law of Thermodynamics.
- plot a graph to define the empirical Kelvin temperature scale.
- explain the empirical temperature scales (Farhenheit, Celsius, Kelvin).
- state three thermometric properties from length, density, electrical resistance, volume or colour and describe a temperature measuring device based on any one of these properties.
- define mechanical stress, strain and Young's Modulus.
- perform at least one practical experiment to apply the concepts of temperature and heat to determine thermal expansion parameters. The experiment should be conducted within health and safety regulations and take account of experimental uncertainties. A laboratory report must be produced that includes all results, calculations and conclusions.
- use thermal expansion theory to calculate expansion coefficients and thermal stresses.

Higher National Unit specification: statement of standards (cont)

Unit title: Physics Principles: Heat and Thermodynamics

Where calculations are performed the candidate must:

- apply appropriate formulae.
- apply the principles of the calculation.
- show all working through a calculation.
- provide reasonable answers to the questions asked. The answer should derive from the application of the formula and correct application of the principles of the calculation.

Assessment Guidelines

It is recommended a single assessment event is conducted for Outcomes 1 and 2. The assessment could be composed of an appropriate balance of short answer, restricted response and structured questions.

The assessment for this Outcome could be composed of an appropriate balance of short answer, restricted response and structured questions. This Outcome has a practical activity, during which candidates could be assessed using an observational checklist for the health and safety element, and through the production of a laboratory report.

Higher National Unit specification: statement of standards (cont)

Unit title: Physics Principles: Heat and Thermodynamics

Outcome 2

Apply temperature difference to heat transfer processes

Knowledge and/or Skills

- Heat transfer by conduction
- Thermal conductivity
- Fourier's law
- Heat transfer by radiation
- Stefan-Boltzmann law
- Emissivity, black body

Evidence Requirements

Evidence for this Outcome will be provided on a sample basis with candidates being required to provide evidence for four of the six Knowledge and/or Skills items. Assessment must be carried out under supervised conditions.

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- explain the meaning of each symbol in Fourier's law.
- describe methods of reducing heat losses by conduction and radiation. The description must include Stefan-Boltzmann law, emissivity and black body.
- perform at least one calculation of the rate of heat flow by conduction.
- perform at least one calculation of the net heat loss by radiation.

Where calculations are performed the candidate must:

- apply appropriate formulae.
- apply the principles of the calculation.
- show all working through a calculation.
- provide reasonable answers to the questions asked. The answer should derive from the application of the formula and correct application of the principles of the calculation.

Assessment Guidelines

Assessment could be composed of an appropriate balance of short answer, restricted response and structured questions.

Higher National Unit specification: statement of standards (cont)

Unit title: Physics Principles: Heat and Thermodynamics

Outcome 3

Apply the First Law of Thermodynamics to physical systems

Knowledge and/or Skills

- State Function, system and surroundings
- Gas laws
- First Law of Thermodynamics
- Work of expansion and contraction
- Thermodynamic Processes
- Thermal changes, work done
- Health and safety regulations
- Experimental uncertainties

Evidence Requirements

Evidence for this Outcome will be provided on a sample basis with candidates being required to provide evidence for four of the six Knowledge and/or Skills items. Assessment must be carried out under supervised conditions.

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- define State Function correctly and give at least one example.
- derive the Ideal Gas Law from Boyle's, Charles', Amonton's and Avogadro's laws.
- apply gas laws correctly to numerical examples.
- apply First Law of Thermodynamics correctly to determine internal energy changes
- calculate the work of expansion and contraction for the following thermodynamic processes: isothermal, isobaric and adiabatic conditions.
- perform at least one experiment that demonstrates the application of the First Law of Thermodynamics to physical systems. The experiment must follow instructions correctly and be conducted in line with health and safety procedures and take account of any experimental uncertainties.
- produce a laboratory report for the experiment. The laboratory report should include all results, calculations and conclusions.

Where calculations are performed the candidate must:

- apply appropriate formulae.
- apply the principles of the calculation.
- show all working through a calculation.
- provide reasonable answers to the questions asked. The answer should derive from the application of the formula and correct application of the principles of the calculation

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Assessment Guidelines

Assessment could be composed of an appropriate balance of short answer, restricted response and structured questions. Candidates could be assessed during practical activity, by use of observational checklist covering the health and safety issues, and a laboratory report.

Outcome 4

Apply the kinetic theory of gases to explain the properties of gases

Knowledge and/or Skills

- Kinetic Theory
- Assumptions
- Applications
- Law of Equipartition of Energy
- Degrees of freedom of molecules
- Average translational kinetic energy and rotational energy of molecules
- Root mean square velocity of molecules
- Momentum of molecules

Evidence Requirements

Evidence for this Outcome will be provided on a sample basis with candidates being required to provide evidence for five of the eight Knowledge and/or Skills items. Assessment must be carried out under supervised conditions.

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- explain at least three assumptions behind the kinetic theory of gases
- apply kinetic theory to describe molecular motion
- state the law of Equipartition of Energy
- calculate total energy of molecules (translational and rotational) knowing molecular degrees of freedom
- calculate root mean square velocities and momentum of molecules

Where calculations are performed the candidate must:

- apply appropriate formulae.
- apply the principles of the calculation.
- show all working through a calculation.
- provide reasonable answers to the questions asked. The answer should derive from the application of the formula and correct application of the principles of the calculation.

Higher National Unit specification: statement of standards (cont)

Unit title: Physics Principles: Heat and Thermodynamics

Assessment Guidelines

Assessment could be composed of an appropriate balance of short answer, restricted response and structured questions.

Administrative Information

Unit code: F43H 34

Unit title: Physics Principles: Heat and Thermodynamics

Superclass category: RC

Original date of publication: August 2008

Version: 01

History of changes:

Version	Description of change	Date

Source: SQA

SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of Higher National qualifications.

Additional copies of this Unit specification can be purchased from the Scottish Qualifications Authority. Please contact the Customer Contact Centre for further details, telephone 0845 279 1000.

Higher National Unit specification: support notes

Unit title: Physics Principles: Heat and Thermodynamics

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

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

Guidance on the content and context for this Unit

This Unit has been designed as part of the HNC/HND Chemical Process Technology. The aim is to give candidates underpinning theoretical and practical knowledge of the principles of heat and thermodynamics.

Topics/areas covered in the Unit:

Outcome 1

- concept of temperature
- Zero'th law and idea of identity of temperature
- the difficulty of quantifying temperature and the assumptions needed to quantify temperature
- Thermoetry explained as the science of quantifying temperature
- volume expansion of fluids
- absence of a natural standard of temperature
- fixed points and empirical nature of temperature scales
- international definition of temperature and temperature scales
- everyday and thermodynamic (absolute) scales
- definition of mechanical stress, Young's modulus and use of expansion theory to calculate expansion coefficients and thermal stresses

Candidates should perform suitable practical work related to this Outcome, this could be, for example, calculating Young's modulus for a length of wire.

Outcome 2

- the effect of temperature difference on matter
- heat as a form of energy
- the interchangability of heat and work
- difference between heat and temperature, extensive and intensive properties
- specific heat as a difference of dH/dT
- Fourier equation
- heat loss by conduction
- heat loss by radiation

Higher National Unit specification: support notes (cont)

Unit title: Physics Principles: Heat and Thermodynamics

Outcome 3

- the ideal gas
- constancy of thermal properties
- gas laws, and calculations involving the gas laws
- Firstlaw of thermodynamics to calculate changes in internal energy of systems
- work of expansion (contraction) at constant pressure, temperature and heat content

Outcome 4

- ideal gas laws related to kinetic principles
- assumptions of ideal gas composed of particles with zero mutual interaction and zero particle volume, perfectly elastic recoil and obeying macroscopic laws of mechanics
- random distribution of momentum
- statistical nature of theory, applicable only to very large number particles

Guidance on the delivery and assessment of this Unit

Whilst this could be delivered as a standalone Unit, it has been designed as part of the HNC/HND Chemical Process Technology. The Unit requires candidates to be familiar with the fundamental concepts of the physics principles, heat and thermodynamics.

Independent study should be encouraged by the use of candidate centred learning material although it is envisaged that candidates will require a significant amount of planned instruction.

The assessments for Outcomes 1, 2, 3 and 4 could be taken by the candidates at the completion of each Outcome. The assessments should be taken under supervised conditions. The practical elements of Outcomes 1 and 3 could be completed at any time during the delivery of these Outcomes when the candidate could apply much of the theory learned during this period.

A note on the Evidence Requirements

The Evidence Requirements state that candidates must ‘provide reasonable answers’ derived ‘from the application of the formulae and correct application of the principles of the calculation’. This allows for acknowledgement of the correct working and application of formulae, even where candidates’ final answer may be inaccurate.

The statement allows for the eventuality where a single error at one stage in an extended calculation sequence has a cumulative effect on the final answer, even though working/formulae are otherwise correctly applied. Acknowledgement of the correct working should be given in such cases.

Higher National Unit specification: support notes (cont)

Unit title: Physics Principles: Heat and Thermodynamics

Opportunities for developing Core Skills

There are opportunities to develop the Core Skill of *Numeracy* and the component Critical Thinking of the Core Skill of *Problem Solving* at SCQF level 6 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Throughout this Unit candidates are required to perform calculations, manage formulae and use equations that provide the opportunity to develop the Core Skill of *Numeracy* at SCQF level 6. In Outcome 1 candidates will also be required to interpret and plot graphs which will aid development of Numeracy skills.

The presentation of practical laboratory experiments which require candidates to interpret results and draw conclusions will develop the Critical Thinking component of *Problem Solving*, at SCQF level 6.

Open learning

If this Unit is delivered by open or distance learning methods, additional planning resources may be required for candidate support, assessment and quality assurance. The practical aspects of the Unit may make certain aspects of delivery via Open Learning difficult to arrange.

Candidates with disabilities and/or additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering alternative Outcomes for Units. Further advice can be found in the SQA document *Guidance on Assessment Arrangements for Candidates with Disabilities and/or Additional Support Needs* **(www.sqa.org.uk)**.

General information for candidates

Unit title: Physics Principles: Heat and Thermodynamics

Whilst this Unit may be studied on a standalone basis, it has been designed as a single-credit HN Unit at SCQF level 7 intended for candidates undertaking HNC/HND Chemical Process Technology. It is designed to provide you with knowledge of the principles of heat and thermodynamics. Whilst access to the Unit is at the discretion of the centre it would be beneficial if you had studied mathematics and/or physics at SCQF level 6.

On completion of this Unit you should be able to:

1 Apply the concepts of temperature and heat to determine thermal expansion parameters.
2 Apply temperature difference to heat transfer processes.
3 Apply the First Law of Thermodynamics to physical systems.
4 Apply the kinetic theory of gases to explain the properties of gases.

You will learn about expansion and contraction and solve problems relating to them, you will learn about heat transfer by conduction or radiation and apply the theory to solve numerical problems relevant to the workplace, and you will learn about gas laws and apply these to an ideal gas. You will have an understanding of different temperature scales and be able to illustrate the Zero'th law of thermodynamics.

For part of the Unit you will undertake suitable practical experiments to provide a context to the theory learned.

The four Outcomes may be assessed in four different assignments, under supervised conditions. You will also write laboratory reports for two practical experiments you perform.

Throughout the Unit you will also have the opportunity to develop Core Skills in *Numerac*y, and *Problem Solving* at SCQF level 6. You will perform calculations, manage formulae and equations that may develop the Core Skill of *Numeracy* at SCQF level 6. You will also be required to interpret and plot graphs, which again provides the opportunity to develop the Core Skill of *Numeracy*.

The laboratory-based practical work provides opportunities to develop critical thinking skills, ensuring development of the Critical Thinking component of the Core Skill of *Problem Solving*, at SCQF level 6.