SQA Advanced Unit Specification

General information for centres

Unit title: Thermodynamics and Kinetics

Unit code: HV99 48

Unit purpose: This Unit is designed to give candidates the underpinning chemistry knowledge, problem solving skills and practical techniques associated with the concepts of Thermodynamics and Kinetics. The practical element of this Unit will support the theoretical aspects and also further develop candidate's practical, analytical and communication skills.

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

1 Describe and use the main principles, laws and formulae associated with chemical thermodynamics.
2 Describe and use the main principles, laws and formulae associated with chemical kinetics.
3 Perform associated chemical techniques and explain the results.

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

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

Recommended prior knowledge and skills: Access to this Unit is at the discretion of the centre, however it is preferable for candidates to be able to demonstrate a knowledge of Physical Chemistry at SCQF level 7. This may be the result of relevant work experience or might be by the possession of the Unit Fundamental Concepts of Physical Chemistry.

Core skills: There may be opportunities to gather evidence towards the Core Skills of Problem Solving, Communication and IT 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: This Unit will be assessed holistically on the theoretical aspects of the content. Assessment will take the form of structured questions based on a sample of the knowledge and skills taught. This assessment will take place under closed-book, controlled conditions and Outcomes 1 and 2 will be assessed together in a single assessment. There should be a mixture of short answer, extended response and structured questions in each part of the assessment. Outcome 3 will be assessed by means of a laboratory report and a laboratory diary for the specified number of experiments.

Candidates will have access to the SQA Databook for Higher/Advanced Higher Chemistry when sitting the assessment. Candidates may also have access to a formula sheet.

Unit specification: statement of standards

Unit title: Thermodynamics and Kinetics

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

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

Outcome 1

Describe and use the main principles, laws and formulae associated with chemical thermodynamics

Knowledge and/or skills

- reaction enthalpies and their temperature variation
- deductions from entropy data concerning the spontaneity of a process
- chemical equilibrium
- chemical equilibria calculations using thermodynamic data
- Clapeyron equation
- Clausius-Clapeyron equation
- validity of Clausius-Clapeyron equation

Evidence requirements

Candidates will need to provide evidence to demonstrate the knowledge and/or skills by showing that they can display competence in a sample of five out of seven of the knowledge and skills on a single occasion. Assessment will be carried out holistically with Outcome 2. This will be under closed-book controlled conditions.

- calculation involving reaction enthalpies and their temperature variation
- deductions from entropy data concerning the spontaneity of a process
- description of factors affecting chemical equilibrium
- chemical equilibria calculations using thermodynamic data
- calculations using the Clapeyron equation
- calculations using Clausius-Clapeyron equation
- identification of conditions necessary for the validity of the Clausius-Clapeyron equation

There should be a mixture of short answer, extended response and structured questions in each part of the assessment. The pass mark for the assessment will be 60%.

Assessment of this Unit will be integrated with that of Outcome 2 in a single assessment.

Assessment guidelines

Where possible candidates should be made aware of the relationship between different topics and encouraged to view the Unit holistically and also to foster links between the various theoretical aspects and the exercises in the practical Outcome. A sympathetic approach may be given to mathematical errors in calculations providing that it is evident that the underlying principles are understood.

Outcome 2

Describe and use the main principles, laws and formulae associated with chemical kinetics

Knowledge and/or skills

- reaction mechanisms in terms of elementary steps
- determining reaction order
- order, rate constant and half-life of reactions using the laws governing rates
- effect of temperature on reaction rate in terms of activation energy
- Arrhenius equation
- catalytic activity with respect to activation energy effects and adsorption theories

Evidence requirements

Candidates will need evidence to demonstrate their knowledge and/or skills by showing that they can display competence in a sample of four out of six of the above list of knowledge and skills on a single occasion. This will be under closed-book controlled conditions. There should be a mixture of short answer, extended response and structured questions in each part of the assessment. The pass mark for the assessment will be 60%.

- reaction mechanisms in terms of elementary steps
- methods of determining reaction order
- calculations of order, rate constant and half-life of reactions using the laws governing rates
- effect of temperature on reaction rate in terms of activation energy
- calculations involving the Arrhenius equation
- catalytic activity with respect to activation energy effects and adsorption theories

Assessment of this Unit will be integrated with that of Outcome 1 in a single assessment.

Assessment guidelines

Where possible candidates should be made aware of the relationship between different topics and encouraged to view the Unit holistically and also to foster links between the various theoretical aspects and the exercises in the practical Outcome. Assessment of this Unit may be integrated with that of Outcome 1 in a single assessment of 1.5 hours.

Outcome 3

Perform associated chemical techniques and report and explain the results concisely

Knowledge and/or skills

- follow instructions to perform a range of chemical experiments
- work in a safe manner regarding current health and safety regulations
- achieve consistent and accurate results
- evaluate errors implicit in experimental results
- report and interpret the results clearly and concisely and relate to theoretical aspects

Evidence requirements

Evidence for this Outcome will be provided by the candidate performing at least two practical assignments from different categories shown in the support notes. It is recommended that the candidate should perform a wide range of practical assignments but that only two practicals from the list provided in the support notes, or equivalent alternatives, should be used for assessment purposes.

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

(a) are of an equivalent standard in terms of skills development
(b) have a direct relationship to a theoretical topic covered in Outcomes 1 and 2
(c) can be placed in one of the two categories A or B

The candidate should produce a laboratory report for one practical. This should be assessed on their:

- performance in completing the laboratory work
- ability to produce a satisfactory laboratory report
- interpretation/explanation of the theoretical aspects of their experiments as appropriate and their ability to discuss the levels of risk

A checklist and the record of results and calculations in a laboratory diary or pro forma should be used to assess performance in the laboratory. This checklist will recognise the need for accuracy and also error evaluation. A laboratory report for one practical should be produced to assess the candidate's ability to plan, analyse and discuss laboratory work. Candidates who fail to submit a satisfactory report will be required, after suitable remediation, to submit an additional report for another experiment.

Assessment guidelines

The experiment selected for assessment purposes should cover a range of techniques to provide a guide to the candidates' all round practical ability. Candidates should be encouraged to view the Unit holistically and also to foster links between the various theoretical aspects and the exercises in the practical Outcome. Candidates will need to become familiar with the evaluation of error.

Administrative information

Unit code: HV99 48

Unit title: Thermodynamics and Kinetics

Superclass category: RD

Date of publication: November 2017

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 SQA Advanced Qualifications.

FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form.

Unit specification: support notes

Unit title: Thermodynamics and Kinetics

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

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

Guidance on the content and context for this Unit

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

Some topics in this Unit are covered at a more elementary level in Fundamental concepts of Physical Chemistry and Fundamental Chemistry: Theory and Practice. Their inclusion here allows an opportunity for revision.

Outcome 1

Candidates should be able to:

- understand the concepts of bond dissociation energy and bond energy
- carry out the calculation of ΔH from bond energies
- apply the Kirchhoff equation
- carry out calculations of the entropy changes for change of temperature, change of phase, change of pressure and volume
- understand and describe the concepts of the reaction isotherm and the relationship between K and temperature and the variation of ΔG with activity
- carry out calculations involving the relationship between ΔG and K
- use thermodynamic data tables
- understand and calculate the effect of pressure on transition temperature for phase changes
- discuss and use the Clapeyron and Clausius-Clapeyron equations and the conditions in which they may be applied

Outcome 2

Candidates should be able to:

- describe reaction mechanisms in terms of elementary steps
- use the methods for determining reaction order
- perform calculations of order, rate constant and half-life of reactions using the laws governing rates
- apply the effect of temperature on reaction rate in terms of activation energy
- perform calculations involving the Arrhenius equation
- understand and describe catalytic activity with respect to activation energy effects and adsorption theories

Outcome 3

Candidates should be introduced to at least two practical techniques from different categories shown below:

1 Category A. Experiments in Thermodynamics

Possible experiments:

(a) Determine the vapour pressure of water over a range of temperatures and hence obtain a value for its latent heat.
(b) Determine the equilibrium constant for the esterification of ethanoic acid over a range of temperatures and use this to obtain a value for ΔG.

2 Category B. Experiments in Kinetics

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Possible experiments:

(a) Hydrolysis of methyl methanoate in excess aqueous solution.
(b) Hydrolysis of methyl methanoate in dilute NaOH solution.
(c) Determination of the energy of activation for the reaction of bromide and bromate ions.
(d) Kinetics of reactions with a sulphonic acid ion exchange resin.

A laboratory diary or pro forma will be kept and learners should be introduced to Standard Operating Procedures (SOPs). Laboratory reports should be in an appropriate format. Health and Safety, in regard to risk and COSHH assessments should be emphasised at all times.

Guidance on the delivery and assessment of this Unit

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

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

The assessment of Outcomes 1 and 2 is by a holistic end of Unit test which could be worth 50 marks. This should cover five out of the seven topics taught from Outcome 1 and four out of the six topics from Outcome 2. Should candidates fail to gain 60% marks on a single occasion then they should be offered a second attempt after sufficient remediation.

Outcomes 1 and 2 will be assessed together in a single assessment of 1.5 hours.

In Outcome 3 candidates should be assessed on their ability to perform laboratory work to a required standard. For example titration results should be both accurate and consistent and determination of constants should be within the limits of the experimental methods used. Practical work may provide an opportunity for candidates to develop the core skill of working with others. Error evaluation and graphical treatment of experimental data should be used where appropriate and candidates should be encouraged to discuss the relationship between the laboratory exercises and the theoretical aspects covered in Outcomes 1 and 2.

Open learning

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

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

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

Equality and inclusion

This unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence.

Further advice can be found on our website www.sqa.org.uk/assessmentarrangements.

General information for candidates

Unit title: Thermodynamics and Kinetics

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

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

On completion of this Unit you should be able:

1 Describe and use the main principles, laws and formulae associated with chemical thermodynamics.
2 Describe and use the main principles, laws and formulae associated with chemical kinetics.
3 Perform chemical techniques and report and explain the results concisely.

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

Outcome 1

In this Outcome you will cover the following:

- the concepts of bond dissociation energy and bond energy
- the calculation of ΔH from bond energies
- application of the Kirchhoff equation
- the calculation of the entropy changes for change of temperature, change of phase, change of pressure and volume
- the description of the concepts of the reaction isotherm and the relationship between K and temperature and the variation of ΔG with activity
- the use of calculations involving the relationship between ΔG and K
- how to use thermodynamic data tables
- the effect and calculation of pressure on transition temperature for phase changes
- how to use the Clapeyron and Clausius-Clapeyron equations and the conditions in which they may be applied

Outcome 2

In this Outcome you will cover the following:

- the distinction between overall equation and mechanism
- determine molecularity of elementary steps (consecutive and chain mechanisms)
- be able to define reaction rate. rate equation; order of reaction; rate constant; half-life for zero, first and second order reactions
- discuss and describe the methods for determining order
- apply and use integrated rate equations, initial rates, half-life method
- understand the relationship between rate of reaction and temperature
- apply the Arrhenius equation
- carry out calculations on any of the above
- describe and discuss the theories of adsorption and their application to catalysis

Outcome 3

In this Outcome you will carry out at least two practical techniques which may involve volumetric analysis and the determination of thermodynamic and kinetic values. You will be encouraged to understand the need for accuracy and the underlying principles behind the experiments you undertake. You will learn the following skills:

How to:

- follow instructions to perform a range of chemical experiments
- work in a safe manner regarding current health and safety regulations
- achieve consistent and accurate results
- evaluate levels of error
- report and interpret the results clearly and concisely and relate to theoretical aspects

Assessment

Outcomes 1 and 2 will be assessed together using a single, end of Unit, closed-book test of 1.5 hours. The pass mark for the test will be 60%. If you fail to gain 60% marks you will be offered a second attempt after sufficient remediation. It is envisaged that you will have access to the SQA Databook for Higher/Advanced Higher Chemistry when sitting the assessment. You may also have access to a data sheet.

Outcome 3 will be assessed using at least 2 laboratory exercises. You will be required to perform at least two experiments to the required standard and to produce a laboratory report for one. You will be required to keep a laboratory diary and to be aware of the risks involved and the precautions to reduce them. If you fail to submit a satisfactory report you will be required, after suitable remediation, to submit an additional report for another experiment. A checklist and the record of results and calculations in a laboratory diary will be used to assess your performance in the laboratory. This checklist will recognise the need for accuracy and error evaluation.