Scheme of Work

AQA Level 3 Certificate and Extended Certificate in Applied Science

**Unit 2**: Applied Experimental Techniques **Unit type:** Centre assessed and externally quality assured

**Guided learning hours:** 60

**Guidance notes**

This scheme of work is a plan of what will be covered in each week or session of the learning programme or course.  It will detail over 30 weeks the delivery of the Applied Science course content for Unit 2 and the evidence required to report on each experimental technique. The scheme of work will also suggest resources and ideas for practical work that can illustrate the written content.

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| **Synoptic learning and assessment** | |
| **Unit 2: Applied Experimental Techniques** | **Unit 1: Key Concepts in Science** |
| 1b: The Hill reaction | 1a: Cell structure |
|  | 1b: Transport mechanisms |
| 1a: Rate of respiration | 1c: The heart |
| 1a: Rate of respiration | 1d: Homeostasis |
| 1a: Rate of respiration | 1e: Breathing / Cell respiration |
| 1b: The Hill reaction | 1f: Photosynthesis / Food chains |
| 2a: Volumetric analysis / 2b: Colorimetry | 2a: Atomic structure |
| 2a: Volumetric analysis / 2b: Colorimetry | 2b: Periodic Table |
| 2a: Volumetric analysis | 2c: Amount of substance |
| 2b: Colorimetry | 2d: Bonding and structure |
| 2a: Volumetric analysis | 2e: Enthalpy |
| 3b: Specific heat capacity | 3a: Useful energy and efficiency |
| 3a: Resistivity | 3b: Electricity and circuits |
|  | 3c: Dynamics |

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| **Week** | **Specification reference** | **Key learning objectives**  Consider inclusion and differentiation  (as appropriate and relevant)  Equality and diversity in blue (to be enhanced by unit teacher as appropriate for learner group) | **Learning activities and resources**  What will be learner-led?  What will be tutor-led?  Topics for plenary?  Homework?  Classroom-based or off-site?  Employer engagement?  Stretch and challenge in red (to be enhanced by unit teacher as appropriate for learner group) | **Plenary**  How will learner  progress be checked?  Evidence  requirements? | **Skills**  Opportunities for skills development  Maths in purple  English in green  Transferable skill opportunities in orange |
| 1 | PO1(a)  Demonstrate  applied  experimental  techniques in  biology:  rate of respiration  PO4  Understand safety procedure and risk assessment when undertaking  scientific practical work | **P1**  Outline the physiological measurements used in relation to the rate of  respiration and photosynthesis  **P10**  In using experimental techniques:   * safely use a range of practical   equipment and materials   * identify hazards * produce risk assessments for **one** applied experimental technique from   **each** of biology, chemistry and physics | **Rate of respiration**  Tutor introduction to unit. Tutor-led discussion on the physiological measurements in respiration and the ethical treatment of all organisms.  Links should be made to Unit 1 to show the roles the heart, respiration and homeostasis play in the rate of respiration.  Tutor-led discussion on risk assessments.  Tutor to demonstrate respiration physiology techniques using peak flow meter and spirometer to show lung volumes and  respiration rates. Using a sphygmomanometer  to show heart rate and blood pressure.  Learners complete appropriate risk assessments (**P10**)and then carry out these techniques on their group. Learners to practise techniques and obtain reproducible results (**P1**).  [yyy.rsmas.miami.edu/groups/ambient/teacher/air/MODULE%20SEGMENTS/V%20PeakFlowMeterExercise.pdf](http://yyy.rsmas.miami.edu/groups/ambient/teacher/air/MODULE%20SEGMENTS/V%20PeakFlowMeterExercise.pdf)  [www.scribd.com/doc/149337998/Measuring-Lung-Capacity-Using-Portable-Spirometer/](https://www.scribd.com/doc/149337998/Measuring-Lung-Capacity-Using-Portable-Spirometer/)  [www.bloodpressureuk.org/BloodPressureandyou/Thebasics/Bloodpressure/](http://www.bloodpressureuk.org/BloodPressureandyou/Thebasics/Bloodpressure/) | Tutor observation  of risk assessments  Tutor observation  of practical techniques | Oral communication  during discussion  Practical skills and health and safety  Recording data and carrying out  calculations |

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| **Week** | **Specification reference** | **Key learning objectives** | **Learning activities and resources** | **Plenary** | **Skills** |
| 2 | PO1(a)  Demonstrate  applied  experimental  techniques in  biology:  rate of respiration  PO4  Understand safety procedure and risk assessment when undertaking  scientific practical work | **M1**  Explain the scientific principles of physiological measurements used in relation to respiration and photosynthesis  **D1**  Explain how these physiological measurements can be applied in a medical or commercial context | Learner-led research into the principles of peak flow, lung volumes, respiration rate, and blood pressure measurement. Learners using the results obtained from the previous session, books and the websites shown below (**M1**).  Tutor divides the class into small groups to investigate the application of these measurements in a medical or commercial context (**D1**).  Class comes together for a plenary session of their findings under the guidance of the tutor.  Learners produce a written report, to be completed for homework, covering the use of physiological measurements. They will be **stretched and challenged** by the complexity of their response.  [www.nhscareers.nhs.uk/explore-by-career/healthcare-science/careers-in-healthcare-science/careers-in-physiological-sciences/](http://www.nhscareers.nhs.uk/explore-by-career/healthcare-science/careers-in-healthcare-science/careers-in-physiological-sciences/).  [www.prospects.ac.uk/exercise\_physiologist\_job\_description.htm](http://www.prospects.ac.uk/exercise_physiologist_job_description.htm) | Discussion of  research findings  Notes made during  research and written report | Oral communication  during discussion  Written  communication  Research |

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| **Week** | **Specification reference** | **Key learning objectives** | **Learning activities and resources** | **Plenary** | **Skills** |
| 3 | PO1(b)  Demonstrate  applied  experimental  techniques in  biology: the light dependent reaction in photosynthesis (the Hill reaction)  PO4  Understand safety procedure and risk assessment when undertaking  scientific practical work | **P1**  Outline the physiological measurements used in relation to the rate of respiration and photosynthesis  **P10**  In using experimental techniques:   * safely use a range of practical   equipment and materials   * identify hazards * produce risk assessments for **one** applied experimental technique from   **each** of biology, chemistry and physics | **Rate of photosynthesis**  Tutor-led discussion on physiological measurements in photosynthesis, such as oxygen levels and starch production and biomass.  Website below gives experiments to show the conditions required for photosynthesis, measurement of starch, rate of photosynthesis and dependency on light (**P1**).  Links should be made to Unit 1 plant cell ultrastructure, especially chloroplasts and vacuoles.  Learners to complete appropriate risk assessment (**P10**) and practise familiar techniques (GCSE level), such as collection of oxygen from aquatic oxygenating plants, testing leaves / leaf discs for starch and measuring plant biomass to obtain reproducible results.  Links should be made to Unit 1, photosynthesis and food chain productivity.  [www.nuffieldfoundation.org/practical-biology/photosynthesis](http://www.nuffieldfoundation.org/practical-biology/photosynthesis)  [saps.org.uk](http://saps.org.uk)  <http://lehiffa.org/Bushman/>  (see ‘Plant anatomy & physiology’ PowerPoint) | Tutor observation  of risk assessments  Tutor observation  of practical techniques | Oral communication  during discussion  Practical skills and health and safety |

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| **Week** | **Specification reference** | **Key learning objectives** | **Learning activities and resources** | **Plenary** | **Skills** |
| 4 | PO1(b)  Demonstrate applied experimental techniques in biology: the  light-dependent reaction in photosynthesis (the Hill reaction)  PO4  Understand safety procedure and risk assessment when undertaking scientific practical work | **M1**  Explain the scientific principles of physiological measurements used in relation to respiration and photosynthesis  **D1**  Explain how these physiological measurements can be applied in a medical or commercial context | Learner-led research into the principles of photosynthesis and its measurement, including the following questions: What are the limiting factors? What is the process of photosynthesis (light-dependent and light-independent stages)? How is the energy produced by photosynthesis used?  Links should be made to Unit 1 photosynthesis and food chain productivity (**M1**).  Class comes together to pool their findings under the guidance of the tutor.  Tutor divides the class into small groups to investigate the application of these measurements in, for example, agriculture, medicine and the cosmetic industry (**D1**).  Class comes together with a plenary of their findings under the guidance of the tutor.  Learners produce a written report, to be completed for homework, covering the physiological measurements researched in weeks 1, 2, 3 and 4, and will be **stretched and challenged** by the complexity of their response.  [www.labochema.com/applications-category/plant-physiology/](http://www.labochema.com/applications-category/plant-physiology/) | Discussion of  research findings  Notes made  during research and written report | Oral communication  during discussion  Written  communication  Research |

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| **Week** | **Specification reference** | **Key learning objectives** | **Learning activities and resources** | **Plenary** | **Skills** |
| 5 | PO1(a)  Demonstrate applied experimental techniques in biology:  rate of respiration  PO4  Understand safety procedure and risk assessment when undertaking scientific practical work | **P2**  Follow a standard procedure to measure the effect of varying **one** given factor on the rate of respiration of a living organism and record results (practice run)  **P10**  In using experimental techniques:   * safely use a range of practical   equipment and materials   * identify hazards * produce risk assessments for **one** applied experimental technique from   **each** of biology, chemistry and physics | Tutor introduces respirometers and their use. The types of organisms that may be used are discussed (living seeds, woodlice, Calliphora larvae) and ethical treatment is considered. Factors affecting respiration rates are explored and their practical applications are considered.  Learners to complete appropriate risk assessment depending on the organism used (**P10**).  Learners work in small groups to consider one of these factors and then practise the techniques in order to obtain reproducible results, noting where improvements can be made (**P2**).  Learner plenary to select their choice of experiment and chosen factor for next week and to submit a request form.  **Stretch and challenge** - complete practical work with no tutor help.  [www.nuffieldfoundation.org/practical-biology/measuring-respiratory-quotient](http://www.nuffieldfoundation.org/practical-biology/measuring-respiratory-quotient) | Tutor observation of practical techniques  Tutor observation of risk assessments and request form | Practical skills and health and safety |

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| **Week** | **Specification reference** | **Key learning objectives** | **Learning activities and resources** | **Plenary** | **Skills** |
| 6 | PO1(a)  Demonstrate applied experimental techniques in biology: rate of respiration  PO4  Understand safety procedure and risk assessment when undertaking scientific practical work | **P2**  Follow a standard procedure to measure the effect of varying **one** given factor on the rate of respiration of a living organism and record results  **P10**  In using experimental techniques:   * safely use a range of practical   equipment and materials   * identify hazards * produce risk assessments for **one** applied experimental technique from **each** of biology, chemistry and physics | Learner-led practical work.  Each learner to check risk assessment and request form orders before starting practical work.  Learner-led practical work for chosen respirometer experiment.   * Check equipment * Follow given procedures to obtain correct data * Record results and carry out calculations * Check accuracy of results * Give equation for the reaction (**P2**)     **Stretch and challenge** - procedure followed with no tutor help, accurate risk assessment, results are clear, sufficient, reproducible / accurate, and correct units used.  [www.nuffieldfoundation.org/practical-biology/measuring-respiratory-quotient](http://www.nuffieldfoundation.org/practical-biology/measuring-respiratory-quotient) | Tutor observation of practical techniques  Tutor observation of risk assessments  and request forms  Correct results  Correct equations | Practical skills and safety  Recording data and carrying out calculations |

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| **Week** | **Specification reference** | **Key learning objectives** | **Learning activities and resources** | **Plenary** | **Skills** |
| 7 | PO1(a)  Demonstrate applied experimental techniques in biology:  rate of respiration | **M2**  Use formulas / calculations / graphical  representations to explain the data  **D2**  Evaluate the results and the method used | Tutor introduces the requirements for a scientific report and provides guidance on data representation and analysis.  One format for a scientific report is:   * aim * hypothesis * apparatus / chemicals * method * results (**P2**) / (**M2**) * conclusion (**M2**) * evaluation (**D2**).   Learners consider suitable ways to present and analyse data (tables, calculations, graphs) for the respiratory quotient and temperature coefficient (RQ / Q10).  Class discusses the results generated and the procedure followed. These are evaluated for **D2**,taking into consideration precision and analysis of the data.  Learners produce a written report, to be completed for homework, covering the respirometer experiment, and will be **stretched and challenged** by the complexity of their response.  [www.nuffieldfoundation.org/practical-biology/measuring-respiratory-quotient](http://www.nuffieldfoundation.org/practical-biology/measuring-respiratory-quotient) | Discussion of results  Written report | Oral communication  during discussion  Written  communication for report  Recording data and carrying out calculations |

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| **Week** | **Specification reference** | **Key learning objectives** | **Learning activities and resources** | **Plenary** | **Skills** | |
| 8 | PO1(b)  Demonstrate applied experimental techniques in biology: the light-dependent reaction in photosynthesis (the Hill reaction)  PO4  Understand safety procedure and risk assessment when undertaking scientific practical work | **P3**  Follow a standard procedure to measure the Hill reaction and record results (practice run)  **P10**  In using experimental techniques:   * safely use a range of practical   equipment and materials   * identify hazards * produce risk assessments for **one** applied experimental technique from **each** of biology, chemistry and physics | Tutor introduces the procedure for the Hill reaction, introducing apparatus and chemicals, and relates its use. Tutor emphasis on working quickly and accurately whilst keeping all relevant materials cool. Collaborative working is advisable.  This should be linked to knowledge of plant cell structure and to the two stages of photosynthesis from Unit 1.  Learners to complete appropriate risk assessment (**P10**).  Learners to work in pairs / small groups to practise techniques and obtain reproducible results. Make notes about where improvements can be made (**P3**).  Learners to submit a detailed request form for next week’s practical, including any special requirements.  **Stretch and challenge** - complete practical work and request form with no tutor help.  [www.nuffieldfoundation.org/practical-biology/photosynthesis](http://www.nuffieldfoundation.org/practical-biology/photosynthesis)  [www.nuffieldfoundation.org/practical-biology/investigating-light-dependent-reaction-photosynthesis](http://www.nuffieldfoundation.org/practical-biology/investigating-light-dependent-reaction-photosynthesis)  [www.youtube.com/watch?v=i9\_h3TSIJzM](https://www.youtube.com/watch?v=i9_h3TSIJzM) | Tutor observation of practical techniques  Tutor observation of risk assessments and request form | Practical skills and health and safety | |
| **Week** | **Specification reference** | **Key learning objectives** | **Learning activities and resources** | **Plenary** | | **Skills** | |
| 9 | PO1(b)  Demonstrate applied experimental techniques in biology: the light-dependent reaction in photosynthesis (the Hill reaction)  PO4  Understand safety procedure and risk assessment when undertaking scientific practical work | **P3**  Follow a standard procedure to measure the Hill reaction and record results  **P10**  In using experimental techniques:   * safely use a range of practical   equipment and materials   * identify hazards * produce risk assessments for **one** applied experimental technique from **each** of biology, chemistry and physics | Learner-led practical work.  Each learner to check risk assessment and request forms before starting practical work.  Learner-led practical work for Hill reaction experiment. Learners to work in pairs / small groups. Follow given procedures to obtain correct data (**P3**).  Record results and carry out calculations including graphical representation of the results.  Give equation for the reaction.  **Stretch and challenge** - procedure followed with no tutor help. Accurate risk assessment, results are clear, sufficient, reproducible / accurate, and correct units used.  [www.biologymad.com/master.html?http://www.biologymad.com/PhotosynResp/PhotosynResp.htm](http://www.biologymad.com/master.html?http://www.biologymad.com/PhotosynResp/PhotosynResp.htm)  <http://openwetware.org/wiki/BISC110:_Series_3_Experiment_9_Hill_Reaction>  [www.nuffieldfoundation.org/practical-biology/investigating-light-dependent-reaction-photosynthesis](http://www.nuffieldfoundation.org/practical-biology/investigating-light-dependent-reaction-photosynthesis) | Tutor observation of practical techniques  Tutor observation of risk assessments  Correct results  Correct equations | | Practical skills and safety  Recording data and carrying out calculations | |

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| **Week** | **Specification reference** | **Key learning objectives** | **Learning activities and resources** | **Plenary** | **Skills** |
| 10 | PO1(b)  Demonstrate applied experimental techniques in biology:  the light-dependent reaction in photosynthesis (the Hill reaction) | **M2**  Use formulas / calculations / graphical  representations to explain the data  **M3**  Explain how this standard procedure could be adapted to investigate **three** limiting factors | Tutor recaps on the requirements for a scientific report (see week 7) and provides guidance on data representation and analysis.  Learners consider suitable ways to present and analyse the data. Use formulas and calculations and present the data as a graph (**M2**).  Class discusses the results generated and the procedures followed.  What are limiting factors for photosynthesis? These were discussed in weeks 3/4. How can this procedure be used to investigate **three** of these factors? (**M3**)  Learners provided with a guide sheet to support these questions.  Learners produce a written report, to be completed for homework, covering the respirometer experiment and will be **stretched and challenged** by the complexity of their response.  [www.nuffieldfoundation.org/practical-biology/investigating-light-dependent-reaction-photosynthesis](http://www.nuffieldfoundation.org/practical-biology/investigating-light-dependent-reaction-photosynthesis) | Discussion of results  Written report | Oral communication  during discussion  Written  communication for report  Recording data and carrying out calculations |

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| Week | **Specification reference** | **Key learning objectives** | **Learning activities and resources** | **Plenary** | **Skills** |
| 11 | PO2(a)  Demonstrate applied experimental techniques chemistry: volumetric analysis  PO4  Understand safety procedure and risk assessment when undertaking scientific practical work | **P4**  Outline basic principles and uses of volumetric analysis and colorimetry  **M4**  Explain the scientific principles of:   * volumetric analysis * colorimetry with reference to: * standard solutions * choice of indicators * consideration of the Beer-   Lambert Law | **Volumetric analysis**  Tutor-led introduction and outline of the principles and uses of volumetric analysis, for example acid-base, reduction/oxidation, complex ion and precipitation. This should be linked to Unit 1, atomic structure and Periodic Table. The websites below give the principles and uses in medicine, food industry and the production of bio-diesel.  <http://chemistry.tutorvista.com/analytical-chemistry/volumetric-analysis.html>  [www.ehow.com/list\_5772040\_titration-used-industry\_.html](http://www.ehow.com/list_5772040_titration-used-industry_.html)  [www.ehow.com/list\_5968981\_real-life-uses-titration.html](http://www.ehow.com/list_5968981_real-life-uses-titration.html)  For **P4**,using notes made, learners should outline the basic principles and uses of volumetric analysis. For **M4** these principles and uses should be explained with examples.  Consideration given to the reaction data, choice of indicator and end point.  Learners to complete appropriate risk assessment (**P10**) / request form. Learners to practise volumetric analysis techniques, taking into account these principles, and obtain reproducible results.  Complete practical work with no tutor help.  [www.wiredchemist.com/chemistry/instructional/laboratory-tutorials/volumetric-analysis](http://www.wiredchemist.com/chemistry/instructional/laboratory-tutorials/volumetric-analysis) | Tutor observation of written notes  Tutor observation of learner behaviour and written risk assessments and request form  Tutor observation of practical techniques | Practical skills and health and safety  Research  Written communication |

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| Week | Specification reference | Key learning objectives | Learning activities and resources | Plenary | Skills |
| 12 | PO2(a)  Demonstrate applied experimental techniques chemistry: volumetric analysis  PO4  Understand safety procedure and risk assessment when undertaking scientific practical work | **P5**  Follow a standardprocedure for volumetric analysis by:   * preparing a standard solution * carrying out a titration * recording all measurements and data   **M5**  Carry out calculations that support:   * preparation of the standard solution * the titration   **P10**  In using experimental techniques:   * safely use a range of practical equipment and materials * identify hazards * produce risk assessments for **one** applied experimental technique from **each** of biology, chemistry and physics | Learner-led practical work.  Each learner to review the risk assessment and request form before starting practical work (previous session) (**P10**).  Learner-led practical work for chosen volumetric analysis, including preparation of a standard solution, carrying out a titration and recording accurate results to the nearest 0.05 cm3 and titres within =/- 0.10 cm3 (**P5**).  Follow given procedures to obtain correct data.  Learners adhere to risk assessment.  Tutor to introduce calculation relevant to the experiment.  Carry out calculations for the preparation of the standard solution using correct units and precision. Dependent on the titration, learners would work out molarity of an unknown or the endpoint of the titration (**M5**).  Learners to work out equation for the reaction.    **Stretch and challenge** - procedure followed with no tutor help, accurate risk assessment, results are clear, sufficient, reproducible / accurate, and correct units used.  <http://chemistry.tutorvista.com/analytical-chemistry/volumetric-analysis.html>  Practice calculations could be given as homework. | Tutor observation of practical techniques  Tutor observation of risk assessments  and request form  Correct results  Correct equations | Practical skills and health and safety  Recording data and carrying out calculations |

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| Week | Specification reference | Key learning objectives | Learning activities and resources | Plenary | Skills |
| 13 | PO2(a)  Demonstrate applied experimental techniques chemistry: volumetric analysis  PO4  Understand safety procedure and risk assessment when undertaking scientific practical work | **P5**  Follow a standardprocedure for volumetric analysis by:   * preparing a standard solution * carrying out a titration * recording all measurements and data   **M5**  Carry out calculations that support:   * preparation of the standard solution * the titration   **P10**  In using experimental techniques:   * safely use a range of practical equipment and materials * identify hazards * produce risk assessments for **one** applied experimental technique from **each** of biology, chemistry and physics | Completion of learner-led volumetric analysis practical.  Risk assessment / order valid from previous session (**P10**).  Learner-led practical work for chosen volumetric analysis.  Follow given procedures to obtain correct data (**P5**).  Tutor to introduce calculation relevant to the experiment.  Record results and carry out calculations (**M5**).  Give equation for the reaction.  Links should be made to Unit 1, amount of substance.  **Stretch and challenge** - procedure followed with no tutor help, results reproducible / accurate, correct units, identification of primary standards and correct stoichiometric equation for the reaction.  <http://chemistry.tutorvista.com/analytical-chemistry/volumetric-analysis.html> | Tutor observation of practical techniques  Tutor observation of risk assessments  Accuracy of results | Practical skills and health and safety  Recording data and carrying out calculations  Writing up report using correct  scientific  terminology |

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| Week | Specification reference | Key learning objectives | Learning activities and resources | Plenary | Skills |
| 14 | PO2(a)  Demonstrate applied experimental techniques chemistry: volumetric analysis  PO4  Understand safety procedure and risk assessment when undertaking scientific practical work | **M5**  Carry out calculations that support:   * preparation of the standard solution * the titration   **D3**  Explore how the technique is used in industry, with reference to accuracy and precision and the use of primary standards | Tutor to introduce calculation relevant to the experiment.  Record results and carry out calculations (**M5**).  Give equation for the reaction.  Links should be made to Unit 1, amount of substance.  Learner-led work:   * correctly record data * carry out calculations * work out correct equations (**M5**).   Check the above from the previous session.  Research into:   * uses in industry for the volumetric analysis * use of primary standard solutions and indicators * what is accuracy? * what is precision? * what is the difference between accuracy and precision? (**D3**)   **Stretch and challenge** - identification of underlying scientific principles, accurate / precise calculations and detailed examples of primary standards and uses in industry. Give clear references.  [www.ausetute.com.au/titrstand.html](http://www.ausetute.com.au/titrstand.html)  [www.rsc.org/learn-chemistry/resource/res00001274/measurement-accuracy-and-precision?cmpid=CMP00002674](http://www.rsc.org/learn-chemistry/resource/res00001274/measurement-accuracy-and-precision?cmpid=CMP00002674) | Learner evidence covering P4, P5, M4, M5, D3 | Writing up report using correct  scientific  terminology  Calculations and equations  Research skills |

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| Week | Specification reference | Key learning objectives | Learning activities and resources | Plenary | Skills |
| 15 | PO2(a)  Demonstrate applied experimental techniques chemistry: volumetric analysis | **M5**  Carry out calculations that support:   * preparation of the standard solution * the titration   **D3**  Explore how the technique is used in industry, with reference to accuracy and precision and the use of primary standards | Tutor to introduce calculation relevant to the experiment.  Record results and carry out calculations (**M5**).  Give equation for the reaction.  Links should be made to Unit 1, amount of substance.  Learner-led work:   * correctly record data * carry out calculations * work out correct equations (**M5**).   Research into:   * uses in industry for the volumetric analysis * use of primary standard solutions and indicators * what is accuracy? * what is precision? * what is the difference between accuracy and precision? (**D3**)   **Stretch and challenge** - independent working for **D3**.  [www.rsc.org/learn-chemistry/resource/res00001274/measurement-accuracy-and-precision?cmpid=CMP00002674](http://www.rsc.org/learn-chemistry/resource/res00001274/measurement-accuracy-and-precision?cmpid=CMP00002674) | Learner evidence covering P4, P5, P10, M4, M5, D3 | Calculations and equations  Spellings and grammar used in report  Ability to work unsupervised  Research skills |

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| Week | Specification reference | Key learning objectives | Learning activities and resources | Plenary | Skills |
| 16 | PO2(b)  Demonstrate applied experimental techniques chemistry: colorimetric analysis  PO4  Understand safety procedure and risk assessment when undertaking scientific practical work | **P4**  Outline basic principles and uses of colorimetry  **M4**  Explain the scientific principles of colorimetry with reference to:   * standard solutions * choice of indicators * consideration of the Beer-Lambert Law   **P10**  In using experimental techniques:   * safely use a range of practical   equipment and materials   * identify hazards * produce risk assessments for **one** applied experimental technique from **each** of biology, chemistry and physics | Tutor-led introduction and outline of the principles of colorimetry: light absorption/wavelength and Beer-Lambert Law.  Links should be made with Unit 1, atomic structure and the Periodic Table.  Tutor-led recap on risk assessments and request form.  Tutor to demonstrate colorimetry techniques and associated practical techniques e.g. making standard solutions.  Learners to complete appropriate risk assessment (**P10**).  Learners to practise techniques of colorimetry and obtain reproducible results.  **Stretch and challenge** - complete practical work and risk assessment with no tutor help.  [www.azosensors.com/Article.aspx?ArticleID=324](http://www.azosensors.com/Article.aspx?ArticleID=324)  [www.docbrown.info/page07/appendixtrans09.htm](http://www.docbrown.info/page07/appendixtrans09.htm)  [www2.vernier.com/sample\_labs/CHEM-A-17-COMP-beers\_law.pdf](http://www2.vernier.com/sample_labs/CHEM-A-17-COMP-beers_law.pdf) | Tutor observation of practical techniques  Tutor observation of risk assessments and request form | Practical work and health and safety  Following  instructions  Research skills |
| Week | Specification reference | Key learning objectives | Learning activities and resources | Plenary | Skills |
| 17 | PO2(b)  Demonstrate applied experimental techniques chemistry: colorimetric analysis  PO4  Understand safety procedure and risk assessment when undertaking scientific practical work | **P6**  Follow a standard procedure for colorimetric analysis using solution dilutions by:   * recording all data and measurements * producing a calibration curve * determining the unknown concentration   **P10**  In using experimental techniques:   * safely use a range of practical   equipment and materials   * identify hazards * produce risk assessments for **one** applied experimental technique from **each** of biology, chemistry and physics | Learner-led practical work.  Each learner to complete a risk assessment / request form before starting practical work.  Learner-led practical work for chosen colorimetric analysis.  Follow given procedures to obtain correct data, record all data and measurements.  Learners adhere to risk assessment and request form.  Record results and carry out calculations.  Prepare the serial dilutions, within an appropriate range, using the website below to give accurate and reproducible results. Work out calibration curve and determine the unknown concentration, preferably using absorbance rather than transmission (**P6**).  Learners to start writing up their experimental report from their notes.    **Stretch and challenge** - procedure followed with no tutor help, accurate risk assessment, and results are clear, sufficient, reproducible / accurate, and correct units used.  <http://abacus.bates.edu/~ganderso/biology/resources/dilutions.html>  [www.globalw.com/support/colorimeter.html](http://www.globalw.com/support/colorimeter.html)  [www2.vernier.com/sample\_labs/CHEM-A-17-COMP-beers\_law.pdf](http://www2.vernier.com/sample_labs/CHEM-A-17-COMP-beers_law.pdf) | Tutor observation of practical techniques  Tutor observation of risk assessments / request form  Correct results  Correct calibration  curve | Practical skills and health and safety  Calculations |
| Week | Specification reference | Key learning objectives | Learning activities and resources | Plenary | Skills |
| 18 | PO2(b)  Demonstrate applied experimental techniques chemistry: colorimetric analysis  PO4  Understand safety procedure and risk assessment when undertaking scientific practical work | **P6**  Follow a standard procedure for colorimetric analysis using solution dilutions by:   * recording all data and measurements * producing a calibration curve * determining the unknown concentration   **M6**  Explain the choice of  filter/wavelength, describing any inconsistencies in the data recorded and making reference to the Beer-Lambert Law  **P10**  In using experimental techniques:   * safely use a range of practical equipment and materials * identify hazards * produce risk assessments for **one** applied experimental technique from **each** of biology, chemistry and physics | Completion of learner-led colorimetric analysis practical.  Risk assessment / request form valid from previous session.  Tutor to introduce the use of different filters and wavelengths.  Learner-led practical work for chosen analysis. Follow given procedures to obtain correct data.  Record accurate results and carry out calculations.  Using calibration curve produced for the reaction, learner to determine the unknown concentration.  Write up the report in the correct format (see week 15) (**P6**).  Were there any anomalous results with reference to the Beer-Lambert Law?  What filter / wavelength did you choose and why? (**M6**)  **Stretch and challenge** - procedure followed with no tutor help results reproducible / accurate, correct units, identification of primary standards and reference to Beer-Lambert Law.  [www.chemguide.co.uk/analysis/uvvisible/analysis.html](http://www.chemguide.co.uk/analysis/uvvisible/analysis.html) | Tutor observation of practical techniques  Tutor observation of risk assessments / request form    Draft report  Correct results | Practical skills and health and safety  Recording data and carrying out calculations and equations |
| Week | Specification reference | Key learning objectives | Learning activities and resources | Plenary | Skills |
| 19 | PO2(b)  Demonstrate applied experimental techniques chemistry: colorimetric analysis | **M6**  Explain the choice of  filter/wavelength, describing any inconsistencies in the data recorded and making reference to the Beer-Lambert Law  **D4**  Evaluate the outcome of analysis with reference to precision, reliability and accuracy | Learner-led research and write up of report:   * data is correctly and precisely recorded * carry out calculations * work out correct calibration curve * determine unknown concentration (**P6**) * choice of filter / wavelength * any anomalous results (**M6**).   Check the above from the notes from the previous session.  Evaluate results obtained with consideration of:   * accuracy of measurements * associated errors * reliability and precision in colorimetry * assessment of the practical method (**D4**).   **Stretch and challenge** - identification of uses in industry and the importance of accuracy and precision.  [www.qualitymag.com/articles/92392-measurement-techniques-in-colorimetry](http://www.qualitymag.com/articles/92392-measurement-techniques-in-colorimetry)  <http://work.chron.com/jobs-use-colorimetry-23498.html> | Learner evidence covering P4, P6, P10, M4, M6, D4 | Writing up report using correct  scientific terminology  Calculations and equations |

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| Week | Specification reference | Key learning objectives | Learning activities and resources | Plenary | Skills |
| 20 | PO2(b)  Demonstrate applied experimental techniques chemistry: colorimetric analysis | **M6**  Explain the choice of filter/wavelength, describing any inconsistencies in the data recorded and making reference to the Beer-Lambert Law  **D4**  Evaluate the outcome of analysis with reference to precision, reliability and accuracy | Learner-led research and write up of report:   * data is correctly and precisely recorded * carry out calculations * work out correct calibration curve * determine unknown concentration (**P6**) * choice of filter / wavelength * any anomalous results (**M6**).   Check the above from the notes from the previous session.  Evaluate results obtained with consideration of:   * accuracy of measurements * associated errors * reliability and precision in colorimetry * assessment of the practical method (**D4**).   **Stretch and challenge** - independent working for D4. | Learner evidence covering P4, P6, P10, M4, M6, D4 | Calculations and equations  Spellings and grammar used in report  Ability to work unsupervised  Research skills |

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| Week | Specification reference | Key learning objectives | Learning activities and resources | Plenary | Skills |
| 21 | PO3(a)  Demonstrate applied experimental techniques in physics:  resistivity  PO4  Understand safety procedure and risk assessment when undertaking scientific practical work | **P7**  Explain the terms:   * resistivity * specific heat capacity   in relation to material properties  **P10**  In using experimental techniques:   * safely use a range of practical   equipment and materials   * identify hazards * produce risk assessments for **one** applied experimental technique from **each** of biology, chemistry and physics | **Resistivity**  Tutor introduces the concept of resistivity and how the resistance of an electrical component relates to the resistivity of the material it is made from.  Links should be made to Unit 1: Electricity and Circuits.  Tutor outlines the importance of knowing the resistivity of a material. Learners make appropriate notes.  Tutor introduces the circuits and components required to measure resistance and the mathematics involved.  Learners adhere to risk assessment and request form.  Learners to practise techniques and obtain reproducible results.  Using meters with an appropriate range and precision; the material to be tested is usually in the form of a wire.  Learners do calculation problems on resistance for homework and will be **stretched and challenged** by the complexity of the problems.  <http://hyperphysics.phy-astr.gsu.edu/hbase/electric/resis.html> | Tutor observation of risk assessments / request form  Notes made and written report  Tutor observation of practical techniques  Responses to  resistance calculations | Resistance  calculations  Written  communication  Practical skills and health and safety |

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| Week | Specification reference | Key learning objectives | Learning activities and resources | Plenary | Skills |
| 22 | PO3(a)  Demonstrate applied experimental techniques in physics:  resistivity  PO4  Understand safety procedure and risk assessment when undertaking scientific practical work | **M7**  Describe how the values of resistivity and specific heat capacity determine the uses of materials in industry | Learner-led research into the resistivity of different materials (conductors, semi-conductors, insulators) and how these materials may be used in industry.  Class comes together to discuss their findings under the guidance of the tutor. The resistivity values (practical and theoretical) can be used to determine the uses in industry based on whether the material is a conductor, semi-conductor or insulator. Some industries to consider could include manufacturing, automotive and medical engineering.  Learners record their findings for **P7**/**M7** (resistivity).  Tutor goes through homework on resistivity calculations.  [www.engineeringtoolbox.com/resistivity-conductivity-d\_418.html](http://www.engineeringtoolbox.com/resistivity-conductivity-d_418.html)  [tap.iop.org/electricity/resistance/112/file\_45987.doc](http://tap.iop.org/electricity/resistance/112/file_45987.doc)  **Stretch and challenge:** thorough research on a variety of materials and their resistivities. | Discussion of findings  Notes made during  research and written evidence | Resistance  calculations  Written  communication  Research |

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| Week | Specification reference | Key learning objectives | Learning activities and resources | Plenary | Skills |
| 23 | PO3(b)  Demonstrate applied experimental techniques in physics: specific heat capacity  PO4  Understand safety procedure and risk assessment when undertaking scientific practical work | **P7**  Explain the terms:   * resistivity * specific heat capacity (SHC)   in relation to material properties  **P10**  In using experimental techniques:   * safely use a range of practical   equipment and materials   * identify hazards * produce risk assessments for **one** applied experimental technique from **each** of biology, chemistry and physics | **Specific heat capacity**  Tutor introduces the concept of SHC and its importance in property of material and object design.  Links should be made to Unit 1: useful energy and efficiency.  Learners make appropriate notes for **P7**.  Tutor introduces a suitable procedure to measure SHC and the mathematics involved. Tutor discusses and shows a variety of measures taken to reduce heat loss.  Learners to complete appropriate risk assessment and request form.  Learners to practise techniques and obtain reproducible results.  SHC can be measured in the solid or liquid phase taking into account heat lost to the environment. Part of the practical work can be looking into insulators to prevent heat loss. Suitable precise equipment will be used to measure temperature, mass, time and energy supplied. For the solid phase it is usually a purpose-made 1 kg cylinder.  Learners do calculation problems on SHC for homework and will be **stretched and challenged** by the complexity of the problems.  <http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/spht.html> | Learner notes and written evidence  Tutor observation of practical techniques  Tutor observation of risk assessments and request form  Responses to resistance  calculations | SHC calculations  Practical skills and health and safety |

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| Week | Specification reference | Key learning objectives | Learning activities and resources | Plenary | Skills |
| 24 | PO3(b)  Demonstrate applied experimental techniques in physics: specific heat capacity  PO4  Understand safety procedure and risk assessment when undertaking scientific practical work | **M7**  Describe how the values of resistivity and SHC determine the uses of materials in industry | Learner-led research into the SHC of different materials (conductors, insulators) and how these materials may be used in industry.  Class comes together to discuss their findings under the guidance of the tutor.  The SHC values (practical and theoretical) can be used to determine the uses in industry based on whether the material has a high or low SHC. Some industries to consider could include manufacturing, automotive and medical engineering.  Learners record their findings for **P7**/**M7**.  Tutor goes through homework on SHC calculations.  <http://study.com/academy/lesson/how-to-calculate-specific-heat-capacity-for-different-substances.html>  [tap.iop.org/energy/thermal/607/file\_47505.doc](http://tap.iop.org/energy/thermal/607/file_47505.doc)  [tap.iop.org/energy/thermal/607/file\_47502.doc](http://tap.iop.org/energy/thermal/607/file_47502.doc)  [tap.iop.org/energy/thermal/607/page\_47500.html](http://tap.iop.org/energy/thermal/607/page_47500.html)  **Stretch and challenge:** thorough research on a variety of materials and their resistivities. | Discussion of findings  Notes made during  research and written evidence | SHC calculations  Written  communication  Research |

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| Week | Specification reference | Key learning objectives | Learning activities and resources | Plenary | Skills |
| 25 | PO3(a)  Demonstrate applied experimental techniques in physics:  resistivity  PO4  Understand safety procedure and risk assessment when undertaking scientific practical work | **P8**  Follow a standard procedure to measure the resistivity of **one** material and record results  **P10**  In using experimental techniques:   * safely use a range of practical   equipment and materials   * identify hazards * produce risk assessments for **one** applied experimental technique from **each** of biology, chemistry and physics | Tutor recaps on the circuits and components used to measure the resistivity of materials. Learners to apply appropriate risk assessment and check their request forms.  Learners to use previous techniques on a chosen material and obtain reproducible results. Learners should repeat their experiments at least three times, recognise anomalies and take a suitable average. Learners should compare the results obtained with published values and consider reasons for any differences.  Tutor recaps on equations and calculations and how to calculate percentage error.  Learners to select their choice of experiment and material for next week and submit a request form.  **Stretch and challenge** - complete practical work with no tutor help.  <https://tap.iop.org/electricity/resistance/112/file_45987.doc> | Tutor observation of practical techniques  Tutor observation of risk assessments / request form | Practical skills and health and safety  Resistance  calculations |

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| Week | Specification reference | Key learning objectives | Learning activities and resources | Plenary | Skills |
| 26 | PO3(a)  Demonstrate applied experimental techniques in physics:  resistivity  PO4  Understand safety procedure and risk assessment when undertaking scientific practical work | **P8**  Follow a standard procedure to measure the resistivity of **one** material and record results  **P10**  In using experimental techniques:   * safely use a range of practical   equipment and materials   * identify hazards * produce risk assessments for **one** applied experimental technique from **each** of biology, chemistry and physics | Learner-led practical work.  Each learner to check risk assessment / order request before starting practical work.  Learner-led practical work for chosen resistivity experiment continued from previous week. Giving the opportunity to develop and improve any experimental skills and results.  Follow given procedures to obtain correct data.  Record results and carry out calculations. Calculate the resistivity using the formula  **R = l / A**.  Calculate the expected percentage error.  **Stretch and challenge** - procedure followed with no tutor help, accurate risk assessment, and results are clear, sufficient, reproducible / accurate, and correct units used. | Tutor observation of practical techniques  Tutor observation of risk assessments / order request  Correct results  Correct equations | Practical skills and safety  Recording data and carrying out calculations |

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| Week | Specification reference | Key learning objectives | Learning activities and resources | Plenary | Skills |
| 27 | PO3(a)  Demonstrate applied experimental techniques in physics:  resistivity | **M8**  Compare results in resistivity with industry standard data, accounting for anomalous readings  **D5**  Compare the methods used in industry to measure resistivity of materials,  including levels of accuracy and precision | Tutor recaps on the requirements for a scientific report.  Learners consider suitable ways to present and analyse data.  Learners discuss the results generated and the procedure followed.  Learners use their previously researched industry data and compare it with their own results; accounting for any anomalous reading they may have obtained (**M8**).  For **D5** learners should compare the various methods used in industry. These methods should be evaluated in terms of precision and accuracy.    Learners produce a written report for homework, covering the resistivity experiment and will be **stretched and challenged** by the complexity and detail of their response.  [www.seaward.co.uk/resistance-measurement](http://www.seaward.co.uk/resistance-measurement)  <http://four-point-probes.com/understanding-volume-resistivity-measurements/>  [www.edn.com/electronics-news/4389712/Resistivity-is-the-key-to-measuring-electrical-resistance](http://www.edn.com/electronics-news/4389712/Resistivity-is-the-key-to-measuring-electrical-resistance) | Discussion of results and  procedure  Written evidence (**P8**, **M8**, **D5**) | Analysing data  Oral communication  during discussion  Written  communication for report  Research |

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| Week | | Specification reference | Key learning objectives | | Learning activities and resources | Plenary | Skills |
| 28 | | PO3(b)  Demonstrate applied experimental techniques in physics: specific heat capacity  PO4  Understand safety procedure and risk assessment when undertaking scientific practical work | **P9**  Follow a standard procedure to measure the SHC of **one** material and record results    **P10**  In using experimental techniques:   * safely use a range of practical   equipment and materials   * identify hazards * produce risk assessments for **one** applied experimental technique from **each** of biology, chemistry and physics | | Tutor recaps on the equipment required to measure the SHC of materials.  Each learner to check risk assessment / order request before starting practical work.  Learners to use previous techniques on a chosen material and obtain reproducible results. Learners should repeat their experiments at least three times, recognise anomalies and take a suitable average. Learners should compare the results obtained with published values and consider reasons for any differences.  Learners note how they can minimise energy losses.  Tutor recaps on equations, calculations and heating / cooling curves and how to calculate percentage error. PV = nRT summarises the physically possible combinations of P, V and T for n moles of the ideal gas.  **Stretch and challenge** - complete practical work with no tutor help.  [http://uk.mt.com/gb/en/home/perm-lp/product-organizations/ana/TA-Cp\_specific\_heat\_capacity.html?cmp=sea\_06010126&bookedkeyword=%2Bmeasurement%20of%20%2Bspecific%20%2Bheat&matchtype=b&adtext=80444361920&placement=&network=g](http://uk.mt.com/gb/en/home/perm-lp/product-organizations/ana/TA-Cp_specific_heat_capacity.html?cmp=sea_06010126&bookedkeyword=%25252Bmeasurement%252520of%252520%25252Bspecific%252520%25252Bheat&matchtype=b&adtext=80444361920&placement=&network=g) | Tutor observation of practical techniques  Tutor observation of risk assessments | Practical skills and health and safety  SHC calculations |
| Week | Specification reference | | Key learning objectives | Learning activities and resources | | Plenary | Skills |
| 29 | PO3(b)  Demonstrate applied experimental techniques in physics: specific heat capacity  PO4  Understand safety procedure and risk assessment when undertaking scientific practical work | | **P9**  Follow a standard procedure to measure the SHC of **one** material  **P10**  In using experimental techniques:   * safely use a range of practical   equipment and materials   * identify hazards * produce risk assessments for **one** applied experimental technique from **each** of biology, chemistry and physics | Learner-led practical work.  Each learner to check risk assessment / order request before starting practical work.  Learner-led practical work for chosen SHC experiment. Follow given procedures to obtain correct data. This gives the opportunity to develop and improve any experimental skills and results.  Record results, taking into account any anomalous readings and carry out calculations and produce heating / cooling curve.  **Stretch and challenge** - procedure followed with no tutor help, accurate risk assessment, results are clear, sufficient, reproducible / accurate, and correct units used. | | Tutor observation of practical techniques  Tutor observation of risk assessments / order request  Correct results  Correct equations | Practical skills and safety  Recording data and carrying out calculations |

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| Week | Specification reference | Key learning objectives | Learning activities and resources | Plenary | Skills |
| 30 | PO3(b)  Demonstrate applied experimental techniques in physics: specific heat capacity  PO4  Understand safety procedure and risk assessment when undertaking scientific practical work | **M9**  Calculate percentage error, produce a graph to show change in temperature of **one** material over time and explain the shape of the graph.  **D6**  Explain how this standard procedure could be adapted to measure the SHC of a material which is in a different phase | Tutor recaps on the requirements for scientific evidence and provides guidance on this.  Tutor to introduce types of calculations and understanding of percentage errors.  Learners consider suitable ways to present and analyse data.  Tutor demonstrates the correct use of error bars.  Learners to produce heating / cooling curves as appropriate for **one** material. This should include percentage error with a logical explanation for the shape of the graph, and should demonstrate scientific understanding (**M9**).  Learner’s review / research procedures for both states and indicate how the procedure could be adapted for the alternative state from the experiment which they investigated, i.e. either solid or liquid. Consider additional precautions to ensure validity and accuracy (**D6**).  Learners produce a written report, to be completed for homework, covering the SHC experiment, and will be **stretched and challenged** by the complexity and detail of their response.  <https://tap.iop.org/energy/thermal/607/file_47502.doc> | Discussion of results  Written evidence (**P9**, **M9**, **D6**) | Analysing data  Oral communication  during discussion  Written  communication for report  Research |