

**Year 12 Chemistry Unit Three**  
**(HEINEMANN 4<sup>th</sup> EDITION) Textbook Questions**

In this unit students investigate the scope of techniques available to the analytical chemist. Chemical analysis is vital in the work of the forensic scientist, the quality control chemist at a food manufacturing plant, the geologist in the field, and the environmental chemist monitoring the health of a waterway. Each technique of analysis depends on a particular property or reaction of the chemical being investigated. Consequently, an understanding of the chemistry is necessary in learning how and why the techniques work. Some techniques of analysis have been refined over many years to make them quicker and more accurate. Other techniques are now used in combination to provide higher and more reliable levels of accuracy, for example gas chromatography, mass spectrometry, or carbon-13 and proton nuclear magnetic resonance spectroscopy.

Students investigate organic reaction pathways and the chemistry of particular organic molecules. A detailed knowledge of the structure and bonding of organic chemicals is important to the work of the synthetic organic chemist. In the wake of the work done on the Human Genome Project, synthesis of new medicines is one of the growth industries for the coming decades. Students investigate the role of organic molecules in the generation of biochemical fuels and medicines. Students use the language and symbols of chemistry, and chemical formulas and equations to explain observations and data collected from experiments. Students complete an extended experimental investigation drawn from Area of Study (AOS) 1 or AOS 2.

The **KEY SKILLS** of VCE Chemistry apply across Units 1 to 4 and are as follows:

**Investigate and inquire scientifically**

- work independently and collaboratively as required to develop and apply safe and responsible work practices when completing all practical investigations including the appropriate disposal of wastes;
- conduct investigations that include collecting, processing, recording and analysing qualitative and quantitative data; draw conclusions consistent with the question under investigation and the information collected; evaluate procedures and reliability of data;
- construct questions (and hypotheses); plan and/or design, and conduct investigations; identify and address possible sources of uncertainty;
- apply ethics of scientific research when conducting and reporting on investigations.

**Apply chemical understandings**

- make connections between concepts; process information; apply understandings to familiar and new contexts;
- use first and second-hand data and evidence to demonstrate how chemical concepts and theories have developed and been modified over time;
- analyse issues and implications relating to scientific and technological developments;
- analyse and evaluate the reliability of chemistry related information and opinions presented in the public domain.

**Communicate chemical information and understandings**

- interpret, explain and communicate chemical information and ideas accurately and effectively;
- use communication methods suitable for different audiences and purposes;
- use scientific language and conventions correctly, including chemical equations and units of measurement.

## AREA OF STUDY ONE – Chemical Analysis

In this AOS students use a variety of analytical techniques to analyse products in the laboratory. They conduct volumetric analyses using acid-base and redox titrations and standard solutions, and carry out gravimetric analyses. They are also introduced to instrumental analytical techniques of spectroscopy and chromatography. Students review and apply their understanding of stoichiometry as they complete calculations related to their practical investigations. Students relate the operation of the analytical techniques and instruments to the chemical reactions and the chemical structures of the materials which are being analysed.

**Outcome 1** - On completion of this unit the student should be able to evaluate the suitability of techniques and instruments used in chemical analyses. To achieve this outcome the student will draw on key knowledge outlined in AOS 1 below and key skills listed above.

### KEY KNOWLEDGE

This knowledge includes:

- volumetric analysis including determination of excess and limiting reagents and titration curves: simple and back titrations, acid-base and redox titrations
- gravimetric analysis
- calculations including amount of solids, liquids and gases; concentration; volume, pressure and temperature of gases
- the writing of balanced chemical equations, including the use of oxidation numbers to write redox equations, and the application of chemical equations to volumetric and gravimetric analyses
- principles and applications of chromatographic techniques (excluding features of instrumentation and operation), and interpretation of qualitative and quantitative data from:
  - thin layer chromatography (TLC), including calculation of  $R_f$
  - high performance liquid chromatography (HPLC) and gas chromatography (GC) including  $R_t$  and the use of a calibration graph to determine amount of analyte
- principles and applications of spectroscopic techniques (excluding features of instrumentation and operation), and interpretation of qualitative and quantitative data from:
  - atomic absorption spectroscopy (AAS) including electron transitions and use of calibration graph to determine amount of analyte
  - infrared spectroscopy (IR) including use of characteristic absorption bands to identify bonds
  - proton and carbon-13 nuclear magnetic resonance spectroscopy (NMR) including spin, the application of carbon-13 to determine number of equivalent carbon environments; and application of proton NMR to determine structure: chemical shift, areas under peak and peak splitting patterns (excluding coupling constants), and application of n+1 rule to simple compounds
  - visible and ultraviolet spectroscopy (visible-UV) including electron transitions and use of calibration graph to determine amount of analyte
  - mass spectroscopy including determination of molecular ion peak and relative molecular mass, and identification of simple fragments
- matching analytical technique/s to a particular task: single and combined techniques.

Chapter	Topic	Page Reference	Questions	Glossary Definitions
1	<b>What is chemical analysis?</b>	2-9	p.5 1a-d p.9 4+5	<b>Chemical analysis</b> <b>Qualitative analysis</b> <b>Quantitative analysis</b>
2	<b>Analysis by mass</b>	10-26	p.12 1, 3, 4a, 5 p.15 6-9 p.18 10-13 p.21 14-16 p.24 17+18 p.25 19-48	<b>Anhydrous</b> <b>Avogadro's number</b> <b>Empirical formula</b> <b>Molecular formula</b> <b>General gas equation</b> <b>Gravimetric analysis</b> <b>Heating to constant mass</b> <b>Ionic equation</b> <b>Limiting reactant</b> <b>Precipitate</b> <b>Spectator ions</b> <b>Standard temperature and pressure (STP)</b> <b>Standard laboratory conditions (SLC)</b>
3	<b>Volumetric analysis</b>	27-35	p.30 1-8 p.33 E1, 9+10 p.34 11-23 p.35 24+25	<b>Aliquot</b> <b>Average titre</b> <b>Burette</b> <b>Concentration</b> <b>Concordant titres</b> <b>End point</b> <b>Equivalence point</b> <b>Indicator</b> <b>Pipette</b> <b>Primary standard</b> <b>Standard solution</b> <b>Titration</b> <b>Titre</b> <b>Uncertainty</b> <b>Volumetric analysis</b>

4	<b>Analysing acids and bases</b>	36-46	<p>p.38 1, 2 + 3-5  p.42 7+8  p.44 9  p.45 10-22  p.46 23-28</p>	<p><b>Acid</b>  <b>Acid-base indicator</b>  <b>Acid-base reaction</b>  <b>Acidity</b>  <b>Back titration</b>  <b>Base</b>  <b>Conjugate acid-base pair</b>  <b>Ionise</b>  <b>Neutralisation</b>  <b>pH</b>  <b>pH curve</b>  <b>Strong acid</b>  <b>Strong base</b>  <b>Weak acid</b>  <b>Weak base</b></p>
5	<b>Analysing oxidants and reductants</b>	47-60	<p>p.51 1+2  p.54 3-6  p.55 7-11  p.57 12+13  p.58 14-22  p.59 23-28  p.60 29-34</p>	<p><b>Half-equation</b>  <b>Oxidant</b>  <b>Oxidation</b>  <b>Oxidation number</b>  <b>Oxidation state</b>  <b>Oxidising agent</b>  <b>Redox reaction</b>  <b>Redox titration</b>  <b>Reducing agent</b>  <b>Reductant</b>  <b>Reduction</b></p>

6	<b>Chromatography</b>	61-75	<p>p.64 1  p.71 2  p.72 3-10  p.73 12  p.74 13-17  p.75 18-21</p>	<p><b>Adsorption</b>  <b>Calibration graph/curve</b>  <b>Carrier gas</b>  <b>Chromatogram</b>  <b>Chromatography</b>  <b>Column chromatography</b>  <b>Desorption</b>  <b>Eluent</b>  <b>Flame ionisation detector (FID)</b>  <b>Gas chromatography (GC)</b>  <b>Gas-liquid chromatography (GLC)</b>  <b>Gas-solid chromatography (GSC)</b>  <b>High performance (or pressure) liquid chromatography (HPLC)</b>  <b>Mobile phase</b>  <b>Origin</b>  <b>Retention time (<math>R_t</math>)</b>  <b><math>R_f</math> value</b>  <b>Solvent</b>  <b>Solvent front</b>  <b>Standards</b>  <b>Stationary phase</b>  <b>Thin-layer chromatography (TLC)</b></p>
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7	Spectroscopy	76-109	<p>p.81 1-4  p.84 5  p.88 6-12  p.96 13-15  p.105 16-18  p.106 19-20 + 23-24  p.107 25-32  p.108 33-37  p.109 38-40</p>	<p><b>Absorbance</b>  <b>Atomic absorption spectroscopy (AAS)</b>  <b>Atomic emission spectroscopy (AES)</b>  <b>Calibration graph/curve</b>  <b>C<sup>13</sup> NMR</b>  <b>Chemical shift</b>  <b>Colorimeter</b>  <b>Colorimetry</b>  <b>Dipole moment</b>  <b>Electromagnetic spectrum</b>  <b>Electron energy levels</b>  <b>Emission spectrum</b>  <b>Excited electrons</b>  <b>Fingerprint region</b>  <b>Frequency</b>  <b>Functional group</b>  <b>Infrared spectroscopy</b>  <b>Nuclear magnetic resonance spectroscopy (NMR)</b>  <b>Nuclear shielding</b>  <b>Photon</b>  <b>H<sup>1</sup>/proton NMR</b>  <b>Quantum of energy</b>  <b>Reference cell</b>  <b>Rotational energy levels</b>  <b>Sample cell</b>  <b>Electron shells</b>  <b>Spectrum</b>  <b>Transmittance</b>  <b>Ultraviolet (UV)</b>  <b>UV-visible spectroscopy</b>  <b>Vibrational energy levels</b>  <b>Wavenumber</b>  <b>Wavelength</b></p>
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8	<b>Combining and choosing analytical techniques</b>	110-123	p.114 1-5 p.119 6-8 p.121 9 p.122 11-13 p.123 14-20	<b>Base peak</b> <b>Fragmentation</b> <b>Free radicals</b> <b>Mass spectroscopy</b> <b>Molecular ion</b> <b>Parent molecular ion</b>
Review	<b>Unit 3 AOS1 Review: Chemical Analysis</b>	124-128	p.124 1-22 p.126 23-26 p.128 27	