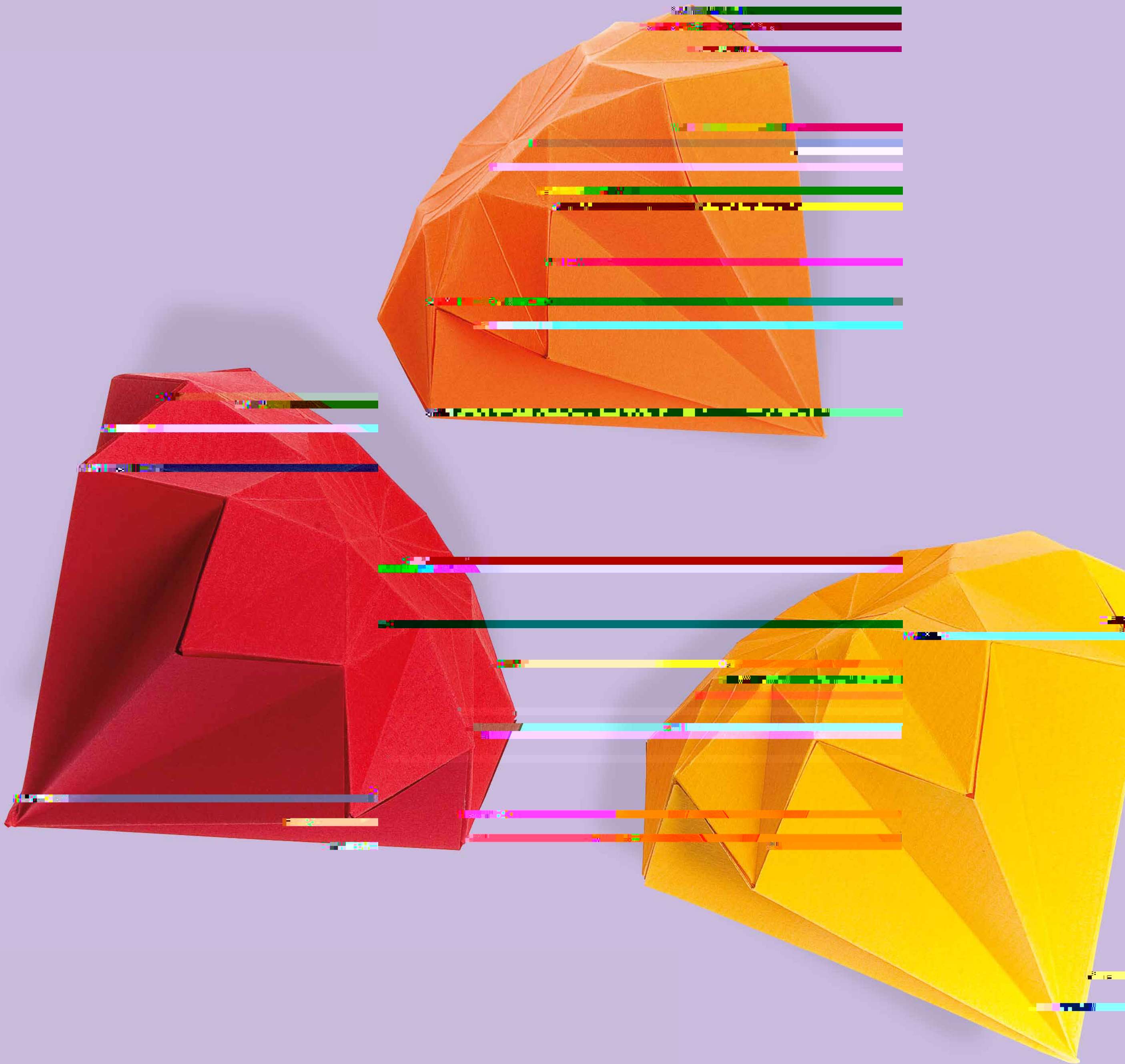
edexcel

A Level First



ALWAYS LEARNING

PEARSON

Pearson Edexcel Level 3 Advanced GCE in Chemistry (9CH0)

Specification

First certification 2017

Issue 2

From Pearson's Expert Panel for World Class Qualifications

Introduction

The Pearson Edexcel Level 3 Advanced GCE in Chemistry is designed for use in schools and colleges. It is part of a suite of GCE qualifications offered by Pearson.

Purpose of the specification

This specification sets out:

- the objectives of the qualification
- any other qualifications that a student must have completed before taking the qualification
- any prior knowledge and skills that the student is required to have before taking the qualification
- any other requirements that a student must have satisfied before they will be assessed or before the qualification will be awarded
- the knowledge and understanding that will be assessed as part of the qualification
- the method of assessment and any associated requirements relating to it
- the criteria against which a student's level of attainment will be measured (such as assessment criteria).

Rationale

The Pearson Edexcel Level 3 Advanced GCE in Chemistry meets the following purposes, which fulfil those defined by the Office of Qualifications and Examinations Regulation (Ofqual) for GCE qualifications in their GCE Qualification Level Conditions and Requirements document, published in April 2014.

The purposes of this qualification are to:

- define and assess achievement of the knowledge, skills and understanding that will be needed by students planning to progress to undergraduate study at UK

The context for the development of this qualification

All our qualifications are designed to meet our World Class Qualification Principles [1] and our ambition to put the student at the heart of everything we do.

We have developed a nd designed this qualification by:

- reviewing other curricula and qualifications to ensure that it is comparable with those taken in high - performing jurisdictions overseas
- consulting with key stakeholders on content and assessment, including subject associa tions, higher education academics, teachers and employers to ensure this qualification is suitaun is ssse

Qualification at a glance

Paper 3: General and Practical Principles in Chemistry *Paper code: 9CH0/03	
- Externally assessed - Availability: May/June - First assessment: 2017	40% of the total qualification
Overview of content - Questions in this paper may draw on any of the topics in this specification. - The paper will include synoptic questions that may draw on two or more different topics listed. - The paper will include questions that assess conceptual and theoretical understanding of experimental methods (indirect practical skills) that will draw on students' experiences of the core practicals.	
Overview of assessment - Assessment is 2 hours 30 minutes. - The paper consists of 120 marks. - The paper may include short open, open-response, calculations and extended writing questions. - The paper will include questions that target mathematics at Level 2 or above (see Appendix 6: Mathematical skills and exemplifications). Overall, a minimum of 20% of the marks across the three papers will be awarded for mathematics at Level 2 or above. - Some questions will assess conceptual and theoretical understanding of experimental methods (see Appendix 5: Working scientifically).	

*See Appendix 3: Codes for a description of this code and all other codes relevant to this qualification.

Science Practical Endorsement**	
	*Paper code: 9CH0/04

- Internally assessed and externally monitored by Pearson.
- Availability: May/June
- First assessment : 2017

Overview of content

The assessment of practical skills is a compulsory requirement of the course of study for A level chemistry. It will appear on all students' certificates as a

Knowledge, skills and understanding

Content overview

Students will be expected to demonstrate and apply the knowledge, understanding and skills described in the content. They will also be expected to analyse, interpret and evaluate a range of scientific information, ideas and evidence using their knowledge, understanding and skills.

To demonstrate their knowledge, students should be able to undertake a range of activities, including the ability to recall, describe and define, as appropriate. To demonstrate their understanding, students should be able to explain ideas and to use their knowledge to apply, analyse, interpret and evaluate, as appropriate.

Core practicals will be assessed through examination.

Topic 1: Atomic Structure and the Periodic Table

In order to develop their practical skills, students should be encouraged to carry out a range of practical experiments related to this topic. Possible experiments include the use of hand-held spectroscopes to investigate spectra from flame tests.

Mathematical skills that could be developed in this topic include calculating a relative atomic mass from isotopic composition data, using simple probability to calculate the peak heights for the mass spectrum of chlorine molecules, using logarithms to compare successive ionisation energies for an element.

Within this topic, students can consider how models for the atom have developed over time, as new evidence has become available. They can also consider how data is used to investigate relationships, such as between the magnitude of ionisation energy and the structure of an atom.

Students should:	
1.	know the structure of an atom in terms of electrons, protons and neutrons
2.	know the relative mass and relative charge of protons, neutrons and electrons
3.	know what is meant by the terms 'atomic (proton) number' and 'mass number'
4.	be able to determine the number of each type of sub-atomic particle in an atom, molecule or ion from the atomic (proton) number and mass number
5.	understand the term 'isotopes'
6.	be able to define the terms 'relative isotopic mass' and 'relative atomic mass', based on the ^{12}C scale
7.	understand the terms 'relative molecular mass' and 'relative formula mass', including calculating these values from relative atomic masses Definitions of these terms will not be expected. The term 'relative formula mass' should be used for compounds with giant structures.
8.	be able to analyse and interpret data from mass spectrometry to calculate relative atomic mass from relative abundance of isotopes and vice versa
9.	be able to predict the mass spectra, including relative peak heights, for diatomic molecules, including chlorine

10. viderstand thtsomass'.

Students should:
15. understand how ideas about electronic configuration developed from: i the fact that atomic emission spectra provide evidence for the existence of quantum shells ii the fact that successive ionisation energies provide evidence for the existence of quantum shells and the group to which the element belongs iii the fact that the first ionisation energy of successive elements provides evidence for electron sub-shells

16. know the n31.74cQ11(e)-11( )1(f)-2(9 re (ua)5(n)1(tes9 re (ua)5(n)1(tes9 re (u5(e)1(s)]9.4s9 r()-11(e)1(l)-s)]9.4

Topic 2: Bonding and Structure

In order to develop their practical skills, students should be encouraged to carry out a range of practical experiments related to this topic. Possible experiments include investigating the migration of ions, for example in a U-tube of copper(II) chromate, seeing the effect of a charged rod on a flow of water.

Mathematical skills that could be developed in this topic include representing shapes of molecules with suitable sketches, plotting data to investigate trends in boiling temperatures of alkanes.

Within this topic, students can consider the strengths and weaknesses of the models used to describe different types of bonding. As part of their study of electron-pair repulsion theory, students can see how chemists can make generalisations and use them to make predictions.

Students should:
Topic 2A: Bonding
1. know that ionic bonding is the strong electrostatic attraction between oppositely charged ions
2. understand the effects that ionic radius and ionic charge have on the strength of ionic bonding
3. understand the formation of ions in terms of electron loss or gain
4. be able to draw electronic configuration diagrams of cations and anions using dot-and-cross diagrams
5. understand reasons for the trends in ionic radii down a group and for a set of isoelectronic ions, e.g. N^{3-} to Al^{3+}
6. understand that the physical properties of ionic compounds and the migration of ions provide evidence for the existence of ions
7. know that a covalent bond is the strong electrostatic attraction between two nuclei and the shared pair of electrons between them
8. be able to draw dot-and-cross diagrams to show electrons in covalent substances, including: i molecules with single, double and triple bonds ii species exhibiting dative covalent (coordinate) bonding, including Al_2Cl_6 and ammonium ion
9. understand the relationship between bond lengths and bond strengths for covalent bonds
10. understand that the shape of a simple molecule or ion is determined by the repulsion between the electron pairs that surround a central atom
11. understand reasons for the shapes of, and bond angles in, simple molecules and ions with up to six outer pairs of electrons (any combination of bonding pairs and lone pairs) Examples should include $BeCl_2$, BCl_3, CH_4, NH_3, NH_4^+, H_2O, CO_2, PCl_5(g) and SF_6(g) and related molecules and ions; as well as simple organic molecules in this specification.

Students should:
12. be able to predict the shapes of, and bond angles in, simple molecules and ions analogous to those specified above using electron -pair repulsion theory
13. know that electronegativity is the ability of an ato m to attract the bonding electrons in a covalent bond
14. know that ionic and covalent bonding are the extremes of a continuum of bonding type and that electronegativity differences lead to bond polarity in bonds and molecules
15. understand that molecul es with polar bonds may not be polar molecules and be able to predict whether or not a given molecule is likely to be polar

16. understand the nature of intermolecular forcese s e is likely to be polar

Topic 3: Redox I

In order to develop their practical skills, students should be encouraged to carry out a range of practical experiments related to this topic. Possible experiments include simple test tube reactions to investigate redox systems.

Mathematical skills that coul

Topic 4: Inorganic Chemistry and the Periodic Table

In order to develop their practical skills, students should be encouraged to carry out a range of practical experiments related to this topic. Possible experiments include reacting Group 2 elements with water, heating nitrates and carbonates of Group 1 and 2 elements, investigating flame colours of s-block elements, preparing iodine from seaweed, investigating displacement reactions in the halogens, reacting Group 1 halides with concentrated sulfuric acid.

Mathematical skills that could be developed in this topic include manipulating data on the solubility of hydroxides.

Within this topic, students can consider how data can be used to make predictions based on patterns and relationships, for example by predicting properties of Group 7 elements.

Students should:
Topic 4A: The elements of Groups 1 and 2
1. understand reasons for the trend in ionisation energy down Group 2
2. understand reasons for the trend in reactivity of the Group 2 elements f 5(tte)-2(r)9(n)-1(s)7( )1(a)3(n)-2(d)18o0

Students should:
Topic 4B: The elements of Group 7 (halogens)
9. understand reasons for the trends in melting and boiling temperatures, physical state at room temperature, and electronegativity for Group 7 elements
10. understand reasons for the trend in reactivity of Group 7 elements down the group
11. understand the trend in reactivity of Group 7 elements in terms of the redox reactions of Cl_2, Br_2 and I_2 with halide ions in aqueous solution, followed by the addition of an organic solvent11(i)a(a17-10(0 4( )1i)6(9()11()-18(c)-2)1(o)1a(a)3)-18(ca(a)3y)6(9()11(w -71oy)

Students should:
12. understand the problems arising from pollutants from the combustion of fuels, limited to the toxicity of carbon monoxide and the acidity of oxides of nitrogen and sulfur

13. understand how the use of a catalytic c

Students should:
24. unde rstand the mechanism of the electrophilic addition reactions between alkenes and: i halogens ii hydrogen halides, including addition to unsymmetrical alkenes iii other given binary compounds 8VH RI WKH FXUO\ DUURZ QRWDWLRQ LV H[SHFWHG í FXUO\ DUURZV should start from either a bond or from a lone pair of electrons . Knowledge of the relative stability of primary, secondary and tertiary carbocation intermediates is expected .
25. know the qualitative test for a C=C double bond using bromine or bromine wat er
26. know that alkenes form polymers through addition polymerisation Be able to identify the repeat unit of an addition polymer given the monomer, and vice versa.

27. know that waste polymers can be separated into specific types of polymer for:

i rec ycling

ii incineration to release energy

iii use as a feedstockofd [(y)17(c)18(li)-11(on3(d)-6(n7373 0 Td (Td (i-9(sst)-19on3(d/51>5-1(a)3(l)Tj -8.072 -

Students should:
33. understand that experimental observations and data can be used to compare the relative rates of hydrolysis of: i primary, secondary and tertiary halogenoalkanes ii chloro-, bromo-, and iodoalkanes using aqueous silver nitrate in ethanol
CORE PRACTICAL 4: Investigation of the rates of hydrolysis of some halogenoalkanes
34. know the trend in reactivity of primary, secondary and tertiary halogenoalkanes
35. understand, in terms of bond enthalpy, the trend in reactivity of chloro-, bromo-, and iodoalkanes
36. understand the mechanisms of the nucleophilic substitution reactions between primary halogenoalkanes and: i aqueous potassium hydroxide ii ammonia
Topic 6E: Alcohols
37. know that alcohols can be classified as primary, secondary or tertiary

38. understand the reactions of alcohols with:

i oxygen in air (combustion)

ii halogenating agents:

- x PCl_5 to produce chloroalkanes
- x 50% concentrated sulfuric acid and potassium bromide to produce bromoalkanes
- x red phosphorus and iodine to produce iodoalkanes

iii potassium dichromate(VI) in dilute sulfuric acid to oxidise primary alcohols to

Topic 7: Modern Analytical Techniques I

In order to develop their practical skills, students should be encouraged to carry out a range of practical experiments related to this topic. Hands-on practical work is limited in this topic, although many universities allow students to visit and learn about instrumentation first hand.

Mathematical skills that could be developed in this topic include analysing fragmentation patterns in mass spectra.

Within this topic, students can consider how different instrumental methods can provide evidence for analysis. They can see how accurate and sensitive methods of analysis can be applied to the study of chemical changes, but also to detect drugs such as in blood or urine testing in sport.

Students should:
Topic 7A: Mass spectrometry
1. be able to use data from a mass spectrometer to: i determine the relative molecular mass of an organic compound from the molecular ion peak ii suggest possible structures of a simple organic compound from the *m/z* of the molecular ion and fragmentation patterns
Topic 7B: Infrared (IR) spectroscopy

2. be able to use data from infrared spectra to deduce functional groups present in organic compounds and to predict infrared absorptions, given wavenumber data, due to familiar functional groups, including:

   i C–

Topic 8: Energetics I

In order to develop their practical skills, students should be encourage d to carry out a range of practical experiments related to this topic. Possible experiments include

Topic 10: Equilibrium I

In order to develop their practical skills, students should be encouraged to carry out a range of practical experiments related to this topic. Possible e xperiments include investigating equilibrium systems, such as iron(III) – thiocyanate, or the effect of temperature on the equilibrium between $[Co(H_2O)_6]^{2+}$ and $[CoCl_4]^{2-}$

Mathematical skills that could be developed in this topic include derivnce 1(e)10( ) 4rcug1( )]TJ b-3(r)ci.004 Tc -0.00

Students should:
16. be able to draw and interpret titration curves using all combinations of strong and weak monobasic acids and bases
17. be able to select a suitable indicator, using a titration curve and appropriate data
18. know what is meant by the term 'buffer solution'
19. understand the action of a buffer solution
20. be able to calculate the pH of a buffer solution given appropriate data
21. be able to calculate the concentrations of solutions required to prepare a buffer solution of a given pH
22. understand how to use a weak acid–strong base titration curve to: i demonstrate buffer action ii determine K_a from the pH at the point where half the acid is neutralised
23. understand why there is a difference in enthalpy changes of neutralisation values for strong and weak acids
24. understand the roles of carbonic acid molecules and hydrogencarbonate ions in controlling the pH of blood

CORE PRACTICAL 9:

Topic 15: Transition Metals

In order to develop their practical skills, students should be encouraged to carry out a range of practical experiments related to this topic. Possible experiments include the stepwise reduction of vanadium(V) to vanadium(II), investigating the reactions of copper(II) ions or chromium(III) ions, using sodium hydroxide and ammonia solution to identify transition metal ions, investigating autocatalysis, preparing a complex transition metal salt.

Mathematical skills that could be developed in this topic include investigating the geometry of different transition metal complexes.

Within this topic, students can consider the model for the filling of electron orbitals encountered in Topic 1, and see how limitations in that model indicate the need for more sophisticated explanations. They can also appreciate that catalyst research is a frontier area, and one which provides an opportunity to show how the scientific community reports and validates new knowledge.

Students should:
Topic 15A: Principles of transition metal chemistry

1. be able to deduce the electronic configurations of atoms and ions of the d-block elements of period 4 (Sc–Zn), given the at

Students should:

14. know that transition metal ions may form tetrahedral complexes with relatively large ligands such as $Cl^{í}$

15. know that square planar complexes are also formed by transition metal ions and that cis-

Students should:

Topic 16: Kinetics II

In order to develop their practical skills, students should be encouraged to carry out a range of practical experiments related to this topic. Possible experiments include investigating different methods for tracking rates of reaction by gas collection or change in mass or colour change, investigating clock reactions such as Harcourt-Essen, using a simple rates experiment to calculate an activation energy.

Mathematical skills that could be developed in this topic include plotting and justifying the shapes of rate–concentration and concentration–time graphs, calculating half-life of a reaction, calculating activation energy from a suitable graph, rearranging the Arrhenius equation in the form *y = mx + c*.

Within this topic, students can consider different methods used to measure reaction rates and collect valid data. Through the analysis of this data, and a knowledge of rate equations, they can see how chemists are able to propose models to describe the mechanisms of chemical reactions.

Students should:
1. understand the terms: i rate of reaction ii rate equation iii order with respect to a substance in a rate equation iv overall order of reaction v rate constant vi half-life vii rate-determining step viii activation energy ix heterogeneous and homogenous catalyst
2. be able to determine and use rate equations of the form: rate = $k[A]^m[B]^n$, where *m* and *n* are 0, 1 or 2

3. be able to select and justify a suitable experimental technique to obta1(u)-1 ions -0.0310.68 465.68 .

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Students should:	
5.	be able to calculate the rate of reaction and the half-life of a first-order reaction using data from a concentration-time or a volume-time graph
6.	be able to deduce the order (0, 1 or 2) with respect to a substance in a rate equation using data from: i a concentration-time graph ii a rate-concentration graph
7.	be able to deduce the order (0, 1 or 2) with respect to a substance in a rate equation using data from an initial-rate method

8. understand hode 8 f 524.28 638.04 0.481 64.08 re f BT /TT0 1 Tf 0.003 Tc -0.003 Tw 9.96 0 0 9.96 85.08 623.

Students should:

8. understand the reactions of carbonyl compounds with:

   i Fehling's or Benedict's solution, Tollens' reagent and acidified dichromate(VI) ions

   In equations, the oxidising agent can be represented as [O]

   ii lithium tetrahydridoaluminate (lithium aluminium hydride) in dry ether

   In equations, the reducing agent can be represented as [H]

   iii

Topic 18: Organic Chemistry III

In order to develop their practical skills, students should be encouraged to carry out a range of practical experiments related to this topic. Possible experiments include investigating the reactions of different functional groups, preparing an aromatic ester such as methyl benzoate, making nylon, purifying an organic solid.

Mathematical skills that could be developed in this topic include calculating the resonance stability of benzene from thermodynamic data, calculating percentage yields.

Within this topic, students can consider how the model for benzene structure has developed in response to new evidence. By this stage, their continuing practical experience should enable them to use techniques to edh29ry out reactions and purify products efficiently and safely.

Students should:

Topic 18A: Arenes - benzene s re T 79228 .819 0 Td50.006 T3e fW φ8(e)1(d)-310(l). W e

Students should:
Topic 18B: Amines, amides, amino acids and proteins
8. be able to identify: i the amine and amide functional groups ii molecules that are amino acids
9. understand the reactions of primary aliphatic amines, using butylamine as an example, with: i water to form an alkaline solution ii acids to form salts iii ethanoyl chloride iv halogenoalkanes v copper(II) ions to form complex ions
10. understand reasons for the difference in basicity of ammonia, primary aliphatic and primary aromatic amines given suitable data
11. understand, in terms of reagents and general reaction conditions, the preparation of primary aliphatic amines: i from halogenoalkanes ii by the reduction of nitriles
12. know that aromatic nitro-compounds can be reduced, using tin and concentrated hydrochloric acid, to form amines
13. understand that amides can be prepared from acyl chlorides
14. know that the formation of a polyamide is a condensation polymerisation reaction
15. be able to draw the structural formulae of the repeat units of condensation polymers formed by reactions between: i dicarboxylic acids and diols ii dicarboxylic acids and diamines iii amino acids
16. understand the properties of 2-amino acids, including: i acidity and basicity in solution, as a result of the formation of zwitterions ii effect of aqueous solutions on plane-polarised monochromatic light

17. understand that the peptide bond in pro Td (79.92 309.6 444.36 0.48 d ( )Tj 0.015 Tc -7 0 Td ( )Tj ET 70.004 3

Students should:
Topic 18C: Organic Synthesis

18. be able to deduce the empirical formulae, molecular formulae and structural formulae of compounds from data obtained from combustion analysis, elemental percentage composition, characteristic reactions of functional groups, infrared spectra, mass spectra nsonune

Students should:
Topic 19C: Chromatography
6. know that chromatography separates components of a mixture between a mobile phase and a stationary phase
7. be able to calculate R_f values from one-way chromatograms
8. know that high performance liquid chromatography, HPLC, and gas chromatography, GC: i are types of column chromatography ii separate substances because of different retention times in the column iii may be used in conjunction with mass spectrometry, in applications such as forensics or drugs testing in sport

Setting practical wo rk

Teaching and learning

Teachers should ensure that the core practicals listed in the subject content are incorporated into teaching and learning

Evidence of practical work

Evidence should be collected of practical work that is sufficient to show that the competencies have been achieved. Evidence may take a variety of forms.

The practical activities prescribed in the specification provide opportunities for demonstrating competence in all the skills identified, together with the use of apparatus and techniques for each subject. However, students can also demonstrate these competencies in any additional practical activity undertaken througho24ro 24row (ib)12(e)31(24r)-1ai i uurndhhiee1 TD [(d)1(e)1

Common Practical Assessment Criteria

Teachers must assess student practicals against the following competencies.

Criteria for the assessment of GCE Science practical competency for biology, chemistry and physics	
Competency	The criteria for a pass In order to be awarded a Pass a learner must, by the end of the practical science assessment, consistently and routinely meet the criteria in respect of each competency listed below. A learner may demonstrate the competencies in any practical activity undertaken as part of that assessment throughout the course of study. Learners may undertake practical activities in groups. However, the evidence generated by each learner must demonstrate that he or she independently meets the criteria outlined below in respect of each competency. Such evidence: (a) will comprise both the learner's performance during each practical activity and his or her contemporaneous record of the work that he or she has undertaken during that activity, and (b) must include evidence of independent application of investigative approaches and methods to practical

Criteria for the assessment of GCE Science practical competency for biology, chemistry and physics	
3. Safely uses a range of practical equipment and materials	a) Identifies hazards and assesses risks associated with these hazards, making safety adjustments as necessary, when carrying out experimental techniques and procedures in the lab or field. b) Uses appropriate safety equipment and approaches to minimise risks with minimal prompting.
4. Makes and records observations	a) Makes accurate observations relevant to the experimental or investigative procedure. b) Obtains accurate, precise and sufficient data for experimental and investigative procedures and records this methodically using appropriate units and conventions.
5. Researches, references and reports	a) Uses appropriate software and/or tools to process data, carry out research and report findings. b) Cites sources of information demonstrating that research has taken place, supporting planning and conclusions.

Marking and standardisation

The practical work is assessed by teachers. Pearson will support teachers in making judgements against the criteria for assessment.

In coordination with other exam boards, Pearson will monitor how schools provide students with opportunities to develop and demonstrate the required practical skills and how they mark the assessments.

Every school will be monitored at least once in a two-year period in respect of at least one of the A level science subjects. These monitoring visits will be coordinated by JCQ, who will undertake communications with centres to facilitate the allocation of exam board monitoring visits.

In common with other exam boards, Pearson will require centres to provide a statement confirming they have taken reasonable steps to secure that students:

- undertook the minimum number of practical activities, and
- made a contemporaneous record of their work.

If a school fails to provide a statement, or provides a false statement, this will be treated as malpractice and/or maladministration.

Students will only get a certificate for the practical assessment if they achieve at least a grade E in the examined part of the qualification.

Students who do not pass the practical assessment will have a 'Not Classified' outcome included on their certificate unless they were exempt from the assessment because of a disability.

Malpractice

Candidate malpractice

Candidate malpractice refers to any act by a candidate that compromises or seeks to compromise the process of assessment or which undermines the integrity of the qualifications or the validity of results/certificates.

Candidate malpractice in controlled assessments discovered before the candidate has signed the declaration of

More

Assessment

Assessment summary

Students must complete all assessment in May/June in any single year.

Paper 1: Advanced Inorganic and Physical Chemistry *Paper code: 9CH0/01	
- Questions draw on content from Topics 1, 2, 3, 4, 5, 8, 10 and Topics 11 –15. - Questions are broken down into a number of parts. - Availability: May/June - First assessment: 2017 - The assessment is 1 hour 45 minutes. - The assessment consists of 90 marks.	30% of the total qualification

Paper 2: Advanced Organic and Physical Chemistry

*Paper code: 9CH0/02

- Questions draw on content from Topics 2, 3, 5, 6, 7, 9 and Topics 16 –19.
- Questions are broken down into a number of parts.
- Availability: May/June
- First assessment: 2017
- The assessment is 1 hour 45 minutes.
-

Breakdown of Assessment Objectives

Paper	AO1	AO2	AO3	

Entry and assessment information

Student entry

Details of how to enter students for the examinations for this qualification can be found in our UK Information Manual. A copy is made available to all examinations officers and is available on our website at: www.edexcel.com/iwantto/Pages/uk-information-manual.aspx

Forbidden combinations and discount code

Centres should be aware that students who enter for more than one GCE qualification with the same discount code will have only one of the grades they achieve counted for the

Equality Act 2010 and Pearson equality policy

Equality and fairness are central to our work. Our equality policy requires all students to have equal opportunity to access our qualifications and assessments, and our qualifications to be awarded in a way that is fair to every student.

We are committed to making sure that:

- students with a protected characteristic (as defined by the Equality Act 2010) are not, when they are undertaking one of our qualifications, disadvantaged in comparison to students who do not share that characteristic
- all students achieve the recognition they deserve for undertaking a qualification and that this achievement can be compared fairly to the achievement of their peers.

Teachers can find details on how to make adjustments for students with protected characteristics in the policy document Access Arrangements, Reasonable Adjustments and Special Consideration, which is on our website,

Progression from Advanced Subsidiary GCE to Advanced GCE

Students who have achieved the Advanced Subsidiary GCE in Chemistry can progress to the Advanced GCE in Chemistry. They would have covered Topics 1–10 which are common to both qualifications but the additional Topics 11–19 will need to be covered; all the assessment for the Advanced GCE qualification must be taken at the end of the course.

Relationship between GCSE and Advanced GCE

Students cover Key Stage 4 fundamental core concepts in sciences at GCSE and continue to cover these concepts and a

Appendix 1: Transferable skills

The need for transferable skills

In recent years, higher education institutions and employers have consistently flagged the need for students to develop a range of transferable skills to enable them to respond with confidence to the demands of undergraduate study and the world of work.

The Organisation for Economic Co-operation and Development (OECD) defines skills, or competencies, as 'the bundle of knowledge, attributes and capacities that can be learned and that enable individuals to successfully and consistently perform an activity or task and can be built upon and extended through learning.'[1]

To support the design of our qualifications, the Pearson Research Team selected and evaluated seven global 21st-century skills frameworks. Following on from this process, we identified the National Research Council's (NRC) framework as the most evidence-based and robust skills framework. We adapted the framework slightly to include the Program for Inteb6362p

Intrapersonal skills

- Adaptability – ability and willingness to cope with the uncertain, handling work stress, adapting to different personalities, communication styles and cultures, and physical adaptability to various indoor and outdoor work environments.
- Self-management and self-development – ability to work remotely in virtual teams, work autonomously, be self-motivating and self-monitoring, willing and able to acquire new information and skills related to work.

Transferable skills enable young people to face the demands of further and higher education, as well as the demands of the workplace, and are important in the teaching and learning of this qualification. We will provide teaching and learning materials, developed with stakeholders, to support our qualifications.

Appendix 2: Level 3 Extended Project qualification

What is the Extended Project?

The Extended Project is a stand-alone qualification that can be taken alongside GCEs. It supports the development of 21st-century independent learning skills and helps to prepare students for their next step – whether that be university study or employment. The qualification:

- is recognised by u-11(T)9-3(e)10()1(cTd 4f)-1(t.)7( )-11(T)6(h)-t.0.66eyr924A.004 T9ro9en736.68 Tm [(AkTr1(t)-9(

Teachers: key information

- The Extended Project has 120 guided learning hours (GLH) consisting of:
  - a 40-GLH taught element that includes teaching the technical skills (for example research skills)
  - an 80-GLH guided element that includes mentoring students through the project work.
- Group work is acceptable, however it is important that each student provides evidence of their own contribution and produces their own report.
- 100% externally moderated.
- Four Assessment Objectives: manage, use resources, develop and realise, review.
- Can be run over 1, 1½ or 2 years.
- Can be submitted in January or June.

What is the Extended Project for chemistry?

How to link the Extended Project with chemistry

The Extended Project creates the opportunity for students to develop transferable skills for progression to higher education and to the workplace through the exploration of either an area of personal interest or a topic of interest from the chemistry qualification content.

For example, chemistry students could choose to carry out an investigation that would give them an opportunity to develop their skills in data collection, in the development and testing of hypotheses and in the application of mathematical models in data analysis.

Skills developed

Through the Extended Project students will develop skills in the following areas:

- independent research skills, including skills in primary research and the selection of appropriate methods for data collection
- extended reading and academic writing, including reading scientific literature and writing about trends or patterns in data sets
- planning/project management, including the refining of hypotheses to be tested in investigations
- data handling and evaluation, including the comparison of data from primary research with published data and exploration of the significance of results
- evaluation of arguments and processes, including arguments in favour of alternative interpretations of data and evaluation of experimental methodology
- critical thinking.

In the context of the Extended Project, critical thinking refers to the ability to identify and develop arguments for a point of view or hypothesis and to consider and respond to alternative arguments.

The Extended Project is an ideal vehicle to develop the skills identified in Appendix 1.

Using the Extended Project to support breadth and depth

There is no specified material that students are expected to study and, in the Extended Project, students are assessed on the quality of the work they produce and the skills they develop and demonstrate through completing this work. Students can use the Extended Project to demonstrate extension in one or more dimensions:

- deepening understanding: where a student explores a topic in greater depth than in the specification content
- broadening skills: the student learns a new skill. In a chemistry-based project, this might involve learning to assemble and manipulate an unfamiliar piece of apparatus or learning advanced data-handling techniques
- widening perspectives: the student's project spans different subjects. This might involve discussing historical, philosophical or ethical aspects of a chemistry-based topic or making links with other subject areas such as economics.

Choosing topics and narrowing down to a question

A dissertation, typically around 6000 words in length, involves addressing a research question through a literature review and argumentative discussion while an investigation/field study involves data collection and analysis, leading to a written report of around 5000 words.

For example, consider a student with an interest in alternatives to conventional fuels who decided to carry out an investigation to compare the strengths and weaknesses of two different types of biodiesel. The investigation involved secondary research to establish the theoretical background to the project, to explore the uses and properties of different biodiesels and to consider what techniques can be used to gather data. The student collected data using appropriately designed experiments. The student's own data were compared with published data, and the trends and patterns in data analysed, with consideration of the significance of the results obtained, and an attempt to interpret them in the light of the mathematical models that the student had learned about through research.

The student drew conclusions about the relative merits of the two biodiesels, basing these conclusions on their own research together with analysis of published data. Finally, the student's project ended with a review of the effectiveness of the investigation and an oral presentation of the main findings and arguments considered.

Chemistry-based dissertation projects can cover a wide variety of topics, as these examples illustrate:

- Should legislation be used to enforce the principles of green chemistry?
- Could nanochemistry revolutionise medicine?

Examples of chemistry-based investigations include:

- Are calorific values in diet foods accurate?
- Can changing the method of synthesis significantly alter the material properties of a polymer?
- Is there a correlation between the chemical composition of a chilli pepper and its taste?
- Is the use of oil-dispersants an effective way of tackling oil spills?

There is also scope for chemistry-based artefact Extended Projects. For example, a student might set out to design, make and test an item of apparatus such as a spectrometer. Extended Projects involving a performance can also be chemistry based. For example, a social issue relating to chemistry could be explored through drama.

Appendix 3: Codes

Type of code	Use of code	Code number
Discount codes	Every qualification is assigned to a discount code indicating the subject area to which it belongs. This code may change. Please go to our website (www.edexcel.com) for details of any changes.	1110
National Qualifications Framework (NQF) codes	Each qualification title is allocated an Ofqual National Qualifications Framework (NQF) code. The NQF code is known as a Qualification Number (QN). This is the code that features in the DfE Section 96 and on the LARA as being eligible for 16–18 and 19+ funding, and is to be used for all qualification funding purposes. The QN is the number that will appear on the student's final certification documentation.	The QN for the qualification in this publication is: 601/5646/6
Subject codes	The subject code is used by centres to enter students for a qualification. Centres will need to use the entry codes only when claiming students' qualifications.	Advanced GCE – 9CH0

Appendix 4: Practical competency authentication sheet

For students to gain the Science Practical Endorsement, centres will need to:

x

Appendix 5: Working scientifically

Appendices 5, 5a, 5b and 5c are taken from the document GCE AS and A level regulatory requirements for biology, chemistry, physics and psychology published by the DfE in April 2014. Working scientifically is achieved through practical activities.

Specifications in biology, chemistry and physics must encourage the development of the skills, knowledge and understanding in science through teaching and learning opportunities for regular hands-on practical work.

In order to develop the necessary skills, knowledge and understanding, students studying biology, chemistry and physics will be required to have carried out a minimum of 12 practical activities,

	Mathematical skills	Exemplification of mathematical skill in the

	Mathematical skills	Exemplification of mathematical skill in the context of A Level chemistry (assessment is not limited to the examples given below)
B.0.3	Make estimates of the results of calculations (without using a calculator).	Candidates may be tested on their ability to: x evaluate the effect of changing experimental parameters on measurable values, e.g. how the value of K_c would change with temperature given different specified conditions
B.0.4	Use calculators to find and use power, exponential and logarithmic functions	Candidates may be tested on their ability to: x carry out calculations using the Avogadro constant x carry out pH and pK_a calculations x make appropriate mathematical approximations in buffer calculations
(ii)	B.1 – handling data	
B.1.1	Use an appropriate number of significant figures	Candidates may be tested on their ability to: x report calculations to an appropriate number of significant figures given raw data quoted to varying numbers of significant figures x understand that calculated results can only be reported to the limits of the least accurate

	Mathem atical skills	Exemplification of mathematical skill in the context of A Level chemistry (assessment is not limited to the examples given below)
(iii)	B.2 – algebra	

Appendix 7: Command words used in examination papers

Command word	Definition
Draw	Produce a diagram either using a ruler or using freehand.
Evaluate	Review information then bring it together to form a conclusion, drawing on evidence including strengths, weaknesses, alternative actions, relevant data or information. Come to a supported judgement of a subject's qualities and relation to its context.
Explain	An explanation requires a justification/exemplification of a point. The answer must contain some element of reasoning/justification, this can include mathematical explanations.
Give/State/Name	All of these command words are really synonyms. They generally all require recall of one or more pieces of information.
Give a reason/reasons	When a statement has been made and the requirement is only to give the reasons why.
Identify	Usually requires some key information to be selected from a given stimulus/resource.
Justify	Give evidence to prove (either the statement given in the question or an earlier answer)
Plot	Produce a graph by marking points accurately on a grid from data that is provided and then drawing a line of best fit through these points. A suitable scale and appropriately labelled axes must be included if these are not provided in the question.
Predict	Give an expected result.
Show that	Verify the statement given in the question.
Sketch	Produce a freehand drawing. For a graph this would need a line and labelled axis with important features indicated, the axis are not scaled.
State what is meant by	When the meaning of a term is expected but there are different ways of how these can be described.
Write	When the questions ask for an equation.

Appendix 8: Data Booklet

This appendix shows the data included in a Data Booklet that will be available on our website. Centres will be sent copies of the Data Booklet for the first examination series.

Centres can make additional fresh copies by printing the Data Booklet from our website. Candidates must use an unmarked copy of the Data Booklet in examinations.

Acknowledgement of source

The data used in the Data Booklet is derived from the Nuffield Advanced Science, Revised Book of Data

Physical constants

Avogadro constant (L) 6.02 x 10 23 3 mol -1 3

Elementary charge (e)

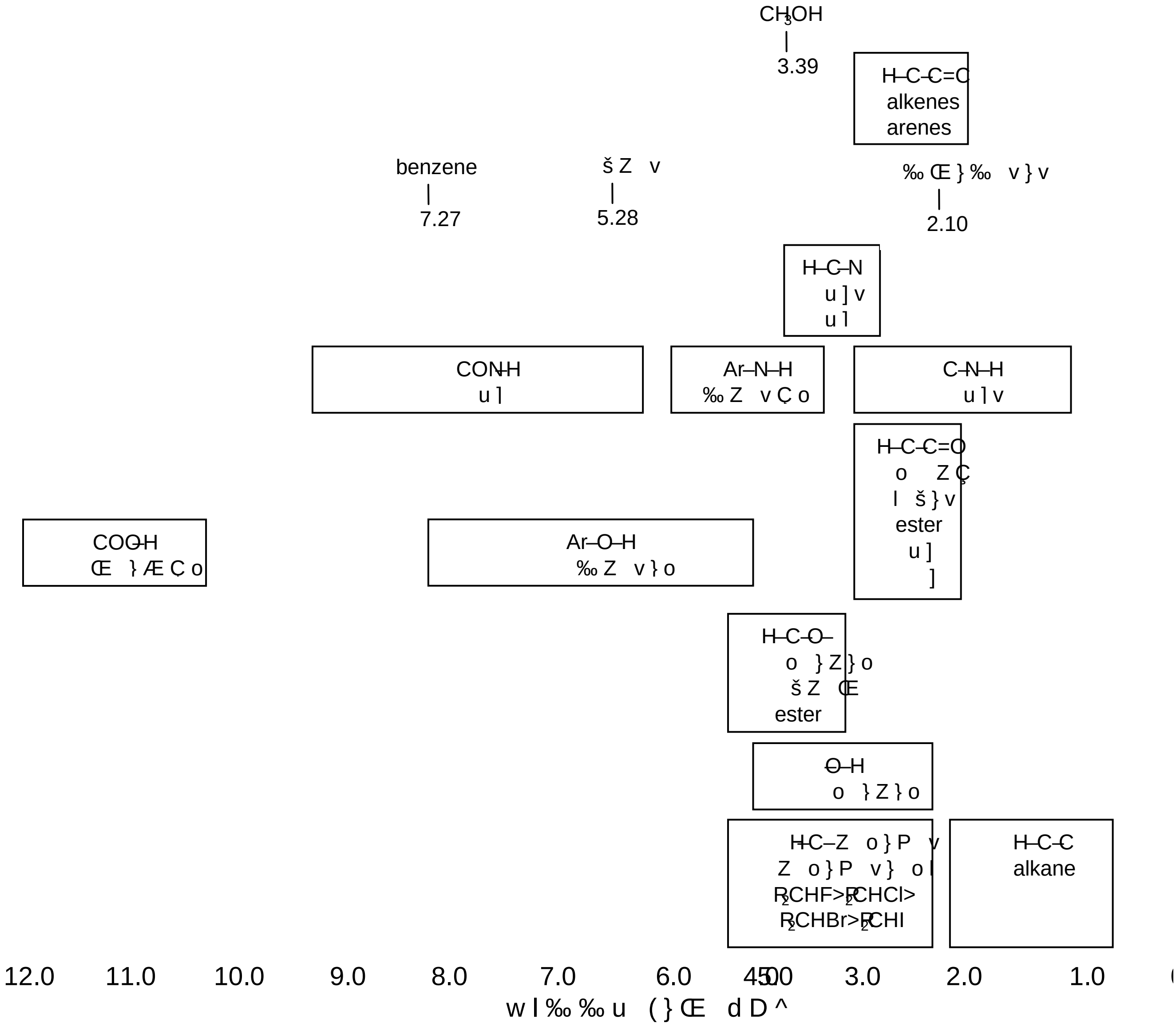
Molar volume of ideal gas:

)

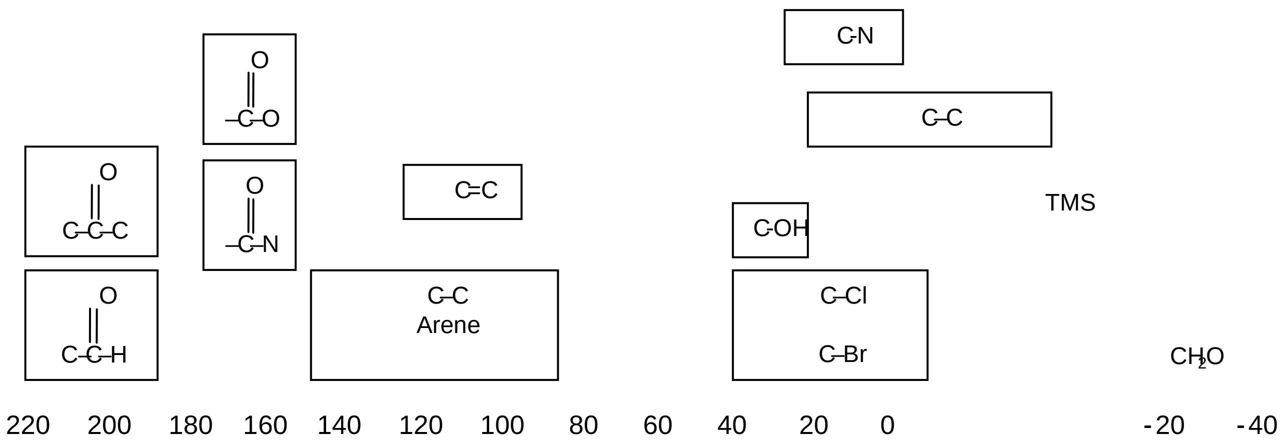
Infrared spectroscopy

Correlation of infrared absorption wavenumbers with molecular structure

[1]H nuclear magnetic resonance chemical shifts relative to tetramethylsilane (TMS)



[13]C nuclear magnetic resonance chemical shifts relative to tetramethylsilane (TMS)



Pauling electronegativities

Pauling electronegativity index

							H										He
							Â										
Li	Be											B	C	N	O	F	Ne
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Na	Mg											Al	Si	P	S	Cl	Ar
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K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
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Rb	Sr	Y	Zr	Nb	Mo	Tc	RuÂ ¦2âù 5 î(ã P–â„P–â„P–â„P– Â ¦2âùYëÂ –VrNyhVP,UbCYëÂ 4L &10’@ @										
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Standard electrode potentials

$E^{\ominus}$ Standard electrode potential of aqueous system at 298 K, that is, standard emf of electrochemical cell in the hydrogen half-cell forms the left-hand side electrode system.

	Right-hand electrode system	$E^{\ominus}$/V
1	$Na^{+} + e^{-}$ – Na	-2.71
2	$Mg^{2+} + 2e^{-}$ – Mg	-2.37
3	$Al^{3+} + 3e^{-}$ – Al	-1.66
4	$V^{2+} + 2e^{-}$ – V	-1.18
5	$Zn^{2+} + 2e^{-}$ – Zn	-0.76
6	$Cr^{3+} + 3e^{-}$ – Cr	-0.74
7	$Fe^{2+} + 2e^{-}$ – Fe	-0.44
8	$Cr^{3+} + e^{-}$ – Cr^{2+}	-0.41
9	$V^{3+} + e^{-}$ – V^{2+}	-0.26
10	$Ni^{2+} + 2e^{-}$ – Ni	-0.25
11	$H^{+} + e^{-}$ – $½H_2$	0.00
12	$½S_4O_6^{2-} + e^{-}$ – $S_2O_3^{2-}$	+0.09
13	$Cu^{2+} + e^{-}$ – Cu^{+}	+0.15
14	$Cu^{2+} + 2e^{-}$ – Cu	+0.34
15	$VO^{2+} + 2H^{+} + e^{-}$ – $V^{3+} + H_2O$	+0.34
16	$½O_2 + H_2O + 2e^{-}$ – $2OH^{-}$	+0.40
17	$S_2O_3^{2-} + 6H^{+} + 4e^{-}$ – $2S + 3H_2O$	+0.47
18	$Cu^{+} + e^{-}$ – Cu	+0.52
19	$½I_2 + e^{-}$ – I^{-}	+0.54
20	$3O_2 + 2H^{+} + 2e^{-}$ – H_2O_2	+0.68
21	$Fe^{3+} + e^{-}$ – Fe^{2+}	+0.77
22	$Ag^{+} + e^{-}$ – Ag	+0.80
23	$NO_3^{-} + 2H^{+} + e^{-}$ – $NO_2 + H_2O$	+0.80
24	$ClO^{-} + H_2O + 2e^{-}$ – $Cl^{-} + 2OH^{-}$	+0.89
25	$VO_2^{+} + 2H^{+} + e^{-}$ – $VO^{2+} + H_2O$	+1.00
26	$½Br_2 + e^{-}$ – Br[illegible]	

2- 73H

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19T /C2_9T1/[illegible]

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