National Certificate of Educational Achievement

2012 Assessment Report

Chemistry Level 3

90696 Describe oxidation-reduction processes

90698 Describe aspects of organic chemistry

90700 Describe properties of aqueous systems

90780 Describe properties of particles and thermochemical principles

COMMENTARY

This was the final year for examinations to assess these achievement standards.

Candidates were more successful if they wrote chemical equations correctly and were able to link the observations in a chemical reaction directly to the species involved.

Candidates who took care when completing calculations and worked through each step logically made fewer errors and were consequently more successful.

Candidates who learned definitions and could apply these definitions to the context of the question also had success.

STANDARD REPORTS

90696 Describe oxidation-reduction processes.

ACHIEVEMENT

Candidates who were awarded Achievement for this standard demonstrated the required skills and knowledge. They typically:

- were familiar with the standard hydrogen electrode (SHE)
- could write balanced half equations
- could complete a standard cell diagram
- could choose an appropriate substance for a salt bridge
- recognised the importance of moving ions in a salt bridge
- recognised the need for the salt bridge substance to be inert
- recognised that electrons flowed through the external circuit in an electrochemical cell, and their direction
- could describe simple changes in both electrochemical cells and reactions clearly
- described oxidation as loss of electrons or an increase in oxidation number and vice versa for reduction
- recognised that the couple with the highest $E°$cell was the strongest oxidant or the most likely to undergo reduction
- could assign oxidation numbers correctly.

NOT ACHIEVED

Candidates who were assessed as Not Achieved for this standard lacked some or all of the skills and knowledge required for the award of Achievement. They typically:

- did not read the question carefully enough to correctly answer it
- were not familiar with the standard hydrogen electrode and its function
- did not know the standard hydrogen electrode had an $E°$ value of 0.00V
- balanced half equations incorrectly
- did not follow convention for representing a standard cell diagram
- thought electrons flowed through the salt bridge

- stated ions flowed through the external circuit
- thought removal of the voltmeter reversed electrochemical cell direction
- thought ions flowed from one half-cell to the other through the salt bridge
- did not complete a diagram of a cell by including a wire
- did not understand the requirements for electrodes to be solid conductors
- could not write correct formulae e.g. KNO_3^-, I for iron, H^-, $KMnO_4^-$ or identify the correct species, e.g. $Cr_2O_7^{2-}$ for potassium permanganate
- did not understand what iron(II) means
- could not give species their correct colours
- did not understand the significance of the $E°$ value and incorrectly assigned values
- stated that a couple was reduced instead of referring to the correct species in the couple
- did not use the unbalanced equations or the $E°$ values to ensure they had the correct species for their half equations.

ACHIEVEMENT WITH MERIT

In addition to the skills and knowledge required for the award of Achievement, candidates who were awarded Achievement with Merit typically:

- assigned the movement of ions in a salt bridge correctly to the correct half-cell with a simple reason of balancing charge
- used specific species in their answer instead of general answers
- related electron direction in the electrochemical cell to reduction and oxidation processes
- linked colours to species correctly
- explained oxidation and reduction processes in terms of electron loss and gain or increase/decrease in oxidation number referring to specific numbers and species
- could write a correctly balanced net ionic equation
- assigned $E°$ values correctly and provided some justification for their choice.

ACHIEVEMENT WITH EXCELLENCE

In addition to the skills and knowledge required for the award of Achievement with Merit, candidates who were awarded Achievement with Excellence typically:

- could choose an appropriate substance for, and discuss the function of, a salt bridge using specific species and linking ideas to correct reasons of balancing charge, inertness and the processes occurring in each half cell
- could discuss the reasons for electron movement in the external circuit, relating this to changes in half-cells and using specific species
- discussed redox reactions correctly including colours linked to species, the explanation of redox reactions in detail, choosing the couple with the highest $E°$ and justifying this sufficiently
- assigned $E°$ values correctly and used specific and correct reasons to justify the choice, either $E°$cell calculations or with some explanation involving a general principle related to the question
- could write answers in a careful and logical manner, ensuring they had covered each bullet point in the question thoroughly.

90698 Describe aspects of organic chemistry

ACHIEVEMENT

Candidates who were awarded Achievement for this standard demonstrated the required skills and knowledge. They typically:

- named and drew organic structures correctly
- defined structural requirements for enantiomers
- identified functional groups correctly from experimental evidence
- described a test to distinguish between aldehydes and ketones
- drew monomers from specified polymers
- described why some organic molecules are soluble in water
- recognised that enantiomers could rotate plane-polarised light in different directions
- identified the reagents for some organic reactions.

NOT ACHIEVED

Candidates who were assessed as Not Achieved for this standard lacked some or all of the skills and knowledge required for the award of Achievement. They typically:

- drew structures with missing hydrogen atoms
- drew structures with 5 bonds on a carbon atom
- omitted or incorrectly used IUPAC numbering system
- omitted the word damp from a description of the litmus test
- confused reagents in reactions
- used other reagents than those specified in the question
- did not interpret statements that gave information about the properties of organic compounds.

ACHIEVEMENT WITH MERIT

In addition to the skills and knowledge required for the award of Achievement, candidates who were awarded Achievement with Merit typically:

- drew structural formulae of enantiomers correctly
- described tests to distinguish between aldehydes, ketones, acyl chlorides and amines
- interpreted statements correctly about the reactions and properties of organic compounds used to identify organic molecules.

ACHIEVEMENT WITH EXCELLENCE

In addition to the skills and knowledge required for the award of Achievement with Merit, candidates who were awarded Achievement with Excellence typically:

- wrote equations involved in the identification of organic molecules
- wrote hydrolysis equations of amides and esters
- understood the importance of water in using litmus as a test
- wrote equations justifying the ‘Tollens’ ’ reagent test, identifying both products
- explained that sodium hydrogencarbonate reacted with the acidic product in the production of nylon

- understood when a reagent required aqueous or alcoholic conditions
- used clear, correct terminology to explain and discuss the properties and reactions of organic compounds.

OTHER COMMENTS

Candidates were more successful when they took care in drawing organic structures. Care was demonstrated when candidates showed correct atom connectivity, e.g. showing the carbon is bonded to the O of an OH group, rather than the H atom.
Successful candidates realised that organic liquids do not react with litmus until water is added.
Candidates need to be careful when giving definitions, often used 'reflect' instead of 'rotate' when explaining a property of enantiomers.

90700 Describe properties of aqueous systems

ACHIEVEMENT

Candidates who were awarded Achievement for this standard demonstrated the required skills and knowledge. They typically:

- identified the species present in solution when a salt dissolved
- wrote correct equations for the dissolution and dissociation of salts
- wrote an equation for the equilibrium present after dissolving and from this generated a K_s expression
- used the correct method for calculating the pH of a weak base
- showed knowledge of the relationship between K_w, $[H_3O^+]$ and $[OH^-]$
- used the correct method to calculate solubility from a K_s value
- identified species produced when common acids and bases were added to water
- described the ability of a solution to conduct as a function of ionic concentration
- linked an equilibrium shift to change in solubility
- calculated a correct value for K_a from pK_a
- wrote a correct equilibrium equation and K_a expression or equation and expression for K_b
- rearranged a K_a expression (in standard or logarithmic form) to make a particular species the subject
- described the function of a buffer in general terms
- recognised which components of a buffer reacted with added acid and added base
- calculated an accurate value for concentration of a solution from titration data
- identified a characteristic of weak acid-strong base solution at the halfway point
- wrote equations for strong/weak acids/bases reacting with water
- identified the effect on pH (concentration of H_3O^+/OH^-) when adding an acid
- carried out simple acid / base titration calculations correctly
- recalled the relationship between pH and pK_a at half the equivalence point
- identified a suitable indicator for a titration with a supporting reason.

NOT ACHIEVED

Candidates who were assessed as Not Achieved for this standard lacked some or all of the skills and knowledge required for the award of Achievement. They typically:

- could not write equations for dissolving, reacting with water or for equilibrium present in a saturated solution
- calculated cube roots incorrectly
- wrote incorrect formulae, omitted charges or used inappropriate charges when describing product species for acid-water and base-water reactions
- stated incorrect species for base-water or acid-water reactions with or without correct charges
- confused the link between high concentrations of H_3O^+ and low pH and reflected the same confusion when describing the influence of OH^- concentration on pH
- did not link the presence of ions to conductivity when describing the conductivity of a solution
- used condensed mathematical process when finding solubility from K_s leading to incorrect equations and subsequently an incorrect answer
- could not write an accurate ionic dissolution equation and K_s expression
- converted pK_a to K_a incorrectly
- wrote a K_a expression for a base reacting with water
- described the concept of a buffer solution and/or its function incorrectly
- showed no understanding of the characteristics of weak-acid, strong-base titration solutions and titration curves for these solutions
- misunderstood the parameters of indicator choice for an acid-base titration
- could not write equations for the reaction of acids/bases with water
- could not complete chemical equations/calculations for pH.

ACHIEVEMENT WITH MERIT

In addition to the skills and knowledge required for the award of Achievement, candidates who were awarded Achievement with Merit typically:

- recognised the concentration of different species in solutions when salts dissolved
- successfully linked pH to the ability of acids/bases to react/protonate/dissociate in dilute water solution and were able to use this to explain differences between strong/weak acids/bases
- linked the conductivity of solutions of strong/weak acids/bases to the concentration of ions in solution
- calculated solubility from K_s accurately
- performed a valid calculation to find solubility in the presence of a common ion to see if a precipitate would form or not
- linked a shift in equilibrium to an imposed change on a system
- performed methodical calculations with only minor (arithmetical) errors
- performed complex calculations to arrive at accurate intermediate answers without correctly proceeding to the correct final result
- explained buffer action in terms of $[H_3O^+]$ / $[OH^-]$ stability and used correct equations to show how added H_3O^+ and OH^- was absorbed by the reaction with acidic and basic species in the buffer solution
- calculated accurately the pH of a weak acid solution given its pK_a and concentration

- explained fully the unique character of weak-acid and strong-base titration solution at the halfway point
- identified a correct indicator for a titration, with justification
- explained the different concentrations of all species present in weak acid/base equilibria
- performed multiple step calculations and linked their answers to the chemistry they described.

ACHIEVEMENT WITH EXCELLENCE

In addition to the skills and knowledge required for the award of Achievement with Merit, candidates who were awarded Achievement with Excellence typically:

- discussed comprehensively the differences in pH AND electrical conductivity of acids, bases and salts
- made accurate calculations regarding the effect of a common ion and were able to predict precipitation by comparing a calculated IP to K_s
- discussed fully the relationship between pH and solubility for a sparingly soluble basic salt
- discussed buffer action in detail with written ionic equations to show buffer species reacting with added acid and base, and provided valid analysis of the buffer composition in terms of the ratio of acid : base, relating this to the pK_a and the pH of the buffer thus being able to argue its greater ability to absorb acid/base additions
- discussed fully a correct choice of indicator for a titration by defining the parameters of choice and consequence of an incorrect choice with respect to the production of an accurately calculated result
- performed calculations for pH and mass of substances required to give a specific pH
- explained points on a titration curve, using calculations.

OTHER COMMENTS

Candidates, when asked to re-arrange a formula to complete a calculation, were more likely to succeed if they fully showed their re-arrangement and did not skip steps. Often skipping steps led to inaccuracies.

Some candidates showed little understanding of conductivity and its link to a weak/strong acid.

90780 Describe properties of particles and thermochemical principles

ACHIEVEMENT

Candidates who were awarded Achievement for this standard demonstrated the required skills and knowledge. They typically:

- wrote correct electron configurations for simple atoms
- linked the colour of transition metal ions to partially filled *d* orbitals
- recognised that atom size decreases across the periodic table
- recognised that positive ions have smaller radii than their atom
- drew correct Lewis diagrams
- used appropriate three-dimensional notation for molecular shapes

- linked the symmetry of a molecule containing polar bonds to the overall polarity of that molecule
- calculated the enthalpy change for the combustion of 2 moles of octane according to the equation provided
- recognised that enthalpy change of a reaction is the sum of the energies of bonds broken minus the sum of the energies of bonds made
- recognised that double bonds are stronger than single bonds and therefore require more energy to break
- identified the process defined by $\Delta_{vap}H$
- recalled some information about intermolecular forces and their effect on melting and boiling points
- recognised that hydrogen bonding exists between certain molecules
- identified correctly the molecule with the highest boiling point as chloroethanol.

NOT ACHIEVED

Candidates who were assessed as Not Achieved for this standard lacked some or all of the skills and knowledge required for the award of Achievement. They typically:

- wrote incorrect electron configurations for Cu and Cu^+ and hence found it difficult to explain the colours of compounds of copper
- stated that atomic size increased from left to right simply because there were more electrons or because there was increased electron-electron repulsion
- used electronegativity to explain a change in radii for Cu, Cu^+ and Ge
- failed to recognise that the formation of Cu^+ involves the loss of an electron energy level
- stated that the radius of an atom or ion simply depends on proton to electron ratio
- did not show all valence electrons in Lewis diagrams
- used two-dimensional representations for molecular shapes
- gave incorrect names for the shapes of different molecules
- failed to recognise that enthalpy of combustion is defined per mole of substance burned
- assumed that all combustion reactions only produce CO_2 and H_2O
- were unable to correctly substitute numerical values into an expression
- believed CO_2 molecule contains C-O single bonds and failed to identify all the bonds present in propan-1-ol
- rearranged incorrectly the equation used to solve for the unknown $E_{C=O}$
- defined bond enthalpy as the energy released on breaking a bond
- could not identify the process defined by $\Delta_{fus}H$, commonly identifying it as the process of forming water from its elements
- described hydrogen bonding as the O-H bond in water
- stated that hydrogen bonding only exists in liquid water and not in the solid state
- described melting as the breaking of intermolecular forces while boiling involves breaking covalent bonds

- identified chloropropane as having a higher boiling point than chloroethanol, due to the former having more bonds to break.

ACHIEVEMENT WITH MERIT

In addition to the skills and knowledge required for the award of Achievement, candidates who were awarded Achievement with Merit typically:

- wrote correct electron configurations for transition metals
- recognised that size decreases from left to right as nuclear charge increases and electrons are added to the same energy level with no additional shielding
- drew correct three-dimensional shapes and correctly named the octahedral shape
- linked polar bonds to differences in electronegativities of bonded atoms
- discussed the repulsion between bonding and non-bonding pairs of electrons on the central atom and its impact on the shape of the molecule
- applied Hess's Law appropriately
- applied mathematical principles involving brackets, subtraction and negative values correctly
- wrote correct equations for enthalpy of fusion and enthalpy of vaporisation
- recognised that both melting and boiling of water involve breaking of the hydrogen bonds between molecules
- identified and explained some of the intermolecular forces in both chloropropane and chloroethanol.

ACHIEVEMENT WITH EXCELLENCE

In addition to the skills and knowledge required for the award of Achievement with Merit, candidates who were awarded Achievement with Excellence typically:

- linked colour to specific electron arrangements for different copper ions
- recognised that size is affected more by the loss of an entire energy level than it is by fewer protons
- identified SF_4 as having a see-saw shape
- used VSEPR theory to comprehensively explain the shape and polarity of ClF_3 and AsF_5
- completed accurate and well set out enthalpy calculations
- recognised that the definition of both $\Delta_c H$ and bond enthalpy are per mole
- recognised that only some of the intermolecular forces are broken when a solid melts but all intermolecular forces are broken on evaporation of a liquid
- justified that chloroethanol has the higher boiling point by correctly listing and explaining the intermolecular forces present in both molecules.

OTHER COMMENTS

Some students are confused in their use of the term 'effective nuclear charge'.
The term fusion used in nuclear chemistry appears to be causing confusion when considering the term fusion with reference to $\Delta_{fus} H$ and the process of melting.

There is a common confusion between the observed colour of transition metal ions and the emission spectrum due to light being emitted as electrons drop from orbitals that are of a higher energy level to a lower energy level.