NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Level 3, 2004

Chemistry

Describe oxidation-reduction processes (90696)

Describe selected atomic, molecular and ionic properties (90697)

Describe the structure and reactions of organic compounds containing selected organic groups (90698)

Describe and use thermochemical principles (90699)

Describe aqueous systems using equilibrium principles (90700)

National Statistics

Assessment Report

Assessment Schedule

Chemistry, Level 3, 2004

General Comments

Candidates gaining Achievement were able to recall and describe principles of chemistry at Level 3. Those gaining Achievement with Merit and Achievement with Excellence were able to apply definitions or principles learned to the specific question being asked, to analyse information, integrate their ideas, and write well-structured discussions that showed they had a depth of understanding of concepts in chemistry.

The questions in this examination were often more open-ended and gave candidates more opportunity and freedom to demonstrate their depth of understanding of concepts than in the past. This was in line with the chemistry examinations at Levels 1 and 2 in 2002 and 2003, and the Level 3 exemplars on the NZQA website.

Despite the challenge of completing the five level 3 papers in three hours, many candidates wrote answers of at least one page in length when the lines provided indicated that a much shorter answer was expected. They tended to write contradictory statements, repeat the same answer in different ways, and included a lot of inappropriate and irrelevant information, all of which would have contributed to their inability to complete the five papers in the set time. For example, when asked to compare the ionisation energy of three atoms, many candidates spent time discussing electronegativity or the tendency to complete outer shells of electrons by gaining or losing electrons, as well as (or instead of) discussing factors affecting ionisation energy. The skill of structuring a clear and concise answer with relevant and appropriate use of chemical terms is what helps identify the candidate who is operating at the Merit or Excellence level.

When writing balanced equations, candidates are expected to be able to write correct formulae for common substances. For example the dichromate ion is $Cr_2O_7^{2-}$ and zinc hydroxide is **not** $ZnOH_2$. Candidates must be able to balance an equation without simply changing the formulae to conveniently use up all the atoms present.

In completing calculations, candidates should be able to provide answers that have an appropriate number of significant figures. They need to be familiar with the particular calculator they are taking into the examination so that they know how and when to use brackets when entering data into the calculator (so that the order of operations is correct).

Chemistry: Describe oxidation-reduction processes (90696)

National Statistics

Number of Results	Percentage			
	Not Achieved	Achieved	Merit	Excellence
6,713	33.2%	49.8%	13.3%	3.7%

Assessment Report

Candidates gaining Achievement in this standard were able to *identify and describe* oxidation-reduction processes by recognising relevant reactants and products (using words and formulae) and describing the operation of electrochemical cells. With guidance (through the nature of the questions) they were able to balance half and full equations.

Candidates who gained Achievement with Merit or Achievement with Excellence were able to *use* the value of electrode potentials to determine whether test tube reactions were spontaneous, and to apply the calculated value to the operation of electrochemical cells. They were able to *analyse and interpret* information about oxidation-reduction reactions, including that given in the context of a titration analysis, and use this to link observations to species present, explain the link between reactions occurring and changes in oxidation numbers, and discuss the operation of cells. They were able to correctly carry out stoichiometric calculations, including interconversions of amount and mass of a substance, with correct use of the mole ratio between species involved in the reaction.

Candidates need to recognise the importance of writing equations in a systematic way, eliminating common species from either side of the balanced equation.

Chemistry: Describe selected atomic, molecular and ionic properties (90697)

National Statistics

Number of Results	Percentage			
	Not Achieved	Achieved	Merit	Excellence
6,724	39.7%	37.3%	18.0%	5.0%

Assessment Report

Candidates who gained Achievement were able to *describe properties* using diagrams, calculations, formulae and simple written descriptions. They were able to present their ideas with appropriate use of relevant chemical terminology. Calculations were generally set out clearly and diagrams drawn accurately. Their answers showed they understood the meaning of key terms such as electron configuration, ionisation energy, polarity, Lewis diagrams, characteristics of transition metals, α and ß emission.

Candidates who gained Achievement with Merit or Achievement with Excellence were able to *apply* the principles of atomic structure and bonding to atoms and molecules by correctly explaining or clearly discussing properties such as the trends in ionisation energy or polarity of molecules. They were also able to demonstrate an understanding of the properties of transition metals.

Candidates must learn to use chemical terminology such as “effective nuclear charge” and “shielding” correctly if they are to achieve to the standard expected. Some common **misconceptions** frequently encountered were:

- that the mass remaining after four half-lives is 1/16th of the mass number
- that sulfur has a higher ionisation energy than sodium because the S atom wants to gain electrons and the Na atom wants to lose electrons
- a molecule such as SF_6 is non-polar because the electrons in its bonds are shared equally between S and F
- a metal has a ‘variable oxidation state’ and is a transition metal if it exists as the atom and as the +2 ion (eg Mg and Mg^{2+})
- that the coloured compounds typical of transition metals includes those ‘coloured’ white.

Chemistry: Describe the structure and reactions of organic compounds containing selected organic groups (90698)

National Statistics

Number of Results	Percentage			
	Not Achieved	**Achieved**	**Merit**	**Excellence**
6,676	**41.6%**	**40.5%**	**12.8%**	**5.2%**

Assessment Report

Candidates who gained Achievement were able to *describe* structures by drawing structural formulae and recognising functional groups using name and formulae. They were able to identify the types of reactions undergone by organic compounds having given functional groups, and how these reactions could be used to identify certain organic molecules.

Candidates should be reminded that while the *"principles of organic chemistry covered in AS 90309 are implicit in this standard"* it does not mean they will gain Achievement by simply naming organic molecules and identifying reactions covered at Level 2.

Candidates who gained Achievement with Merit or Achievement with Excellence were able to *apply* principles of organic chemistry and *integrate* these in relation to a range of ideas and reaction schemes. They were able to make comparisons between the reactions of organic compounds with different functional groups, both in the nature of the reaction and the practical observations to be expected. They were able to apply principles of organic chemistry with respect to physical and chemical properties, including the nature of enantiomers and their ability to rotate (NOT reflect) plane polarised light.

Chemistry: Describe and use thermochemical principles (90699)

National Statistics

Number of Results	Percentage			
	Not Achieved	**Achieved**	**Merit**	**Excellence**
6.634	**44.3%**	**30.0%**	**22.8%**	**2.8%**

Assessment Report

Candidates who gained Achievement showed an understanding of, and were able to use, terms such as endothermic and exothermic change, $\Delta_f H$, $\Delta_{vap} H$, $\Delta_{fus} H$ as well as the principles of enthalpy change. They were able to identify and use an appropriate mathematical procedure to determine the molar enthalpy change for a given reaction.

Those candidates who set out their calculations in a logical, stepwise sequence enabled "follow-on marking" to be applied if necessary. Candidates need to be reminded of the importance of using brackets (to order operations correctly) when entering numbers into calculators.

Candidates who gained Achievement with Merit or Achievement with Excellence were able to apply their understanding of thermochemical principles. They used the appropriate mathematical procedure to solve problems, and completed the calculations correctly. This included an ability to manipulate negative numbers and demonstrate an understanding of units.

They were able to interpret data and explain it in terms of the nature of the solid and the forces of attraction between the particles. At this level, candidates were able to write a response which linked their understanding of thermochemical principles to the question, rather than simply write all they knew about the topic.

Many candidates who completed other parts of the paper to at least merit level omitted Question Three (a), suggesting that they were unfamiliar with the concept of specific heat capacity. This is one of the thermochemical principles included in the explanatory notes for this standard.

Candidates need to be reminded that the "fusion" referred to in $\Delta_{fus}H$ is not the fusion of nuclei (found in radiochemistry). In the case of $\Delta_{fus}H$ (H_2O), it is simply the melting of water and NOT the reaction to produce H_2 and O_2. A very high proportion of the candidates in this paper gave answers that conveyed the latter misconception.

Chemistry: Describe aqueous systems using equilibrium principles (90700)

National Statistics

Number of Results	Percentage			
	Not Achieved	Achieved	Merit	Excellence
6,616	72.4%	15.7%	7.7%	4.1%

Assessment Report

Candidates gaining Achievement were able to *describe* the dissolving of sparingly soluble salts and demonstrate a simple understanding of proton transfer reactions using appropriate terminology. They could describe the nature of species present in solution and the relative pH values. Candidates could effectively substitute numbers into a learned mathematical expression, although their mathematical skills did not always mean that they could complete the calculation correctly or accurately. They showed they had a basic understanding of species present at key points in the titration curve, including the ability to select a relevant indicator.

Candidates need to be made aware of the importance of setting out calculations in a logical sequence, and to show their working clearly, so that "follow-on marking" can be applied if necessary. The use of an incorrect logarithmic expression (containing inverted concentration ratio or incorrect sign) in the calculation of a buffer meant many candidates could not use their selected expression to help them 'describe' the nature of the buffer solution.

Candidates who gained Achievement with Merit or Achievement with Excellence were able to use correct and relevant equations, formulae and chemical terms when presenting evidence. They were able to apply equilibrium principles to specific situations, and their answers showed a logical sequence of thought in both discussions and calculations. These candidates generally answered all aspects referred to in the question.

Assessment Schedule

Chemistry: Describe oxidation-reduction processes (90696)

Evidence Statement

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
1(a)	$2H_2(g) + O_2(g) \rightarrow 2H_2O$	Correct equation.		
1(b)(i) (ii)	Anode is H_2 electrode on left, cathode O_2 electrode on right. Oxidant is O_2 and reductant is H_2.	Either all of answer (i) or (ii) correct.		
1(c)	$E^o(H_2O/H_2,OH^-) = -0.83$ V	Correct value but wrong sign (ie + 0.83 V).	Correct answer with units.	
2(a)(i) (ii)	Fe^{3+} Fe	Both correct.		
2(b)	$2H^+ + H_2O_2 + 2e^- \rightarrow 2H_2O$ $H_2O_2 \rightarrow O_2 + 2H^+ + 2e^-$ $2H_2O_2 \rightarrow 2H_2O + O_2$	Correctly balanced equation.		
2(c)	H_2O_2 – because it is the oxidant in the redox couple with the most positive reduction potential and is therefore most easily reduced.	H_2O_2 identified (may be included as part of a half-cell).	H_2O_2 identified with appropriate justification. (Must be more than just 'highest E^o value'.)	
2(d)(i)	E^o_{cell} for this reaction is +1.01 V and since it is positive the reaction occurs.	+1.01 V with no justification **or** +2.55 V with justification.	+1.01V with justification.	
2(d)(ii)	$2H^+ + H_2O_2 + 2Fe^{2+} \rightarrow 2H_2O + 2Fe^{3+}$	Correct equation		
2(d)(iii)	Colourless (or very pale green) solution will turn an orange colour (due to the formation of Fe^{3+}).	Colour **change** correct		
3(a)	The solution will go from colourless to yellow-brown (some black solid may form) – or from colourless to red/brown (recognising formula of I_3^- ion).	Appropriate observation. (black solution not accepted)		
3(b)	$n(S_2O_3^{2-}) = 6 \times n(IO_3^-) = 9.00 \times 10^{-4}$ mol Exam paper shows incorrect charge on iodate ion; should have been noted by the supervisor, but allowance may have to be made for this.		Correct answer.	

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
3(c)	The iodine in IO_3^- has oxidation number +5 and the iodine in I_2 has oxidation number 0. This decrease in oxidation number means the IO_3^- is reduced. The I^- has oxidation number −1 and the increase to the value 0 in I_2 means the iodide is oxidised.	Correct identification of oxidation number increase for I^- and I_2 **OR for** IO_3^- to I_2.	Full and correct discussion referring to all 3 oxidation numbers.	
4(a)	0.46 V	Correct answer.		
4(b)	Cu(*s*) I Cu^{2+}(*aq*) II Ag^+(*aq*) I Ag(*s*)	Correct answer. (States do not need to be included.)		
4(c)	Electrons flow through the external circuit from the Cu to the Ag electrode. Ions move through the salt bridge, cations move towards the Ag^+/Ag half-cell while anions move through the salt bridge towards the Cu^{2+}/Cu half-cell.	Partial description of charge movement, eg movement of electrons through external circuit.	Description of electron movement in external circuit and ion movement through salt bridge.	Full description of electron and ion movement.
4(d)(i)	$2Ag^+ + Cu \rightarrow 2Ag + Cu^{2+}$	Correctly balanced equation.		
4(d)(ii)	In the Cu^{2+}/Cu half-cell the blue colour of the solution would become darker and the copper electrode would erode away. In the silver electrode half-cell more grey solid would be deposited on the electrode increasing its mass.	Any two correct observations. If equation is reversed, or colour described as green, but all else is as schedule, reduce grade by one level.	Any two correct observations with an explanation of the chemistry involved.	Full discussion including colours of species produced.
4(e)	*n*(Cu) = 3.20 g / 63.5 g mol^{-1} = 0.0500 mol $Cu + 2Ag^+ \rightarrow Cu^{2+} + 2Ag$ *n*(Ag) 2 × 0.0500 mol = 0.100 mol *m*(Ag) = 0.100 mol × 108 g mol^{-1} = 10.8 g Mass increases by 10.8 g.	Appropriate calculation but uses 1:1 ratio for Cu:Ag^+. Must show working.	Appropriate calculation with one minor error.	Mass change correctly calculated.
4(f)	The standard hydrogen electrode (SHE) has a standard reduction potential set at 0.00 V. This means that when it is connected to the Cu^{2+}/Cu half-cell the Cu^{2+} would now be reduced and this would be the positive electrode or cathode, while the SHE will be the negative electrode or anode. The overall cell voltage will be +0.34 V. The blue colour of the Cu^{2+} solution will fade and pink Cu metal will be deposited on the electrode. The acidity of the other electrode would increase as acid is produced.	Recall of a single relevant concept such as the fact that the SHE has a reduction potential of 0.00 V.	Single idea related to the operation of the cell.	In-depth discussion of change in voltage and reverse direction of current.

For any question, the assessor only needs to award the highest grade that is justified for that answer.

Judgement Statement

Chemistry: Describe oxidation-reduction processes (90696)

Achievement

Total of **EIGHT** opportunities answered at Achievement (or higher)

8 × A

Merit

Total of TEN opportunities answered with **FIVE** at Merit level and FIVE at Achievement level.

5× M + 5 × A

Excellence

Total of TEN opportunities answered with **TWO** at Excellence level and THREE at Merit level and FIVE at Achievement level.

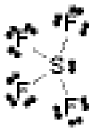
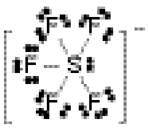
2 × E + 3 × M + 5 × A

Assessment Schedule

Chemistry: Describe selected atomic, molecular and ionic properties (90697)

Evidence Statement

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
1(a)	$^{243}Am \rightarrow {}^{239}Np + \alpha$ $^{239}Np \rightarrow {}^{239}Pu + \beta$ Atomic nos $_{95}Am$, $_{93}Np$ and $_{94}Pu$ can be included.	Both eqns correct. If atomic no. given it must be correct.		
1(b)	No. of half lives = $\frac{2.8 \times 10^9}{7 \times 10^8}$ = 4 Decay in 4 half lives to 6.25% = 0.0625 or 1/16	Correct number of half lives	Correct answer for fraction (or percentage) remaining	
1(c)	I-123 used in body so short half-life means cells not exposed to radiation for long time. γ radiation least damaging to cells because low ionising ability and **highly penetrating** therefore it is easily detected outside the body. Iodine used because can be absorbed into thyroid. Am-241: α particles easily stopped by casing so not likely to cause harm to people, long half-life means only a small amount of radiation is released and will last a long time (no need to replace). It is highly ionizing radiation and this is important in the operation of the smoke detector.	Links 1 property to its use OR Identifies at least 2 different properties – but not both of these are related to length of half life.	Brief discussion about properties and uses but lacks detail – eg clear links between 2 different properties and their use in at least one of the isotopes, OR clear link between half life and use for both isotopes and mentions one other factor such as gamma rays are highly penetrating.	Comprehensive discussion of both radioisotopes – *eg discusses half life and type of emission and explains why this is significant in each case.* ie makes 4 connections between property and use but this may be the same 2 properties linked to use in each of the isotopes.
2(a)	Se: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^4$ OR [Ar] $3d^{10} 4s^2 4p^4$ S^{2-}: $1s^2 2s^2 2p^6 3s^2 3p^6$ (accept eg $3s^2 p^6$) OR [Ar] OR [Ne] $3s^2 3p^6$	One correct.		
2(b)(i) 2(b)(ii)	When the sodium ion is formed one electron is removed. This results in the loss of a complete energy level. Hence sodium ion has one less energy level so is smaller. (There is a higher effective nuclear charge for Na^+ or Na atom has more shielding. **Not** just less electrons therefore stronger proportional hold.) Sulfide ion is formed by adding (2) electrons into the valence shell of the sulfur atom. Repulsive forces between the valence electrons increase the size of the electron cloud. Invalid to discuss gain or loss of electrons to increase stability. Neutral to say S^{2-} has lower effective nuclear charge. NOT larger nucleus.	Brief explanation for either (i) or (ii) making connection between gain or loss of electrons and relative size.	Both explanations correct showing clear understanding of relative atomic and ionic size.	

Question	**Evidence**	**Evidence contributing to Achievement**	**Evidence contributing to Achievement with Merit**	**Evidence contributing to Achievement with Excellence**
2(c)(i)	S(*g*) → S^+ (*g*) + e^-	Correct including at least one inclusion of (*g*) state.		
2(c)(ii)	S > Na; e^- removed from **same E level** (so same shielding), but **nuclear charge greater** in S so e^-s more strongly held. S > Se because **valence e^- is in E level further from the nucleus** (with more shielding by inner electron shells), so weaker electrostatic attraction and therefore takes less energy to remove an electron.	Answer makes basic link eg ionisation energy increases going across a row and decreases down a group.	Discussion of both but lacks some detail eg no mention of valence electrons of Na and S being in the same shell or energy level.	Full and correct discussion.
2(d)	 SF_4  SF_5^-	Diagrams show correct number of valence electrons OR one diagram correct.	Both diagrams correct.	
	Trigonal (or trianglar) pyramid (not JUST pyramidal or trigonal) Octahedral NOT hexahedral	2 shapes correct.		
2(e)	SF_6 is a **symmetrical molecule** so although **bonds are polar** due to difference in electronegativity of S and F atoms, **the polarities (or dipole moments) will cancel**. **SF_4 is not a symmetrical molecule** because as well as the polar bonds there is a pair of non-bonded e^-s on **the S atom** so molecule is polar, so charge distribution is not symmetrical.	Correctly identifies polarity of both molecules (allowing follow-on from diagram drawn for SF_4) OR Makes an appropriate connection between polarity and shape for 1 molecule.	Comparison of symmetry of molecules. Discussion lacks detail or has some misconception eg electronegativity cancels or bonds cancel.	Discussion shows clear understanding of polarity of molecules.

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
3(a)(i)	Cr^{3+} green/blue, CrO_4^{2-} yellow (NOT orange or yellow/orange).	Both colours correct.		
3(a)(ii)	Able to **lose 4 *s* electrons** and **varying numbers of *d* electrons**.	Answer relates to partially filled *d* subshell or losing varying no of 3*d* electrons with no mention of 4*s*.	Valid explanation.	
3(b)(i) 3(b)(ii) 3(b)(iii)	$Cr(OH)_3 + OH^- \rightarrow Cr(OH)_4^-$ OR $Cr(OH)_3 + 3OH^- \rightarrow Cr(OH)_6^{3-}$ $Cr(OH)_3 + 3H_3O^+ \rightarrow Cr^{3+} + 6H_2O$ OR $Cr(H_2O)_6^{3+}$ $2CrO_4^{2-} + 2H_3O^+ \rightarrow Cr_2O_7^{2-} + 3H_2O$ OR $2CrO_4^{2-} + H_3O^+ \rightarrow Cr_2O_7^{2-} + H_2O + OH^-$	One chromium product correct.	Two chromium products correct and one equation correctly balanced.	2 equations balanced with all correct species in these 2 equations.
3(c)	$Zn^{2+}(aq) + 2OH^-(aq) \rightarrow Zn(OH)_2(s)$ OR $ZnCl_2(aq) + 2NaOH(aq) \rightarrow 2NaCl(aq) + Zn(OH)_2(s)$ $Zn(OH)_2(s) + 2OH^-(aq) \rightarrow Zn(OH)_4^{2-}(aq)$ OR $Zn^{2+}(aq) + 4OH^-(aq) \rightarrow Zn(OH)_4^{2-}(aq)$ States do not need to be included.	Precipitate and complex ion identified OR one balanced equation correct. (*Ignore states.)*	All species correct and 1 equation balanced.	
3(d)(i) 3(d)(ii)	$ZnCl_2$ (not zinc) is **white**, but most **transition metal compounds are coloured**. Zn^{2+} ion has no **partially filled *d* orbitals** so *d* electrons (NOT orbitals) cannot be excited to (vacant or partially filled d) orbitals of higher energy by absorption of light energy in the visible range. OR Zinc does not have variable oxidation state because it only loses the 4*s* electrons and none of the 3*d*. $Zn(OH)_4^{2-}$ is a complex ion. These are able to be formed by (transition) metals with high charge density (small radius and high charge) {which can attract the negative ions or nonbonding electrons on molecules such as water} OR Readily forms a **+2 ion by losing its 4*s* electrons** (accept use as a catalyst eg $ZnCl_2$ in Lucas Reagent BUT must specify example of catalyst use).	Correctly identifies one similarity and one difference OR Correctly explains one similarity or difference.	Correctly identifies one similarity and one difference AND clearly explains one of them.	

For any question the assessor only needs to award the highest grade that is justified for that answer.

Judgement Statement

Chemistry: Describe selected atomic, molecular and ionic properties (90697)

Achievement

Total of **EIGHT** opportunities answered at Achievement (or higher)

8 × A

Achievement with Merit

Total of NINE opportunities answered with **FIVE** at Merit level and FOUR at Achievement level.

5 × M + 4 × A

Achievement with Excellence

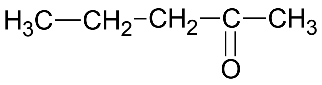
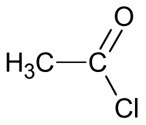
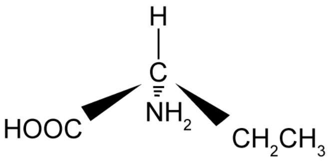
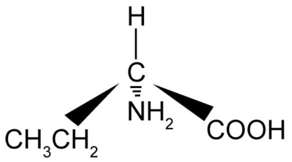
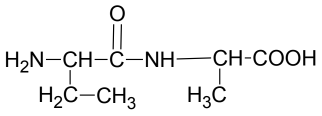
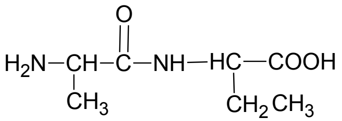
Total of ELEVEN opportunities answered with **TWO** at Excellence level and FIVE at Merit level and FOUR at Achievement level.

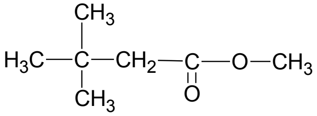
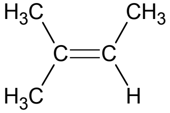
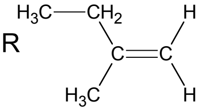
2 × E + 5 × M + 4 × A

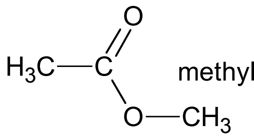
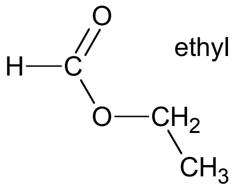
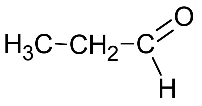
Assessment Schedule

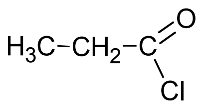
Chemistry: Describe the structure and reactions of organic compounds containing selected organic groups (90698)

Evidence Statement

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Merit	Evidence contributing to Excellence
1(a)(i) 1(a)(ii) 1(a)(iii) 1(a)(iv)	3-methylbutanal  $H_3C-CH_2-CH_2-\underset{O}{\underset{\Vert}{C}}-CH_3$  2-aminobutanoic acid (Refer Assessment Specifications for acceptable structural formulae)	3 of 4 answers correct. Shows ability to draw and name molecules at Level 3.		
1(b)	(i) Aldehyde / carbonyl group / alkanal (II) carboxyl / alkanoic acid / carboxylic acid, amino group	2 of 3 correct indicating correct knowledge of groups in Level 3.		
1(c)	  	One isomer drawn **correctly** with 3-dimensional arrangement of groups around chiral C (three types of bond lines).	Both isomers correctly drawn showing 3-dimensional arrangement around chiral C **and** correct mirror images.	
1(d)	Solutions rotate plane polarised light in different directions. Same physical properties eg same bp, mp, density, polarity; very similar chemical properties (identical in reaction with optically inactive molecules because the same bonds will be broken).	Brief description, with appropriate reference to rotation of polarized light.	Description recognising **similarity** and differences **in physical and chemical properties** including **rotation of polarized light.**	
1(e)(i)	 $H_2N-\underset{H_2C-CH_3}{CH}-\overset{O}{\overset{\Vert}{C}}-NH-\underset{H_3C}{CH}-COOH$  $H_2N-\underset{CH_3}{CH}-\overset{O}{\overset{\Vert}{C}}-NH-\underset{CH_2CH_3}{HC}-COOH$	Molecule drawn has an amide link.	1 correct dipeptide drawn OR both correctly drawn as part of a polymer chain.	Both dipeptides correctly drawn.

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Merit	Evidence contributing to Excellence
1(e)(ii)	Condensation rxn results in removal of a small molecule OR water during the bonding reaction between the 2 molecules, in this case a water molecule is produced for every peptide bond formed. The OH is removed from the carboxylate or OH ends and the H is removed from the amine group.	Correct definition of condensation reaction given but not in relation to explanation of (i) above.	Correct definition related to (i) referring to the dipeptides formed.	
2(a)(i) 2(a)(ii) 2(b)	 $H_3C-\overset{CH_3}{\underset{CH_3}{C}}-CH_2-\underset{O}{\underset{\Vert}{C}}-O-CH_3$  OR  Reaction (a)(i) condensation /esterification/substitution Reaction (a)(ii) elimination	One structure correct.	One structure drawn correctly and linked to the appropriate type of reaction.	Both structures correct with a link to the appropriate reaction type in part (b), reflecting an appreciation of both esterification and elimination.
3(a) 3(b)	Only the propanal will react with Tollens', Fehling's or Benedict's. The aldehyde reduces Tollens' reagent producing a silver mirror on the side of the test tube (on warming); reduces Benedict's soln, colour change blue to brick-red ppt; (similar for Fehling's). The amine $CH_3CH_2NH_2$ is a weak base, it will dissolve in water to give a basic solution, the amide forms a neutral solution when dissolved in water e.g. litmus solution changes colour from red to blue when placed in an alkaline solution. / amines form deep blue colored complex ions with copper(II), amides do not.	Test correctly identified by name or reagent for both pairs of compounds OR tests distinguishing one pair described in full.	Clear explanation for distinguishing between both pairs.	

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Merit	Evidence contributing to Excellence
4(a)	 methyl ethanoate  ethyl methanoate	One structural isomer correctly drawn and named.		
4(b)	Possible oxidising agent acidified potassium dichromate / or potassium permanganate / chromic acid. Diagram (ii) shows a condenser attached on top of the flask to be heated. As water passes through the condensor jacket it cools any vapour which is then returned to the solution. In this way the rate of reaction is increased by heating and none of the organic material is lost through evaporation.	**One of**: • Appropriate oxidising agent identified as well as diagram (ii) as being appropriate experimental arrangement or • **how** the experimental arrangement works or • **why** it is necessary to heat under reflux.	**Two of**: • Appropriate oxidising agent identified as well as diagram (ii) as being appropriate experimental arrangement or • **how** the experimental arrangement works or • **why** it is necessary to heat under reflux.	**All of**: • Appropriate oxidising agent identified as well as diagram (ii) as being appropriate experimental arrangement and • **how** the experimental arrangement works and • **why** it is necessary to heat under reflux.
4(c)(i) 4(c)(ii)	 propanal The mixture should not be refluxed, but as the oxidising agent is added to the alcohol and acid catalyst it should be heated and the aldehyde distilled off as it forms.	Molecule correctly drawn and named **OR** description of how to obtain aldehyde, not carboxylic acid, by distilling off the aldehyde as it forms.	Achieved AND description of how to obtain aldehyde, not carboxylic acid, by distilling off the aldehyde as it forms.	

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Merit	Evidence contributing to Excellence
4(d)(i) 4(d)(ii)	 propanoyl chloride Anhydrous means in the absence of water ie dry conditions; water will influence the yield as it will produce the reverse reaction – turning the acid chloride into the carboxylic acid / hydrolysing the PCl_5.	**Either** name or structure identifies an acid chloride OR correct definition of anhydrous.	Correct name and structure with appropriate definition of the word anhydrous.	All correct with a discussion recognising that any water present would react with and hydrolyse the acid chloride / PCl_5.
4(e)(i) 4(e)(ii)	E = propanamide G = ammonia /NH_3	Correct name and reagent given.		
4(f)	Ammonia NH_3 Sodium propanoate CH_3CH_2COONa (or the propanoate ion) / Propanoic acid	Correct name and structure of one of products / correct structural formula for both.	Correct name and structure of the ammonia, and hydrolysis product identified as propanoic acid.	Correct name and structure of both products showing understanding of reaction under basic conditions to produce the salt.
5	Aspirin is an ester, formed from an equilibrium rxn producing water. In the presence of water (humidity) the reverse rxn occurs, producing ethanoic acid, and the alcohol. Rxn may be drawn.	Discussion identifies that a hydrolysis reaction occurs, but lacks depth / correct formulae of products.	Brief discussion of **hydrolysis reaction of ester correct AND correct formulae of products.**	Full discussion of **hydrolysis reaction of ester AND correct formulae of products provided AND identify the smell of ethanoic acid OR increased rate of reaction explained.**

Judgement Statement

Chemistry: Describe the structure and reactions of organic compounds containing selected organic groups (90698)

Achievement

Total of **SEVEN** opportunities answered at Achievement (or higher)

7 × A

Achievement with Merit

Total of EIGHT opportunities answered with **FIVE** at Merit level and THREE at Achievement level.

5 × M + 3 × A

Achievement with Excellence

Total of EIGHT opportunities answered with **THREE** at Excellence level and THREE at Merit level and TWO at Achievement level.

3 × E + 3 × M + 2xA

Assessment Schedule

Chemistry: Describe and use thermochemical principles (90699)

Evidence Statement

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
1(a)	$S + O_2 \rightarrow SO_2$ -297 kJ mol^{-1} $SO_2 + ZnO \rightarrow ZnS + 1\frac{1}{2}O_2$ $+441$ kJ mol^{-1} $Zn + \frac{1}{2} O_2 \rightarrow ZnO$ -348 kJ mol^{-1} By Hess's law of heat summation – adding these equations and the enthalpies gives $\Delta_r H = -297 + 441 - 348 = -204$ kJ mol^{-1}	Correct process with one error.	Correct value $\Delta_r H$ with units. (accept kJ or kJ mol^{-1}).	
1(b)	Reaction is exothermic since $\Delta_r H$ is negative.	Explanation links answer to sign of $\Delta_r H$ calculated.		
2(a)	$\Delta_r H = \Sigma E_{\text{bonds broken}} - \Sigma E_{\text{bonds made}}$ $=(2 \times 436 + 498) - (4 \times 460) = +1370 - 1840$ $= -470$ kJ mol^{-1}	Correct process with one error.	Correct value of $\Delta_r H$ with units. (accept kJ or kJ mol^{-1}).	
2(b)	$H_2O(\ell) \rightarrow H_2O(g)$	Correct equation showing states and 1 mol.		
2(c)	Energy must be absorbed to break the attractions (hydrogen bonds) holding the molecules together in the liquid state.	Recognition that bond breaking is endothermic or that energy has to be put in to overcome the intermolecular attractive forces in liquid state.		
2(d)	$2H_2O(\ell) \rightarrow 2H_2(g) + O_2(g)$ $\Delta_r H = +572$ kJ $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ $\Delta_r H = -470$ kJ $2H_2O(\ell) \rightarrow 2H_2O(g)$ $\Delta_r H = +102$ kJ $H_2O(\ell) \rightarrow H_2O(g)$ $\Delta_r H = +51$ kJ $\Delta_{vap}H^o(H_2O) = +51.0$ kJ mol^{-1}	Some recognition of the fact that $\Delta_{vap}H^o$ can be related to the enthalpies of the two reactions at the top of the page.	Appropriate calculation with one error.	Correct answer with units of kJ mol^{-1}.
3(a)	$E = 200 \times 4.18 \times 18 = 15\ 048$ joules = 15.048 kJ released n(ethanol) = 1.00 g / 46 g mol^{-1} = 0.0217 mol $\Delta_c H = -15.048$ kJ/ 0.0217 mol = – 693 kJ mol^{-1}	One step calculated correctly.	One error in calculation.	$\Delta_c H$ calculated correctly including negative sign & correct units of kJ mol^{-1}.
3(b)	$\Delta_c H° = \Sigma\Delta_f H_{\text{products}} - \Sigma\Delta_f H_{\text{reactants}}$ $= (2 \times -394 + 3 \times -286) - (-277)$ $= -1369$ kJ mol^{-1}	Correct process for calculation with one error.	Answer calculated correctly. (accept kJ or kJ mol^{-1}).	

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
3(c)	1. Heat is lost to the surroundings/lack of insulation. 2. Some of the ethanol that is burned undergoes incomplete combustion that releases less energy. 3. Experiment not carried out under standard conditions.	One correct reason given.	A physical **and** a chemical reason given.	
4(a)	It is the enthalpy change when one mole of a solid is melted to its liquid state under standard conditions.	Correct definition.		
4(b)	Heptane Heptane is a small non-polar molecule so the only intermolecular forces are weak. This means heptane will have low values for melting point, boiling point and heats of fusion as all are measures of the strength of intermolecular forces. Sodium chloride is an ionic solid with strong ionic bonds between all ions in the 3-D network. Water has hydrogen bonds between its molecules and this type of intermolecular attraction is stronger than the instantaneous dipole-dipole attractions that exist between the non-polar heptane or nitrogen molecules. This type of attraction is greater for heptane than nitrogen because of its larger electron cloud/molar mass. Specific comparisons or justifications that can be made include: • Boiling point of heptane should be higher than its melting point. • Melting point for heptane is wrong as it is a liquid at room temperature. • The high heat of fusion for heptane is inconsistent with its low boiling point. • The boiling point of heptane should be higher than that for nitrogen. • The heat of fusion for heptane should be lower than the value for either NaCl or H_2O. • The melting point for heptane should be lower than that for water. • Heptane has a boiling point much lower than water so also should have a heat of fusion that is much lower – contradictory.	Incorrect line of data identified with at least one valid justification.	Incorrect line of data identified with justifications recognising the link between the type of attractive forces and the physical property.	Incorrect line of data identified with a comprehensive justification clearly linking the appropriate comparison to the difference in the nature of the attractions involved.

For excellence in Q2(d) and Q3(a) use of unit of kJ instead of kJ mol^{-1} is only penalised once.

Judgement Statement

Chemistry: Describe and use thermochemical principles (90699)

Achievement

Total of **SIX** opportunities answered at Achievement (or higher)

6 × A

Achievement with Merit

Total of SEVEN opportunities answered with **FOUR** at Merit level and THREE at Achievement level.

4 × M + 3 × A

Achievement with Excellence

Total of EIGHT opportunities answered with **TWO** at Excellence level and THREE at Merit level and THREE at Achievement level.

2 × E + 3 × M + 3 × A

Assessment Schedule

Chemistry: Describe aqueous systems using equilibrium principles (90700)

Evidence Statement

<table>
<tr><th>Question</th><th>Evidence</th><th>Evidence contributing to Achievement</th><th>Evidence contributing to Achievement with Merit</th><th>Evidence contributing to Achievement with Excellence</th></tr>
<tr><td>1</td><td>After mixing volume = 100 mL
$[Ag^+] = 0.020 \div 2 = 0.01$ mol L^{-1}
$[Cl^-] = 0.100 \div 2 = 0.05$ mol L^{-1}
$IP = [Ag^+][Cl^-] = 0.01 \times 0.05 = 5 \times 10^{-4}$
IP > K_s so precipitate forms.</td><td>Correct calculation of IP
or
correct comparison of IP and K_s based on incorrect but relevant calculation</td><td>Correct calculation
and
correct comparison of IP and K_s.</td><td></td></tr>
<tr><td rowspan="2">2(a)</td><td>$PbBr_2(s) \rightleftharpoons Pb^{2+}(aq) + 2Br^-(aq)$</td><td>Equilibrium equation in either direction (accept →).
States not required.</td><td></td><td></td></tr>
<tr><td>$K_s = [Pb^{2+}][Br^-]^2$</td><td>K_s expression correct</td><td></td><td></td></tr>
<tr><td>2(b)</td><td>$n(PbBr_2)$ in 50 mL = 0.422 ÷ 367
= 1.15×10^{-3} mol
$n(PbBr_2)$ in 1 L = $1.15 \times 10^{-3} \times 20$
= 2.30×10^{-2} mol
solubility(s) of $PbBr_2$ = 2.30×10^{-2} mol L^{-1}
or directly $n(PbBr_2)$ in 1 L = 8.44 ÷ 367
= 2.30×10^{-2} mol
$[Pb^{2+}] = 2.30 \times 10^{-2}$ mol L^{-1}
$[Br^-] = 4.60$ X 10^{-2} mol L^{-1}
$K_s = [Pb^{2+}][Br^-]^2$
$= 2.30 \times 10^{-2} \times (4.60 \times 10^{-2})^2$
$= 4.87 \times 10^{-5}$
Or $4s^3 = 4(2.30 \times 10^{-2})^3$
$K_s = 4.87 \times 10^{-5}$ (3 s.f.)</td><td>Correct calculation of number of moles
or
One other correct process step completed
eg correct calculation of $[Pb^{2+}]$ and $[Br^-]$ from incorrect n / correct calculation of K_s from incorrect ion conc.</td><td>Calculation process for K_s correct
(allow 1 process error eg ratio $[Pb^{2+}]$: $[Br^-]$ is 1:1 or no. of moles in 50 mL used instead of conc.)</td><td>K_s is correct and is in the range 4.86 - 4.88 $(X10^{-5})$</td></tr>
<tr><td>3</td><td><table>
<tr><th></th><th>type</th><th>reason</th></tr>
<tr><td>NaCl</td><td>neutral</td><td>NaCl completely soluble to give Na^+ and Cl^-, neither of which react with water – neutral solution.</td></tr>
<tr><td>NH_4Cl</td><td>acidic</td><td>NH_4Cl completely soluble to give NH_4^+ and Cl^-.
$NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$.
So solution is acidic due to increase in conc of H_3O^+.</td></tr>
<tr><td>NaOCl</td><td>alkaline</td><td>NaOCl completely soluble to give Na^+ and OCl^-.
$OCl^- + H_2O \rightleftharpoons HOCl + OH^-$.
So solution is alkaline due to increase in conc of OH^-.</td></tr>
</table></td><td>Type of solution (acidic etc) correctly stated for two solutions</td><td>For <u>all</u> solutions the type of solution (acidic etc) is correctly stated
And
For <u>two</u> solutions Type is linked to relevant species (OH^- or H_3O^+ or H_2O)</td><td>Appropriate discussion for all three examples with correct chemical or word equations for the formation of $OH^-$and H_3O^+</td></tr>
</table>

Question	**Evidence**	**Evidence contributing to Achievement**	**Evidence contributing to Achievement with Merit**	**Evidence contributing to Achievement with Excellence**
4(a)	NaOH: volume = 0.015 L: conc = 0.125 mol L^{-1} Propanoic acid: volume = 0.025 L: conc = c Conc × 0.025 = 0.015 × 0.125 **= 0.0750 mol L^{-1}**	Correct concentration including units.		
4(b)	**pK_a = 4.9 (±0.1)**	Correct value		
4(c)	**$CH_3CH_2COO^-$ + H_2O □ CH_3CH_2COOH + OH^-** $K_b = \frac{[CH_3CH_2COOH][OH^-]}{[CH_3CH_2COO^-]}$ At equiv.pt conc sodium propanoate = 0.0469 mol L^{-1} (0.046875 calc.) (either from 0.0750 × $\frac{25}{40}$ or 0.125 × $\frac{15}{40}$) **OR** **using K_b** $[OH^-]^2 = 10^{-9.1} \times 0.0469 = 3.725\ldots \times 10^{-11}$ $[OH^-] = 6.103\ldots \times 10^{-6}$ pOH = 5.21 and **pH = 8.79.** **OR** **using the formula** **$[H_3O^+] = \sqrt{}\ K_a \times K_w \div [base]$** $= \sqrt{}10^{-4.9} \times 1 \times 10^{-14} \div 0.0469$ $= 1.638.. \times 10^{-9}$ pH = 8.79 **OR using K_a expression** to correctly arrive at any of the formulae above.	Describes solution as alkaline either by writing the **balanced equation** Or Writing a correct **K_b expression** Or by **writing a correct formula** / correctly **substituted formula** to use in the calculation	Method for calculation of pH generally correct with only one error eg no dilution factor in calculation of [$CH_3CH_2COO^-$]	pH correctly calculated as 8.79 ±0.01 Or pH correctly calculated from student's incorrect answers to 4(a) and 4(b)
4(d)	Species present: [Na^+] > (=/≈) [CH_3CH_2COOH]= [$CH_3CH_2COO^-$] > [H_3O^+]>>([OH^-])	Identifies [CH_3CH_2COOH]= [$CH_3CH_2COO^-$] or [CH_3CH_2COOH]= [CH_3CH_2COONa]	Concentration of all species correctly compared. (may omit OH^- but must include Na^+).	
4(e)	**Cresol red and Thymolphthalein** could be chosen because the pH ranges for the colour changes of these two indicators (and their pK_a values) lie within the range of the equivalence point i.e. the vertical portion of the graph/ the portion where there is a dramatic change in pH. Since vertical portion starts at pH =7.4 and the equivalence point is at pH 8.79 (8.8) then an indicator that changes colour in the range 8.8± 1.4 ie 7.4 →10.2 would be suitable. (The pK_a of the indicator will also lie within this range but need not be "at" or "close" to the exact equivalence point pH.)	Chooses both suitable indicators (explanation may be missing/ incorrect / irrelevant) Or Chooses only one of the two suitable indicators with a valid reason (ie a reason that could also be applied to the second indicator that has not been selected).	Recognises that **two** indicators are suitable **and** links their suitability to the presence in the **vertical portion of the graph** of either the pH range for the colour change or the pK_a value	

Question	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
5(a)	**Either** **$K_a = \frac{[NH_3][H_3O^+]}{[NH_4^+]}$** $[NH_4^+] = \frac{0.05 \times 10^{-8.8}}{10^{-9.24}}$ = 0.138 mol L^{-1} (0.137714 calc) mass NH_4Cl in one litre = 0.138.. × 53.5 g =7.37 g OR **pH = pK_a + log $\frac{[NH_3]}{[NH_4^+]}$** 8.80 = 9.24 + log(0.05/c) c = 0.05 ÷ $10^{-0.44}$ = 0.138 mol L^{-1} (0.137714.....calc) mass NH_4Cl in one litre = 0.138.. × 53.5 g = 7.37 g (3 sig. fig.)	Correctly **substituted expression** chosen that could lead to a correct concentration of NH_4^+ ie must correctly identify that NH_3 is the "base" with concentration 0.05 and that $[NH_3] \neq [H_3O^+]$	Correct expression is used to calculate mass of NH_4Cl (allow 1 arithmetic error) OR correct value for $[NH_4^+]$ but does not calculate mass/ or calculates incorrect mass	Completes all steps in calculation of correct mass and includes unit (g)
5(b)	For **this buffer** with pH =8.80 the $[NH_3]$ is less than $[NH_4^+]$ pH <pK_a (since log($[NH_3]$/NH4$^+$]) is < 0) • the solution is a more effective buffer against added base than it is against added acid. This is because there is a larger proportion of acid to react with / neutralise the added base: $NH_4^+ + OH^-$ □ $NH_3 + H_2O$ When $[NH_3]$ is greater than $[NH_4^+]$ pH is greater than 9.24 since log($[NH_3]$/NH4$^+$]) > 0 • the solution buffers well against added acid, but less well against added OH^-. This is because there is a larger concentration of base to react with and neutralize the added acid. • $NH_3 + H_3O^+$ □ $NH_4^+ + H_2O$ When $[NH_3]$ is equal to $[NH_4^+]$ • pH is 9.24 (because log($[NH_3]$/ [NH4$^+$] = 0) • the solution is an equally effective buffer against the addition of either acid or base as either of the two previous reactions can occur **A non-specific description at Achieve level may include:** If [base] > [acid] pH is more alkaline/more basic/increases. If [base] < [acid] pH is more acidic / decreases. When small amounts of either acid or base are added to a buffer the pH changes very little because the acid species reacts with the added base (or OH^-)and the base reacts with added acid (H_3O^+)	Description of this buffer solution / a general buffer solution includes ONE of the following: • Variation in pH of the buffer with different [acid] or [base] present • The effectiveness of the buffer if [acid]>[base] or [acid]<[base] • the effect of adding small amounts of acid and base to a buffer	Uses the relative [species] present in **this buffer** i.e. **$[NH_4^+]$ and $[NH_3]$** to explain TWO of the following: • variation in pH of this buffer with $[NH_3]$ >$[NH_4]$ and $[NH_3]$<$[NH_4]$ • The effectiveness of the buffer if $[NH_3]$ >$[NH_4^+]$ and if $[NH_3]$<$[NH_4^+]$ • the effect of adding small amounts of **H_3O^+ and OH^-** to this specific buffer (Correct chemical equations may be used.)	Detailed discussion clearly identifies how variations in the relative concentrations of NH_3 and NH_4^+ ie > and < and = affect **both the pH and the effective working of this buffer** with reference to either pK_a (=9.24) or the pH of the buffer in 5(a) (=8.80) (Correct chemical equations may be used.)

Judgement Statement

Chemistry: Describe aqueous systems using equilibrium principles (90700)

Achievement

Total of **SEVEN** opportunities answered at Achievement (or higher)

7 × A

Achievement with Merit

Total of EIGHT opportunities answered with **FOUR** at Merit level and FOUR at Achievement level.

4 × M + 4 × A

Achievement with Excellence

Total of NINE opportunities answered with **THREE** at Excellence level and TWO at Merit level and FOUR at Achievement level.

3 × E + 2 × M + 4 × A