Government of **Western Australia**
School Curriculum and Standards Authority

WACE
Western Australian Certificate of Education

CHEMISTRY

Stage 3

WACE Examination 2015

Marking Key

Marking keys are an explicit statement about what the examiner expects of candidates when they respond to a question. They are essential to fair assessment because their proper construction underpins reliability and validity.

2016/4660
Web version of 2015/101842

Section One: Multiple-choice **25% (25 Marks)**

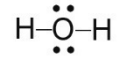
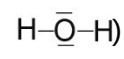
Question No.	Answer
1	a
2	a
3	c
4	c
5	b
6	a
7	d
8	a
9	b
10	c
11	a
12	b
13	c
14	a
15	d
16	b
17	b
18	d
19	c
20	b
21	c
22	b
23	d
24	d
25	b

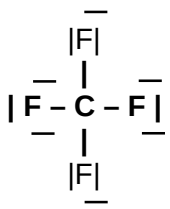
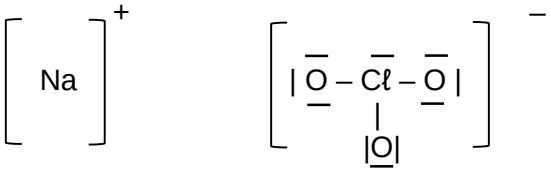
Section Two: Short answer **35% (70 Marks)**

Question 26 **(5 marks)**

(a) Draw the Lewis structure (electron dot) diagram for both compounds listed in the table below.

For Lewis structures, any lone electron pairs must be shown.
All valence shell electron pairs should be represented either as : or as —

(for example, water  or  or )

Compound	Lewis structure (electron dot) diagram
CF_4	 (2 marks)
$NaC\ell O_3$	 (3 marks)

Description	Marks
CF_4 correctly showing all bonding electrons	1
CF_4 correctly showing all non-bonding electrons	1
Na^+ correctly showing no electrons, + charge (and brackets)	1
$C\ell O_3^-$ correctly showing all bonding and non-bonding electrons	1
$C\ell O_3^-$ correctly showing charge and brackets	1
Total	**5**

Question 27 **(8 marks)**

(a) The two substances CS_2 and HCN have linear molecules but CS_2 molecules are non-polar while HCN molecules are polar. Explain why these molecules have different polarities. Support your explanation with appropriate diagrams. (4 marks)

Description	Marks
Recognition of the presence of polar (covalent) bonds in each molecule	1
In CS_2, the polarity of each C-S bond is identical and hence the molecule is symmetrical about C and the bond dipoles cancel each other out to give a non-polar molecule.	1
In HCN, due to the difference electronegativities of H and N, the molecule is non-symmetrical with respect to bond dipoles and hence is polar.	1
Suitable diagrams with appropriate annotation. CS_2 diagram: δ- δ- S = C = S HCN diagram: δ+ δ- H – C ≡ N	1
Total	**4**

(b) Complete the table below by choosing **one** molecule from the following list to match the description given.

H_2CO PH_3 SO_3 $CHBr_3$ H_2 CO SiF_4 (4 marks)

Description		Marks
a molecule which is tetrahedral and polar	**$CHBr_3$**	1
a diatomic molecule with only dispersion forces between its molecules	**H_2**	1
a molecule which is trigonal planar and polar	**H_2CO**	1
a molecule which is pyramidal and has dipole-dipole forces of attraction between its molecules	**PH_3**	1
	Total	**4**

Question 28 **(6 marks)**

(a) Explain why chlorine has a higher electronegativity than iodine. (3 marks)

Description	Marks
Recognition that electronegativity is a measure of the electron attraction power of an atom in a bond	1
Chlorine has a smaller atomic radius than iodine, hence higher electronegativity	1
Decreased atomic radius increases the attraction experienced by electrons to the positive nucleus	1
Total	**3**

Notes:
Atomic radius refers to the distance between the valence electrons and nucleus.
A sample answer:
Electronegativity is a measure of the electron attracting power of an atom in a bond. When considering elements further down a Group, the electronegativity decreases due to a decreasing electrostatic attraction between the nucleus and valence electrons caused by the increase in the radius of the atom.
(Although the number of protons is also increasing, the effect of increasing positive charge is negated by the increase in number of electron shells. Partial shielding effect and greater distance between positive and negative charges).

(b) With reference to the nature of their bonding, explain why magnesium has a higher melting point than sodium. (3 marks)

Description	Marks
Recognition that • the magnesium cation has a higher charge density than the sodium cation or • the charge on the magnesium cation is greater (+2) than the sodium cation (+1)	1
Magnesium cation has two de-localised valence electrons per cation while the sodium cation has only one de-localised valence electron per cation	1
Recognition that the melting point is dependent upon the strength of attraction between the metallic cations and the delocalised electrons. The greater charges in magnesium leads to a stronger attraction for valence electrons. More energy is required to overcome magnesium's attraction between cations and delocalised electrons.	1
Total	**3**

Sample answer:
Metallic bonding involves metallic cations held together in a lattice by simultaneously attraction to mobile de-localised valence electrons. The melting point of a metal depends on the strength of this attraction between the cations and these electrons.

Mg has a higher melting point than Na since
- both Mg^{2+} and Na^{+} cations have a similar radius but
- the cationic charge in Mg is Mg^{2+} and has two de-localised valence electrons per cation whilst in cationic charge in Na is Na^{+} and has only one de-localised valence electron per cation. The greater charges in Mg leads to a stronger attraction for the valence electrons and hence more energy required to overcome this attraction resulting in the melting of the metal.

Question 29 **(7 marks)**

A 25.0 mL of a solution of nitric acid at 25.0 °C contains 8.50×10^{-3} moles of hydrogen ions.

(a) Calculate the hydrogen ion concentration and the pH of the solution. (2 marks)

Description	Marks
$c(H^+) = n/v = 8.50 \times 10^{-3} / 0.025 = 0.340$ mol L^{-1}	1
$pH = -\log[H^+] = -\log(0.340) = 0.469$	1
Total	**2**

(b) Calculate the pH of the solution after 20.0 mL of 0.300 mol L^{-1} potassium hydroxide solution is added to the original 25.0 mL of nitric acid. (5 marks)

Description	Marks
$n(OH^-) = cv = 0.3 \times 0.02 = 0.006$ mol	1
Recognition that OH^- and H^+ react in 1:1 ratio	1
$n(H^+)$ in excess $= 0.0085 - 0.006 = 2.5 \times 10^{-3}$ mol	1
$c(H^+) = 2.5 \times 10^{-3} / 0.045 = 0.0556$ mol L^{-1}	1
$pH = -\log[H^+] = -\log(0.0556) = 1.26$	1
Total	**5**

Question 30 **(6 marks)**

(a) What characteristic of equilibrium is indicated on the graph by the section from 0 to 4 minutes? (1 mark)

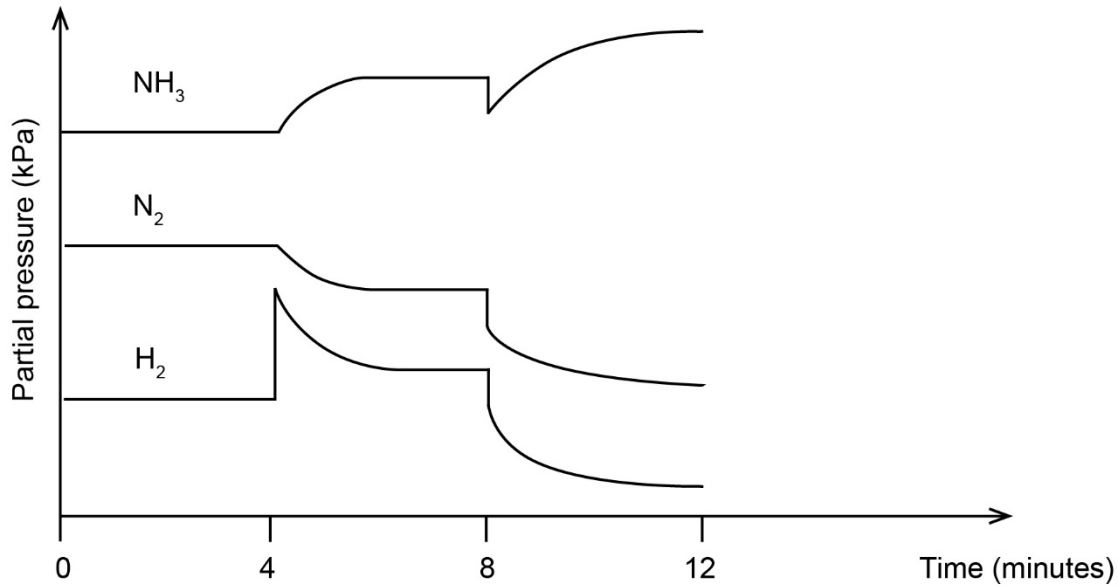
Description	Marks
Recognition that between 0 and 4 minutes, the partial pressures (concentration) of all gases were constant	1
Total	**1**

(b) A change was imposed on the system at the 4 minute mark. What change could have produced the results indicated on the graph? (1 mark)

Description	Marks
Addition of H_2 gas	1
Total	**1**

(c) The system was **suddenly** cooled at 8 minutes and then reached equilibrium again at 12 minutes. Using this information, complete the graph from the 8 to the 12 minute mark. (4 marks)

Description	Marks
All initially decrease rapidly	1
H_2 and N_2 decrease NH_3 increases	1
Graph represents correct ratio, for example H_2 gradient 3 x gradient N_2	1
All lines are horizontal at 12 min	1
Total	**4**



Question 31 **(6 marks)**

(a) Write a balanced ionic equation to represent the reaction described below. Include all state symbols.

0.100 mol L^{-1} aqueous solutions of silver nitrate and potassium carbonate are mixed.

(3 marks)

$$2Ag^{+}(aq) + CO_3^{2-}(aq) \rightarrow Ag_2CO_3(s)$$

Description	Marks
All correct reactants and products	1
Balanced	1
All correct state symbols	1
Total	**3**

Notes:
- Only reacting species should be represented.
- No mark should be given for "correct reactants and products" if 'spectator ions' shown.

(b) Describe a chemical test that can be used to distinguish between magnesium solid and cobalt solid. State the observations expected for each of the solids when tested.

(3 marks)

Description	Marks
Describes a valid chemical test	1
Examples: • To each metal add a solution of dilute hydrochloric acid, HCl(aq) (or H_2SO_4, CH_3COOH etc.) • To a sample of each metal in a different test tube add 0.100 mol L^{-1} solution of chromium nitrate solution.	
Correct distinguishing observation with each substance. One mark for each substance. Maximum two marks.	1–2
Example 1: **magnesium solid** (Grey solid dissolves), colourless, odourless gas evolved (and the solution remains colourless) **cobalt solid** (Grey solid dissolves), colourless, odourless gas evolved and the solution turns pink Example 2: **magnesium solid** Green solution decolourises, (grey metal dissolves, and a silvery grey solid appears) **cobalt solid** No observable change	
Total	**3**

Notes:
- Accept any chemically valid test/s, e.g. metal displacement
- The test must be described. Just stating the name of a chemical (e.g. hydochloric acid) does not justify the description of a test and so no mark should be awarded.

Question 32 **(7 marks)**

(a) Draw the structural formula for the **two** monomers that react to form this polymer. (2 marks)

Description	Marks
	1
For copyright reasons this image cannot be reproduced in the online version of this document, but may be viewed at www.essentialchemicalindustry.org/polymers/polyesters.html	1
Total	**2**
N.B.: Names are not required nor have any mark allocation.	

(b) Name the other product of this polymerisation reaction. (1 mark)

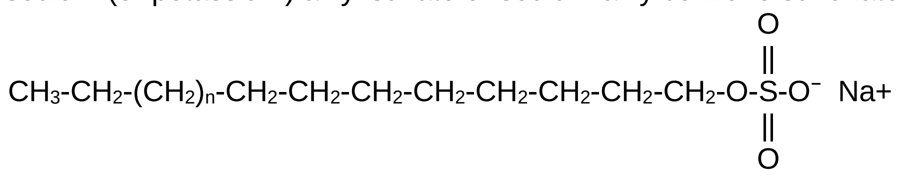
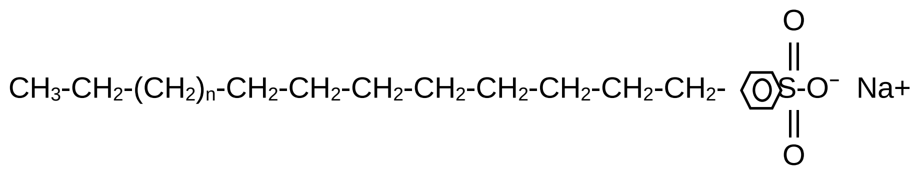
Description	Marks
Water or H_2O (Either the common name or formula is acceptable)	1
Total	**1**

(c) Predict and explain the effect on the polyester's rigidity and melting point as the polymer chains increase in length. (4 marks)

Description	Marks
Increasing the length of the polymer chain	
• (increase its molar mass and) • increases the dispersion forces of the benzene rings and alkyl sections of the polymers	1
• increases the number of dipole – dipole attractions along the length of the polymer chains	1
This increases the magnitude of its interactions with neighbouring chains making the polymer more rigid	1
More energy is required to overcome the attraction of the chains of the polymer from each other thereby raising the melting point	1
Total	**4**

Question 33 **(9 marks)**

(a) Draw the general structure of a typical detergent formula unit. (2 marks)

Description	Marks
Detergent: A sodium (or potassium) alkyl sulfate or sodium alkylbenzene sulfonate.  or  or $CH_3(CH_2)_n$-O-$SO_3{}^-$ Na^+ or $CH_3(CH_2)_n$-O-SO_3Na or R-O-SO_3Na where R represents a long hydrocarbon chain	
Structure showing long hydrocarbon chain	1
Structure showing the head on detergent as either: • sodium alkyl sulfate or alkyl sulfate ion • sodium alkylbenzene sulfonate or alkylbenzene sulfonate ion	1
Total	**2**
Note: Stating Na^+ is not necessary for the mark. Accept quaternary ammonium salts attached to a long carbon chain	

(b) Explain why detergents are soluble in both water and grease. (6 marks)

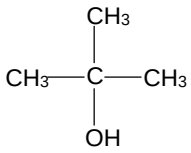
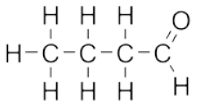
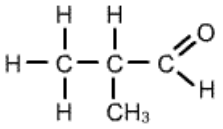
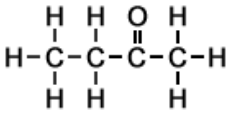
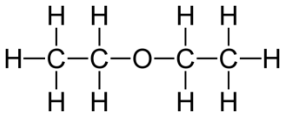
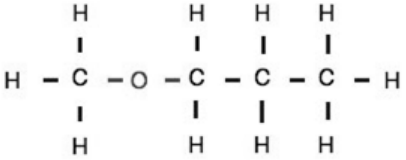
Description	Marks
One mark for each point about the hydrocarbon tail. Maximum three marks. One mark for each point about the anionic head. Maximum three marks.	
• the long chain hydrocarbon tail is non-polar	1
• so its predominant force of attraction is through dispersion forces	1
• this end of detergent is most soluble in non-polar substances such as oil, fats and grease.	1
• the charged head of the detergent is ionic	1
• so the predominant forces of attraction are ion-dipole forces (and hydrogen bonding)	1
• this end of detergent is most soluble in polar substances such as water.	1
Total	**6**

(c) State why detergents are more effective in hard water than soaps. (1 mark)

Description	Marks
Soaps combine with Ca^{2+} and/or Mg^{2+} ions in hard water to form a precipitate (while modern detergents do not form precipitates)	1
Total	**1**

Question 34 **(10 marks)**

(a) Complete the table below, identifying the:
- functional group responsible for the observations made
- organic compound, by drawing its structural formula **or** giving its name. (6 marks)

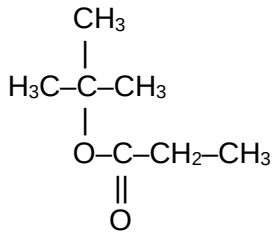
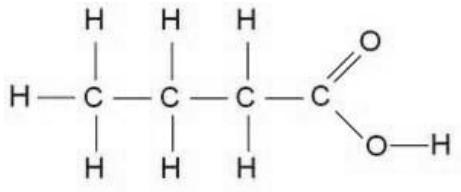
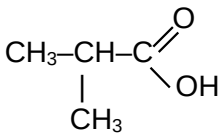
Unknown organic Compound	Functional group	Structural formula or name of the organic compound
1	alcohol	methylpropan-2-ol 
2	aldehyde	butanal or methylpropanal  
3	ketone (or ether)	Butanone  or ethoxyethane  or methoxypropane 

Description	Marks
One mark for correct identification of each functional group:	
• (tertiary) alcohol • aldehyde • ketone (ether is acceptable)	1–3
One mark for correct name **or** structure of each compound	1–3
Total	**6**

Note:
- If both the name and structural formula are given, award the mark if the
  - structural formula given is correct
  - name given is correct with a correct skeleton rather than full formula is given
- If naming the alcohol it does require the number 2
- No penalty if correct but superfluous numbers are included in the names of the aldehyde and ketone.

(b) Draw the structural formula, showing all atoms of the organic product of the reactions of Compound 1 and Compound 2.

(i) Organic Compound 1 with the acidified propanoic acid. (2 marks)
(ii) Organic Compound 2 with the acidified sodium permanganate solution. (2 marks)

Description	Marks
(i)  Correct structure and linkage of an ester Correct number and placement of carbon and hydrogen atoms	 1 1
(ii)  **or**  Correct structure and linkage of a carboxylic acid Correct number and placement of carbon and hydrogen atoms	 1 1
Total	**4**

Note:
- Condensed structural formula acceptable
- Marks can be awarded if the correct products are drawn based on the compounds given in (a)
- allow follow through marks.

Question 35 **(6 marks)**

(a) Draw an **arrow** between **A** and **B** on the diagram to indicate the direction of electron flow. (1 mark)

Description	Marks
Arrow to the left on the wire, from B to A (Cu to $C\ell_2$)	1
Total	**1**

(b) Write a balanced equation to represent the overall reaction occurring in this cell. (2 marks)

Description	Marks
$C\ell_2(g) + Cu(s) \rightarrow Cu^{2+}(aq) + 2C\ell^-(aq)$	
Correct reactants and products	1
Correctly balanced	1
Total	**2**

(c) State the reason for the reactants being kept in separate half-cells. (1 mark)

Description	Marks
The electrons which are transferred can then pass through an external circuit (rather than being transferred through direct contact) Accept: To prevent direct exchange of electrons To create a current To create a potential difference across the half cells	1
Total	**1**

(d) State the observation predicted to occur in the $C\ell_2$ / $NaC\ell$ half-cell. (1 mark)

Description	Marks
Greenish yellow gas dissolves	1
Total	**1**
Note: Accept yellow gas.	

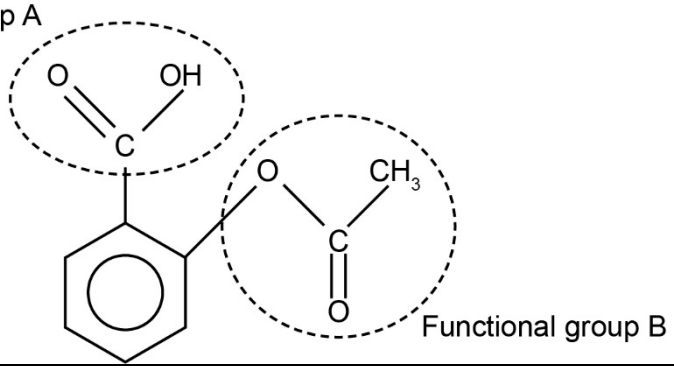
(e) Predict a metal/metal ion cell that could be used in place of the Cu/Cu^{2+} cell to give a higher emf (volts). (1 mark)

Description	Marks
Any metal/metal ion below 0.34 V excluding Na, Ca, Sr, Ba and K Example: Zn/Zn^{2+}	1
Total	**1**

Section Three: Extended answer **40% (77 Marks)**

Question 36 (20 marks)

(a) (i) On the diagram of aspirin above, circle the **two** functional groups. Label them A and B. (2 marks)

Description	Marks
One mark for each valid group. Maximum two marks.	
Functional group A 	1–2
Total	**2**

(ii) Name each functional group. (2 marks)

Description	Marks
Group A: carboxylic acid	1
Group B: ester	1
Total	**2**

(b) (i) This is a titration between a strong acid and strong base. Strong acid–strong base titrations typically result in an equivalence point with a pH close to 7. Phenolphthalein was chosen as the indicator for this titration. Considering all of the species present in the solution at the equivalence point, explain why phenolphthalein is a suitable indicator to show the end-point. Support your answer with a suitable equation. (3 marks)

Description	Marks
Recognition that at the equivalence point the Na^+ and $C\ell^-$ ions are neutral (or do not undergo hydrolysis)	1
The carboxylate ions react with water to a slight extent to form hydroxide ions $RCOO^-(aq) + H_2O(\ell) \rightarrow RCOOH(aq) + OH^-(aq)$	1
The hydrolysis of the ion makes it slightly basic which means that it is necessary to use an indicator that changes colour on the base side of pH 7	1
Total	**3**

Question 36(b) (continued)

(ii) Calculate how many moles of hydroxide ions reacted with the aspirin. (5 marks)

Description	Marks
$n(H^+) = cv = 0.125 \times 0.01789 = 2.236 \times 10^{-3}$ mol	1
$n(OH^-)_{excess}$ in 20 mL = $n(H^+) = 2.236 \times 10^{-3}$ mol	1
$n(OH^-)_{excess}$ in 100 mL = $2.236 \times 10^{-3} \times 5 = 1.118 \times 10^{-2}$ mol	1
$n(OH^-)_{initially}$ in 100 mL = cv = $0.204 \times 0.1 = 0.0204$ mol	1
$n(OH^-)_{reacting\ with\ aspirin} = 0.0204 - 0.01118$ $= 0.00921$ or 9.21×10^{-3} mol	1
Total	**5**

(iii) Each aspirin molecule requires two hydroxide ions for complete reaction. Calculate the percentage by mass of aspirin in one aspirin tablet. (The molar mass of aspirin is 180.154 g mol^{-1}.) (4 marks)

Description	Marks
$n(aspirin) = ½\ n(OH^-) = ½ \times 0.00921 = 0.00461$ mol	1
$m(aspirin) = 0.00461 \times 180.154 = 0.8304$ g	1
m(aspirin) in 1 tablet = 0.8304 ÷ 3 = 0.2768 g	1
% aspirin in 1 tablet = 0.2768/0.3 x 100 = 92.3%	1
Total	**4**

(c) Before performing the experiment, the glassware was washed with the solutions given in the table. Complete the table below by stating the effect of the washing. (4 marks)

Description			Marks
Washing procedure	Effect on the volume of hydrochloric acid used	Effect on the % of aspirin calculated	
The conical flask was washed with distilled water	**no change**	**no change**	1–2
The burette was washed with distilled water	**increased**	**decrease**	1–2
		Total	**4**

Question 37 **(16 marks)**

(a) (i) Complete the table below by writing balanced half-equations and the final redox equation for the reaction of tetrathionate and hydrogen peroxide. (6 marks)

Description	Marks
Oxidation half-equation: • reactants and products, including electrons, correct • balanced	 1 1
Reduction half-equation: • reactants and products, including electrons, correct • balanced	 1 1
Redox equation: • reactants and products correct • balanced	 1 1
Total	**6**
Half-equation one: $4\ H_2O + S_4O_6^{2-} \rightarrow S_3O_6^{2-} + SO_4^{2-} + 8\ H^+ + 6\ e^-$	
Half-equation two: $2\ e^- + 2\ H^+ + H_2O_2 \rightarrow 2\ H_2O$	
Redox: $S_4O_6^{2-} + 3\ H_2O_2 \rightarrow S_3O_6^{2-} + SO_4^{2-} + 2\ H_2O + 2\ H^+$	

(ii) Which substance is being oxidised? (1 mark)

Description	Marks
tetrathionate or $S_4O_6^{2-}$	1
Total	**1**

(b) Calculate the maximum mass of sulfur that can be formed if the process is 96.8% efficient. Express your answer to **three** significant figures. (9 marks)

Description	Marks
$n(H_2S) = 19.5 \times 10^3 / 34.086 = 572.08$ mol	1
$n(SO_2) = \frac{PV}{RT} = \frac{68.3 \times 43.4 \times 1000}{8.314 \times 1064.15}$ $n(SO_2) = 335.04$ mol	1–2
Appropriate limiting reagent working with reasoning/logic $n(H_2S)$ required $= 2\ n(SO_2)$ $= 2 \times 335.04$ $= 670.08$ mol Since there is insufficient H_2S (572 mol) for all SO_2 to react, the SO_2 is in excess and H_2S is the limiting reagent	1–2
$n(S) = 3/2 \times n(H_2S) = 3/2 \times 572.08 = 858.12$ mol	1
$m(S) = 858.12 \times 32.07$ $= 27\ 519.9$ g $= 27.5$ kg or 2.75×10^4 g	1
For 96.8% efficiency: $m(S) = 27.5 \times 0.968 = 26.6$ kg	1
Final answer accurately expressed to 3 significant figures	1
Total	**9**

Question 38 **(16 marks)**

(a) Complete the table below by predicting the:

- change in concentration, if any, of each of the ions in solution compared to the inital solution, after a new equilibrium position is reached.
- colour change, if any, that takes place from the initial purple-coloured solution.

(6 marks)

Description					**Marks**
One mark for each row of correct concentrations of ions. One mark for each correct colour change.					
Additions to the test tube	**Change in concentration from initial equilibrium to final equilibrium (increase, decrease, unchanged)**			**Colour favoured (pink, blue or unchanged)**	
	$[Co(H_2O)_6^{2+}]$	**$[C\ell^-]$**	**$[CoC\ell_4^{2-}]$**		
1. add $H_2O(\ell)$	decrease	decrease	decrease	pink	1–2
2. add $HC\ell(aq)$	decrease	increase	increase	blue	1–2
3. add $AgNO_3(aq)$	increase	decrease	decrease	pink	1–2
				Total	**6**

(b) Other than a colour change, what else should be observed in test tube 3? (1 mark)

Description	**Marks**
Recognition that a precipitate is produced. Eg: • The test tube goes cloudy or becomes opaque when shaken • A (white) precipitate forms	1
Total	**1**

(c) Using Collision Theory, explain your predicted observations when hydrochloric acid is added to test tube 2. (3 marks)

Description	**Marks**
Addition of $HC\ell(aq)$ causes the concentration of the chloride ions to increase and hence the number of collisions between $Co(H_2O)_6^{2+}$ and $C\ell^-$ increases	1
The rate of the forward reaction increases relative to the reverse reaction (and hence shifts right)	1
This leads to a greater concentration of the blue $CoC\ell_4^{2-}$ (and a lower concentration of the pink $Co(H_2O)_6^{2+}$ ion, hence the solution looks more blue)	1
Total	**3**

(d) Determine whether the forward reaction, as illustrated by the equation below, is exothermic or endothermic. Use Le Châtelier's Principle to justify your answer.

$$\underset{\text{pink}}{Co(H_2O)_6^{2+}(aq)} + 4\,C\ell^-(aq) \rightleftharpoons \underset{\text{blue}}{CoC\ell_4^{2-}(aq)} + 6\,H_2O(\ell)$$

(4 marks)

Description	Marks
Decreasing the temperature shifts the equilibrium position to the left favouring the production $Co(H_2O)_6^{2+}(aq)$, a pink solution	1
(According to Le Châtelier's principle) decreasing the temperature favours the exothermic reaction to oppose/counteract the change	1
Since the reverse reaction has been favoured, it is the exothermic reaction	1
Hence the forward reaction is endothermic	1
Total	**4**
Note: The corollary is true and acceptable. • When increasing the temperature the reaction to the right is favoured as indicated by the formation of the blue coloured $CoC\ell_4^{2-}(aq)$. • (According to Le Châtelier's principle), increasing the temperature favours the endothermic reaction to oppose/counteract the change. • Therefore the forward reaction as written is endothermic.	

(e) State **one** specific hazard to the environment that the disposal of chemicals from this experiment poses and state what could be done in the laboratory to reduce this hazard.

(2 marks)

Description	Marks
One mark for hazard. Any reasonable hazard that is relevant to this specific experiment. For example:	
• the disposal of concentrated hydrochloric acid • many chemicals such as transition metals are poisonous. • cobalt and silver salts are in fact poisonous.	1
One mark for method. Any reasonable method that is relevant to this specific experiment. For example:	
• dilute with copious amounts of water when emptying down the sink (add acid to the running water) • neutralise the acid (with a sodium carbonate) before emptying down the sink • it is safe practice that unless the toxicity of a substance is known to treated it as poisonous. Rather than emptying down the sink, empty into a hazardous waste disposal or recover the cobalt and silver salts by precipitation ready for re-use.	1
Total	**2**

Question 39 **(10 marks)**

(a) Alanine is an alpha (α) amino acid. State the structural feature of alanine that allows it to be classified as an **alpha** (α) amino acid. (1 mark)

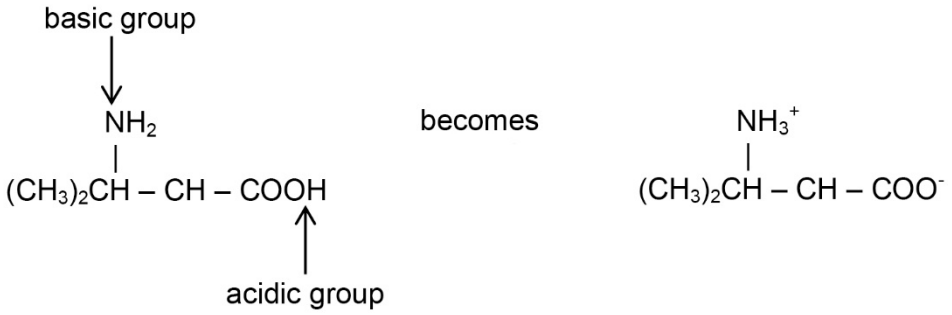
Description	Marks
The -NH_2 group and the -COOH group must be attached to the same carbon atom	1
Total	**1**

(b) Use the following information to demonstrate that the molecular formula of alanine is the same as its empirical formula.

When 1.86 g of alanine was vaporised at 550.0 ˚C and 50.0 kPa pressure, it occupied a volume of 2.86 L. (4 marks)

Description	Marks
<u>From the formula</u> The empirical formula is $C_3NH_7O_2$ Empirical formula mass ($C_3NH_7O_2$) = 89.094	1
<u>From the empirical data</u> n(alanine) = $\frac{PV}{RT} = \frac{50.0 \times 2.86}{8.314 \times 823.15}$ = 0.020895 mol M(alanine) = mass/moles = 1.86 / 0.02089 = 89.02 g mol^{-1}	1 1
The empirical formula mass (89.094) is effectively the same as the calculated molecular formula mass (89.02 g mol^{-1}) Recognition that Molecular Formula ($C_3NH_7O_2$) of alanine is confirmed as its Empirical Formula	1
Total	**4**

(c) Explain why amino acids form crystalline solids and have significantly higher melting points than other organic molecules of similar mass and structure. Refer to the information provided in the table on page 34 and include a labelled diagram using the amino acid valine to illustrate your answer. (5 marks)

Description	Marks
Diagram to show the transfer a proton/hydrogen ion from the -COOH/carboxylic acid group to the -NH_2/amine group.  	1
This transfer produces a dipolar amino acid, an ion with both a negative charge and a positive charge. (This is called a ***zwitterion***. It has no overall electrical charge, but contains separate parts which are positively and negatively charged. The term "zwitterion" is not required.)	1
Rather than being hydrogen bonding as the predominate attractive force as in the di-amine and di-carboxylic acid	1
There is now the much stronger ionic attraction between one ion and its neighbours. (This forms a crystalline lattice in the solid state)	1
These ionic attractions require more energy to break (and so the amino acids have high melting points for the size of the molecules)	1
Total	**5**

Question 40 **(15 marks)**

(a) (i) Name the electrostatic attractive force that holds the hydrogen and fluorine atoms together **within** hydrogen fluoride molecules. (1 mark)

Description	Marks
Covalent bond	1
Total	**1**

(ii) Name the electrostatic attractive force **between** the hydrogen fluoride molecules. (1 mark)

Description	Marks
Hydrogen bonding	1
Total	**1**

(iii) Explain the origin of the attractive force **between** the hydrogen fluoride molecules. (2 marks)

Description	Marks
Hydrogen bonding arises from the: • large difference between the electronegativity of the hydrogen atom and the fluorine atom • small size the hydrogen atom (allowing it to approach relatively closer to the fluorine than other atoms)	 1 1
Total	**2**

(b) The equilibrium constant (K) for the dissociation of hydrofluoric acid is 6.8×10^{-4}, and for hydrochloric acid K is very large. To make a solution of hydrofluoric acid with the same pH as hydrochloric acid, a greater concentration of hydrofluoric acid is required. Explain why this is so. (3 marks)

Description	Marks
Both acids will have to have the same $[H^+]$ to have the same pH	1
HF does not ionise to the same extent as HCℓ	1
Greater concentration of HF is needed to give the required $[H^+]$	1
Total	**3**

(c) The salts, sodium chloride and sodium fluoride, readily dissolve in water. At 25.0 °C the pH of the sodium chloride solution is equal to 7 whereas the pH of the sodium fluoride solution is greater than 7. Explain this difference in pH. Include any relevant equation(s) to support your answer. (3 marks)

Description	Marks
Recognition that fluorine hydrolyses resulting in the formation of hydroxide ions results in a solution with a pH >7	1
$F^-(aq) + H_2O(l) \rightleftharpoons HF(aq) + OH^-(aq)$	1
The chloride ion (is the very weak conjugate base of a strong acid and hence) cannot hydrolyse and/or is a neutral ion	1
Total	**3**
Note: A comment regarding Na^+ is not required for the mark.	

(d) (i) Addition of 10.00 mL of 1.00 mol L^{-1} HCℓ(aq) to this buffer does not significantly change its pH. Explain this observation, including any relevant equation(s). (3 marks)

Description	Marks
Equation for the hydrolysis of propanioc acid: $CH_3CH_2COOH + H_2O \rightleftharpoons CH_3CH_2COO^-(aq) + H_3O^+(aq)$	1
As hydrogen ions are added to the buffer equilibrium, the equilibrium will shift left to use up the added H^+ ions	1
Due to the shift in equilibrium, the overall concentration of hydrogen ion is minimised (and so the pH change is insignificant)	1
Total	**3**

(ii) State **two** conditions required to ensure this system has a high buffering capacity. (2 marks)

Description	Marks
Equal concentrations (of acid and conjugate base)	1
High concentrations (of acid and conjugate base)	1
Total	**2**

End of questions

ACKNOWLEDGEMENTS

Section Two

Question 32(a) Terephthalic acid and ethylene glycol diagrams from: CIEC Promoting Science. (2013). *Polyesters*. Retrieved September, 2015, from www.essentialchemicalindustry.org/polymers/polyesters.html

Published by the School Curriculum and Standards Authority of Western Australia
303 Sevenoaks Street
CANNINGTON WA 6107