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

WACE
Western Australian Certificate of Education

CHEMISTRY

WACE Sample Examination 2016

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.

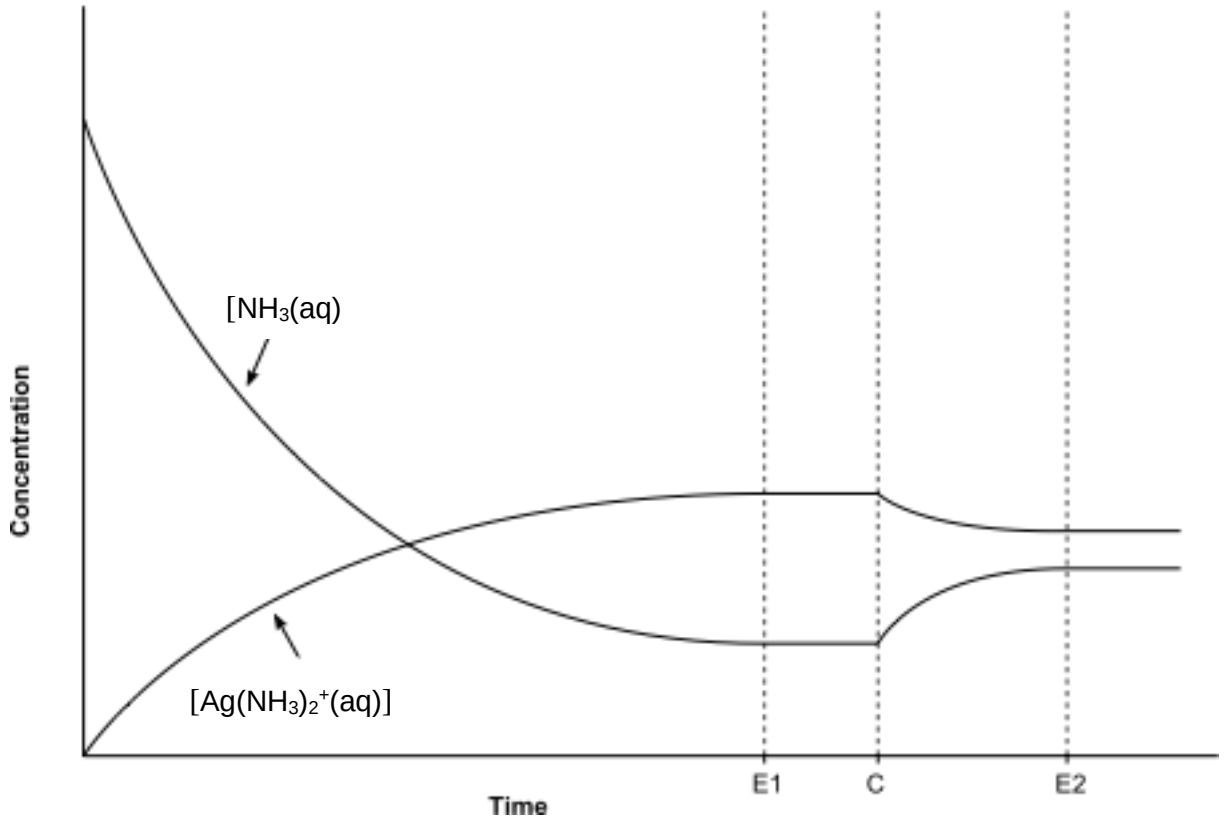
Section One: Multiple-choice **25% (25 Marks)**

Question No.	Answer
1	B
2	B
3	C
4	D
5	C
6	C
7	A
8	B
9	B
10	A
11	B
12	C
13	A
14	C
15	C
16	D
17	C
18	D
19	D
20	C
21	C
22	B
23	A
24	A
25	C

Section Two: Short answer **35% (75 Marks)**

Question 26 **(6 marks)**

(a) On the axes below, draw separate curves to show how the concentrations of $NH_3(aq)$ and $[Ag(NH_3)_2]^+(aq)$ change with time as the system approaches, and finally reaches, equilibrium (Time E1). Label clearly your curve for $NH_3(aq)$ and your curve for $[Ag(NH_3)_2]^+(aq)$. Continue your curves from Time E1 to Time C. (3 marks)



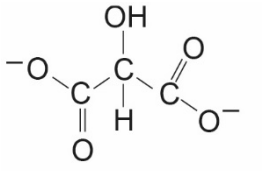
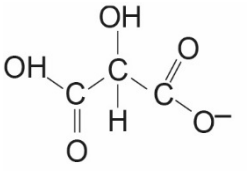
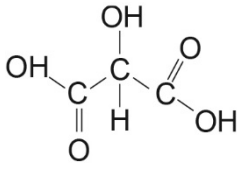
Description	Marks
curves of correct shape for $NH_3(aq)$ **and** $[Ag(NH_3)_2]^+$((aq)	1
straight line (concentration constant) at E1 to C	1
correct final position of reactant and product concentrations relative to each other at E1 (i.e. conc. (NH_3) < conc. $[Ag(NH_3)_2]^+(aq)$)	1
question incorrectly answered or not attempted	0
Total	**3**
Note: Change in concentration shown correctly (i.e., reactant decreasing and product increasing) but shown as straight lines rather than curves), award one mark.	

(b) At Time C, as shown on the axis, a small quantity of concentrated NaCℓ solution is added to the system, and the system is then again allowed to reach equilibrium at Time E2. On the same axes above, show how the concentrations of $NH_3(aq)$ and $[Ag(NH_3)_2]^+(aq)$ would change in response to the addition of NaCℓ solution from Time C until equilibrium is reached at Time E2. (3 marks)

Description	Marks
curves of correct shape for $NH_3(aq)$ **and** $[Ag(NH_3)_2]^+(aq)$	1
correct direction of concentration change for both $NH_3(aq)$ and $[Ag(NH_3)_2]^+(aq)$	1
equilibrium reached at E2 and not before	1
question incorrectly answered or not attempted	0
Total	**3**

Question 27 **(10 marks)**

(a) Complete the table by writing the formula or drawing the structure for the conjugate base, species X or conjugate acid in each blank space as appropriate. Species X is the species that is able to form both a conjugate base and a conjugate acid. (6 marks)

Conjugate base	Species X	Conjugate acid
CH_3NH^-	CH_3NH_2	$CH_3NH_3^+$
$C_2O_4^{2-}$	$HC_2O_4^-$	$H_2C_2O_4$
		

Description	Marks
1 mark for each correct response in the table	1–6
question incorrectly answered or not attempted	0
Total	**6**

(b) State whether the ratio of organic products to organic reactants will be equal to one, less than one (< 1) or greater than one (> 1) for this system at equilibrium at 25 °C. (1 mark)

Description	Marks
ratio of P to R less than one <1; OR there are less P than R	1
question incorrectly answered or not attempted	0
Total	**1**

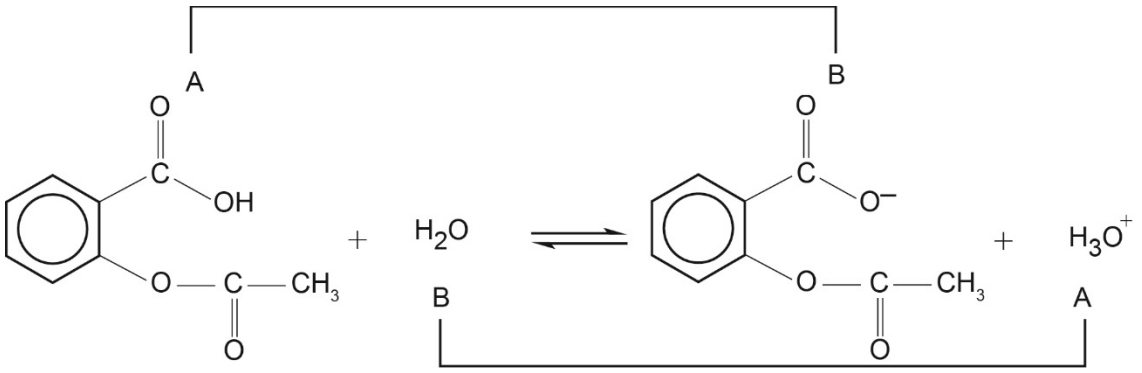
(c) Predict the direction in which the equilibrium will shift immediately after the changes indicated in the table below. Write ‘left’, ‘right’ or ‘no change’. (3 marks)

Change	Direction of initial equilibrium shift
decreasing the temperature	right
adding hydrochloric acid	left
adding sodium hydroxide	right

Description	Marks
1 mark for each correct response in the table	1–3
question incorrectly answered or not attempted	0
Total	**3**

Question 28 **(6 marks)**

(a) Write the equation for the ionisation of acetylsalicylic acid in the space below, and identify the conjugate acid and base pairs in the reaction. Connect each acid-base pair with a line, and label the conjugate acid in the pair 'A', and the conjugate base 'B'. (3 marks)



Description	Marks
correct ionisation reaction $RCOOH + H_2O \rightleftharpoons RCOO^- + H_3O^+$ R does not need to be correct	1
2 × connections of acid-base pairs	1
1 or both pairs correctly labelled	1
question incorrectly answered or not attempted	0
Total	**3**

(b) Acetylsalicylic acid is a weak acid, and only partly ionises in water. It is poorly soluble in water, and far less soluble than a related compound, acetic acid (CH_3COOH). Explain why the water solubility of molecular acetylsalicylic acid is less than that of CH_3COOH. (3 marks)

Description	Marks
recognition of predominance of dispersion forces between acetylsalicylic acid and water	1
recognition of predominance of H-bonding between acetic acid and water	1
statement about solute-solvent interactions being sufficient to overcome solute-solute/solvent-solvent interactions	1
question incorrectly answered or not attempted	0
Total	**3**

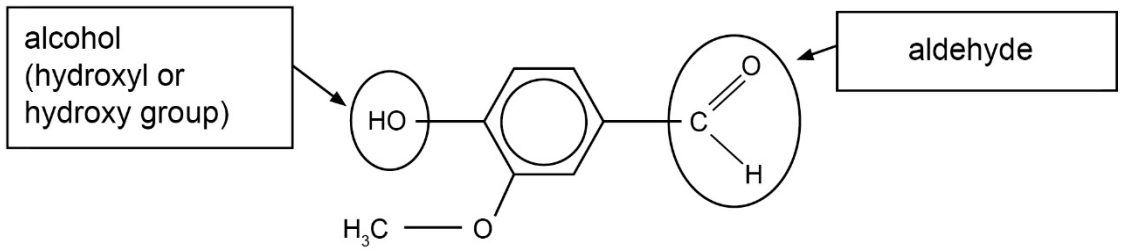
OR

Description	Marks
recognition of proportion of polar to non-polar	1
for acetylsalicylic acid there is only limited interaction between solute-solvent particles.	1
for acetic acid, as it is a predominantly polar molecule there will be significant interactions between solute-solvent particles	1
question incorrectly answered or not attempted	0
Total	**3**

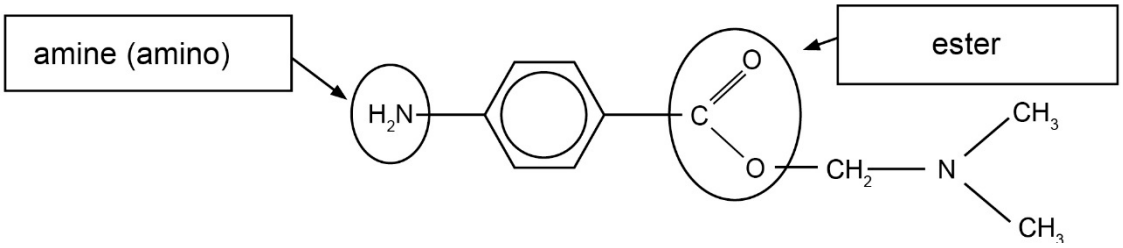
Note: Although the carboxylic acid functional group may form hydrogen bonds with water, the acetylsalicylic acid molecule is composed of large non-polar functional groups that are not water-soluble. These groups compose a significant proportion of the molecule. While acetic acid also contains non-polar groups, these groups make up a smaller proportion of the molecule

Question 29 **(4 marks)**

Examine the two compounds below. Compound 1 is the naturally-occurring flavouring agent vanillin. Compound 2 is the local anaesthetic procaine. Name the functional groups circled in these two compounds.



Compound 1: Vanillin



Compound 2: Procaine

Description	Marks
1 mark for each correctly named functional group	1–4
question incorrectly answered or not attempted	0
Total	**4**

Question 30 **(8 marks)**

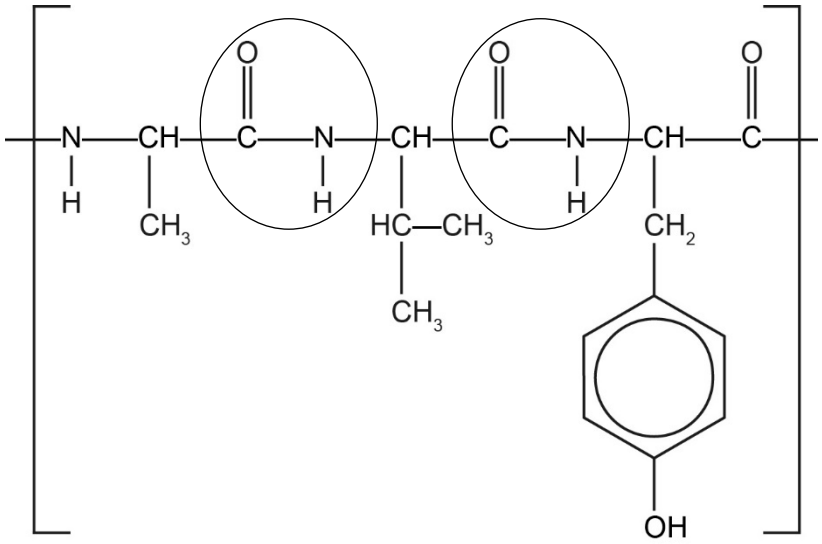
Write the phase, i.e. solid (s), liquid (ℓ) or gas (g), of each species in this system at the temperatures shown in the table below, and predict the effect of an increase in total pressure on this equilibrium at each of the temperatures.

Temperature (°C)	**Phase (s, ℓ or g)**				**Shift in equilibrium (right, left or no change)**
	CH_3OH	$HC\ell$	$CH_3C\ell$	H_2O	
-50	ℓ	g	ℓ	s	right
40	ℓ	g	g	ℓ	no change
70	g	g	g	ℓ	right
110	g	g	g	g	no change

Description	**Marks**
1 mark for correctly identifying phases at each temperature for each substance (all four at each temperature must be correct)	1–4
1 mark for correct shift in equilibrium; award the mark if the phases are incorrect but the shift is correct based on incorrect phases (see note)	1–4
question incorrectly answered or not attempted	0
Total	**8**
Note: Shift in equilibrium must correspond with phases identified.	

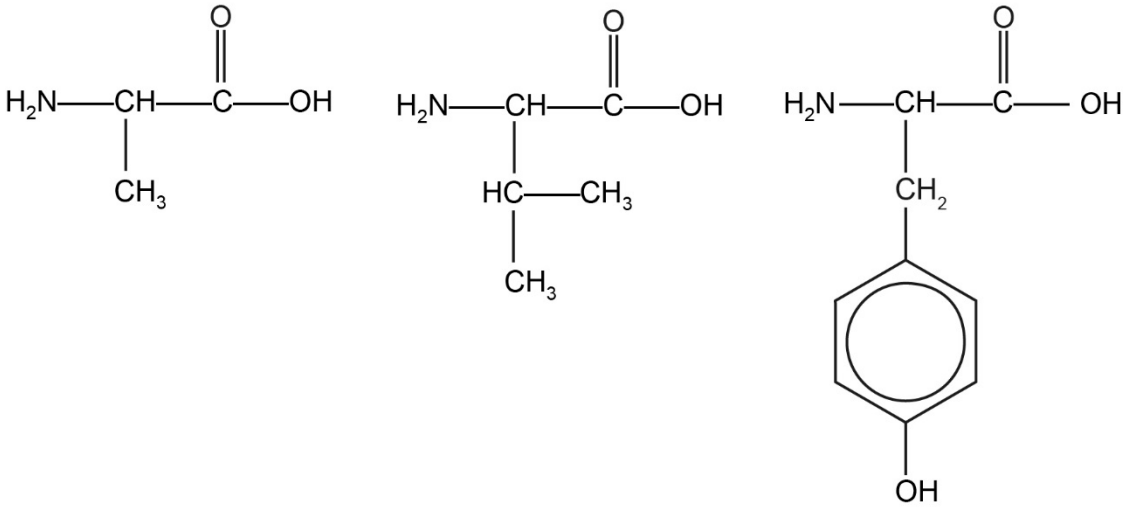
Question 31 **(6 marks)**

(a) Circle **all** the peptide linkages (functional groups that link the monomers) represented in the above structure. (1 mark)



Description	Marks
all peptide linkages identified and circled (end linkages may also be circled)	1
question incorrectly answered or not attempted or not all linkages circled	0
Total	**1**

(b) Draw the molecular structures of the **three** α-amino acids that form this segment of insulin. (3 marks)



Description	Marks
α-amino acids correctly drawn (accept zwitterion form)	1–3
question incorrectly answered or not attempted	0
Total	**3**

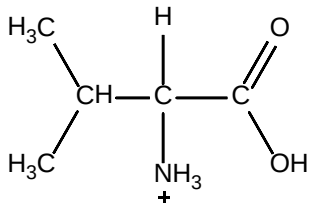
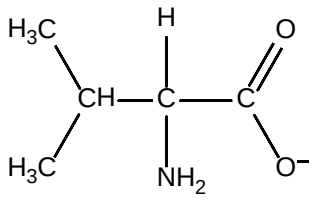
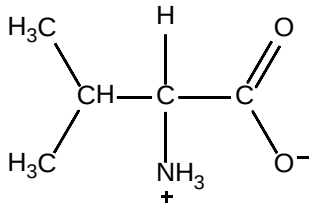
(c) The active form of insulin is made up of two polypeptide chains that contain five alpha helices. State the type of interactions that stabilises these secondary structures and the functional groups involved. (2 marks)

Type of interaction	Functional groups
hydrogen bonding	carbonyl and amide groups

Description	Marks
recognition that the interaction is hydrogen bonding	1
recognition that the H-bonding is between the carbonyl and amide groups	1
question incorrectly answered or not attempted	0
Total	**2**

Question 32 **(3 marks)**

Below are the structures for the amino acid valine under different pH conditions. In the spaces provided, give the approximate pH range (acidic, basic or neutral) under which each valine structure would exist.

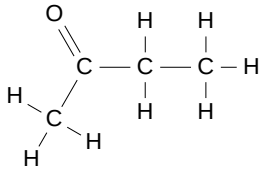
Valine structure	pH range
	acidic (pH < 7) or any range of acidic values
	basic (pH > 7) or any range of basic values
	neutral (pH ~ 7)

Description	Marks
1 mark each (either words or pH range acceptable)	1–3
question incorrectly answered or not attempted	0
Total	**3**

Question 33 **(6 marks)**

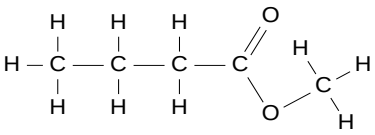
Consider the following reactions and complete the tables that follow.

(a) An excess of 2-butanol is oxidised by acidified $Na_2Cr_2O_7$ solution. (3 marks)

Observations	the solution turns from orange to green
Structural formula of organic product **(show all atoms)**	
Name of organic product	butanone

Description	Marks
1 mark for each correct answer in the table	1–3
question incorrectly answered or not attempted	0
Total	**3**

(b) Butanoic acid reacts with methanol in the presence of H_2SO_4 solution. (3 marks)

Observations	a fruity smell develops (single layer forms)
Structural formula of organic product **(show all atoms)**	
Name of organic product	methylbutanoate

Description	Marks
1 mark for each correct response in the table	1–3
question incorrectly answered or not attempted	0
Total	**3**

Note: One mark deducted in total for question 33 if no hydrogen atoms shown for structures of organic products in question 33 (a) and/or question 33(b).

Question 34 **(6 marks)**

Ocean acidification results from carbon dioxide dissolving in water and an equilibrium being established between the water and carbon dioxide to produce carbonic acid, (H_2CO_3).

(a) Write a balanced equation for this equilibrium. (2 marks)

$CO_2(aq) + H_2O(\ell) \rightleftharpoons H_2CO_3(aq)$

Description	Marks
balanced equation	1
double arrows for equilibrium	1
question incorrectly answered or not attempted	0
Total	**2**

(b) The formation of carbonic acid leads to an increase in the hydronium ion (H_3O^+) concentration in water. Show the equilibrium that results in the formation of hydronium ions when carbonic acid reacts with water. (1 mark)

$H_2CO_3(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$

Description	Marks
balanced equation	1
question incorrectly answered or not attempted	0
Total	**1**

(c) State **one** problem ocean acidification is causing for marine organisms. Explain how this problem arises and support your answer with an appropriate balanced equation. (3 marks)

$H_3O^+(aq) + CaCO_3(s) \rightarrow Ca^{2+}(aq) + HCO_3^-(aq) + H_2O(\ell)$

OR

$2\ H_3O^+(aq) + CaCO_3(s) \rightarrow Ca^{2+}(aq) + CO_2(g) + 3\ H_2O(\ell)$

Description	Marks
correct problem stated	1
recognition that lowered pH reduces an organism's capacity to form calcium carbonate (or other correct explanation)	1
balanced equation (equations showing H^+ are acceptable)	1
question incorrectly answered or not attempted	0
Total	**3**
Note: A range of responses can be accepted around lowered ability of organisms to form calcium carbonate. For example, reduced ability of shell fish or corals to form calcium carbonate because of the potential for $CaCO_3$ to dissolve at lower pH. (Potential for decreased pH in an organism's body fluids may also be accepted.)	

Question 35 **(9 marks)**

Complete the table below, which relates to the properties and uses of plastics.

Select from the list below to complete the 'Property' column of the table. A property may only be used **once**. State a different use for each polymer.

- hydrophobic
- high tensile strength
- biodegradable
- rigid
- chemically inert
- heat resistant

Plastic	Type of polymer (addition or condensation)	Property	Use related to property
High density polyethene (HDPE)	addition	high tensile strength	furniture
Polytetrafluoroethene (Teflon)	addition	heat resistance	coating on frypans and other cookware
Polyethylene terephthalate (PET)	condensation	chemically inert	drink bottles

Description	Marks
1 mark for each correct response in the table (any property from the list appropriate to the plastic, can be placed in the property cell)	1–9
question incorrectly answered or not attempted	0
Total	**9**
Note: The use must relate to the property to be awarded the mark, if any property is used a second time, no mark for second use.	

Question 36 **(5 marks)**

(a) Identify these types of interactions, labelled **A**, **B**, **C** and **D**, by completing the table below. (4 marks)

Label	Type of interaction
A	dispersion forces
B	ionic bond
C	covalent bond or disulfide bond
D	hydrogen bond

Description	Marks
interactions correctly identified	1–4
question incorrectly answered or not attempted	0
Total	**4**

(b) State what is meant by the ‘tertiary structure’ of a protein. (1 mark)

Description	Marks
the tertiary structure is a protein’s overall 3-dimensional shape	1
question incorrectly answered or not attempted	0
Total	**1**

Question 37 **(6 marks)**

Ethanol may be produced by fermentation or the hydrolysis of ethene. Conditions are indicated in the table below.

	Temperature (°C)	**Pressure (kPa)**	**Raw material**
fermentation	60	101.3	plant material, (e.g. starch, corn)
hydrolysis of ethene	300	7000	crude oil

(a) Complete the table above to indicate the raw materials for each process. (2 marks)

Description	**Marks**
plant material, (e.g. starch, corn)	1
crude oil	1
question incorrectly answered or not attempted	0
Total	**2**

(b) Explain the lower temperature conditions of the fermentation process. (2 marks)

Description	**Marks**
enzymes catalyse reactions at economic rates at lower temperatures than industrial catalysts (OR Yeast would die at higher temperature)	1
it uses an enzyme	1
question incorrectly answered or not attempted	0
Total	**2**

(c) In addition to lower temperature conditions, state **tw**o other advantages of the fermentation process compared with the hydrolysis of ethene. (2 marks)

Description	**Marks**
advantages: renewable raw material, lower emissions, can be produced from waste material, (any two appropriate reasons)	1–2
question incorrectly answered or not attempted	0
Total	**2**

Section Three: Extended answer **40% (83 Marks)**

Question 38 **(22 marks)**

(a) Give **two** reasons why anhydrous sodium carbonate is an appropriate standard. (2 marks)

Description	Marks
Any two of the following: • it can be obtained with a high degree of purity and has a known formula • it undergoes reactions according to known chemical equations • it is stable (to air) • it has a high formula mass • reacts rapidly with acids • dissolves readily to give standard solutions	1–2
question incorrectly answered or not attempted	0
Total	**2**

(b) Calculate the concentration of the standardised HCℓ solution. (4 marks)

$$Na_2CO_3 + 2\ HC\ell \rightarrow CO_2 + H_2O + 2\ NaC\ell$$

$n(Na_2CO_3) = 0.025\ L \times 0.0248\ mol\ L^{-1} = 6.2 \times 10^{-4}\ mol\ Na_2CO_3$
$n(HC\ell) = 2 \times 6.2 \times 10^{-4} = 1.24 \times 10^{-3}\ mol$

$$c(HC\ \ell) = \frac{1.24 \times 10^{-3}\ mol}{0.02435\ L} = 0.05092 = 5.09 \times 10^{-2}\ mol\ L^{-1}$$

Fast mark

Description	Marks
concentration = 5.09×10^{-2} mol L^{-1} full marks for any valid method of determining the concentration	4
question incorrectly answered or not attempted	0
Total	**4**

Part mark

Description	Marks
balanced reaction equation or correct ratio of reactants	1
$n(Na_2CO_3) = 6.20 \times 10^{-4}$ mol	1
$n(HC\ell) = 1.24 \times 10^{-3}$ mol	1
5.09×10^{-2} mol L^{-1} (accept answers between 5.04×10^{-2} mol L^{-1} and 5.14×10^{-2} mol L^{-1})	1
question incorrectly answered or not attempted	0
Total	**4**

(c) Below is a list of common errors that can occur in titrations. From this list select **one** source of random error and **one** source of systematic error and explain your choice in the tables below. (4 marks)

- reading of burette
- bubbles in the pipette
- not drying Na_2CO_3 in an oven prior to its use as a primary standard
- rinsing all glassware with distilled water
- incorrect indicator
- perception of colour change at the end point

Description	Marks
Random error • reading of burette – there is random uncertainty when reading the analogue scale.	1–2
Note: Accept any other error with logical reasoning.	
Systematic error • rinsing all glassware in distilled water – will dilute burette and pipette contents lowering their concentration. • incorrect indicator – the endpoint will not coincide with the equivalence point. • not drying Na_2CO_3 – will give incorrect concentration of primary standard and so alter the titre volume. • perception of colour change – if readings are taken beyond the point of colour change consistently it will increase titre.	1–2
question incorrectly answered or not attempted	0
Total	**4**

(d) Account for the need for four trials in the titration. (1 mark)

Description	Marks
to increase precision (reliability) (to obtain results within the uncertainty of the procedure) / to reduce the random error	1
question incorrectly answered or not attempted	0
Total	**1**

(e) (i) Calculate the concentration, in moles per litre (mol L^{-1}), of $A\ell(OH)_3$, in the original $A\ell(OH)_3$ suspension. (5 marks)

$A\ell(OH)_3 + 3\ HC\ell \rightarrow A\ell C\ell_3 + 3\ H_2O$

$n(HCl) = 0.05092\ mol\ L^{-1} \times 0.02194\ L = 1.1171848 \times 10^{-3}\ mol$

$n(Al(OH)_3) = \frac{1.1171848 \times 10^{-3}\ mol}{3} = 3.723949 \times 10^{-4}\ mol$

3.723949×10^{-4} mol in 10 mL
x = mol in 250 mL

$x = \frac{3.723949 \times 10^{-4} \times 250}{10} = 9.3098733 \times 10^{-3} mol\ in\ \ 250\ mL$

i.e. 9.3098733×10^{-3} mol $A\ell(OH)_3$ in 20 mL of antacid

$c(A\ell(OH)_3) = 9.3098733 \times 10^{-3}$ mol /0.020 L
= 0.47549 mol L^{-1}
= 0.475 mol L^{-1} (3 s.f.)

Fast mark

Description	Marks
$c(A\ell(OH)_3) = 0.475$ mol L^{-1} full marks for any valid method of determining the concentration	5
question incorrectly answered or not attempted	0
Total	**5**

Part mark

Description	Marks
balanced equation or correct ratio of reactants.	1
$n(HC\ell)$ (1.12×10^{-3})	1
$n(A\ell(OH)_3)$ in 10 mL diluted antacid (3.72×10^{-4})	1
$n(A\ell(OH)_3)$ in 20 mL undiluted antacid $(9.31 \times 10^{-3}$ mol)	1
calculation of concentration (0.475 mol L^{-1})	1
question incorrectly answered or not attempted	0
Total	**5**

(ii) From his titration of the $Mg(OH)_2$ diluted suspension, the student found the mass of $Mg(OH)_2$ in the 250 mL **diluted** suspension to be 1.13 g. Determine the concentration of $Mg(OH)_2$ in the original **undiluted** suspension and express your answer in moles per litre (mol L^{-1}). (2 marks)

$n(Mg(OH)_2) = 1.13 / 58.326 = 0.0193739$ mol
$c(Mg(OH)_2) = 0.0193739$ mol $/ 0.020$ L $= 0.968693$ mol $L^{-1} = 0.969$ mol L^{-1}

Description	Marks
calculation of moles of $Mg(OH)_2$ (0.0194 mol)	1
calculation of concentration (0.969 mol L^{-1})	1
question incorrectly answered or not attempted	0
Total	**2**

(f) Which of the preparations would be more effective (neutralise more HCℓ) for a given volume? Show your workings. (4 marks)

$n(Mg(OH)_2)$ in 20 mL of antacid = 0.0193739 mol

$Mg(OH)_2$ neutralises 2 mol of HCℓ per mole $= 2 \times 0.0193739$ mol $= 3.87 \times 10^{-2}$ mol HCℓ neutralised

$n((A\ell(OH)_3)$ in 20 mL of antacid $= 9.3098733 \times 10^{-3}$ mol

$A\ell(OH)_3$ neutralises 3 mol of HCℓ per mole $= 3 \times 9.3098733 \times 10^{-3}$ mol $= 2.79 \times 10^{-2}$ mol HCℓ neutralised

Thus $Mg(OH)_2$ will be more effective

Description	Marks
1 mark each for $n(Mg(OH))_2$ and $n(A\ell(OH))_3$ in 20 mL of each of the antacids (transposed from (e)(i) and (e)(ii))	1
1 mark each for number of moles of HCℓ neutralised by each antacid	1–2
statement that $Mg(OH)_2$) will be most effective (any valid method e.g. candidate may do a calculation based on 1 mL of antacid rather than 20 mL)	1
question incorrectly answered or not attempted	0
Total	**4**

Question 39 **(18 marks)**

(a) Determine the empirical formula of the compound. (10 marks)

Description	Marks
$n(C)=n(CO_2)=\frac{PV}{RT}=\frac{102.8\times0.7007}{8.314\times373.15}=2.3218\times10^{-2}\text{mol}$	1
$m(C) = 12.01 \times 2.3216 \times 10^{-2} = 0.27885$ g	1
$n(H_2O) = \frac{0.416}{18.016} = 2.3090586 \times 10^{-2}\text{mol}$	1
$n(H) = 2 \times 2.3090586 \times 10^{-2} = 4.6181 \times 10^{-2}$ mol	1
$m(H) = 1.008 \times 4.6181 \times 10^{-2} = 4.655 \times 10^{-2}$ g	1
$m(O) = 0.5096 - (0.27885 + 4.655 \times 10^{-2}) = 0.18423$ g	1
$n(O) = \frac{0.18423}{16.00} = 1.1514 \times 10^{-2}\text{mol}$	1
C H O 0.02319 0.04618 0.011514 ÷ by smallest $\frac{0.02319}{0.011514}$ $\frac{0.04618}{0.011514}$ 1.000 2.014 4.011 1.000 2 4 1 1 mark for ÷ by smallest; 1 mark for rounding	1–2
thus EF is C_2H_4O	1
Total	**10**

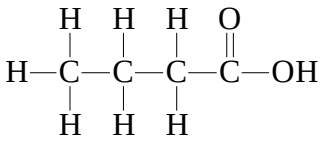
Note:
If students don't multiply H × 2
Ratio 1.79 1.79 1
EF is C_2H_2O 8 marks
$C_9H_9O_5$ 9 marks

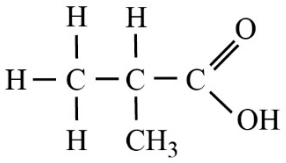
If students divide H by 2
EF is $C_7H_6O_5$ 9 marks
$C_4H_2O_5$ 9 marks

(b) A second 0.4832 g sample of the compound was heated to 261 °C. The vaporised sample was found to exert a pressure of 241 kPa in a 100.0 mL container. Use this information to determine the molecular formula of the compound. (5 marks)

Description	Marks
$n(\text{sample}) = \frac{PV}{RT} = \frac{241 \times 0.100}{8.314 \times 534.15} = 5.4268 \times 10^{-3} \text{mol}$	1–2
$M(\text{compound}) = \frac{m}{n} = \frac{0.4832}{5.4268 \times 10^{-3}} = 89.04 \text{g mol}^{-1}$	1
since empirical formula mass = 44.052	1
then MF is 2 × EF = $C_4H_8O_2$	1
question incorrectly answered or not attempted	0
Total	**5**
Note: If EF is incorrect, the maximum mark possible is 3 marks.	

(c) When the original compound was reacted with acidified ethanol, it produced a fruity-smelling liquid. Infer the structure of the original compound, and draw its structure in the box below. Name the original compound. (2 marks)





butanoic acid OR **methylpropanoic acid**

Description	Marks
correct structure	1
correct name	1
question incorrectly answered or not attempted	0
Total	**2**
Note: Award one mark for correct name for incorrect structure, or incorrect name for correct structure. Must be carboxylic acid structure.	

(d) Describe briefly and give observations for an additional chemical test to confirm the identity of the functional group in the original compound. (2 marks)

Description	Marks
any correct chemical test e.g. react with acid suitable indicator that changes colour at appropriate pH (e.g. Universal Indicator, but not phenolphthalein)	1
any correct observation	1
question incorrectly answered or not attempted	0
Total	**2**
Note: Addiction of MnO_4^- and 'no reaction', is not acceptable.	
Answers could include: • test – reaction with a carbonate or Mg or Na • observation – effervescence	

Question 40 **(16 marks)**

(a) State another catalyst that can be used in the production of biodiesel. (1 mark)

Description	Marks
lipase	1
question incorrectly answered or not attempted	0
Total	**1**

(b) The vegetable oil in the reaction on page 30 has a molar mass of 855.334 g mol^{-1}. If 1.50 tonnes of vegetable oil is reacted, what mass of methanol will be required to react with this amount of oil? (1 tonne = 1×10^6 g) (3 marks)

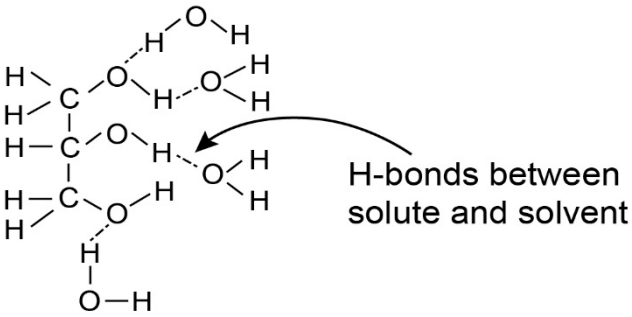
Description	Marks
n(veg oil) = $\frac{1.50\times10^6}{855.334} = 1.754\times10^3$ mol	1
$n(CH_3OH) = 3 \times n(\text{veg oil}) = 5.261 \times 10^3$ mol	1
$m(CH_3OH) = 5.261 \times 10^3 \times 32.042 = 1.69 \times 10^5$ g	1
question incorrectly answered or not attempted	0
Total	**3**

(c) Three different methyl esters, denoted by **A**, **B** and **C**, are produced from this reaction. What is the mass of Ester **A** produced in this process if the reaction is 78% efficient in production of this ester? Express your final answer to the appropriate number of significant figures. (5 marks)

Description	Marks
for 100% efficient: $n(A) = n(\text{Veg oil}) = 1.754 \times 10^3$ mol	1
78% efficient, thus $n(A) = 0.78 \times 1.754 \times 10^3 = 1.368 \times 10^3$ mol	1
MF Ester A is $C_{17}H_{34}O_2$ thus M(A) = 270.442 g mol^{-1}	1
$m(A) = 1.368 \times 10^3 \times 270.442 = 3.70 \times 10^5$ g	1
answer expressed to three significant figures	1
question incorrectly answered or not attempted	0
Total	**5**
Note: The 78% efficiency step can be done based on the theoretical 100% efficient mass of A rather than number of moles of A.	

(d) The glycerol produced can be used as anti-freeze due to its high water solubility. Explain, with the aid of a diagram, why glycerol has water solubility. (5 marks)

Possible diagram



Description	Marks
1 mark for recognition that both water and glycerol have H-bonding as their predominant type of IMF	1
1 mark for showing that their similar IMFs leads to a high degree of interaction between solvent and solute molecules/formation of H-bonding	1
1 mark for recognising that solubility arises due to the strength of attraction between solute and solvent molecules being sufficient to overcome attraction between solute-solute and solvent-solvent molecules (see note)	1–2
1 mark for a suitable, labelled diagram representing H-bonding between water and glycerol molecules	1
question incorrectly answered or not attempted	0
Total	**5**
Note: An explanation in terms of the competing forces of attraction between solute-solute molecules, solvent-solvent molecules and between solvent-solute molecules is also acceptable. Students may also discuss the energy released when solvent-solute molecules attract being sufficient to overcome the energy to separate solute-solute molecules and solvent-solvent molecules. 'Like dissolves like', contains no chemistry and should not be awarded any marks.	

(e) To prevent different products forming in an alternative synthesis pathway, the quantity of sodium hydroxide present in the reaction must be kept low, compared with the vegetable oil. If the mole ratio of NaOH to vegetable oil approaches the ratio 3:1, the alternative pathway becomes significant.

(i) What type of organic product forms in this alternative pathway? (1 mark)

Description	Marks
soap/sodium salt of long chain fatty acid	1
question incorrectly answered or not attempted	0
Total	**1**

(ii) Draw the structure for **one** organic product that forms in the alternative synthesis pathway from this vegetable oil. (1 mark)

Description	Marks
sodium salt for long chain fatty acid component of either A, B or C	1
question incorrectly answered or not attempted	0
Total	**1**

Question 41 **(10 marks)**

You are supplied with strips of three unknown metals, **A**, **B** and **C**, and are required to determine the order in which they are reduced, from most easily to least easily.

Using a voltmeter, electrical leads and clips, standard laboratory glassware and the typical range of chemicals found in most laboratories, design an investigation and describe the procedures to be followed to determine the order of reduction for the metals. Use a labelled diagram to support your description. Ensure that you explain the purposes of substances or equipment (excluding beakers or other glassware) used.

Indicate the data you will collect and explain how these data give the order of reduction.

Description	Marks
recognition that 3 Galvanic cells with A and B as electrodes, then A and C as electrodes and B and C as electrodes need to be constructed	1
recognition that the cells will need an electrolyte (eg. NaCℓ dissolved in water or 0.1 mol L^{-1} HCℓ)	1
recognition of role of ions as electrolyte to complete the circuit	1
recognition that voltmeter needs to be connected in the external circuit to measure potential difference between electrodes	1
recognition E(A/B), E(A/C) and E(B/C) is the data that needs to be collected	1
recognition that direction of current flow can be used to identify the anode and cathode in each of the cell couples and the magnitude of voltage can be used to order the 3 metals from most easily to least easily reduced	1–2
labelled diagram to show typical Galvanic cell (electrodes, voltmeter, salt bridge if 2 beakers used)	1–2
Recognition of variables to control. any 2 variables e.g. temp, conc. of electroyle soln, surface area of electrodes in contact with electrolyte	1
question incorrectly answered or not attempted	0
Total	**10**

Question 42 **(17 marks)**

(a) Write the balanced equation for the reaction of chlorine gas with water. (1 mark)

$C\ell_2 + H_2O \rightarrow HOC\ell + HC\ell$

Description	Marks
balanced equation	1
question incorrectly answered or not attempted	0
Total	**1**

(b) Explain briefly how the addition of hydroxide ions to the water through which the chlorine is bubbled will increase the amount of hypochlorous acid produced. (3 marks)

Description	Marks
recognition that the hydroxide will react with the H^+	1
recognition that removal of H^+ will prevent reverse reaction from occurring	1
recognition that the forward reaction will thus continue until close to completion thus increasing yield of $HOC\ell$	1
question incorrectly answered or not attempted	0
Total	**3**

(c) Give the oxidation state of chlorine in hypochlorous acid and the oxidation state of chlorine in hydrochloric acid. (2 marks)

Oxidation state of $C\ell$ in hypochlorous acid	Oxidation state of $C\ell$ in hydrochloric acid
+1	-1

Description	Marks
oxidation state of $C\ell$ in $HOC\ell$ = +1	1
oxidation state of $C\ell$ in $HC\ell$ = -1	1
question incorrectly answered or not attempted	0
Total	**2**

(d) Identify the species oxidised and the species reduced when chorine gas reacts with water. (2 marks)

Species oxidised	Species reduced
$C\ell_2$	$C\ell_2$

Description	Marks
species oxidised is $C\ell_2$	1
species reduced is $C\ell_2$	1
question incorrectly answered or not attempted	0
Total	**2**

(e) Write the half-equation for the reduction of hypochlorous acid to chloride ion. (1 mark)

$$HOC\ell + H^+ + 2\,e^- \rightarrow C\ell^- + H_2O$$

Description	Marks
balanced equation	1
question incorrectly answered or not attempted	0
Total	**1**

(f) For every one mole of formula units of sodium percarbonate, how many mole of hydrogen peroxide are released when it is dissolved in water? (1 mark)

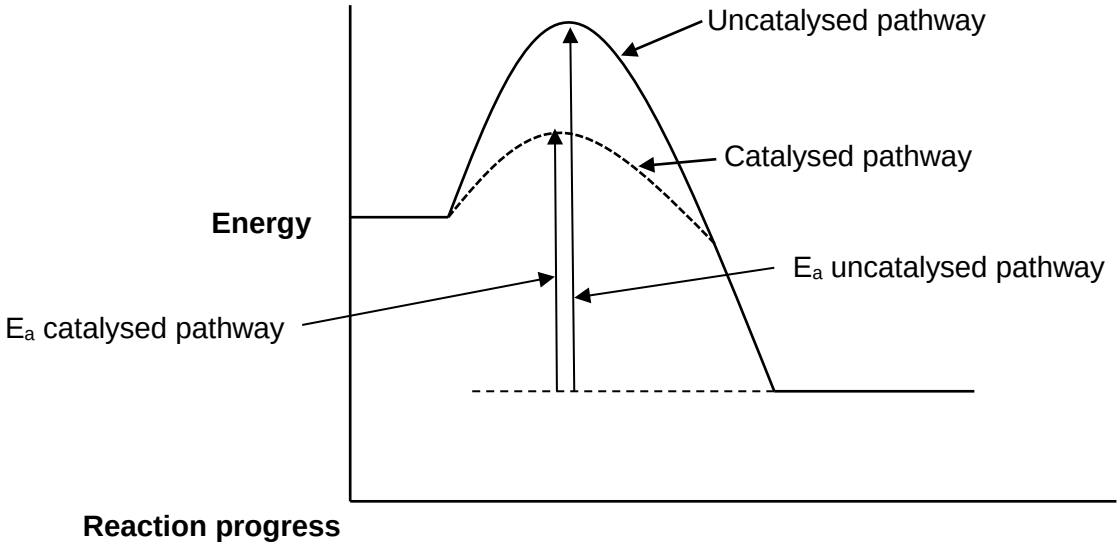
Description	Marks
3 moles	1
question incorrectly answered or not attempted	0
Total	**1**

(g) Compare the activation energy for oxidation reactions involving chlorine-based bleaches to those using peroxide-based bleaches (in the absence of catalysts). Explain the reasons for your answer. (2 marks)

Description	Marks
activation energy for oxidation of peroxides is higher than E_a of chlorine based bleaches	1
the oxidation of peroxide based bleaches requires higher temperatures than for oxidation of chlorine based bleaches	1
question incorrectly answered or not attempted	0
Total	**2**

(h) Draw a fully labelled energy profile diagram showing the progress of the decomposition of hydrogen peroxide with and without TAML molecules. (4 marks)

The equation for the reaction is $2H_2O_2 \rightarrow 2H_2O + O_2 + \text{energy}$.



Description	Marks
vertical axis labelled energy and horizontal axis labelled progress of reaction (or similar)	1
curve for both catalyst free and catalysed pathways shown with E_a of catalysed pathway less than E_a for uncatalysed pathway; curves labelled correctly	1
E_a labelled for both pathways	1
curve is for exothermic reaction	1
question incorrectly answered or not attempted	0
Total	**4**

Published by the School Curriculum and Standards Authority of Western Australia
27 Walters Drive
OSBORNE PARK WA 6017