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

CHEMISTRY

Stage 2

WACE Examination 2014

Marking Key

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

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

1	b
2	a
3	d
4	d
5	a
6	d
7	a
8	c
9	a
10	c
11	d
12	b
13	c
14	d
15	d
16	b
17	a
18	c
19	c
20	a
21	b
22	b
23	a
24	d
25	c

Section Two: Short answer **40% (101 Marks)**

Question 26 **(5 marks)**

Complete the table below.

	Element	Atomic N°	Mass N°	Number of electrons	Symbol
(a)	Sulfur	**16**	32	**18**	$^{32}_{16}S^{2-}$
(b)	Chlorine	17	**35**	18	$^{35}_{17}C\ell^{-}$
(c)	Sodium	11	23	10	$^{23}_{11}Na^{+}$
(d)	Phosphorus	15	31	18	$^{31}_{15}P^{3-}$

Description	Marks
One mark for each correct answer: 16, 18, 35, $^{23}_{11}Na^{+}$, $^{31}_{15}P^{3-}$	1–5
Total	**5**

Question 27 **(5 marks)**

(a) Complete the table below by writing the names of the ionic compounds. (3 marks)

Formula	Name
$CaSO_4$	**calcium sulfate**
Fe_2O_3	**iron(III) oxide**
K_3PO_4	**potassium phosphate**

Description	Marks
calcium sulfate	1
iron(III) oxide (need the (III) for the mark)	1
potassium phosphate	1
Total	**3**

(b) Complete the table below by writing the formulae of the ionic compounds. (2 marks)

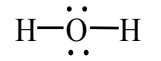
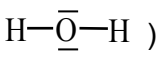
Name	Formula
chromium(III) chloride	**$CrC\ell_3$**
calcium hydrogencarbonate	**$Ca(HCO_3)_2$**

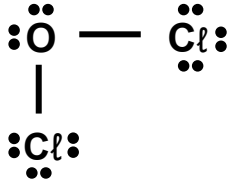
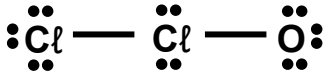
Description	Marks
$CrC\ell_3$	1
$Ca(HCO_3)_2$	1
Total	**2**

Question 28 **(6 marks)**

For the species listed in the table below, draw Lewis structure (electron dot) diagrams.

All valence shell electron pairs should be represented either as **:** or as —

(for example, water  or  or )

Description	Marks
	
• Ca shown with no valence electrons	1
• O shown with 8 valence electrons	1
• Ions in brackets with correct charges	1
	
• 1 bonding pair or covalent bond shown between O and each Cℓ atom	1
• 2 non-bonding pairs of electrons shown on the oxygen	1
• 3 non-bonding pairs of electrons shown on both Cℓ atoms	1
or	**or**
	
• 2 bonding pairs or covalent bonds one each between middle Cℓ and the other two atoms	1
• 2 non-bonding pairs of electrons on the middle Cℓ atomshown on the oxygen	1
• 3 non-bonding pairs of electrons shown on outer Cℓ atom and O atom	1
Total	**6**

Question 29 **(3 marks)**

Calculate the percentage by mass of oxygen in slaked lime, $Ca(OH)_2$.

Description		Marks
M $Ca(OH)_2$	= 40.08 + 2 x 16.00 + 2 x 1.008 = 74.096	1
%m(O)	= (2 x MO / M$Ca(OH)_2$) x 100	1
	= 2 x 16.00 / 74.096 x 100	
	= 43.187	
	= 43.2 %	1
	Total	**3**

Question 30 **(8 marks)**

(a) Classify the following pure substances into their bonding class by placing each symbol or formula into the appropriate box in the table below. (6 marks)

Fe Si $NH_4C\ell$ $HC\ell$ H_2O $CaC\ell_2$

Metallic	Ionic	Covalent network	Covalent molecular
Fe	$NH_4C\ell$ $CaC\ell_2$	Si	$HC\ell$ H_2O

Description	Marks
One mark for each correct answer No marks allocated to a formula used more than once.	1–6
Total	**6**

(b) What is it about the bonding of solid metals that explains why they are good conductors of electricity? (2 marks)

Description	Marks
• Their valence electron are delocalised	1
• Valence electrons are free to move through the solid lattice of cations, carrying their negative charge	1
Total	**2**

Question 31 **(12 marks)**

Sodium carbonate solid is added to excess nitric acid solution.

(a) Write an ionic equation for the reaction. (3 marks)

$$Na_2CO_3(s) + 2\,H^+(aq) \rightarrow 2\,Na^+(aq) + CO_2(g) + H_2O(\ell)$$

Description	Marks
• Correct formulae used	1
• Balanced equation	1
• Only species that react or are produced in the reaction are included	1
Total	

(b) Describe the predicted observations for this reaction. (2 marks)

Description	Marks
• White solid dissolves (in a colourless liquid)	1
• Bubbles produced. (effervescence)	1
Total	**2**

Question 31 (continued)

(c) When concentrated nitric acid is added to copper metal, a brown gas, NO_2, is produced. The equation is shown below.

$$Cu(s) + 4\ HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2\ NO_2(g) + 2\ H_2O(\ell)$$

0.444 g of Cu reacts with excess 6.00 mol L^{-1} nitric acid.

(i) Calculate the number of moles of Cu consumed. (2 marks)

Description	Marks
n(Cu) = m/M = 0.444/63.55	1
= 0.0069867 = 6.99 x 10^{-3} mol	1
Total	**2**
NB: No penalty if units missing or more than 3 significant figures are given.	

(ii) Calculate the number of moles of NO_2 produced. (2 marks)

Description	Marks
$n(NO_2)$ = 2 x n(Cu) = 2 x 0.0069867 or 2 x 6.99 x 10^{-3} or 2 x value given in (c)(i)	1
= 0.013973 = 1.40 x 10^{-2} mol	1
Total	**2**
NB: No penalty if units missing or more than 3 significant figures are given	

(iii) What volume of NO_2 was produced at STP?
(Give your answer to **three** significant figures and with the correct units.) (3 marks)

Description	Marks
$V(NO_2)$ = 22.71 x $n(NO_2)$ = 22.71 x 0.013973 or 22.71 x 1.40 x 10^{-3} or 22.71 x value given in (c)(ii)	1
= 0.3173 L or 0.317 L or 3.17 x 10^{-1} L	1
Notes: • Accept 0.318 L due to rounding error during step (ii)	
Expressed to 3 significant figures and with the correct unit	1
Total	**3**

Question 32 **(8 marks)**

(a) Classify the following 1.00 mol L^{-1} solutions as acidic, basic or neutral. (5 marks)

Solution	Acidic, basic or neutral
CH_3COOH	Acidic
NH_3	Basic
$CaC\ell_2$	Neutral
HNO_3	Acidic
$Ba(OH)_2$	Basic

Description	Marks
One mark for each correct answer	1–5
Total	**5**

(b) (i) Which solution will have the highest pH? (1 mark)

Description	Marks
$Ba(OH)_2$	1
Total	**1**

(ii) Explain your choice. (2 marks)

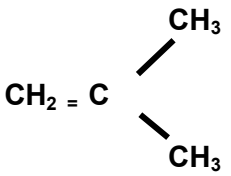
Description	Marks
$Ba(OH)_2$ is the strongest base out of the solutions listed, which under the same conditions produces the highest concentration of hydroxide (OH^-) ions in solution	1
The higher the concentration of hydroxide (OH^-) ions in solution, the higher the pH	1
Total	**2**

Question 33 **(12 marks)**

(a) State **two** features about the bonding of carbon that account for the great diversity of carbon-based compounds. (2 marks)

Description	Marks
One mark each for **any two** of the following reasons • Carbon atoms can form bonds other carbon atoms forming chains and rings • Each carbon atom can form up to four separate bonds • Carbon atoms can form combinations of single, double and triple bonds	1–2
Total	**2**

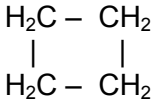
(b) Draw the structural formula of but-1-ene (C_4H_8) and one of its isomers (show **all** H atoms). (4 marks)

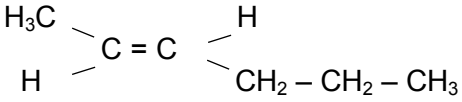
Description	Marks
$CH_2 = CH - CH_2 - CH_3$	**For structure of but–1–ene** 1 mark for correct structure; 1 mark for correct bonding and number of atoms
Any one of the structures provided: $CH_3 - CH = CH - CH_3$ **(either cis or trans)**  	**For structure of isomer** 1 mark for correct structure; 1 mark for correct bonding and number of atoms
Total	**4**
Note: If more than two structures are drawn, ignore the third and subsequent structures	

(c) State the IUPAC name for each of the following organic compounds.

(i) $CH_3 – CHBr – CH_2 – CH_2 – CHBr – CH_2 – CH_3$ (1 mark)

(ii) $CH_2 = CH – CH_2 – CH_2 – CH_2 – CH_3$ (1 mark)

(iii)

(1 mark)

(iv)

(1 mark)

Description		Marks
(i)	2,5-dibromoheptane	1
(ii)	hept-1-ene	1
(iii)	cyclobutane	1
(iv)	*trans*-hex-2-ene	1
	Total	**4**

(d) Draw the structural formula for any product(s) formed when pent-1-ene ($CH_2 = CH – CH_2 – CH_2 – CH_3$) is mixed with hydrogen gas (H_2) in the presence of a catalyst (show **all** H atoms). (2 marks)

Description	Marks
$CH_3 – CH_2 – CH_2 – CH_2 – CH_3$	
1 mark for an alkane structure	1
1 mark for correct structural formula	1
Maximum of 1 mark if more than one product given	
Total	**2**

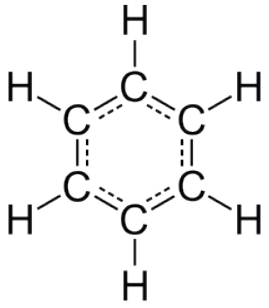
Question 34 **(8 marks)**

(a) The labels have fallen off two bottles containing colourless liquids. One label reads 'octane' and the other label reads 'oct-2-ene'. Describe a chemical test and expected observations that could be used to identify each liquid. (3 marks)

Description	Marks
Slowly add bromine water to a sample of each liquid	1
The liquid which decolourises the orange bromine water is oct-2-ene	1
The liquid in which no change is observed is octane	1
Total	**3**

(b) (i) Another bottle contains a colourless liquid. Its label read 'benzene'. Draw a structural formula for benzene, showing **all** of its bonds. (2 marks)

Structural formula

Description	Marks
	
Hexagon of 6 carbon atoms each with 1 hydrogen atom attached	1
A ring (full or dashed) representing the 6 pi electrons	1
Total	**2**
Note: Marks to be credited for drawing the resonance pair structure. No credit for indicating 3 static double bonds.	

(ii) Describe how benzene's reactivity is different from carbon compounds containing double bonds. (3 marks)

Description	Marks
Benzene is less reactive than alkenes of similar size and mass (Alkenes and cycloalkenes tend to be more reactive than their corresponding alkanes as they tend to undergo addition reactions in which the double bond can "open up" and two other atoms can then bond to the carbon atoms across that bond. Although the formula of benzene suggested it contains 3 double bonds)	1
Benzene **does not undergo addition reactions** (that alkenes normally undergo)	1
It remains intact and **tends to undergo substitution reactions**. (The bonding structure of benzene is very stable so the benzene ring tends to act a as a single entity where)	1
Total	**3**

Question 35 **(14 marks)**

(a) Describe this reaction by using the appropriate words from this list. These words may be used more than once. Write either the word or corresponding capital letter in the spaces provided below the text. (10 marks)

Description				Marks
One mark for each correct answer				1–10
(i)	A. exothermic	(vi)	L. products	
(ii)	C. released to	(vii)	O. bonds	
(iii)	E. raising	(viii)	N. absorbs	
(iv)	G. breaking	(ix)	M. releases	
(v)	H. forming	(x)	Q. more or I. greater	
			Total	**10**

(b) Match each common chemical listed below to its household use. Each chemical may only be used once. (4 marks)

sodium chloride sodium hypochlorite (bleach) ammonia solution caustic soda

Household use	Household chemical
Glass cleaner	**ammonia solution**
Food additive	**sodium chloride**
Drain cleaner	**caustic soda**
Washing clothes	**sodium hypochlorite (bleach)**

Description	Marks
One mark for each correct answer	1–4
Total	**4**

Question 36 **(13 marks)**

A 375 mL can of ginger beer contained 41.0 g of sugar. Assume all the sugar in ginger beer is a sugar called sucrose ($C_{12}H_{22}O_{11}$).

(a) Calculate the concentration of sugar in:

(i) grams per litre (g L^{-1}). (1 mark)

Description	Marks
Concentration $= \frac{41.0}{0.375}$	1
$= 109 \text{ g L}^{-1} = 1.09 \times 10^2 \text{ g L}^{-1}$	1
Total	**2**

(ii) moles per litre (mol L^{-1}). (3 marks)

Description	Marks
$M(C_{12}H_{22}O_{11}) =$ **342.296 g mol^{-1}**	1
$n(C_{12}H_{22}O_{11}) = \frac{41.0}{342.296} =$ **0.1198 mol**	1
$c(C_{12}H_{22}O_{11}) = \frac{0.1198}{0.375} =$ **0.319 mol L^{-1}**	1
Total	**3**

(b) The first stage of the digestion of sucrose in the human body is the breakdown of the sucrose into glucose as shown in the **incomplete** equation below.

$$\underset{\text{(sucrose)}}{C_{12}H_{22}O_{11}\,(aq)} \rightarrow \underset{\text{(glucose)}}{2\ C_6H_{12}O_6\,(aq)}$$

(i) By adding a water molecule, re-write a balanced chemical equation for this process. (1 mark)

Description	Marks
$C_{12}H_{22}O_{11}(aq)$ + **$H_2O(\ell)$** $\rightarrow$ $2\ C_6H_{12}O_6(aq)$	1
Total	**1**

(ii) Use the idea of conservation of mass in a chemical reaction to explain why a water molecule is required for this equation. (2 marks)

Description	Marks
• Mass cannot be created or destroyed in a chemical reaction so	1
• two hydrogen atoms and one oxygen atom are required on the reactant side (LHS) of the equation to indicate the same mass (number of atoms) exists before and after the reaction.	1
Total	**2**

Question 36 (continued)

(iii) What information does the state symbol (aq) provide about the reaction? (1 mark)

Description	Marks
The glucose (and sucrose) is present in the form of an aqueous solution/dissolved in water.	1
Total	**1**

(c) Within living cells, glucose ($C_6H_{12}O_6$) provided the human body with energy by undergoing the reaction represented in the following equation.

$$C_6H_{12}O_6(aq) + 6\ O_2(aq) \rightarrow 6\ CO_2(aq) + 6\ H_2O(\ell)$$

The normal human body temperature isf 37 °C.

(i) Predict what will happen to the rate of this reaction if the human body temperature drops below 37 °C. (1 mark)

Description	Marks
Decrease	1
Total	**1**

(ii) Use the collision theory to explain your answer to part (c)(i). (3 marks)

Description	Marks
• A lower temperature reduces the average velocity and average kinetic energy of the particles.	1
• This reduces the rate of the collisions and the proportion of particles with energy at least equal to the activation energy.	1
• Therefore rate of successful collisions decrease so the rate of reaction decreases.	1
Total	**3**

Question 37 **(7 marks)**

(a) Name the substance that forms on the surface of the iron nail. (1 mark)

Description	Marks
(Solid) Copper (metal)	1
Total	**1**

(b) Write a half-equation showing the reaction of Cu^{2+} ions that occurs at the surface of the nail. Include state symbols. (2 marks)

Description	Marks
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	
• Correct and balanced half-equation	1
• Correct state symbols	1
Total	**2**

(c) Use this half-equation to explain why the blue colour of the solution fades. 2 marks)

Description	Marks
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	
• The copper (Cu^{2+}) ions cause the blue coloration	1
• The concentration of Cu^{2+} ions decreases as they are used in the reaction (to produce the copper metal Cu(s))	1
Total	**2**

(d) The student conducting the investigation had a second beaker of copper(II) sulfate that she used as a control so she did not add a nail to this beaker. Explain why a control was used. (2 marks)

Description	Marks
So a comparison can be made with the only difference being the presence of the nail.	1
It allows for the identification of the colour change of the solution. Any change in appearance can then be conclusively attributed to the presence of the iron nail.	1
Total	**2**

Section Three: Extended answer **35% (85 Marks)**

Question 38 **22 marks**

(a) From these observations, identify each of the liquids. (4 marks)

Description		Marks
A	phosphoric acid	1
B	barium hydroxide	1
C	phenolphthalein	1
D	water	1
	Total	**4**

(b) Write an ionic equation for the reaction between phosphoric acid solution and barium hydroxide solution. Include the state symbols. (3 marks)

Description	Marks
$H_3PO_4(aq) + 3\ OH^-(aq) \rightarrow 3\ H_2O(\ell) + PO_4^{3-}(aq)$	
or	
$3\ Ba^{2+}(aq) + 2\ PO_4^{3-}(aq) \rightarrow Ba_3(PO_4)_2(s)$	
Correct formula*	1
Balanced correctly	1
Correct states of matter	1
Total	**3**
* No marks if molecular formulae used for hydroxide and phosphate.	

Question 38 (continued)

(c) Phosphoric acid is a polyprotic acid. With the aid of equations, use phosphoric acid as an example to explain the term 'polyprotic'. (4 marks)

Description	Marks
A polyprotic acid is an acid that can donate more than one proton (hydrogen ion) per molecule (to an aqueous system).	1
Containing three hydrogen atoms available for ionisation, phosphoric acid can undergo three successive ionisation reactions, each releasing one hydrogen ion (proton)	1
Reaction 1 $H_3PO_4(aq) \rightleftharpoons H_2PO_4^-(aq) + H^+(aq)$ or $H_3PO_4(aq) + H_2O(\ell) \rightleftharpoons H_2PO_4^-(aq) + H_3O^+(aq)$ **Reaction 2** $H_2PO_4^-(aq) \rightleftharpoons HPO_4^{2-}(aq) + H^+(aq)$ or $H_3PO_4^-(aq) + H_2O(\ell) \rightleftharpoons HPO_4^{2-}(aq) + H_3O^+(aq)$ **Reaction 3** $HPO_4^{2-}(aq) \rightleftharpoons PO_4^{3-}(aq) + H^+(aq)$ or $HPO_4^{2-}(aq) + H_2O(\ell) \rightleftharpoons PO_4^{3-}(aq) + H_3O^+(aq)$	1
At least two of the three sets of equations are required for the mark.	
Overall $H_3PO_4(aq) \rightleftarrows PO_4^{3-}(aq) + 3\ H^+(aq)$ or $H_3PO_4(aq) + 3\ H_2O(\ell) \rightleftarrows PO_4^{3-}(aq) + 3\ H_3O^+(aq)$	1
Total	**4**

(d) Phosphoric acid is a weak acid and a weak electrolyte. Barium hydroxide is a strong base and a strong electrolyte. Using equations containing phosphoric acid and barium hydroxide, explain the difference between the terms 'strong' and 'weak' when referring to electrolytes. (4 marks)

Description	Marks
A strong electrolyte, like barium hydroxide, is a solute that (to the extent to which it dissolves) completely or almost completely ionises or dissociates in a solution resulting in a completely ionic solution.	1
$Ba(OH)_2(s) \rightarrow Ba^{2+}(aq) + 2\ OH^-(aq)$ 100% conversion	1
A weak electrolyte, like phosphoric acid, is a solute that only ionises or dissociates in a solution to a limited degree, creating a system of both ionic products and the original molecule.	1
$H_3PO_4(aq) \rightleftharpoons PO_4^{3-}(aq) + 3\ H^+(aq)$ limited conversion	1
Total	**4**

(e) A student reacts 125 mL of 0.250 mol L^{-1} nitric acid with 50.0 mL of 1.13 mol L^{-1} potassium hydroxide solution.

(i) How many moles of hydrogen ions are available for reaction? (2 marks)

Description	Marks
$n(H^+) = c.v$ $= 0.250 \times 0.125$	1
$= 0.03125$ $= 3.12 \times 10^{-2}$ mol	1
Total	**2**

(ii) How many moles of hydroxide ions are available for reaction? (2 marks)

Description	Marks
$n(OH^-) = c.v$ $= 1.13 \times 0.0500$	1
$= 0.0565$ $= 5.65 \times 10^{-2}$ mol	1
Total	**2**

Question 38 (continued)

(f) Identify the limiting reagent when the two solutions from part (e) are mixed together. Show your reasoning. (3 marks)

Description	Marks
HNO_3 + KOH → KNO_3 + H_2O $n(HNO_3)$ = n(KOH) (1 mol HNO_3 requires 1 mol KOH to completely react)	1
3.12×10^{-2} HNO_3 requires 3.12×10^{-2} KOH to completely react But 5.65×10^{-2} mol KOH is available More KOH available than required, therefore KOH is in excess (Or by comparing ratios of actual to stoichiometric ratios)	1
Therefore HNO_3 is the limiting reagent	1
Total	**3**

(g) Circle whether the resulting solution has a pH above, below or equal to 7 at 25 °C. (1 mark)

Below 7 Above 7 Equal to 7

Description	Marks
pH would be above 7 (As the limiting reagent is HNO_3 the resulting solution will be basic.)	1
Total	**1**

N.B: To be awarded the mark there should be reasoning shown in (f)

Question 39 **(21 marks)**

An organic compound was found to contain carbon, hydrogen and chlorine. When a 2.62 g sample of the compound was combusted, it produced 3.69 g of carbon dioxide and 1.13 g of water.

(a) Determine the number of moles and the mass of carbon in the sample. (4 marks)

Description	Marks
$n(C) = n(CO_2)$ $= m/M$ $= 3.69/44.01$ $= 0.08384$ $= 0.0838$ mol	1 1
$m(C) = n.M$ $= 0.08384 \times 12.01$ $= 1.00697$ $= 1.01$ g	1 1
Total	**4**

(b) Determine the number of moles and mass of hydrogen in the sample. (4 marks)

Description	Marks
$n(H) = 2 \times n(H_2O)$ $= 2 \times m/M$ $= 2 \times 1.13/18.016$ $= 0.1254$ $= 0.125$ mol	 1 1
$m(H) = n.M$ $= 0.1254 \times 1.008$ $= 0.1264$ $= 0.126$ g	1 1
Total	**4**

(c) Determine the mass and number of moles of chlorine in the sample. (3 marks)

Description	Marks
$m(Cl) =$ m(total) – (m(C) + m(H)) $= 2.62 - (1.00697 + 0.1264)$ $= 1.487$ g	1 1
$n(Cl) = m/M$ $= 1.483 / 35.45$ $= 0.04185$ $= 0.0419$ mol	1
Total	**3**

Question 39 (continued)

(d) Determine the simplest mole ratio of carbon, hydrogen and chlorine in the compound. (2 marks)

Description		Marks
	C : H : Cℓ	
Mole ratio	0.0838 : 0.125 : 0.0418	1
Simplify (÷ 0.0418)	2 : 3 : 1	1
	Total	**2**

(e) Write the empirical formula for this compound. (1 mark)

Description	Marks
$C_2H_3C\ell$	1
Total	**1**
Note: No penalty if 1 is placed after the Cℓ	

(f) In the gaseous state at STP, 25.0 g of the compound occupies 4.54 L.

(i) Determine the molar mass of the compound. (4 marks)

Description	Marks
n = V / 22.71 at STP = 4.54 / 22.71 = 0.1999 = 0.200 mol	 1 1
M = m / n = 25.0 / 0.1999 = 125.1 g mol^{-1} L	 1 1
Total	**4**

(ii) Determine the molecular formula of the compound. (3 marks)

Description	Marks
MF = Molecular Formula EF = Empirical Formula MFM = Molecular Formula Mass (M = Molar mass) EFM = Empirical Formula Mass EFM = 2 x 12.01 + 3 x 1.008 + 35.45 = 62.494 g mol^{-1}	 1
MF = (MFM / EFM) x EF = (125.06/62.494) x $C_2H_3C\ell$ = 2 x $C_2H_3C\ell$ = $C_4H_6C\ell_2$	 1 1
Total	**3**

Question 40 **(11 marks)**

Copper is a widely used metal which can be refined by electrolysis.

(a) State **one** use of copper in the home. (1 mark)

Description	Marks
Any one of: • decorations • electrical wiring, switches • (bottom of) saucepans, kettles or other cookware • cutlery Accept any other correct and clearly stated use	1
Total	**1**

(b) State **two** properties of copper that make it suitable for the use stated in part (a). (2 marks)

Description	Marks
Any two properties • high electrical conductivity • high thermal conductivity • resistance to corrosion • low reactivity • high melting point • malleable • ductile • high lustre when polished • unique colour Property must be directly linked to the stated use. For example: electrical wiring → high electrical conductivity and ductility	1–2
Total	**2**

Question 40 (continued)

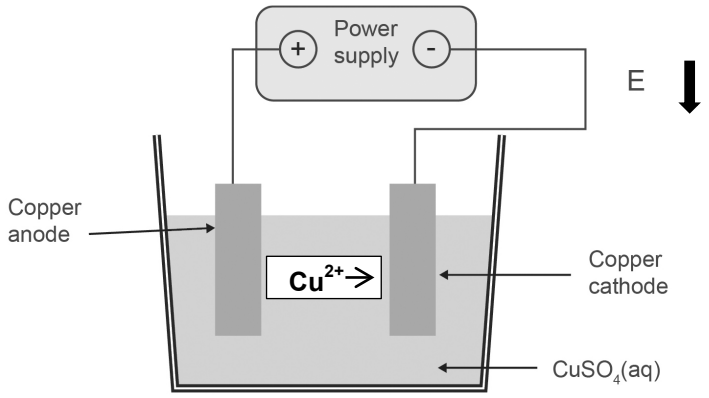
(c) (i) Draw an arrow on the diagram to show the direction of the movement of electrons in the external circuit at point E. (1 mark)

Description	Marks
Downward direction of arrow (towards the copper cathode)	1
Total	**1**

(ii) Draw an arrow on the diagram to show the direction of the movement of copper ions (Cu^{2+}) in the solution. (1 mark)

Description	Marks
Arrow moving to the right (towards the copper cathode)	1
Total	**1**

Answer could include:



(d) Why must the power supply be direct current (DC) and not alternating current (AC)? (3 marks)

Description	Marks
• DC stands for direct current which means a current constantly moving in one direction around the circuit resulting in the same reaction occurring. • If AC (alternating current) is used, the electron flow is in a continual state of reversing direction and consequently the reaction would alternate between the forward and reverse reaction, resulting in no net reaction.	1 1–2
Total	**3**

(e) Explain why the copper(II) sulfate needs to be dissolved in water for the electrolysis process to work. (3 marks)

Description	Marks
Any three of the following:	
• Electrolysis requires the movement of charge around the complete circuit, (electrons in the wiring and electrodes) and ions in the electrolyte • In the solid state, the ions within copper(II) sulfate are not free to move so no current can flow • When dissolved in water the copper(II) ions and sulfate ions are now free to move through the electrolyte and so complete the circuit • Copper(II) sulfate is the source of the Cu^{2+} ions required for the reaction.	1–3
Total	**3**

Question 41 **(15 marks)**

(a) Calculate the average time taken for the whole tablets to release 20 mL of gas. (2 marks)

Description	Marks
T = (15.4 + 16.2 + 15.8) ÷ 3 = 15.8 s	1 1
Total	**2**

(b) Calculate the average time taken for the crushed tablets to release 20 mL of gas. (2 marks)

Description	Marks
T = (4.5 + 8.1 + 6.3) ÷ 3 = 6.3 s	1 1
Total	**2**
Note: Although not within normally accepted experimental error margins, both values of 4.5 and 8.1 are 1.8 different from the median and average value of 6.3. It would not make sense to eliminate either or both values.	

(c) What conclusion can be drawn by comparing the answers for part (a) and part (b)? (1 marks)

Description	Marks
The crushed tablets produce 20.0 mL of gas more quickly than whole tablets. Or It takes less time for the crushed tablets than the whole tablets to produce 20.0 mL of gas.	1
Total	**1**

Question 41 (continued)

(d) Suggest why the three results for the crushed tablet show greater variation than those for the whole tablet. (1 mark)

Description	Marks
The crushed tablets react more quickly which introduces human error in timing OR In the crushing process not all the tablet might have been transferred OR The crushed tablets are not necessarily equally crushed	1
Total	**1**
(Accept other valid explanations – but not that **all** the tablet will have been used up)	

(e) Which hypothesis (1 or 2) is **best** supported by the results of the experiment? (1 mark)

Description	Marks
Hypothesis 2	1
Total	**1**

(f) Rewrite the hypothesis chosen in part (e), using scientific language that demonstrates your understanding of rates of reaction. (3 marks)

Description	Marks
Crushing the tablet will increase the **surface area** which will increase the **rate of the reaction** and a link between these two statements e.g. increasing the chance of collisions	1 1 1
Total	**3**

(g) In this experiment the rate of the reaction was monitored by measuring the time taken to produce a certain volume of gas. Outline one other way in which the rate of this reaction could be monitored. Explain your answer with reference to the equation for the reaction. (3 marks)

Description	Marks
Measuring the loss of mass of the products (by using a balance)	1
Carbon dioxide is produced in the reaction as a gas	1
(In an open system) as the gas escapes, the mass of the contents in flask will reduce	1
Total	**3**
Note: Up to 2 marks will be credited if reference is made to measuring the change in the pH of the acid by using a pH meter because the acid is being neutralised (This will not work as the acid is in excess but it does demonstrate understanding of the concepts involved in rate measurement).	

(h) Suggest a source of error in this experiment and what could be done to minimise the error. (2 marks)

Description	Marks
Relevant source of error Matching means of minimising the stated error Example: Relevant source of error • Individual reaction time • Parallax error Matching means of minimising the stated error • Same experimenter does each timing • Take readings perpendicular to the mark on the gas syringe	1 1
Total	**2**
Note: No mark allocated to the means of minimising error if it does not relate to the stated source of error.	

Question 42 **(15 marks)**

The formation of acid in the environment can have a significant impact on the environment. Examples of such acid formation include:

- acid rain
- soil acidification in agriculture
- acidification of ground water.

(a) Choose **one** of the above examples and explain what the term means. (2 marks)

(i) 'Acid rain'

Description	Marks
Rainfall becoming more acidic than normal i.e. pH of less than 6. Caused by the dissolving of acidic gases present in the atmosphere dissolving in water in the atmosphere (clouds or precipitation).	1–2
Total	**2**

OR

(ii) 'Soil acidification in agriculture'

Description	Marks
The reduction in pH/increase in the acidity of soil on farmland. Caused by the use/overuse of acidic chemicals which remain in the soil and build up over time.	1–2
Total	**2**

OR

(iii) 'Acidification of ground water'

Description	Marks
The reduction in pH/increase in the acidity of water in rivers/lakes/water in the ground/aquifers. Caused by the use/overuse of acidic chemicals which run off from sources such as gardens/farmland/industry into natural water supplies.	1–2
Total	**2**

(b) Name **two** chemicals that contribute to the formation of the acid described in part (a). For each chemical, name **one** source. (4 marks)

Description	Marks
Two chemicals (accept names or correct formulae)	1–2
Source of each chemical	1–2
Total	**4**

Examples of possible answers:

(i) 'Acid rain'

Name of chemical	Source of chemical
Sulfur dioxide	Burning fossil fuels/transport fuels/production of gold/roasting sulfide ores
Nitrogen dioxide (or other nitrogen oxides)	Car exhaust fumes/industry

(ii) 'Soil acidification in agriculture'

Name of chemical	Source of chemical
ammonium nitrate	Fertiliser (weakly acidic salt)
ammonium sulfate	Fertiliser (weakly acidic salt)
nitric acid	Waste from manufacture of fertilisers

(iii) 'Acidification of ground water'

Name of chemical	Source of chemical
sulfur dioxide	Burning fossil fuels / transport fuels/production of gold
nitrogen dioxide	Car exhaust fumes Industry
sulfuric acid	Waste from industry (e.g. manufacture of detergents/paint)/car batteries
nitric acid	Waste from industry (e.g. manufacture of fertilisers)

(c) Outline **two** negative impacts that such acid formation has on the environment. (4 marks)

Description	Marks
Two from: (1–2 marks for each answer) • Prevention of the growth of crops and plants due to the environment/soil being too acidic for the plants to survive • Prevention of the growth of animals (including fish) due to the change in the acidity of the environment being too rapid for the animals to adapt (via natural selection) in order to survive • Damage to limestone buildings caused by acid dissolving the calcium carbonate • Increased levels of corrosion of metal caused by acid reacting with the metal • Pollution of drinking water supplies resulting in increased costs for water purification	1–4
Total	**4**

Question 42 (continued)

(d) Using **one** of the chemicals and its source listed in part (b), explain how the acid in the environment is formed. Include relevant equations. (5 marks)

Description	Marks
Correctly balanced equations for the reactions occurring during the formation of the acid	1–2
Description of the process and/or conditions occurring	1–2
Linking the equations and description	1
Total	**5**

Example of possible answer:
Sulfurous acid (H_2SO_3) causes rain water to become acidic.

Sulfur present in fossil fuels burns when the fuel burns to form sulfur dioxide:

$$S(s) + O_2(g) \rightarrow SO_2(g)$$

The sulfur dioxide reacts with water in the atmosphere to form sulfurous acid

$$SO_2(g) + H_2O(\ell) \rightleftarrows H_2SO_3(g)$$

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