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

CHEMISTRY

ATAR course examination 2022

Marking key

Marking keys are an explicit statement about what the examining panel expect of candidates when they respond to particular examination items. They help ensure a consistent interpretation of the criteria that guide the awarding of marks.

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

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

Section Two: Short answer **35% (71 Marks)**

Question 26 **(12 marks)**

For each of the applied changes after equilibrium is re-established, predict the:
- shift in equilibrium position (left, right or no change)
- rate of the forward reaction compared to the original rate (increase, decrease or no change)
- colour of the reaction mixture.

Description	Marks
Correctly predicts the shift in equilibrium position.	1–4
Correctly predicts the effect on rate of the forward reaction.	1–4
Correctly predicts the colour of the reaction mixture.	1–4
Total	**12**

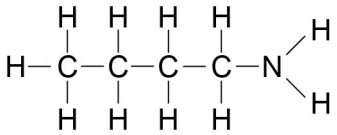
Accept arrows for equilibrium position shift but not for rate of forward reaction.

Change	Shift in equilibrium position (left, right or no change)	Rate of the forward reaction compared to original rate (increase, decrease or no change)	Colour of reaction mixture
The reaction mixture is heated	Left	Increase	(More) brown/orange/pale brown
A few crystals of $FeC\ell_3$ are added	Right	Increase	(More) red/deeper red
Water is added to the reaction mixture	Left	Decrease	(Very) pale brown
A few drops of concentrated Na_3PO_4 are added	Left	Decrease	(Very) pale brown

Note: The colour choice must represent the correct equilibrium shift direction.

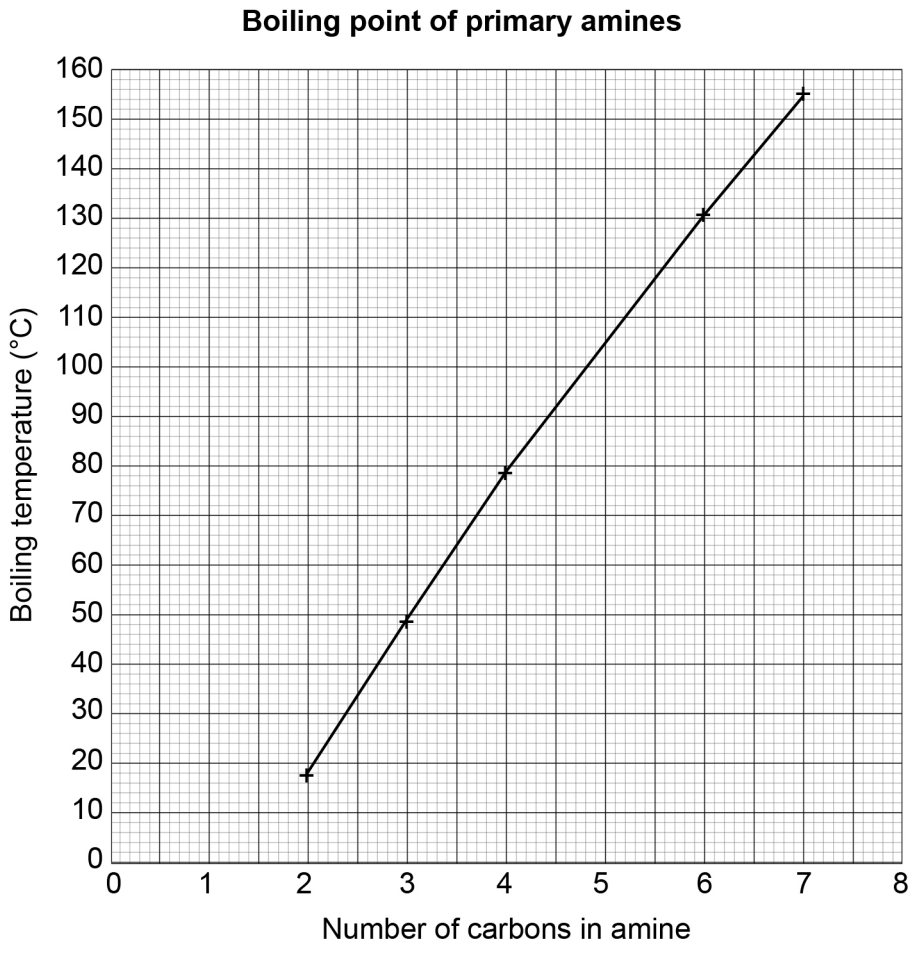
Question 27 **(12 marks)**

(a) Draw the structure of butan-1-amine as a primary amine showing all atoms and bonds. (2 marks)

Description	Marks
Correct structure 	1–2
Total	**2**
Maximum 1 mark if minor error, e.g. missing hydrogens. Note: condensed structure maximum of one mark.	

(b) Use the data in the table on the previous page to graph the boiling temperature of amines versus the number of carbons in the amines on the grid below. The x-axis has been labelled for you. (5 marks)

Description	Marks
appropriate title	1
y-axis labelled with units	1
scales	1
points plotted correctly	1
line/curve of best fit	1
Total	**5**



(c) Use your graph to predict the boiling temperature of pentan-1-amine. (1 mark)

Description	Marks
104 ˚C	1
Total	**1**
Note: Follow through from graph – if student reads graph correctly, award one mark.	

(d) Use your understanding of intermolecular forces, to explain the relationship shown in your graph. (4 marks)

Description	Marks
Recognition that all primary amines have NH_2 on terminal carbon so hydrogen bonding/polar forces of attraction is not the determining factor in the increase in boiling temperature.	1
Recognition that the boiling temperature of the primary amines increases as the hydrocarbon chain length increases.	1
Recognition that as chain length increases the magnitude of dispersion forces increases.	1
Recognition that increase in magnitude of dispersion forces requires more energy to overcome and allow the primary amine to boil.	1
Total	**4**
Note: Also accept increasing number of electrons in answer.	

Question 28 **(7 marks)**

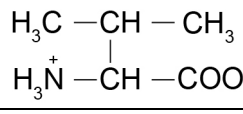
Explain why potassium hydrogensulfite, $KHSO_3$, produces an acidic solution when dissolved in water, while potassium hydrogencarbonate, $KHCO_3$, produces a basic solution when dissolved in water. Use equations to illustrate your explanation.

Description	Marks
Recognition that the K^+ ions in solution are neutral/do not react with water.	1
Recognition that the HSO_3^- and HCO_3^- ions undergo hydrolysis reactions	1
Recognition that for the hydrolysis reactions for HSO_3^-, the reaction that produces H_3O^+ occurs to a greater extent than the reaction that produces OH^-, (therefore the solution will be acidic)	1
Recognition that for the hydrolysis reactions for HCO_3^-, the reaction that produces OH^- occurs to a greater extent than the reaction that produces H_3O^+, (therefore the solution is basic).	1
Recognition that a basic solution has a greater concentration of OH^- ions than H_3O^+ ions/an acidic solution has a greater concentration of H_3O^+ ions than OH^- ions.	1
Minimum of two appropriate equations, which could include: At least one equation for HSO_3^- $HSO_3^-(aq) + H_2O(\ell) \leftrightharpoons SO_3^{2-}(aq) + H_3O^+(aq)$ $(HSO_3^-(aq) + H_2O(\ell) \leftrightharpoons H_2SO_3(aq) + OH^-(aq))$	1
At least one equation for HCO_3^- $HCO_3^-(aq) + H_2O(\ell) \leftrightharpoons H_2CO_3(aq) + OH^-(aq)$ $(HCO_3^-(aq) + H_2O(\ell) \leftrightharpoons CO_3^{2-}(aq) + H_3O^+(aq))$	1
Total	**7**

Question 29 **(11 marks)**

(a) Keratins are also known to contain relatively large amounts of the α-amino acid valine. A property of α-amino acids is that they can form zwitterions.

(i) Draw the structure of valine as a zwitterion. (2 marks)

Description	Marks
	1–2
Total	**2**
Maximum 1 mark if any minor errors including • missing hydrogens • missing charge/incorrect location • missing carbon • incorrect amino acid • incorrect connectivity.	

(ii) State the condition that is required for zwitterions of α-amino acids to form in aqueous solution. (1 mark)

Description	Marks
neutral or pH 7 or isoelectric point	1
Total	**1**

(b) The strength of hair keratin is attributed to a relatively high content of the α-amino acid cysteine.

(i) State which interaction is possible in proteins due to the presence of cysteine. (1 mark)

Description	Marks
disulfide bridges	1
Total	**1**

(ii) Define 'protein tertiary structure' and describe how it is formed. (3 marks)

Description	Marks
Definition	
(three-dimensional) shape of a protein/folding of secondary structure	1
Subtotal	**1**
Description	
• due to interactions of (α-amino acid) side chains (in the polypeptide)	1–2
• such as hydrogen bonding/dipole-dipole interactions/dispersion forces/ionic interactions/disulfide bridges	
Subtotal	**2**
Total	**3**

(c) Proteins are distinguished at the level of the primary structure. Describe this level of protein structure. (2 marks)

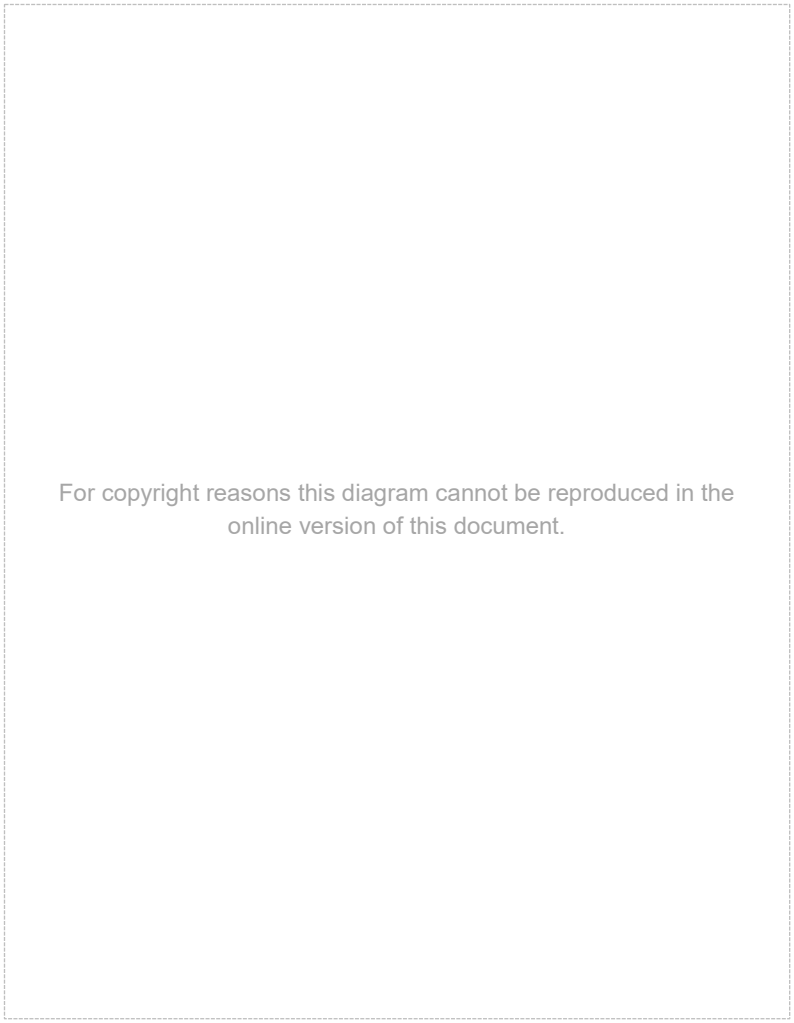
Description	Marks
the sequence of	1
(α-)amino acids (in a protein/polypeptide chain)	1
Total	**2**

Question 29 (continued)

The α-helix is a common secondary structure observed in keratins.

(d) Draw dotted lines (.....) on the diagram below to show the position of at least **two** hydrogen bond interactions that stabilise the helical shape. (1 mark)

Description	Marks
Two of the correct hydrogen bonding interactions shown below.	1
Total	**1**



The nature of the α-amino acid side chain or R-group in the helical part of keratins is critical to the overall structure. In certain positions the side chains are non-polar.

(e) Identify **one** α-amino acid from the Data booklet with a non-polar side chain. (1 mark)

Description	Marks
One of: alanine, glycine, isoleucine, leucine, methionine, phenylalanine, proline, valine (hydrocarbon or no polar functional groups).	1
Total	**1**

Question 30 **(5 marks)**

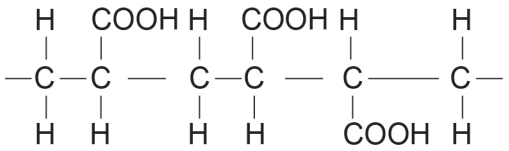
Drinking milk is effective in reducing the 'hotness' of chillies, by dissolving the capsaicin due to the presence of fats in the milk and removing it from the tongue. Capsaicin does not dissolve in water, and so drinking water does not reduce the effect of the compound when eaten. Explain this observation, using your understanding of intermolecular forces.

Description	Marks
Recognition of the forces of attraction present between the molecules in • capsaicin are predominantly dispersion • fats are predominantly dispersion.	1
Recognition of the forces of attraction present between the molecules in water are predominantly hydrogen bonds.	1
Recognition that the forces of attraction formed between water and capsaicin are relatively weak compared to the forces of attraction formed between capsaicin and fat	1
Recognition that the energy produced by the forces of attraction formed between capsaicin and fats are sufficient to overcome the existing forces of attraction between the molecules of fats and between the molecules of capsaicin (and so capsaicin dissolves in milk).	1
Recognition that the energy produced between the forces of attraction formed between capsaicin and water is insufficient to overcome the existing forces of attraction between the molecules of capsaicin and between the molecules of water (and so capsaicin does not dissolve in water).	1
Total	**5**
Also accept a response in terms of strength and number of bonds.	

Question 31 **(7 marks)**

(a) Draw the structure of the polymer polyacrylic acid showing at least **three** repeating units. (2 marks)

Description	Marks
three correct monomers linked	1
ends are not terminated	1
Total	**2**



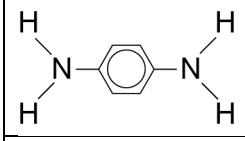
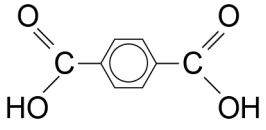
Maximum 1 mark if any minor errors, including:
- missing or too many hydrogens
- bond lines connected to wrong atoms.

(b) A child's nappy contains approximately 3.97 g of polyacrylate, and a particular company state that their nappies are at least 97.4% efficient at absorbing water. After thorough testing it was demonstrated that this brand of nappies could absorb 691 g of water. Use a calculation to determine whether the claims of the company that manufacture the nappies are true. (3 marks)

Description	Marks
Nappy should absorb 3.97 × 180 = 715 g of water.	1
At 97.4% efficiency nappies hold 715 × 0.974 = 696 g	1
696 g > 691 g therefore the company's claims are not true	1
Total	**3**

Accept alternative approaches
i.e. percent absorbed = 691/714.6 × 100 = 96.7%
96.7% < 97.4% therefore false

(c) Draw the structure of the **two** monomers from which Kevlar is made. (2 marks)

Description	Marks
	1
	1
Total	**2**

Question 32 **(6 marks)**

(a) State the IUPAC name for each isomer. (3 marks)

Description	Marks
Correctly names each isomer	1–3
Total	**3**

Isomer	IUPAC name
I	hexan-1-ol
II	2-methylpentan-2-ol
III	hexan-2-ol

(b) Propose a chemical test and state the expected observations for each isomer that could be used to distinguish between isomer I and isomer II. (3 marks)

Description	Marks
proposes an appropriate chemical test	1
states the expected observations for isomer 1	1
states the expected observations for isomer 2	1
Total	**3**

Answers could include:

Chemical test: Addition of (limited amount of) acidified potassium permanganate solution.

Expected observations:
Isomer 1: purple solution decolourised
Isomer 2: solution remains purple/no visible reaction

Chemical test: Addition of (limited amount of) acidified potassium dichromate solution.

Expected observations:
Isomer 1: solution becomes green
Isomer 2: solution remains orange/no visible reaction

Chemical test: Addition of sodium.

Expected observations:
Isomer 1: rapid generation of bubbles
Isomer 2: less rapid/slower generation of bubbles

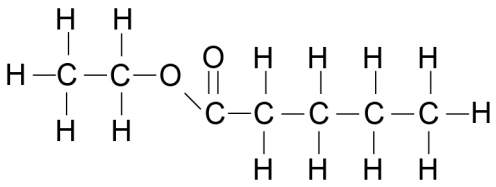
Accept other correct, relevant answers.

Question 33 **(11 marks)**

(a) Two methods of producing ethanol industrially include fermentation of glucose and hydrolysis of ethene. Write a chemical equation for each process and state any conditions that are required. (8 marks)

Description	Marks
Process: Fermentation of glucose	
$C_6H_{12}O_6(aq) \rightarrow 2\ CH_3CH_2OH(aq) + 2\ CO_2(g)$	
correct products	1
correct balancing	1
Zymase/yeast used as a catalyst	1
Conditions – any one of: • temperature stated (range 25 °C – 37 °C) • pH range 3–5 • atmospheric pressure.	1
Subtotal	**4**
Process: Hydrolysis of ethene	
$CH_2CH_2(g) + H_2O(g) \leftrightharpoons CH_3CH_2OH(g)$	
correct reactants	1
correct products	1
acid catalyst ($H^+/H_3PO_4/H_2SO_4$)	1
Conditions – any one of: • temperature of 300 °C/moderate temperature • pressure of 6000–7000 kPa/high pressure • water in the gas state.	1
Subtotal	**4**
Total	**8**
Accept other correct, relevant answers for conditions.	

(b) The ethanol produced was added to pentanoic acid along with a few drops of concentrated sulfuric acid. This mixture was then heated. Draw the structure and state the IUPAC name of the ester that is formed in this reaction. Include **all** atoms. (3 marks)

Description	Marks
	1–2
Ethyl pentanoate	1
Total	**3**
Maximum one mark for structure if any minor errors including: • missing hydrogens • if pentyl ethanoate is drawn.	

Section Three: Extended answer **40% (90 Marks)**

Question 34 **(12 marks)**

Fluconazole is an antifungal medication that contains carbon, hydrogen, fluorine, nitrogen and oxygen.

A 3.42 g sample of fluconazole was combusted and produced 6.39 g of carbon dioxide and 1.21 g of water. All of the nitrogen in a second 0.422 g sample of fluconazole was converted into nitric acid, which was neutralised by 16.5 mL of a 0.500 mol L^{-1} solution of sodium hydroxide. The second sample was also found to contain 0.0525 g of fluorine.

Determine the empirical formula of fluconazole.

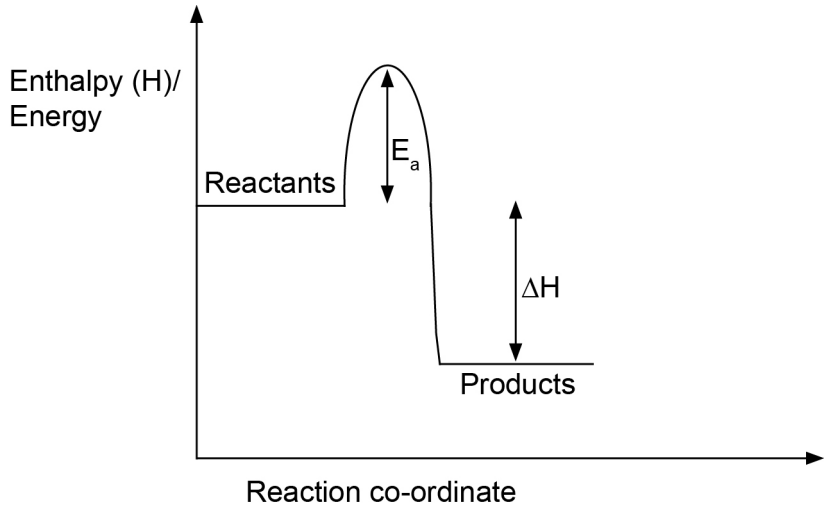
Description						Marks
$m(C) = \frac{6.39}{44.01} \times 12.01$ = 1.744 g						1
$\%(C) = \frac{1.744}{3.42} \times 100$ = 51.0%						1
$m(H) = \frac{1.21}{18.016} \times 2 \times 1.008$ = 0.1354 g						1
$\%H = \frac{0.1354}{3.42} \times 100$ =3.96%						1
$\%F = \frac{0.0525}{0.422} \times 100$ = 12.4%						1
$n(OH^-) = 0.0165(0.500)$ $=8.25 \times 10^{-3}$ mol $=n(H^+)$ =n(N)						1
$m(N) = (8.25 \times 10^{-3}) \times 14.01$ = 0.1156 g						1
$\%N = \frac{0.1156}{0.422} \times 100$ = 27.4%						1
%O = 100 – (51.0 + 3.96 + 12.4 + 27.4) = 5.24%						1
	C	**H**	**F**	**N**	**O**	1
M in 100 g	51.0	3.96	12.4	27.4	5.24	
n	$\frac{51.0}{12.01}$ = 4.25	$\frac{3.96}{1.008}$ = 3.93	$\frac{12.4}{19.00}$ 0.653	$\frac{27.4}{14.01}$ = 1.96	$\frac{5.24}{16.00}$ = 0.328	
ratio	$\frac{4.25}{0.328}$ =13	$\frac{3.93}{0.328}$ = 12	$\frac{0.653}{0.328}$ = 2	$\frac{1.96}{0.328}$ = 6	$\frac{0.328}{0.328}$ = 1	1
Empirical Formula is $C_{13}H_{12}F_2N_6O$						1
					Total	**12**
Accept alternative methods, e.g. proportions.						

Question 35 **(17 marks)**

(a) Use the following axes to sketch an energy profile diagram for the thermite reaction. Label the:

- axes
- reactants and products
- activation energy
- change in enthalpy. (4 marks)

Description	Marks
correctly labelled axes	1
correctly labelled reactants and products	1
E_a and ΔH correctly labelled	1
Scale (large values for E_a and ΔH)	1
Total	**4**



Maximum 3 marks if an endothermic energy profile is drawn.

(b) In order for the reaction to occur, the iron(III) oxide and aluminium are mixed as powders and a heat source, such as burning magnesium, is used to ignite the mixture. Using your understanding of collision theory, explain these observations. (4 marks)

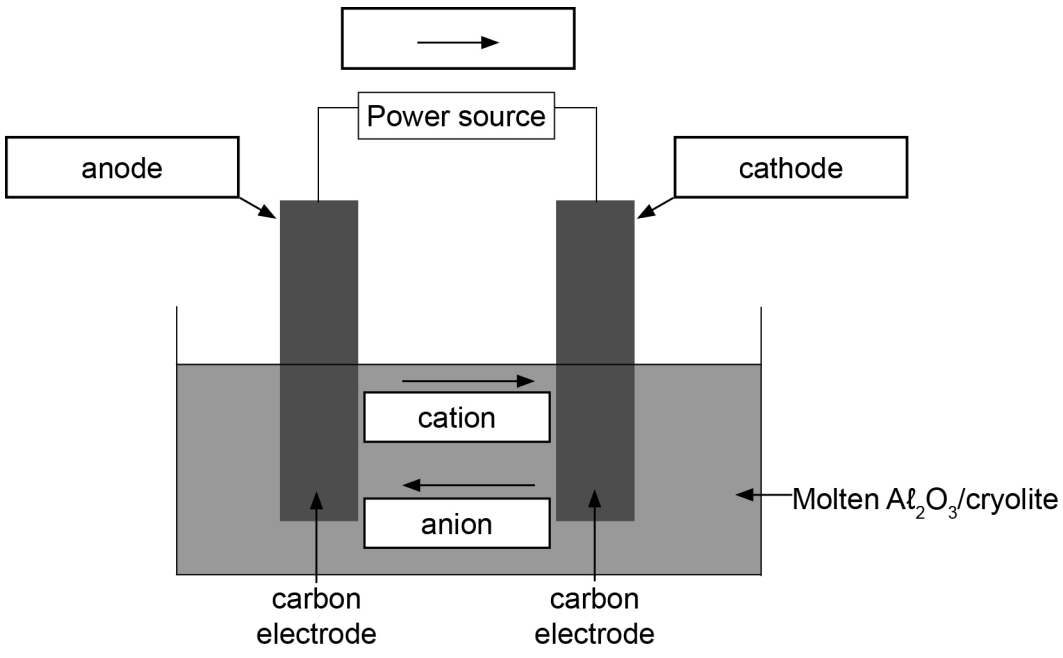
Description	Marks
Recognition that a high activation energy requires an additional energy source for the reaction to occur.	1
For successful reactions, particles must collide with sufficient energy.	1
Recognition that powders have a large surface area, and so there are more particles available for reaction.	1
Increased availability of particles increases likelihood of collisions (frequency of collisions) and so reaction more likely to occur.	1
Total	**4**

(c) If the thermite reaction is 89.5% efficient, what mass of iron(III) oxide will be required to produce 667 kg of iron? Give your answer to the appropriate number of significant figures. (6 marks)

Description	Marks
$m(Fe) = 667 \times 1000$ $= 6.67 \times 10^5$ g	1
$n(Fe) = \frac{6.67 \times 10^5}{55.85}$ $= 1.194 \times 10^4$ mol	1
$n(Fe_2O_3) = ½(1.194 \times 10^4)$ $= 5.971 \times 10^3$ mol	1
$m(Fe_2O_3) = 5.971 \times 10^3(159.7)$ $= 9.536 \times 10^5$ g	1
$m(Fe_2O_3) = \frac{100}{89.5} \times (9.536 \times 10^5)$ $= 1.07 \times 10^6$ g	1
Answer given to three significant figures.	1
Total	**6**

(d) On the diagram below label, correctly place the following in the boxes:
- anode
- cathode
- direction of cation flow and direction of anion flow
- direction of electron flow. (3 marks)

Description	Marks
anode and cathode correctly labelled	1
cations shown flowing to cathode and anions shown flowing to anode	1
electrons shown flowing towards cathode	1
Total	**3**



Note: all answers can be flipped for full marks.

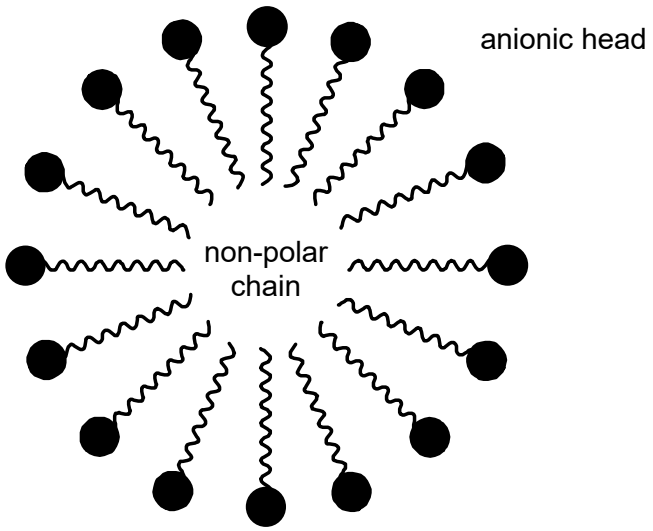
Question 36 **(12 marks)**

Compare soaps and detergents in terms of the following:

(a) structure (2 marks)

Description	Marks
Recognition that soaps and detergents both contain a long (non-polar) hydrocarbon chain.	1
Recognition that soaps contain a carboxylate group whereas detergents contain a sulfonate group.	1
Total	**2**

(b) cleaning action; include a labelled diagram to illustrate the cleaning action(s) (7 marks)

Description	Marks
Recognition that soaps and detergents have the same cleaning action.	1
Labelled drawing of a micelle with correct orientation of charged group and non-polar chain, e.g.  	1–2
Recognition that charged groups are soluble in water through ion-dipole attraction.	1
Recognition that chains are non-polar (and aggregate together).	1
Recognition that non-polar grease/dirt aggregates with the hydrocarbon chains within the micelle through dispersion forces.	1
Recognition that grease/dirt becomes 'soluble'/suspended in water and washed away via agitation.	1
Total	**7**
Accept labelled diagrams showing the non-polar ends sticking into the grease and the polar/charged ends outwards from the grease	

(c) properties in hard water. (3 marks)

Description	Marks
Recognition that cleaning action of soap is diminished in hard water whereas detergents are effective.	1
Recognition that hard water contains (divalent) cations such as Ca^{2+}/Mg^{2+}.	1
Recognition that the Ca^{2+} salts of soaps are insoluble in water and precipitate to form 'soap scum' and the Ca^{2+} salts of detergents are soluble in water.	1
Total	**3**

Question 37 **(18 marks)**

(a) Write balanced half-equations for the oxidation and reduction reactions and a balanced overall redox equation for the reaction in Step 1. (5 marks)

Description	Marks
correctly places oxidation and reduction half-equations	1
Cu half-equation correct	1
reduction half equation has correct species	1
reduction half equation correctly balanced	1
overall equation is correctly balanced	1
Total	**5**

Oxidation half-equation	$Cu \rightarrow Cu^{2+} + 2\ e^-$
Reduction half-equation	$NO_3^- + 2\ H^+ + e^- \rightarrow NO_2 + H_2O$
Overall redox equation	$Cu + 2\ NO_3^- + 4\ H^+ \rightarrow Cu^{2+} + 2\ NO_2 + 2\ H_2O$
Note: Equation must have some merit for follow through marks.	

(b) Describe all the observations for this reaction, including colour changes. (2 marks)

Description	Marks
describes all observations, including reactants and products	2
describes some observations	1
Total	**2**

- a blue solution is added to a colourless solution
- a blue precipitate and a colourless solution are formed.

(c) Write an equation for Step 3, including state symbols. (3 marks)

Description	Marks
correct species	1
correct balancing	1
correct state symbols	1
Total	**3**

$Cu(OH)_2(s) \rightarrow CuO(s) + H_2O(g)$

Note: Equation must have some merit for follow through marks
e.g. using CuOH instead of $Cu(OH)_2$

(d) Write an equation for this reaction. (2 marks)

Description	Marks
correct species	1
correct balancing	1
Total	**2**

$CuO(s) + 2\ H^+(aq) \rightarrow Cu^{2+}(aq) + H_2O(\ell)$

Note: Equation must have some merit for follow through marks
e.g. using Cu_2O instead of CuO

Question 37 (continued)

(e) Write an equation for this reaction. (2 marks)

Description	Marks
correct species	1
correct balancing	1
Total	**2**
$Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$	

(f) If 0.616 g of magnesium was required to react with the copper(II) sulfate, calculate the mass of copper produced and, therefore, the percentage yield of copper from the series of reactions. (4 marks)

Description	Marks
$n(Mg) = \frac{0.616}{24.31}$ $= 2.534 \times 10^{-2}$ mol	1
$n(Mg) = n(Cu)$	1
$m(Cu) = 63.55(2.534 \times 10^{-2})$ $= 1.61$ g	1
$\%\ \text{yield Cu} = \frac{1.61}{2.54} \times 100$ $= 63.4\ \%$	1
Total	**4**

Question 38 **(15 marks)**

(a) Calculate the average titre that would have been obtained to produce these results. (8 marks)

Description	Marks
$n(NaHCO_3) = \frac{0.1065}{84.008} \times 5$ $= 6.339 \times 10^{-3}$ mol in 250 mL	1
$n(Na_2CO_3) = \frac{0.1875}{105.99} \times 5$ $= 8.845 \times 10^{-3}$ mol in 250 mL	1
$n(NaHCO_3) = \frac{25}{250} \times 6.339 \times 10^{-3}$ $= 6.339 \times 10^{-4}$ mol in one aliquot	1
$n(Na_2CO_3) = \frac{25}{250} \times 8.845 \times 10^{-3}$ $= 8.845 \times 10^{-4}$ mol in one aliquot	1
Recognition that $n(H^+) = n(NaHCO_3)$ in titration $= 6.339 \times 10^{-4}$ mol	1
Recognition that $n(H^+) = 2\ n(Na_2CO_3)$ in titration $= 2(8.845 \times 10^{-4})$ $= 1.769 \times 10^{-3}$ mol	1
$n(H^+ \text{ total}) = 6.339 \times 10^{-4} + 1.769 \times 10^{-3}$ $= 2.403 \times 10^{-3}$ mol	1
$V(\text{HCl required}) = \frac{2.403 \times 10^{-3}}{0.0955}$ $= 0.02516$ L (25.16 mL)	1
Total	**8**
Note: accept alternative approaches.	

(b) Hydrochloric acid must be standardised against a primary standard before it can be used in titrations such as the one described in part (a). List **three** properties of substances suitable for use as primary standards. (3 marks)

Description	Marks
Lists three properties of substances used as primary standards	3
Lists two properties of substances used as primary standards	2
States one property of substances used as primary standards	1
Total	**3**
Answers could include: • high molar mass • not hygroscopic • not deliquescent • available with a known purity • does not react with substances in the atmosphere (e.g. CO_2) • (highly) soluble • predictive reactivity.	

Question 38 (continued)

(c) Methyl orange, which changes colour between a pH of 3.1 and a pH of 4.4, was chosen as the indicator for this reaction. Justify, with the aid of an equation, the selection of this indicator for the titration. (4 marks)

Description	Marks
Recognition that CO_2 is produced in the reaction with acid	1
Recognition that CO_2 reacts with water to produce H_3O^+	1
therefore, at the equivalence point there will be a greater concentration of H_3O^+ than OH^-, so the solution will have a pH of less than 7	1
appropriate equation (accept any reasonable, correct equation) e.g. $CO_2(aq) + 2\ H_2O(\ell) \leftrightharpoons HCO_3^- + H_3O^+(aq)$ $H_2CO_3(aq) + H_2O(\ell) \leftrightharpoons HCO_3^- + H_3O^+(aq)$	1
Total	**4**

Question 39 **(16 marks)**

(a) State a hypothesis for this investigation. (2 marks)

Description	Marks
Writes a hypothesis that gives the relationship between the independent and dependent variables.	2
Writes a hypothesis that includes the independent and dependent variables without giving their relationship.	1
Total	**2**
Answer could include: Increasing the temperature will decrease the time taken for the acidified potassium permanganate to decolourise (change from purple to pale pink/colourless as the rate of reaction increases with increasing temperature).	
Accept other relevant answers.	

(b) Identify the independent and dependent variables. (2 marks)

Description	Marks
independent variable: temperature (of solution)	1
dependent variable: time taken (for potassium permanganate solution/mixture) to decolourise	1
Total	**2**
Accept other relevant answers.	

(c) Identify **two** control variables. (2 marks)

Description	Marks
Identifies control variables	1–2
Total	**2**
Answers could include: • concentration of acidified potassium permanganate solution • concentration of oxalic acid solution • volume of acidified potassium permanganate solution • volume of oxalic acid solution • stopwatch/timer • person timing/observing.	
Accept other relevant answers.	

(d) Describe a procedure for this investigation. (6 marks)

Description	Marks
Recognition that fixed volumes of oxalic acid and acidified potassium permanganate are used.	1–2
Recognition that temperature must be varied and measured.	1
Recognition that time must be measured from mixing.	1
Any two of the following: • recognition of appropriate method for determining end point of the reaction (decolourisation) e.g. use a white paper base • recognition of the use of trials • recognition of the use of appropriate glassware • recognition that solutions are mixed in appropriate proportions e.g. 2:5 ratio of solutions.	1–2
Total	**6**
Accept other relevant answers.	

(e) Outline the difference between systematic and random errors. Use an example of each from this investigation to support your answer. (4 marks)

Description	Marks
Recognises that systematic errors produce consistently high or consistently low measurements compared to the true value.	1
Recognises that random errors produce measurements that can be either high or low/fluctuate around the true value.	1
Example of a systematic error. Any one of: • only heating one solution • using an inappropriate proportion of reactants • errors in calibration with equipment • inappropriate rinsing of glassware.	1
Example of a random error. Any one of: • parallax (reading of meniscus) • judging the end point • use of stopwatch • reading thermometer • not using the same measuring equipment during the reaction • using measuring cylinder rather than pipette.	1
Total	**4**
Accept other correct relevant answers.	

ACKNOWLEDGEMENTS

Question 29(d) Adapted from: Morganti, P., & Li, H. Y. (2015). Innovation in Cosmetic and Medical Science. The Role of Chitin Nanofibrils Composites (Fig. 2) [Diagram]. *Journal of Applied Cosmetology, 33*(1–2). Retrieved May, 2022, from https://www.researchgate.net/figure/The-alpha-helix-structure-of-keratins_fig3_282148893

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