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ATAR examination, Semester 2, 2021

Question/Answer booklet

CHEMISTRY ANSWER KEY

Student Name: _____

Student Number: In figures | | | | | | | | |

In words

Teacher Name: _____

Marker	Score
M/C	
AP	
KH	
CR	
JD	
BR	
Total (/221)	
Percent (%)	

Time allowed for this paper

Reading time before commencing work: ten minutes
Working time for paper: three hours

Materials required/recommended for this paper

To be provided by the supervisor
This Question/Answer booklet
Multiple-choice answer sheet
Chemistry Data booklet

To be provided by the candidate
Standard items: pens (blue/black preferred), pencils (including colours), sharpener, correction fluid/tape, eraser, ruler, highlighters

Special items: up to three calculators, which do not have the capacity to create or store programmes or text, are permitted

Important note to candidates

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised material. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of examination	Your mark
Section One Multiple-choice	25	25	50	50	23	
Section Two Short answer	7	7	60	73	33	
Section Three Extended answer	5	5	70	98	44	
				Total	100	

Instructions to candidates

1. The rules for the conduct of the Western Australian external examinations are detailed in the *Year 12 Information Handbook 2021: Part II Examinations*. Sitting this examination implies that you agree to abide by these rules.

2. Write your answers in this Question/Answer booklet preferably using a blue/black pen. Do not use erasable or gel pens.

3. Answer the questions according to the following instructions.

   Section One: Answer all questions on the separate Multiple-choice answer sheet provided. For each question, shade the bubble to indicate your answer. Use only a blue or black pen to shade the bubbles. Do not use erasable or gel pens. If you make a mistake, place a cross through the bubble, then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

   Sections Two and Three: Write your answers in this Question/Answer Booklet.

4. When calculating numerical answers, show your working or reasoning clearly. Your working should be in sufficient detail to allow your answers to be checked readily and for marks to be awarded for reasoning. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

5. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

6. Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

7. The Chemistry Data booklet is not to be handed in with your Question/Answer booklet.

Multiple Choice

Question	Answer
1	B
2	A
3	C
4	C
5	D
6	D
7	C
8	D
9	B
10	A
11	D
12	B
13	B
14	C
15	B
16	D
17	C
18	B
19	D
20	B
21	A
22	D
23	C
24	A
25	A

See next page

Section One: Multiple-choice **23% (50 Marks)**

This section has **25** questions. Answer **all** questions on the separate Multiple-choice answer sheet provided. For each question shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. Do not use erasable or gel pens. If you make a mistake, place a cross through that square, then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 50 minutes

Questions 1 and 2 refer to the following information

A chemist investigates how the equilibrium constant for the hydrolysis of an ester in water changes with increasing carbon-chain length.

1. The validity of this experiment can be best improved by:

a) Controlling the initial concentration of ester species.
b) Controlling the temperature of the solution.
c) Repeating the experiment three times and taking an average.
d) Using the same quantity of sulfuric acid catalyst.

2. Which of the following is the dependent variable in the experiment?

a) Equilibrium constant
b) Temperature of the solution
c) Carbon-chain length
d) Initial concentration of the ester species

3. Which of the following mixtures will there be no spontaneous reaction?

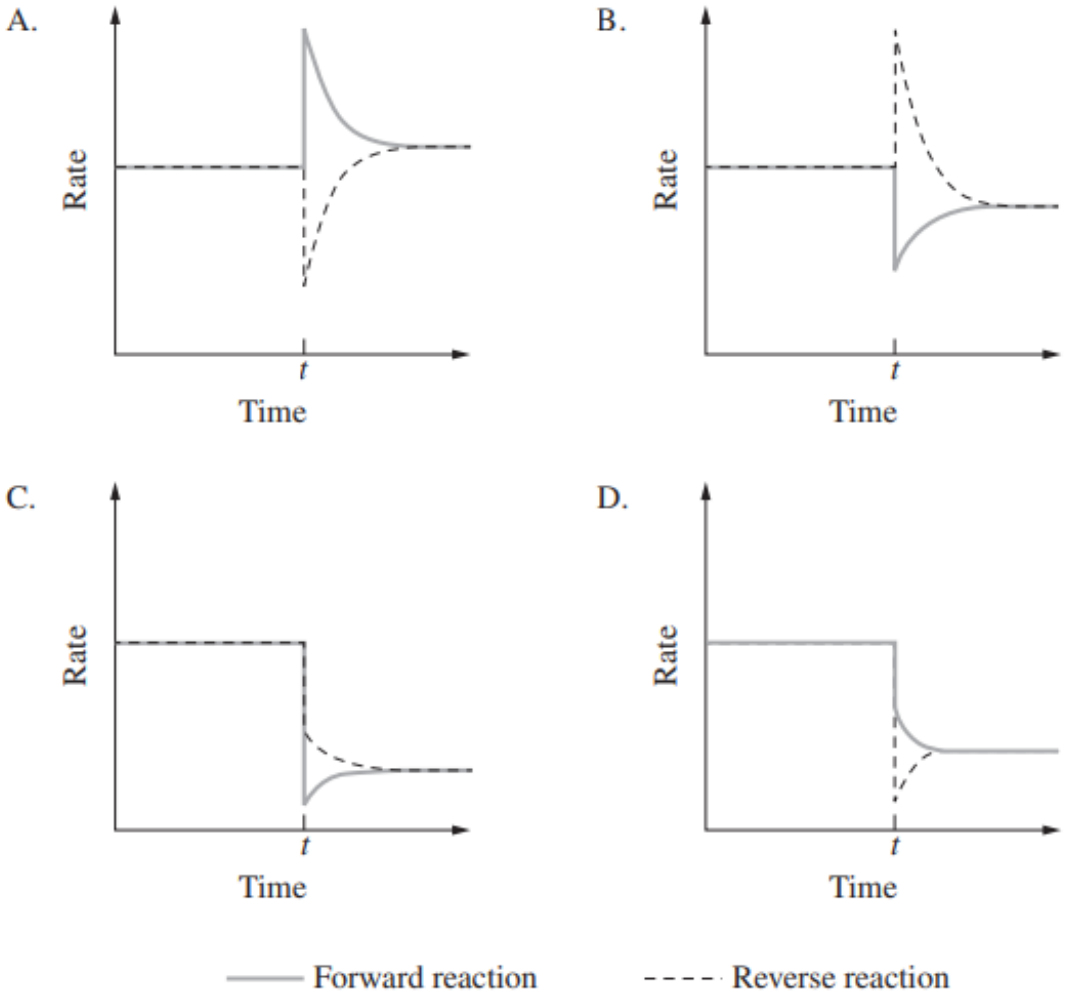
(a) Copper metal and concentrated nitric acid
(b) Acidified sodium permanganate and propan-2-ol
(c) 3-methylhexan-3-ol and acidified potassium dichromate
(d) Copper metal and silver nitrate solution

4. Nitrogen reacts with hydrogen in a sealed flask according to the following equation:

$$N_2\,(g) + O_2\,(g) \rightleftharpoons 2\,NO\,(g) \quad \Delta H > 0$$

Which graph best represents the rates of both the forward and reverse reactions when an equilibrium system containing this equilibrium system is cooled at time t?

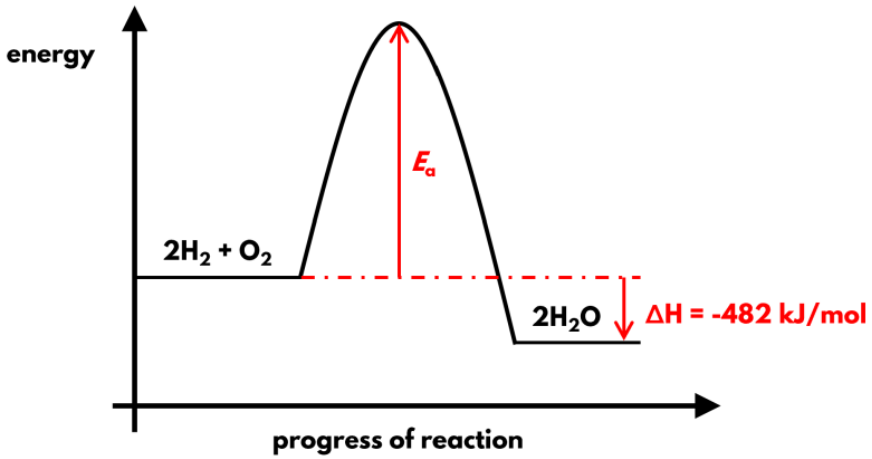
<C>



5. Identify the incorrect statement below regarding chemical equilibrium.

a) All chemical reactions are, in principle, reversible.
b) Equilibrium is achieved when the forward reaction rate equals the reverse reaction rate.
c) Equilibrium is achieved when the concentrations of species become constant.
d) Equilibrium is achieved when reactant and product concentrations are equal.

6. The diagram below represents an energy profile diagram for a fuel cell.



The effect of increasing the partial pressure of hydrogen and oxygen in the fuel cell is:

a) The change in enthalpy becomes more negative.
b) The activation energy for the reaction decreases.
c) The reaction becomes endothermic.
d) There is no change to the energy profile diagram.

7. Ammonium butanoate is a salt of the following acid and base:

$NH_3\ (aq) + H_2O\ (\ell) \rightleftharpoons NH_4^+\ (aq) + OH^-\ (aq)$ $K = 1.8 \times 10^{-5}$

$C_4H_8O_2\ (aq) + H_2O\ (\ell) \rightleftharpoons C_4H_7O_2^-\ (aq) + H_3O^+\ (aq)$ $K = 1.5 \times 10^{-5}$

Which of the following is correct with respect to the ammonium butanoate salt?

a) It is a neutral salt of a weak acid and weak base
b) It is an acidic salt of a weak acid and weak base
c) It is a basic salt of a weak acid and weak base
d) It is a neutral salt of a weak acid and strong base

8. Evidence of ocean acidification includes the recording of “fewer and smaller marine calcifiers” in the ocean compared to 100 years ago.

Which of the following is an appropriate inference to this observation?

a) Carbonate ion concentration increases as ocean pH decreases.
b) Carbonate ions are consumed by hydronium ions in basic waters.
c) Carbonate ions convert to hydrogen carbonate ions as part of the hydrogen carbonate buffer system when atmospheric carbon dioxide decreases.
d) Carbonate ions react with hydronium ions to reduce carbonate ion concentration in low pH waters.

9. Mycolic acid is a weak monoprotic acid ($C_{88}H_{176}O_4$) present in the cell walls of mycobacteria. Which of the following is the conjugate base of mycolic acid?

a) $C_{88}H_{177}O_4^+$
b) $C_{88}H_{175}O_4^-$
c) $C_{88}H_{174}O_4^{2-}$
d) $C_{88}H_{176}O_3^-$

10. An aqueous solution of sodium hydrogen carbonate has a pH greater than 7. Which statement best explains this observation?

a) H_2O (ℓ) is a stronger acid than HCO_3^- (aq).
b) HCO_3^- (aq) is a weaker acid than H_2CO_3 (aq)
c) Na^+ (aq) reacts with water to produce the strong base NaOH (aq).
d) The conjugate acid of HCO_3^- (aq) is a stronger acid than H_2O (ℓ)

See next page

11. A solution containing dipotassium phthalate ($K_2C_8H_4O_4$) and potassium hydrogen phthalate ($KC_8H_5O_4$) is a common laboratory buffer with a pH close to 7.

Which row of the table best identifies the chemistry of this buffer system?

	Buffer Equation	Equilibrium shift	
		Acid is added to the solution	Base is added to the solution
a)	$C_8H_6O_4 + H_2O \rightleftharpoons C_8H_5O_4^- + H_3O^+$	Right	Left
b)	$C_8H_6O_4 + H_2O \rightleftharpoons C_8H_5O_4^- + H_3O^+$	Left	Right
c)	$C_8H_5O_4^- + H_2O \rightleftharpoons C_8H_4O_4^{2-} + H_3O^+$	Right	Left
d)	$C_8H_5O_4^- + H_2O \rightleftharpoons C_8H_4O_4^{2-} + H_3O^+$	Left	Right

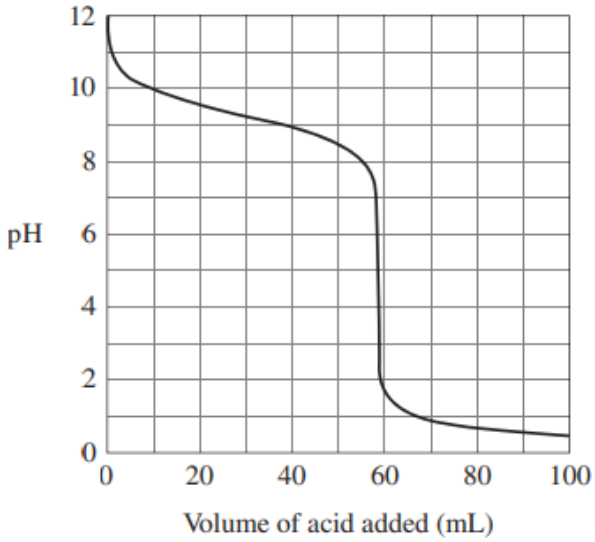
12. Each of the salts listed below are added to pure water and the pH tested.

I. KNO_3
II. Na_3PO_4
III. $Ni(CH_3COO)_2$
IV. $Ba(OH)_2$

Which of the salt solutions are likely to give a pH significantly greater than 7?

a) I, II, III, IV,
b) II, III, IV
c) III, IV
d) IV only

13. A weak base is titrated with 1.0 mol L^{-1} aqueous HNO_3. The pH curve is shown.



At which pH value would the solution be most effective as a buffer?

a) 12
b) 9
c) 3
d) 5

14. Which of the following compounds is the most basic?

a) Ethanoic acid
b) Ethanol
c) Ethanamine
d) Ethyl ethanoate

15. Which of the following isomeric alkanes has the highest vapour pressure?

a) 2-methylpentane
b) 2,2-dimethylbutane
c) 3-methylpentane
d) Hexane

See next page

16. The following reactions occur spontaneously:

$Co\ (s) + Hg^{2+}\ (aq) \rightleftharpoons Co^{2+}\ (aq) + Hg\ (\ell)$

$Hg\ (\ell) + 2Ce^{4+}\ (aq) \rightleftharpoons Hg^{2+}\ (aq) + 2Ce^{3+}\ (aq)$

$2Cr^{2+}\ (aq) + Co^{2+}\ (aq) \rightleftharpoons Co\ (s) + 2Cr^{3+}\ (aq)$

Using the information provided, which of the following pairs of reactants would be expected to react spontaneously?

a) Co (s) and Ce^{3+} (aq)
b) Cr^{3+} (aq) and Hg (ℓ)
c) Co^{2+} (aq) and Ce^{4+} (aq)
d) Hg^{2+} (aq) and Cr^{2+} (aq)

17. The equation below represents a reaction in the extraction of chromium from its ore.

$$2Fe_2O_3.Cr_2O_3 + 4Na_2CO_3 + 3O_2 \rightarrow 2Fe_2O_3 + 4Na_2CrO_4 + 4CO_2$$

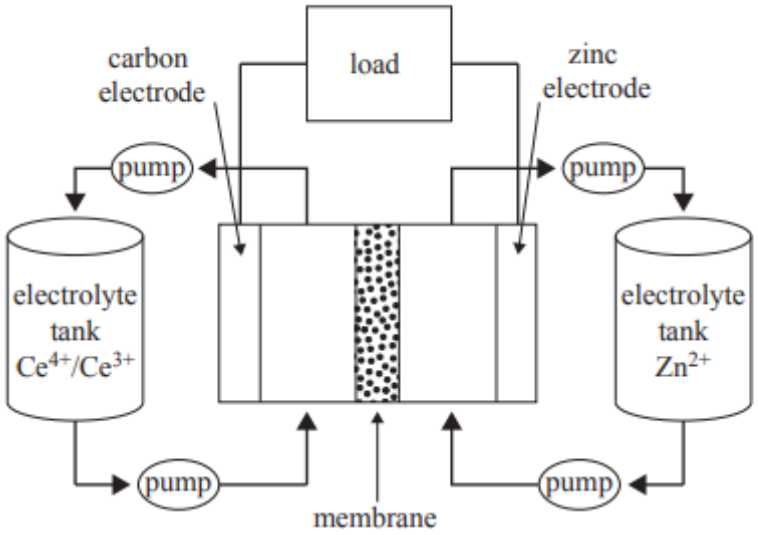
Which one of the following statements about the oxidation states of the substances is correct?

a) The carbon has been oxidised from a +2 state to a +4 state.
b) The iron has been reduced from a +3 state to a +2 state.
c) The chromium has been oxidised from a +3 to a + 6 state.
d) There is no change in the oxidation state of any of the substances in the reaction

18. Which of the following will <u>not</u> offer corrosion protection to an underground pipeline made of iron metal?

a) Attaching zinc metal at regular intervals along the pipeline.
b) Decreasing the pH of the soil surrounding the pipeline.
c) Impressing direct current through the pipeline.
d) Coating the surface of the pipe with a polymer-based paint.

Questions 19 and 20 refer to the zinc-cerium battery depicted below:



The following standard reduction half-cell reactions occur in the zinc–cerium cell.

- $Zn(CH_3SO_3)_2\ (aq) + 2\ H^+\ (aq) + 2\ e^- \rightleftharpoons Zn\ (s) + 2\ CH_3SO_3H\ (aq)$ $E_0 = -0.76$ V
- $Ce(CH_3SO_3)_4\ (aq) + H^+\ (aq) + e^- \rightleftharpoons Ce(CH_3SO_3)_3\ (aq) + CH_3SO_3H\ (aq)$ $E_0 = 1.64$ V

19. The potential difference in this cell during <u>charging</u> is:

a) 0.88 V
b) 2.40 V
c) -0.88 V
d) -2.40 V

20. A maintenance worker noted the following with regards to the cell:

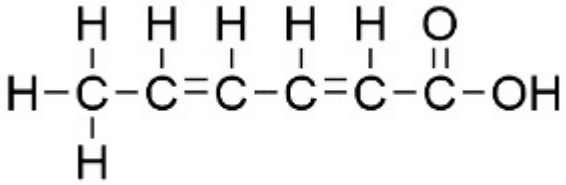
I during discharge the carbon electrode is the anode, site of oxidation
II electrons flow from the zinc electrode to the carbon electrode during discharge
III it is a secondary cell and zinc solid deposits at the cathode during charging.

Which of the following statements are correct?

a) I and III
b) II and III
c) I, II and III
d) I only

See next page

21. Sorbic acid (hexa-2,4-dienoic acid) has the structure shown below.



Which row of the table correctly identifies observations when this compound is added to bromine water and phenolphthalein indicator?

	Bromine water	**Phenolphthalein indicator**
a)	Orange mixture decolourises	No visible change
b)	Orange mixture decolourises	Turns pink
c)	No visible reaction	No visible change
d)	No visible reaction	Turns pink

22. An innovative French brand of nail polish remover created a 'waxy' formula consisting of ethyl ethanoate dissolved in a sea of pure triglycerides extracted from macadamia oil.

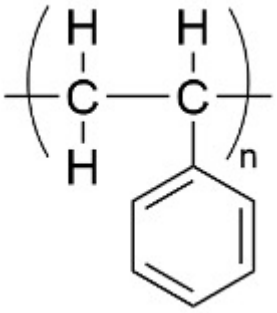
Which of the following correctly lists the functional groups present in this mixture?

a) Carboxylic acid and ester
b) Carboxylic acid and alcohol
c) Carboxylic acid only
d) Ester only

23. Hair irons are used to straighten curly hair by applying heat to denature the keratin protein in the hair. Select the best option that describes how the hair goes straight after the heat is removed:

a) The heat applied alters the primary structure of protein by disrupting intermolecular forces.
b) The heat applied alters the primary structure by breaking the peptide bonds.
c) The heat applied alters the secondary and tertiary structure by disrupting intermolecular forces.
d) The heat applied alters the secondary and tertiary structure by breaking covalent bonds between side chains.

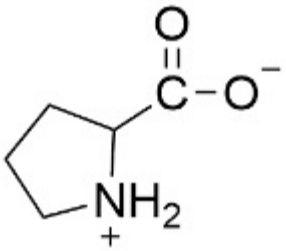
24. The structure of part of a polymer chain is shown below:



Which of the following lists the type of intermolecular forces and applied use of this polymer?

	Intermolecular forces	Applied use
a)	Dispersion only	Food packaging
b)	Dispersion and dipole-dipole	Non-stick cookware
c)	Dispersion and dipole-dipole	Beanbag foam
d)	Dispersion only	PET water bottle

25. The α-amino acid, proline, is depicted below:



Which of the following best describes this compound?

a) A neutral compound capable of ionic interactions.
b) An ionic compound with a net negative charge.
c) An ionic compound with a net positive charge.
d) A zwitterion capable of forming β-pleated sheets with other zwitterions.

End of Section 1

See next page

Section Two: Short Answer **33% (73 Marks)**

This section has **seven (7)** questions. Answer **all** questions. Write your answers in the spaces provided.

Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

Suggested working time: 60 minutes.

Question 26 **(7 marks)**

(a) Propene gas is mixed with water vapour (steam) at 300 °C in the presence of a phosphoric acid catalyst. Write an appropriate balanced equation for this chemical reaction and name the product(s). (4 marks)

Description	**Marks**
$CH_2CH_2CH_3 + H_2O \rightarrow CH_3CH_2OHCH_3$ OR $CH_2OHCH_3CH_3$	2
NOTE: one mark for each correct isomer product, Condensed or molecular formula accepted	
Products: propan-1-ol, propan-2-ol (e.c.f. must match structure drawn)	2
Total	**4 marks**

(b) Solutions of silver nitrate and saturated calcium hydroxide were combined. Write an appropriate balanced equation and an observation for this chemical reaction. (3 marks)

Description	**Marks**
Two colourless slns are mixed to form a <u>brown solid</u> in a colourless solution.	1
$2\ Ag^+(aq) + 2\ OH^-(aq) \rightarrow Ag_2O(s) + H_2O(\ell)$	2
$Ag^+(aq) + OH^-(aq) \rightarrow AgOH(s)$	1
Total	**3 marks**

Question 27 **(7 marks)**

Up until the 1970s, lead was extracted from lead (II) carbonate ore called cerussite, and used in paints that were applied to homes, offices, and schools.

To analyse for lead (II) carbonate content, a 1.235 g sample of the mineral which is considered to contain only lead (II) carbonate is treated with 250 mL of standardised 0.0516 mol L^{-1} nitric acid. An observation was noted that all the solid disappears, effervescence occurs, and a clear and colorless solution remains.

(c) Write a balanced equation for the reaction that occurs. (2 marks)

Description	**Marks**
$PbCO_3$ (s) + 2 H^+ (aq) → Pb^{2+} (aq) + CO_2 (g) + H_2O (ℓ)	2
Must have state symbols	
Total	**2**

To the clear and colourless liquid that remained, 250 mL of standardised 0.0148 mol L^{-1} sodium hydroxide solution was added and the resulting white precipitate was separated by filtration. The filtrate was made up to exactly 1.50 L with distilled water.

(d) Determine the pH (to 2 d.p) of the resulting solution. (5 marks)

Description	**Marks**
n(Pb) = 1.235 / 267.2 = 0.004622 mol n(H+) = 0.0516 x 0.25 = 0.01290 mol	1
n(xs H+ from 1st rxn) = 0.01290 – (2 x 0.004622) = 0.003656 mol n(OH^-) = 0.25 x 0.0148 = 0.00370 mol n(OH- in xs) = 0.003656 – 0.00370 = 0.000044 mol	1
[OH-] = 0.00044 / 1.5 = 2.9333 x 10^{-5} mol L^{-1}	1
[H+] = 1 x10^{-14} / 2.9333 x 10^{-5} = 3.409 x 10^{-10} OR pOH = -log(2.9333 x 10^{-5}) = 4.53	1
pH = -log(3.409 x 10^{-10}) = 9.47	1

See next page

OR pH = 14 – pOH = 14 – 4.53 = 9.47	
If not to 2 d.p.	-1
NOTE: pOH method accepted with working shown in full.	
Total	**5 marks**

Question 28 **(10 marks)**

A solution comprising methylpropanoic acid and the soluble salt, sodium methylpropanoate was prepared and had measured to have a pH of 5.6. After each successive addition 0.1 mL of sodium hydroxide solution, the pH was recorded.

Cumulative Volume of NaOH added (mL)	pH
0	5.6
0.5	5.8
1.0	6.0
1.5	6.3
2.0	8.9
2.5	10.4

(a) Write a hydrolysis equation for aqueous methylpropanoic acid in water to describe the buffer system. (2 marks)

Description	**Marks**
$CH_3(CH_3)CH_2COOH$ (aq) + H_2O (ℓ) ←→ $CH_3(CH_3)CH_2COO^-$ (aq) + H_3O^+ (aq)	2
Accept structural / condensed / molecular formula	
Total	**2 marks**

(b) Refer to Le Châtelier's principle to explain how this system is responding when the first three portions of sodium hydroxide solution were added (5 marks)

Description	**Marks**
Addition OH^- added consumes H^+	1
System opposes imposed change (refer to LCP)	1
Shifts equilibrium to right	1
Increase conc H+ / [H^+]	1
Reducing pH / counteracting increase in pH from NaOH	1
Total	**5 marks**

See next page

(c) Provide a reason as to why a larger pH change was suddenly observed after the fourth and fifth successive amounts had been added. (3 marks)

Description	Marks
Buffer capacity exceeded (or description of buffer capacity)	1
All $CH_3(CH_3)CH_2COOH$ consumed system cannot produce any more H_3O^+	1
pH increases as NaOH is added	1
Total	**3 marks**

Question 29 **(13 marks)**

Nitric acid, (HNO_3), is a colourless, and highly corrosive liquid that is a common laboratory reagent and an important industrial chemical for the manufacture of fertilisers and explosives. Nitric acid can be produced through the reaction of nitrogen dioxide and water following the equation below:

$$3\ NO_2\ (g) + H_2O\ (\ell) \rightleftharpoons 2\ HNO_3\ (\ell) + NO\ (g) \qquad \Delta H < 0$$

(a) Write an equilibrium expression for this reaction. (2 marks)

Description	**Marks**
$K = [NO] / [NO_2]^3$	2
One extra substance included / No K= / $[NO_2]$ not raised to power 3 / K_w / K_a	1
All substances included / two errors or more	0
Total	**2**

It is supposed that this reaction is a redox system where the nitrogen in nitrogen dioxide is both oxidised and reduced.

(b) Write the half equations for this process showing nitrogen being oxidised and reduced. (2 marks)

Description	**Marks**
Ox: $NO_2 + H_2O \rightarrow HNO_3 + H^+ + e^-$ Note: $NO_3^- + 2\ H^+ + e^-$ also accepted, charges must balance	1
Red: $NO_2 + 2\ H^+ + 2e^- \rightarrow NO + H_2O$	1
Note: equilibrium arrows should not be used here – only the forward reactions give a spontaneous redox reaction. Use of equilibrium arrows – minus 1 mark	
Total	**2**

See next page

(c) Explain, using your understanding of collision theory, how increasing the temperature of this reaction system will impact the compromise of yield, rate and cost of the production of nitric acid. (9 marks)

Description	**Marks**
RATE	
Increase temp increases <u>average kinetic energy</u> of particles.	1
Increase <u>average velocity / speed</u> of particles	1
Increase <u>frequency of collisions</u>	1
Increase proportion of collisions which overcome <u>activation energy</u>	1
Increase <u>rate</u> of reaction(s).	1
YIELD	
<u>Collision theory used</u> to justify reverse endothermic reaction increasing in rate to a greater extent than forward exothermic reaction, eg: Endothermic reaction has <u>larger E_A</u> so rate increases to greater extent	1
Yield <u>decreases</u>	1
COST	
High temperature increases cost of process / equipment / fuel / energy Note: some qualification desired here!	1
COMPROMISE	
Should use <u>moderate temperature</u> to optimise high rate, without compromising yield and cost Note: discussion of compromise should cover all 3 factors	1
Total	**9 marks**

Comments:
High quality responses often addressed rate first, then used the ideas covered to <u>explain</u> decrease in yield. Addressing yield first often led to <u>description</u> of decrease in yield, without explanation.
If the question asks for use of collision theory to explain, discussion of LCP, directions or sides being “favoured” etc is unlikely to gain credit.
Comments unrelated to increase in temp not relevant – stick to the question!
Quoting <u>definitions</u> of Collision Theory (or LCP!) rarely gain much credit in <u>explanations</u>.
See next page for great response.

Question 30 **(12 marks)**

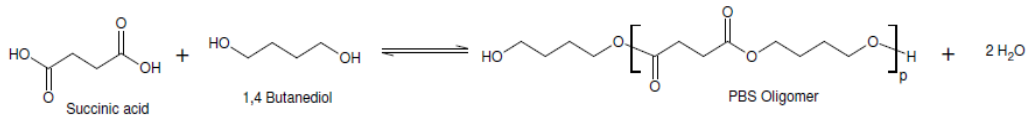
Polybutylene succinate (PBS) is a polymer of interest as it is considered biodegradable; it decomposes naturally into water and carbon dioxide. PBS is a plastic that finds use in packaging and commercial fishing lines/nets. It can be made by reacting butane-1,4-diol, which is a liquid at room temperature and soluble in water, with succinic acid (butanedioic acid) which is a solid at room temperature and insoluble in water. Succinic acid is soluble in butane-1,4-diol.

A Chemist claims to be able to produce PBS in two steps from a selection of the chemicals listed below:

- liquid butan-1,4-diol
- aqueous potassium dichromate
- concentrated sulfuric acid

Clearly describe the two-step process the chemist deployed to synthesise PBS from these reagents. Describe the conditions needed for the reactions, any observations and applicable equations with correct chemical formula (condensed structures).

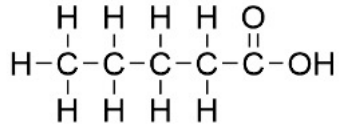
See next page

Description	Marks
Step 1 - Oxidation of diol to diacid using potassium dichromate	
Description: • To a solution of potassium dichromate add butane-1,4-diol • as well as a sulfuric acid / description of acidified conditions Note: acid is not a catalyst, this was not awarded.	0-2
Observation: • An orange solution turns green • with a white solid being produced	0-2
Equation: Ox: $C_4H_{10}O_2 + 2\ H_2O \rightarrow C_4H_6O_4 + 8\ H^+ + 8\ e^-$ Overall: $3\ C_4H_{10}O_2 + 4\ Cr_2O_7^{2-} + 32\ H^+ \rightarrow 3\ C_4H_6O_4 + 22\ H_2O + 8\ Cr^{3+}$ NOTE: allow follow through for correct overall from incorrect half equation.	0-2
Step 2 – polyesterification / condensation to form PBS	
Description: • Combine the succinic acid with butane-1,4-diol • as well as a sulfuric acid catalyst (to produce PBS)	0-2
Observation: • A white solid is added to a colourless solution, (solid consumed,) • to produce a white / transparent solid (in colourless solution). Any reasonable description of polymer accepted, however description of polymer *molecules* not accepted. Must be observation! Note: polyesters do not have the same fruity smell as esters! Massive polymer molecules are not sufficiently volatile to have an aroma.	0-2
Equation:  Succinic acid 1,4 Butanediol PBS Oligomer Notes: Must be a polymerisation reaction for any credit – formation of a single ester not awarded. Good polymerization = 2, polymerization with minor error(s) = 1 Must show water but balancing not required, i.e allow H_2O, $2\ H_2O$, $n\ H_2O$, $2n\text{-}1\ H_2O$. Common errors included: use of molecular type formulae, which meant the polymer repeating unit was incoherent / had CH_2 missing / missing ester links on polymer	0-2
General notes: • State symbols are not required. • Accept equations written with full structural or condensed molecular formulae without any penalty	
Total	**12**

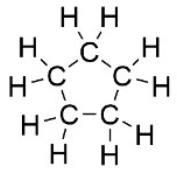
Question 31 **(9 marks)**

(a) Draw the structure and give the IUPAC name for the organic compounds that match the following descriptions – show all atoms and bonds in each structure.

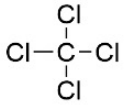
(i) The product of the reaction of pentanal and acidified sodium permanganate.

Description	**Marks**
Name pentanoic acid	1
	1
Total	**2 marks**

(ii) The product of the reaction between an unsaturated cyclic hydrocarbon with a molecular formula C_5H_8, which is warmed with hydrogen gas in the presence of a nickel catalyst.

Description	**Marks**
Name cyclopentane	1
	1
Total	**2 marks**

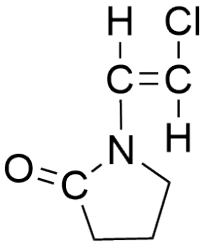
(iii) The product when chlorine gas is bubbled though liquid trichloromethane in the presence of UV light.

Description	**Marks**
Name: tetrachloromethane NOTE: do not accept carbon tetrachloride	1
	1

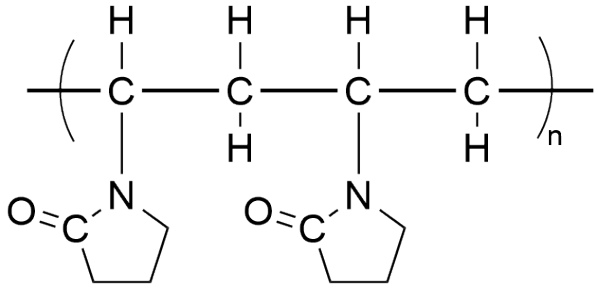
See next page

Total	2 marks

(b) A research scientist in the hair gel industry is experimenting with the monomer, *N*-(2-chlorovinyl)pyrrolidone, depicted below:



(i) Draw the structure of the addition polymer that could be made from this monomer, showing two repeating units. (2 marks)

Description	Marks
	
Two repeating units	1
Brackets and 'n'	1
Total	**2 marks**

(i) Name the polymer made from *N*-(2-chlorovinyl)pyrrolidone. (1 mark)

Description	Marks
Poly(*N*-(2-chlorovinyl)pyrrolidone)	1
NOTE: add 'poly' in front of the monomer name.	
Total	**1 mark**

See next page

Question 32 **(15 marks)**

Schweizer's reagent, $[Cu(NH_3)_4(H_2O)_2](OH)_2$, has been used since the 1800s as a compound that can dissolve cellulose from wood pulp, cotton fiber, and other natural cellulose sources. A possible four-step procedure for the synthesis of Schweizer's reagent is shown below:

Step	Equation	Yield (%)
1	$N_2\,(g) + 3\,H_2\,(g) \rightleftharpoons 2\,NH_3\,(g)$	94
2	$NH_3\,(g) \rightleftharpoons NH_3\,(aq)$	41
3	$CuSO_4{\cdot}5H_2O\,(s) + 2\,NH_3\,(aq) + \rightleftharpoons Cu(OH)_2{\cdot}H_2O\,(s) + (NH_4)_2SO_4{\cdot}(aq) + 2\,H_2O\,(\ell)$	88
4	$Cu(OH)_2{\cdot}H_2O\,(s) + 4\,NH_3\,(aq) + H_2O\,(\ell) \rightleftharpoons [Cu(NH_3)_4(H_2O)_2](OH)_2\,(aq)$	92

(a) Express the production of Schweizer's reagent as a one-step overall reaction.

(3 marks)

Description	Marks
$3\,N_2\,(g) + 9\,H_2\,(g) + CuSO_4{\cdot}5H_2O\,(s) \rightleftharpoons (NH_4)_2SO_4{\cdot}(aq) + H_2O\,(l) + [Cu(NH_3)_4(H_2O)_2](OH)_2\,(aq)$	3
$N_2\,(g) + 3H_2\,(g) + CuSO_4{\cdot}5H_2O\,(s) + 4\,NH_3\,(aq) \rightleftharpoons (NH_4)_2SO_4{\cdot}(aq) + H_2O\,(l) + [Cu(NH_3)_4(H_2O)_2](OH)_2\,(aq)$	2
Two minor errors	1
Total	**3 marks**

(b) Show by calculation that the overall percentage yield for the four-step production of Schweizer's reagent. (1 mark)

Description	Marks
0.94 x 0.41 x 0.88 x 0.92 x 100 = 31 %	1
Total	**1 mark**

For step 4 of the process each batch will use 55.67 kg of copper (II) hydroxide hydrate, with purity of 91.2%, added to 120.8 L of saturated ammonia solution that has concentration of 308 g L^{-1}.

(c) Copper (II) hydroxide hydrate is the most expensive reagent and must not be wasted. Confirm that copper (II) hydroxide hydrate is the limiting reagent. (5 marks)

Description	Marks
m($Cu(OH)_2.H_2O$ at 91.2%) = 55.67 kg x 0.912 = 50.77 kg	1
n($Cu(OH)_2.H_2O$) = 50.77 kg / 115.582 g mol^{-1} = 439 mol OR n($Cu(OH)_2.H_2O$) = 55.67 kg / 115.582 g mol^{-1} x 0.912= 439 mol	1
m(NH_3) = 308 g L^{-1} x 120.8 L = 37206 g	1
n(NH_3) = 37206 g / 17.034 g mol^{-1} = 2184 mol	1
Logic that determines Limiting Reagent n(NH_3) / n($Cu(OH)_2.H_2O$) = 2184 / 439 = 4.97 which is more than stoic ratio (4/1 = 4) Hence $Cu(OH)_2.H_2O$ is the LR	1
Total	**5 marks**

(d) The company expects to fill a consignment order of 425 kg of Schweizer's reagent in five batches. Show by calculation that the consignment order can be met in five batches. (4 marks)

Description	Marks
n(product)expected = n(copper hydroxide hydrate) = 439 mol	1
m(product) = 439 mol x 201.73 g mol^{-1} x 0.92 = 81.5 kg per batch	1
425 / 81.5 = 5.2 batches OR 81.5 x 5 batches = 407.5 kg, therefore less than 425 kg.	1
Confirm more than five batches needed	1
Total	**4 marks**

See next page

Safety is very important when performing all laboratory operations. Operators are always ensuring they mitigate harm by either wearing the appropriate Personal Protective Equipment (PPE) or selecting a procedure that removes or reduces likelihood of harm. Sections from a Material Safety Data Sheet (MSDS) for ammonia solution are below:

Safety Data Sheet
according to 29CFR1910/1200 and GHS Rev. 3

Effective date : 12.31.2014 Page 1 of 7

Ammonia

SECTION 2 : Hazards identification

Classification of the substance or mixture:

Corrosive
Skin corrosion, category 1B

Environmentally Damaging
Acute hazards to the aquatic environment, category 1

Irritant
Specific target organ toxicity following single exposure, category 3

STOT SE 3
AcAq Tox 1
Skin Corr. 1B

Signal word :Danger

Hazard statements:
Causes severe skin burns and eye damage
May cause respiratory irritation
Very toxic to aquatic life

(e) Outline <u>two</u> PPE that should be used by the operators when working with ammonia and describe how that PPE mitigates harm to the operators. (2 marks)

Description	**Marks**
Any two from list but mitigation must be applicable to that PPE and link to harm to the person.	0-2
Protective clothing – prevent burns to skin Eye glasses / face shields – prevent chemical damage to eyes Gloves – prevent damage to hands Safety shoes – prevents injury from slips or spilled chemicals	
Total	**2 marks**

End of Section Two

See next page

Section Three: Extended Answer **44% (98 Marks)**

This section contains **five (5)** questions. You must answer **all** questions. Write your answers in the spaces provided.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression. Lists or dot points are unlikely to gain full marks.

Final answers to calculations should be expressed to the appropriate number of significant figures.

Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original question where the answer is continued, i.e. give the page number.

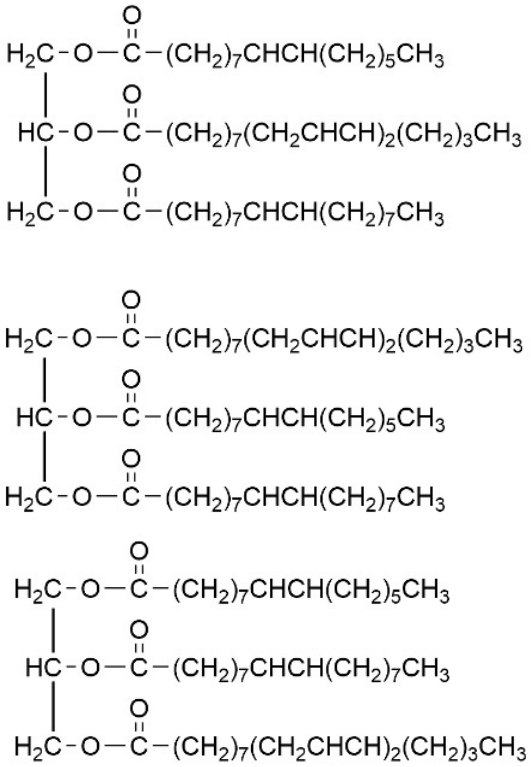
Suggested working time: 70 minutes

Question 33 **(17 marks)**

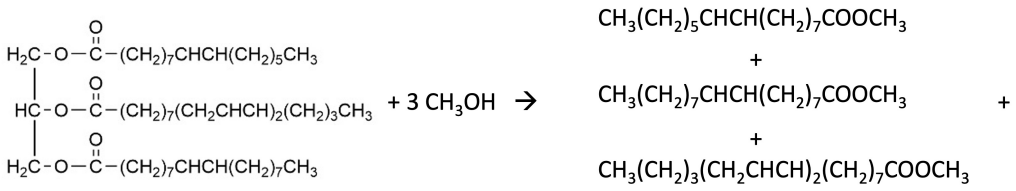
Brazil nut oil is used in many cosmetic products for its pleasant odour and moisturising capacity for skin and hair. The oil is composed of triglycerides containing the following fatty acids:

Fatty acid	Condensed Structure	Composition (%)
Palmitic	$CH_3(CH_2)_{14}COOH$	18.20
Palmitoleic	$CH_3(CH_2)_5CHCH(CH_2)_7COOH$	0.75
Stearic	$CH_3(CH_2)_{16}COOH$	13.20
Oleic	$CH_3(CH_2)_7CHCH(CH_2)_7COOH$	47.00
Linoleic	$CH_3(CH_2)_3(CH_2CHCH)_2(CH_2)_7COOH$	15.20
Other		5.65

(a) Draw the structure of a possible triglyceride of Brazil nut oil containing three different unsaturated fatty acids. (3 marks)

Description	Marks
Correct structure including palmitoleic, oleic, or linoleic acids One of:	3
 	
Minor error	-1 each
Total	**3 marks**

(b) Brazil nut oil can be used in the manufacture of biodiesel. Write an equation to show the production of a biodiesel using the compound drawn in part (a). (4 marks)

Description	Marks
	

See next page

Methanol (1), glycerol (1). NOTE: accept ethanol.	0-2
Correct esters (accept ethyl) (1)	1
Correct stoichiometry	1
Total	**6 marks**

(c) State why biofuel based on Brazil nut oil can be considered a "renewable" fuel.

(1 mark)

Description	**Marks**
Brazil nut oil is replenished within the average life of one human OR CO_2 released in burning is used by plants in photosynthesis to produce more Brazil nut oil.	1
Total	**1 mark**

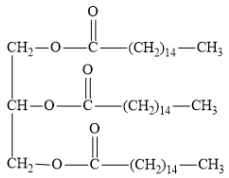
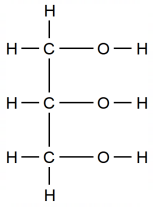
(d) Provide two reasons to that support using a sodium hydroxide catalyst over a lipase catalyst for the industrial production of biodiesel using Brazil nut oil. (2 marks)

Description	**Marks**
Argument must concentrate on industrial preferences (economic, rate & yield) not environmental (principles of Green Chem) preferences	
NaOH – any two points from the following: Can operate and high temp to deliver BioD at high rate NaOH is cheap to purchase Produce BioD at high purity NaOH does not denature due to changes in pH or Temp	0-2
Total	**2 marks**

Glyceryl tripalmitate is a common triglyceride found in palm and coconut oils made of glycerol and three palmitic acid components.

(e) Show how glyceryl tripalmitate can be converted into the soap, sodium palmitate.

(4 marks)

Description	Marks
 glyceryl tripalmitate + 3NaOH → 3 $CH_3(CH_2)_{14}COONa$ + 	
NaOH (1), glycerol (1).	0-2
Correct sodium palmitate	1
Correct stoichiometry	1
NOTE: Accept equation with or without Na+ spectator.	
Total	**4 marks**

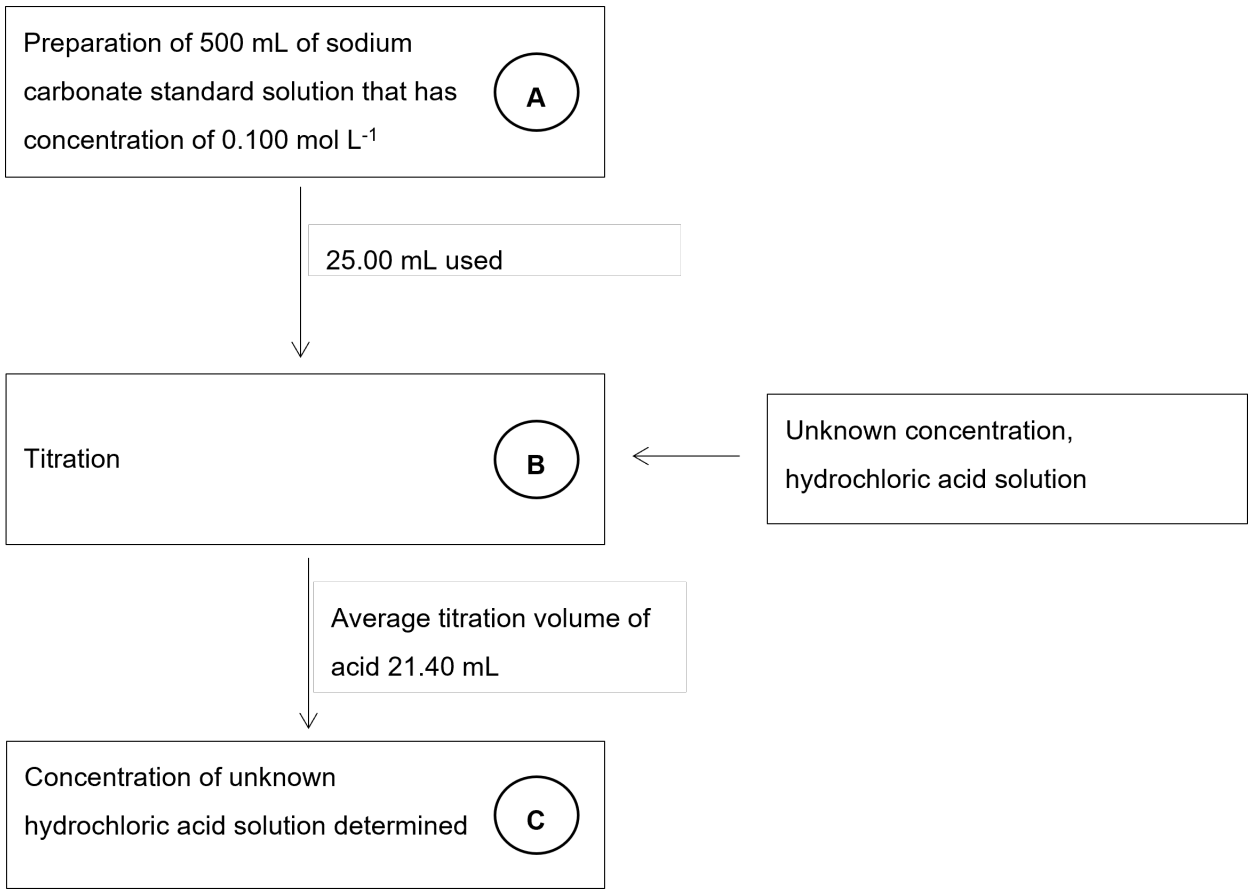
(a) Sodium palmitate has a reduced cleaning power in hard water. Explain this observation with use of an appropriate net ionic equation to support your response. (3 marks)

Description	Marks
2 $CH_3(CH_2)_{14}COO^-$ (aq) + Ca^{2+} (aq) → $Ca(CH_3(CH_2)_{14}COO)_2$ (s) State symbols required	1
Comment indicating solid magnesium palmitate (or scum) removes soap from water	1
Reducing number of soap molecules available to form <u>micelles</u> and perform cleaning action	1
Total	**3 marks**

See next page

Question 34 **(22 marks)**

A sewage analysis plant in Perth undertakes frequent titration analysis of sullage water to provide evidence of total acidity and pH of wastewaters. In standardisation of their stocks of hydrochloric acid, a reliable procedure is followed. The flow chart below outlines the sequence of steps (A, B, C) that was used to determine the concentration of a hydrochloric acid solution on a sunny September afternoon.



Indicators available:

Name	Low pH	Color transition range	High pH
Methyl Orange	Red	3.1 – 4.4	Yellow
Methyl Violet	Yellow	0.5 – 2.0	Violet
Phenolphthalein	Colourless	8.2 – 10	Pink
Universal Indicator	Red	0 – 14	Blue

The analysts value reliable and accurate results from their analysis.

(a) Outline a method for steps A and B of the experimental procedure. In your method include a description of correct technique, rinsing of glassware, and use of equipment. (10 marks)

Description	Marks
Volumetric Flask: Clean and rinse with distilled water.	0-2
Description of preparing primary standard: Add the weighted Na_2CO_3 to the volumetric flask using a funnel and wash using distilled water. Add distilled water to the flask to the bottom of the meniscus. Weigh out accurately using a mass balance.	0-2
Burette: Clean, rinse, and fill with the unknown acid	0-2
Conical flask: Clean and rinse with distilled water.	0-2
25 mL Pipette: Clean and rinse with 0.1 mol L^{-1} Na_2CO_3 solution. Fill pipette with Na_2CO_3 solution to bottom of meniscus.	0-2
Total	**10 marks**

(b) Justify the indicator that should be selected for the titration in step B. (2 marks)

Description	Marks
Add pipette volume into conical flask. Add Methyl Orange indicator to the conical flask.	1
Justifying indicator selection - Equivalence point is less than pH 7 as strong acid and weak base and equivalence point is acidic OR Justifying indicator selection – endpoint closest to equivalence point based from above	1
NOTE: universal indicator not acceptable and many colour changes (must change close to end point).	
Total	**2 marks**

See next page

(c) Describe how the sewage chemist would ensure that the titration in step B was valid and reliable. (2 marks)

Description	Marks
Reliable: Titration experiment repeated multiple times (an average taken)	1
Valid: evidence that all controlled variables were controlled.	1
Total **NOTE – Must identify which one is which**	**2 marks**

(d) Determine the unknown concentration of hydrochloric acid. (3 marks)

Description	Marks
Evidence of equation $2H^+ (aq) + CO_3^{2-} (aq) \rightarrow H_2O(l) + CO_2(g)$ OR $2\ HCl\ (aq) + Na_2CO_3\ (aq) \rightarrow NaCl\ (aq) + CO_2\ (g) + H_2O\ (l)$	1
Moles of carbonate $2H^+ (aq) + CO_3^{2-} (aq) \rightarrow H_2CO_3(aq) \rightarrow H_2O(l) + CO_2(g)$ moles of $Na_2CO_3 = 0.1 \times 0.025 = 2.5 \times 10^{-3}$	1
Concentration of HCl moles of HCl = 2 × moles of $Na_2\ CO_3 = 5 \times 10^{-3}$ Concentration of HCl = moles of HCl / vol of HCl $= 5 \times 10^{-3} / 21.4 \times 10^{-3}$ $= 0.234\ mol\ L^{-1}$	1
Total	**3**

(e) Sodium carbonate was use as a primary standard in this experiment.

i) State two reasons why sodium carbonate can be used as an appropriate primary standard. (2 marks)

Description	Marks
1. Obtain in high purity - and without too much effort. 2. High stability (low reactivity).	0-2

3. Low hygroscopicity (don't want it soaking up water) 4. High equivalent weight (to minimize weighing errors) 5. Non-toxic 6. Cheap and readily available	
Total	**2**

ii) Describe the potential effect on the calculated hydrochloric acid concentration if a sodium hydroxide primary standard was used in this experiment. (3 marks)

Description	**Marks**
Sodium hydroxide is diluted by atmospheric H_2O (hydroscopic)	1
Conc NaOH less than calculated	1
Conc HCl calculated higher than expected.	1
Total **If gibberish has been written BUT correctly identified increase HCl 1 mark max**	**3**

See next page

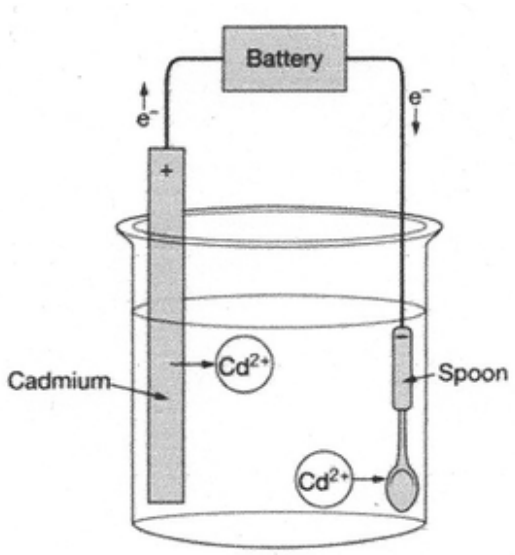
Question 35 **(18 marks)**

Cadmium has long been used as a corrosion-resistant plating on steel, and currently finds use in nickel-cadmium batteries as well as in cadmium telluride solar panels. Cadmium metal can be obtained by the smelting of cadmium sulfide ores that contain a mixture of zinc, nickel, aluminum, copper and iron present as sulfides. The cadmium metal that is produced by the smelting process can also contain the above-mentioned metals as impurities summing to be as high as 7%.

(a) Under certain conditions the smelting process can convert CdS and O_2 into Cd and SO_2. Justify, using oxidation numbers, the elements which are oxidised and reduced in the process. (3 marks)

Description	**Marks**
Reduced: cadmium, 2+ → 0	1
Reduced: oxygen, 0 → -2	1
Oxidised: sulfur, -2 → +4	1
Total **LOTS missed the 3rd element or did not correctly identify the correct reduction or oxidation**	**3**

Using electrochemical techniques, such as electrowinning, cadmium briquettes that are 95% cadmium are able to be refined to contain cadmium metal of purity in excess of 99.99%. An industrious metallurgist made a small-scale cadmium electrowinning cell in their backyard with impure Cd and a spoon. See depiction below:



(a) Draw a large-scale electrorefining cell for this cadmium purification process that could be used by a mining company. On your diagram show:

- Labels for the anode and cathode
- the movement of the electrons in the external circuit
- polarity of the electrodes (5 marks)

Description	Marks
Anode: impure cadmium	1
Cathode: pure cadmium	1
Electrons move from anode to cathode	1
Anode (+), Cathode (-)	1
Appropriate cell drawn (i.e. one cell)	1
Total	**5**

(b) Write the half-cell equations which occur at the anode and cathode. (2 marks)

Description	Marks
Anode: $Cd_{(s)} \rightarrow Cd^{2+}_{(aq)} + 2e^{--}$	1
Cathode: $Cd^{2+}_{(aq)} + 2e^{-} \rightarrow Cd_{(s)}$	1
Total	**2**

See next page

(c) State the name and role of an appropriate electrolyte for the cell. (2 marks)

Description	Marks
Electrolyte: $CdSO_{4\ (aq)}$ or $Cd(NO_3)_2$ Not sulfuric acid – would redissolve Cd	1
Electrolyte provides charge carriers in solution / balance charge / maintain charge neutrality	1
Total	**2**

(d) Describe the magnitude of the potential (voltage) applied to the cell and explain what happens to zinc, nickel, iron, copper and aluminium in the unrefined cadmium.

(3 marks)

Description	Marks
Sufficient voltage applied to oxidise Cd, Zn, Fe and Al	1
More inert metals (Cu and Ni) not oxidised become insoluble slag removed periodically	1
More reactive metal (Al, Zn, Fe) enter solution as ions	1
Total	**3**

The metallurgist claims that a large-scale cadmium electrolysis plant could run economically using 50% fossil fuel energy, 30% hydrogen fuel cell energy and 20% biodiesel energy; therefore consuming 50% “green” energy.

(e) Justify the claim that a hydrogen fuel cell and biodiesel are “green” alternatives to fossil fuels. (3 marks)

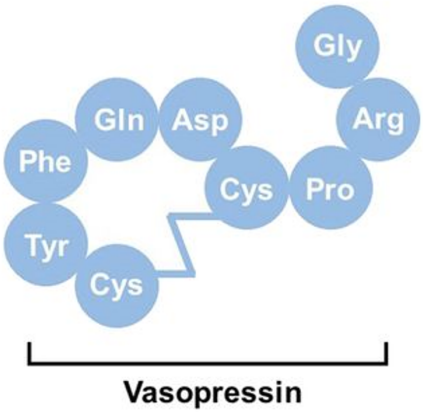
Description	Marks
<u>Fuel Cell</u> Appropriate green principle	1
<u>Biodiesel</u> Appropriate green principle	1

Claim is supported	1
Total	**1 marks**

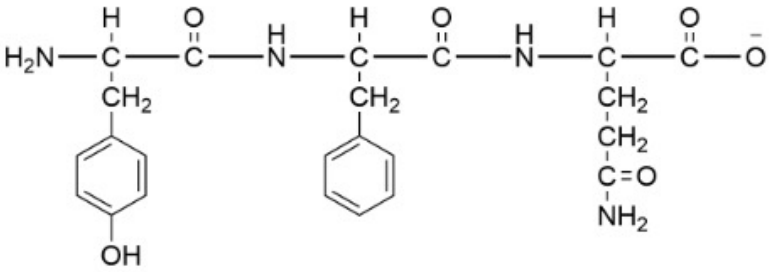
See next page

Question 36 **(25 marks)**

Vasopressin, also known as antidiuretic hormone (ADH), plays an important role in regulating water reabsorption in the nephrons of the kidney. It is a short chain polypeptide, composed of nine amino acids, having with a disulfide bridge forming a ring structure between two cysteine components.



(a) The tripeptide segment of the polypeptide (Tyr – Phe – Gln) was isolated. Draw this tripeptide, clearly circling all the peptide bonds, in basic conditions. Condensed structures are accepted (6 marks)

Description	**Marks**
	
Correct structure and order of amino acid residues NOTE: -1 per error in chain	0-3
Circle correct peptide bonds – must be only the C – N bonds (not entire linkage)	1
Tyr terminal group NH_2.	1
Gln COO- terminal group	1
Total	**6 marks**

Neurophysin II is a carrier protein for vasopressin and has a primary structure containing up to 95 amino acids. A portion of a neurophysin II molecule is shown below:

- Cys – Pro – Ser -

(b) Use your understanding of primary, secondary and tertiary structures of proteins to account for how this portion can influence the shape of the protein. (7 marks)

Description	**Marks**
Primary structure definition (order/sequence of amino acids)	1
Secondary structure hydrogen bonding between N-H and C=O on main/primary chain. NOTE: do not accept between COOH and NH_2 groups / amine and carboxylate.	1
Can form a-helices or b-pleated sheets	1
Tertiary structure Indicates tertiary structure is influenced by IMFs between side chains	1
Statements indicating the IMFs possible between each side chain: Underlined IMFs must be mentioned. • Cys – dispersion and disulfide bridging • Pro – dispersion forces only (NOTE: Proline COOH and NH bond in primary structure and H-bond in secondary structure) • Ser – dispersion, and dipole-dipole, H-bonding	0-3
Total	**7 marks**

(c) Suggest why neurophysin II has an observable secondary structure but vasopressin does not. (2 marks)

Description	**Marks**
Vasopressin is not long enough	1
to form observable a-helices/b-pleated sheets (observable secondary structure). NOTE: no e.c.f. here if a-helices/b-pleated sheets referred to as tertiary structure.	1
Total	**1 mark**

See next page

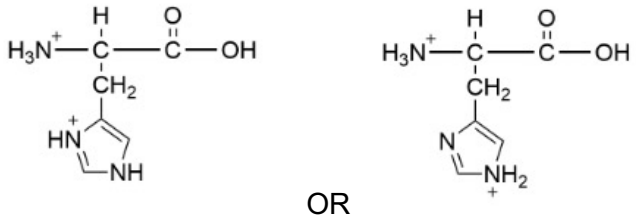
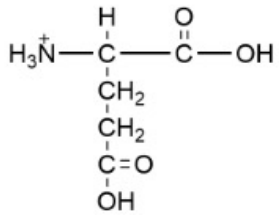
Histidine and glutamic acid are amino acids within the neurophysin II primary structure with similar molecular weights of 155 and 147 g mol^{-1}, respectively.

Despite the similar molecular weights, scientists have observed different behaviour of the individual amino acids in water. A scientist analysed the solubility of the two amino acids in water at pH = 4, and the following data was recorded.

Amino acid	**Solubility in water (mol kg^{-1})**
Glutamic acid	9.1×10^{-2}
Histidine	26

(a) Use your knowledge of intermolecular forces, and appropriate diagrams, to explain the discrepancy observed in solubility of the two amino acids in water at pH = 4.

(10 marks)

Description	Marks
Diagrams	
Histidine  OR $^{+}NH_3$ (1), imidazolium N^{+} (1) Glutamic acid  Structure (1)	0-3
Solute-solute / solvent-solvent	
Any three of: • His and Glu have similar strength dispersion forces • His and Glu – H-bonds between molecules • His and Glu – ion-dipole bonds between molecules • Water H-bonds between molecules NOTE: must describe IMF between solute-solute and solvent-solvent!	0-3
Solute-Solvent	
Any one of: • His has more ion-dipole opportunities than Glu • His more positively charged than Glu NOTE: don't accept, more H-bonds	1
Comment indicating: His sum of IMFs with water molecules greater than Glu	1
His-water interaction overcomes water-water interactions	1
Solubility: Histidine is more soluble than Glutamic acid	1
Total	**10 marks**

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Question 37 **(16 marks)**

A new molecule has been synthesised and purified. Samples of the molecule were analysed to determine its molecular formula. It is known that the molecule has a general formula of, $C_vH_wO_xN_yS_zC\ell_\alpha$. Four samples were analysed with results summarised below.

Sample 1 was combusted:
A 0.3956g sample yielded 60.50 mg of water and 254.2 mL of carbon dioxide at STP.

Sample 2 was analysed for nitrogen:
A 15.453 mg sample had all the nitrogen converted to 1.37 mL of ammonia at 190 kPa and 85 ^oC.

Sample 3 was analysed for sulfur:
A 9.659 mg sample hall all the sulfur converted to 12.77 mg of barium sulfate.

Sample 4 analysed for chlorine:
All the chorine contained in the 4.587 mg fourth sample was converted to chloride ions which was then dissolved in water and excess silver nitrate solution added. The precipitate was separated and dried to a constant weight of 3.723 mg.

Mass spectral analysis of the new compound confirmed that the molecular mass of the compound is 529.422 g mol^{-1}.

Use this information to determine the molecular formula of this synthesised molecule.

Description	**Marks**
Combustion	
$n(CO_2) = n(C) = V / 22.71 = 0.2542 / 22.71 = 0.01119$ mol $m(C) = 0.1344$ g $\%(C) = 0.13247 / 0.3956 = 33.98\%$	0-2
$n(H) = 2 \times 60.5 / 18.016 = 6.7162$ mmol $m(H) = 6.76998$ mg $\%(H) = 6.7868 / 395.6 = 1.71\%$	0-2

Nitrogen	
$n(N) = PV / RT = 190 \times 0.00137 / 8.314 \times 358.15 = 8.743 \times 10^{-5}$ mol m(N) = 1.225 mg %(N) = 12.238 / 15.453 = 7.93 %	0-2
Sulfur	
$n(S) = n(BaSO_4) = 12.77 / 233.38 = 0.05474$ mmol m(S) = 1.755 mg %(S) = 1.755 / 9.659 = 18.16 %	0-2
Chlorine	
$n(C\ell) = n(AgC\ell) = 3.723 / 143.32 = 0.02597$ mmol $m(C\ell) = 0.02597 \times 35.45 = 0.921$ mg $\%(C\ell) = 0.9209 / 4.587 = 20.07$ %	0-2
Oxygen	
%(O) = 100 – 33.98 – 1.71 – 7.93 – 18.16 – 20.07 = 18.15 % m(N) = 0.3956 g x 7.93% = 0.0314 g (0.0022 mol) m(S) = 0.3956 g x 18.16 = 0.0718 g (0.0022 mol) $m(C\ell) = 0.3956$ g x 20.07 = 0.0794 g (0.0022 mol) m(O) = 0.3956 g - 0.1344 g – 0.00676 g - 0.0314 g - 0.0718 g - 0.0794 g = 0.0718 g (0.00449 mol)	1

	C	H	N	$C\ell$	O	S	
%	33.98	1.71	7.93	20.07	18.15	18.16	
Moles	2.829 (0.0112)	1.696 (0.00672)	0.566 (0.0022)	0.566 (0.0022)	1.134 (0.00449)	0.566 (0.0022)	1
Ratio /0.566 (/0.0022)	5	3	1	1	2	1	1

Empirical formula is $C_5H_3NC\ell O_2S$ (must be labelled)	1
Empirical formula mass is 176.49	
MF is 529.422/ 176.49 = 3 x EF	1
MF is $C_{15}H_9N_3C\ell_3O_6S_3$ (must be labelled)	1

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FAST MARK: EF: $C_5H_3NSO_2Cl$, MF: $C_{15}H_9N_3S_3O_6Cl_3$ (16 marks) EF and MF not labelled but correct (15 marks)	
Total	**16 marks**

End of Questions

Supplementary page

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Supplementary page

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