WATP

CHEMISTRY
UNIT 3 & 4
2016

MARKING GUIDE

Section One: Multiple-choice **25% (50 marks)**

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

(2 marks per question)

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

This section has **10** questions. Answer **all** questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

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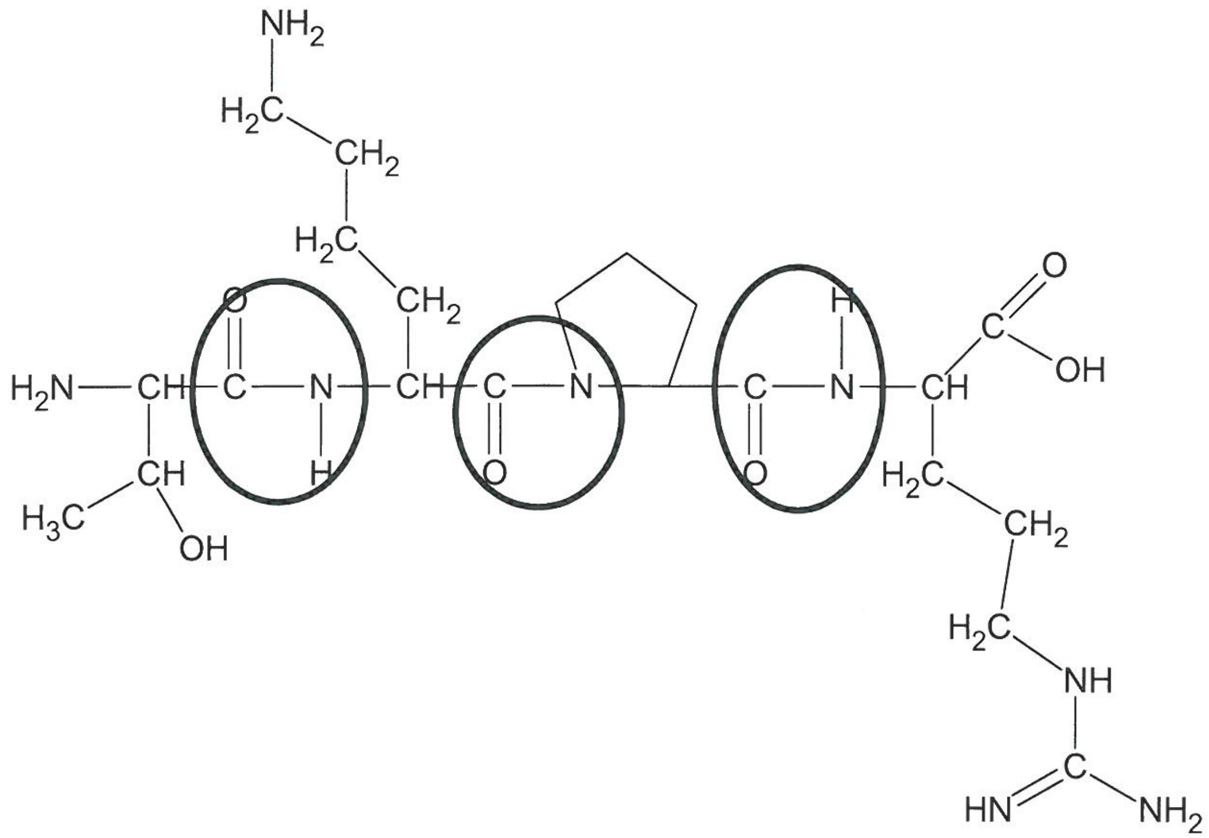
Suggested working time: 60 minutes.

Question 26 **(8 marks)**

Tuftsin is a tetrapeptide (a molecule consisting of four amino acid residues) which is produced by the spleen. It has been found that people with low levels of tuftsin in their bodies are susceptible to repeated frequent infections of the skin, lymph nodes and lungs. Low tuftsin levels can be inherited genetically or can be the result of a spleen operation. The tuftsin tetrapeptide molecule is shown below.



(a) On the diagram above, circle the peptide bonds and then complete the primary sequence of tuftsin below using the standard three letter abbreviations. (3 marks)

thr – lys – **pro** – **arg** **(1m circles, 2m aa's)**

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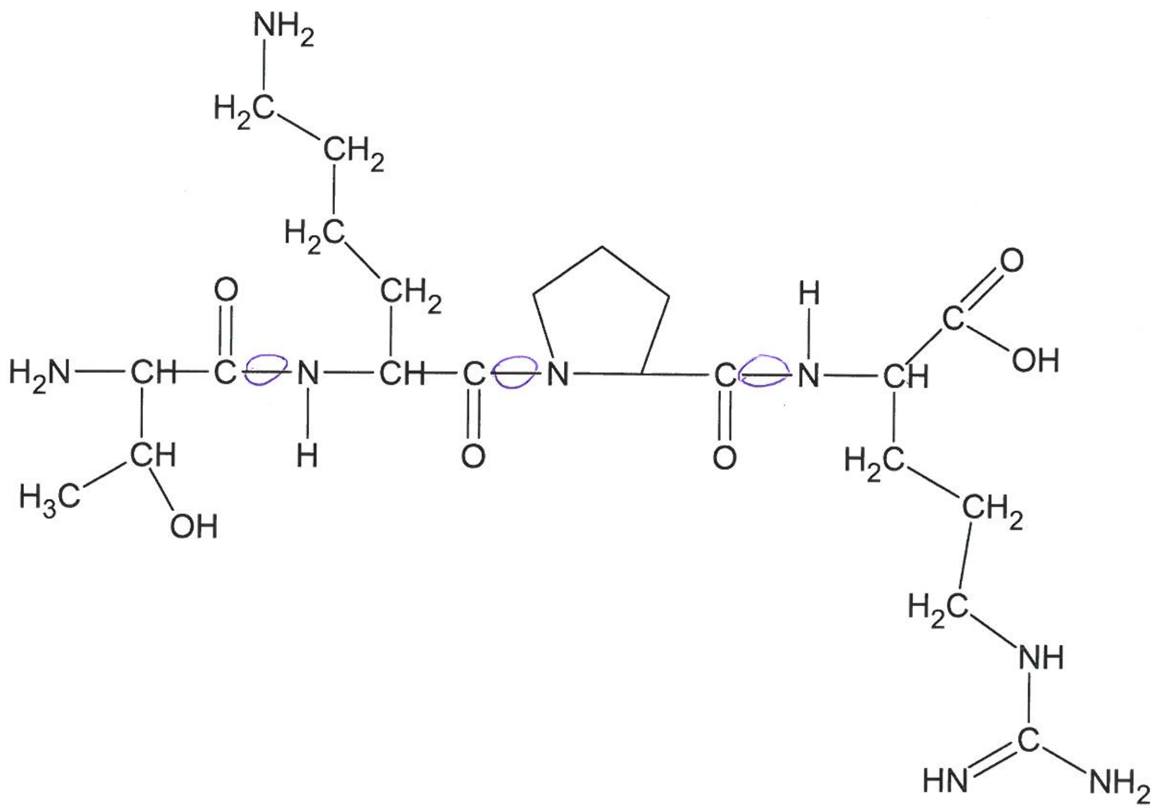
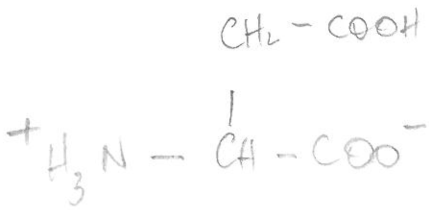


(a) On the diagram above, circle the peptide bonds and then complete the primary sequence of tuftsin below using the standard three letter abbreviations. (3 marks)

thr – lys – PRO – ARG

One medical study has shown that some people have a genetic mutation which causes the lysine residue in tuftsin to be replaced with a glutamic acid residue instead.

(b) Draw a diagram of glutamic acid in zwitterion form and use this example to explain what a zwitterion is. (2 marks)



Molecule that has both a positive charge and a negative charge at different positions on the molecule.

In the mutated form of tuftsin, the primary sequence of the tetrapeptide has been changed, altering its function.

(c) In general terms, explain how alteration of the primary sequence of a protein can affect its secondary and tertiary structures. (3 marks)

2° : arrangement of $-NH_2$ and $-COOH$ groups different ∴ α - helix or β - pleated

3° : arrangement of side groups different ∴ will change shape and ability to link/bond with other proteins.

Question 27 **(8 marks)**

Consider the equation for the following reversible chemical system. Gaseous hydrogen and bromine were injected into an empty flask and allowed to establish equilibrium at 25 °C.

$$H_2(g) \; + \; Br_2(g) \; \rightleftharpoons \; 2\,HBr(g) \qquad \Delta H = -104 \text{ kJ mol}^{-1}$$ exo

The activation energy for this reaction is 188 kJ mol $^{-1}$. The value of K_c for this reaction at 25 °C is 2.0×10^{19}.

(a) Does this question refer to an open or closed system? Explain. (2 marks)

CLOSED ✓

No loss / gain of chemical ✓

OR No equilbm if open flask

(b) What information does the value of K_c provide about the; (2 marks)

(i) equilibrium position?

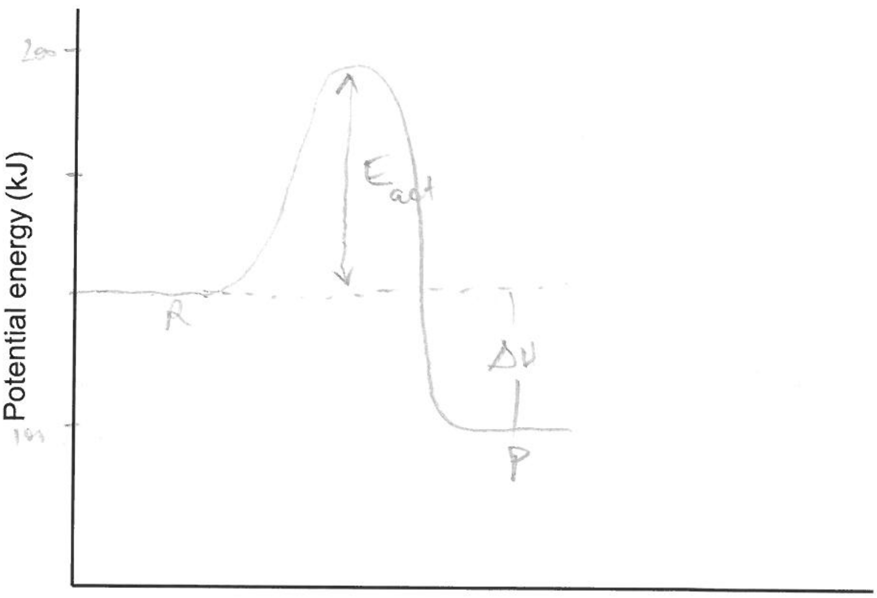
favours RHS / [HBr] is v high ✓

(ii) rate of reaction?

nothing ✓

(c) Draw an energy profile diagram for this reaction. Label the activation energy and the enthalpy change. (4 marks)

Potential energy (kJ)

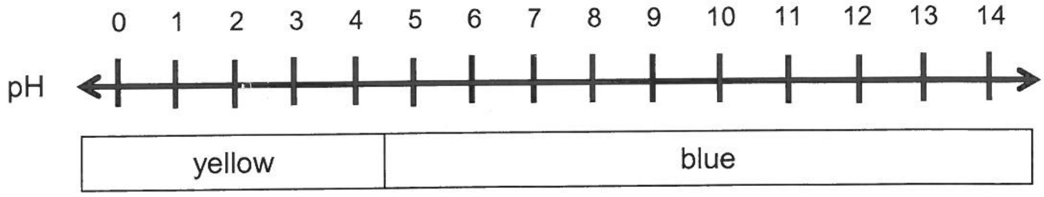


Progress of reaction

Shape ✓
E_{act} ✓
ΔH ✓
Approx Scale OR R & P ✓

Question 28 **(7 marks)**

Bromocresol green is an indicator that can be used in biological laboratories when growing microorganisms as well as for titrations or as a tracking dye. It displays two colours, yellow and blue, as shown in the diagram below.



(a) What types of substances are acid-base indicators? (2 marks)

weak acids or bases ✓ that change colour ✓
~~there~~ with addition / loss of H^+

(b) What colour would the following aqueous solutions turn, if a few drops of bromocresol green was added to each? Use a chemical equation to support your answer where appropriate. (3 marks)

	Solution	Colour	Chemical equation
pH = 7	$Mg(NO_3)_2(aq)$	Blue ✓	N/A
pH > 7	$Na_2SO_3(aq)$	Blue ✓	$SO_3^{2-} + H_2O \rightleftharpoons HSO_3^- + OH^-$ ✓

A standardised solution of hydrochloric acid, HCl(aq), was being used in a titration with a sodium hydrogencarbonate solution, $NaHCO_3(aq)$, of unknown concentration.

(c) Would bromocresol green be an appropriate indicator for this titration? Explain your answer. (2 marks)

Strong acid vs Weak base ✓
i.e. equiv point ~ pH 4 ✓

Question 29 **(6 marks)**

Tin is a metallic element located in Group 14 of the periodic table. It is used to make many different alloys such as bronze and solder, as well as finding application in the plating of steel to produce 'tin cans' for storage.

A chemistry student had 1.0 mol L^{-1} solutions of the following four substances;

$Ni(NO_3)_2$ ↓ $Zn(NO_3)_2$ ↓ $Pb(NO_3)_2$ ↑ $Mg(NO_3)_2$ ↓

(a) Which of these solutions could **not** be stored in a tin container? Explain your answer using a relevant chemical equation. (3 marks)

$Pb(NO_3)_2$ ✓

Pb^{2+} will oxidize Sn as Pb less active ✓

ie $Sn + Pb^{2+} \rightarrow Pb + Sn^{2+}$

E = 0.01 V ✓

∴ Rxn possible

When tin metal is placed in an acidified solution containing the weak acid hydrogen chromate ($HCrO_4^-$) a deep green solution containing chromium(III) ions is formed, and the tin metal dissolves producing tin(II) ions.

(b) Write the oxidation and reduction half-equations and the overall redox equation for this reaction. (3 marks)

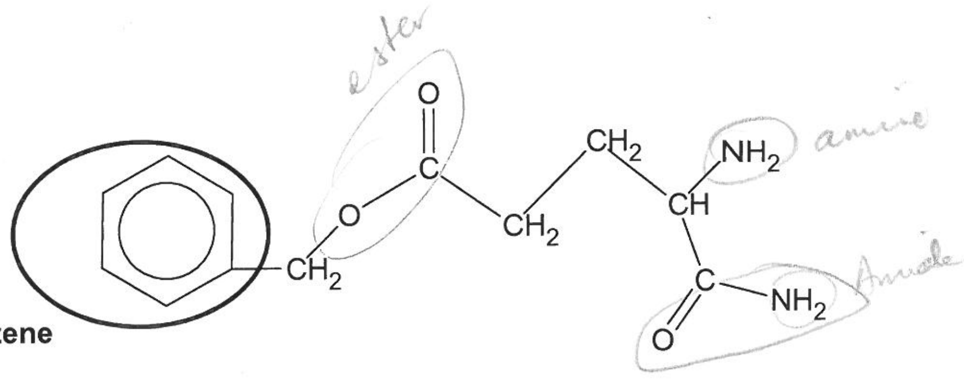
SRP table.

Oxidation half-equation	$Sn \rightarrow Sn^{2+} + 2e$	×3
Reduction half-equation	$HCrO_4^- + 7H^+ + 3e^- \rightarrow Cr^{3+} + 4H_2O$	×2
Overall redox equation	$3Sn + 2HCrO_4^- + 14H^+ \rightarrow 3Sn^{2+} + 2Cr^{3+} + 8H_2O$	

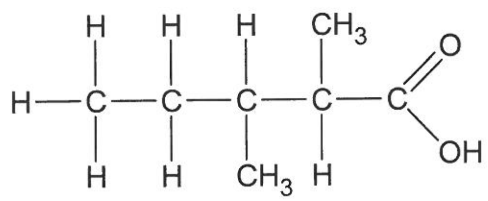
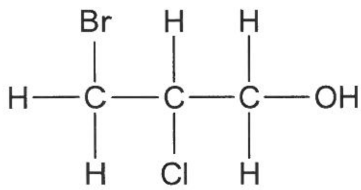
Question 30 **(7 marks)**

Consider the various organic molecules shown below.

(a) Circle and name the three (3) remaining functional groups on the molecule below. (One functional group has been circled for you.) (3 marks)



(b) Give the IUPAC names for the following organic molecules. (2 marks)

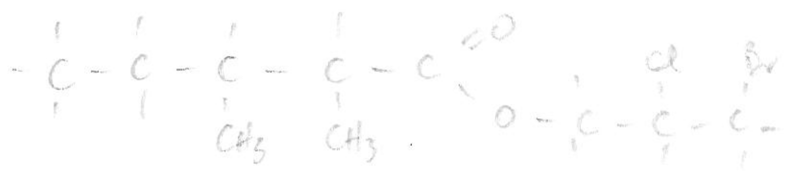
	
Name: 2,3-dimethyl pentanoic acid	Name: 3-bromo-2-chloro-1-propanol

(c) If the two substances shown in part (b) were mixed together and warmed in the presence of sulfuric acid; (2 marks)

(i) name the type of reaction that would occur.

esterificatn

(ii) draw the structure of the organic product that would form.



Question 31 **(7 marks)**

Ammonium carbamate can decompose in a reversible, endothermic reaction, according to the chemical equation shown below.

$$\text{heat} + NH_4COONH_2(s) \rightleftharpoons 2\,NH_3(g) + CO_2(g)$$

(a) If the total volume of the system was decreased, state the effect this would have on the equilibrium position and note an observation. (2 marks)

equilibrium position: equil^bm^ ←

observation: mass NH_4COONH_2 ↑

oR temp ↑

(b) If the temperature of the system was decreased, explain the effect this would have on the equilibrium in terms of reaction rates. (3 marks)

reaction rates → & ← would ↓ ✓

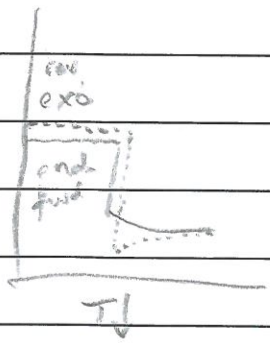
but ↓ T favours rev exo rxn ✓

∴ reverse rxn would be favoured over fwd

∴ ↓ fwd rxn rate < ↓ rev rxn rate ✓

= endo Fwd ↓ ↓

= exo Rev ↓



(c) One of the products of this decomposition reaction is carbon dioxide gas. Write two (2) chemical equations that illustrate how increasing atmospheric CO_2 levels may contribute to ocean acidification. (2 marks)

1.	$H_2O + CO_2 \rightarrow H_2CO_3$
2.	$H_2CO_3\ (+ H_2O) \rightarrow H^+\ (H_3O^+) + HCO_3^-$

Question 32 **(6 marks)**

Hydrofluoric acid, HF(aq), is a colourless, highly corrosive solution, used in the manufacture of many pharmaceuticals. Hydrofluoric acid has a K_a value of 6.76×10^{-4}.

(a) Write an equilibrium constant (K_a) expression for the ionisation of HF in water and explain what information the value of K_a provides. (2 marks)

$K_a = \frac{[H_3O^+][F^-]}{[HF]}$ ✓

low Ka means small numerator / large denominator ✓

∴ equilbm ← ∴ weak acid

$HF + H_2O \leftrightarrows H_3O^+ + F^-$

A student was given 0.500 L of a 0.250 mol L^{-1} hydrofluoric acid solution and instructed to produce a buffer.

(b) What substance could the student add to the HF(aq) to produce a buffer? Explain your answer. (2 marks)

NaF, KF, F^- ✓

Buffer consist of wk acid / base and a salt of that acid / base

(c) Write a chemical equation for the buffer system that would be formed and label the conjugate acid-base pairs. (2 marks)

Check Mon

$\underset{\text{base}}{F^-} + H_3O^+ \rightleftharpoons \underset{\text{conj acid}}{HF} + \underset{\text{conj base}}{H_2O}$

OR

$HF + \underset{\text{acid}}{H_2O} \rightleftharpoons H_3O^+ + F^-$

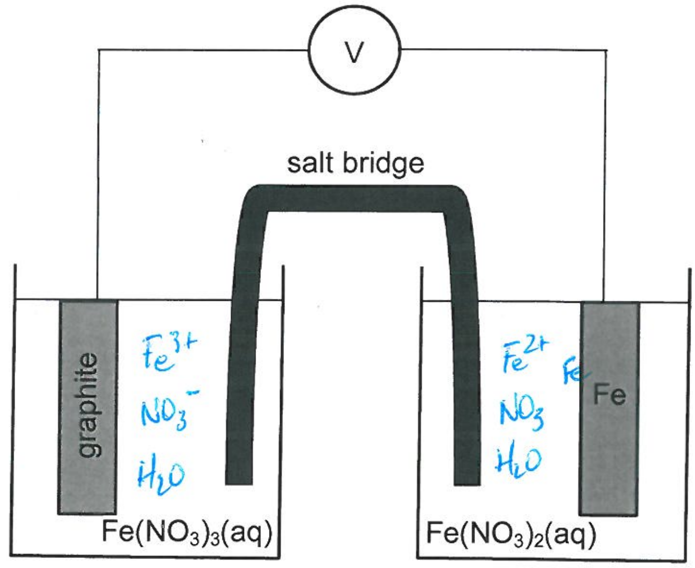
$\underset{\text{acid}}{HF} + \underset{\text{base}}{OH^-} \rightleftharpoons \underset{\text{c.a}}{H_2O} + \underset{\text{c.b}}{F^-}$

SEE NEXT PAGE

Question 33 **(5 marks)**

Consider the electrochemical cell shown below.

$Fe^{3+} \rightarrow Fe^{2+}$
$+0.77$
red
cath



$Fe \rightarrow Fe^{2+}$
$+0.44$
ox
anode

(a) Determine the half-equations occurring at each electrode. (2 marks)

Cathode	$Fe^{3+} + e^- \rightarrow Fe^{2+}$ $\cancel{+2e^-}$
Anode	$Fe \rightarrow Fe^{2+} + 2e^-$

(b) Calculate the EMF of this cell under standard conditions. (1 mark)

1.21 V

(c) Note an observation for each electrode. (2 marks)

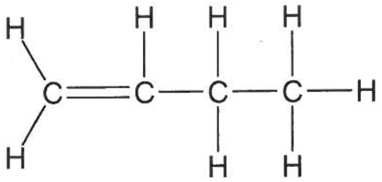
Cathode	solⁿ turns pale green (from orange/brown)
Anode	loses mass

Question 34 **(9 marks)**

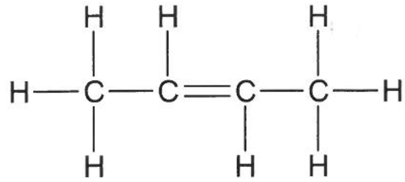
But-2-ene is produced from crude oil and its main use is in the production of petrol.

(a) Explain why but-2-ene exhibits *cis-trans* (geometric) isomerism while but-1-ene does not. (3 marks)

but-1-ene



but-2-ene



– double bond fixed / attachment fixed

– 1-butene has 2 H on terminal C

∴ no difference "above" or "below" molecular axis

A chemistry fact sheet about but-2-ene stated, *"But-2-ene is often used to produce the solvent butanone via hydration to butan-2-ol followed by oxidation".*

(b) Elaborate on this statement, by giving a brief description of the reaction processes involved and using chemical equations to illustrate the reaction sequence described. (6 marks)

$C-C=C-C + H_2O \rightarrow C-\overset{H}{C}-\overset{OH}{C}-C$ ✓

– H_2O undergoes addition reaction to produce 2-butanol ✓

– 2-butanol – 2° alcohol can be oxidized ✓

with MnO_4^- / H^+ to produce butanone ✓

$Cr_2O_7^{2-} / H^+$

ie $CH_3CH_2CHOHCH_3 \rightarrow CH_3CH_2COCH_3 + 2H^+ + 2e^-$ ✓

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

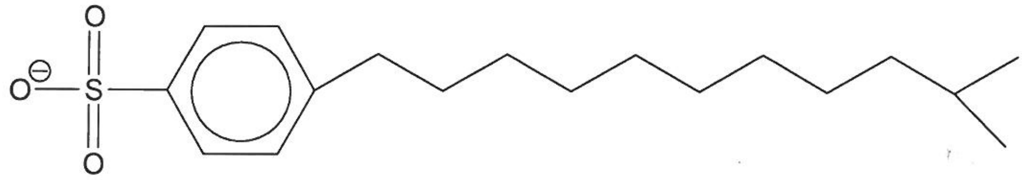
$5\,CH_3CH_2CHOHCH_3 + 2MnO_4^- + 6H^+ \rightarrow 5\,CH_3CH_2COCH_3 + 2Mn^{2+} + 8H_2O$

OR ✓

$3\,CH_3CH_2CHOHCH_3 + Cr_2O_7^{2-} + 8H^+ \rightarrow 3\,CH_3CH_2COCH_3 + 2Cr^{3+} + 7H_2O$

Question 35 **(7 marks)**

The structure of a detergent molecule called 'branched dodecylbenzene sulfonate' is shown below.



(a) Note one similarity and one difference between the structure of this detergent molecule and a soap molecule. (2 marks)

Similarity	long non-polar H-C tail ✓
Difference	polar end : soap $-C^{O}_{O^-}$ det $-SO_3^-$ ✓

(b) Describe the cleaning action of detergents. Include in your answer a discussion of the advantage detergents have over soaps when used in hard water. (5 marks)

Action – micelles ✓
– non polar tail into fat/oil ✓
– lifts oil from surface / "dissolves" into H_2O ✓
Adv – detergents don't form ppt/scum with Ca^{2+} ✓ ✓

End of Section Two

Section Three: Extended answer **40% (80 marks)**

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

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.

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Suggested working time: 70 minutes.

Question 36 **(17 marks)**

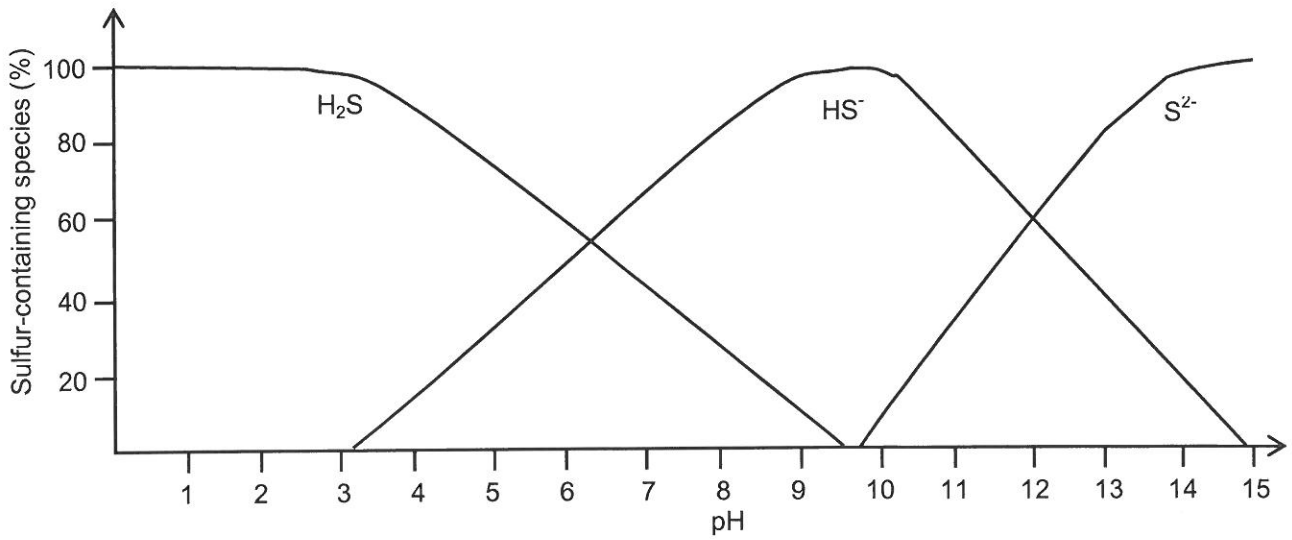
Hydrogen sulfide (H_2S) is a poisonous, colourless gas with the distinctive odour of rotten eggs. It is found in some types of rock salt, as well as volcanic gas and natural gas. Some sources of spring water with high hydrogen sulfide levels are used as medicinal baths, and there is evidence to suggest that H_2S may have some anti-ageing properties.

When hydrogen sulfide gas dissolves in water, it ionises as shown in the equations below to produce the following equilibria, which is comprised of the three sulfur-containing species (H_2S, HS^- and S^{2-}).

① $H_2S(aq) + H_2O(l) \rightleftharpoons HS^-(aq) + H_3O^+(aq)$

② $HS^-(aq) + H_2O(l) \rightleftharpoons S^{2-}(aq) + H_3O^+(aq)$

Scientists noted that the percent of each sulfur-containing species (H_2S / HS^- / S^{2-}) present in a given aqueous sample was dependent upon the pH of the solution. An investigation was conducted to examine how the concentrations of each of these sulfur-containing species changed with respect to pH. The results of the investigation are displayed in the graph below.



(a) State each of the variables for the investigation described above. (3 marks)

Independent	pH.
Dependent	%/conc^n of H_2S / HS^- / S^{2-}
Controlled	amount of H_2S in system temp H_2O. envir. P_{atm}

(b) Using your knowledge of collision theory and chemical equilibrium, explain the results displayed in this graph. (4 marks)

At low pH $H_2S + H_2O \rightleftharpoons HS^- + H_3O^+$

High $[H_3O^+]$ means ← favoured

- ↓ pH = ↑ $[H_3O^+]$

- more collisions between H_3O^+ and HS^-/S^{2-}

- ← favoured

- ↑ ~~?~~pH - effect reversed.

Hydrogen sulfide is often found in sources of drinking water, as it is produced by the decomposition of organic matter. It can cause the water to have an unpleasant smell and taste when present in as little as 0.05 mg L^{-1} concentrations. Hydrogen sulfide can be removed from water sources by the addition of chlorine gas, which reacts according to the equation below.

$$\underset{-2}{H_2S(aq)} + 4\,\underset{0}{Cl_2(g)} + 4\,H_2O(l) \rightarrow 10\,H^+(aq) + \underset{+6}{SO_4^{2-}(aq)} + 8\,\underset{-1}{Cl^-(aq)}$$

(c) Use oxidation numbers to demonstrate that this is a redox reaction. State which substance is oxidised and reduced in this process. (2 marks)

S ox no −2 → +6 ∴ ~~~~ loses e⁻ ∴ ox ✓

Cl 0 → −1 ∴ gains e⁻ ∴ red. ✓

A 2000 L tank of water contaminated with hydrogen sulfide at a concentration of 0.173 mg L^{-1} was to be treated with chlorine gas. If the chlorine was stored under a pressure of 395 kPa and at a temperature of 20.0 °C;

(d) Calculate the volume of chlorine gas that would be required to remove all the hydrogen sulfide from the water. (You may disregard the presence of other sulfur-containing species and assume all the chlorine gas added will dissolve in the water). (5 marks)

mg ≠ mol.

$m(H_2S^{2-}) = 0.173 \times 2000$ ✓

$= 346 \text{ mg} = 0.346 \text{ g}$ ✓

$n(H_2S) = \frac{0.346}{34.08} = 1.0151 \times 10^{-2}$ mol. ✓

$n(Cl_2) = 4. \, n(H_2S) = 4.06 \times 10^{-2}$ mol ✓

$V(Cl_2) = \frac{nRT}{P}$

$= \frac{4.06 \times 10^{-2} \times 8.314 \times 293.15}{395} = 0.251$ L. ✓

(e) Calculate the final pH of the water in the tank after the chlorination process was complete and all the hydrogen sulfide had been removed. (You may disregard the presence of other sulfur-containing species and assume that the original pH of the water was 7). (3 marks)

$n(H^+ \text{ produced}) = 10. \, n(H_2S) = 1.0151 \times 10^{-1}$ mol.

$c(H^+) = \frac{1.0151 \times 10^{-1}}{2000} = 5.08 \times 10^{-5}$ mol/L.

$pH = 4.29.$

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Question 37 **(15 marks)**

Ammonia (NH_3) is produced industrially by the Haber process. Ammonia is an important chemical, particularly in the agricultural industry, where it is used to produce many different types of fertilisers. The Haber process involves the reaction between gaseous nitrogen and hydrogen to produce ammonia. The nitrogen gas is extracted from air, whilst the hydrogen gas is produced via the 'shift' and 'steam reforming' processes, using methane from natural gas.

The two equations below can be used to summarise the chemical processes involved in industrial ammonia production. Step 1 represents the overall process that produces hydrogen gas from methane, and Step 2 shows the subsequent reaction with nitrogen gas to produce ammonia.

① $CH_4(g) + 2\,H_2O(g) \rightleftharpoons 4\,H_2(g) + CO_2(g)$

② $N_2(g) + 3\,H_2(g) \rightleftharpoons 2\,NH_3(g)$

The conditions for Step 2 are optimised for both rate and yield of ammonia production. A pressure of between 100-350 atm is maintained and a moderate temperature of 350-550 °C is used, in conjunction with an Fe_3O_4 catalyst. Using these conditions, a yield of 20-30% is obtained for each reaction cycle, but the overall yield is much closer to 100% due to the continuous cycling of unreacted materials back through the chamber.

If 311 tonnes of nitrogen gas and 71.0 tonnes of hydrogen gas are injected into a reaction chamber with a 25 000 kL capacity;

(a) Calculate the initial pressure inside the reaction chamber if the temperature was maintained at 450 °C. (4 marks)

273

$n(N_2) = \frac{311 \times 10^6}{28} = 1.1107 \times 10^7$ mol ✓

$n(H_2) = \frac{71 \times 10^6}{2.016} = 3.522 \times 10^7$ mol ✓

$PV = nRT$

$P = \frac{4.6325 \times 10^7 \times 8.314 \times 723}{25\,000 \times 10^3}$ ✓

$= 1.114 \times 10^4$ kPa ✓

(b) Determine the limiting reagent. (2 marks)

1.1107×10^7 mol N_2 ≡ 3.3321×10^7 mol H_2

3.522×10^7 mol H_2 present

∴ H_2 in xs

N_2 is lim.

After one reaction cycle, the yield of ammonia was determined to be 25.7%. This ammonia was removed from the chamber, liquefied and pumped into cylinders that each hold 400 kg of ammonia. These cylinders are used to store or transport the ammonia.

(c) How many cylinders would you need to store the ammonia produced from one reaction cycle? (4 marks)

$n(NH_3) = 0.257 \times 1.1107 \times 10^7 \times 2$

$= 5.709 \times 10^6$ mol

$m = \text{"} \times 17.034$

$= 9.7247 \times 10^4$ kg.

∴ no. $= 9.7247 \div 400$

$= 243.1$ containers ∴ 244.

If 150 tonnes of methane gas was used to produce the 71.0 tonnes of hydrogen used in this reaction;

(d) Calculate the yield of Step 1. (3 marks)

$$n(CH_4) = \frac{150 \times 10^6}{16.042} = 9.35 \times 10^6 \text{ mol}$$ ✓

$$\therefore n(H_2/100\%) = 4 . n(CH_4) = 3.74 \times 10^7 \text{ mol}$$ ✓

$$n(H_2) = \frac{71 \times 10^6}{2.016} = 3.522 \times 10^7 \text{ mol}$$

$$\% \text{ Yield} = \frac{3.522 \times 10^7}{3.74 \times 10^7} \times 100 = 94.2\%$$ ✓

(e) Give two (2) reasons that may have contributed to the yield of Step 1 being lower than 100%. (2 marks)

- methane impure / side rxns
- loss of reagent gases
- reversible rxn don't go to completion
- product separation

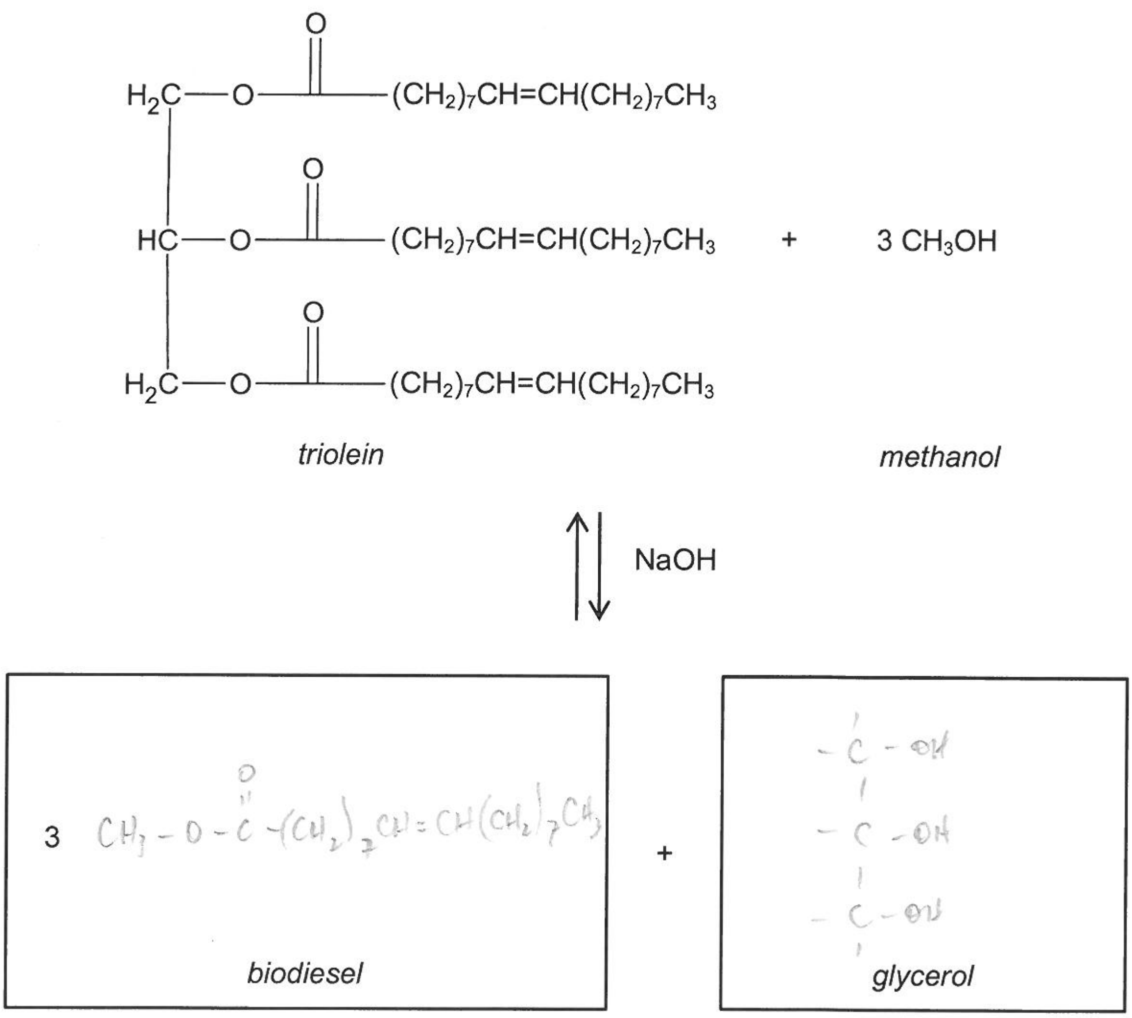
Question 38 **(20 marks)**

Biodiesel is commonly manufactured by a transesterification reaction between oil and methanol. There are many different types of oils that can be used in this process, providing great scope for the range of sources from which biodiesel can be manufactured.

(a) Explain why biodiesel is considered a more sustainable 'green' alternative to traditional fuels such as petrol. (2 marks)

- renewable vs non
- C offset (some) vs nil
- recycles waste vs nil.

An example of the biodiesel-producing transesterification reaction is shown below using the oil *triolein*, which is one of the triglycerides commonly found in olive oil.



(b) Complete the reaction above by filling in the boxes. (2 marks)

Due to the slow rate of the transesterification reaction, a sodium hydroxide (NaOH) catalyst is used and a temperature of around 60 °C is maintained.

(c) Explain how each of these factors increases the rate of reaction. (4 marks)

NaOH catalyst	– alternative / lower E_{act} pathway ✓ ∴ greater proportion of successful collisions ✓
Temperature of 60 °C	– ↑ E_K ✓ – greater proportion of collisions have enough energy ✓

During the manufacture of biodiesel, an unwanted side-reaction occurs where soap is produced. This is problematic as it reduces the purity of the biodiesel product and requires further refining to be performed before the biodiesel can be used or sold.

(d) Explain how this soap-producing reaction can occur. (Chemical equations are **not** required in your answer). (2 marks)

– NaOH react with oil ✓

→ saponification / hydrolysis rxn → soap instead ✓

To ensure that the levels of soap in commercial biodiesel are not too high, a 'soap test titration' is performed once a batch of biodiesel is produced. An acceptable level of purity requires the soap content of the biodiesel to be no higher than 41 ppm (parts per million).

To perform this titration, a sample of biodiesel is dissolved in pure isopropyl alcohol. Bromophenol blue indicator is added and a blue colour should be observed. The biodiesel is then titrated against a standard solution of hydrochloric acid (HCl) until a colour change from blue to yellow is observed.

The titration equation is given below.

$$C_{17}H_{33}COONa(aq) + HCl(aq) \rightarrow C_{17}H_{33}COOH(aq) + NaCl(aq)$$

soap present in biodiesel

A 60.00 mL sample of a particular batch of biodiesel was taken and made up to 150.0 mL with pure isopropyl alcohol. 35.00 mL aliquots were then titrated against a standard 1.65 x 10^{-4} mol L^{-1} hydrochloric acid solution, requiring an average of 8.83 mL for equivalence. If the density of the biodiesel is 0.833 g mL^{-1};

(e) Determine the soap content of this biodiesel sample in parts per million (ppm) and state whether or not the soap content is at an acceptable level for sale. (6 marks)

$n(HCl) = cV = 1.65 \times 10^{-4} \times 0.00883$ ✓

$= 1.457 \times 10^{-6}$ mol

$\therefore n(soap/35\ mL) = 1.457 \times 10^{-6}$ mol

$\therefore n(soap)_T = 1.457 \times 10^{-6} \times \frac{150}{35} = 6.244 \times 10^{-6}$ mol ✓

$\therefore m(soap) = 6.244 \times 10^{-6} \times 304.434$ ✓

$= 1.901 \times 10^{-3}$ g

$= 1.901$ mg ✓

$m(bio) = 60\ mL \times 0.833\ \frac{g}{mL}$

$= 49.98$ g $= 0.04998$ kg ✓

$ppm = \frac{1.901}{0.04998} = 38.0$ ppm ✓

< 41 ppm → YES.

Current research is focussing on alternate catalysts for biodiesel manufacture, and one of the most promising candidates is the enzyme *lipase*. When *lipase* is used to catalyse the transesterification reaction, this prevents the alternate soap-producing pathway from occurring.

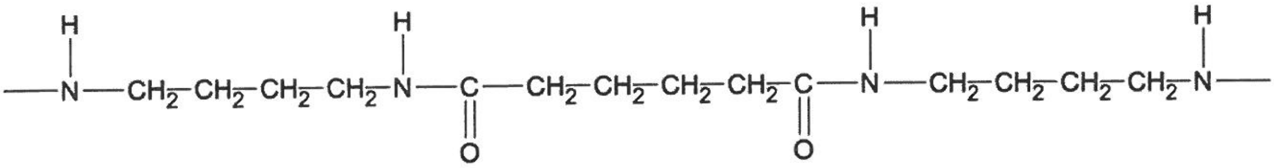
(f) Describe what an enzyme is and explain why enzymes are able to minimise the occurrence of unwanted side reactions. (4 marks)

- biological protein → catalyst ✓
- speed rxn by providing lower E_{act} ✓
- lock and key mechanism ✓
- specific to rxn ∴ no unwanted side rxn ✓
- operate at low/optimum temp/pH

Question 39 **(15 marks)**

'Nylon 4/6' is a polymer which can be obtained as a fibre, film, rod or sheet. It has wide ranging applications owing to its high heat and chemical resistance in comparison with other nylons. It is most often used for electrical and electronic components, in particular those that must withstand high temperatures for a long period of time.

A segment of nylon 4/6 is shown in the diagram below.



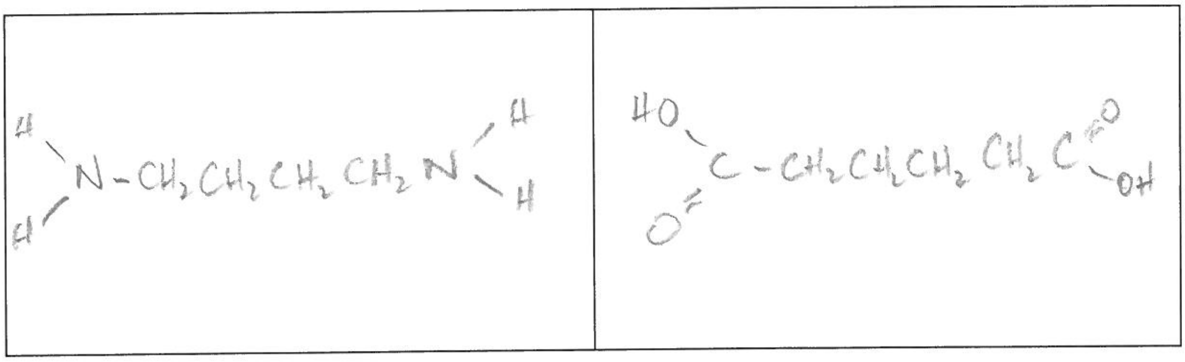
(a) Nylons have the ability to form hydrogen bonds between polymer strands. How does this bonding affect the physical properties of nylon polymers? (2 marks)

— High MPt / BPt

— strong

— resist breaking / wear & tear

(b) Draw the two (2) monomers from which nylon 4/6 is composed. (2 marks)



(c) Name and briefly describe the process by which these monomers are able to form this nylon polymer. (2 marks)

— condensation

— COOH reacts with NH_2 functional group → H_2O.
combines

A pure sample of an amine (containing only the elements carbon, hydrogen and nitrogen) was analysed to determine its composition. The amine was combusted in oxygen and produced 6.43 g of carbon dioxide, 3.93 g of water and 2.04 g of nitrogen gas.

(d) Calculate the empirical formula of the amine. (7 marks)

$n(CO_2) = \frac{6.43}{44.01} = 0.146$ mol C ✓

$n(H_2O) = \frac{3.93}{18.016} = 0.218$ mol ✓ $\rightarrow$ 0.4363 mol H

$n(N_2) = \frac{2.04}{28.02} = 0.0728$ mol ✓ $\rightarrow$ 0.1456 mol N

	C	H	N
Moles	0.146	0.4363 ✓	0.1456 ✓
Ratio	1	3	1 ✓

CH_3N ✓

Comprehending Q.

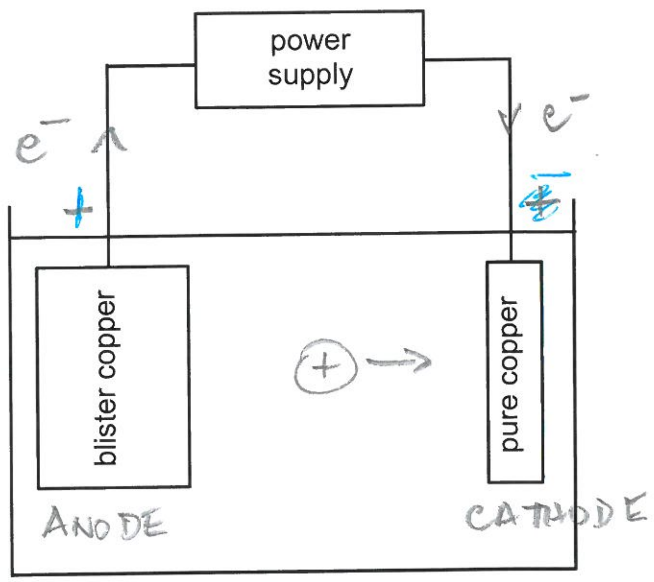
(e) Did this analysis provide sufficient information to identify whether this amine is one of the monomers used to produce nylon 4/6? Explain. (2 marks)

Yes but emp form of monomer : C_2NH_3 ✓

∴ not monomer ✓

Question 40 **(13 marks)**

A group of chemistry students set up an experiment to replicate the electrolytic refining of copper metal. They obtained some impure 'blister copper' as well as a thin piece of pure copper and set up an electrochemical cell as shown in the diagram below.



(a) Explain the chemical principles of an electrolytic cell. (2 marks)

- electrical energy used
- to drive chemical rxn.

(b) On the diagram above label; (4 marks)

(i) the anode and cathode
(ii) the sign of each electrode
(iii) the direction of cation flow
(iv) the direction of electron flow

(c) State two (2) safety considerations the students would have to take into account when conducting this experiment. (2 marks)

- safety glasses
- electrical safety — keep V low.
- $CuSO_4$ toxic

The students recorded the mass of the blister copper and pure copper electrodes before allowing the cell to run for a period of time. They then recorded the mass of each electrode again. Their results are shown in the table below.

	Blister copper	Pure copper
Initial mass (g)	65.8	11.9
Final mass (g)	52.3	25.1

(d) Calculate the percent purity of the blister copper. (3 marks)

m(Cu pure) = 13.2 g deposited ✓

m(blister) = 13.5 g lost ✓

$\% = \frac{13.2}{13.5} \times 100$

$= 97.8\%$ ✓

(e) What factors or problems with an experiment can cause; (2 marks)

(i) random error? unpredictable events incl. measurement errors.

(ii) systematic error? consistant error eg measuring error in procedure / techniques.

End of questions

Spare answer page

Question number: ____________________