WESLEY COLLEGE

SEC 1		~~30~~
SEC 2		77
SEC 3		73
TOTAL		~~179~~ 200

YEAR 12 Mock EXAMINATIONS 11th Oct 2016

CHEMISTRY ATAR YEAR 12

CANDIDATE'S NAME: Solutions

NAME OF YOUR TEACHER: .....

TIME ALLOWED FOR THIS PAPER

Reading time before commencing work: Ten Minutes
Working time for paper: 3 Hours

MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

TO BE PROVIDED BY THE SUPERVISOR

Two Question/Answer booklets: The first booklet containing sections 1 and 2 and the second booklet contains section 3
Separate Chemistry Data Sheet

TO BE PROVIDED BY THE CANDIDATE

Standard Items: Pens, pencils, eraser or correction fluid and ruler

Special Items: Calculators satisfying the conditions set by the Curriculum Council.

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 notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you hand it to the supervisor BEFORE reading any further.

STRUCTURE OF PAPER

Section	Format	No. of Questions Set	No. of Questions to be Attempted	Marks Allocated	Recommended Time (Approx) /Minutes
1	Multiple choice	25	ALL	~~25~~ 50	45
2	Short answer	11	ALL	77	65
3	Extended answer	6	ALL	73	70

Total marks for paper = 165 (100%)

INSTRUCTIONS TO CANDIDATES

Reading Time: The examiner recommends that candidates spend the reading time mainly reading the Instructions to Candidates and Sections 2 and 3

Section 1 – Multiple Choice
Answer ALL questions in Section 1 on the Multiple Choice Answer Sheet by placing a CROSS in the appropriate box.

If you consider that two or more of the alternative responses are correct, choose the one you think is best. If you think you know an answer, mark it even if you are not certain you are correct. Marks will **not** be deducted for incorrect answers.

FEEL FREE TO WRITE OR DO WORKING ON THE QUESTION PAPER; many students who score high marks on the Multiple Choice Section do this.

Sections 2 and 3
Use a ballpoint or ink pen. **Do not** answer in pencil. Write your answers in the appropriate Section 2 or 3 Question/Answer Booklets.

At the end of the examination make sure that your name is on each of your Question/Answer Booklets and on your separate Multiple Choice Answer Sheet.

CHEMICAL EQUATIONS

For full marks, chemical equations should refer only to those specific species consumed in the reaction and the new species produced. These species may be **ions** [for example $Ag^{+}_{(aq)}$], **molecules** [for example $NH_{3(g)}$, $CH_3COOH_{(l)}$, $CH_3COOH_{(aq)}$] or **solids** [for example $BaSO_{4(s)}$, $Cu_{(s)}$, $Na_2CO_{3(s)}$].

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Section One: Multiple-choice **25%** **(25 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. 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.

1. Old fashioned 'smelling salts' are made of ammonium carbonate crystals, which decompose in an endothermic reaction to produce the pungent-smelling ammonia gas. The decomposition equation is shown below.

$$(NH_4)_2CO_3(s) \rightleftharpoons 2\,NH_3(g) + CO_2(g) + H_2O(g)$$

Which of the following statements regarding this equilibrium is **not** correct?

(a) The reverse reaction rate would increase if the volume of the system was decreased.
(b) The forward reaction would be favoured by having more finely divided ammonium carbonate crystals.
(c) The reverse reaction rate would be increased on a warmer day.
(d) More ammonia would be produced on a warmer day.

2. The equation below shows the key step involved in the Contact process.

$$2\,SO_2(g) + O_2(g) \rightleftharpoons 2\,SO_3(g) \qquad \Delta H = -198\ kJ\ mol^{-1}$$

Which of the following sets of conditions would increase both the rate and yield of $SO_3(g)$?

	Increased rate	**Increased yield**
(a)	High temperature	Low pressure
(b)	High pressure	Low temperature
(c)	Low temperature	High pressure
(d)	Low pressure	High temperature

3. Considering only the information given below, which reaction is **most likely** to proceed quickly in the reverse direction?

	ΔH(forward) (kJ mol^{-1})	**E_a(forward) (kJ mol L^{-1})**
(a)	+850	875
(b)	+120	645
(c)	-95	730
(d)	-545	90

Questions 4, 5 and 6 relate to the equilibrium system below.

At temperatures greater than 1000 °C, gaseous octasulfur (S_8) can undergo an endothermic decomposition to form gaseous disulfur (S_2) as shown in the equation below.

$$S_8(g) \rightleftharpoons 4\ S_2(g)$$

Some $S_8(g)$ was placed in an empty rigid container and allowed to establish equilibrium at 1052 °C. At this temperature the value of K for this equilibrium system is 324.

4. Once the system has established equilibrium, which of the following statements are **correct**?

(i) The total pressure inside the container will be constant. ✓
(ii) The pressure inside the container will be higher than initially. ✓
(iii) The colour of the gaseous mixture will be constant. ✓
(iv) The rates of the forward and reverse reactions will be equal. ✓
(v) The concentration of S_8 and S_2 will be equal. ✗

(a) (i), (iii) and (iv) only
(b) (ii), (iv) and (v) only
(c) (i), (ii), (iii) and (iv) only
(d) (i), (ii), (iii), (iv) and (v)

5. Which of the following statements regarding K for this equilibrium system is **correct**?

(a) At equilibrium there is a higher concentration of $S_8(g)$ present than $S_2(g)$.
(b) If the temperature of the system was decreased the value of K would increase.
(c) The equilibrium constant expression can be written $K = \frac{[S_8]}{[S_2]}$
(d) The equilibrium constant expression can be written $K = \frac{[S_2]^4}{[S_8]}$

6. Once the system had established equilibrium, various changes were imposed on the system and the effects of these changes were predicted using Le Chatelier's principle. Which of the following is **not** correct (i.e. the predicted effect on the equilibrium position does **not** match the imposed change stated)?

	Imposed change	**Effect on equilibrium position**
✓ (a)	Pressure increase	←
✗ (b)	Removal of S_2	←
✓ (c)	Temperature increase	→
✓ (d)	Addition of S_8	→

7. Which one of the following 1.0 mol L^{-1} solutions will have the lowest pH?

(a) sodium hydrogencarbonate
(b) ammonium chloride
(c) sodium ethanoate
(d) sodium hydrogenphosphate

$NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$ ← acid ∴ low pH.

8. Water ionises according to the following reaction.

$2\,H_2O(\ell) \rightleftharpoons OH^-(aq) + H_3O^+(aq)$

At 25 °C the concentration of H^+ is 10^{-7} mol L^{-1} and the pH of pure water is 7.0. When the temperature is increased, the pH of water reduces. Which of the following statements below is correct?

(a) The forward reaction is endothermic.
(b) The concentration of $OH^-(aq)$ reduces, making the water more acidic. ✗
(c) The water is no longer neutral, so the pH of water reduces. ✗
(d) The concentration of the $H_3O^+(aq)$ reduces. ✗

9. Consider 0.25 mol L^{-1} aqueous solutions of the following salts;

$NaHSO_4$ K_3PO_4 $Ca(NO_3)_2$

Rank these three (3) solutions in order of ~~decreasing~~ increasing pH (i.e. highest to lowest).

	8		7		2	
(a)	K_3PO_4 ✓	>	$Ca(NO_3)_2$	>	$NaHSO_4$	
(b)	$Ca(NO_3)_2$ low	>	$NaHSO_4$ high	>	K_3PO_4 high	
(c)	$NaHSO_4$	>	$Ca(NO_3)_2$	>	K_3PO_4	
(d)	$NaHSO_4$	>	K_3PO_4	>	$Ca(NO_3)_2$	

10. The hydrogencarbonate / carbonic acid buffering system in blood helps to maintain our blood at a pH of 7.4. Carbon dioxide (CO_2) can be exhaled by the lungs and hydrogen ions (H^+) can be excreted by the kidneys to help maintain the delicate balance of our blood chemistry. The equations for this buffer system are shown below, along with the concentration of the two main buffer components. Breathing ↑

$$HCO_3^-(aq) + H^+(aq) \rightleftharpoons H_2CO_3(aq) \rightleftharpoons H_2O(l) + CO_2(g)$$

0.0245 mol L^{-1} (c ↑) *0.0012 mol L^{-1}* (← ↓ (d) ↑)

Which of the following statements regarding this buffer system is **not** correct?

(a) H_2CO_3/HCO_3^- are a conjugate acid-base pair. ✓
(b) The buffering capacity is greater for a rise in H^+ concentration than for a fall in H^+ concentration. ✗
(c) A rise in H^+ concentration in the blood would shift the equilibrium to the right. ✓
(d) Increased breathing would decrease the pH of blood. ✗

↓ Their would increase pH (shift right)

11. Consider the information below, relating to malonic acid ($C_3H_4O_4$), which is a weak, organic, diprotic acid.

$$C_3H_4O_4(aq) + H_2O(l) \rightleftharpoons C_3H_3O_4^-(aq) + H_3O^+(aq) \qquad K_{a1} = 1.48 \times 10^{-3}$$

$$C_3H_3O_4^-(aq) + H_2O(l) \rightleftharpoons C_3H_2O_4^{2-}(aq) + H_3O^+(aq) \qquad K_{a2} = 1.10 \times 10^{-6}$$

Which of the following statements is **true** regarding **diprotic** acids?

(a) They have only 2 hydrogen atoms per molecule.
(b) They have a lower pH than monoprotic acids of the same concentration.
(c) They are all weak acids.
(d) The value of K_{a1} is always greater than the value of K_{a2}.

12. Consider the incomplete chemical equation shown below.

$$2\ Cr(s) + 3\ ClO_3^-(aq) + H^+(aq) \rightarrow Cr^{3+}(aq) + HClO_2(aq) + H_2O(l)$$

When this redox reaction is completed and balanced correctly (using whole numbers), the coefficient in front of $H^+(aq)$ will be;

(a) 1
(b) 3
(c) 6
(d) 9

$2Cr \rightarrow Cr^{3+} + 3e^-$

$8H^+ + 3ClO_3^- + 2e^- \rightarrow HClO_2 + H_2O$

(+5 on ClO_3^-; +3 on $HClO_2$)

13. Rank the following substances in order of increasing **nitrogen** oxidation number (i.e. from species with nitrogen in lowest oxidation state to highest oxidation state).

	NO_3^- (+5)		N_2O (+1)		HNO_2 (+3)		NH_4^+ (−3)		N_2 (0)
(a)	NH_4^+	<	N_2	<	N_2O	<	HNO_2	<	NO_3^-
(b)	NO_3^-	<	N_2O	<	HNO_2	<	N_2	<	NH_4^+
(c)	NH_4^+	<	HNO_2	<	N_2	<	NO_3^-	<	N_2O
(d)	N_2	<	NH_4^+	<	NO_3^-	<	N_2O	<	HNO_2

14. Which of the following halogen displacement reactions would **not** occur under standard conditions?

(a) $Cl_2(aq) + 2\ Br^-(aq) \rightarrow 2\ Cl^-(aq) + Br_2(aq)$
(b) $I_2(aq) + 2\ Br^-(aq) \rightarrow 2\ I^-(aq) + Br_2(aq)$
(c) $Cl_2(aq) + 2\ I^-(aq) \rightarrow 2\ Cl^-(aq) + I_2(aq)$
(d) $Br_2(aq) + 2\ I^-(aq) \rightarrow 2\ Br^-(aq) + I_2(aq)$

15. In which of the following processes is chlorine being oxidised?

i. $PCl_3 + Cl_2 \rightarrow PCl_5$

ii. $Cl_2 + H_2O \rightarrow Cl^- + HClO + H^+$

iii. $2\,Cl^- \rightarrow Cl_2 + 2\,e^-$

iv. $HClO_3 + H_2O_2 \rightarrow HClO_4 + H_2O$

(a) i, ii and iv only
(b) ii, iii and iv only
(c) i, ii, iii and iv
(d) ii and iv only

16. Which one of the following is the purpose of the salt bridge?

(a) To increase the concentration of the ions in order to speed up the rate of the reaction.
(b) To allow the flow of electrons between the two electrodes.
(c) To complete the circuit to allow ions to flow between the two half-cells.
(d) To allow copper ions to flow to the zinc electrode

17. Which one of the following statements is **false**?

(a) The zinc electrode is the anode.
(b) The electrons in the wire move towards the copper electrode.
(c) The mass of the copper electrode will ~~increase~~ decrease.
(d) Positive ions in the salt bridge move towards the lead electrode.

18. Which of the following reactions will occur spontaneously?

i. $2\,I^-(aq) + Br_2(aq) \rightarrow 2\,Br^-(aq) + I_2(aq)$

ii. $Cu(s) + 2\,HCl(aq) \rightarrow CuCl_2(aq) + H_2(aq)$

iii. $Sn(s) + Cd^{2+}(aq) \rightarrow Sn^{2+}(aq) + Cd(s)$

iv. $H_2O_2(aq) + Ni^{2+}(aq) \rightarrow O_2(g) + 2\,H^+(aq) + Ni(s)$

(a) i and iv only
(b) i only
(c) iii and iv
(d) iv only

Question 19, 20 and 21 relate to the following information

An aluminium-air battery is a fuel cell that involves aluminium reacting with oxygen in the air. The relevant half-equations are shown below.

$$3\,O_2(g) + 6\,H_2O(\ell) + 4\,e^- \rightleftharpoons 12\,OH^-(aq)$$

$$4\,Al^{3+}(aq) + 12\,e^- \rightleftharpoons 4\,Al(s)$$

19. This cell is described as a fuel cell because

(a) it is a sustainable power source that can be used to replace fossil fuels.
(b) both half-reactions are reversible so the cell can be recharged.
(c) it involves a gas as a reactant at one of the electrodes.
(d) it requires the reactants to be supplied to the cell during operation.

20. Which one of the following is the overall equation for the cell?

(a) $Al(s) + O_2(g) + 2\,H_2O(\ell) \rightarrow OH^-(aq) + Al^{3+}(aq)$
(b) $4\,Al^{3+}(aq) + 3\,O_2(g) + 6\,H_2O(\ell) \rightarrow 12\,OH^-(aq) + 4\,Al\,(s)$
(c) $Al^{3+}(aq) + O_2(g) + 2\,H_2O(\ell) \rightarrow 4\,OH^-(aq) + Al\,(s)$
(d) $4\,Al(s) + 3\,O_2(g) + 6\,H_2O(\ell) \rightarrow 12\,OH^-(aq) + 4\,Al^{3+}(aq)$

21. The theoretical voltage obtainable from this cell is

(a) 1.88 V.
(b) 2.08 V.
(c) 2.91 V.
(d) 5.52 V.

1.68
+0.40
2.08

22. The partially completed equations below show the various chemical reactions involved in the synthesis of ethyl ethanoate.

Equation 1: $CH_2CH_2 + \mathbf{A} \overset{H_2O,\ Cat.\ \mathbf{D}}{\rightleftharpoons} CH_3CH_2OH$

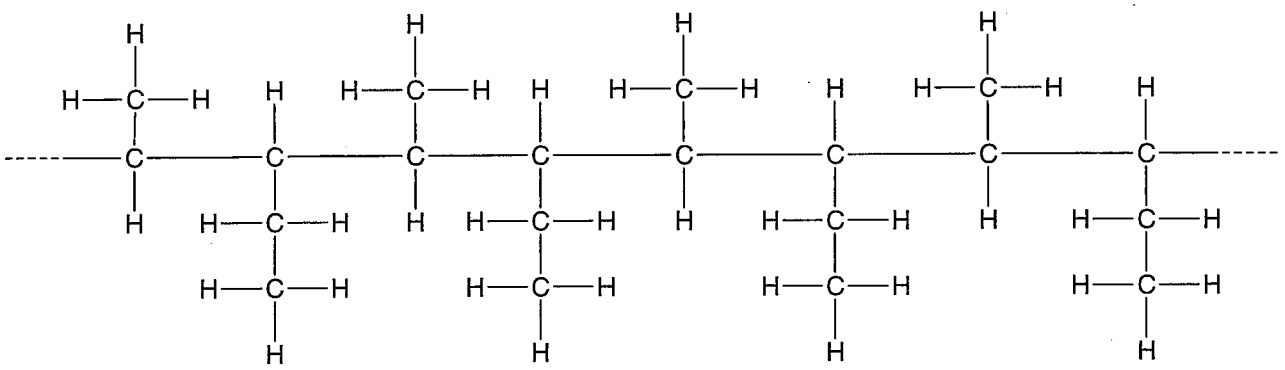
Equation 2: $3\,CH_3CH_2OH + \mathbf{B}\,Cr_2O_7^{2-} + 16\,H^+ \rightarrow 3\,\mathbf{C} + 4\,Cr^{3+} + 11\,H_2O$ (B = 2)

Equation 3: $\mathbf{C} + CH_3CH_2OH \overset{\mathbf{D}}{\rightleftharpoons} CH_3COOCH_2CH_3 + \mathbf{A}$ (C = CaM; A = H_2O)

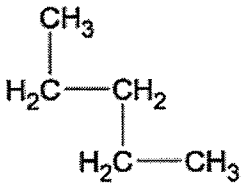
Which of the following correctly identifies the unknowns A, B, C & D?

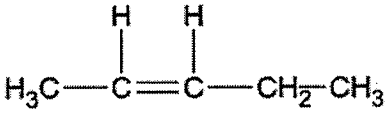
	A	B	C	D
(a)	H_2O	2	CH_3COOH	H^+
(b)	H_2O	2	CH_3COOH	catalyst
(c)	H_2O	2	CH_3CHO	H^+
(d)	H^+	4	CH_3CHO	H_2O

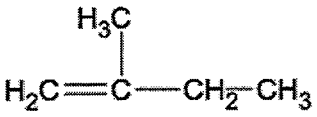
23. Consider the section of polymer shown below.

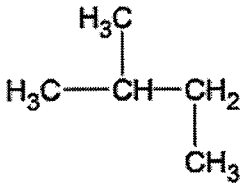


Which of the following monomers could be used to produce this polymer?

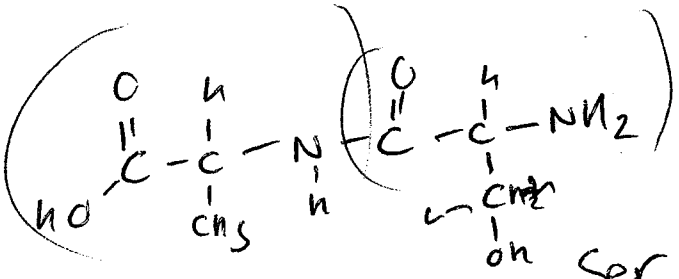
(a) 

(b) 

(c) 

(d) 

24. Consider the dipeptide below.

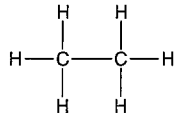
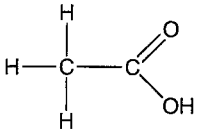
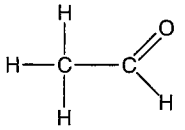
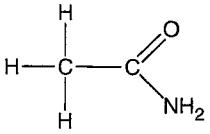
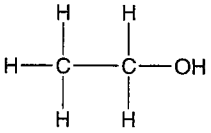


$HOOCCH(CH_3)NHCOCH(CH_2OH)NH_2$

Use your data sheet to identify which pair of amino acids below would form this dipeptide.

(a) alanine and valine
(b) valine and threonine
(c) glycine and serine
(d) serine and alanine

25. Consider the following five (5) organic compounds.

(i)	(ii)	(iii)	(iv)	(v)
				
CH_3CH_3	CH_3COOH	CH_3CHO	CH_3CONH_2	CH_3CH_2OH

Which of the following lists contain compounds that **all** have the ability to form hydrogen bonds?

(a) all of (i), (ii), (iii), (iv) and (v)
(b) (ii), (iii), and (iv) only
(c) (i), (ii), (iii) and (v) only
(d) (ii), (iv) and (v) only

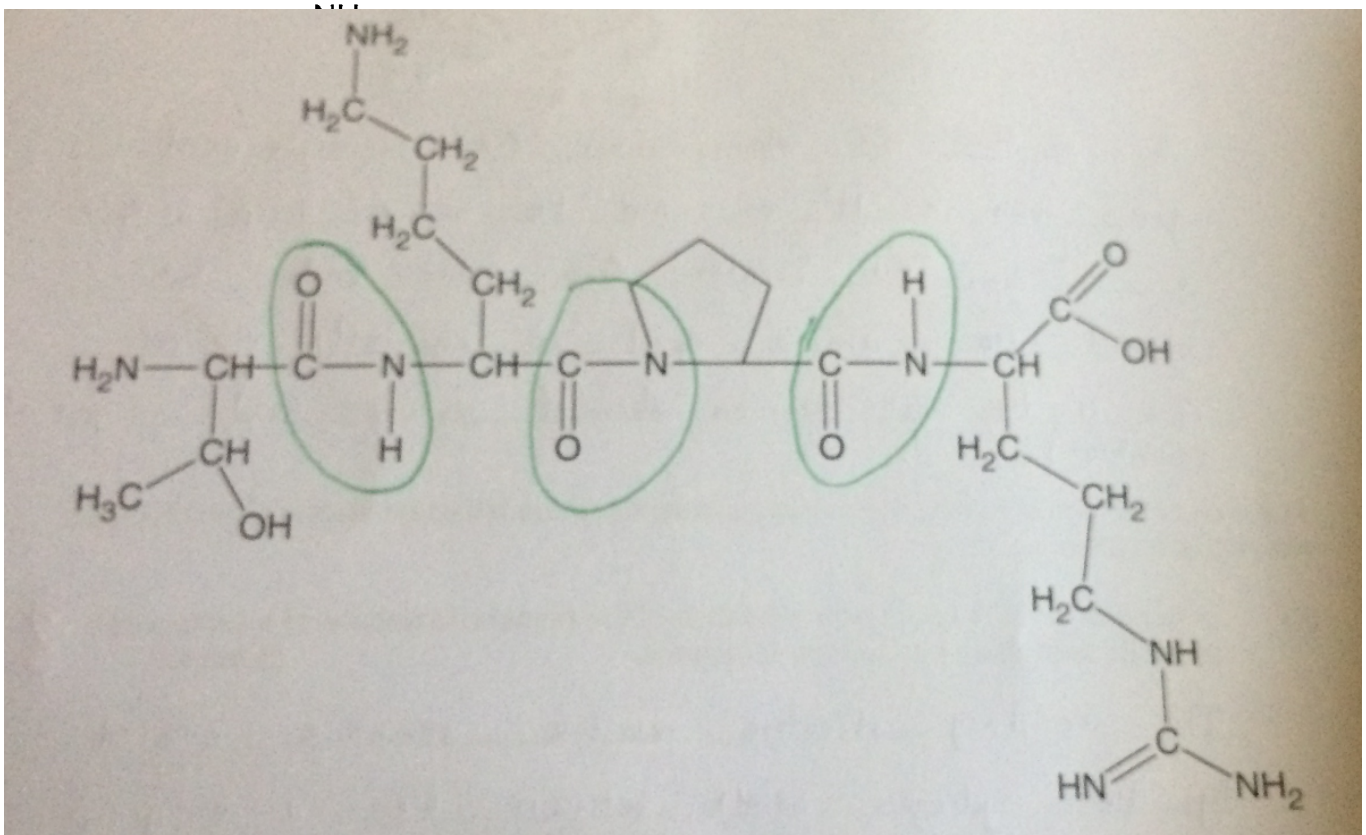
24.28

End of Multiple Choice

SECTION 2: SHORT ANSWER SECTION
Answer ALL questions in the spaces provided below. This section is worth 77 marks 44%

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 ✓3

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.

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

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)

This reaction refers to a closed system as a point of equilibrium is said to have been established. 2 (1) (1)

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

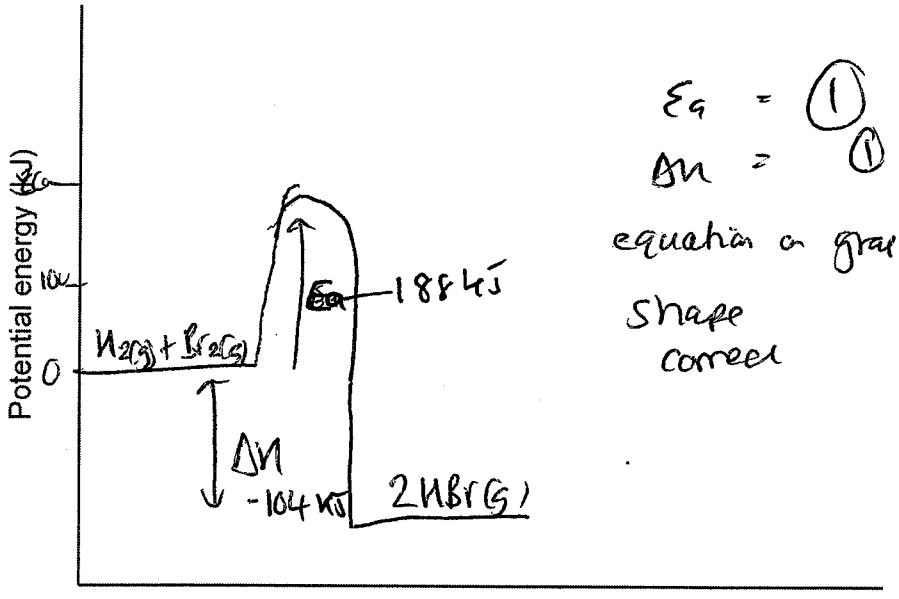
(i) equilibrium position?

heavily to the right. (1)

(ii) rate of reaction?

no valid info K_c does not help explain the rate only the yield (1)

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



Progress of reaction

E_a = (1)

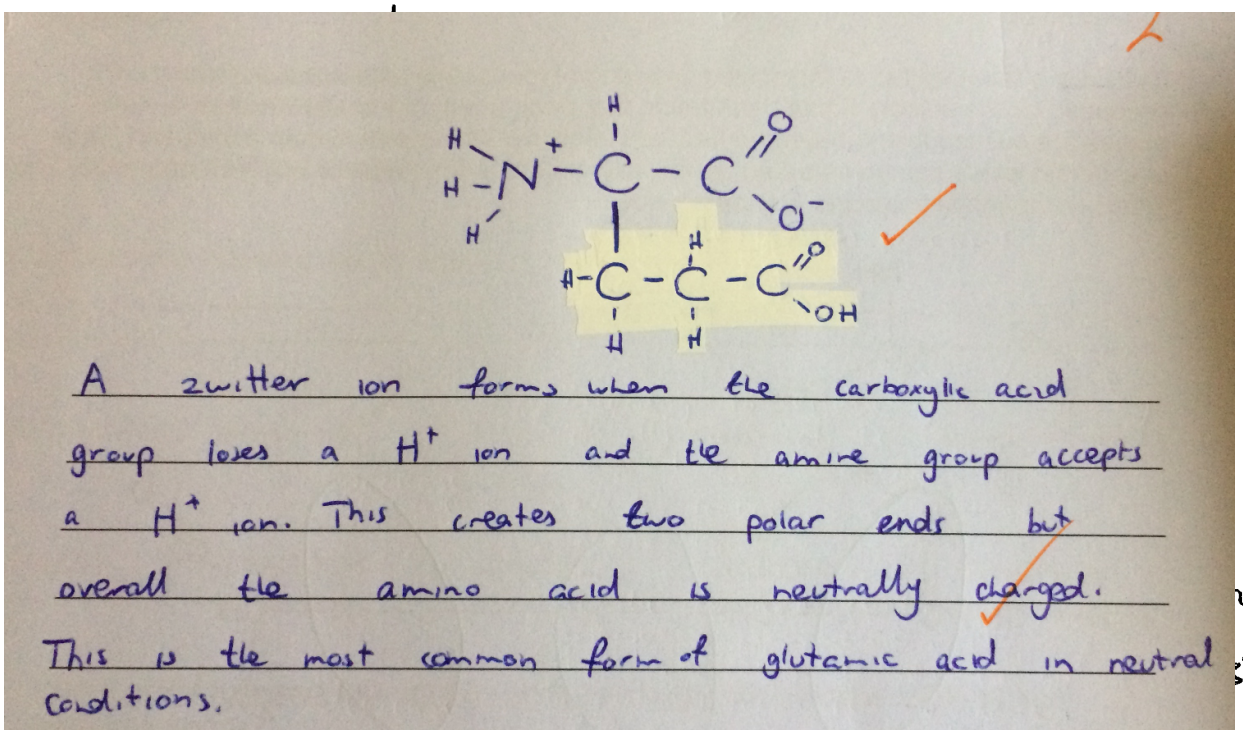
ΔH = (1)

equation on graph (1)

shape correct (1)

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)



A zwitter ion forms when the carboxylic acid group loses a H^+ ion and the amine group accepts a H^+ ion. This creates two polar ends but overall the amino acid is neutrally charged. This is the most common form of glutamic acid in neutral conditions.

(1)

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)

The secondary structure is the structure created by the hydrogen bonds between the amine group and the double bonded oxygen. This creates an α-helix or β-pleated sheets. If the primary sequence is changed or charged then these hydrogen bonds could become disrupted and hence the secondary structure of the protein will change. A tertiary structure is created by the interactions of the side chains. If the primary structure is changed, then the side chains present in the protein will also change. Hence, the interaction occuring between the side chains will change and therefore the tertiary structure is altered.

excellent.

(1)

Question 28 **(10 marks)**

Swimming pool maintenance uses sodium hypochlorite (NaClO), to control algae and bacteria. The swimming pool water can be considered as an equilibrium system as shown below, where hypochlorite ions are converted in to hypochlorous acid (HClO).

$$ClO^-(aq) + H_3O^+(aq) \rightleftharpoons HClO(aq) + H_2O(\ell) + \text{HEAT}$$

For best results, the concentration of the hypochlorous acid should be kept above 1.00 ppm.

(a) Complete the table by using Le Châtelier's principle to predict, with reasoning, the effect of the following changes on the concentration of the hypochlorous acid (HClO) in the swimming pool. (6 marks)

Imposed	Prediction for any change to the		Description	Marks
Increasing the pH of the pool	decreases	1	system shifts to the left to produce $H_3O^+(aq)$	1
			to oppose the reduction in $H_3O^+(aq)$ caused by the increase in pH / concentration of OH^- ions	1
Increasing the temperature of the pool	decreases	1	endothermic reverse reaction favoured	1
			to oppose the increase in heat	1
	Total	**2**		**4**

(b) (i) If the concentration is 1.50 ppm, calculate the mass of hypochlorous acid in a pool that has a capacity of 120 ~~000~~ litres. (Assume 1.00 L of pool water has a mass of 1.00 kg) (1 mark)

1·5 mg/kg × 120 = 180 mg. (1)

(ii) Assuming 60% conversion of sodium hypochlorite to hypochlorous acid, calculate the mass of sodium hypochlorite that would be required provide this mass of hypochlorous acid. (3 marks)

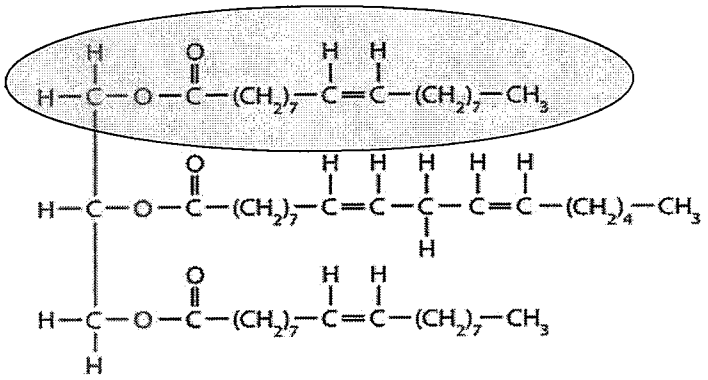
$n(NaClO) \frac{180}{52460} = \frac{3.4 \text{ mol}}{0.6 - 60\%} = 5.718 \text{ mol}$

$m(NaClO) = 5.718 \times 74.442 = 425.7$

4.26×10^2 g

Question 29 **(6 marks)**

Biodiesel is a fuel that can be synthesised from natural oils and fats. The molecule below is a triglyceride present in vegetable oil that can be used for this process.

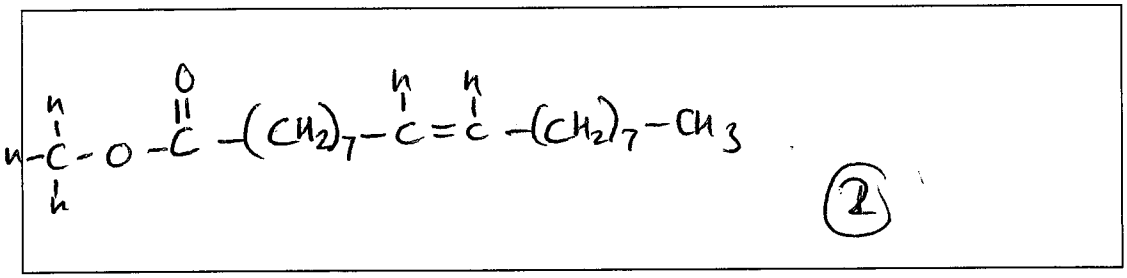


Biodiesel can be synthesised using a base-catalysed reaction with methanol. The triglyceride breaks down into fatty acids and these undergo esterification with methanol to form methyl esters. The methyl esters are the main components of biodiesel.

(a) State why the compound above is described as an unsaturated oil. (1 mark)

it contains double bonds. (1)

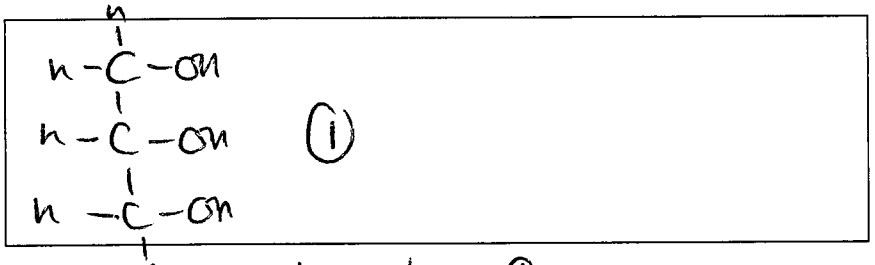
(b) Draw the structural formula of the methyl ester formed from the section of the molecule circled in the above diagram. ~~(1 mark)~~ (2)



(c) Name a catalyst that can be used in this process. (1 mark)

NaOH or enzyme (1)

(d) As well as the methyl esters (the biodiesel), there is one other product of this reaction. Name and draw the structural formula of this product. (2 marks)



Name glycerol (1)

Question 30 **(6 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: Pressure ↑ ∴ favour less mols

∴ shift to the left

observation: More solid would be produced.

(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)

The reverse reaction and forward reaction rates will both slow, as less particles will have the required activation energy due to their decreased kinetic energy. The forward reaction will slow more than the reverse reaction due to its endothermic nature and hence the reverse reaction will be slightly faster than the forward for a period of time before equilibrium is established. This causes the reverse reaction to be favoured and shifts equilibrium to the left.

(1) re (1)

(c) One of the products of this decomposition reaction is carbon dioxide gas. Write one chemical equation that illustrate how increasing atmospheric CO_2 levels may contribute to ocean acidification. (1 marks)

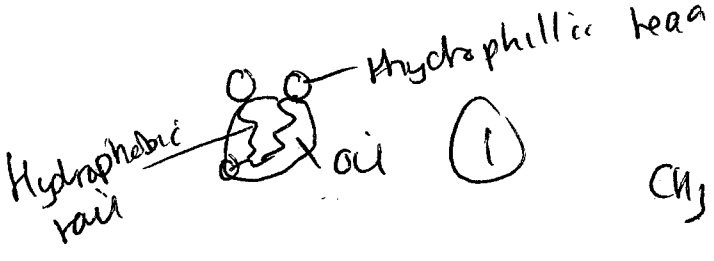
1. $CO_2 + H_2O \rightleftharpoons H_2CO_3 + H_2O \rightleftharpoons HCO_3^- + H_3O^+$

acid

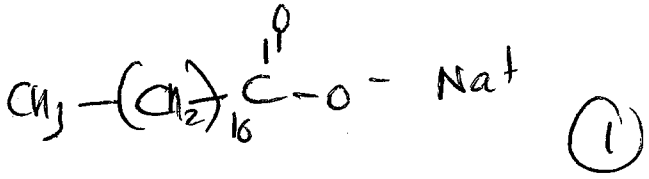
Question 31 **(9 marks)**

Sodium stearate ($CH_3(CH_2)_{16}COONa$) is a soap.

(a) Using a diagram, and your knowledge of intermolecular forces, explain how the polarity of the stearate ion enables the soap to remove grease from a surface. (4 marks)



(1)

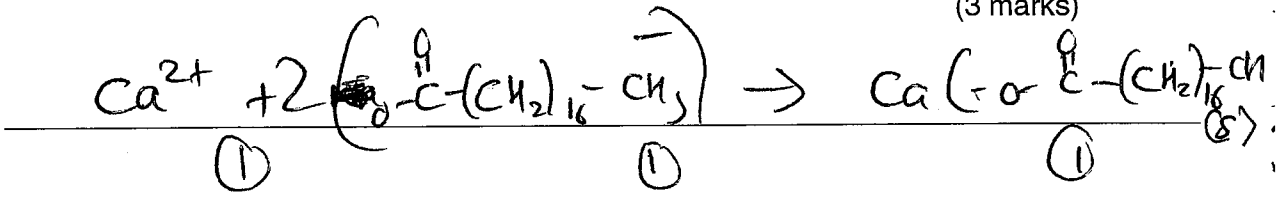


(1)

Description	Marks
diagram showing the polar and non-polar regions of the stearate ion	1
the non-polar part of the molecule forms dispersion forces with non-polar dirt/ fat/oil	1
the polar head of the molecule is available to form dipole-dipole bonding with water	1
therefore, the dirt/ fat/oil becomes water soluble and can be washed away	1
Total	**4**

(b) In hard water, soaps can form a precipitate of calcium stearate (scum).

(i) Write an ionic equation, including state symbols, showing this process. (3 marks)



(1) (1) (1) (s)

(ii) Describe two problems caused by the formation of scum. (2 marks)

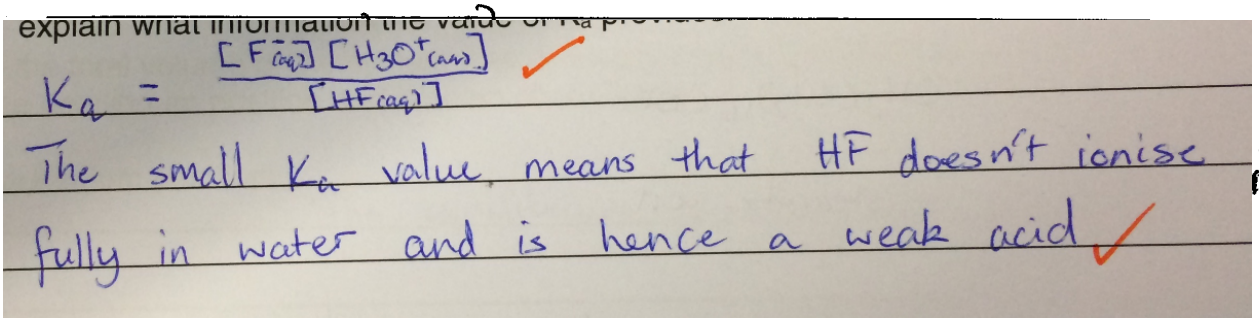
any (2)

- Stops the cleaning / foaming action of soap
- leaves an unsightly residue
- uses up the soap

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)

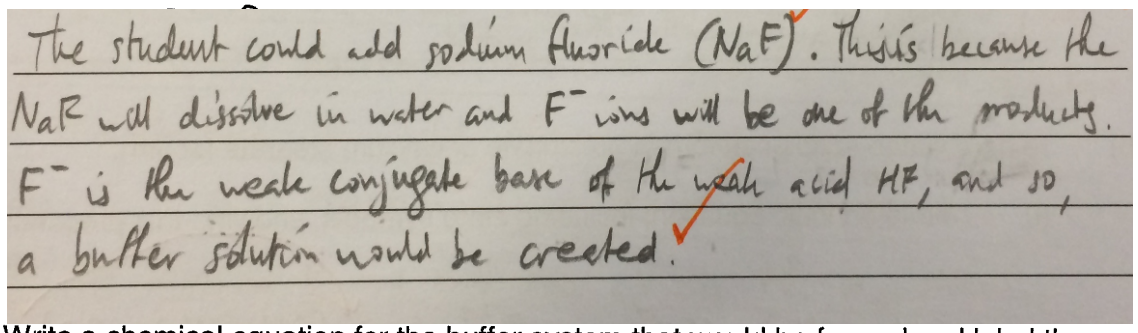

explain what information the value of K_a provides.

$K_a = \frac{[F^-_{(aq)}][H_3O^+_{(aq)}]}{[HF_{(aq)}]}$ ✓

The small K_a value means that HF doesn't ionise fully in water and is hence a weak acid ✓

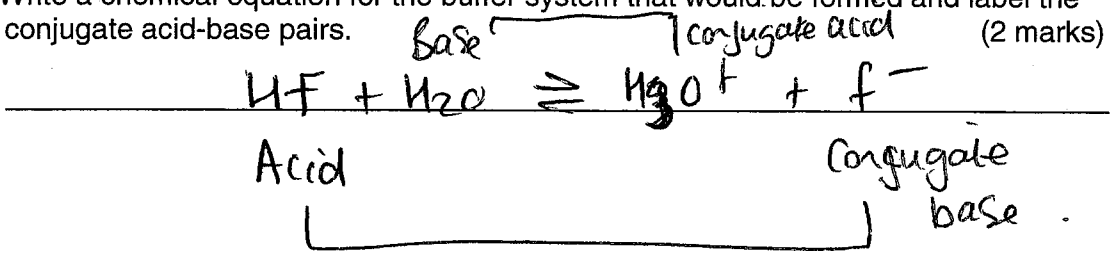
A student was given 0.500 L of a 0.250 mol L^{-1} hydrofluoric acid solution and instructed to produce a buffer.

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


The student could add sodium fluoride (NaF). This is because the NaF will dissolve in water and F^- ions will be one of the products. F^- is the weak conjugate base of the weak acid HF, and so, a buffer solution would be created. ✓

(1)

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

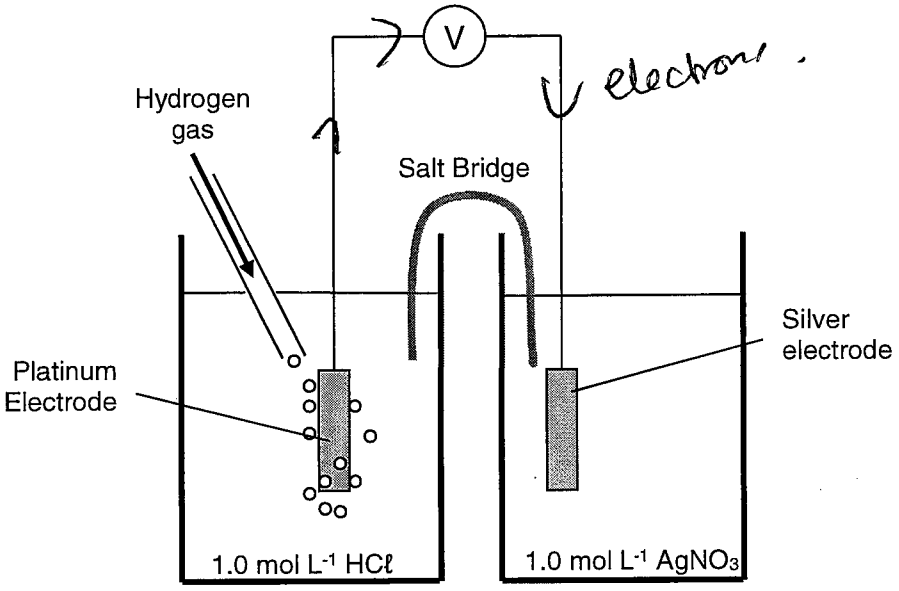

base — conjugate acid

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

Acid — Conjugate base

Question 33 **(8 marks)**

Below is a representation of an electrochemical cell used to measure the standard reduction potential for the Ag/Ag^+ half-cell.



(a) Give the half-equation for the reactions occurring at the anode and cathode and write an overall redox equation for the reaction occurring in the cell. (3 marks)

Anode half-equation:	$H_{2(g)} \rightarrow 2H^+ + 2e^-$
Cathode half-equation:	$2Ag^+_{(aq)} + e^- \rightarrow Ag_{(s)}$
Overall equation:	$H_{2(g)} + 2Ag^+ \rightarrow 2H^+_{(aq)} + Ag_{(s)}$

(b) Use an arrow to show the movement of electrons in the external circuit on the diagram above. (1 mark)

(c) Explain why 1.0 mol L^{-1} sulfuric acid is not used as the electrolyte in the hydrogen half-cell.(2 marks)

H_2SO_4 is stronger than 1 mol ∴ ion conc ①

to even ∴ not a fair test ①

(d) Apart from the concentrations of the solutions, state two other conditions required to achieve an accurate measurement of the standard reduction potential for the Ag^+/Ag half cell. (2 marks)

Same pressure ①

Same temperature. ①

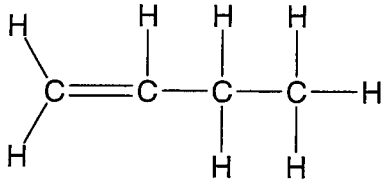
Question 34 **(9 marks)**

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

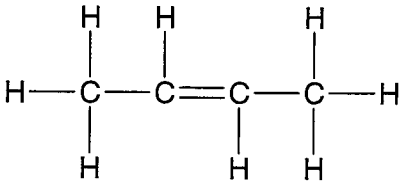
(a) Explain why but-2-ene exhibits *cis-trans* (geometric) isomerism while but-1-ene does not.

(3 marks)

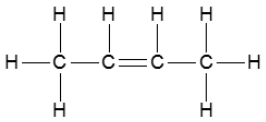
but-1-ene



but-2-ene



- **but-1-ene has two identical H atoms attached to C1, therefore if they are swapped no alternate isomer is formed**
- **but-2-ene has two different groups attached to both C2 and C3**
- **therefore allowing *trans* conformation (which is shown) as well as *cis* conformation**



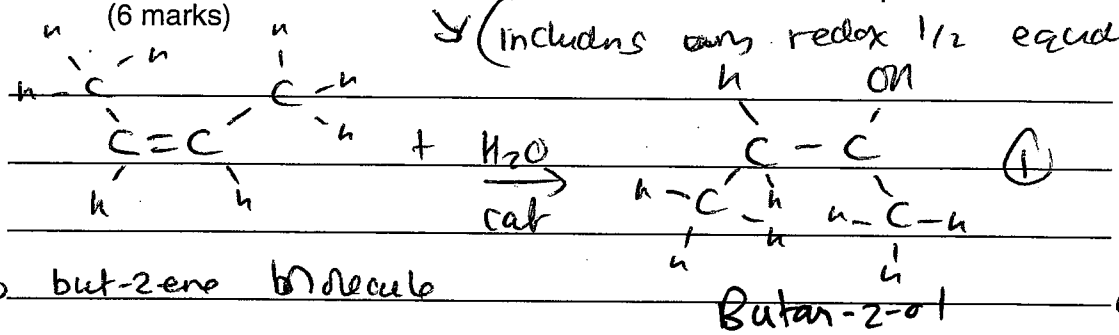
he
- two differen
- group
- behin

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)

✓ (includes any redox 1/2 equation)



(1) Hydration addition of OH + H to but-2-ene molecule

Butan-2-ol

(1) (2)

$KMnO_4$

$CH_3CH_2C(OH)-CH_3 \longrightarrow CH_3CH_2COCH_3 + 2H^+$ (1)

$2\times(8H^+ + 2MnO_4^- + 5e^- \rightarrow 2Mn^{2+} + 8H_2O)$ (1) (1/2) equation

(1) $(CH_3CH_2CH(OH)CH_3 \longrightarrow CH_3CH_2COCH_3 + 2e^- + 2H^+)\times 5$

$5CH_3CH_2CH(OH)CH_3 \rightarrow 5CH_3CH_2COCH_3 + 10e^- + 10H^+$

(2) $6H^+ + 2MnO_4^- + 5CH_3CH_2CH(OH)CH_3 \rightarrow 5CH_3CH_2COCH_3 + 8H_2O$

Balanced redox equation

Question 35 **(7 marks)**

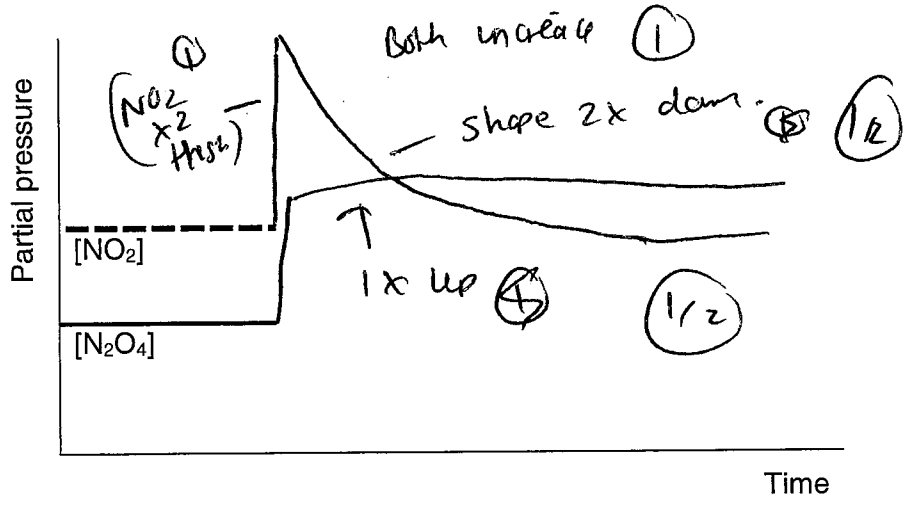
A student was investigating the equilibrium between the brown gas, nitrogen dioxide (NO_2) and the colourless gas dinitrogen tetroxide (N_2O_4). The gases were contained in a syringe. The syringe was suddenly squeezed to reduce the volume of the system. The temperature of the system was not changed. The equation for the equilibrium is shown below.

$$2\ NO_2(g) \rightleftharpoons N_2O_4(g) \qquad \Delta H = -57.2\ kJ\ mol^{-1}$$

(a) Write the equilibrium constant expression for this reaction. (1 mark)

$K = \dfrac{[N_2O_4]}{[NO_2]^2}$

(b) Complete the following graph to show what happens to the partial pressures of nitrogen dioxide and dinitrogen tetroxide as the syringe is squeezed and the system responds to the change by re-establishing equilibrium. (3 marks)



(c) Explain, with reference to reaction rates and collision theory, the shape of the graph drawn in part (b) (3 marks)

Description	Marks
more collisions so the rates of the forward and reverse reactions are both increased	1
the rate of the forward reaction is increased more than the reverse reaction	1
over time, the rates of the forward and reverse reactions become the same and equilibrium is re-established	1
Total	**3**

End of Section Two

WESLEY COLLEGE

SEC 3		73

SECTION 3

EXTENDED ANSWER SECTION

CANDIDATE'S NAME: .....

NAME OF YOUR TEACHER: .....

Instructions for Section 3:

Answer ALL 5 questions in Section 3 in this booklet. Remember all final numerical answers need to be corrected to three (3) significant figures where appropriate, and you must also provide correct units where applicable. Clear reasoning needs to be shown and failure to do so will result in loss of marks.

This section carries 73 marks.

PTO

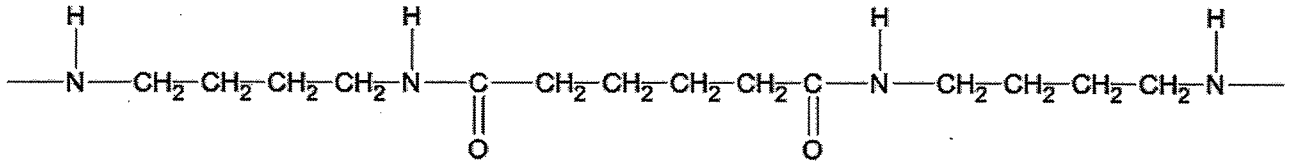
Section Three: Extended answer **42% (73 marks)**

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

Question 36 **(~~15~~ 6 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.

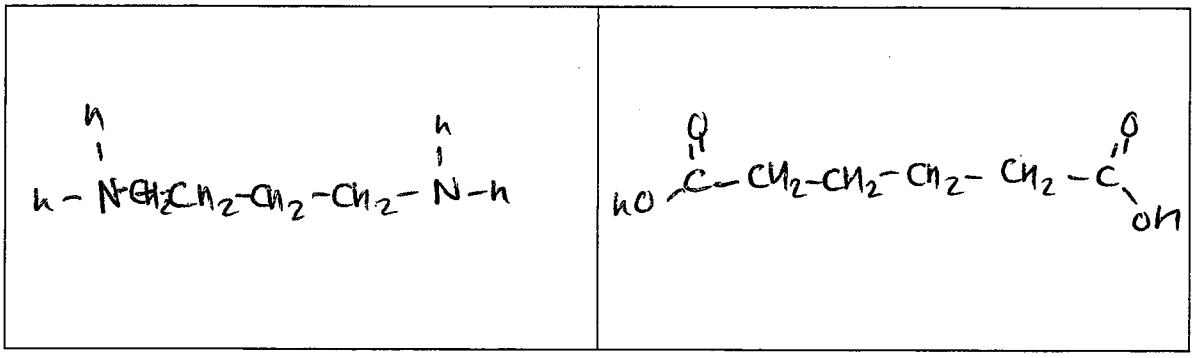
A segment of nylon 4/6 is shown in the diagram below.



(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)

H bonds increase the strength of the fibres and increases the mp + bp of the fibres, resist wear + tear, v strong

(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 polymerisation (1)

loss of a H_2O molecule (1)

OH loss of Carboxylic acid and H from amine group

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.

150 71

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)

$m_{(N_{2(g)})} = 3.11 \cdot 10^8 g$

$m_{(H_{2(g)})} = 7.1 \cdot 10^7 g$

$V = 2.5 \cdot 10^7 L$

$T = 723.15 K$ ✓

$n(N_{2(g)}) = \frac{m}{M}$

$= \frac{3.11 \cdot 10^8}{14.01 \cdot 2}$

$= 1.1 \cdot 10^7 mol \Rightarrow A$ ✓

$n(H_{2(g)}) = \frac{m}{M}$

$= \frac{7.1 \cdot 10^7}{1.008 \cdot 2}$

$= 3.5 \cdot 10^7 mol \Rightarrow B$ ✓

$\therefore$ moles of gas $= 4.6 \cdot 10^7 mol$ ✓

$PV = nRT$

$P = \frac{nRT}{V}$

$P = \frac{(4.6 \cdot 10^7) \cdot (8.314) \cdot 723.15}{2.5 \cdot 10^7}$

$= 11\,062.5\ kPa$

good well set out

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

$n(N_2) = 1.10714 \times 10^7$ mols

$n(H_2) = 3.5218 \times 10^7$ mol

$n(N_2)$ reacts with $\frac{3}{1} \times n(N_2)$ of H_2

$= 3.3$ mols

$\therefore$ N_2 is LR.

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)

$n(NH_3) = \frac{2}{1} \times n(N_2) = 2 \times 1.10714 \times 10^7$

$= 2.21428 \times 10^7$ mol

25.7% yield

$= 2.21428 \times 10^7 \times 0.257 =$

5.69×10^6 mol

$\therefore$ mass NH_3 produced

$= 5.69 \times 10^6 \times (14.01 + (1.008 \times 3)) = 9.6915 \times 10^7$ g

15.018

400,000

243 cylinders

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)

$\frac{150 \times 10^6}{16.04} = 9.35 \times 10^5$ mol

$n(H_2) = \frac{4}{1} \times n(CH_4) = 37.4$

$m(H_2) = 75.39$ tons should be produced

% Yeild $= \frac{71}{75.39} \times 100 = 94.16\ \%$

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

CH_4 not being a pure gas has other gas -

(20)

Question 38 **(22 marks)**

Aspartic acid ($C_4H_7O_4N$) is a diprotic α-amino acid. Aspartic acid has solubility of 4.5 g L^{-1} at 25 °C and a K_a value of 1.26×10^{-4}. Aspartic acid increases resistance to fatigue and is often found in food supplements, especially those used by athletes and body builders.

A chemist was asked to analyse the contents of a food supplement to check the manufacturer's claims that it contained 97.0% aspartic acid by mass. To check this claim, the following experiment was carried out. (It can be assumed that aspartic acid is the only active ingredient in the supplement)

1. 1.546 g of the supplement powder was weighed and dissolved in warmed distilled water in a beaker.
2. The solution was transferred to a 500.0 mL volumetric flask and was made up to the mark with distilled water.
3. 25.00 mL aliquots of the resulting solution were titrated, using phenolphthalein indicator, against 0.0570 mol L^{-1} sodium hydroxide solution.

1.546 scan

The results obtained are shown below.

Burette readings (mL)	Titrations			
	1	2	3	4
Final volume	20.30	40.05	19.80	39.50
Initial volume	0.00	20.30	0.00	19.80
Titration volume (titre)	20.30	(19.75	19.80	19.70)

25 .0570 0.01975 L 25 acid

19.75 (av) (1)

(a) Calculate the percentage purity of the supplement. (7 marks)

$n(NaOH) = C \times V = 0.0570 \times 0.01975 = 0.00112575$ mol (1)

$n(\text{diprotic acid}) = \frac{1}{2} \times n(OH) = 5.628 \times 10^{-4}$ mol (1)

$n(\text{in tablet}) = \frac{500}{25} \times n(\text{acid}) = 1.1126 \times 10^{-2}$ mol

$m(\text{Aspartic acid}) = 1.1126 \times 10^{-2} \times 133.103 = 1.498$ g

$(C_4H_7O_4N)$ ∴ % $= \frac{1.498}{1.546} \times 100 = 96.9$ %

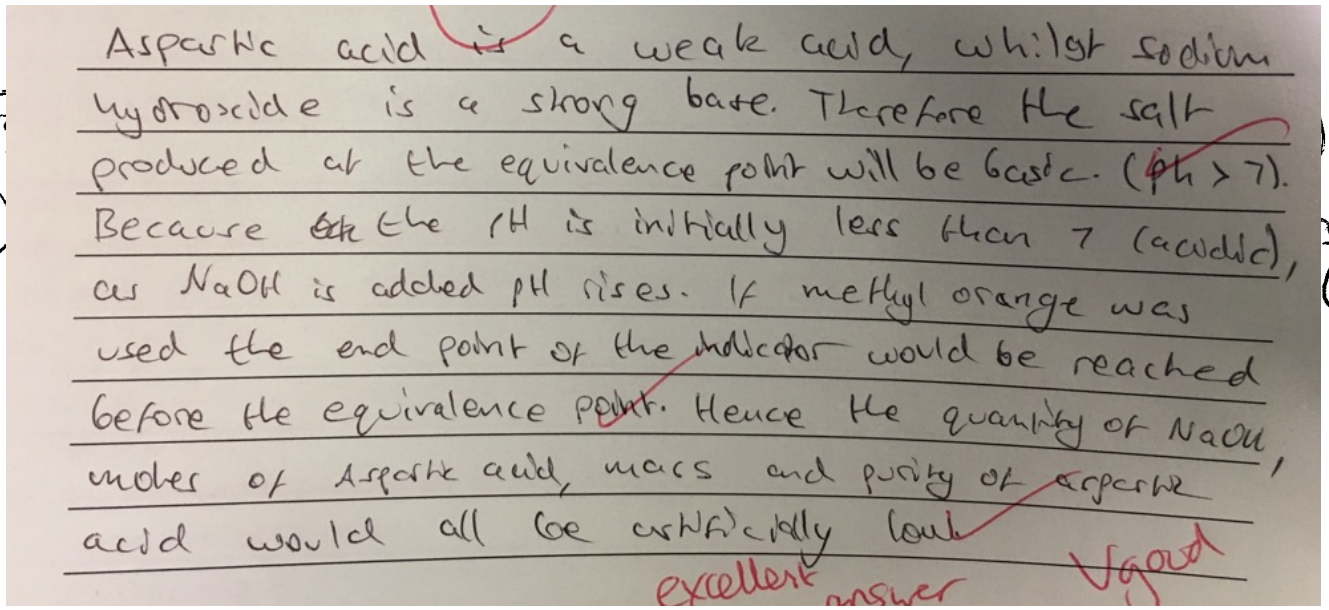
A pure sample of an amine (containing only the elements carbon, hydrogen and nitrogen) was analysed to determine its composition. The amine was combusted in oxygen and produced 6.43 g of carbon dioxide, 3.93 g of water and 2.04 g of nitrogen gas.

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

(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)

(iii)

Phenolphthalein changes colour at between pH 9 –10. Methyl orange changes colour at between pH 4 –5. In Step 3, predict and explain the effect on the final result if methyl orange was used as the indicator instead of phenolphthalein. (3 marks)



Aspartic acid is a weak acid, whilst sodium hydroxide is a strong base. Therefore the salt produced at the equivalence point will be basic. (pH > 7). Because the pH is initially less than 7 (acidic), as NaOH is added pH rises. If methyl orange was used the end point of the indicator would be reached before the equivalence point. Hence the quantity of NaOH, moles of Aspartic acid, mass and purity of aspartic acid would all be artificially low.

excellent answer Vgood

(c) (i) Due to the low solubility of the aspartic acid, it was suggested to the students that they use a 'back titration'. This would require the addition of a known amount of sodium hydroxide (in excess) to the aspartic acid and the titration of the unreacted hydroxide against a standard solution of acid.

Sodium hydroxide solution with a concentration of 0.978 mol L^{-1} is used and there is a standard solution of ~~0.100~~ 1.00 mol L^{-1} hydrochloric acid available.

There are three pipettes to choose from (20.00 mL, 25.00 mL or 50.00 mL) for adding sodium hydroxide solution to the 1.546 g of the supplement powder.

Calculate which volume pipette the student should use to add the sodium hydroxide in order to get a titration volume (titre) of approximately 20 mL of the hydrochloric acid. (7 marks)

$n(\text{Acid}) = \frac{1.546}{133.103} = 0.011615$ mol (1)

$n(OH) = \frac{2}{1} \times \text{Acid} = 0.02322$ mol (1)

$V(OH) = \frac{n}{c} = \frac{0.02322}{0.978} = 23.75$ ml = equal. (1)

20 ml HCl = $0.02 \times 1 = 0.02$ mol (1)

$V(OH) = \frac{0.02}{0.978} = 20.44$ ml (1)

use 50ml pipper (1)

PTO

total volume = 44.19 ml (1)

∴ total volume NaOH needed

= 23.75

+ 20.44

48.19 ml (1)

I would use the 50 ml (1)

(b) Consider the method used in this experiment.

(i) In Step 1, suggest a reason why the distilled water was warmed. (1 mark)

The increase the solubility of acid (1)

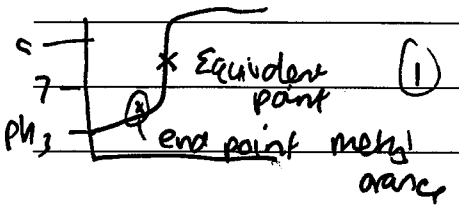
(ii) In Step 2, the solution was transferred from a beaker into the volumetric flask. Explain why this process could be a source of systematic error. (2 marks)

some solid could remain in the beaker (1)

some impurities could be in the flask (1)

b(iii)

Phenolphthalein changes colour at between pH 9 –10. Methyl orange changes colour at between pH 4 –5. In Step 3, predict and explain the effect on the final result if methyl orange was used as the indicator instead of phenolphthalein. (3 marks)



(1)

The end point would appear before the equivalence point (1)

∴ The conc of Acid would appear less and % aspartic acid would be less (1)

C(i)

Due to the low solubility of the aspartic acid, it was suggested to the students that they use a 'back titration'. This would require the addition of a known amount of sodium hydroxide (in excess) to the aspartic acid and the titration of the unreacted hydroxide against a standard solution of acid.

Sodium hydroxide solution with a concentration of 0.978 mol L^{-1} is used and there is a standard solution of 0.100 mol L^{-1} hydrochloric acid available.

There are three pipettes to choose from (20.00 mL, 25.00 mL or 50.00 mL) for adding sodium hydroxide solution to the 1.546 g of the supplement powder.

Calculate which volume pipette the student should use to add the sodium hydroxide in order to get a titration volume (titre) of approximately 20 mL of the hydrochloric acid. (7 marks)

$n(\text{Acid}) = \frac{1.546}{133.103} = 0.011615$ mol (1)

$n(OH) = \frac{2}{1} \times (\text{Acid}) = 0.0232$ mol (1)

$V(OH) = \frac{n}{c} = \frac{0.0232}{0.978} = 23.75$ ml = Equivalence point (1)

$20\text{ml}(\text{HCl needed}) = 0.02 \times 1 = 0.02$ mol (1)

$V(OH) = \frac{0.02}{0.978} = 0.02044 = 20.44$ ml (1) Extra need

Total volume = 44.19 ml (1)

∴ use 50ml pipet (1)

(ii) Explain why having a titre of less than 20 mL could increase the random error in this experiment.

(2 marks)

% error would be greater for smaller volume,

eg 1ml % error with 0.05 ml ± = $\frac{0.05}{1} \times 100 = 5\%$

if used

20ml % error = $\frac{0.05}{20} \times 100 = 0.25\%$

Question 39 **(18 marks)**

Oxidation involves the loss of electrons from a chemical species. Redox reactions involve the oxidation of one species and reduction of another species. Electrochemical cells, including galvanic and electrolytic cells, consist of oxidation and reduction half-reactions connected via an external circuit.

The following situations all involve a species being oxidised.

1. An iron nail slowly dissolving in a solution of copper(II) sulphate.
2. The dissolving of a piece of impure copper at the anode of a cell used to purify copper.
3. The reaction occurring at the anode of a galvanic cell made up of zinc metal in aqueous zinc nitrate and tin metal in aqueous tin(II) nitrate.

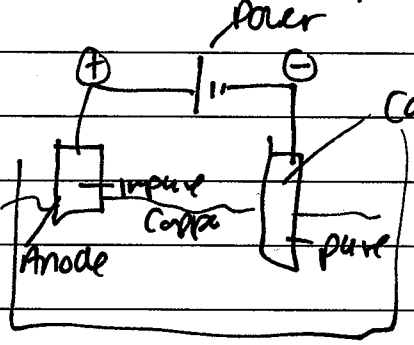
Using the following headings and using only examples from the above situations to illustrate your explanations, and including equations and diagrams where appropriate, compare

(i) spontaneous and non-spontaneous reactions. (6 marks)

(ii) galvanic cells and electrolytic cells. (6 marks)

(iii) weak and strong oxidising agents. (6 marks)

(i) $Fe_{(s)} + Cu^{2+}_{(aq)} \rightarrow Fe^{2+}_{(aq)} + Cu_{(s)}$ this is (1)
a spontaneous chemical reaction, fe is a (1)
stronger ~~oxidising~~ reductant compared to Cu so (1)
displaces it.

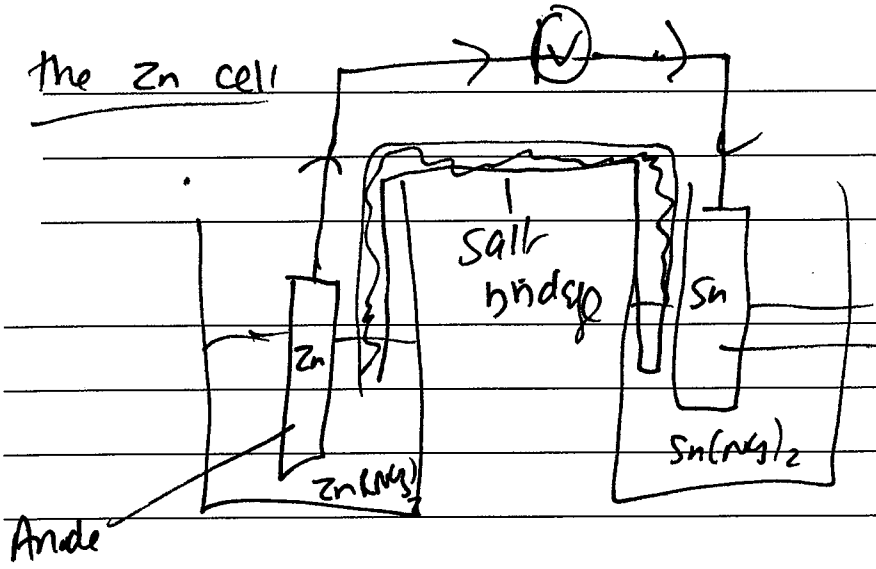


A non-spontaneous (1)
reaction can happen
when voltage is supplied.

(1) At the anode copper dissolves $Cu_{(s)} \rightarrow Cu^{2+}_{(aq)} + 2e^-$

(ii) The example above is an example of an electrolytic (1)
energy is needed (1)

the Zn cell



(3) for diagram

(1) this is a galvanic cell where voltage is produced
(1) from the sponaneous reaction between Zn and Sn

(1) The voltage produce would be

$E_{cell} = +0.76\ V + -0.14$ (1)

$= 0.62\ V$ (1)

(iii) weak oxiding agents do not easily gain electrons a weak oxidizing agent is the K^+ ion, It is difficult to reduce this chemical (1)
∴ is a weak oxidizing agent

A shong oxidizing agent is $F_2(g)$ this chemical gains electrons (1)

The difference in oxidants and reductants (1)
shenght enable the creation of galvanic cell

Question 40 **(10 marks)**

Banana oil contains an ester which gives the oil its distinctive odour. A series of experiments were carried out to determine the formula of this ester, which was known to contain just carbon, hydrogen and oxygen.

1.51 g of the ester was combusted in excess oxygen and 3.57 g of carbon dioxide was produced.

A second sample weighing 2.11 g was combusted in excess oxygen and 2.04 g of water was produced.

(a) Calculate the empirical formula of the ester. **(8 marks)**

C H O

$n(CO_2) \quad \frac{3.57}{44} \times 12.01 = 0.974\ g$ (1)

$\% = \frac{0.974}{1.51} \times 100 = 64.533\ \%$ (1)

$n(H_2O) \quad \frac{2.04}{18.016} = 0.1132\ mol \times 2 = 0.2264$

$\times 1.001$

$0.2283\ g$ (1)

$\% H = \frac{0.02285}{2.11} = 10.81\ \%$ (1)

$O\ \% = 100 - (64.533 + 10.81) = 24.649\ \%$ (1)

C	H	O	
64.53	10.81	24.65	
12.01	1.08	16	(1)
5.37	10.72	1.54	
1.54	1.54	1.54	
3.5	6.96	1	(1)
7	14	2	

2x

$C_7H_{14}O_2$ (1)

A third sample weighing 0.401 g was vaporised and the gas produced was found to occupy a volume of 162 mL at 150 °C at 67.0 kPa.

(b) From this information, prove that the empirical formula of the ester is the same as the molecular formula. (4 marks)

PV=nRT

150
273
423

$n = \frac{PV}{RT} = \frac{67.0 \times 0.162}{8.314 \times 423} = 0.00308$ mol (1)

$M = \frac{m}{n} = \frac{0.401}{0.00308} = 129.93$ g/mol (1)

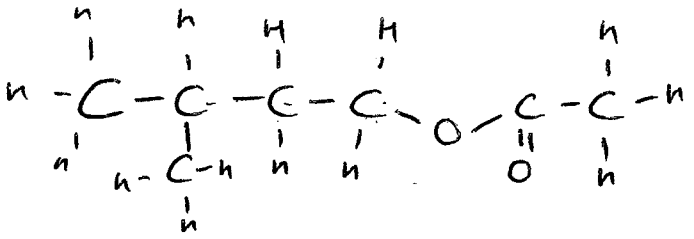
$Mf = \frac{\text{Molar mass}}{\text{Empirical mass}} = \frac{130}{129.5} = 1$ (1)

$\therefore Mf = C_7H_{14}O_2$ (1)

(c) (This ester can be synthesised from an alcohol and a carboxylic acid. The alcohol required is 3-methylbutan-1-ol.

Draw the structural formula of the ester present in banana oil. (2 mark)

and name



(1)

3-methylbutylethanoate (1)

End Of Exam !!

Spare answer page

Question number: _____