

Semester Two
Examination 2022
Question/Answer booklet

CHEMISTRY
UNITS 3 & 4

Name: _____

Teacher: _____

TIME ALLOWED FOR THIS PAPER

Reading time before commencing work: Ten minutes

Working time for the 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 Book

To be provided by the candidate:

Standard items: pens, pencils, eraser or correction fluid, ruler, highlighter.

Special items: calculators satisfying the conditions set by the SCSA for this subject.

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 this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Multiple-choice	25	25	50	25	25
Section Two: Short answer	8	8	60	75	35
Section Three: Extended answer	5	5	70	81	40
					100

Instructions to candidates

1. 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 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.

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

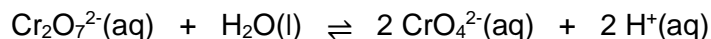
2. When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.
3. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.
4. 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.
 - Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
 - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.
5. The Chemistry Data Book is **not** handed in with your Question/Answer Booklet.

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

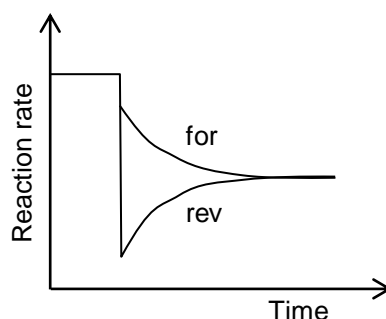
This section has **25** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question, shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square then shade your new answer. 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.

Suggested working time: 50 minutes.

1. Consider the equilibrium between dichromate and chromate ions.



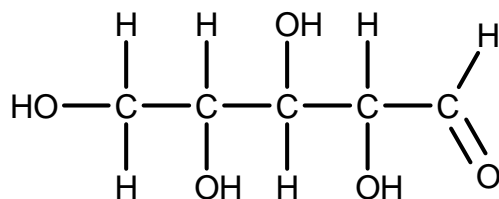
A change was imposed upon the system, the result of which can be represented by the following rate graph.



What was the imposed change?

- (a) Addition of $\text{Na}_2\text{Cr}_2\text{O}_7(\text{aq})$.
(b) Addition of $\text{H}_2\text{O}(\text{l})$.
(c) Addition of $\text{Na}_2\text{CrO}_4(\text{aq})$.
(d) Addition of $\text{HCl}(\text{aq})$.
2. Which of the **bolded** elements has a different oxidation number to the others?
- (a) $\text{K}_2\mathbf{S}_2\text{O}_3$
(b) $\text{Na}_3\mathbf{P}\text{O}_4$
(c) $\mathbf{H}\text{NO}_3$
(d) $\mathbf{V}_2\text{O}_5$
3. Excess chlorine water was added to a test tube containing potassium bromide solution. The mixture was shaken and allowed to sit until all reactions were complete. The final mixture in the test tube would contain
- (a) $\text{Cl}_2(\text{aq})$, $\text{Cl}^-(\text{aq})$ and $\text{Br}_2(\text{aq})$ only.
(b) $\text{K}^+(\text{aq})$, $\text{Br}_2(\text{aq})$ and $\text{Cl}_2(\text{aq})$ only.
(c) $\text{Br}^-(\text{aq})$, $\text{Cl}^-(\text{aq})$, $\text{Cl}_2(\text{aq})$ and $\text{Br}_2(\text{aq})$ only.
(d) $\text{K}^+(\text{aq})$, $\text{Cl}_2(\text{aq})$, $\text{Cl}^-(\text{aq})$ and $\text{Br}_2(\text{aq})$ only.

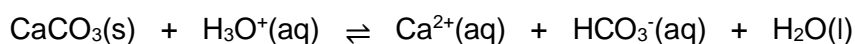
4. Consider the organic compound shown below.



When this compound was **completely** oxidised with excess acidified sodium dichromate solution, which of the following would be the major organic product formed?

- (a)
$$\begin{array}{cccccc}
 & \text{O} & \text{H} & \text{OH} & \text{H} & \text{H} \\
 & // & | & | & | & / \\
 & \text{C} & - \text{C} & - \text{C} & - \text{C} & - \text{C} \\
 & | & | & | & | & \backslash \\
 & \text{H} & \text{OH} & \text{H} & \text{OH} & \text{O} \\
 & & & & & // \\
 & & & & & \text{O}
 \end{array}$$
- (b)
$$\begin{array}{cccccc}
 & \text{O} & \text{H} & \text{OH} & \text{H} & \text{OH} \\
 & // & | & | & | & / \\
 & \text{C} & - \text{C} & - \text{C} & - \text{C} & - \text{C} \\
 & | & | & | & | & \backslash \\
 & \text{HO} & \text{OH} & \text{H} & \text{OH} & \text{O} \\
 & & & & & // \\
 & & & & & \text{O}
 \end{array}$$
- (c)
$$\begin{array}{cccccc}
 & \text{O} & & \text{O} & & \text{H} \\
 & // & & // & & / \\
 & \text{C} & - \text{C} & - \text{C} & - \text{C} & - \text{C} \\
 & | & || & | & || & \backslash \\
 & \text{H} & \text{O} & & \text{O} & \text{O} \\
 & & & & & // \\
 & & & & & \text{O}
 \end{array}$$
- (d)
$$\begin{array}{cccccc}
 & \text{O} & & \text{O} & & \text{OH} \\
 & // & & // & & / \\
 & \text{C} & - \text{C} & - \text{C} & - \text{C} & - \text{C} \\
 & | & || & | & || & \backslash \\
 & \text{HO} & \text{O} & & \text{O} & \text{O} \\
 & & & & & // \\
 & & & & & \text{O}
 \end{array}$$

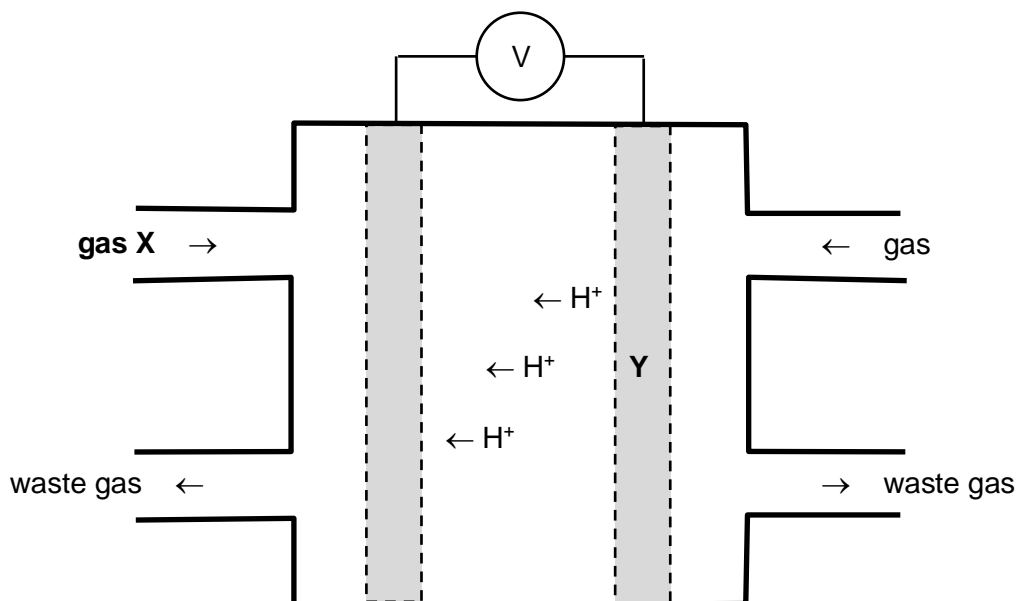
5. Ocean acidification has severe consequences for many calcifying species. The following equation shows the interaction between solid calcium carbonate and hydronium ions in the ocean.



An increase in the concentration of $\text{H}_3\text{O}^+(\text{aq})$, as caused by ocean acidification, would **not** result in

- (a) the equilibrium position shifting to the right.
 (b) an increase in $\text{HCO}_3^-(\text{aq})$ concentration.
 (c) a decrease in the mass of $\text{CaCO}_3(\text{s})$ present.
 (d) an increase in the K value.

6. Consider the partially drawn diagram of a hydrogen-oxygen fuel cell.



Which of the following correctly identifies reactant gas X and the polarity of electrode Y?

	Gas X	Polarity of Electrode Y
(a)	H ₂ (g)	positive
(b)	H ₂ (g)	negative
(c)	O ₂ (g)	positive
(d)	O ₂ (g)	negative

Question 7 and 8 refer to the information below.

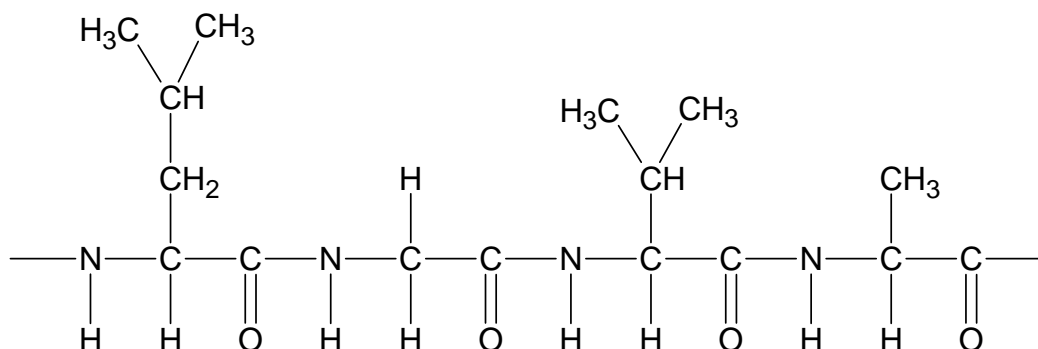
Consider the following five (5) pairs of substances.

- | | | | |
|-------|--------------------------------|-----|---------------------------------|
| (i) | H ₂ SO ₄ | and | NaHSO ₄ |
| (ii) | HCl | and | NaCl |
| (iii) | H ₂ SO ₃ | and | NaHSO ₃ |
| (iv) | HNO ₃ | and | CH ₃ COOH |
| (v) | NaHSO ₄ | and | Na ₂ SO ₄ |

7. Which pairs contain one strong acid and one weak acid?
- (a) (i) and (ii) only.
 (b) (i) and (iii) only.
 (c) (i) and (iv) only.
 (d) (ii) and (iv) only.
8. Which pairs could be mixed in aqueous solution to form a buffer?
- (a) (i) and (v) only.
 (b) (ii), (iii) and (v) only.
 (c) (ii) and (iv) only.
 (d) (iii) and (v) only.

Questions 9 and 10 refer to the α -amino acids alanine, glycine, leucine and valine.

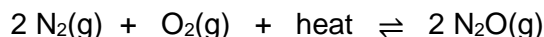
A section of protein contained four (4) α -amino acids as shown in the diagram below.



9. What is the primary sequence of this section of protein?
- Leu – Gly – Val – Ala
 - Val – Gly – Leu – Ala
 - Leu – Ala – Val – Gly
 - Val – Ala – Leu – Gly
10. Which of these α -amino acids has the IUPAC name 2-amino-3-methylbutanoic acid?
- Alanine
 - Glycine
 - Leucine
 - Valine
11. A particular reaction has a forward activation energy of 393 kJ and a reverse activation energy of 321 kJ. The forward reaction is therefore
- endothermic with $\Delta H = +72$ kJ.
 - endothermic with $\Delta H = -72$ kJ.
 - exothermic with $\Delta H = +72$ kJ.
 - exothermic with $\Delta H = -72$ kJ.
12. A sample of waste vegetable oil was divided in half and then each half was converted to biodiesel. One half of the vegetable oil was converted to biodiesel using a sodium hydroxide catalyst, whilst the other half was converted using a lipase catalyst.
- Which of the following would remain the same, regardless of the choice of catalyst?
- The chemical structure of the biodiesel.
 - The rate of production of the biodiesel.
 - The purity of the biodiesel.
 - The cost of the biodiesel production.

Questions 13 and 14 refer to the equilibrium system below.

The following system is at equilibrium.



Consider the effect of imposing the following changes on this equilibrium. The effect of each of these changes should be considered in isolation.

- (i) Adding $\text{N}_2(\text{g})$
- (ii) Removing $\text{O}_2(\text{g})$
- (iii) Increasing the volume of the system
- (iv) Increasing the temperature of the system
- (v) Adding a catalyst to the system

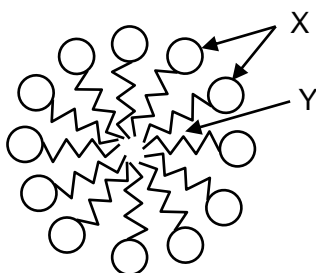
13. Which of these changes would **instantaneously** increase the rate of the reverse reaction?

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

14. Which of these changes would result in the reverse reaction being favoured?

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

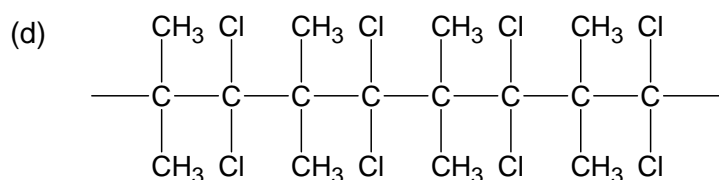
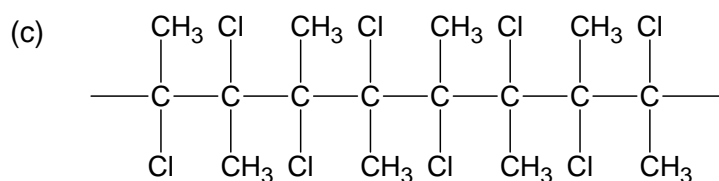
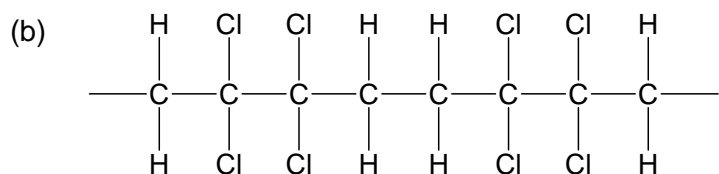
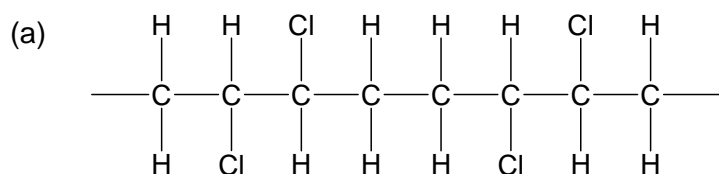
15. Consider a micelle formed from soap particles, as shown below. The two (2) distinct regions of the soap particle are labelled as X and Y.



Which statement is **not** correct?

- (a) X would form ion-dipole interactions with water.
- (b) X is the hydrophilic part of the soap.
- (c) Y would interact through hydrogen bonding.
- (d) Y would dissolve in oil or grease.

16. Which of the following polymers would be formed from the polymerisation of trans-2,3-dichlorobut-2-ene?



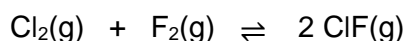
17. Which of the following metals could **not** be used as a sacrificial anode, to reduce the rate of corrosion of iron?

- (a) Zinc
(b) Magnesium
(c) Chromium
(d) Tin

18. A student incorrectly named an organic substance 1,1,2-tribromo-3-methylhexan-4-one. What is the correct IUPAC name for this organic substance?

- (a) 1,1,2-tribromo-3-methylhexan-2-one
(b) 5,6,6-tribromo-4-methylhexan-3-one
(c) 1,1,2-tribromo-3-methylhexan-3-one
(d) 5,6,6-tribromo-4-methylhexan-4-one

19. Consider the following equilibrium system.

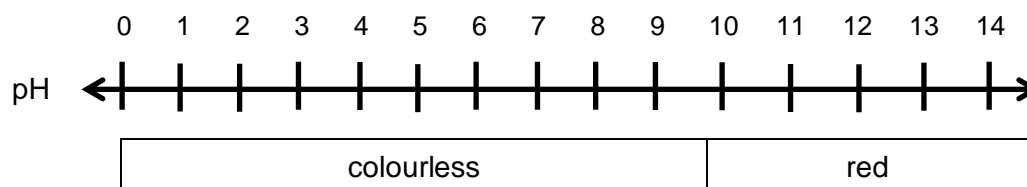


If the volume of this equilibrium system was increased,

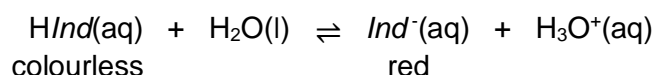
- (a) the forward reaction rate would increase more than the reverse reaction rate.
(b) the forward reaction rate would decrease less than the reverse reaction rate.
(c) both forward and reverse reaction rates would increase equally.
(d) both forward and reverse reaction rates would decrease equally.

Questions 20 and 21 refer to the indicator o-cresolphthalein.

o-Cresolphthalein indicator displays two (2) different colours and has an end point of approximately pH 9.6, as shown in the diagram below.



o-Cresolphthalein indicator can also be represented by the following chemical equilibrium system.



A dilute solution of $\text{Na}_2\text{HPO}_4\text{(aq)}$ was known to have a pH of 8.2. A few drops of o-cresolphthalein indicator were added to this solution and it remained colourless.

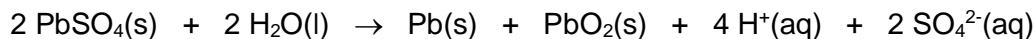
20. Which of the following correctly shows the relative concentrations of the o-cresolphthalein indicator species, when in the dilute Na_2HPO_4 solution?

- (a) $[\text{HInd}] > [\text{Ind}^{\ominus}]$
- (b) $[\text{Ind}^{\ominus}] > [\text{HInd}]$
- (c) $[\text{HInd}] = [\text{Ind}^{\ominus}]$
- (d) More information is required.

21. Which of the following equations best demonstrates why the pH of $\text{Na}_2\text{HPO}_4\text{(aq)}$ is 8.2?

- (a) $\text{Na}_2\text{HPO}_4\text{(aq)} \rightarrow 2 \text{Na}^+\text{(aq)} + \text{HPO}_4^{2-}\text{(aq)}$
- (b) $\text{HPO}_4^{2-}\text{(aq)} + \text{H}_2\text{O(l)} \rightleftharpoons \text{PO}_4^{3-}\text{(aq)} + \text{H}_3\text{O}^+\text{(aq)}$
- (c) $\text{Na}^+\text{(aq)} + 2 \text{H}_2\text{O(l)} \rightleftharpoons \text{NaOH(aq)} + \text{H}_3\text{O}^+\text{(aq)}$
- (d) $\text{HPO}_4^{2-}\text{(aq)} + \text{H}_2\text{O(l)} \rightleftharpoons \text{H}_2\text{PO}_4^{\ominus}\text{(aq)} + \text{OH}^{\ominus}\text{(aq)}$

22. The chemical equation below represents the process occurring in a lead-acid accumulator whilst it is being recharged.

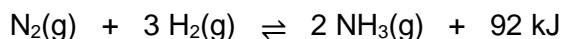


Which of the following statements is **correct** regarding this recharging process?

- (a) The redox reaction occurring would be spontaneous.
- (b) The cathode would be assigned a positive polarity.
- (c) The pH of the electrolyte would decrease.
- (d) Lead would be formed at the anode.

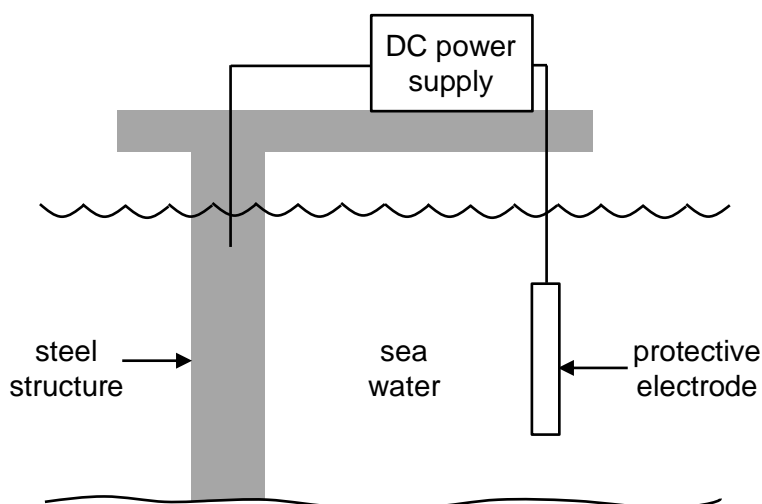
23. Consider a sample of the electrolyte solution taken from a cell carrying out the electrolytic refining of copper metal. The ion **least** likely to be present in this solution is
- (a) $\text{Cu}^{2+}(\text{aq})$.
 - (b) $\text{Au}^{3+}(\text{aq})$.
 - (c) $\text{Ni}^{2+}(\text{aq})$.
 - (d) $\text{SO}_4^{2-}(\text{aq})$.

24. The Haber process is used to produce ammonia gas, $\text{NH}_3(\text{g})$, and can be represented by the equation below. Assume the following species had established equilibrium.



If the temperature of the reaction system was increased, this would

- (i) increase the frequency of collisions
 - (ii) increase the proportion of successful collisions
 - (iii) increase the rate of the forward reaction
 - (iv) increase the yield
 - (v) increase the value of K
- (a) (ii) and (iii) only.
 - (b) (i), (ii) and (iii) only.
 - (c) (iii) and (iv) only.
 - (d) (iv) and (v) only.
25. The following diagram shows one type of cathodic protection that can be used to prevent corrosion.



Assuming a suitable EMF was applied,

- (a) oxidation would occur at the steel structure.
- (b) oxidation would occur at the protective electrode.
- (c) oxidation would occur at various locations in the sea water.
- (d) oxidation would not occur.

End of Section One

SEE NEXT PAGE

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Section Two: Short answer**35% (75 marks)**

This section has **8** 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.

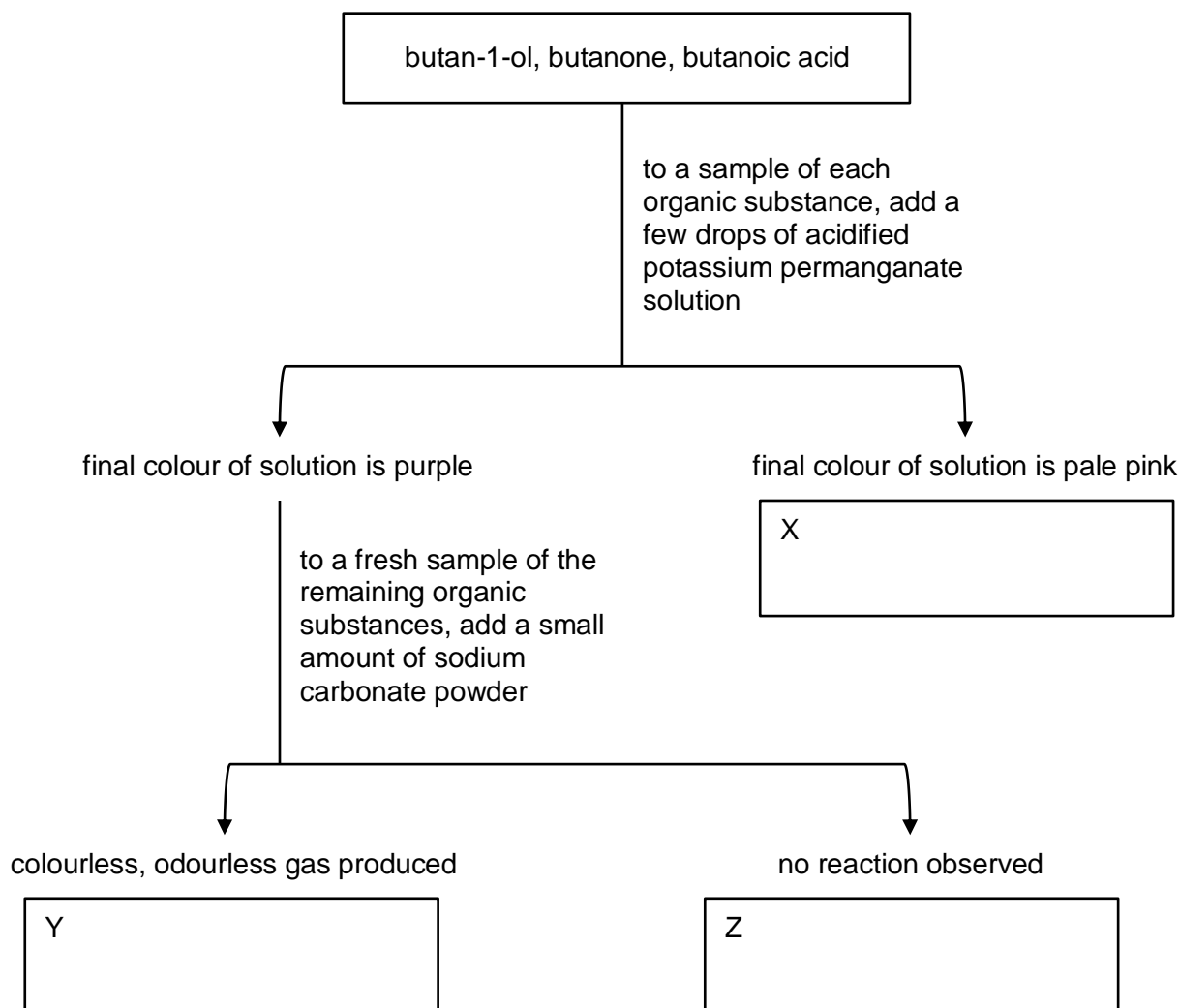
Question 26**(11 marks)**

A group of chemistry students were given samples of three (3) colourless organic substances;

- butan-1-ol
- butanone, and
- butanoic acid.

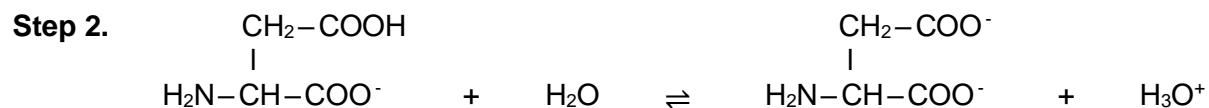
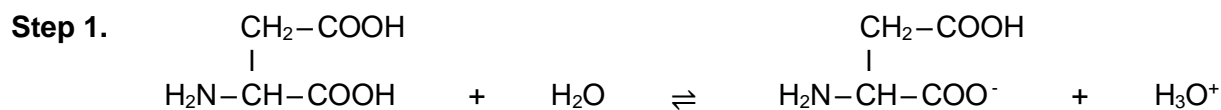
Their teacher asked them to design a series of chemical tests to distinguish and identify each of these substances.

The students devised the following flow chart.



Question 27**(8 marks)**

The following equations demonstrate how the α -amino acid 'aspartic acid' ionises in solution.



- (a) Describe how the equations above demonstrate an understanding of the following terms. Your answer may refer to one or both equations, as required. **(6 marks)**

Bronsted-Lowry theory	
Diprotic	
Weak acid	

- (b) Which of the ionisation steps would have a higher K_a value? (circle your choice) **(1 mark)**

Step 1

OR

Step 2

- (c) Draw a structural diagram for the conjugate acid of 'aspartic acid'. **(1 mark)**

Question 28

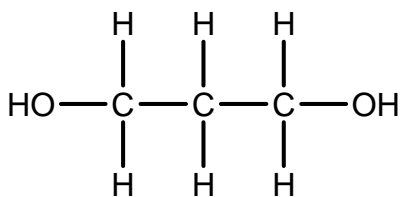
(10 marks)

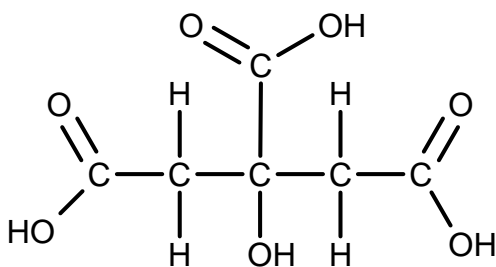
The following diagram shows part of the label on a bottle of shampoo.

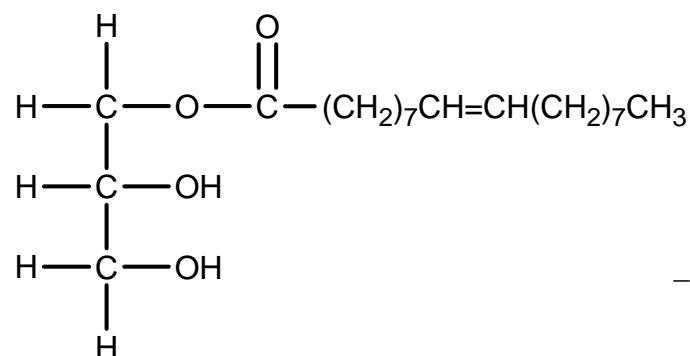
INGREDIENTS: Water, Sodium Coco-Sulfate, Cocamide MIPA, Cocamidopropyl Betaine, Caprylyl Glucoside, **Glyceryl Oleate**, Coco-Glucoside, **Propanediol**, PEG-12 Dimethicone, Hydrogenated Ethylhexyl Olivatate, Hydrogenated Olive Oil Unsaponifiables, Panthenol, *Hydrolysed Wheat Protein*, Persea Gratissima Oil, Aloe Barbadensis Leaf Juice, Chamomilla Recutita Flower Extract, Citrus Aurantium Amara Flower Extract, Panax Ginseng Root Extract, Polyquarternium-10, Tetrasodium Glutamate Diacetate, Polyquarternium-7, Phenoxyethanol, Fragrance, **Citric Acid**, Sodium Benzoate, Potassium Sorbate.

The structure of three (3) ingredients, shown above in **bold**, are given below.

- (a) Using your knowledge of IUPAC nomenclature, match each of these 3 ingredients to their corresponding molecular structure. (3 marks)







Another ingredient listed on the shampoo label is 'Hydrolysed Wheat Protein' (shown in *italics*). This refers to protein extracted from wheat, that has been treated in order to hydrolyse or 'cut' the protein into much shorter polypeptides. This process destroys most of the secondary and tertiary structures of the protein.

- (b) Describe a 'polypeptide'. (2 marks)

- (c) State the key difference between the secondary and tertiary structure of a protein. Give at least one example of each type of structure. (4 marks)

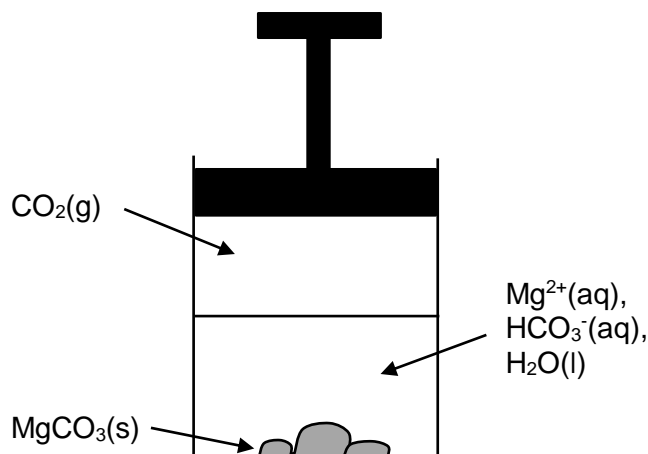
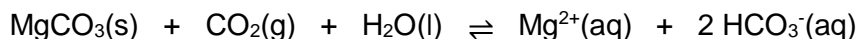
The shampoo label also states that the bottle is made entirely from recycled PET (RPET).

- (d) What does 'PET' stand for? (1 mark)

Question 29**(5 marks)**

Magnesium hydrogencarbonate (MgHCO_3) is not found in solid form. When $\text{CO}_2(\text{g})$ dissolves into a saturated solution containing magnesium carbonate (MgCO_3), a small amount of the magnesium carbonate dissolves to form aqueous, colourless magnesium hydrogencarbonate.

The equilibrium system described above, was established in a closed vessel that was stoppered with a plunger, as shown in the diagram below. The chemical equation for the equilibrium system is also given.



- (a) Write the equilibrium constant (K) expression for this system. (2 marks)

- (b) Consider the effect of imposing the following changes on this system. Complete the table below by stating in which direction, if any, an equilibrium shift would occur. (3 marks)

	Equilibrium shift (left, right, no change)
A small amount of $\text{MgCO}_3(\text{s})$ is added.	
A few drops of $2 \text{ mol L}^{-1} \text{MgCl}_2(\text{aq})$ is added.	
The volume of the system is decreased (by pressing on the plunger).	

Question 30**(11 marks)**

There are two (2) industrial methods of ethanol ($\text{CH}_3\text{CH}_2\text{OH}$) manufacture. The 'fermentation method' has many advantages, including the use of the enzyme *zymase*, which is used to speed up the rate of reaction.

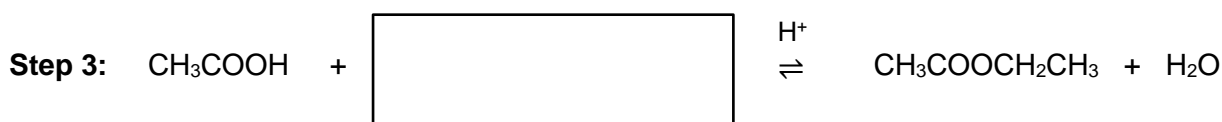
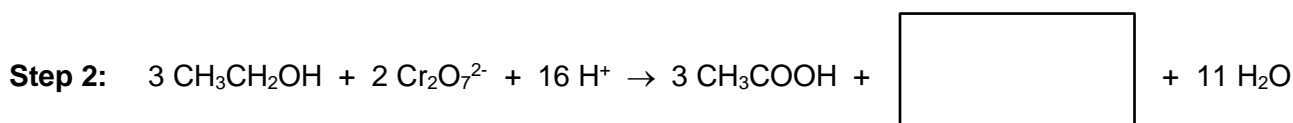
- (a) What is an enzyme? (1 mark)

- (b) List four (4) additional advantages, relating to the principles of green chemistry, of the fermentation method of producing ethanol. (4 marks)

1	
2	
3	
4	

The following reaction sequence shows the alternate method of ethanol manufacture (Step 1). The ethanol can then undergo further reactions (Step 2 and 3), to form the compound ethyl ethanoate.

- (c) Complete the reaction sequence below, by filling in the boxes. (3 marks)

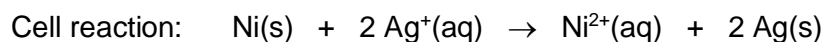
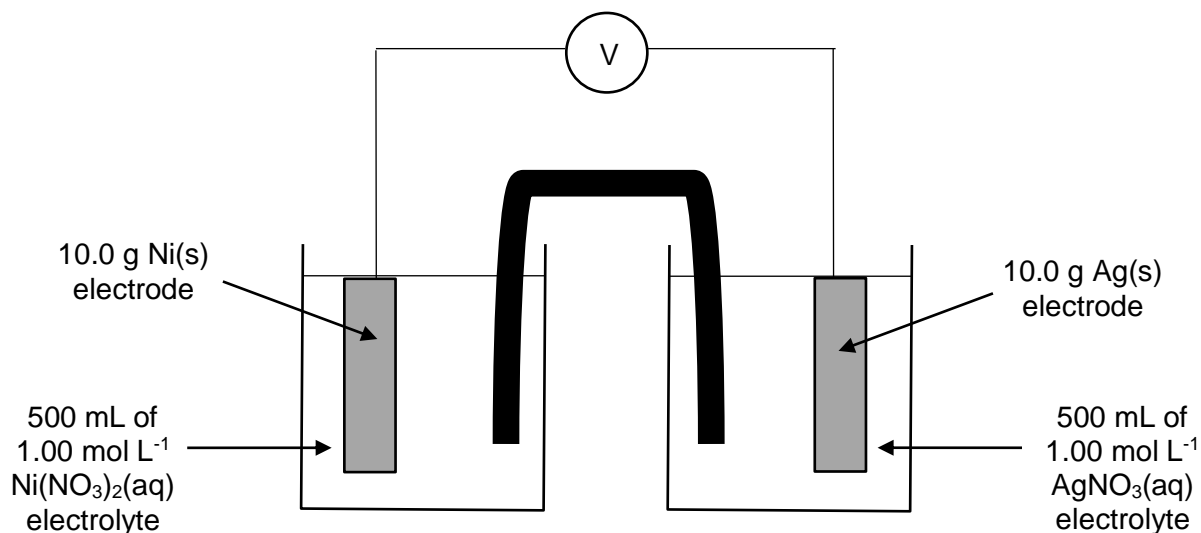


- (d) Name the type of reaction occurring in each step of the sequence. (3 marks)

Step 1	
Step 2	
Step 3	

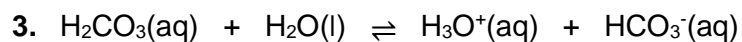
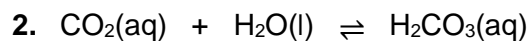
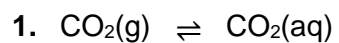
Question 31**(11 marks)**

Consider the galvanic cell shown in the diagram below. The cell is composed of Ni(s)/Ni²⁺(aq) and Ag(s)/Ag⁺(aq) half-cells. The mass, concentration and volumes of the various chemicals used to design this cell are also shown, in addition to the overall cell equation.



- (a) On the diagram above, label the (3 marks)
- anode and cathode
 - direction of electron flow
 - direction of anion flow through the salt bridge.
- (b) Calculate the EMF of the cell under standard conditions. (1 mark)

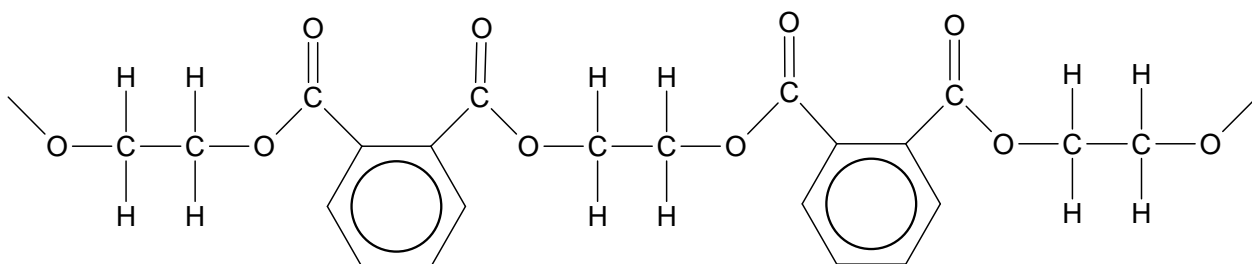
The chemical processes that cause rain to be acidic are similar to those involved in the acidification of our oceans. These processes can be represented by the equations below.



- (c) Use Le Chatelier's principle, to justify how an increase in the concentration of atmospheric $\text{CO}_2(\text{g})$ can lower the ocean pH. (3 marks)

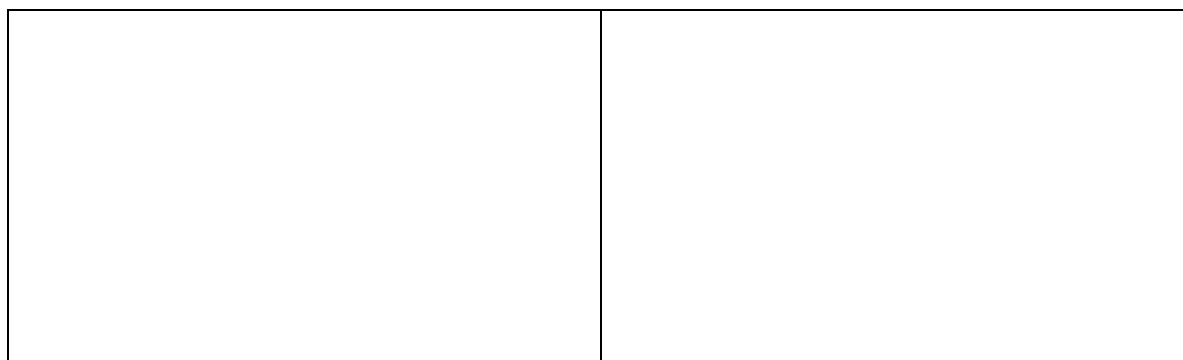
Question 33**(8 marks)**

Consider the polymer fragment drawn below.

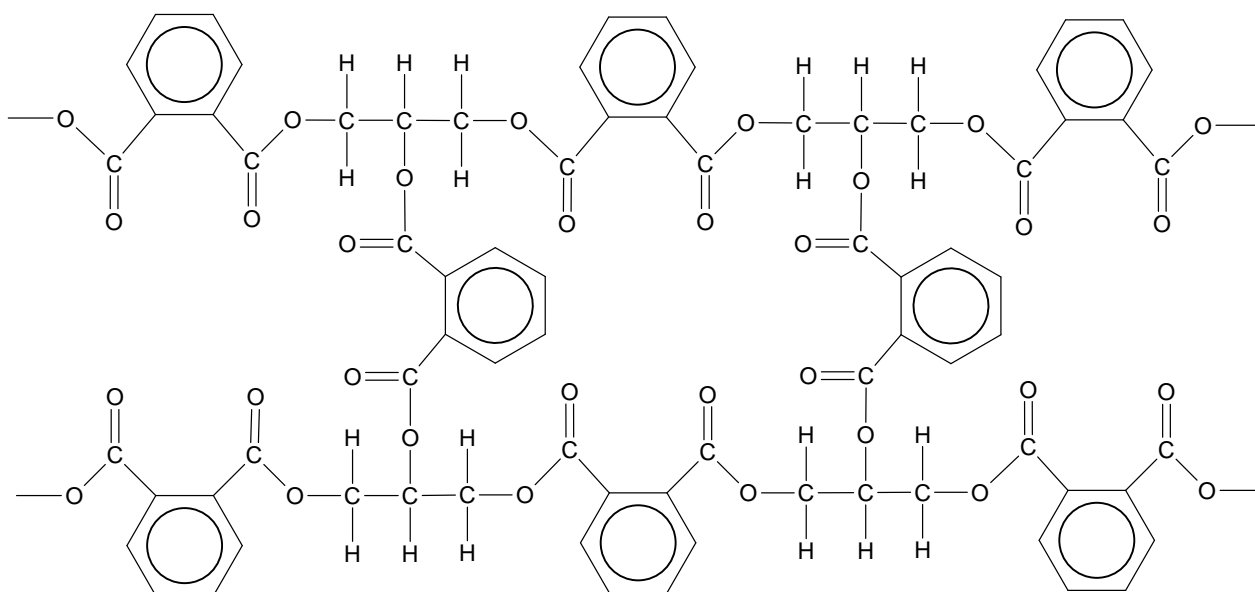


- (a) What type of condensation polymer is shown? (1 mark)

- (b) Draw structural diagrams of the monomers used to produce this polymer. (2 marks)



If **one** of the monomers used to form the polymer above is changed, this allows for the possibility of crosslinks to form between polymer strands, as shown in the diagram below.



- (c) Define 'crosslinking'. (1 mark)

The crosslinked polymer shown above has different physical properties when compared to the original polymer. Namely, it has;

- a much higher melting point, and
- a higher physical strength.

- (d) Choose one (1) of these altered properties, and describe how crosslinking can result in this change to the polymer. (2 marks)

- (e) Draw a structural diagram and give the name for the **new** monomer that has been used to form this crosslinking polymer. (2 marks)

Structural diagram	Name

End of Section Two

SEE NEXT PAGE

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Section Three: Extended answer**40% (81 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.

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.

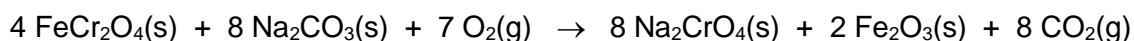
Suggested working time: 70 minutes.

Question 34**(24 marks)**

The two major uses of chromium metal are in the production of stainless steel and electroplating. Many objects such as tools, musical instruments, car parts and kitchen utensils are commonly plated in chromium metal. Chrome plating can be done for decorative reasons, or to improve the surface hardness or corrosion resistance of the object.

The following series of equations shows how chromium(III) oxide can be extracted from chromite ore, and then dissolved in an acidic solution to ready it for use in chrome plating.

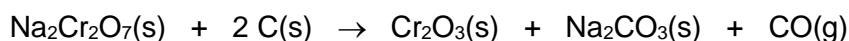
Step 1: Chromite (FeCr_2O_4) is first roasted in the presence of oxygen gas and excess sodium carbonate, to form sodium chromate (Na_2CrO_4).



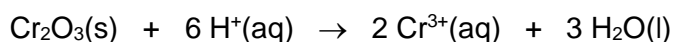
Step 2: The sodium chromate is then converted to sodium dichromate ($\text{Na}_2\text{Cr}_2\text{O}_7$). This is the most important chromium-containing species, from which many other chromium compounds can be synthesised.



Step 3: The sodium dichromate solution is concentrated by evaporation, and then heated in the presence of charcoal to produce chromium(III) oxide.



Step 4: Chromium(III) oxide is dissolved in sulfuric acid to produce a solution containing chromium(III) ions. This solution is then used for chrome plating.



A 3.21 tonne sample of FeCr_2O_4 was processed and placed into a 1500 kL reaction chamber. An excess of solid Na_2CO_3 was added, and the temperature of the chamber was maintained at $1100\text{ }^\circ\text{C}$. Oxygen gas was then pumped into the reaction chamber. The pressure was measured to determine when enough $\text{O}_2(\text{g})$ had been added. Assume the volume occupied by the solids is insignificant.

- (a) Calculate the minimum pressure that would need to be exerted by the $\text{O}_2(\text{g})$ in the reaction chamber, to ensure sufficient $\text{O}_2(\text{g})$ was present for all the chromite to react. State your answer to the appropriate number of significant figures. (5 marks)

If the combined yield of Step 1 and Step 2 is 68.9%;

- (b) Calculate the mass of $\text{Na}_2\text{Cr}_2\text{O}_7(\text{s})$ produced. (4 marks)

If 1.28 tonnes of $\text{Cr}_2\text{O}_3(\text{s})$ was produced;

- (c) Calculate the percentage yield of Step 3. (3 marks)

The entire 1.28 tonnes of $\text{Cr}_2\text{O}_3(\text{s})$ was then dissolved in concentrated excess $\text{H}_2\text{SO}_4(\text{aq})$, as shown in Step 4. The final volume of this solution was 3500 L.

- (d) Calculate the concentration of $\text{Cr}^{3+}(\text{aq})$ ions, in **grams per litre**, in the final solution. (4 marks)

This solution containing $\text{Cr}^{3+}(\text{aq})$ was then prepared for use as an electrolyte in a cell set up for chrome plating. The electrolytic cell had been designed to electroplate car parts, such as door handles, alloy wheels and bumper bars, with chromium metal.

- (e) What is an electrolytic cell? (2 marks)

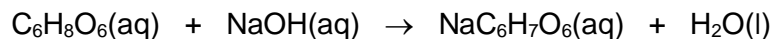
Question 35**(10 marks)**

Gumbi-gumbi (scientific name: *Pittosprum angustifolium*) is a small tree native to Australia. It is traditionally used in Aboriginal medicine to treat coughs, colds and eczema. Gumbi-gumbi leaves can be used, either fresh or dried, to make a tea drink. In addition to their antibacterial, antifungal, antiviral and antioxidant properties, gumbi-gumbi leaves are known to have very high levels of ascorbic acid.

Ascorbic acid is also known by the common name 'Vitamin C'. It is a weak, monoprotic acid with molecular formula $C_6H_8O_6$.

A 30.0 g sample of dried gumbi-gumbi leaves was ground into a fine powder and then soaked for 2 hours in hot water, to ensure all the Vitamin C had dissolved.

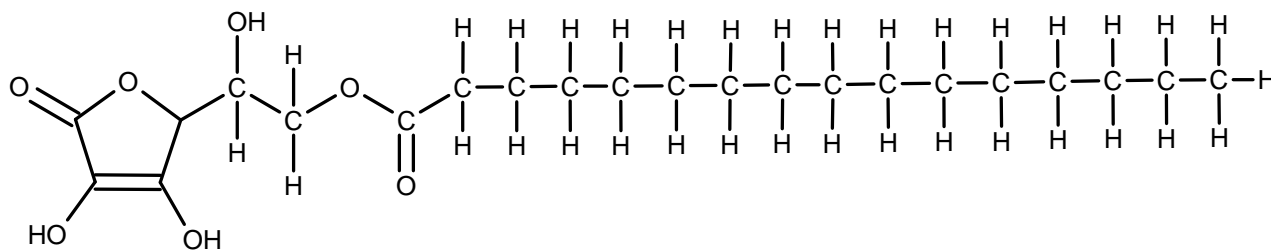
Once the gumbi-gumbi solution had cooled it was filtered, made up to 25.00 mL, and transferred to a conical flask. The sample was then titrated against $0.01118 \text{ mol L}^{-1}$ NaOH(aq) and required 18.28 mL to reach equivalence. The titration reaction can be represented by the chemical equation below.



- (a) Select an appropriate indicator from the table below for use in this titration. Justify your indicator choice, including a relevant chemical equation in your answer. (3 marks)

Indicator	End point pH range
chlorophenol red	4.8 - 6.4
thymol blue	8.0 - 9.6
brilliant yellow	6.6 - 7.8
bromophenol blue	3.0 - 4.6

In addition to its acidic properties, ascorbic acid (Vitamin C) also has hydroxyl (–OH) groups, allowing it to react as an alcohol to form an ester. For example, it can react with palmitic acid to form the ester ‘ascorbyl palmitate’, which is shown below.



(c) Draw structural formulas for both ascorbic and palmitic acids.

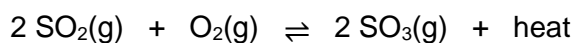
(2 marks)

Ascorbic acid	
Palmitic acid	

Question 36

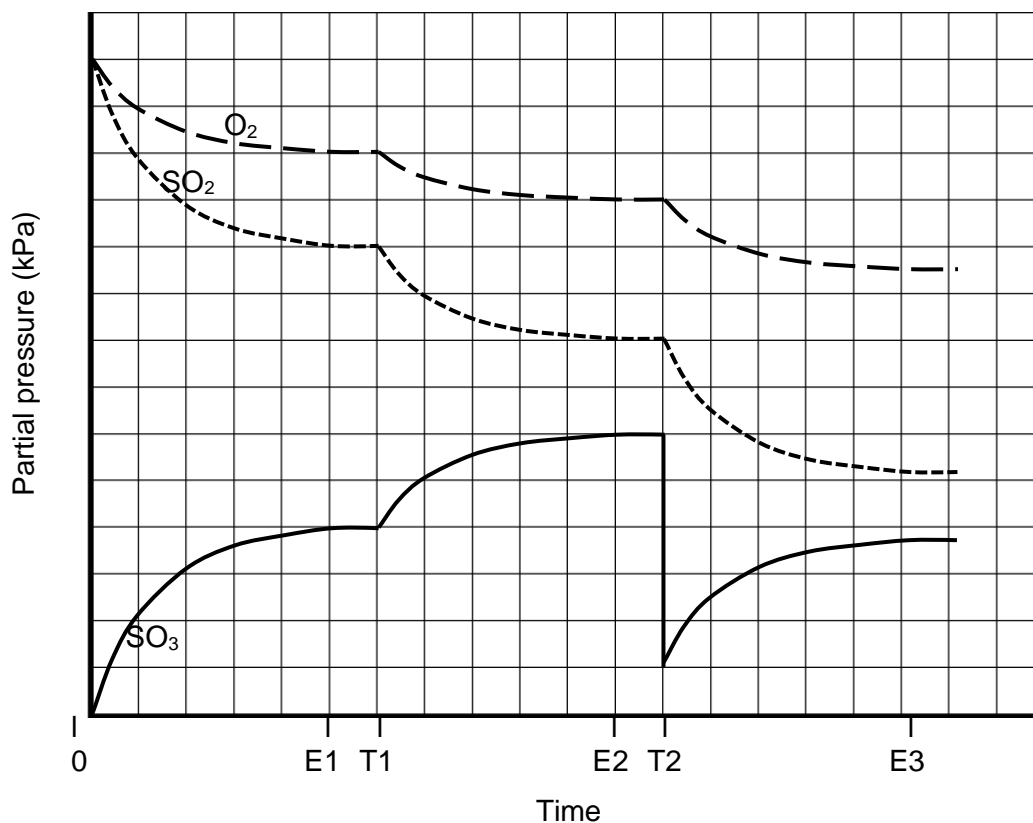
(17 marks)

The Contact Process is used to manufacture sulfuric acid. There are several steps involved in this process, but the key equilibrium reaction involves the conversion of sulfur dioxide to sulfur trioxide, as shown in the reversible reaction below.



This reaction takes place in the presence of an appropriate catalyst. The reaction chamber is maintained at a temperature of around 450 °C and a pressure of between 1 - 2 atm.

The graph below shows the results of a small-scale simulation of this equilibrium process.



Consider the processes occurring between Time 0, when the reactants are introduced, and Time E1, when equilibrium is established for the first time.

- (a) Describe what is happening to both the forward and reverse reaction rates from Time 0 to Time E1. (3 marks)

- (b) Complete the table below, by stating how the pressure and temperature of the system are different at Time E1, compared to Time 0. Justify each of your choices. (4 marks)

	Conditions at Time E1 compared to Time 0 (circle your choice)	Justification
Pressure	increased OR decreased	
Temperature	increased OR decreased	

At Time T1, the temperature of the system was decreased from 450 °C to 300 °C. This results in an increased yield of sulfur trioxide.

- (c) Explain, in terms of the collision theory, why the actual temperature used in the Contact Process is not lowered to 300 °C. (4 marks)

Consider the change imposed on the system at Time T2.

- (d) State the change that was imposed, and justify why the system would temporarily be classified as an 'open system'. (2 marks)

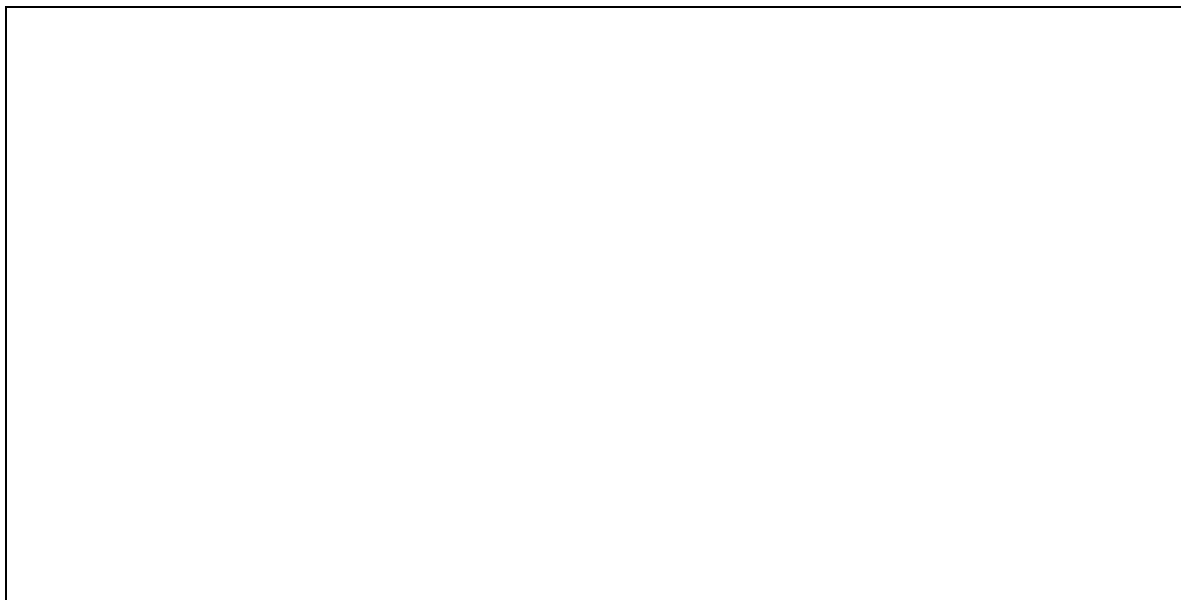
Consider the various changes made throughout this simulation, and any effect they would have had on the value of the equilibrium constant (K_c).

- (e) State when (i.e. at Time E1, E2 or E3) the value of K_c would have been highest and when it would have been lowest. Justify your answers. (4 marks)
(Note: calculations of K_c values are not required.)

The resultant NaOH(aq) was then mixed with jojoba oil and heated. The structure of the soap produced in the saponification reaction is shown below.



- (b) Draw a structural diagram of the triglyceride found in jojoba oil. (2 marks)



- (c) Draw the chemical structure of the scum that would form if this soap was used in hard water. (2 marks)



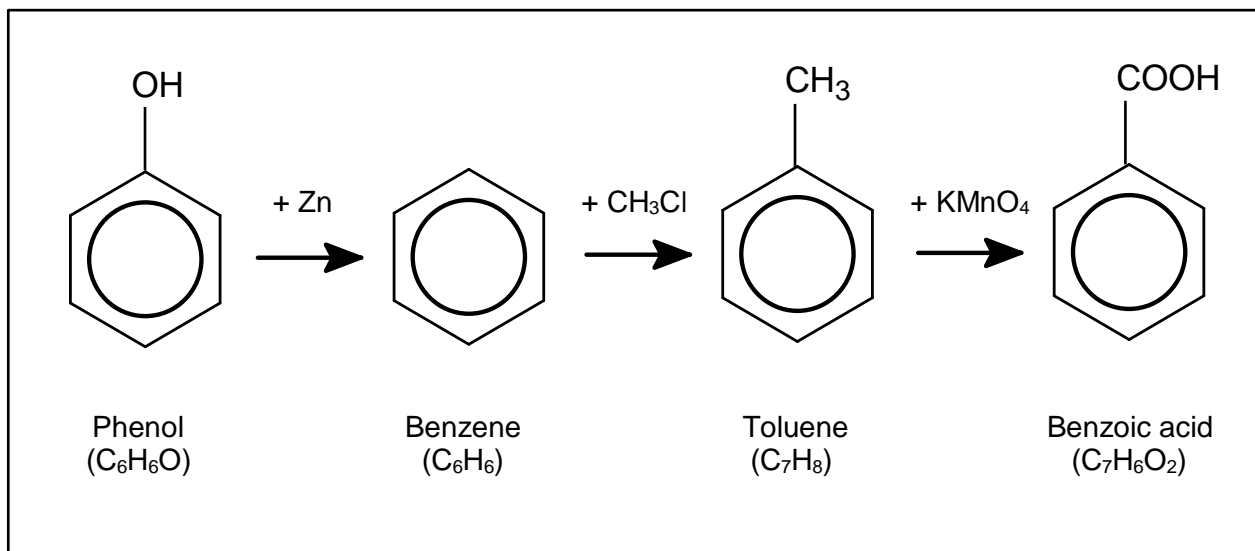
- (d) Draw a structural diagram for an anionic detergent with the same number of carbon atoms as the soap. Assume the detergent is an 'alkylbenzene sulfonate'. (2 marks)



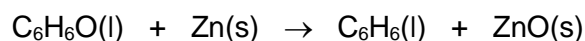
Question 38**(20 marks)**

Benzoic acid is a colourless crystalline solid, which is often used as a food preservative. It is also found in relatively high amounts in fruit such as blueberries, cranberries and cherries.

Consider the reaction sequence below, which summarises the conversion of phenol to benzoic acid, through the intermediates of benzene and toluene.



In the first step of the reaction sequence, phenol is reacted with zinc dust, to produce benzene and zinc oxide residue, as shown in the chemical equation below.



- (a) Demonstrate that this is a redox reaction, using oxidation numbers to support your answer. (2 marks)

In the second step, benzene is converted to toluene by the reaction with chloromethane, CH_3Cl .

- (b) Predict the substance formed, in addition to toluene. (1 mark)

In the last step of the reaction sequence, toluene reacts with potassium permanganate solution to form benzoic acid. This reaction also produces solid manganese(IV) oxide, MnO_2 .

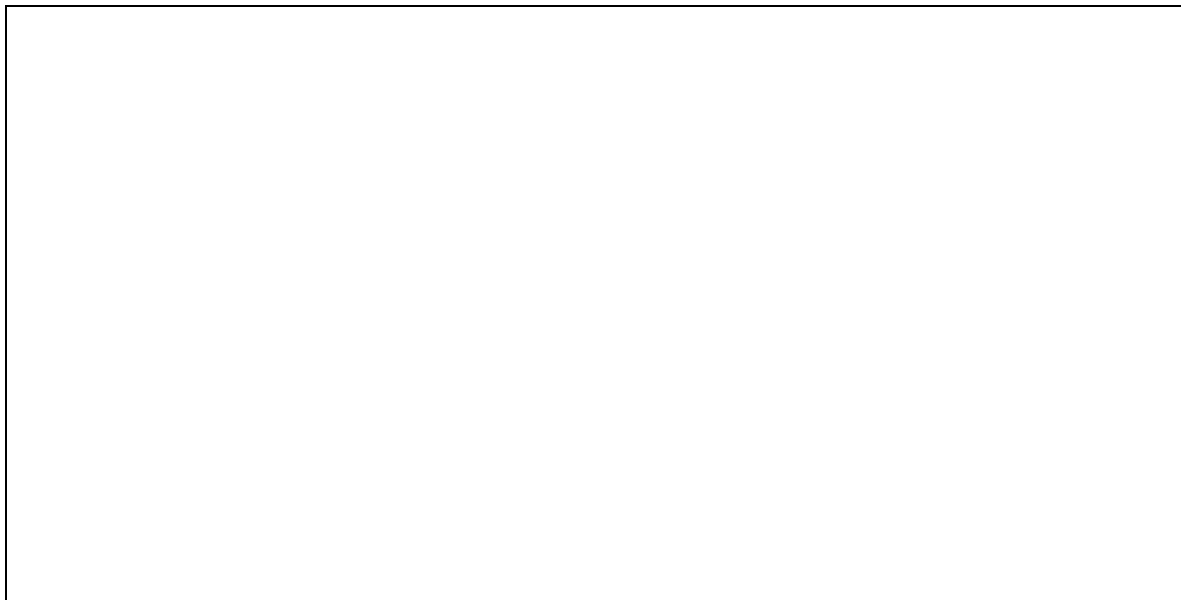
- (c) Write the oxidation and reduction half-equations and overall redox reaction for this process, assuming acidic conditions. (6 marks)

Oxidation half-equation	
Reduction half-equation	
Overall redox equation	

In the human body, benzoic acid reacts with the α -amino acid glycine, to form hippuric acid. The hippuric acid is then excreted in urine.

To form the hippuric acid, benzoic acid and glycine react and are joined by an amide bond (amide link). This reaction also produces a molecule of water.

- (e) Draw the chemical structure of hippuric acid. (2 marks)



End of questions

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