



Rossmoyne Senior High School

ATAR course examination

Question/Answer booklet

Semester 2 2020

CHEMISTRY

Please place your student identification label in this box

WA Student number: In figures

In words **MARKING**
KEY _____

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TIME ALLOWED FOR THIS PAPER

Reading time before commencing work:
Working time for the paper:

ten minutes
three hours

Number of additional
answer booklets used
(if applicable)

MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

To be provided by the supervisor:

This Question/Answer Booklet
Multiple-choice Answer Sheet
Chemistry Data Booklet

To be provided by the candidate:

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener,
eraser, correction tape/fluid, ruler, highlighters

Special items: non-programmable calculators approved for use in the WACE
examinations

IMPORTANT NOTE TO CANDIDATES

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

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of examination
Section One Multiple-choice	25	25	50	/ 25	/ 25
Section Two Short answer	8	8	60	/ 83	/ 35
Section Three Extended answer	5	5	70	/ 93	/ 40
					/ 100

Instructions to candidates

- Write your answers in this Question/Answer booklet preferably using a blue/black pen. Do not use erasable or gel pens.
- 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. Do not use erasable or gel pens. If you make a mistake, place a cross through that square then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

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

- When calculating numerical answers, show your working or reasoning clearly. Your working should be in sufficient detail to allow your answer to be checked readily and for marks to be awarded for reasoning. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.
- You must be careful to confine your answers to the specific questions asked and to follow any instructions that are specific to a particular question.
- 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.
- The Chemistry Data booklet is not to be handed in with your Question/Answer booklet.

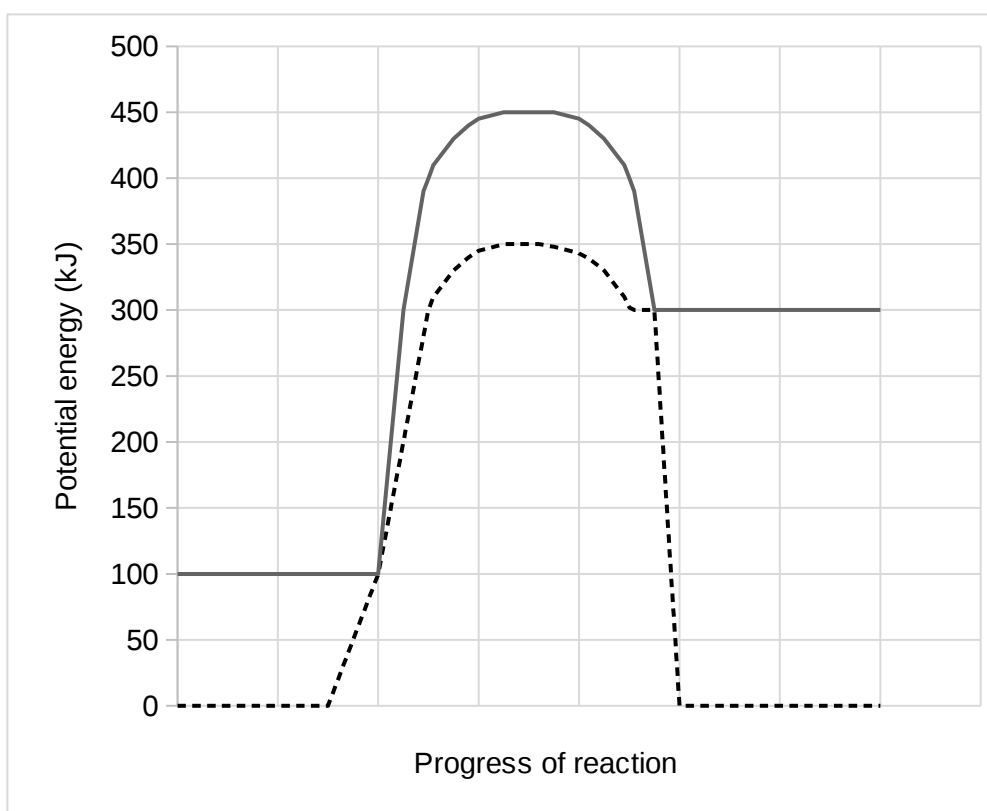
Section One: Multiple-choice

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.

Questions 1 and 2 refer to the energy profile diagram below.



- The reaction represented by the **solid** line
 - is exothermic.
 - has an activation energy of +200 kJ.
 - has an enthalpy change of +350 kJ mol⁻¹.
 - involves a gain in energy by the system.**
- When compared to the reaction represented by the solid line, which of the following statements is **not** correct regarding the reaction represented by the **dashed** line?
 - It would occur at a faster rate.
 - It would have a lower enthalpy change.**
 - It would have a lower activation energy.
 - It involves an alternate reaction pathway.

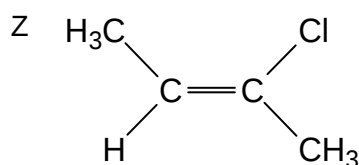
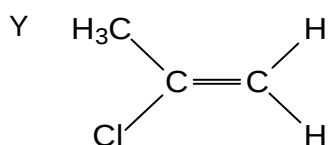
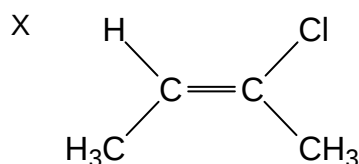
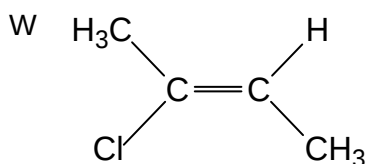
3. Determine the pattern for the oxidation number of **manganese** in the following compounds.



Select the compound that would continue this pattern.

- (a) Mn₂O₇
 (b) MnF₃
 (c) Mn₂O₃
 (d) **K₂MnO₄**

4. Which two molecules are cis/trans isomers of each other?



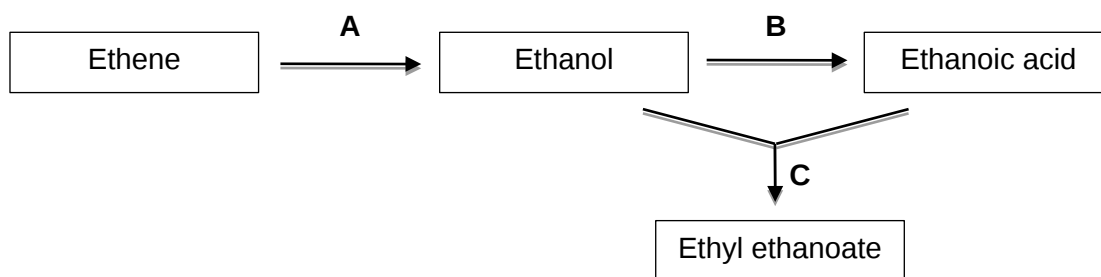
- (a) **X and Z**
 (b) X and Y
 (c) W and Y
 (d) W and Z
5. Which of the following polymers is able to form hydrogen bonds between its chains?
- (a) Polyethene
 (b) Polytetrafluoroethene
 (c) **Nylon 6,6**
 (d) Polyethylene terephthalate

Questions 6, 7 and 8 refer to the data shown in the table below.

Acid	K _a at 25 °C	K _a at 50 °C
Hydrofluoric acid (HF)	7.2×10^{-4}	9.1×10^{-4}
Ethanoic acid (CH ₃ COOH)	1.8×10^{-5}	3.5×10^{-5}

6. Based on the table above which one of the following statements is true?
- (a) A solution of CH₃COOH will always have a higher pH than a solution of HF.
 - (b) A solution of CH₃COOH will always have a lower pH than a solution of HF.
 - (c) A 0.1 mol L⁻¹ solution of CH₃COOH has a higher pH than a 0.1 mol L⁻¹ solution of HF.**
 - (d) A 0.1 mol L⁻¹ solution of CH₃COOH has a lower pH than a 0.1 mol L⁻¹ solution HF.
7. Consider the two conclusions made regarding the data above.
- I. Ethanoic acid is a stronger acid than hydrofluoric acid.
 - II. The ethanoate ion is a stronger base than the fluoride ion.
- Which of the statements above is/are correct?
- (a) statement I only
 - (b) statement II only**
 - (c) statements I and II
 - (d) neither statement is true
8. Based on the information in the table, which one of the following conclusions could be made concerning the heating of the acids?
- (a) The ionisation of the acids is an endothermic process and the pH of the solutions will decrease.**
 - (b) The ionisation of the acids is an exothermic process and the pH of the solutions will decrease.
 - (c) The ionisation of the acids is an endothermic process and the pH of the solutions will increase.
 - (d) The ionisation of the acids is an exothermic process and the pH of the solutions will increase.

Questions 9 and 10 refer to the chemical synthesis reaction sequence shown below.



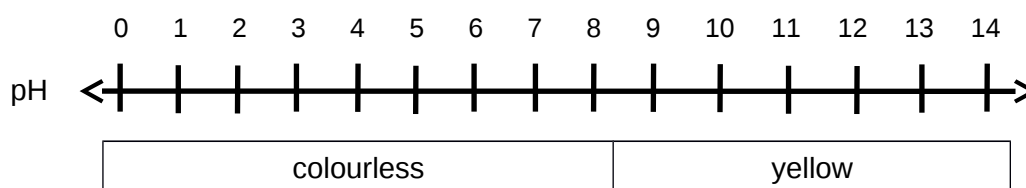
9. Name the processes occurring at A, B and C.

	A	B	C
(a)	hydration	oxidation	esterification
(b)	oxidation	addition	esterification
(c)	addition	hydration	hydrolysis
(d)	hydrogenation	oxidation	dehydration

10. Which catalyst needs to be added at A, B and C for the reactions to proceed as indicated?

- (a) **H₂SO₄**
 (b) H₂O
 (c) NaOH
 (d) H₂O₂

11. The indicator M-Nitrophenol is used for an acid-base titration.

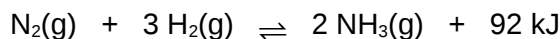


Select the option below that lists the appropriate solution in each flask and the corresponding colour change that would be observed.

	Burette	Conical flask	Colour change
(a)	KOH(aq)	CH₃COOH(aq)	colourless to yellow
(b)	HCl(aq)	NH ₃ (aq)	yellow to colourless
(c)	HF(aq)	NaOH(aq)	colourless to yellow
(d)	Ba(OH) ₂ (aq)	HNO ₃ (aq)	yellow to colourless

Questions 12 and 13 relate to the Haber process.

The Haber process can be represented by the chemical equation below.



12. Periodically, the ammonia is removed from the reaction chamber. What **immediate** effect would this have on the rate of reaction?

- (a) The forward reaction rate would increase.
- (b) The reverse reaction rate would increase.
- (c) The forward reaction rate would decrease.
- (d) The reverse reaction rate would decrease.**

13. Which of the following conditions will maximise **both** the rate of formation and equilibrium yield of ammonia?

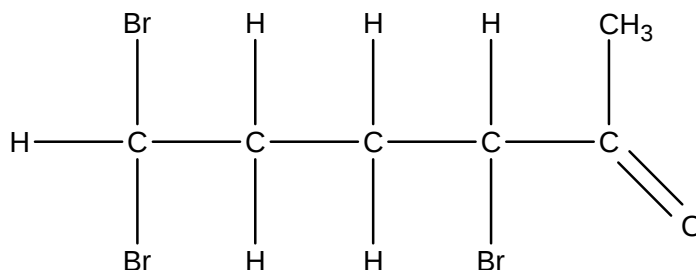
- (i) An increased concentration of reactants
- (ii) An increased pressure caused by a decrease in volume
- (iii) An increased temperature
- (iv) Addition of a catalyst

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

14. During the process of electrorefining impure (blister) copper, several different metal impurities are removed. Which statement is **incorrect** regarding the various metal impurities found in blister copper?

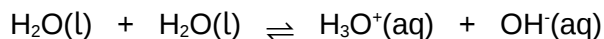
- (a) Ag would be found in the anode slime.
- (b) Zn would be oxidised to $\text{Zn}^{2+}(\text{aq})$.
- (c) Ni would be found in the anode slime.**
- (d) Fe would be oxidised to $\text{Fe}^{2+}(\text{aq})$.

15. Select the correct IUPAC name for the molecule shown below.

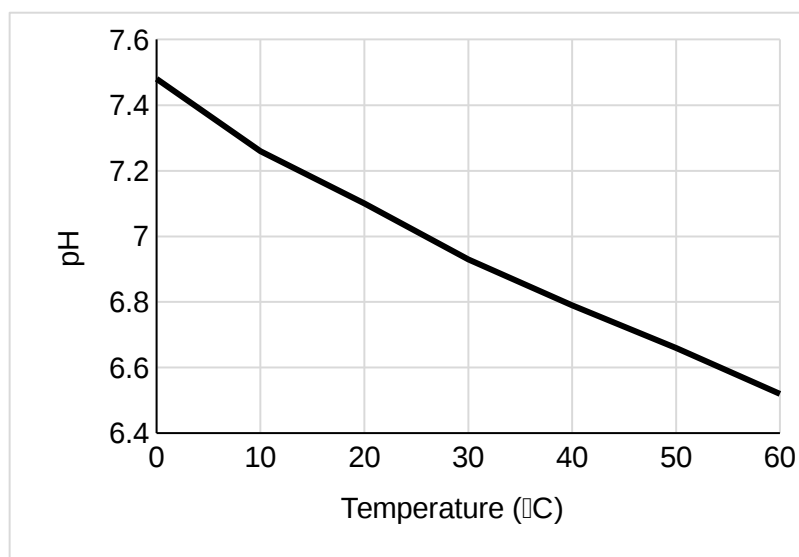


- (a) 2,5,5-tribromo-1-methylpentanal.
- (b) 1,1,4-tribromohexan-5-one.
- (c) 3,6,6-tribromohexan-2-al.
- (d) 3,6,6-tribromohexan-2-one.**

16. A chemist carried out an experiment to investigate the auto-ionisation of water.

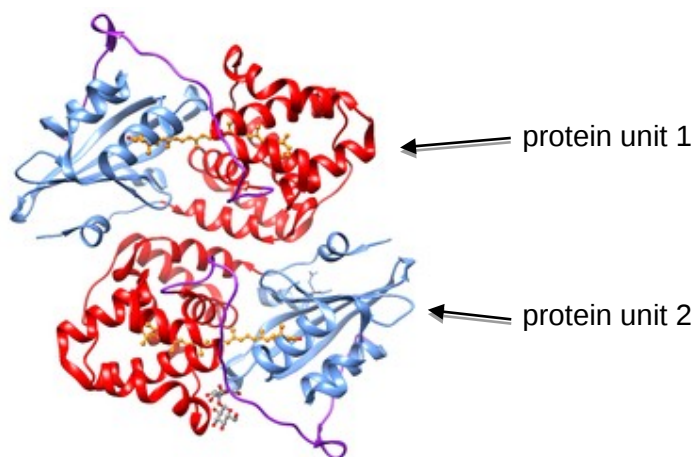


The data collected by the chemist is shown in the graph below.



Which of the following hypotheses is **not** directly related to the data collected in this experiment?

- (a) An increase in water temperature will favour the forward reaction.
 - (b) An increase in water temperature will increase the forward reaction rate.**
 - (c) The auto-ionisation of water is exothermic.
 - (d) The concentration of $\text{H}_3\text{O}^+(\text{aq})$ in water is temperature-dependant.
17. The following diagram has been taken from the Protein Data Bank (PDB). It shows the structure of the 'orange carotenoid protein' which is a dimer consisting of two proteins.



This type of 'ribbon structure' provides **least** information about the

- (a) primary structure of the protein.**
- (b) secondary structure of the protein.
- (c) tertiary structure of the protein.
- (d) protein-protein interactions.

Questions 18 and 19 refer to the information in the table below.

	Boiling point	Solubility in water at 20 °C
Butan-1-ol	118 °C	7.7 g / 100 mL
Octan-1-ol	195 °C	0.1 g / 100 mL

18. The boiling point of octan-1-ol is higher than butan-1-ol because octan-1-ol has

- (a) **stronger dispersion forces.**
- (b) stronger dipole-dipole forces.
- (c) stronger hydrogen bonds.
- (d) stronger ion-dipole forces.

19. The aqueous solubility of butan-1-ol is greater than octan-1-ol because butan-1-ol has

- (a) more significant dispersion forces.
- (b) more significant dipole-dipole forces.
- (c) **more significant hydrogen bonds.**
- (d) more significant ion-dipole forces.

Question 20 and 21 refer to the information below

Biodiesel is normally produced from vegetable oils, animal fats and waste cooking oils through a transesterification process. At present, biodiesel is mainly produced using alkaline catalysts such as NaOH and KOH. An alternative method to produce biodiesel has been developed using lipase instead of the alkaline catalysts.

20. A list of **potential** benefits of using lipase instead of NaOH as a catalyst is written below.

- I. reduction in unwanted saponification
- II. improved quality of glycerol by-products requiring less purification
- III. faster rate of reaction

Which one of the following lists the **true benefits** of using lipase instead of NaOH solution?

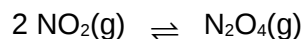
- (a) I only
- (b) **I and II only**
- (c) I and III only
- (d) II and III

21. Which one of the following statements is **NOT** true of lipase?

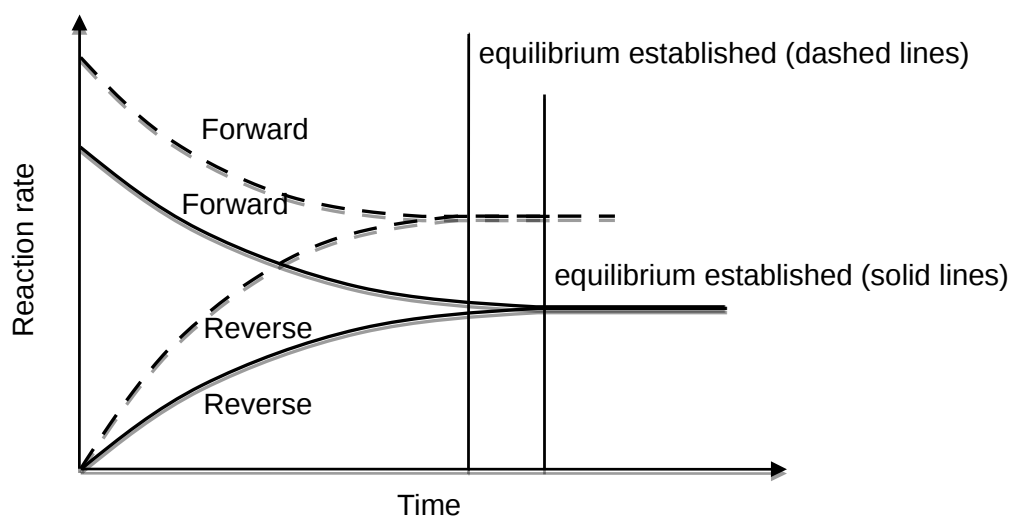
- (a) Lipase is a protein.
- (b) Lipase has high reusability.
- (c) Lipase reduces the need for high operating temperatures.
- (d) **Lipase functions best between 70 and 80 °C.**

22. Soaps are less effective than detergents in hard water, because the soap ion
- does not contain a charged group.
 - only contains a short non-polar region.
 - neutralises hard water.
 - precipitates $\text{Ca}^{2+}(\text{aq})$ ions in hard water.**

23. Consider the following gaseous equilibrium system;



The **solid** lines on the following graph represent the establishment of equilibrium under a particular set of conditions for this system.



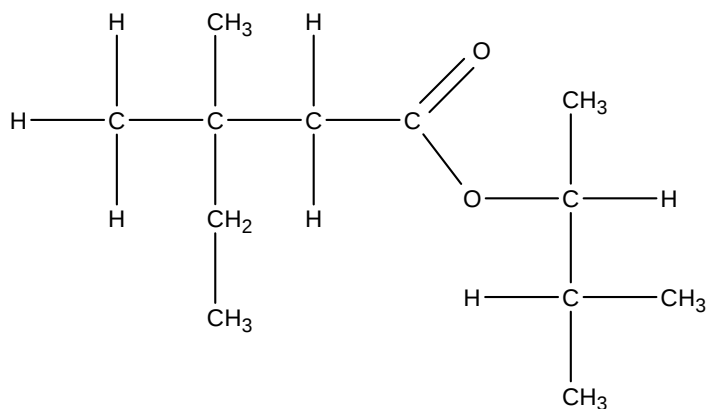
Which of the following changes to this system would **not** result in the establishment of a new equilibrium as indicated by the **dashed** lines?

- An increase in the temperature of the system.
 - A decrease in the volume of the system.
 - The addition of helium gas to the system.**
 - The addition of an appropriate catalyst.
24. The wet corrosion of iron (Fe) occurs in the presence of oxygen gas (O_2) and water (H_2O). The iron reacts to become iron(II) ions, $\text{Fe}^{2+}(\text{aq})$, whilst the water and oxygen gas form hydroxide ions, $\text{OH}^-(\text{aq})$. The iron(II) ions and hydroxide ions then precipitate to form iron(II) hydroxide, $\text{Fe}(\text{OH})_2(\text{s})$. Over time, this precipitate forms iron(III) hydroxide, $\text{Fe}(\text{OH})_3(\text{s})$ which then dehydrates to form iron(III) oxide, $\text{Fe}_2\text{O}_3(\text{s})$, which is commonly called rust.

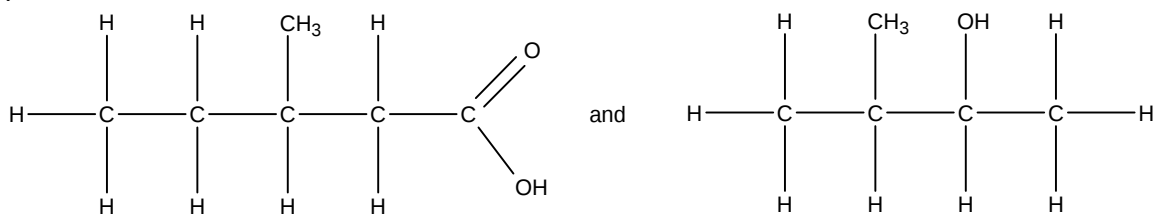
Which of the following statements is **not** correct, regarding the corrosion process described?

- The oxidation number of O_2 is decreased.
- The solid Fe loses electrons.
- The H_2O acts as the oxidising agent.**
- The precipitation of $\text{Fe}(\text{OH})_2$ is not a redox process.

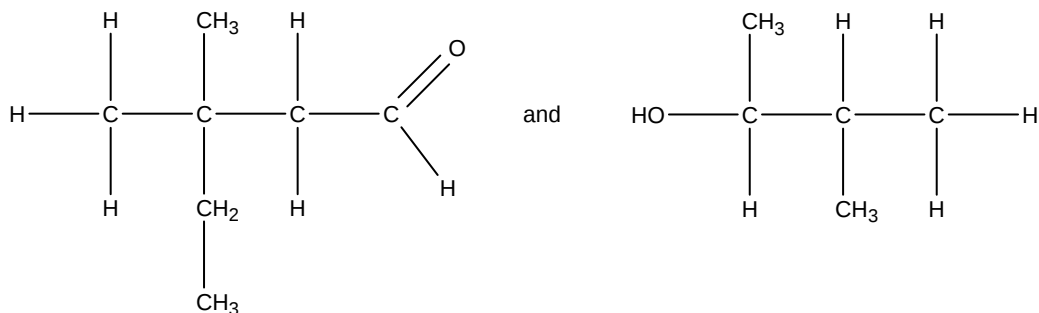
25. Which pair of substances could react, in the presence of an appropriate catalyst, to form the compound below?



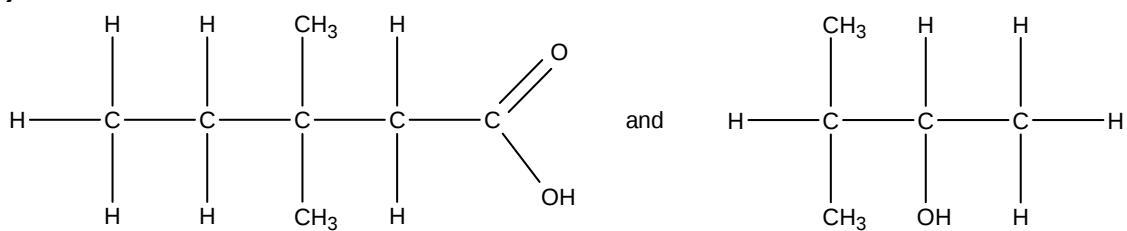
(a)



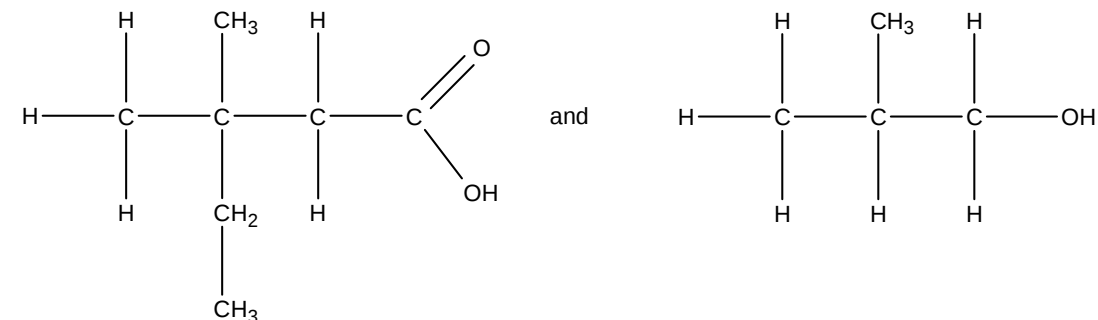
(b)



(c) **THIS ONE:**



(d)



End of Section One



Rossmoyne Senior High School

ATAR course examination

Semester 2 2020

Multiple-choice Answer Sheet

Name: _____

INSTRUCTIONS

For each question shade the box to indicate your answer.
Use **only** a blue or black **pen** to shade the boxes.

For example, if b is your answer:

a b c d

If you make a mistake, place a cross through that square and shade your new answer. **Do not** erase or use correction fluid/tape.

For example, if b is a mistake and d is your answer:

a b c d

If you then want to use your first answer b, cross out d and then circle b.

a b c d

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

1	a <input type="checkbox"/>	b <input type="checkbox"/>	c <input type="checkbox"/>	d <input checked="" type="checkbox"/>
2	a <input type="checkbox"/>	b <input checked="" type="checkbox"/>	c <input type="checkbox"/>	d <input type="checkbox"/>
3	a <input type="checkbox"/>	b <input type="checkbox"/>	c <input type="checkbox"/>	d <input checked="" type="checkbox"/>
4	a <input checked="" type="checkbox"/>	b <input type="checkbox"/>	c <input type="checkbox"/>	d <input type="checkbox"/>
5	a <input type="checkbox"/>	b <input type="checkbox"/>	c <input checked="" type="checkbox"/>	d <input type="checkbox"/>

11	a <input checked="" type="checkbox"/>	b <input type="checkbox"/>	c <input type="checkbox"/>	d <input type="checkbox"/>
12	a <input type="checkbox"/>	b <input type="checkbox"/>	c <input type="checkbox"/>	d <input checked="" type="checkbox"/>
13	a <input checked="" type="checkbox"/>	b <input type="checkbox"/>	c <input type="checkbox"/>	d <input type="checkbox"/>
14	a <input type="checkbox"/>	b <input type="checkbox"/>	c <input checked="" type="checkbox"/>	d <input type="checkbox"/>
15	a <input type="checkbox"/>	b <input type="checkbox"/>	c <input type="checkbox"/>	d <input checked="" type="checkbox"/>

21	a <input type="checkbox"/>	b <input type="checkbox"/>	c <input type="checkbox"/>	d <input checked="" type="checkbox"/>
22	a <input type="checkbox"/>	b <input type="checkbox"/>	c <input type="checkbox"/>	d <input checked="" type="checkbox"/>
23	a <input type="checkbox"/>	b <input type="checkbox"/>	c <input checked="" type="checkbox"/>	d <input type="checkbox"/>
24	a <input type="checkbox"/>	b <input type="checkbox"/>	c <input checked="" type="checkbox"/>	d <input type="checkbox"/>
25	a <input type="checkbox"/>	b <input type="checkbox"/>	c <input checked="" type="checkbox"/>	d <input type="checkbox"/>

6	a <input type="checkbox"/>	b <input type="checkbox"/>	c <input checked="" type="checkbox"/>	d <input type="checkbox"/>
7	a <input type="checkbox"/>	b <input checked="" type="checkbox"/>	c <input type="checkbox"/>	d <input type="checkbox"/>
8	a <input checked="" type="checkbox"/>	b <input type="checkbox"/>	c <input type="checkbox"/>	d <input type="checkbox"/>
9	a <input checked="" type="checkbox"/>	b <input type="checkbox"/>	c <input type="checkbox"/>	d <input type="checkbox"/>
10	a <input checked="" type="checkbox"/>	b <input type="checkbox"/>	c <input type="checkbox"/>	d <input type="checkbox"/>

16	a <input type="checkbox"/>	b <input checked="" type="checkbox"/>	c <input type="checkbox"/>	d <input type="checkbox"/>
17	a <input checked="" type="checkbox"/>	b <input type="checkbox"/>	c <input type="checkbox"/>	d <input type="checkbox"/>
18	a <input checked="" type="checkbox"/>	b <input type="checkbox"/>	c <input type="checkbox"/>	d <input type="checkbox"/>
19	a <input type="checkbox"/>	b <input type="checkbox"/>	c <input checked="" type="checkbox"/>	d <input type="checkbox"/>
20	a <input type="checkbox"/>	b <input checked="" type="checkbox"/>	c <input type="checkbox"/>	d <input type="checkbox"/>

Section Two: Short answer

35% (83 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

(12 marks)

Consider 0.05 mol L⁻¹ solutions of sodium hydrogencarbonate, potassium hydrogensulfate and lithium phosphate. The table below lists these salts, along with K_c values for the corresponding hydrolysis reactions.

0.05 mol L ⁻¹ solution	Hydrolysis equation	K _c of hydrolysis reaction
NaHCO ₃ (aq)	$\text{HCO}_3^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_2\text{CO}_3(\text{aq}) + \text{OH}^-(\text{aq})$	2.4×10^{-8}
KHSO ₄ (aq)	$\text{HSO}_4^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{SO}_4^{2-}(\text{aq}) + \text{H}_3\text{O}^+(\text{aq})$	1.2×10^{-2}
Li ₃ PO ₄ (aq)	$\text{PO}_4^{3-}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{HPO}_4^{2-}(\text{aq}) + \text{OH}^-(\text{aq})$	2.3×10^{-2}

1 mark each correct hydrolysis equation (states not required)

- (a) Complete the table above, by writing the hydrolysis equation that would take place in each solution. (3 marks)
- (b) Rank these solutions in order from lowest to highest pH. (3 marks)

Lowest pH		Highest pH
KHSO₄	NaHCO₃	Li₃PO₄

Description	Mark
All correct	3
-1 mark for each species in wrong order	

The pH of a lithium carbonate solution, $\text{Li}_2\text{CO}_3(\text{aq})$, was tested with a pH meter and determined to be 10.3.

A chemistry student had 8.50 mL of $0.0500 \text{ mol L}^{-1}$ barium hydroxide solution, $\text{Ba}(\text{OH})_2(\text{aq})$. They wanted to dilute the barium hydroxide so that it would have the same pH as the lithium carbonate solution.

- (c) Calculate the volume of water the student would need to add to the barium hydroxide solution, to produce the same pH as the lithium carbonate. (6 marks)

For a solution of pH = 10.3;

$$\begin{aligned} [\text{H}^+] &= 10^{-\text{pH}} && \text{(1 mark - Formula)} \\ &= 10^{-10.3} \\ &= 5.01187 \times 10^{-11} \text{ mol L}^{-1} && \text{(1 mark)} \end{aligned}$$

$$\begin{aligned} [\text{OH}^-] &= \text{kw} / [\text{H}^+] = (1.0 \times 10^{-14}) / (5.01187 \times 10^{-11}) \\ &= 1.99526 \times 10^{-4} \text{ mol L}^{-1} && \text{(1 mark)} \end{aligned}$$

Therefore want (using barium hydroxide concentrations);

$$\begin{aligned} c(\text{Ba}(\text{OH})_2) &= \frac{1}{2} \times [\text{OH}^-] \\ &= \frac{1}{2} \times 1.99526 \times 10^{-4} \\ &= 9.9763 \times 10^{-5} \text{ mol L}^{-1} && \text{(1 mark)} \end{aligned}$$

Using $c_1V_1 = c_2V_2$;

$$\begin{aligned} V_2 &= c_1V_1 / c_2 \\ &= (0.050 \times 0.0085) / 9.9763 \times 10^{-5} \\ &= 4.2601 \text{ L (final diluted volume)} && \text{(1 mark)} \end{aligned}$$

(Can also calculate using $[\text{OH}^-]$ to determine final volumes, above two marks)

$$\begin{aligned} V(\text{H}_2\text{O}) &= V_2 - V_1 = 4.2601 - 0.0085 \\ &= 4.252 \text{ L needs to be added} \\ &= 4.25 \text{ L (3 SF)} && \text{(1 mark)} \end{aligned}$$

OR

For a solution of pH = 10.3;

$$\begin{aligned} [\text{H}^+] &= 10^{-\text{pH}} && \text{(1 mark - Formula)} \\ &= 10^{-10.3} \\ &= 5.01187 \times 10^{-11} \text{ mol L}^{-1} && \text{(1 mark)} \end{aligned}$$

$$\begin{aligned} [\text{OH}^-] &= \text{kw} / [\text{H}^+] = (1.0 \times 10^{-14}) / (5.01187 \times 10^{-11}) \\ &= 1.99526 \times 10^{-4} \text{ mol L}^{-1} && \text{(1 mark)} \end{aligned}$$

In the $\text{Ba}(\text{OH})_2$ solution;

$$\begin{aligned} n(\text{OH}^-) &= 2 \times n(\text{Ba}(\text{OH})_2) = 2 \times 0.050 \times 0.0085 \\ &= 0.00085 \text{ mol} && \text{(1 mark)} \end{aligned}$$

If desired OH^- concentration is $1.99526 \times 10^{-4} \text{ mol L}^{-1}$

$$\begin{aligned} V(\text{OH}^-) &= n/c \\ &= 0.00085 / 1.99526 \times 10^{-4} \\ &= 4.2601 \text{ L} && \text{(1 mark)} \end{aligned}$$

$$\begin{aligned} V(\text{H}_2\text{O}) &= V_{\text{final}} - V_{\text{initial}} = 4.2601 - 0.0085 \\ &= 4.252 \text{ L needs to be added} \\ &= 4.25 \text{ L} && \text{(1 mark)} \end{aligned}$$

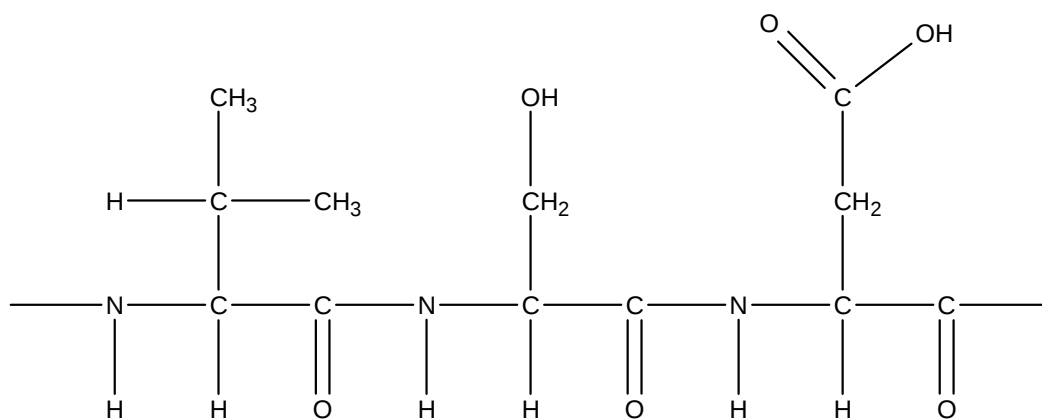
(Should be 3 S.F. but no penalty applied for this question)

Question 27

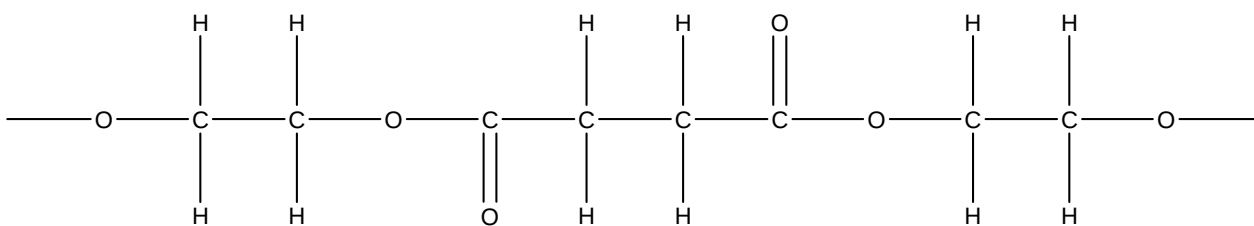
(9 marks)

Consider the three (3) different polymer fragments shown below.

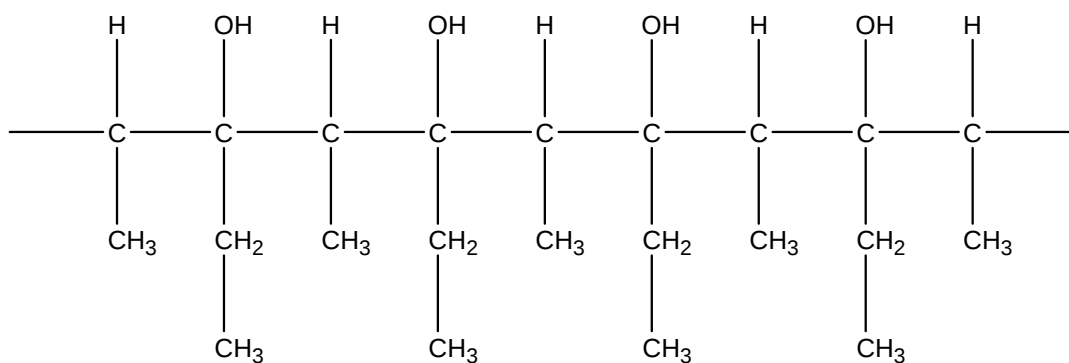
A



B



C



- (a) Classify the polymers as having been formed by addition or condensation polymerisation by writing the letters A, B and C in the appropriate column in the table. (3 marks)

Addition polymerisation	Condensation polymerisation
C	A B

1 mark for each correct identification

- (b) Draw the monomer(s) used to form each of these polymers. (6 marks)

A	<p style="text-align: center;">(1 mark each for a total of 3 marks)</p>
B	<p style="text-align: center;">(1 mark each for a total of 2 marks)</p>
C	<p style="text-align: center;">(1 mark)</p>

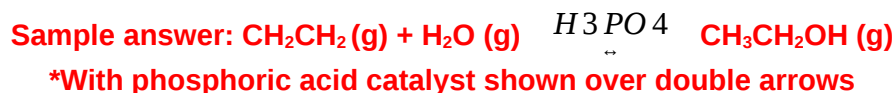
Question 28

(7 marks)

Ethanol is a flammable liquid that can be used as a fuel for cars. One method for producing ethanol is by first producing ethene. Ethene is obtained by the cracking of long hydrocarbon chains found in crude oil. Ethene is then converted to ethanol.

(a) Write a balanced chemical equation to show the production of ethanol from ethene.

(3 marks)



Description	Marks
Correct reactants: $\text{CH}_2\text{CH}_2 + \text{H}_2\text{O}$	1
Double arrow used and a balanced chemical equation	1
Phosphoric acid catalyst shown	1
Total	3

(b) Another method for producing ethanol is from the fermentation of sugar from sugar cane. The method is described below.

- Sugar cane plants are grown as a crop on farmland.
- Sugar cane plants are crushed and soaked in water to produce a sugar solution.
- The sugar solution is separated from the plant material.
- Yeast is added to the sugar solution and fermented.
- The yeast is separated from the solution of water and ethanol.
- Ethanol is separated from water by fractional distillation.

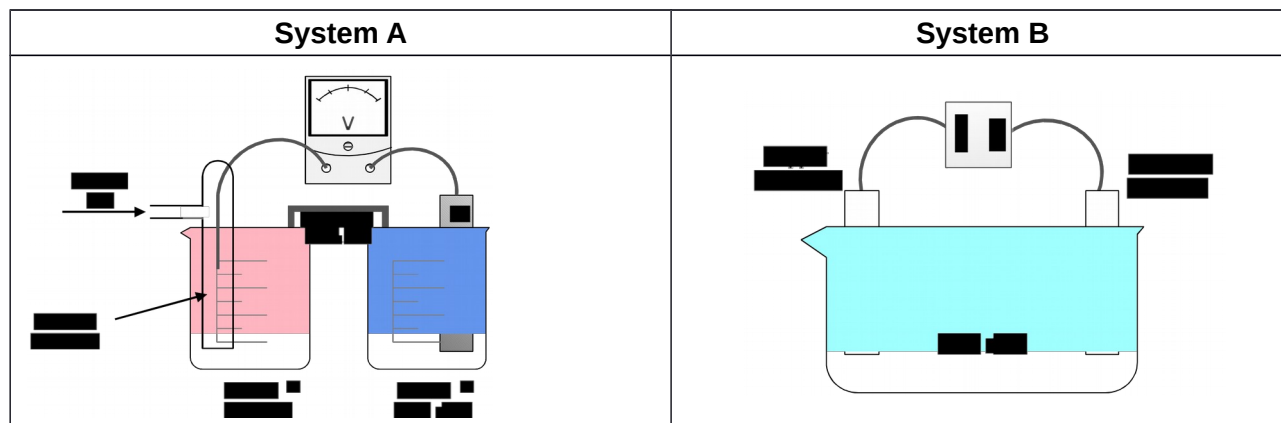
Describe the advantages of producing ethanol by fermentation compared with ethanol production using crude oil. Your answer must include environmental advantages, in terms of sustainability, local resources, economics and environmental impacts. (4 marks)

Description	Marks
It is more sustainable – The fermentation process uses renewable resources unlike hydration of ethene which is derived from non-renewable fossil fuels	1
Reaction conditions are safer for fermentation process (lower temperatures, pressures and less toxic chemicals required)	1
Ethanol production makes use of local resources in terms of local crops which provides work and income for the local communities/economies.	1
Lower operating temperatures for fermentation method reduces energy requirements and thus reduces need to burn fossil fuels to generate required heat and in turn reduces carbon dioxide emissions.	1
<i>* Other correct answers can also be used.</i>	
Total	4

Question 29

(13 marks)

Consider the two systems below operating at standard conditions.



- (a) Contrast the **function** of these two systems by listing three key differences between system A and B (3 marks)

Description (Any 3 from below)	Marks
Other correct statements providing difference between an electrolytic cell and a galvanic cell can be included.	
System A converts chemical energy into electrical energy whilst System B converts electrical energy into chemical energy.	1
System A produces electrical energy (a voltage) and System B requires electrical energy .	1
System A involves a spontaneous redox reaction System B is not a spontaneous reaction.	1
System A is galvanic and system B is electrolytic	1
Total	3

- (b) Label the anode in each system on the diagrams above. (2 marks)

Description	Marks
System A – Copper electrode clearly labelled	1
System B – Platinum electrode clearly labelled	1
Total	2

- (c) Write the anode half equation for each system (2 marks)

Description	Marks
System A – $\text{Cu(s)} \rightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{e}^{-}$	1
System B – $2\text{H}_2\text{O}(\text{l}) \rightarrow \text{O}_2(\text{g}) + 4\text{H}^{+}(\text{aq}) + 4\text{e}^{-}$	1
Total	2
Note: Despite data sheet not having E° for pure water H_2O will be oxidised before Cl^- at a lower supplied voltage (accept both??)	

- (d) State three observations what would be made as 'System B' operates. (3 marks)

Description	Marks
Colourless gas (bubbles) observed at the Pt electrode.	1
Copper electrode increases in mass/size.	1
Blue colour of the electrolyte fades over time.	1
Total	3
Note: if we accept Cl⁻ being oxidised we could observe a green gas at the Pt electrode???	

- (e) Explain why silver nitrate solution would not be suitable for the salt bridge in 'System A'. (3 marks)

Description	Marks
The insoluble precipitate AgCl will form	1
This will prevent the flow of ions/charge along the salt bridge	1
The result will be that the cell will no longer produce a voltage	1
Total	3

Question 30

(9 marks)

Telluric acid has the formula H_6TeO_6 . In solid form, it is found as white crystals. These crystals dissolve in water to produce hydronium ions, $\text{H}_3\text{O}^+(\text{aq})$. The K_a values for telluric acid at 18°C are given below.

$$K_{a1} = 2.09 \times 10^{-8} \qquad K_{a2} = 1.00 \times 10^{-11}$$

- (a) Classify telluric acid as strong or weak (circle your choice). Justify your answer. (2 marks)

strong OR weak

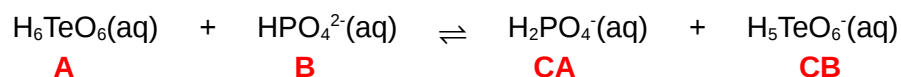
Description	Marks
Weak circled	1
Low K_a value indicates a small degree of ionisation in water / indicates the ratio of ions to molecules in the acid solution is low	1
Total	2

- (b) Classify telluric acid as monoprotic or polyprotic (circle your choice). Justify your answer. (2 marks)

monoprotic OR polyprotic

Description	Marks
Polyprotic circled	1
Two K_a values indicates more than one acidic / ionisable hydrogen / more than one proton donated per molecule	1
Total	2

- (c) Label and link the conjugate acid-base pairs in the following equation. (2 marks)



Telluric acid can be produced by the oxidation of solid tellurium dioxide, $\text{TeO}_2(\text{s})$, by hydrogen peroxide solution. In this reaction, hydrogen peroxide forms water.

- (d) Write the oxidation and reduction half-equations and the overall redox equation for this reaction, assuming acidic conditions. (3 marks)

Oxidation half-equation	$\text{TeO}_2 + 4 \text{H}_2\text{O} \rightarrow \text{H}_6\text{TeO}_6 + 2 \text{H}^+ + 2 \text{e}^-$
Reduction half-equation	$\text{H}_2\text{O}_2 + 2 \text{H}^+ + 2 \text{e}^- \rightarrow 2 \text{H}_2\text{O}$
Overall redox equation	$\text{TeO}_2 + \text{H}_2\text{O}_2 + 2 \text{H}_2\text{O} \rightarrow \text{H}_6\text{TeO}_6$

1 mark for each correct equation. No follow through marks for Overall given incorrect half-equation(s)

Question 31

(8 marks)

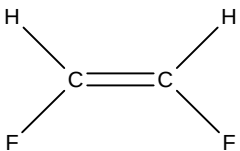
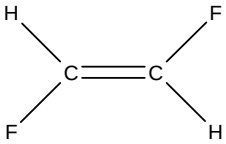
- (a) Give the IUPAC names for isomers of
- $C_3H_6O_2$
- matching each description below. (2 marks)

	IUPAC Name
A sweet or fruity smelling liquid	Methyl ethanoate / ethyl methanoate
A weak electrolyte with a pH below 7	Propanoic acid

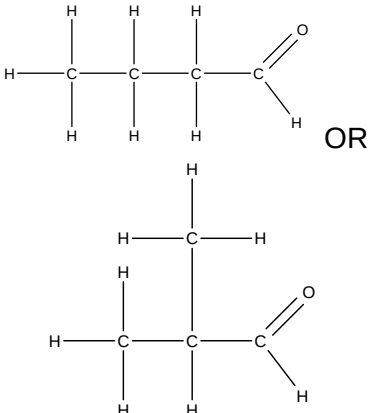
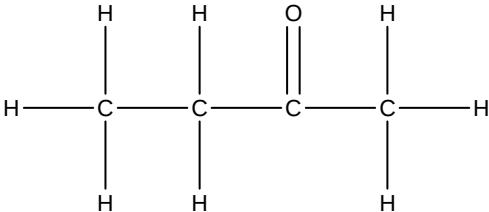
- (b) Give the IUPAC names for isomers of
- $C_5H_{12}O$
- matching each description below. (2 marks)

	IUPAC Name
A primary alcohol	Pentan-1-ol / 2-methylbutan-1-ol / 3-methylbutan-1-ol 2,2-dimethyl-1-propanol
A tertiary alcohol	2-methylbutan-2-ol

- (c) Draw full structural diagrams for isomers of
- $C_2H_2F_2$
- matching each description below. Include
- all**
- bonds and
- all**
- atoms. (2 marks)

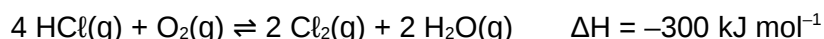
The <i>cis</i> geometric isomer	The <i>trans</i> geometric isomer
	

- (d) Draw full structural diagrams for isomers of C_4H_8O matching each description below. Include **all** bonds and **all** atoms. (2 marks)

A compound that can be oxidised by acidified $KMnO_4$ solution	A compound that cannot be oxidised by acidified $KMnO_4$ solution
	

Question 32**(18 marks)**

Consider the following system in a closed 1.00 L container at equilibrium.



- (a) Compare and contrast the terms 'open system' and 'closed system.' (2 marks)

Description	Marks
Open systems allow both matter and energy to be exchanged with surroundings	1
Whereas closed systems allow only energy to be exchanged with surroundings (not matter)	1
Total	2

- (b) Explain the meaning of the term *dynamic equilibrium*. (2 marks)

Description	Marks
The rate of the forward reaction equals the rate of the reverse reaction.	1
Since the two rates are equal, it looks like nothing is happening, but in reality, the reactions (forward and reverse reactions) are continuously occurring.	1
Total	2
Note: No macroscopic observations	

- (c) Apply collision theory to the forward and reverse reactions to explain the effect on the yield of the reaction above by removing oxygen gas from the closed system. (4 marks)

Description	Marks
Removing oxygen gas decreases its concentration	1
Frequency of collisions between reactants O ₂ (g) and HCl(g) molecules decreases. Frequency of collisions between products Cl ₂ and H ₂ O unaffected by change.	1
As a result, the rate of the forward reaction decreases whilst the reverse reaction remains initially unchanged.	1
Now the reverse reaction is faster than the forward reaction so products are consumed faster than produced, hence the yield of products decreases.	1
Total	4

- (d) The system above has an equilibrium constant value much greater than 1. Based on this information, describe the appearance of the system above at equilibrium. (2 marks)

Description	Marks
Knowing that $K > 1$ would indicate at equilibrium having more products than reactants.	1
The gaseous mixture would appear an intense greenish yellow colour and would remain constant colour at equilibrium.	1
Total	2

- (e) Complete the table below by circling the correct option, describing the equilibrium after sufficient time has elapsed from the imposed change. (8 marks)

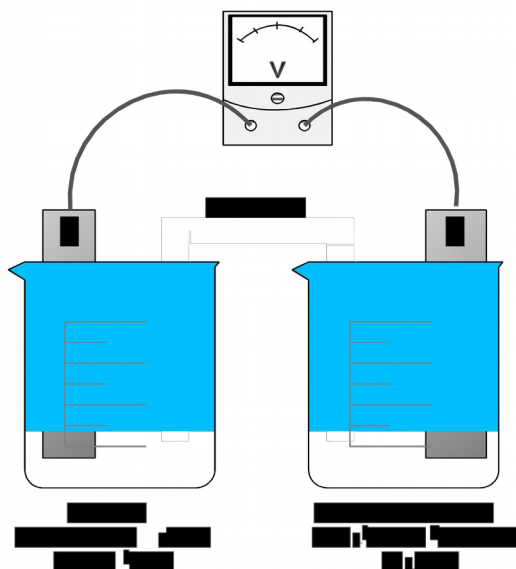
Imposed change	Effect on appearance of the system	Effect on rate of the forward reaction
Decreasing the volume of the vessel	<p>Appears more greenish yellow</p> <p>Appears less greenish yellow</p> <p>No observable change</p>	<p>Faster</p> <p>Slower</p> <p>No Effect</p>
Addition of a catalyst	<p>Appears more greenish yellow</p> <p>Appears less greenish yellow</p> <p>No observable change</p>	<p>Faster</p> <p>Slower</p> <p>No Effect</p>
Increasing the temperature of the system	<p>Appears more greenish yellow</p> <p>Appears less greenish yellow</p> <p>No observable change</p>	<p>Faster</p> <p>Slower</p> <p>No Effect</p>
Removing water vapour	<p>Appears more greenish yellow</p> <p>Appears less greenish yellow</p> <p>No observable change</p>	<p>Faster</p> <p>Slower</p> <p>No Effect</p>

Description	Marks
See sample answers above. 1 mark per correct box.	8
Total	8

Question 33

(7 marks)

Consider the galvanic cell below using platinum electrodes X and Y.



Upon analysis, it is found that as the cell above discharges the bromate ion (BrO_3^-) is converted to bromine (Br_2) in the half cell connected to electrode Y.

- (a) In the spaces below write the equations for the reactions occurring at the anode and the cathode. (3 marks)

Description	Marks
Anode reaction: $2\text{Br}^-(\text{aq}) \rightarrow \text{Br}_2(\text{aq}) + 2\text{e}^-$	1
Cathode reaction: $2\text{BrO}_3^-(\text{aq}) + 12\text{H}^+(\text{aq}) + 10\text{e}^- \rightarrow \text{Br}_2(\text{aq}) + 6\text{H}_2\text{O}(\ell)$	1
Anode reaction is the oxidation process and the Cathode reaction is the reduction process	1
Total	3

- (b) Combine these two equations to provide the overall redox equation. (2 marks)

Description	Marks
$2\text{BrO}_3^-(\text{aq}) + 12\text{H}^+(\text{aq}) + 10\text{Br}^-(\text{aq}) \rightarrow 6\text{Br}_2(\text{aq}) + 6\text{H}_2\text{O}(\ell)$	2
Total	2
-1 mark for small error eg not balanced for charge or species (states not required)	

- (c) When the cell above discharges (at standard conditions) 0.43 volts are generated. Use this information to calculate the standard reduction potential for the half cell connected to electrode Y. (2 marks)

Description	Marks
$E^{\circ}_{\text{cell}} = E^{\circ}_{\text{ox}} + E^{\circ}_{\text{red}}$	1
$0.43 \text{ v} = (-1.08) + E^{\circ}_{\text{red}}$	
$E^{\circ}_{\text{red}} = 1.51 \text{ v}$ Therefore... Standard reduction potential for the half cell = 1.51 v	1
Total	2

End of Section Two

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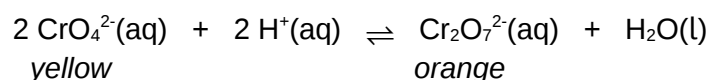
Section Three: Extended answer**40% (93 marks)**

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

Suggested working time: 70 minutes.

Question 34**(20 marks)**

The following reversible reaction between chromate (CrO_4^{2-}) and dichromate ($\text{Cr}_2\text{O}_7^{2-}$) was set up in a beaker and allowed to establish equilibrium. The initial colour of the equilibrium system was a light orange. The equilibrium can be represented by the following equation;



This equilibrium system is 'pH dependent'.

- (a) Complete the following table, by writing the colour this equilibrium system would appear at both a low and a high pH. (2 marks)

Colour at low pH	Colour at high pH
Orange (1 mark)	Yellow (1 mark)

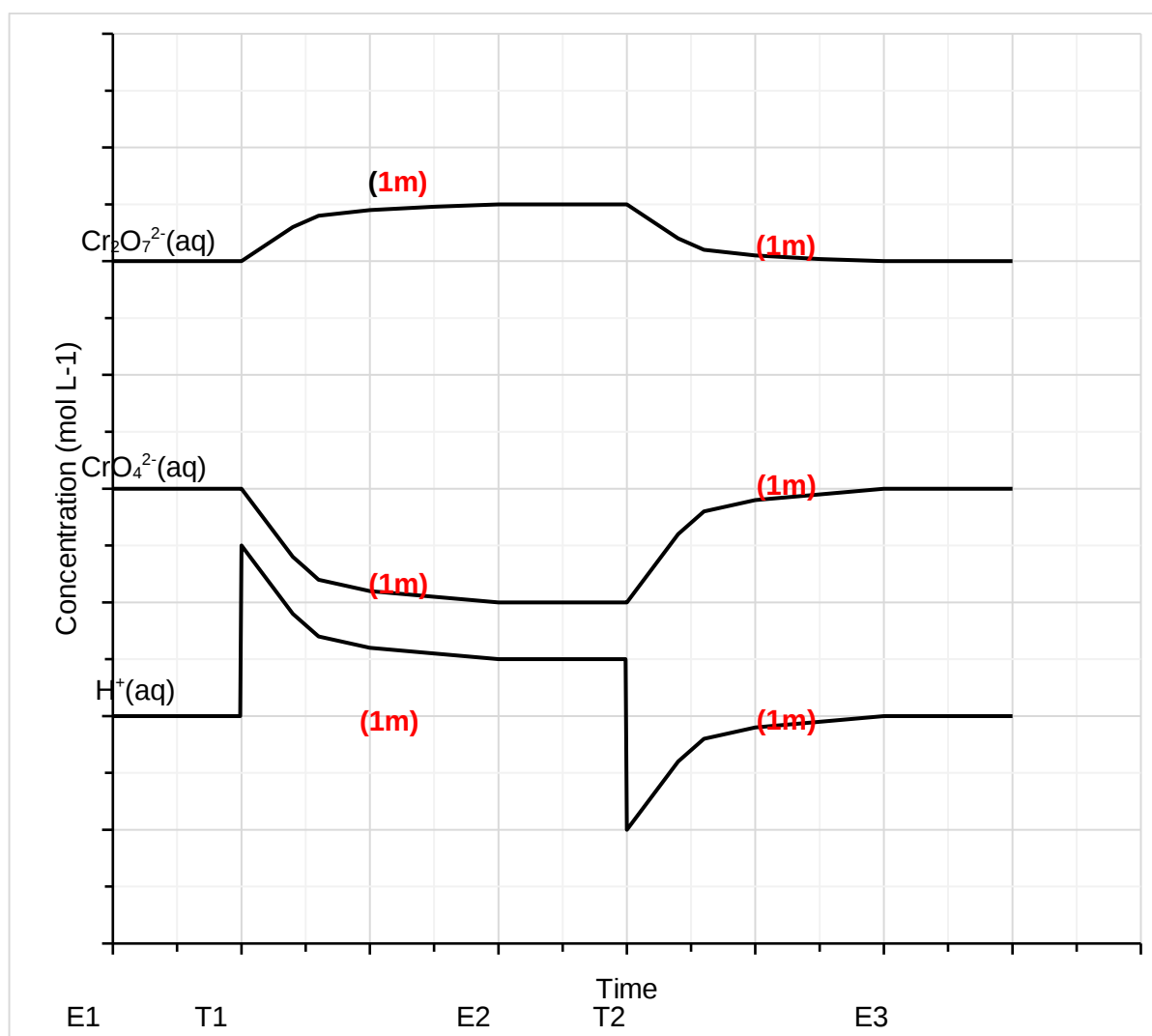
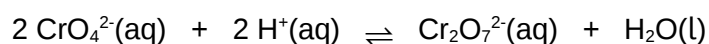
The equilibrium mixture was then divided equally into 2 smaller beakers. The separate beakers, Beaker 1 and Beaker 2, were treated as described below.

Beaker 1

- Firstly, 10 drops of $2 \text{ mol L}^{-1} \text{ HCl(aq)}$ were added at Time T1, and equilibrium was re-established at Time E2.
- Next, 10 drops of $2 \text{ mol L}^{-1} \text{ NaOH(aq)}$ were added at Time T2, and equilibrium was once again re-established at Time E3.

You may assume the increase in volume due to the added HCl(aq) and NaOH(aq) are negligible.

The following graph represents the equilibrium in Beaker 1.



- (b) Plot the concentration for each of the ions shown on the graph, from Time T1 to Time E3. (8 marks)

T1-E2

Description	Marks
Favours the forward reaction	1
Rise in $[\text{Cr}_2\text{O}_7^{2-}]$ / fall in $[\text{CrO}_4^{2-}]$, $[\text{H}^+] = 1:2$ ratio	1
(correct shapes and orientation of all curves)	1
Total	3

E2-T2 ---horizontal

1 mark

T2-E3

Description	Marks
Immediate fall in $[\text{H}^+]$	1
(correct shapes and orientation of all curves)	1
Fall in $[\text{Cr}_2\text{O}_7^{2-}]$ / rise in $[\text{CrO}_4^{2-}]$, $[\text{H}^+] = 1:2$ ratio	1
Total	3

(lines at E3 match starting concentrations at E1)

1 mark

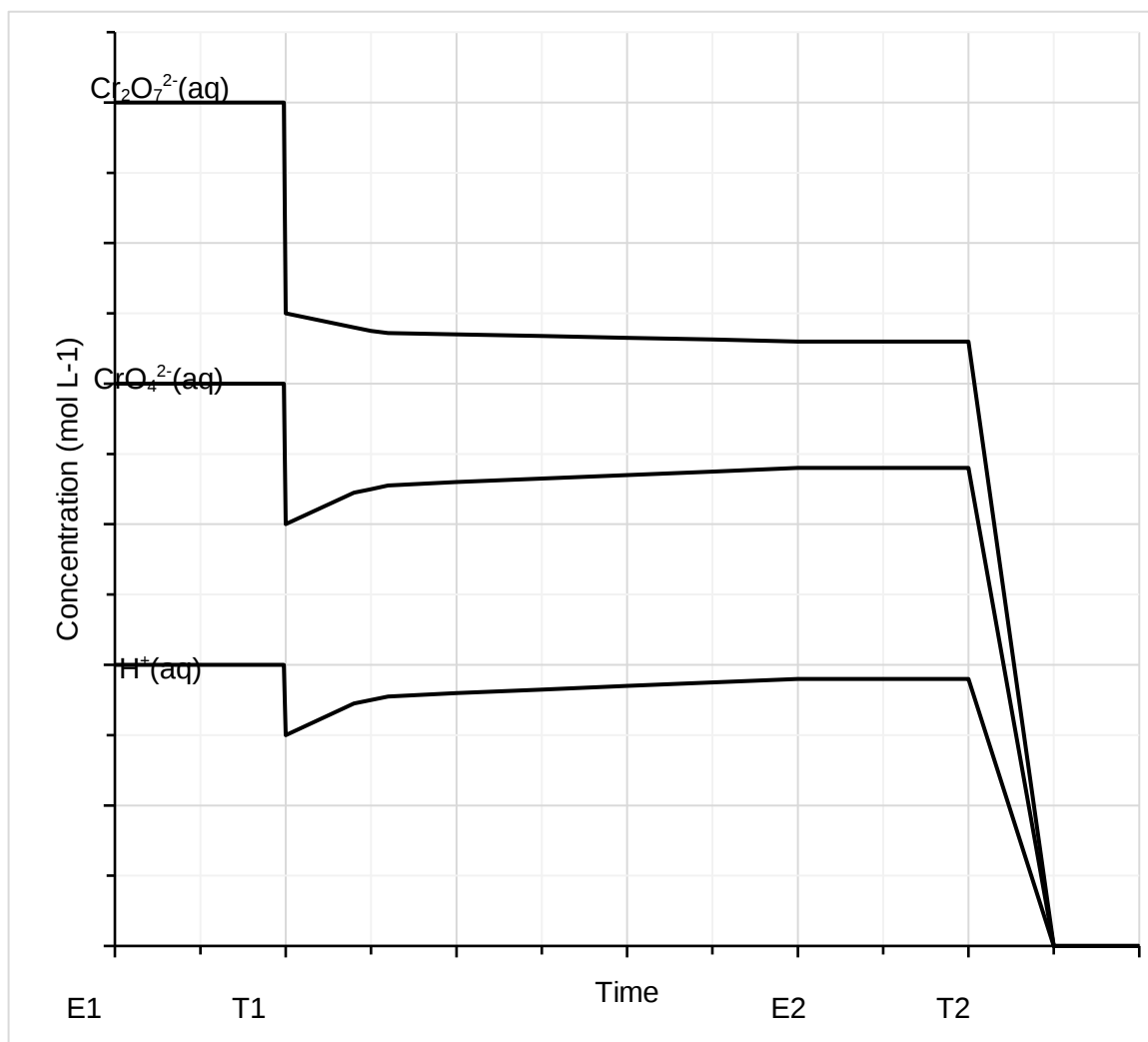
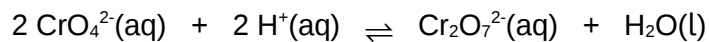
(c) Why isn't a curve for water concentration plotted on the graph?

(1 mark)

Description	Marks
Water is in the liquid state and therefore has a fixed concentration that does not change (approx. 55 mol L^{-1}).	1
Total	1

Question 34 (continued)**Beaker 2**

The following graph represents the equilibrium in Beaker 2.



- (d) State the change imposed at Time T1. Justify the subsequent equilibrium shift using Le Chatelier's Principle. (3 marks)

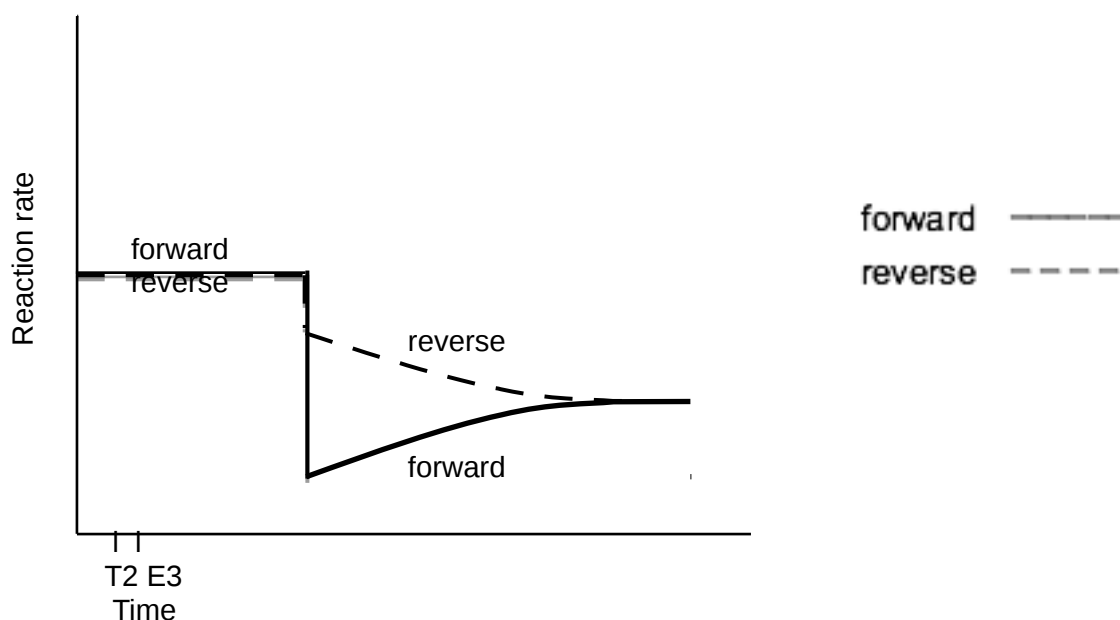
Description	Marks
Addition of (distilled) water	1
Since all aqueous species are diluted (by same factor), system favours direction which produces greatest number of aqueous species	1
Ratio of aqueous species is 4:1 therefore the reverse reaction is favoured / there is a shift left	1
Total	3

At Time T2, Beaker 2 was placed into an ice bath. Over several minutes, the equilibrium became a more yellow colour.

- (e) Explain what information this provides about the heat of reaction (ΔH) for this equilibrium system. (3 marks)

Description	Marks
A decrease in temperature will favour the exothermic direction	1
Since the system becomes more yellow, the reverse reaction must be favoured	1
Therefore the reverse reaction is exothermic and the forward reaction (as written) is endothermic, i.e. ΔH is positive	1
Total	3

- (f) Complete the reaction rate graph below, for both the forward and reverse reaction rates, from Time T2 until the re-establishment of equilibrium at Time E3. (3 marks)



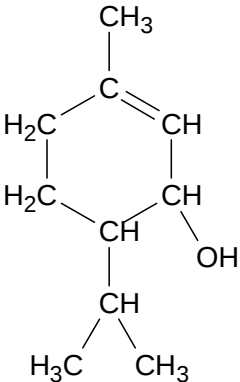
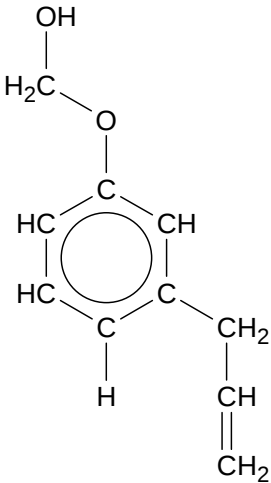
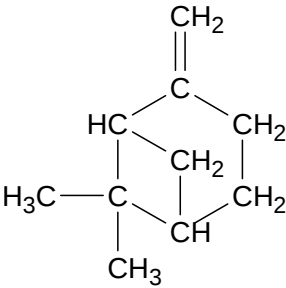
Description	Marks
Both rates decrease	1
Forward rate decreases more than reverse rate	1
Rates change to reach new equilibrium at E3	1
Total	3

Question 35

(16 marks)

In traditional Aboriginal culture, native plants have been used for many generations to treat or heal those who are sick or injured. Research is now being carried out on many of the various plants that were used by Aboriginal peoples and has found that they often contain well known anti-bacterial or anti-inflammatory compounds.

The table below gives information on three (3) compounds that have been identified in native Australian plants which were used by Aboriginal peoples to treat various medical conditions.

Name of compound	Terpinenol	Eugenol	Pinene
Extracted from	Tea tree oil	Australian lemongrass	Eucalyptus oil
Aboriginal medicinal use	treating wounds and throat ailments	treating headaches, colds and muscle pain	treating body pain, fever and chills
Structure			

A chemist was given a pure sample of each of these 3 compounds for analysis. However, the samples were not labelled.

- (a) Explain why the addition of bromine water to each of these samples would **not** be a useful distinguishing test. (2 marks)

Description	Marks
All substances have a carbon-carbon double bond	1
Therefore all would undergo addition(halogenation) reactions and decolorise bromine water	1
Total	2

The compound 'pinene' could quickly be distinguished from the other two compounds by adding a few drops of acidified sodium dichromate solution to each.

- (b) Justify how this test would allow for the identification of pinene, including relevant observations in your answer. (Note that equations are **not** required.) (3 marks)

Description	Marks
Acidified sodium dichromate solution can oxidise primary and secondary alcohols with a colour change.	1
Terpinenol and Eugenol contain an alcohol group (that can be oxidised) and would observe a change in colour from orange to green.	1
Pinene cannot be oxidised and would remain orange in colour	1
Total	3

The chemist then used combustion analysis to distinguish 'terpinenol' and 'eugenol'. A 7.58 g sample of one of the compounds was taken for analysis. Upon combustion, 20.33 g of carbon dioxide and 4.99 g of water vapour was produced.

- (c) Determine the empirical formula of this sample and identify which compound was being analysed. (9 marks)

$$\begin{aligned}
 n(\text{CO}_2) &= m/M \\
 &= 20.33 / 44.01 \\
 &= 0.46194 \text{ mol} \\
 &= n(\text{C}) \qquad \qquad \qquad (1 \text{ mark})
 \end{aligned}$$

$$\begin{aligned}
 m(\text{C}) &= nM \\
 &= 0.46194 \times 12.01 \\
 &= 5.5479 \text{ g} \qquad \qquad \qquad (1 \text{ mark})
 \end{aligned}$$

$$\begin{aligned}
 n(\text{H}_2\text{O}) &= 4.99 / 18.016 \\
 &= 0.276976 \text{ mol} \\
 n(\text{H}) &= 2 \times n(\text{H}_2\text{O}) \\
 &= 0.5539484 \text{ mol} \qquad \qquad \qquad (1 \text{ mark})
 \end{aligned}$$

$$\begin{aligned}
 m(\text{H}) &= nM \\
 &= 0.5539484 \times 1.008 \\
 &= 0.55838 \text{ g} \qquad \qquad \qquad (1 \text{ mark})
 \end{aligned}$$

$$\begin{aligned}
 m(\text{O}) &= 7.58 - (5.5479 + 0.55838) \\
 &= 1.4737 \text{ g} \qquad \qquad \qquad (1 \text{ mark})
 \end{aligned}$$

$$\begin{aligned}
 n(\text{O}) &= m/M \\
 &= 1.4737 / 16.00 \\
 &= 0.0921073 \text{ mol} \qquad \qquad \qquad (1 \text{ mark})
 \end{aligned}$$

	C	H	O
n (values from above)	n(C) = 0.46194 mol	n(H) = 0.5539484 mol	n(O) = 0.0921073 mol
ratio (1 mark)	0.46194 / 0.0921073 = 5	0.5539484 / 0.0921073 = 6	0.0921073 / 0.0921073 = 1

Therefore EF is C₅H₆O (1 mark)

Substance is 'eugenol' as the MF is 2 x this EF (1 mark)
(MF of terpinenol does not match this EF)

OR

$$\begin{aligned} m(\text{C}) &= 12.01 / 44.01 \times 20.33 \\ &= 5.5479 \text{ g} \end{aligned} \quad (1 \text{ mark})$$

$$\begin{aligned} m(\text{H}) &= 2.016 / 18.016 \times 4.99 \\ &= 0.55838 \text{ g} \end{aligned} \quad (1 \text{ mark})$$

$$\begin{aligned} m(\text{O}) &= 7.58 - (5.5479 + 0.55838) \\ &= 1.4737 \text{ g} \end{aligned} \quad (1 \text{ mark})$$

	C	H	O
n	n(C) = m/M = 5.5479 / 12.01 = 0.46194 mol (1m)	n(H) = m/M = 0.55838 / 1.008 = 0.5539484 mol (1m)	n(O) = m/M = 1.4737 / 16.00 = 0.0921073 mol (1m)
ratio (1 mark)	0.46194 / 0.0921073 = 5	0.5539484 / 0.0921073 = 6	0.0921073 / 0.0921073 = 1

Therefore EF is C₅H₆O (1 mark)

Substance is 'eugenol' as the MF is 2 x this EF (1 mark)
(MF of terpinenol does not match this EF)

The chemist then carried out two further chemical tests with the compound identified by combustion analysis in part (c).

- (d) Draw structural diagrams for the resulting organic compound formed when the substance identified in (c) reacts
- with bromine water
 - with acidified sodium dichromate.
- (2 marks)

	bromine water, Br ₂ (aq)	chemical test described in part (b)
Organic product formed		<p>(accept also formation of aldehyde)</p>

If students incorrectly say 'terpinenol' was identified in part (c), award full marks if their answers in part (d) use terpinenol correctly

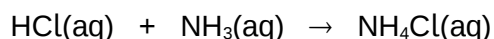
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Question 36

(15 marks)

A beaker contained 135 mL of 0.273 mol L⁻¹ hydrochloric acid, HCl(aq). A group of chemistry students were given some 0.198 mol L⁻¹ ammonia solution, NH₃(aq), and asked to neutralise the acid.

They measured 344 mL of the ammonia solution and poured it into the beaker containing the hydrochloric acid. The equation for the reaction that took place is given below.



- (a) Determine, by calculation, whether all the hydrochloric acid was neutralised upon addition of the ammonia. (4 marks)

$$\begin{aligned} n(\text{HCl}) &= cV \\ &= 0.273 \times 0.135 \\ &= 0.036855 \text{ mol} \end{aligned} \quad (1 \text{ mark})$$

$$\begin{aligned} n(\text{NH}_3) &= cV \quad (*\text{assumes } 100\% \text{ available as } \text{NH}_3) \\ &= 0.198 \times 0.344 \\ &= 0.068112 \text{ mol} \end{aligned} \quad (1 \text{ mark})$$

Since 1:1 stoich ratio, $n(\text{NH}_3) > n(\text{HCl})$ (1 mark)
(some justification of limiting reagent required)

Therefore all the HCl was neutralised (i.e. HCl is the limiting reagent) (1 mark)

- (b) Calculate the final concentration, in mol L⁻¹, of any excess reagent present. (3 marks)

$$n(\text{NH}_3) \text{ (consumed)} = 1/1 \times n(\text{HCl}) = 0.036855 \text{ mol} \quad (1 \text{ mark})$$

$$\begin{aligned} n(\text{NH}_3) \text{ (remaining)} &= n(\text{NH}_3) \text{ initial} - n(\text{NH}_3) \text{ (consumed)} \\ &= 0.068122 - 0.036855 \\ &= 0.031257 \text{ mol} \end{aligned} \quad (1 \text{ mark})$$

$$\begin{aligned} c(\text{NH}_3) &= n/V \\ &= 0.031257 / 0.479 \quad (\text{note mixed; sum of volumes}) \\ &= 0.065255 \text{ mol L}^{-1} \\ &= 0.0653 \text{ mol L}^{-1} \quad (3 \text{ SF}) \quad (1 \text{ mark must have correct three Significant Figures for awarding mark}) \end{aligned}$$

This is the only question that will penalise for inappropriate Sig Figs *

- (c) Calculate the final concentration, in mol L⁻¹, of ammonium chloride product. (2 marks)

$$n(\text{NH}_4\text{Cl}) = 1/1 \times n(\text{HCl}) = 0.036855 \text{ mol} \quad (1 \text{ mark})$$

$$\begin{aligned} c(\text{NH}_4\text{Cl}) &= n/V \\ &= 0.036855 / 0.479 && \text{(note mixed; sum of volumes)} \\ &= 0.0769 \text{ mol L}^{-1} && (1 \text{ mark}) \end{aligned}$$

One of the chemistry students in the group, proposed that the final mixture in the beaker would act as a buffer solution.

- (d) Was this student correct? Justify your answer using relevant chemical theory. Include a brief description of how the student's hypothesis could be tested experimentally. (6 marks)

Description	Marks
Yes, the solution can act as a buffer	1
The excess ammonia (unreacted) is a weak base and the ammonium ion formed from the neutralisation is its conjugate acid.	1
Both species are present at similar concentrations and will establish an equilibrium buffer system $\text{NH}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq})$	1
To test experimentally: Separate the mixture into 2 beakers and measure the initial pH	1
Add a small amount of strong acid to one and a small amount of strong base to the other, measure the resulting pH	1
A buffer solution will have no significant changes in pH	1
Total	6

Note not accepting Universal Indicator (magnitude too large)

(Note: if students get the calculations incorrect, and then argue against the final mixture acting as a buffer based on their answers, follow through marks may be awarded as appropriate.)

Question 37

(21 marks)

A student was asked to determine the percentage purity of a sample of salicylic acid ($C_7H_6O_3$). The method used by the student is described below.

- 1.500 g of portion of the impure salicylic acid being analysed was placed in a weighing bottle.
- The contents were tipped into a beaker and approximately 100 mL of distilled water was added.
- Salicylic acid does not dissolve well in cold water so the beaker and its contents were heated gently until all the solid had dissolved.
- The solution was poured into a 250.0 mL volumetric flask and made up to the mark with distilled water.
- 25 mL samples of the solution were then titrated against a standard solution of sodium hydroxide with a concentration of $0.0776 \text{ mol L}^{-1}$ and the following results were obtained.

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Initial reading	0.55 mL	13.05 mL	24.65 mL	0.85 mL	12.55 mL
Final reading	13.05 mL	24.65 mL	37.85 mL	12.55 mL	24.10 mL
Volume added	12.50	11.60	13.20	11.70	11.55

- (a) Complete the table above and calculate the average titre for the experiment. Show clearly how you calculated the average titre. (3 marks)

Description	Marks
See table above completed values correct – must have 2 decimal places (keeps measurement precision)	1
Average calculated using just trial 2,4 and 5 (uses three trials within $\pm 0.1\text{mL}$) $\text{Ave Titre} = (11.60 + 11.70 + 11.55) / 3$	1
Average titre = 11.62 mL	1
Total	3

- (b) Salicylic acid ($C_7H_6O_3$) is a weak monoprotic acid. Given this information use the results above to calculate the percentage by mass of the 1.500 g portion of the impure salicylic acid being analysed. (7 marks)

Description	Marks
For titre: $n(\text{NaOH}) = cV = 0.0776 \text{ mol L}^{-1} \times 0.001162 \text{ L}$ $= 0.00009017 \text{ mol}$	1
At equivalence point: (Acid is monoprotic so reaction has 1:1 ratio) $n(C_7H_6O_3)_{25\text{mL aliquot}} = 1/1 \times n(\text{NaOH}) = 0.00009017 \text{ mol}$	1
For aliquot: $c(C_7H_6O_3) = n / V = 0.00009017 / 25 \times 10^{-3}$ $= 0.03607 \text{ mol L}^{-1}$	1

$n(\text{C}_7\text{H}_6\text{O}_3)_{1.50\text{g sample}} = 0.0009017 \text{ mol}$	1
$m(\text{C}_7\text{H}_6\text{O}_3)_{1.50\text{g sample}} = n \times M = 0.0009017 \text{ mol} \times 138.118 \text{ g mol}^{-1}$ $= 0.1245\text{g}$	1
$\%(\text{C}_7\text{H}_6\text{O}_3) = \frac{m(\text{pure C}_7\text{H}_6\text{O}_3)}{m(\text{impure})} \times 100$	1
$\%(\text{C}_7\text{H}_6\text{O}_3)_{1.50\text{g sample}} = 0.1245 / 0.150 \times 100 = 83.0\%$	1
Total	7

- (c) Explain how the calculated percentage composition of salicylic acid would be affected (above or below the true value) if the pipette used to collect each of the 25.00 mL samples of dilute acid solution were rinsed with water before each use. (4 marks)

Description	Marks
It would reduce the concentration of the dilute acid aliquot being analysed.	1
It would now require less base to neutralise / bring about colour change/reach end point in the titration and the average titre is lower.	1
If less moles are present in the dilute sample it will follow that less moles of acid will be calculated to be present in the solid sample.	1
Calculated percentage composition of salicylic acid would below the true value	1
Total	4

Question 37 (continued)

- (d) This titration (between the weak monoprotic salicylic acid ($C_7H_6O_3$) and the strong base., sodium hydroxide) was carried out using phenolphthalein as an indicator since it changes colour at a pH greater than 7. Using chemical equations to justify your answer, show that this indicator was the correct choice. (4 marks)

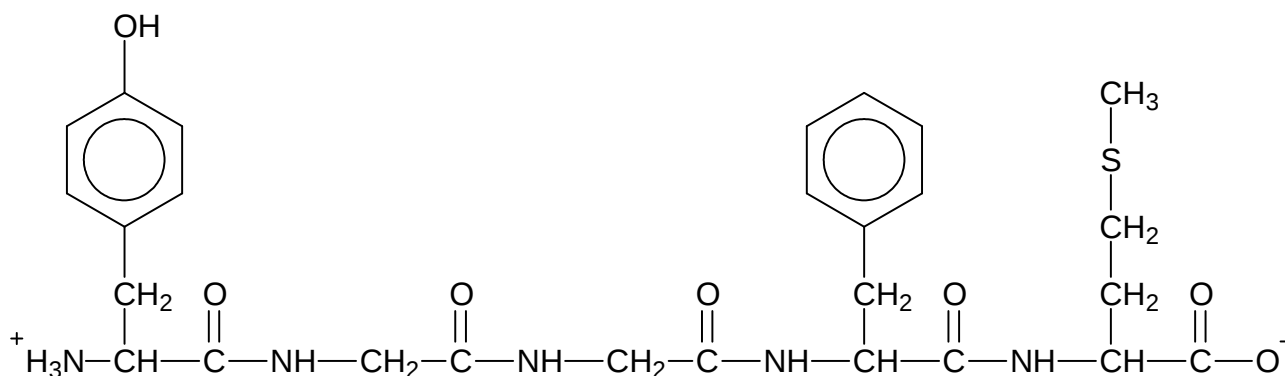
Description	Marks
The salt produced in this titration is basic – $NaC_7H_5O_3$	1
The salt can react with water (hydrolysis) as follows: $C_7H_5O_3^-(aq) + H_2O(l) \rightleftharpoons C_7H_6O_3(aq) + OH^-(aq)$	1
Therefore, the equivalence point is basic/alkaline (occurs at a pH greater than 7)	1
So, it follows that phenolphthalein (which changes colour at a pH greater than 7) will provide an accurate approximation of the equivalence point. i.e. The end point will coincide with the equivalence point	1
Total	4

- (e) Salicylic acid can be used to make a home remedy to remove warts from skin. Calculate the amount of the impure salicylic acid that would need to be dissolved in 1.00 L of distilled water to produce a 'home remedy solution' with a salicylic acid concentration of 17 mg per 100 mL. (If you could not work out part (b) use 85.0%) (3 marks)

Description	Marks
$m(C_7H_6O_3)$ required = $17\text{mg}/100\text{mL} \times 1000\text{mL}$ $= 170\text{ mg} = 0.170\text{ g}$	1
$m(\text{impure } C_7H_6O_3) = m(\text{pure } C_7H_6O_3) / \% \text{ purity} = 0.170 \times 100/83.0$	1
$m \text{ impure } (C_7H_6O_3) \text{ required} = 0.205\text{ g}$	1
Total	3
For 85.0 % pure: $m(\text{impure } C_7H_6O_3) = m(\text{pure } C_7H_6O_3) / \% \text{ purity} = 0.170 \times 100/85.0$ $m \text{ impure } (C_7H_6O_3) \text{ required} = 0.200\text{ g}$	

Question 38**(21 marks)**

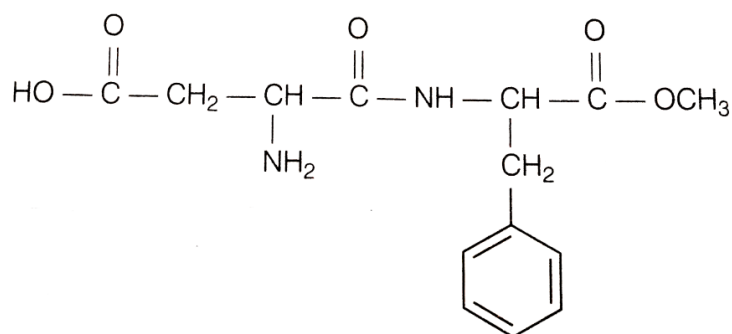
The combination of several amino acids can produce small polypeptide molecules. Below is a representation of a pentapeptide.



- (a) In the space provided write the primary structure of the pentapeptide above using the abbreviated (three-letter) codes for each amino acid. (3 marks)

Tyr	Gly	Gly	Phe	Met
Description				Marks
See correct answers in box above (all five correct)				3
See correct answers in box above (four correct)				2
See correct answers in box above (three correct)				1
Total				3
Note: primary sequence is N-terminal to C-terminal				

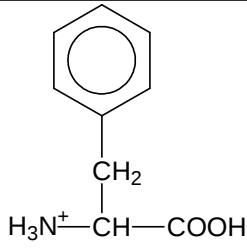
- (b) Below is the structure of an artificial sweetener known as aspartame. It is used in foods and beverages as a sugar substitute. It is a methyl ester of a simple dipeptide. When it is heated under acidic conditions, two amino acids are produced.



- (i) One of the amino acids produced is phenylalanine, name the other amino acid. (1 mark)

Description	Marks
Aspartic acid	1
Total	1

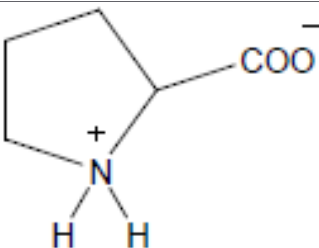
- (ii) Draw the structure of the amino acid phenylalanine as it would predominantly exist when in acidic solution. (1 mark)

Description	Marks
	1
Total	1

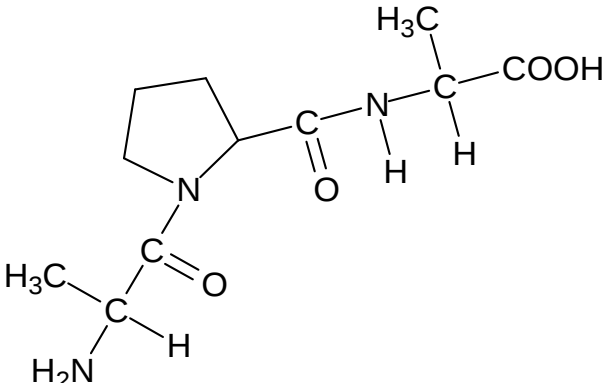
NOTE: The + must be on the N

- (c) Consider the structures and common names of two amino acids proline and alanine.

- (i) Draw the structure of the zwitterion of proline in the box below. (2 marks)

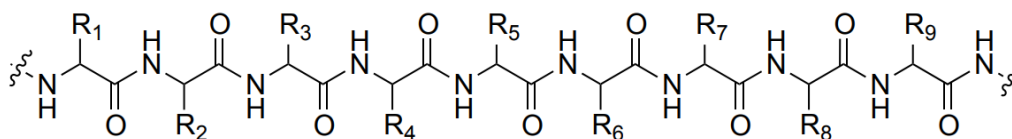
Description	Marks
	2
1 mark for each correct functional group with charge CO_2^- and NH_2^+	
Total	2

- (ii) Draw the structure of the tripeptide formed when a proline molecule bonds to two alanine molecules, one on each side. (2 marks)

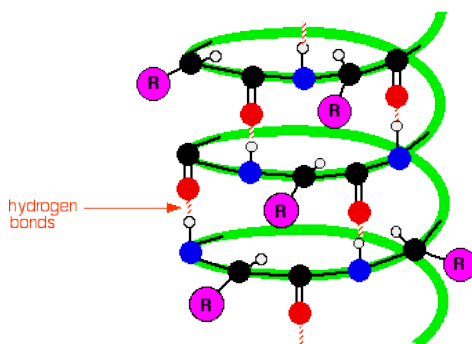
	
Description	Marks
Correct link between alanine and proline amino group	1
Correct link between alanine and proline carboxylic acid group	1
Total	2

- (d) Describe, using diagrams to assist your answer, how the polypeptide chain shown below would form an alpha helix given that the interaction that stabilises the structure is between

amino acid 5 (the one with the R5 side chain) and amino acid 1 (the one with the R1 side chain). (4 marks)



Description	Marks
An alpha helix involves the interactions via hydrogen bonding between the functional groups on the peptide backbone.	1
The hydrogen attached to the nitrogen on one amino acid residue is attracted to the lone electron pairs from the oxygen from another amino acid residue group down the chain. (describes hydrogen bond) OR Between dipoles on carbonyl group (C=O) of one amino acid and the dipoles on amide (N-H) group on another amino acid.	1
Shows hydrogen bond using a diagram: <i>Draws spiral showing correct placement of hydrogen bond for 1st and 5th amino acid residue.</i>	1
Electrostatic attraction between these dipoles causes the polypeptide chain to twist into a helix structure	1
Total	4
Note: There are no interactions between the 'R; groups/sidechains for the alpha helix. They are orientated outwards. Must state the H bonding is on the main chain.	



Question 38 (continued)

- (e) Any given protein is characterised by a unique primary structure and tertiary structure. Explain how these are related. (2 marks)

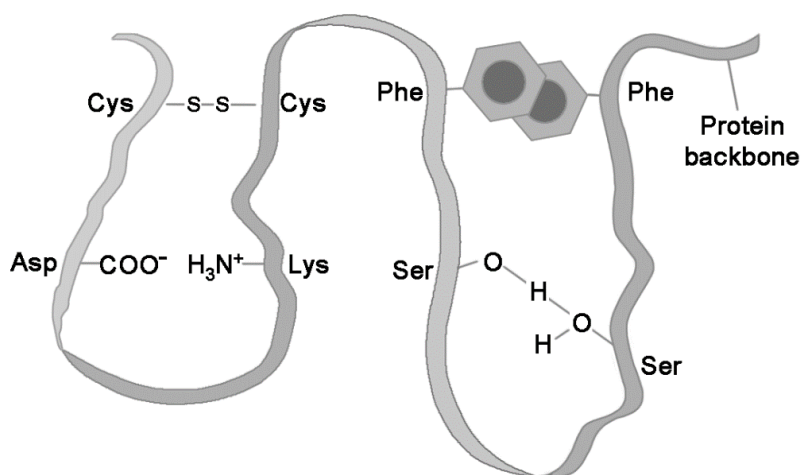
Description	Marks
The primary structure is the sequence of the amino acids/peptides in the protein chain.	1
It determines what side chains are available for tertiary structures to form. These interactions between side chains determine how the chain folds into its overall three-dimensional shape.	1
Total	2

- (f) Consider a large protein molecule composed of only the following amino acids (Cysteine, Methionine, Valine and Threonine) combined repeatedly and in random orders. List three types of interactions (bonds or other forces) that would contribute to the tertiary structure of this protein. (3 marks)

Description (Any 3 from below)	Marks
Dispersion/hydrophobic	1
Dipole–Dipole	1
Hydrogen bonding	1
Disulfide bridge	1
Total	3
<p>Note: no specific combinations of amino acids for each interaction is required to be listed but for interest include: Cys-Cys – disulfide bridges ; Val and Val – Dispersion interactions Cys – Thr – dipole-dipole; Thr-Thr – hydrogen bonding etc</p>	

NOTE: Mark deducted for including Ionic Bonding

- (g) Consider the protein representation below. Using the diagram to assist your answer, explain clearly how reducing the pH can result in denaturing the protein. (3 marks)



Description	Marks
Reducing pH results in an increase in hydrogen ions which will cause the functional group on the aspartic acid amino acid to change (gain the H ⁺ ion to form COOH)	1
This disrupts the ionic interactions between the Lys and Asp side chains	1
Thus, the shape of the protein will change, becoming denatured.	1
Total	3

End of questions

Spare answer page

Question number: _____

Spare answer page

Question number: _____

Spare answer page

Question number: _____

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Question number: _____

Acknowledgements

Q 17 Orange carotenoid protein
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