

**Australian Islamic College**  
**ATAR course examination, Semester 2, 2020**

**Question/Answer booklet**

**CHEMISTRY**

**Weighting 30%**

Student Name: \_\_\_\_\_

Teacher Name: \_\_\_\_\_

**Time allowed for this paper**

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

**Materials required/recommended for this paper**

***To be provided by the supervisor***

This Question/Answer booklet  
Multiple-choice answer sheet  
Chemistry Data booklet

***To be provided by the candidate***

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

Special items: non-programmable calculators approved for use in this examination

**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 total exam	Your mark
Section One Multiple-choice	25	25	50	25	25	
Section Two Short answer	9	9	60	88	35	
Section Three Extended answer	6	6	70	95	40	
<b>Total</b>					100	

### Instructions to candidates

- The rules for the conduct of ATAR course examinations are detailed in the *Year 12 Information Handbook 2020*. Sitting this examination implies that you agree to abide by these rules.
- 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 the 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.

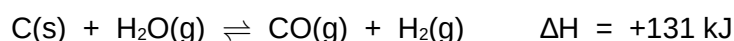
- When calculating numerical answers, show your working or reasoning clearly. Your working should be in sufficient detail to allow your answers to be checked readily and for marks to be awarded for reasoning. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.
- 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.
- 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. Do not use erasable or gel pens. If you make a mistake, place a cross through that square, then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

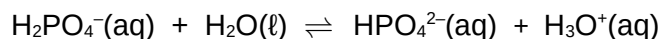
Suggested working time: 50 minutes

1. Which one of the following changes to the system at equilibrium shown below will increase the value of the equilibrium constant?



- (a) increase temperature
  - (b) decrease temperature
  - (c) add a catalyst
  - (d) increase the partial pressure of CO(g)
2. Which of the following statements describe the endothermic self-ionisation of water?
- (i) a neutral solution above 25 °C has a pH >7
  - (ii) all aqueous solutions contain both H<sub>3</sub>O<sup>+</sup>(aq) and OH<sup>-</sup>(aq)
  - (iii) in a neutral solution at 100 °C [H<sub>3</sub>O<sup>+</sup>(aq)] = [OH<sup>-</sup>(aq)]
  - (iv) K<sub>w</sub> increases with increasing temperature
- (a) i only
  - (b) i and ii only
  - (c) i, ii and iii only
  - (d) ii, iii and iv only
3. In which of the following mixtures of metals and solutions will a reaction be observed?
- |       | <b>metal</b> | <b>0.1 mol L<sup>-1</sup> solution</b> |
|-------|--------------|--|
| (i)   | zinc         | copper sulfate                         |
| (ii)  | iron         | zinc nitrate                           |
| (iii) | cobalt       | silver nitrate                         |
| (iv)  | manganese    | sodium chloride                        |
- (a) i only
  - (b) i and ii only
  - (c) i and iii only
  - (d) ii and iv only

4. Consider the following buffer system.



Which one, if any, of the following will be higher after a small amount of strong base is added and equilibrium is re-established?

- (a)  $[\text{H}_2\text{PO}_4^-(\text{aq})]$
  - (b)  $[\text{OH}^-(\text{aq})]$
  - (c)  $[\text{H}_3\text{O}^+(\text{aq})]$
  - (d) none of these will be higher
5. Which one of the following compounds has the highest solubility in water?
- (a) butane
  - (b) butan-1-ol
  - (c) butanal
  - (d) but-1-ene
6. Which one of the following is the reason why, at room temperature, methane gas does not ignite spontaneously with oxygen gas from the air?
- (a) The reaction is endothermic.
  - (b) The activation energy is too small.
  - (c) The collision energy is less than the activation energy.
  - (d) The energy of the reactants is much greater than that of the products.

**Questions 7 and 8 refer to the information below.**

The table shows the data for four titrations carried out to determine the concentration of an unknown NaOH solution with 20.00 mL of standardised 0.2000 mol L<sup>-1</sup> HCl solution using phenolphthalein as the indicator.

Trial	Volume of NaOH(aq) (mL)
1	19.26
2	19.35
3	19.15
4	19.30

7. Which statement best accounts for the lower volume of NaOH(aq) in Trial 3?
- (a) Some of the neutralised solution from Trial 2 was left in the conical flask for Trial 3.
  - (b) The pipette was rinsed with water before filling with hydrochloric acid.
  - (c) Three drops of phenolphthalein were used instead of two drops in the other trials.
  - (d) A few drops of NaOH solution spilled over the edge of the conical flask in Trial 3.
8. Which one of the following is the correct volume (in mL) to use in calculating the NaOH concentration?
- (a) 19.30
  - (b) 19.27
  - (c) 19.33
  - (d) 19.15

9. A student standardised a sodium hydroxide solution against a hydrochloric acid solution, of accurately known concentration, with phenolphthalein as the indicator. An average burette volume of 18.90 mL from four trials of sodium hydroxide was obtained.

A second student, using the same solutions, obtained an average of four trials of 19.35 mL.

Which one of the following statements is the best reason for this difference?

- (a) The first student didn't dry the flask into which the hydrochloric acid was placed.
  - (b) The second student didn't wait for a permanent colour change to persist.
  - (c) The second student tapped the pipette against the side of the conical flask to discharge all the acid solution.
  - (d) The second student didn't remove traces of water from the burette by first rinsing it with sodium hydroxide solution.
10. Which one of the following statements is correct if excess hydrochloric acid is added to an open beaker containing a small piece of magnesium?
- (a) Gas is evolved until the magnesium has fully reacted.
  - (b) Gas is evolved until an equilibrium amount of magnesium remains.
  - (c) White magnesium chloride is produced.
  - (d) The magnesium dissolves, heat is produced but no other reaction occurs.
11. In a series of experiments the rate of the same chemical reaction was studied changing one variable each time. The following data were obtained.

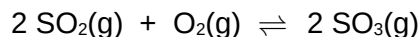
Experiment using 1 mol L <sup>-1</sup>	
Temperature (°C)	Time taken to complete reaction (s)
10	30
20	15

Experiment at 10 °C	
Concentration of reactant (mol L <sup>-1</sup> )	Time taken to complete reaction (s)
1	30
2	15

Which one or more of the following conclusions can be made?

- (i) Doubling the concentration doubles the rate of reaction.
  - (ii) Doubling the temperature doubles the rate of reaction.
  - (iii) A small increase in temperature causes a large increase in reaction rate.
  - (iv) A small increase in concentration causes a large increase in reaction rate.
- (a) i only
  - (b) i and ii only
  - (c) ii and iv only
  - (d) i and iii only

12. Consider the reaction represented by the following equation as it approaches equilibrium.



Which one of the following statements about the rate (measured in moles per second) of this reaction is correct?

- (a) Sulfur dioxide gas is used up at the same rate as oxygen gas.
  - (b) Oxygen gas is used up twice as fast as sulfur dioxide gas.
  - (c) Sulfur trioxide is produced at the same rate as sulfur dioxide is used up.
  - (d) The rate of the forward reaction is equal to the rate of the reverse reaction.
13. In a reaction between dilute sulfuric acid and solid calcium carbonate there is almost no sign of a gas being produced. Which one of the following is the best reason for this observation?
- (a) Calcium carbonate does not dissolve in water.
  - (b) Dilute sulfuric acid is a weak acid.
  - (c) Carbon dioxide is very soluble in dilute sulfuric acid.
  - (d) Calcium sulfate does not dissolve in water.
14. Iron and aluminium window frames corrode differently. Iron forms a flaky oxide/hydroxide while aluminium forms a stable layer of aluminium hydroxide. Which of the following statements best describes why aluminium window frames last longer than iron window frames?
- (i) aluminium has a higher  $E^\circ$  value
  - (ii) iron compounds are more soluble
  - (iii) oxygen is excluded from the aluminium
  - (iv) water can enter the corroded iron
  - (v) aluminium does not require an electrolyte to corrode
- (a) i and ii only
  - (b) i, ii and iii only
  - (c) iii and iv only
  - (d) iii and v only
15. Dry ice is solid carbon dioxide which forms at temperatures below  $-78.5^\circ\text{C}$ . When dry ice is placed in a warm environment it sublimates to  $\text{CO}_2(\text{g})$ . Which one of the following statements best describes why dry ice can cause severe skin damage?

Solid carbon dioxide

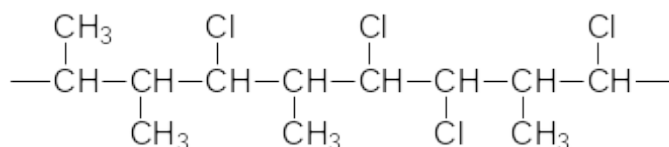
- (a) sublimates instead of melting.
- (b) absorbs considerable heat from the skin while subliming.
- (c) releases considerable heat to the skin while subliming.
- (d) forms an acid when dissolved in the moisture of the skin.

16. Which of the following compounds are isomers of ethyl ethanoate?

- (i)  $\text{CH}_3\text{OCH}_2\text{CH}_2\text{OCH}_3$
- (ii)  $\text{CH}_3\text{CH}_2\text{COOCH}_3$
- (iii)  $\text{CH}_3\text{COCH}_2\text{CH}_2\text{OH}$

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

17. Examine this section of the structure of an addition polymer:



Which one of the following is the monomer for this substance?

- (a)  $\text{CH}_3\text{CHCHCl}$
- (b)  $\text{CH}_3\text{CHCHCH}_2\text{Cl}$
- (c)  $\text{CH}_3\text{CClCHCH}_3$
- (d)  $\text{CH}_3\text{CHCHCHCHCl}$

18. Which one of the following statements best describes the function of an  $\text{H}_2/\text{O}_2$  fuel cell?

- (a) It converts thermal energy into electrical energy.
- (b) It stores electrical energy produced from the redox reaction of  $\text{H}_2$  with  $\text{O}_2$ .
- (c) It converts energy from the oxidation of  $\text{H}_2$  directly into electrical energy.
- (d) An external energy source is used to enable a reaction between  $\text{H}_2$  and  $\text{O}_2$ .

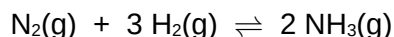
19. Which one of the following statements is correct when comparing electrochemical cells with electrolytic cells?

- (a) The anode is positive and the cathode is negative in both cells.
- (b) Reduction occurs at the negative electrode in an electrochemical cell.
- (c) Oxidation occurs at the cathode in an electrolytic cell.
- (d) Reduction occurs at the cathode in both cases.

20. In which one of the following structures does *cis-trans* isomerism exist?

- (a)  $\text{CH}_2\text{CHCH}_2\text{Cl}$
- (b)  $\text{CH}_3\text{CHCHCH}_2\text{Cl}$
- (c)  $(\text{CH}_3)_2\text{CCHCH}_3$
- (d)  $\text{ClCH}_2\text{CH}_2\text{Cl}$

21. The Haber Process is based on the exothermic reaction between nitrogen gas and hydrogen gas to form ammonia gas as shown by the following equation.



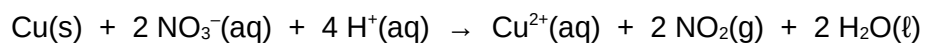
Which one of the following statements is correct?

The equilibrium yield of ammonia increases when

- (a) the temperature is increased.  
 (b) the pressure is increased.  
 (c) a catalyst is added.  
 (d) the pressure is decreased.
22. Which of the following types of bonding can exist in the tertiary structure of a protein?
- (i) disulfide bridges  
 (ii) hydrogen bonding  
 (iii) dipole–dipole bonding  
 (iv) dispersion forces  
 (v) ionic bonding
- (a) i, ii and iii only  
 (b) ii, iii, iv only  
 (c) ii, iii, iv and v only  
 (d) all of the above
23. Which two of the following substances are commonly used in the manufacture of soap?
- (i) stearic acid  
 (ii) tristearin  
 (iii) sodium hydroxide  
 (iv) dodecylbenzenesulfonate
- (a) i and ii only  
 (b) i and iii only  
 (c) ii and iii only  
 (d) ii and iv only
24. Which one of the following correctly shows a common use of each plastic?
- |     | <b>polythene</b>   | <b>polytetra-<br/>fluoroethylene</b> | <b>polystyrene</b> | <b>polyvinyl<br/>chloride</b> |
|-----|--------------------|--------------------------------------|--------------------|-------------------------------|
| (a) | plastic bags       | non-stick surfaces                   | foam cups          | water pipes                   |
| (b) | non-stick surfaces | plastic bags                         | water pipes        | foam cups                     |
| (c) | non-stick surfaces | foam cups                            | plastic bags       | water pipes                   |
| (d) | water pipes        | non-stick surfaces                   | foam cups          | plastic bags                  |



25. Which one of the following correctly describes the redox chemistry in the following reaction?



- (a) Nitrogen is reduced and copper is oxidised.
- (b) Nitrogen is oxidised and oxygen is reduced.
- (c) Nitrogen is oxidised and copper is reduced.
- (d) Nitrogen is reduced and oxygen is oxidised.

**End of section 1**

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## Section Two: Short answer

35% (88 Marks)

This section has 9 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****(9 marks)**

An excess of  $0.100 \text{ mol L}^{-1}$  acidified potassium permanganate solution is added to a  $0.100 \text{ mol L}^{-1}$  solution of iron(II) sulfate.

- (a) Write a balanced chemical equation for this reaction. (2 marks)

- (b) List all observations as the excess acidified potassium permanganate is slowly added to the iron(II) sulfate solution. (4 marks)

- (c) State why it is necessary to acidify the potassium permanganate and why sulfuric acid not hydrochloric acid is used. (3 marks)

See next page



## Question 27

(7 marks)

Carbon dioxide gas dissolves in the ocean and a small proportion of this dissolved gas reacts with water reducing the pH of the ocean.

- (a) Write a balanced equation for the reaction between  $\text{CO}_2(\text{aq})$  and water. (2 marks)

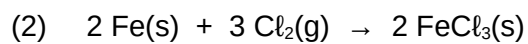
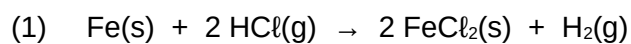
- (b) Use this equation and any other relevant equations to explain the decrease in pH of the ocean. (5 marks)

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## Question 28

(6 marks)

Consider the two equations below representing the oxidation of metallic iron.



(a) Name the oxidising agent in each reaction.

(2 marks)

Equation 1 \_\_\_\_\_

Equation 2 \_\_\_\_\_

(b) By referring to the standard reduction potential table explain why reaction 2 produces  $\text{Fe}^{3+}$  whereas reaction 1 produces  $\text{Fe}^{2+}$ . (4 marks)


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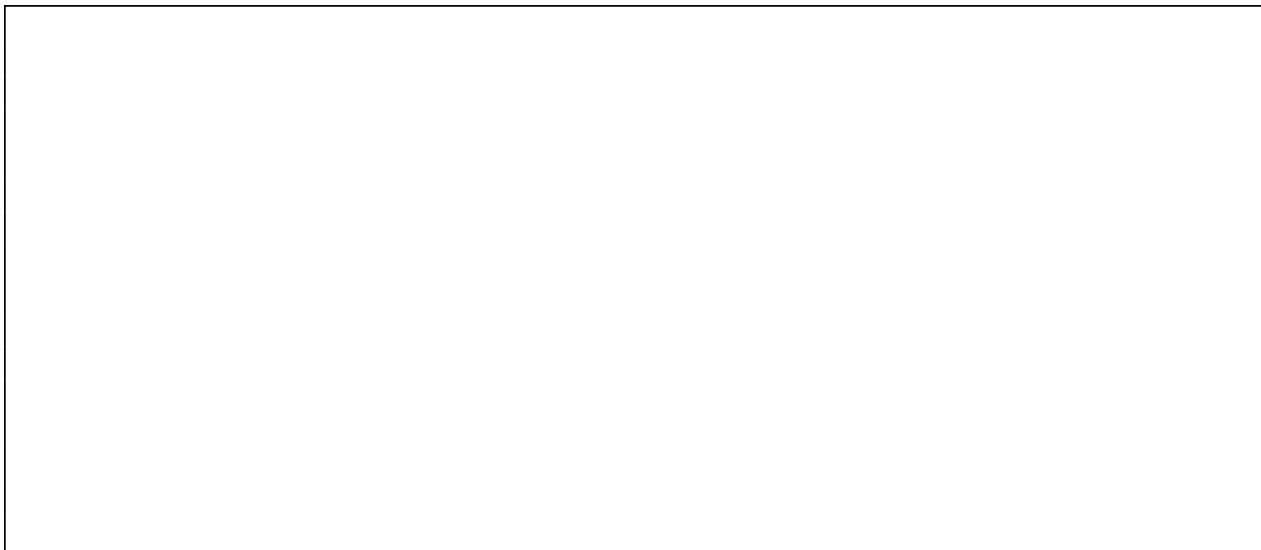
## Question 29

(11 marks)

Benzalkonium chloride is a quaternary ammonium salt with the cation based on the structure of the ammonium ion. In the cation the four hydrogens of the ammonium ion are replaced by

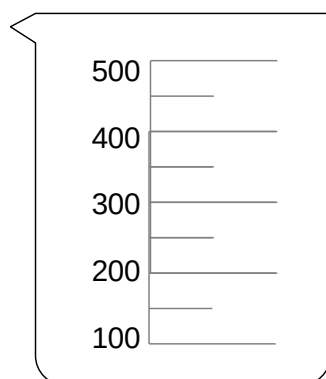
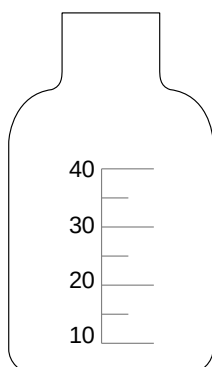
- a benzyl group
- two methyl groups
- an alkyl group of between 6 and 10 carbons with an even number of carbons in its chain.

- (a) Draw a full structural formula of the benzalkonium ion. The alkyl group should be drawn with 6 carbons. (4 marks)



Benzalkonium chloride can safely be used, at a concentration just below 0.1%, as a disinfectant in surface sprays, hand wipes and sanitisers.

During the Covid-19 pandemic a shopkeeper bought some benzalkonium chloride disinfectant to use as a hand sanitiser. It was available in a concentrated form ( $15 \text{ g L}^{-1}$ ) and the instructions said, "dilute 1 part disinfectant to 20 parts of water". He wished to fill a standard 500 mL spray bottle and had available the pictured measuring cups shown below.



- (b) Describe how this dilution could be done using the cups shown on the previous page.

(2 marks)

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- (c) By considering the uncertainty in the measuring cups, calculate if it is possible to be certain the final diluted solution will be under the safe level of 0.1%. (5 marks)

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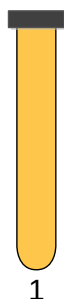
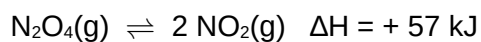
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## Question 30

(11 marks)

Consider two sealed test tubes each containing the same volume of an equilibrium mixture of colourless dinitrogen tetroxide and brown nitrogen dioxide at 25 °C. The reaction is shown below.



- (a) State the appearance of both flasks at equilibrium.

(1 mark)

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- (b) A student claims that the reaction has ceased. Discuss this statement.

(2 marks)

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Flask 1 is opened to the atmosphere.

- (c) Will a new equilibrium be reached? **YES** **NO** (circle one)

(1 mark)

Justify your choice.

(2 marks)

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See next page



Justify your choice. (4 marks)

**Question 31** (7 marks)

Determine the final pH when 1.00 g of NaOH solid is added to 100.0 mL of a solution at pH 1.00. Assume no change in volume.

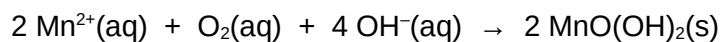
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**Question 32****(10 marks)**

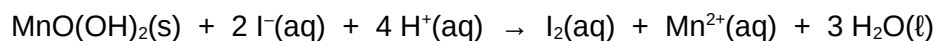
The Winkler method can be used to determine the concentration of dissolved oxygen in water samples.

The following procedure and reactions occur.

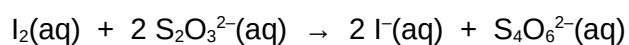
Manganese sulfate is added to the water sample in alkaline conditions.



The reaction is acidified and iodide ions added.



The iodine is titrated with thiosulfate ions ( $\text{S}_2\text{O}_3^{2-}(\text{aq})$ ).



Consider the following steps in the procedure.

1. The water sample must fill the test container and be stoppered.
2. The water sample must not contain any substance that can reduce dissolved iodine.

(a) Explain why these steps are done. (4 marks)

Step 1.

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Step 2.

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In the titration of a 200.0 mL sample of water, 7.17 mL of 0.0180 mol L<sup>-1</sup> thiosulfate solution was required.

- (b) Calculate the concentration of dissolved oxygen (in ppm) to the appropriate number of significant figures. (6 marks)

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## Question 33

(12 marks)

- (a) Draw the structural formula or name the following molecules, all of which can be found in nail polish or nail polish remover. (4 marks)

Common name	IUPAC name	Full structural formula
acetone		$  \begin{array}{c}  \text{H} \quad \quad \text{H} \\    \quad \quad   \\  \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\    \quad    \quad   \\  \text{H} \quad \text{O} \quad \text{H}  \end{array}  $
isopropyl alcohol	propan-2-ol	
butyl acetate		$  \begin{array}{c}  \text{H} \quad \quad \text{O} \\    \quad \quad // \\  \text{H}-\text{C}-\text{C} \\    \quad \quad \backslash \\  \text{H} \quad \quad \text{O}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\  \quad \quad   \quad   \quad   \quad   \\  \quad \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H}  \end{array}  $
methyl ethyl ketone	butanone	

- (b) Describe how, with the aid of a suitable reagent, propan-2-ol can be converted to propanone. (Equation not required) (2 marks)

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Ethyl ethanoate is a commonly used alternative solvent to acetone.

- (c) Starting only with ethene (from crude oil) describe, with relevant equations, how it is possible to synthesise ethyl ethanoate. You do not need to state reaction conditions. (6 marks)

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**(15 marks)**

$$2 \text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2 \text{SO}_3(\text{g}) + 198 \text{ kJ}$$

- (a) Identify the effect of each of the following changes on the yield of sulfur trioxide gas. (4 marks)

Change made to system	Effect on yield (circle one)		
increase $\text{ppSO}_2(\text{g})$	increase	no change	decrease
decrease temperature	increase	no change	decrease
decrease volume	increase	no change	decrease
add a catalyst	increase	no change	decrease

- (b) Use collision theory to explain the effect of increasing the partial pressure of sulfur dioxide gas on the system at equilibrium. (5 marks)

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Diluting concentrated sulfuric acid is a highly exothermic reaction.

(c) To achieve this dilution safely should you

(i) add the concentrated acid to water

or

(ii) add water to the concentrated acid.

Circle the correct answer and justify your choice

(2 marks)

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(d) Write balanced chemical equations for the successive ionisations of sulfuric acid ( $K_{a1} \approx 10^9$  and  $K_{a2} = 10^{-2}$ ). Account for the difference in  $K_a$  values.

(4 marks)

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End of section two

See next page

## Section Three: Extended answer

40% (95 Marks)

This section contains **six** questions. You must answer **all** questions. Write your answers in the spaces provided.

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

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

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

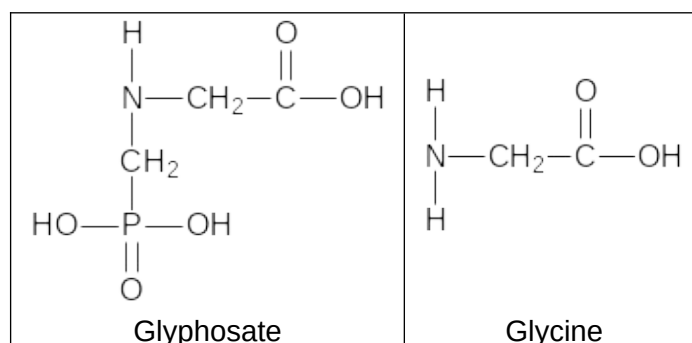
Suggested working time: 70 minutes

## Question 35

(14 marks)

Glyphosate is a chemical commonly used for killing weeds in both domestic and commercial agriculture. It is the main ingredient in the weed killer "Roundup".

The molecule glyphosate has a similar structure to glycine. Both structural formulas are shown below



Consider the two structures.

(a) Are they both  $\alpha$ -amino acids? Justify your answer.

(2 marks)

When a plant is sprayed with glyphosate, the glyphosate replaces glycine at a crucial point in the amino acid sequence of an essential plant enzyme. This makes the enzyme inactive causing the plant to die.

- (b) Explain how the replacement of a single amino acid in the enzyme can affect its ability to act as a catalyst. (3 marks)

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Alanine, threonine and glycine are part of the sequence of amino acids that make up the plant enzyme.

- (c) Draw this section of the enzyme, with the amino acids in the order written, showing the peptide bonds in full and all hydrogen atoms. (3 marks)



Alpha helices and beta pleated sheets are part of the overall structure of this enzyme.

- (d) Briefly differentiate between an alpha helix structure and a beta pleated sheet. (3 marks)

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**Question 35** continued

(e) Draw the three possible pH dependent structures of glycine.

(3 marks)

Low pH
Neutral pH
High pH

## Question 36

(28 marks)

Chromium (chrome) plating is widely used as a shiny decorative coating but can also reduce corrosion and increase surface hardness of the base metal.

Plating is normally carried out using a solution of chromium trioxide ( $250 \text{ g L}^{-1}$ ) containing a small quantity of sulfuric acid ( $2.5 \text{ g L}^{-1}$ ).

Chromium trioxide forms chromic acid ( $\text{H}_2\text{CrO}_4$ ) in water and the resulting mixture with sulfuric acid has a pH of about 0 at  $25^\circ\text{C}$ .

- (a) State what a pH of 0 indicates about the acidity of the solution. (2 marks)

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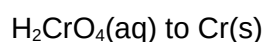
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- (b) Calculate the oxidation number of chromium in chromic acid. (1 mark)

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In chrome plating the object to be plated is the cathode.

The required cathode reaction is:

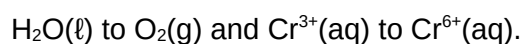


but competing reactions include:



The anode is generally lead or a lead alloy (not Cr as it will oxidise to  $\text{Cr}^{3+}$ ) with a coating of black/brown lead oxide.

Useful reactions at the anode include:

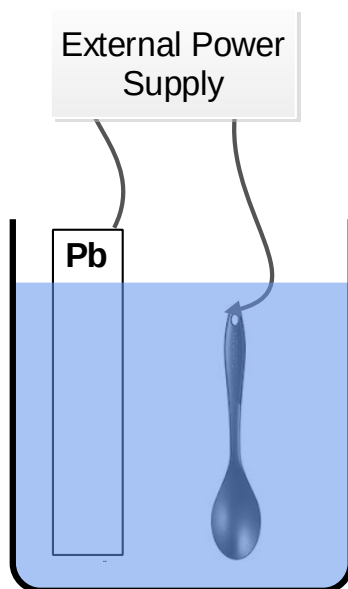


## Question 36 continued

(c) Label the diagram below to show the:

- cathode and anode
- direction of electron flow
- direction of ion flow
- polarity (positive/negative) of each electrode.

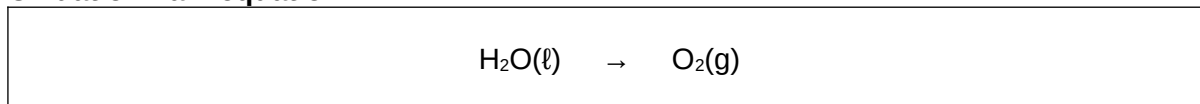
(4 marks)



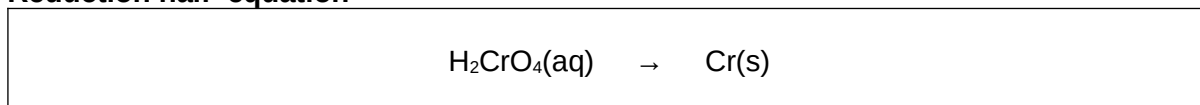
(d) Write the two half equations and the overall balanced redox equation for the main reactions in this electrolytic process.

(6 marks)

**Oxidation half-equation**



**Reduction half-equation**



**Overall redox equation**



The efficiency of the process is about 10–20%.

- (e) In a small batch (100.0 L) of chrome plating solution the mass of the object at the end of the plating increased by 1.93 kg. Determine the percentage of the available chromium that plated out. (5 marks)

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**See next page**

## Question 36 continued

**Material Safety Data Sheet**  
**Chromic Acid****Potential Health Effects**

Eye:	Causes severe eye burns. May cause irreversible eye injury. Causes redness and pain.
Skin:	Harmful if absorbed through the skin. Causes skin burns. May cause deep, penetrating ulcers of the skin. Causes redness and pain.
Ingestion:	Harmful if swallowed. May cause severe and permanent damage to the digestive tract. May cause liver and kidney damage.
Inhalation:	May cause irritation of the respiratory tract with burning pain in the nose and throat. May cause asthmatic attacks. Causes chemical burns to the respiratory tract. Prolonged exposure to dusts, vapours, or mists may result in perforation of the nasal septum.

Bubbles of hydrogen gas released at the cathode may contain small amounts of highly toxic chromic acid in fine mist form.

- (f) Use the extract from the Materials Safety Data Sheet to suggest three suitable safety measures for a worker in a chrome plating workshop and justify your choices. (6 marks)

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A contaminating precipitate of chromium(III) hydroxide can form around the cathode.

- (g) By considering the various reactions occurring at the cathode explain how this precipitate of chromium(III) hydroxide can form. (4 marks)

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## Question 37

(13 marks)

Caprolactam is a cyclic amide used to make nylon-6.

A 5.000 g sample of caprolactam ( $M = 113.158$ ) was fully combusted producing 5.483 L of carbon dioxide (at 150.0 kPa and 100.0 °C) and 4.378 g of water vapour. A further 8.000 g sample was decomposed to form a mixture of nitrogen compounds as follows

- 0.3244 g HCN
- 0.3977 g  $\text{NH}_3$
- 1.061 g NO

Determine by calculation the empirical formula and molecular formula of caprolactam.

(13 marks)

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**Question 38****(13 marks)**

Bio-based polyethene can be produced from ethene which is sourced from bagasse (sugarcane residue). The process is:

bagasse → glucose → ethanol → ethene → polyethene

The quantity of usable material in bagasse varies but generally 80% by weight recovery of glucose sugar from bagasse can be achieved with a 60% by weight conversion of glucose to 95% ethanol.

- (a) Calculate the mass of pure ethanol that can be produced from 1.0 tonne of bagasse. (1 mark)

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- (b) State one way production of bioplastics by this process can

(i) be sustainable

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(ii) make use of local resources

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(iii) minimise environmental impact

(3 marks)

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(d) Calculate the maximum theoretical mass of 99.7% ethene that can be produced per hour and therefore the percentage efficiency of the process. (6 marks)

[illegible]

## Question 39

(16 marks)

In the final step to produce polymer-grade ethene the mixture is cooled to remove impurities such as water, ethanoic acid and any unreacted ethanol. Ethene remains as a gas.

- (a) List the three impurities in order of increasing boiling point. Explain your reasoning.

(7 marks)

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The remaining gas mixture, consisting of ethene with small amounts of water vapour and carbon dioxide, is passed through a sodium hydroxide solution to remove the carbon dioxide.

- (b) Write a balanced chemical equation for the reaction between carbon dioxide gas and sodium hydroxide solution. Include state symbols. (2 marks)

- (c) With the aid of a suitable equation explain why the salt produced in this reaction is basic. (4 marks)

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- (d) What type of polymerisation produces polyethene? (1 mark)

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- (e) Draw a section of polyethene with at least three units of monomer. (2 marks)



**Question 40****(11 marks)**

Micellar water is a cosmetic product advertised for use as a facial wash, makeup remover and moisturiser. Micellar water is made up of micelles of surfactant (detergent) molecules suspended in pure water. Most people use micellar water by placing some on cotton wool (a naturally hydrophilic substance) and wiping it over their skin.

- (a) Explain how a detergent solution can remove grease from your skin. (3 marks)

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- (b) Show in a simple labelled diagram how micellar water behaves on cotton wool and how this aids its ability to remove makeup and grease. (4 marks)

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- (c) Explain, with the aid of a suitable equation, how a soap such as sodium stearate behaves differently from a detergent in hard water. (4 marks)

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