

ATAR course examination, Semester 2, 2020

CHEMISTRY ANSWER KEY

Structure of this paper

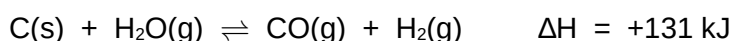
Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of total exam	Your mark
Section One Multiple-choice	25	25	50	25	25	
Section Two Short answer	9	9	60	88	35	
Section Three Extended answer	6	6	70	95	40	
Total					100	

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?

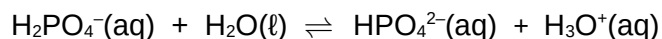
- (i) a neutral solution above 25 °C has a pH >7
 - (ii) all aqueous solutions contain both H₃O⁺(aq) and OH⁻(aq)
 - (iii) in a neutral solution at 100 °C [H₃O⁺(aq)] = [OH⁻(aq)]
 - (iv) K_w increases with increasing temperature
- (a) i only
 - (b) i and ii only
 - (c) i, ii and iii only
 - (d) ii, iii and iv only

3. In which of the following mixtures of metals and solutions will a reaction be observed?

	metal	0.1 mol L ⁻¹ solution
(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⁻¹ 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

See next page

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.

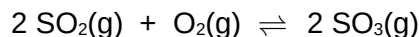
Experiment using 1 mol L ⁻¹	
Temperature (°C)	Time taken to complete reaction (s)
10	30
20	15

Experiment at 10 °C	
Concentration of reactant (mol L ⁻¹)	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?

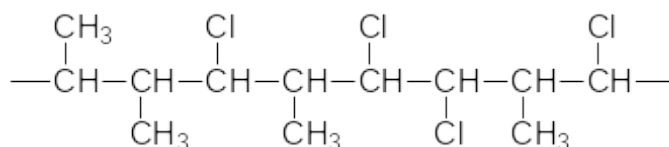
- (a) Sulfur dioxide gas is used up at the same rate as oxygen gas.
 - (b) Oxygen gas is used up twice as fast as sulfur dioxide gas.
 - (c) Sulfur trioxide is produced at the same rate as sulfur dioxide is used up.
 - (d) The rate of the forward reaction is equal to the rate of the reverse reaction.
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° 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°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) CH_3CHCHCl
- (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 H_2/O_2 fuel cell?

- (a) It converts thermal energy into electrical energy.
- (b) It stores electrical energy produced from the redox reaction of H_2 with O_2 .
- (c) It converts energy from the oxidation of H_2 directly into electrical energy.
- (d) An external energy source is used to enable a reaction between H_2 and O_2 .

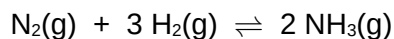
19. Which one of the following statements is correct when comparing electrochemical cells with electrolytic cells?

- (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.



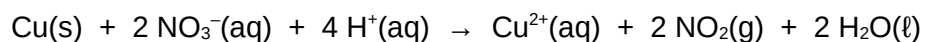
Which one of the following statements is correct?

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?

	polythene	polytetra-fluoroethylene	polystyrene	polyvinyl chloride
(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

1	A	14	C	A	6
2	D	15	B	B	6
3	C	16	D	C	7
4	B	17	A	D	6
5	B	18	C		
6	C	19	D		
7	B	20	B		
8	A	21	B		
9	C	22	D		
10	A	23	C		
11	D	24	A		
12	C	25	A		
13	D				

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

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

Description	Marks
Correct balanced redox equation	2
1 minor error in balancing	1
Total	2
Example of a 2 mark response $5 \text{Fe}^{2+}(\text{aq}) + \text{MnO}_4^{-}(\text{aq}) + 8 \text{H}^{+}(\text{aq}) \rightarrow 5 \text{Fe}^{3+}(\text{aq}) + \text{Mn}^{2+}(\text{aq}) + 4 \text{H}_2\text{O}(\ell)$	

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

Description	Marks
Purple solution (liquid) fades (becomes very pale pink) initially when added to	1
a pale green solution (liquid)	1
(Pale green liquid) becomes more yellow/brown	1
solution suddenly stays purple/purple colour persists	1
Total	4

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

Description	Marks
Acidic conditions ensure correct products/prevent insoluble MnO_2 forming.	1
$\text{MnO}_4^{-}(\text{aq})$ can oxidise $\text{Cl}^{-}(\text{aq})$ (so it will interfere with the desired reaction)	1
but not $\text{SO}_4^{2-}(\text{aq})$	1
Total	3

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)

Description	Marks
correct balanced equation including double arrows (state symbols not required)	2
1 minor error or double arrows missing	1
Example of a two mark response $\text{CO}_2(\text{aq}) + \text{H}_2\text{O}(\ell) \rightleftharpoons \text{H}_2\text{CO}_3(\text{aq})$ or $\text{CO}_2(\text{aq}) + \text{H}_2\text{O}(\ell) \rightleftharpoons \text{HCO}_3^-(\text{aq}) + \text{H}^+(\text{aq})$	
Total	2

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

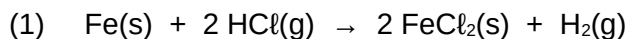
Description	Marks
$\text{H}_2\text{CO}_3(\text{aq})$ partially ionises	1
to form $\text{H}^+(\text{aq})/\text{H}_3\text{O}^+(\text{aq})$	1
two marks for suitable equation/s including double arrows $\text{H}_2\text{CO}_3(\text{aq}) \rightleftharpoons \text{H}^+(\text{aq}) + \text{HCO}_3^-(\text{aq})$ and $\text{HCO}_3^-(\text{aq}) \rightleftharpoons \text{H}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq})$ or $\text{H}_2\text{CO}_3(\text{aq}) \rightleftharpoons 2 \text{H}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq})$ or OK to use Bronsted-Lowry reactions instead. No marks off for no state symbols.	1-2
Increased $[\text{H}^+]/[\text{H}_3\text{O}^+]$ decreases pH	1
Total	5

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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)

Description		Marks
1	HCl / Hydrochloric acid (accept H^+ / hydrogen ions)	1
2	Chlorine gas / Cl_2 . Accept 'chlorine' but not 'Cl'.	1
Total		2

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

(4 marks)

Description		Marks
Oxidation of $\text{Fe} \rightarrow \text{Fe}^{2+}$ $E^\circ = +0.44$		1
Oxidation of $\text{Fe} \rightarrow \text{Fe}^{3+}$ $E^\circ = +0.44 - 0.77 = -0.33 \text{ V}$		1
Reduction of $\text{Cl}_2 \rightarrow 2 \text{Cl}^-$ $E^\circ = +1.36$ and $2 \text{H}^+ \rightarrow \text{H}_2$ $E^\circ = +0.00 \text{ V}$		1
Therefore Cl_2 is capable of oxidising Fe to Fe^{3+} ($E^\circ = +1.00$) or H^+ will not oxidise Fe to Fe^{3+} ($E^\circ = -0.33 \text{ V}$)		1
1 mark for discussing relative location on ERP table without referring to specific E° values.		
Total		4

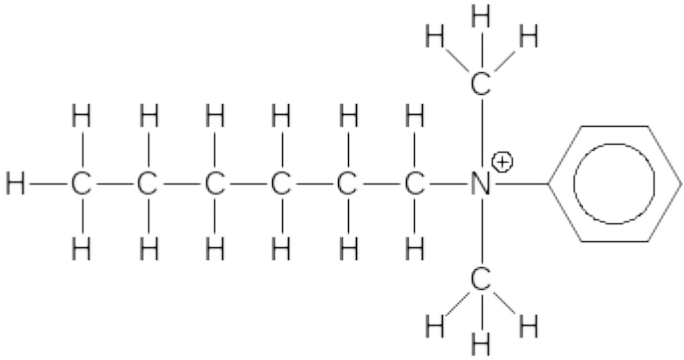
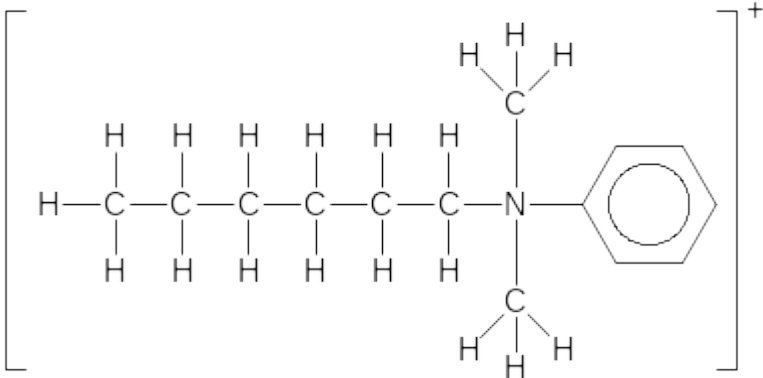
Question 29

(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.

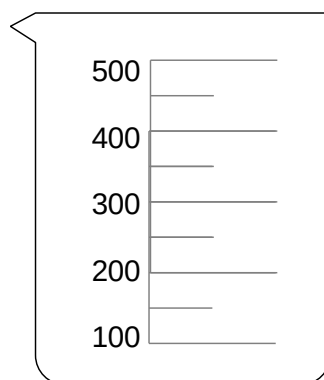
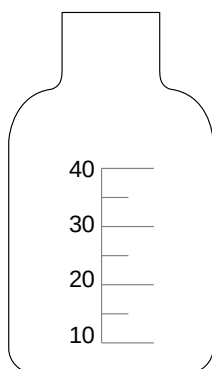
- (a) Draw a full structural formula of the benzalkonium ion. The alkyl group should be drawn with 6 carbons. (4 marks)

Description	Marks
	
<p>Alternative correct structure</p> 	
Correct attachment of four groups to the nitrogen and + charge included	1
Alkyl group (6 carbons) correctly drawn	1
Both methyl groups correctly drawn	1
Benzyl group correctly drawn	1
Total	4

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 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.

See next page



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

(2 marks)

Description	Marks
Measure 20 mL of concentrated benzalkonium chloride in small cup.	1
Measure 400 mL of water in large cup and mix both in spray bottle.	1
Other combinations are possible but total volume must not exceed 500 mL.	
Total	2

(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)~~

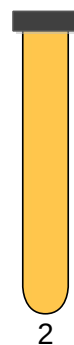
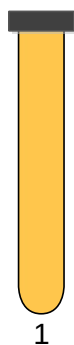
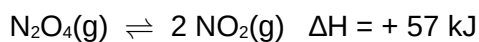
Description	Marks
15 g L = 1.5 %	1
In small cup error = +/- 2.5 mL so assume volume 20.0 + 2.5 = 22.5 mL	1
In large cup error = +/- 25 mL so assume volume 400 - 25 = 375 mL (only penalise once for incorrect assumption about size of uncertainty/measuring error)	1
Max concentration is $22.5 / (375 + 22.5) \times 1.5 \% = 0.085 \%$ so below safe level 0.1 %	1
Total	5

Question 29 (c) removed, 5 marks subtracted from total. Outside syllabus.

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)

Description	Marks
(light) brown gas	1
Total	1

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

(2 marks)

Description	Marks
Reaction has not ceased/reaction is continuing.	1
(No observable changes are visible as) both forward and reverse reactions are occurring at equal rates .	1
Total	2

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)

Description	Marks
It is an open system/equilibrium requires a closed system.	1
Reactant and product molecules can leave the flask so forward and reverse rates of reaction cannot become equal.	1
Total	2

Flask 2 is placed in a warm water bath.

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

(1 mark)

Justify your choice.

(4 marks)

Description	Marks
It is still a closed system	1
Rates of both forward and reverse reactions will become equal again	1
As temperature changes (increases) K_c changes (increases) and	1
A new equilibrium will be reached	1
Total	4

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.

Description	Marks
$n(\text{OH}^-) = (\text{NaOH}) = 1.00/39.998 = 0.02500 \text{ mol}$	1
$[\text{H}^+] = \text{inverse log } (-1.00) = 0.100 \text{ mol L}^{-1}$	1
$n(\text{H}^+) = 100.0/1000 \times 0.100 = 0.0100 \text{ mol}$	1
$n(\text{OH}^-) - n(\text{H}^+) = 0.02500 - 0.0100 = 0.01500 \text{ mol}$	1
$[\text{OH}^-] = 0.0150/0.100 = 0.1500 \text{ mol L}^{-1}$	1
$\text{pOH} = 0.8239$	1
$\text{pH} = 14 - 0.8239 = 13.2$	1
Total	7

Alternative last 2 steps

Description	Marks
$[\text{H}^+] = K_w/[\text{OH}^-] = 1.00 \times 10^{-14}/0.1500 = 6.667 \times 10^{-14}$	1
$\text{pH} = -\log(6.667 \times 10^{-14}) = 13.2$	1

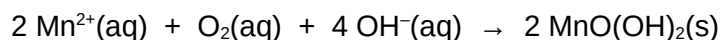
Question 32

(10 marks)

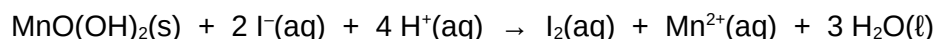
The Winkler method can be used to determine the concentration of dissolved oxygen in water samples.

The following procedure and reactions occur.

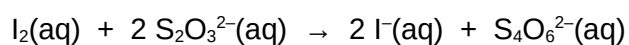
Manganese sulfate is added to the water sample in alkaline conditions.



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)

Description	Marks
Step 1	
Any air space above water sample will contain oxygen gas that could dissolve and give a higher $[\text{O}_2]$.	1
Stoppering prevents oxygen entering or escaping the water sample.	1
OR To prevent evaporation of water – 1 mark.	
Step 2	
The titration requires I_2 to reduce to I^{-} .	1
A contaminant/reductant can lower titratable I_2 and give a lower $[\text{O}_2]$.	1
Total	4

In the titration of a 200.0 mL sample of water, 7.17 mL of 0.0180 mol L⁻¹ thiosulfate solution was required.

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

Description	Marks
Correct stoichiometry $n(\text{O}_2) = \frac{1}{4} \times n(\text{S}_2\text{O}_3^{2-})$	1
$n(\text{S}_2\text{O}_3^{2-}) = 7.17/1000 \times 0.0180 = 1.2906 \times 10^{-4} \text{ mol}$	1
$n(\text{O}_2) = \frac{1}{4} \times 1.2906 \times 10^{-4} = 3.2265 \times 10^{-5} \text{ mol}$	1
$m(\text{O}_2) = 3.2265 \times 10^{-5} \times 32.00 = 1.03248 \times 10^{-3} \text{ g} = 1.03248 \text{ mg}$	1
$[\text{O}_2] = 1.03248 \div 0.200 = 5.1624 \text{ mg L}^{-1} \text{ or ppm}$	1
Answer to 3 sf = 5.16 ppm	1
Total	6

Final mark not awarded if SF or unit wrong.

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)

Description		Marks
IUPAC name for acetone	Propanone (accept propan-2-one)	1
Full structural formula for propan-2-ol	$ \begin{array}{ccccc} & \text{H} & & \text{OH} & & \text{H} \\ & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - \text{H} \\ & & & & & \\ & \text{H} & & \text{H} & & \text{H} \end{array} $	1
IUPAC name for butyl acetate	butyl ethanoate	1
Full structural formula for methyl ethyl ketone	$ \begin{array}{ccccccc} & \text{H} & & \text{O} & & \text{H} & & \text{H} \\ & & & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - \text{H} \\ & & & & & & & \\ & \text{H} & & & & \text{H} & & \text{H} \end{array} $	1
Total		4

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

Description	Marks
By reacting with acidified (1) dichromate or permanganate ions (1) (or a specific example e.g. KMnO_4)	2
Total	2

Ethyl ethanoate is a commonly used alternative solvent to acetone.

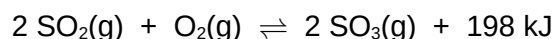
- (c) Starting only with ethene (from crude oil) describe with relevant equations how it is possible to synthesise ethyl ethanoate. You do not need to state reaction conditions. (6 marks)

Description	Marks
Ethene can undergo addition with steam (water) to produce ethanol	1
Balanced equation $\text{CH}_2\text{CH}_2(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{C}_2\text{H}_5\text{OH}(\text{l})$	1
Ethanol can be oxidised to ethanoic acid	1
Balanced equation $\text{C}_2\text{H}_5\text{OH}(\text{l}) \xrightarrow{[\text{O}]} \text{CH}_3\text{COOH}(\text{l})$ (full equation with oxidising agent not necessary)	1
Reaction of ethanol with ethanoic acid produces ethyl ethanoate and water	1
Balanced equation $\text{C}_2\text{H}_5\text{OH}(\text{l}) + \text{CH}_3\text{COOH}(\text{l}) \rightleftharpoons \text{CH}_3\text{COOCH}_2\text{CH}_3(\text{l}) + \text{H}_2\text{O}(\text{l})$	1
Total	6

Question 34

(15 marks)

Consider the second stage in the production of sulfuric acid as shown in the balanced equation below. The system has reached equilibrium.



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

Description				Marks
Change made to system	Effect on yield (circle one)			1–4
increase ppSO ₂ (g)	increase	no change	decrease	
decrease temperature	increase	no change	decrease	
decrease volume	increase	no change	decrease	
add a catalyst	increase	no change	decrease	
Total				4

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

Description	Marks
increased partial pressure of SO ₂ (g) increases the frequency of successful collisions with O ₂ (g).	1
this increases the rate of the forward reaction relative to the reverse reaction.	1
as the [SO ₂ (g)] decreases/is used up, the rate of successful collisions with O ₂ (g) decreases thus decreasing the rate of the forward reaction.	1
at the same time the increased [SO ₃ (g)] increases the frequency of successful collisions between SO ₃ (g) and therefore increases the rate of the reverse reaction	1
the system eventually establishes a new equilibrium with equal rates of both reactions	1
Reaction is pushed to the right / yield is increased	1
Any 5 points	5

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)

Description	Marks
(i) Add acid to water	1
Heat produced is safely absorbed into the large volume of water	1
Total	2

Question 34 continued.

- (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)

Description	Marks
1 st ionisation $\text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{H}^+(\text{aq}) + \text{HSO}_4^-(\text{aq})$ ($K_{a1} \approx 10^9$)	1
2 nd ionisation $\text{HSO}_4^-(\text{aq}) \rightleftharpoons \text{H}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq})$ ($K_{a2} = 10^{-2}$) (double arrow required)	1
OK to use Bronsted-Lowry equations.	
K_{a1} is very large as 1 st hydrogen is fully ionised	1
K_{a2} is much smaller as H^+ (a proton) is difficult to remove from a negatively charged species	1
Total	4

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.

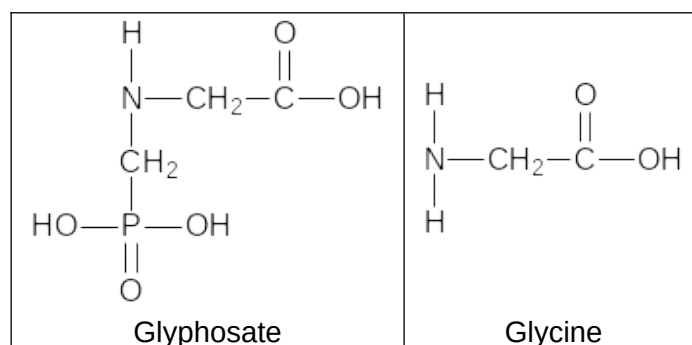
Suggested working time: 70 minutes

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 α -amino acids? Justify your answer.

(2 marks)

Description	Marks
yes	1
Amine group and carboxylic acid group attached to same carbon in each molecule.	1
Alternatively, if answered 'no' above, 1 mark for recognising that an alpha amino acid has a carboxyl group and an amine group attached to the same carbon atom.	
Total	2

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)

Description	Marks
Enzymes are (catalysts and) usually specific to a particular reaction.	1
This requires the enzyme to have specific 3D shape/conformation.	1
Which is affected by the alteration of a single amino acid.	1
Total	3

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)

Description	Marks
$ \begin{array}{ccccccc} & & & & \text{CH}_3-\text{CH}-\text{OH} & & \\ & & & & & & \\ \text{H} & \text{CH}_3 & \text{O} & \text{H} & & \text{O} & \text{H} \\ & & & & & & \\ -\text{N}- & \text{CH}- & \text{C}- & \text{N}- & \text{CH}- & \text{C}- & \text{N}-\text{CH}_2-\text{C}- \\ & & & & & & \\ & & & & & & \text{O} \end{array} $	
Correct structure (peptide bonds and order Ala–Thr–Gly correct)	3
Terminated structure drawn or Amino acids are correct but drawn in incorrect order	2
Peptide links correct but rest of structure incorrect (if peptide links incorrect = 0 marks)	1
Total	3

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)

Description	Marks
Both involve hydrogen bonds between the carbonyl and amide residues along a chain	1
Alpha helices form when the polypeptide chains twist into a coiled or spiral shape.	1
Beta pleated sheets form when polypeptide chains fold so that they lie alongside each other. It forms a corrugated or wave like shape.	1
Total	3

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

(3 marks)

Description			Marks
Low pH			
$\begin{array}{c} \text{H} \\ \\ \text{H}-\text{N}^+-\text{CH}_2-\text{C}(=\text{O})-\text{O}-\text{H} \\ \\ \text{H} \end{array}$			1
Neutral pH	OR	$\begin{array}{c} \text{H} \\ \\ \text{H}-\text{N}^+-\text{CH}_2-\text{C}(=\text{O})-\text{O}^- \\ \\ \text{H} \end{array}$	1
High pH			
$\begin{array}{c} \text{H} \\ \\ \text{H}-\text{N}-\text{CH}_2-\text{C}(=\text{O})-\text{O}^- \\ \\ \text{H} \end{array}$			1
Total			3

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 g L^{-1}) containing a small quantity of sulfuric acid (2.5 g L^{-1}).

Chromium trioxide forms chromic acid (H_2CrO_4) in water and the resulting mixture with sulfuric acid has a pH of about 0 at 25°C .

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

(2 marks)

Description	Marks
pH 0 means a high $[\text{H}^+]$	1
So very acidic	1
Total	2

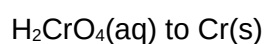
(b) Calculate the oxidation number of chromium in chromic acid.

(1 mark)

escription	Marks
+6	1
Total	1

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

The required cathode reaction is:



but competing reactions include:

$\text{H}^+(\text{aq})$ to $\text{H}_2(\text{g})$ and $\text{Cr}^{6+}(\text{aq})$ to $\text{Cr}^{3+}(\text{aq})$.

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

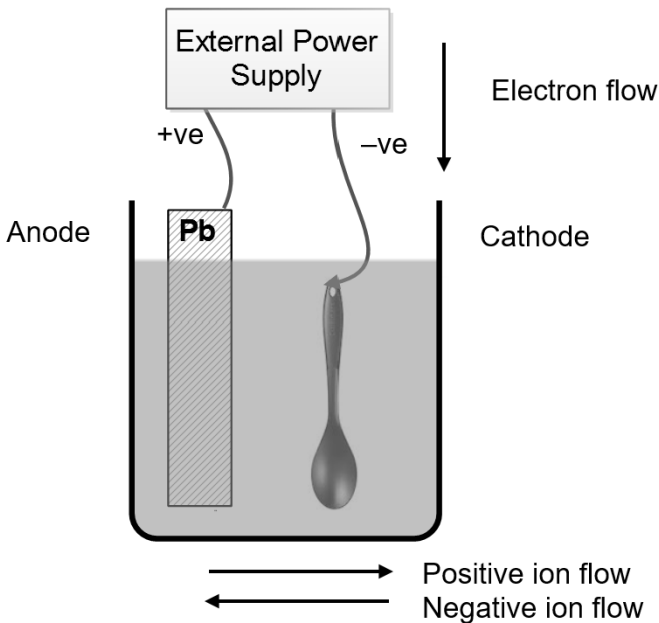
Useful reactions at the anode include:

$\text{H}_2\text{O}(\ell)$ to $\text{O}_2(\text{g})$ and $\text{Cr}^{3+}(\text{aq})$ to $\text{Cr}^{6+}(\text{aq})$.

(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)

Description	Marks
Diagram shows correctly labelled	
Cathode and anode	1
Direction of electron flow	1
Direction of ion flow	1
Polarity (positive/negative) of each electrode	1
Example of a four mark response	
	
Total	4

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

(6 marks)

Description	Marks
Oxidation half equation	
Correct reactants and products	2
Correct balancing	1
Total	2
Example of a two mark response	
$2 \text{H}_2\text{O}(\ell) \rightarrow \text{O}_2(\text{g}) + 4 \text{H}^+(\text{aq}) + 4 \text{e}^-$	
Reduction half equation	

See next page

Correct reactants and products	2
Correct balancing	1
Total	2
Example of a two mark response $\text{H}_2\text{CrO}_4(\text{aq}) + 6 \text{H}^+(\text{aq}) + 6 \text{e}^- \rightarrow \text{Cr}(\text{s}) + 4 \text{H}_2\text{O}(\ell)$	
Overall redox equation	
Correct reactants and products	2
Correct balancing	1
Total	2
Example of a two mark response $2 \text{H}_2\text{CrO}_4(\text{aq}) \rightarrow 2 \text{Cr}(\text{s}) + 2 \text{H}_2\text{O}(\ell) + 3 \text{O}_2(\text{g})$	

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)

Description	Marks
$m(\text{Cr})_{\text{plated}} = 1.93 \times 1000 = 1930 \text{ g}$	1
$m(\text{Cr}(\text{OH})_3)_{\text{initial}} = 250 \text{ g L}^{-1} \times 100.0 \text{ L} = 25\,000 \text{ g}$	1
$n(\text{Cr}(\text{OH})_3)_{\text{initial}} = 25000 \div (52.00 + 3 \times 16.00 + 3 \times 1.008) = 242.662 \text{ mol} = n(\text{Cr})$	1
$m(\text{Cr})_{\text{initial}} = 242.662 \times 52.00 = 12618.42 \text{ g}$	1
$\% \text{ Cr plated} = 1930/12618.42 \times 100 = 15.3 \%$	1
Total	5

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)

Description	Marks
Wear goggles	1
Any one suitable reason To prevent: <ul style="list-style-type: none"> severe eye burns. irreversible eye injury. redness and pain. 	1
Wear a face mask	1
Any one suitable reason To prevent <ul style="list-style-type: none"> irritation of the respiratory tract with burning pain in the nose and throat. harm if swallowed. 	1
Wear protective clothing	1
Any one suitable reason To prevent <ul style="list-style-type: none"> harm if absorbed through the skin. skin burns. deep, penetrating ulcers of the skin. redness and pain. 	1
Total	6

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)

Description	Marks
Both these reactions use up $H^+(aq)$ $H_2CrO_4(aq)$ to $Cr(s)$ $H^+(aq)$ to $H_2(g)$	1
As $[H^+(aq)]$ decreases	1
$[OH^-]$ increases relative to $[H^+]$	1
Increased $[OH^-]$ can form a precipitate with Cr^{3+}	1
Total	4

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 NH_3
- 1.061 g NO

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

13 marks)

Calculation of EF by %

Description					Marks
Percentage carbon in 5.000 g sample using PV = nRT					
$n(\text{CO}_2) = \frac{150.0 \times 5.483}{8.314 \times (100.0 + 273.15)} = 0.265104 = n(\text{C})$ $m(\text{C}) = 0.265104 \times 12.01 = 3.18389 \text{ g}$ (1) $\% \text{C} = 3.18389/5.000 = 63.6779\%$ (1)					2
Percentage hydrogen in 5.000 g sample					
$n(\text{H}_2\text{O}) = 4.378/18.016 = 0.243006 \text{ mol}$ $n(\text{H}) = 2 \times n(\text{H}_2\text{O}) = 0.48061 \text{ mol}$ $m(\text{H}) = 0.48061 \times 1.008 = 0.489900 \text{ g}$ (1) $\% \text{H} = 0.489900/5.000 = 9.79801 \%$ (1)					2
Percentage nitrogen in 8.000 g sample					
$n(\text{N}) = n(\text{HCN}) = 0.3244/27.028 = 0.0120024 \text{ mol}$ $n(\text{N}) = n(\text{NH}_3) = 0.3977/17.034 = 0.0233474 \text{ mol}$ $n(\text{N}) = n(\text{NO}) = 1.061/30.01 = 0.0353549 \text{ mol}$ $\text{total } n(\text{N}) = 0.0120024 + 0.0233474 + 0.0353549 = 0.0707047 \text{ mol}$ (1) $m(\text{N}) = 0.0707047 \times 14.01 = 0.99057 \text{ g}$ (1) $\% \text{N} = 0.99057/8.000 = 12.3821\%$ (1)					3
Percentage oxygen by subtraction					
$\% \text{O} = 100 - \% \text{C} - \% \text{H} - \% \text{N}$ $\% \text{O} = 100 - 63.6779 - 9.79801 - 12.3821 = 14.14199$					1
	C	H	N	O	
Mass in 100 g	63.6779	9.79801	12.3821	14.14199	
n	5.3022	9.72025	0.8838	0.8839	1
÷ by smallest and round	6	11	1	1	1
Writing the empirical formula	$\text{C}_6\text{H}_{11}\text{NO}$				1

Calculation of EF by proportion

Description					Marks
carbon in 5.000 g sample using PV = nRT					
$n(\text{CO}_2) = \frac{150.0 \times 5.483}{8.314 \times (100.0 + 273.15)} = 0.265104 = n(\text{C})$ (1) $m(\text{C}) = 0.265104 \times 12.01 = 3.18389 \text{ g}$ (1)					2

hydrogen in 5.000 g sample					
$n(\text{H}_2\text{O}) = 4.378/18.016 = 0.243006 \text{ mol}$ $n(\text{H}) = 2 \times n(\text{H}_2\text{O}) = 0.48061 \text{ mol} \quad (1)$ $m(\text{H}) = 0.48061 \times 1.008 = 0.489900 \text{ g} \quad (1)$					2
nitrogen in 8.000 g sample					
$n(\text{N}) = n(\text{HCN}) = 0.3244/27.028 = 0.0120024 \text{ mol}$ $n(\text{N}) = n(\text{NH}_3) = 0.3977/17.034 = 0.0233474 \text{ mol}$ $n(\text{N}) = n(\text{NO}) = 1.061/30.01 = 0.0353549 \text{ mol}$ $\text{total } n(\text{N}) = 0.0120024 + 0.0233474 + 0.0353549 = 0.0707047 \text{ mol} \quad (1)$ $m(\text{N}) = 0.0707047 \times 14.01 = 0.99057 \text{ g} \quad (1)$					2
nitrogen in 5.000 g sample					
$m(\text{N}) \text{ in } 5.000 \text{ g sample} = 0.99057 \times 5.000/8.000 = 0.619106 \text{ g}$					1
oxygen by subtraction in 5.000 g					
$m(\text{O}) = 5.000 - 3.18389 - 0.489900 - 0.619106 = 0.707104 \text{ g}$					1
	C	H	N	O	
Mass in 5.000 g	3.18389	0.489900	0.619106	0.707104	
n	0.2651	0.4860	0.04419	0.04419	1
÷ by smallest and round	6	11	1	1	1
Writing the empirical formula	$\text{C}_6\text{H}_{11}\text{NO}$				1

Determination of Molecular formula

Description	Marks
EF mass = $6 \times 12.01 + 11 \times 1.008 + 14.01 + 16 = 113.158 \text{ g}$	1
EF mass = Molecular mass given (113.158) Therefore molecular formula is $\text{C}_6\text{H}_{11}\text{NO}$	1

DO NOT WRITE IN THIS AREA AS IT WILL BE CUT OFF

Question 38

(13 marks)

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



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)

Description	Marks
$80\% \times 60\% \times 95\% \times 1.0 \times 10^6 = 460\,000 \text{ g or } 0.46 \text{ tonnes}$	1
No mark if no or wrong unit. Do not apply significant figure rules.	
Total	1

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

(i) be sustainable

(ii) make use of local resources

(iii) minimise environmental impact

(3 marks)

Description	Marks
(i) supply of bagasse maintained by sugar cane production / it uses crops (instead of crude oil)	1
(ii) ethene can be produced locally near the resource (sugar cane)	1
(iii) no pollution associated with transport or doesn't use fossil fuels to make plastic or reduces waste as it uses a waste product of sugarcane production	1
Other answers may be correct, at the teacher's discretion.	
Total	3

- (c) Ethene is produced by the endothermic dehydration of ethanol with an alumina catalyst at a temperature between 300 °C and 500 °C. Write a full structural equation for the production of ethene including the heat of reaction. (3 marks)

Description	Marks
Correct reactants and products	1
Heat of reaction shown correctly (catalyst not required)	1
Full structural formulas shown (accept H ₂ O)	1
Total	3

Example of a 3 mark response

$$\begin{array}{c} \text{H} & \text{H} \\ | & | \\ \text{H}-\text{C}-\text{C}-\text{O}-\text{H} \\ | & | \\ \text{H} & \text{H} \end{array} + \text{Heat} \xrightarrow{\text{Al}_2\text{O}_3} \begin{array}{c} \text{H} & & \text{H} \\ & \diagdown & / \\ & \text{C}=\text{C} \\ & / & \diagdown \\ \text{H} & & \text{H} \end{array} + \begin{array}{c} \text{O} \\ / \quad \backslash \\ \text{H} & & \text{H} \end{array}$$

One such industrial process consumes 1.0×10^2 tonnes/hour of 95% by weight ethanol and produces 53 tonnes/hour of 99.7% by weight polymer-grade ethene.

- (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)

Description	Marks
$M(\text{ethanol}) = 1.0 \times 10^2 \text{ t} \times 0.95\% = 95 \text{ t} = 9.5 \times 10^7 \text{ g}$	1
$n(\text{ethanol}) = 9.5 \times 10^7 \div (2 \times 12.01 + 6 \times 1.008 + 16) = 2.0622 \times 10^6 \text{ mol}$	1
$n(\text{ethene}) = n(\text{ethanol}) = 2.0622 \times 10^6 \text{ mol}$	1
$\text{max } m(\text{ethene } 100\%) = 2.0622 \times 10^6 \times (2 \times 12.01 + 4 \times 1.008) = 5.7848 \times 10^7 \text{ g}$	1
$m(\text{ethene } 99.7\%) = 5.7848 \times 10^7 \div 0.997 = 5.8022 \times 10^7 \text{ g} = 58.02 \text{ t}$	1
$\text{efficiency of process} = 53/58.02 \times 100 = 91\%$	1
Do not award this mark if SFs are wrong.	
Total	6

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)

Description	Marks
Ethanol water ethanoic acid	1
Boiling point is determined by the strength of the intermolecular forces	1
Dispersion forces will be present (but low/not significant as these are all small molecules)	1
Major intermolecular force in each molecule is hydrogen bonding	1
Ethanol has weaker hydrogen bonding than the similar size molecule ethanoic acid as it has less points to hydrogen bond	1
Hydrogen bonding occurs only between –OH in ethanol and both –C=O and –OH in ethanoic acid	1
For its size water has very strong hydrogen bonding putting its boiling point above the larger ethanol molecule.	1
Ethanol and ethanoic acid also have dipole-dipole forces.	1
Total	Max 7

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)

Description	Marks
Correct reactants and products	1
Correct state symbols	1
Total	2
Example of a two mark response $\text{CO}_2(\text{g}) + \text{OH}^-(\text{aq}) \rightarrow \text{HCO}_3^-(\text{aq})$ OK to write a molecular equation instead. Pay state symbols even if equation is wrong.	

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

(4 marks)

Description	Marks
$\text{HCO}_3^-(\text{aq})$ reacts with/hydrolyses in water	1
Causing an excess of $\text{OH}^-(\text{aq})$ or $[\text{OH}^-(\text{aq})] > [\text{H}^+]$	1
Two marks for equation	
Correct reactants and products	1
Equation is balanced and has double arrows	1
Example of a two mark response $\text{HCO}_3^-(\text{aq}) + \text{H}_2\text{O}(\ell) \rightleftharpoons \text{H}_2\text{CO}_3(\text{aq}) + \text{OH}^-(\text{aq})$	
If the student wrote an equation that produced carbonate ions in part (b) above then accept an equation showing the hydrolysis of carbonate ions here.	
Total	4

- (d) What type of polymerisation produces polyethene?

(1 mark)

Description	Marks
addition	1
Total	1

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

Description	Marks
$\left[\begin{array}{cccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & & \\ -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}- \\ & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array} \right]$	
Correct structure with at least 3 units of monomer and ends not terminated (square brackets not required)	2
Terminated structure drawn or Less than 3 monomers drawn correctly	1
Total	2

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Question 40

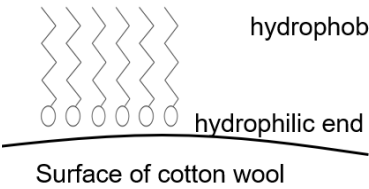
(11 marks)

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)

Description	Marks
Detergent molecule has hydrophilic (water attracting) and hydrophobic (grease attracting) ends.	1
In a detergent solution the hydrophilic end of the molecule is attracted to water and the hydrophobic end attracted to the grease.	1
A micelle (a spherical structure) forms around the grease removing from the skin.	1
Total	3

- (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)

Description	Marks
Diagram (max 2 marks)	
<p>Behaviour of micelle on cotton wool</p>  <p>Diagram must be labelled.</p>	1-2
Explanation (max 2 marks) (sufficient explanation may be on diagram)	
Attraction of hydrophilic ends (of detergent molecules) to cotton wool allows the hydrophobic (grease attracting) ends (of the detergent molecules) to face outwards/away	1
The hydrophobic ends are then attracted to grease and remove grease from skin	1
Total	4

- (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)

Description	Marks
Hard water contains Ca^{2+} and Mg^{2+} ions	1
Soaps form a precipitate with these ions in water; detergents do not	1
Two marks for equation	
Correct reactants and products	1
Equation is balanced	1
Example of a two mark equation ((s) required)	4
$2 \text{CH}_3(\text{CH}_2)_{16}\text{COO}^-(\text{aq}) + \text{Ca}^{2+}(\text{aq}) \rightleftharpoons \text{Ca}(\text{CH}_3(\text{CH}_2)_{16}\text{COO})_2(\text{s})$ <p>1 mark only for a word equation.</p>	

End of questions

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