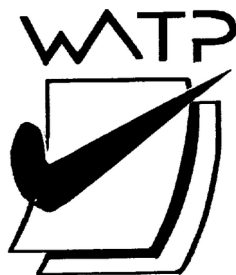


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# CHEMISTRY

## UNIT 3

### 2021

## MARKING GUIDE

### Section One: Multiple-choice

(25 marks)

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

(1 mark per question)

**Section Two: Short answer****35% (80 marks)****Question 26****(7 marks)**

- (a) Write balanced chemical equations representing the combustion of ethane gas, in both excess and limited oxygen environments. (4 marks)

Description	Marks
Excess equation: $2 \text{C}_2\text{H}_6(\text{g}) + 7 \text{O}_2(\text{g}) \rightarrow 4 \text{CO}_2(\text{g}) + 6 \text{H}_2\text{O}(\text{g})$	
Correct reactants and products	1
Balanced	1
Limited equation: $2 \text{C}_2\text{H}_6(\text{g}) + 5 \text{O}_2(\text{g}) \rightarrow 4 \text{CO}(\text{g}) + 6 \text{H}_2\text{O}(\text{g})$	
Correct reactants and products	1
Balanced	1
<b>Total</b>	<b>4</b>
Note: also accept equations for limited oxygen showing production of soot, C(s) e.g. $\text{C}_2\text{H}_6(\text{g}) + 2 \text{O}_2(\text{g}) \rightarrow \text{CO}(\text{g}) + \text{C}(\text{s}) + 3 \text{H}_2\text{O}(\text{l})$	

- (b) Use oxidation numbers to demonstrate which process results in the complete oxidation of ethane. (3 marks)

Description	Marks
Oxidation number of carbon changes from (-3) in $\text{C}_2\text{H}_6$ to (+4) in $\text{CO}_2$	1
Oxidation number of carbon changes from (-3) in $\text{C}_2\text{H}_6$ to (+2) in $\text{CO}$	1
Therefore complete oxidation takes place in excess oxygen (since this produces carbon in a higher oxidation state)	1
<b>Total</b>	<b>3</b>

**Question 27****(6 marks)**

Complete the following table;

Description			Marks
Rate of forward reaction:	increase	decrease	2
Position of equilibrium:	shift left	shift left	2
Concentration of $\text{NO}_2(\text{g})$ :	increase	decrease	2
<b>Total</b>			<b>6</b>

**Question 28****(9 marks)**

- (a) Calculate the initial pH of the hydrochloric acid solution.

(1 mark)

Description	Marks
$\text{pH} = -\log 0.55 = 0.26$	1
<b>Total</b>	<b>1</b>

- (b) Calculate the pH of the mixture, after the 200 drops of nitric acid was added.

(6 marks)

Note: 1 drop = 0.05 mL.

Description	Marks
$n(\text{H}^+ \text{ in HCl}) = 0.55 \times 0.325$ $= 0.17875 \text{ mol}$	1
$V(\text{HNO}_3) = 200 \times 0.05$ $= 10 \text{ mL}$	1
$n(\text{H}^+ \text{ in HNO}_3) = 2 \times 0.01$ $= 0.02 \text{ mol}$	1
$n(\text{H}^+ \text{ total}) = 0.17875 + 0.02$ $= 0.19875 \text{ mol}$	1
$c(\text{H}^+ \text{ total}) = 0.19875 / 0.335$ $= 0.59328 \text{ mol L}^{-1}$	1
$\text{pH} = -\log(0.59328)$ $= 0.23$	1
<b>Total</b>	<b>6</b>

- (c) Use relevant chemical theory to justify the teacher's statement, with reference to the results obtained.

(2 marks)

Description	Marks
The solution is not a buffer because: there is no conjugate acid-base pair present <b>or</b> both acids are strong and cannot be used to form a buffer <b>or</b> a buffer must be formed from a weak acid and its conjugate base or a weak base and its conjugate acid	1
The pH change of 0.03 units may be rationalised by: addition of a base was not tested, which would have resulted in a substantial/rapid increase in pH <b>or</b> pH is a log scale, therefore at these low values a large amount of acid would be required to see a 'substantial' decrease in pH <b>or</b> pH is a log scale, therefore at these low values this change in pH could be regarded as quite substantial (considering a relatively small amount of acid was added)	1
<b>Total</b>	<b>2</b>

**Question 29****(8 marks)**

Write four (4) half-equations representing the steps in the sulfur cycle described above, assuming acidic conditions. Classify each step as a reduction (R) or oxidation (O) process.

Description	Marks
Step 1: $8 \text{H}_2\text{S} \rightarrow \text{S}_8 + 16 \text{H}^+ + 16 \text{e}^-$	
Correct half-equation	1
Oxidation (O)	1
Step 2: $\text{S}_8 + 32 \text{H}_2\text{O} \rightarrow 8 \text{SO}_4^{2-} + 64 \text{H}^+ + 48 \text{e}^-$	
Correct half-equation	1
Oxidation (O)	1
Step 3: $\text{SO}_4^{2-} + 2 \text{H}^+ + 2 \text{e}^- \rightarrow \text{SO}_3^{2-} + \text{H}_2\text{O}$	
Correct half-equation	1
Reduction (R)	1
Step 4: $\text{SO}_3^{2-} + 8 \text{H}^+ + 6 \text{e}^- \rightarrow \text{H}_2\text{S} + 3 \text{H}_2\text{O}$	
Correct half-equation	1
Reduction (R)	1
<b>Total</b>	<b>8</b>

**Question 30****(9 marks)**

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

Description	Marks
Equation: $\text{Pb}^{2+}(\text{aq}) + 2 \text{I}^{-}(\text{aq}) \rightarrow \text{PbI}_2(\text{s})$	
Correct reactants and products	1
Balanced	1
<b>Total</b>	<b>2</b>

- (b) Sketch an energy profile diagram for this reaction on the axes below. Label the activation energy and change in enthalpy. (5 marks)

Description	Marks
Reactants and products labelled	1
Activation energy labelled	1
Enthalpy change labelled	1
Exothermic curve	1
Shape of curve in (approximate) proportion with $E_a$ and $\Delta H$ values	1
<b>Total</b>	<b>5</b>

Example of a five mark response:

The diagram shows an exothermic reaction. The reactants are  $\text{Pb}^{2+} + 2 \text{I}^{-}$  and the products are  $\text{PbI}_2$ . The activation energy  $E_a$  is the energy barrier from the reactants to the transition state. The enthalpy change  $\Delta H$  is the energy difference between the reactants and the products, which is negative, indicating an exothermic process.

- (c) Comment, with justification, on the likely reversibility of this reaction at 25 °C. (2 marks)

Description	Marks
Not likely to be reversible	1
Large value of $K_c$ indicates $\text{PbI}_2$ product is very stable at this temperature or The reverse $E_a$ is large (four times greater) compared to the forward $E_a$ or $\text{PbI}_2$ is an insoluble salt, therefore unlikely to dissociate to any great extent	1
<b>Total</b>	<b>2</b>

**Question 31****(5 marks)**

Describe, with reference to relevant chemical theory, what information the data represented in the graph provides, regarding the enthalpy change of the autoionisation of water. Include a relevant chemical equation in your answer.

Description	Marks
Autoionisation of water: $\text{H}_2\text{O}(\text{l}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{OH}^-(\text{aq})$	1
An increase in conductivity corresponds to an increase in mobile charge / an increase in concentration of ions	1
Therefore the forward reaction rate must be favoured, as this produces more ions	1
An increase in temperature favours the endothermic direction <b>or</b> An increase in temperature increases the rate of the endothermic direction more than the exothermic direction	1
Therefore $\Delta H$ must be positive for the autoionisation of water, thus the forward reaction is endothermic	1
<b>Total</b>	<b>5</b>

**Question 32****(9 marks)**

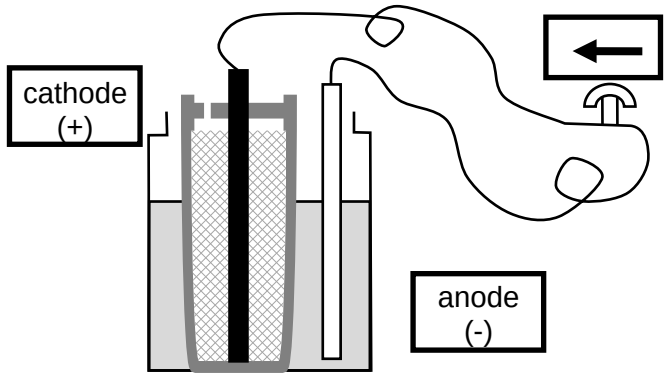
- (a) Define a primary cell.

(1 mark)

Description	Marks
A cell that cannot be recharged	1
<b>Total</b>	<b>1</b>

- (b) In the boxes on the diagram above, label the anode and cathode, polarity of each electrode, and direction of electron flow.

(3 marks)

Description	Marks
Cathode and anode labels	1
Polarity (+/-) labels	1
Direction of electron flow label	1
<b>Total</b>	<b>3</b>
<p>Example of a three mark response:</p> 	

- (c) The Leclanché cell provides an EMF of +1.4 V. If this EMF was produced under standard conditions, complete the table above by adding in the
- $E^0$
- values.

(2 marks)

Description	Marks
$E^0(\text{red}) = + 0.64 \text{ V}$	1
$E^0(\text{ox}) = + 0.76 \text{ V}$	1
<b>Total</b>	<b>2</b>

- (d) Which component on the diagram above is acting as the 'salt bridge'? Describe the functions of this component.

(3 marks)

Description	Marks
Porous pot	1
Any <b>two</b> of the following:	
<ul style="list-style-type: none"> <li>allows ions to flow between half-cells</li> <li>complete the electrical circuit</li> <li>prevents reactants from coming into contact</li> <li>maintains electrical neutrality</li> </ul>	2
<b>Total</b>	<b>3</b>

**Question 33****(6 marks)**

- (a) Which of the changes below was imposed on the system? (circle your choice) (1 mark)

Description	Marks
'Increase in temperature of system' (circled)	1
<b>Total</b>	<b>1</b>

- (b) Justify why you **did not choose** the two remaining options. (2 marks)

Description	Marks
The addition of nitrogen gas to the system would instantaneously increase the forward reaction rate only <b>or</b> The instantaneous increase seen in both forward and reverse reaction rates is not consistent with the addition of nitrogen gas / change in concentration	1
A decrease in total volume would increase the forward and reverse reaction rates equally (and would not shift the position of equilibrium) <b>or</b> The increase in forward reaction rate relative to reverse reaction rate is not consistent with a system that has a reactant to product ratio of 2:2 gas moles	1
<b>Total</b>	<b>2</b>

- (c) Explain the resultant shift that was observed. (3 marks)

Description	Marks
A temperature increase would increase (both forward and reverse reaction rates, by increasing) the average kinetic energy of particles, resulting in an increase in the proportion and frequency of successful collisions	1
However the forward / endothermic reaction rate would increase more than the reverse reaction rate	1
This would result in a shift to the right / the forward reaction being favoured	1
<b>Total</b>	<b>3</b>



**Question 34****(6 marks)**

- (a) Write a balanced ionic equation for the chemical reaction that would occur when ethanoic acid is mixed with sodium carbonate solution. (2 marks)

Description	Marks
Equation: $2 \text{CH}_3\text{COOH}(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow 2 \text{CH}_3\text{COO}^-(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$	
Correct reactants and products	1
Balanced	1
<b>Total</b>	<b>2</b>
Note: one mark may be allocated for the correctly balanced molecular equation	

- (b) State all observations that would be noted, when several drops of bromine water are added to a beaker containing excess potassium iodide. (2 marks)

Description	Marks
Orange and colourless solutions are mixed,	1
to form a brown solution	1
<b>Total</b>	<b>2</b>

- (c) Write the equilibrium constant expression for the reaction that would occur, when a piece of barium metal is dropped into a large bowl of warm water. (2 marks)

Description	Marks
$K = [\text{Ba}^{2+}] [\text{OH}^-]^2 [\text{H}_2]$	2
<b>Total</b>	<b>2</b>
Note: one mark may be allocated for minor error such as no 'K='	

**Question 35****(7 marks)**

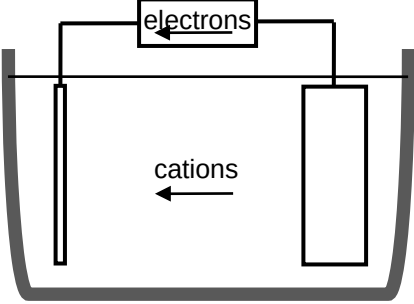
Identify whether the laboratory technician used potassium hydrogen phthalate or potassium hydrogen iodate as the primary standard. Use appropriate calculations to support your answer.

Description		Marks			
Correct values in table (see below)		1			
average titre*	= (28.87 + 28.92 + 28.93) / 3 = 28.91 mL	1			
n(NaOH)	= 0.06723 x 0.02891 = 0.0019436 mol	1			
n(acid in 20 mL)	= 0.0019436 mol	1			
n(acid in 250 mL)	= 0.0019436 x (250/20) = 0.024295 mol = n(acid in 4.962 g)	1			
M(acid)	= 4.962 / 0.024295 = 204.24 g mol <sup>-1</sup>	1			
Therefore the acid is potassium hydrogen phthalate		1			
Total		7			
Correctly completed table:					
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Titre (mL)	29.59	28.87*	29.38	28.92*	28.93*

**Question 36****(8 marks)**

- (a) On the diagram above, label the
- direction of electron flow through the power source, and
  - direction of cation flow.

**(2 marks)**

Description	Marks
Direction of electron flow label	1
Direction of cation flow label	1
<b>Total</b>	<b>2</b>
<p>Example of a two mark response:</p> 	

- (b) Write balanced half-equations representing the processes occurring at the cathode and the anode.

**(2 marks)**

Description	Marks
cathode: $\text{Pb}^{2+}(\text{aq}) + 2 \text{e}^{-} \rightarrow \text{Pb}(\text{s})$	1
anode: $\text{Pb}(\text{s}) \rightarrow \text{Pb}^{2+}(\text{aq}) + 2 \text{e}^{-}$	1
<b>Total</b>	<b>2</b>

- (c) State the overall EMF for the reaction occurring, and justify why a voltage is applied.

**(2 marks)**

Description	Marks
0 volts	1
This is a non-spontaneous reaction, therefore an external voltage is required <b>or</b> Without an external voltage no reaction will take place	1
<b>Total</b>	<b>2</b>

- (d) If copper metal was one of the impurities in the lead, would this likely be found in the electrolyte or the anode mud, once the electrorefining process was complete? Justify your answer. (2 marks)

Description	Marks
Anode mud	1
Copper has a lower oxidation potential than lead <b>or</b> Copper is a less reactive metal than lead	1
<b>Total</b>	<b>2</b>
Note: full marks may be awarded if students predict that copper is present in the electrolyte, and justify this by saying that the voltage of 0.5 V used in the Betts process is greater than the 0.2 V used in the electrolytic refining of copper, therefore the copper has the potential to be oxidised.	

## Section Three: Extended answer

40% (90 marks)

## Question 37

(17 marks)

- (a) Determine the concentration of
- $\text{FeSCN}^{2+}(\text{aq})$
- present at equilibrium.

(1 mark)

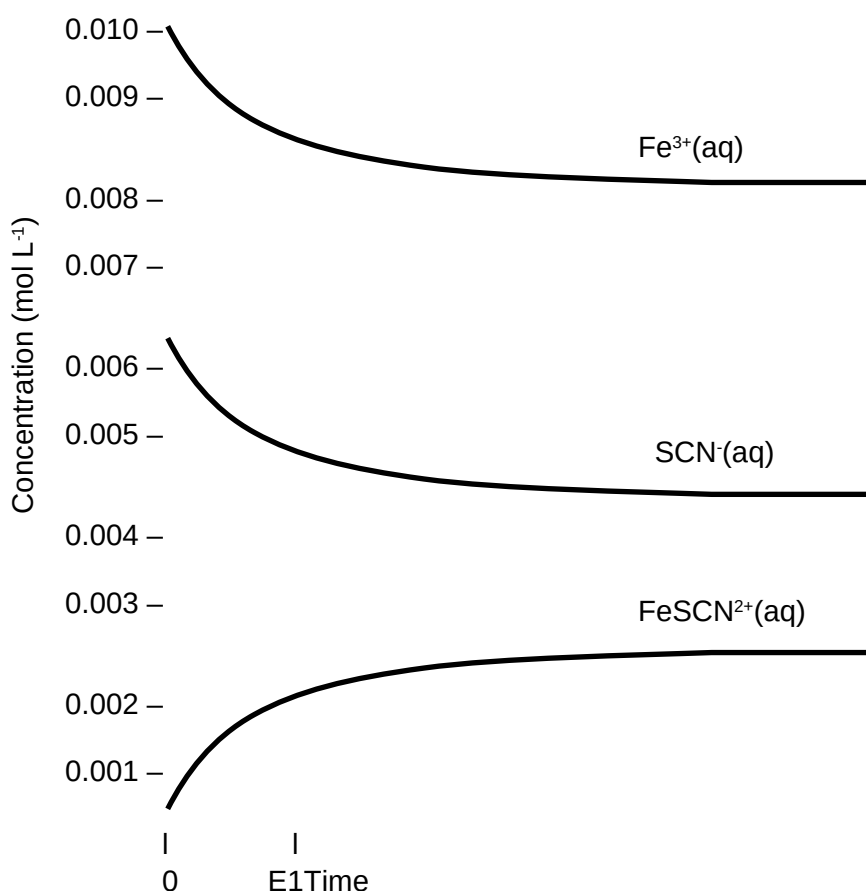
Description	Marks
0.002 mol L <sup>-1</sup>	1
<b>Total</b>	<b>1</b>

- (b) Sketch a graph, including all relevant species, showing the establishment of equilibrium, from Time 0 where the reactants were mixed, to Time E1, where equilibrium was established and maintained.

(5 marks)

Description	Marks
$\text{Fe}^{3+}(\text{aq})$ concentration decreases from 0.01 to 0.008 mol L <sup>-1</sup>	1
$\text{SCN}^{-}(\text{aq})$ concentration decreases from 0.006 to 0.004 mol L <sup>-1</sup>	1
$\text{FeSCN}^{2+}(\text{aq})$ concentration increases from 0 to 0.002 mol L <sup>-1</sup>	1
Horizontal lines from E1 onwards	1
Labels on each of the three curves	1
<b>Total</b>	<b>5</b>

Example of a five mark response



- (c) Justify these results by using Le Chatelier's principle and making reference to any appropriate equations provided. (6 marks)

Description	Marks
Addition of $\text{H}_3\text{O}^+$ :	
The $\text{H}_3\text{O}^+(\text{aq})$ added will react with $\text{SCN}^-(\text{aq})$ as shown in equation (ii)	1
The $\text{SCN}^-(\text{aq})$ concentration will therefore be lowered	1
The original equilibrium will therefore shift left to increase the concentration of $\text{SCN}^-(\text{aq})$	1
Addition of $\text{OH}^-$ :	
The $\text{OH}^-(\text{aq})$ added will react with $\text{Fe}^{3+}(\text{aq})$ as shown in equation (iii)	1
The $\text{Fe}^{3+}(\text{aq})$ concentration will therefore be lowered	1
The original equilibrium will therefore shift left to increase the concentration of $\text{Fe}^{3+}(\text{aq})$	1
<b>Total</b>	<b>6</b>

- (d) Describe the observation that would have distinguished between the addition of acid and base to the equilibrium system. (1 mark)

Description	Marks
Addition of $\text{OH}^-(\text{aq})$ would cause a pale brown precipitate to form	1
<b>Total</b>	<b>1</b>

- (e) Explain, in terms of reaction rates, the effect this would have on the equilibrium position. (4 marks)

Description	Marks
Adding $\text{KF}(\text{aq})$ would (increase the concentration of $\text{F}^-(\text{aq})$ which will react with, and) lower the concentration of $\text{Fe}^{3+}(\text{aq})$	1
This would decrease both the forward and reverse reaction rates (due to a decreased frequency of collisions)	1
The reverse reaction rate would not decrease by as much as the forward reaction rate <b>or</b> The forward reaction rate would decrease more, relative to the reverse reaction rate	1
This would result in a shift to the left / the reverse reaction being favoured	1
<b>Total</b>	<b>4</b>

**Question 38****(16 marks)**

- (a) Explain why the pH at the first equivalence point is acidic, whilst the pH at the second equivalence point is basic. Include relevant chemical equations in your answer. (4 marks)

Description	Marks
At the first equivalence point:	
The salt produced ( $\text{NaH}_2\text{PO}_4$ ) is acidic due to the presence / hydrolysis of $\text{H}_2\text{PO}_4^-$ (aq) ions (which results in an excess of $\text{H}_3\text{O}^+$ ions)	1
$\text{H}_2\text{PO}_4^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{HPO}_4^{2-}(\text{aq}) + \text{H}_3\text{O}^+(\text{aq})$	1
At the second equivalence point:	
The salt produced ( $\text{Na}_2\text{HPO}_4$ ) is basic due to the presence / hydrolysis of $\text{HPO}_4^{2-}$ (aq) ions (which results in an excess of $\text{OH}^-$ ions)	1
$\text{HPO}_4^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{PO}_4^-(\text{aq}) + \text{OH}^-(\text{aq})$	1
<b>Total</b>	<b>4</b>

- (b) Suggest one practical reason a pH meter is used to detect the equivalence point, instead of the indicator phenolphthalein. (1 mark)

Description	Marks
The colour of the Coca-Cola would obscure the indicator colour	1
<b>Total</b>	<b>1</b>

- (c) Calculate the milligrams of phosphorus present in a 375 mL can of Coca-Cola. (6 marks)

Description	Marks
$n(\text{NaOH}) = 0.1005 \times 0.01665$ $= 0.0016733 \text{ mol}$	1
$n(\text{H}_3\text{PO}_4) = 0.0016733 / 2$ $= 0.00083666 \text{ mol}$ $= n(\text{H}_3\text{PO}_4 \text{ in } 150 \text{ mL Coca-Cola})$ $= n(\text{P in } 150 \text{ mL Coca-Cola})$	1
$n(\text{P in } 375 \text{ mL can}) = 0.00083666 \times (375 / 150)$ $= 0.00209165 \text{ mol}$	1
$m(\text{P}) = 0.00209165 \times 30.97$ $= 0.064778 \text{ g}$	1
$= 64.78 \text{ mg}$	1
<b>Total</b>	<b>6</b>

- (d) Justify why this step is important for the **validity** of the experiment. (2 marks)

Description	Marks
If $\text{H}_2\text{CO}_3$ is present, it will consume / react with some of the added $\text{OH}^-(\text{aq})$ in the titration	1
This would interfere with / inflate / give an invalid calculation of the concentration of $\text{H}_3\text{PO}_4$	1
<b>Total</b>	<b>2</b>

- (e) Classify this error as random or systematic. Justify your choice and state the likely effect this would have on the students' calculated phosphorus content. (3 marks)

Description	Marks
Systematic	1
This error would result in consistently higher titre values	1
The calculated concentration of P would be greater than the true value	1
<b>Total</b>	<b>3</b>

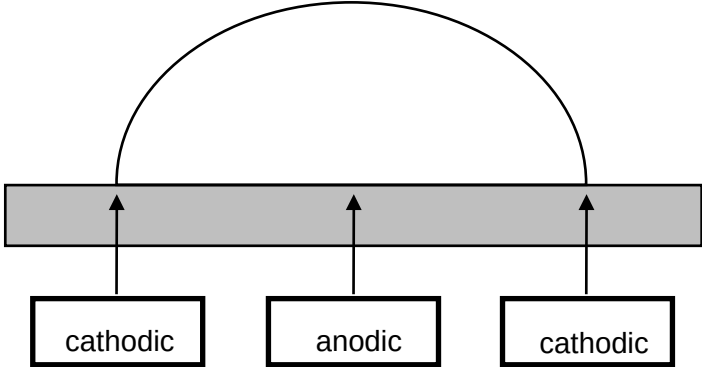


**Question 39****(18 marks)**

- (a) In the boxes on the diagram, label these sites as cathodic or anodic. (2 marks)

Description	Marks
Cathodic (left and right boxes)	1
Anodic (middle box)	1
<b>Total</b>	<b>2</b>

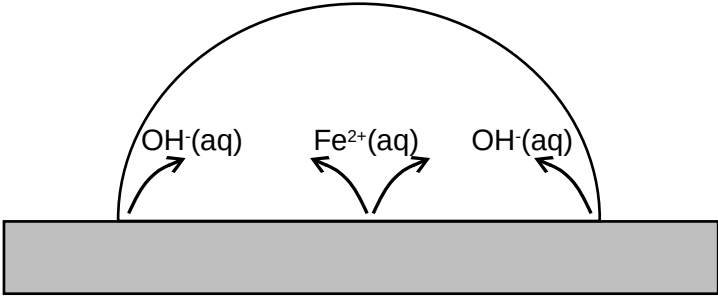
Example of a two mark response



- (b) On the diagram above, label the direction of cation and anion flow. Your labels should indicate the **identity** of each ion. (2 marks)

Description	Marks
Cation ( $\text{Fe}^{2+}$ label and direction)	1
Anion ( $\text{OH}^-$ label and direction)	1
<b>Total</b>	<b>2</b>

Example of a two mark response



Note: if ion flow is only labelled on one 'side' of the water droplet, allocate full marks

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

Description	Marks
Oxidation of iron atoms from (0) in Fe to (+2) in $\text{Fe}^{2+}$	1
Reduction of oxygen atoms from (0) in $\text{O}_2$ to (-2) in $\text{OH}^-$	1
<b>Total</b>	<b>2</b>

- (d) Write a balanced ionic equation for this step. (1 mark)

Description	Marks
$\text{Fe}^{2+}(\text{aq}) + 2 \text{OH}^{-}(\text{aq}) \rightarrow \text{Fe}(\text{OH})_2(\text{s})$	1
<b>Total</b>	<b>1</b>

- (e) Calculate the volume of  $\text{O}_2(\text{g})$  that would have reacted to produce this rust. The partial pressure of  $\text{O}_2(\text{g})$  in air is 21.2 kPa and the temperature of the air was 19.3 °C. State your answer to the appropriate number of significant figures. (5 marks)

Description	Marks
$m(\text{Fe reacted}) = 84.2 - 77.1$ $= 7.1 \text{ g}$	1
$n(\text{Fe}) = 7.1 / 55.85$ $= 0.12713 \text{ mol}$	1
$n(\text{O}_2) = 0.12713 / 2$ $= 0.063563 \text{ mol}$	1
$V(\text{O}_2) = (0.063563 \times 8.314 \times 292.45) / 21.2$ $= 7.29006 \text{ L}$ $= 7.29 \text{ L (3 SF)}$	1
<b>Total</b>	<b>5</b>

- (f) Calculate the maximum mass of rust,  $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}(\text{s})$ , that would have formed from this corrosion. (2 marks)

Description	Marks
$n(\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}) = 0.12713 / 2$ $= 0.063563 \text{ mol}$	1
$m(\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}) = 0.063563 \times 177.716$ $= 11.3 \text{ g}$	1
<b>Total</b>	<b>2</b>

- (g) Explain these observations. (4 marks)

Description	Marks
The zinc coating acts as a sacrificial anode	1
This is because zinc has a higher oxidation potential / is more reactive than iron	1
Therefore the zinc coating will be preferentially oxidised	1
The iron is thus protected, and no evidence of corrosion is seen (until all of the Zn coating has been oxidised)	1
<b>Total</b>	<b>4</b>

**Question 40****(20 marks)**

- (a) Define a buffer.

(2 marks)

Description	Marks
A solution containing a weak conjugate acid-base pair,	1
that can resist a change in pH when small amounts of acid or base are added to it	1
<b>Total</b>	<b>2</b>

- (b) Describe how the large increase in atmospheric  $\text{CO}_2(\text{g})$  caused by human activity, results in a higher  $\text{H}_3\text{O}^+(\text{aq})$  concentration in seawater. (Note: chemical equations are **not** required in your answer).

(3 marks)

Description	Marks
Some of the excess atmospheric $\text{CO}_2(\text{g})$ dissolves into seawater,	1
which then forms carbonic acid	1
Carbonic acid then hydrolyses / ionises to produce $\text{H}_3\text{O}^+(\text{aq})$	1
<b>Total</b>	<b>3</b>

- (c) Justify, using Le Chatelier's principle, how the hydrogencarbonate / carbonate buffer system in seawater responds to this increase in  $\text{H}_3\text{O}^+(\text{aq})$ .

(2 marks)

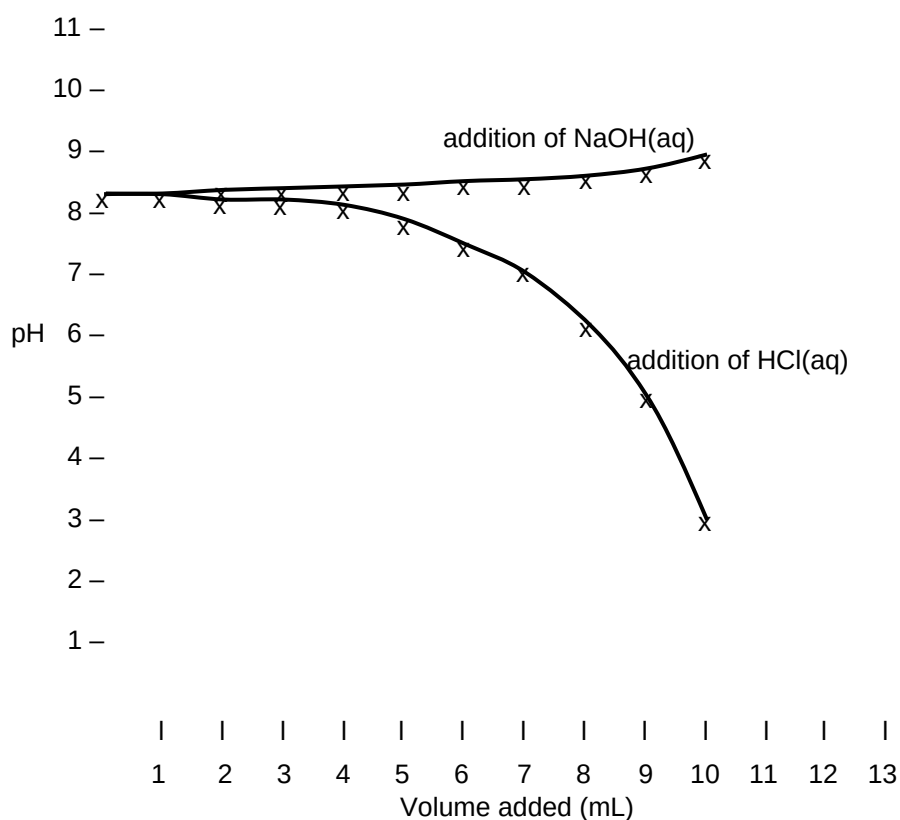
Description	Marks
The increase in $\text{H}_3\text{O}^+(\text{aq})$ shifts the equilibrium to the left	1
This will partially counteract the change by decreasing the $\text{H}_3\text{O}^+(\text{aq})$ concentration / using up some of the extra $\text{H}_3\text{O}^+(\text{aq})$	1
<b>Total</b>	<b>2</b>

(d) Plot this data on the same set of axes, using the grid below.

(5 marks)

Description	Marks
x-axis label and scale	1
y-axis label and scale	1
Points and curve for addition of HCl(aq)	1
Points and curve for addition of NaOH(aq)	1
Labels on each curve	1
<b>Total</b>	<b>5</b>

Example of a five mark response



- (e) Does seawater contain a higher concentration of  $\text{HCO}_3^-(\text{aq})$  or  $\text{CO}_3^{2-}(\text{aq})$ ? Justify your answer, by referring to the data collected in this investigation. (4 marks)

Description	Marks
Higher concentration of $\text{HCO}_3^-(\text{aq})$	1
The seawater has a higher buffering capacity for the addition of $\text{OH}^-(\text{aq})$	1
This is shown by the seawater resisting a pH change upon addition of a greater amount of $\text{OH}^-(\text{aq})$	1
Therefore there must be a higher concentration of the conjugate acid species present (relative to the conjugate base species)	1
<b>Total</b>	<b>4</b>

- (f) State two (2) negative consequences associated with the cuttlefish not being able to form its internal calcium carbonate shell. (2 marks)

Description	Marks
Any <b>two</b> of the following (or other relevant answers):	
<ul style="list-style-type: none"> <li>may disrupt the food web</li> <li>species may be unable to reproduce</li> <li>species may become endangered / extinct</li> <li>reduced biodiversity of ecosystem (if endangered / extinct)</li> </ul>	2
<b>Total</b>	<b>2</b>

- (g) Suggest two (2) ways humans can reduce their production of  $\text{CO}_2(\text{g})$ . (2 marks)

Description	Marks
Any <b>two</b> of the following (or other relevant answers):	
<ul style="list-style-type: none"> <li>reduce reliance on fossil fuels</li> <li>reduce car use / take public transport / ride bikes</li> <li>decrease use of electricity</li> <li>reduce consumption of meat</li> <li>reduce deforestation</li> <li>increase use of biofuels / renewable sources of energy</li> </ul>	2
<b>Total</b>	<b>2</b>

**Question 41****(19 marks)**

- (a) Calculate the mass of gold that was leached into solution.

(6 marks)

Description		Marks
m(NaCN initial)	= $0.478 \times 25000$ = 11950 g	1
m(NaCN final)	= $0.083 \times 25000$ = 2075 g	1
m(NaCN reacted)	= $11950 - 2075$ = 9875 g	1
n(NaCN)	= $9875 / 49.01$ = 201.4895 mol	1
n(Au)	= $(1/2) \times 201.4895$ = 100.7447 mol	1
m(Au)	= $100.7447 \times 197$ = 19847 g (2.0 x 10 <sup>4</sup> g)	1
<b>Total</b>		<b>6</b>

- (b) Calculate the final pH of the leaching solution. (You may assume that only the OH
- <sup>-</sup>
- (aq) ions produced are contributing to pH).

(4 marks)

Description		Marks
n(OH <sup>-</sup> )	= 100.7447 mol	1
c(OH <sup>-</sup> )	= $100.7447 / 25000$ = 0.0040298 mol L <sup>-1</sup>	1
[H <sup>+</sup> ]	= $(1.0 \times 10^{-14}) / 0.0040298$ = $2.4815 \times 10^{-12}$ mol L <sup>-1</sup>	1
pH	= $-\log(2.4815 \times 10^{-12})$ = 11.6 (12)	1
<b>Total</b>		<b>4</b>
Alternate working:		
pOH	= $-\log(0.0040298)$ = 2.3947	
pH	= $14 - 2.3947$ = 11.6 (12)	

- (c) State the oxidant and the reductant in this process. (2 marks)

Description	Marks
Oxidant: $\text{Au(CN)}_2^-$	1
Reductant: Zn	1
<b>Total</b>	<b>2</b>

- (d) Explain, in terms of the collision theory, why zinc **dust** is used to precipitate the gold out of solution. (3 marks)

Description	Marks
The dust has a high surface area / high state of subdivision	1
This results in an increased frequency of collision,	1
and therefore a faster reaction rate	1
<b>Total</b>	<b>3</b>

- (e) Explain how this would allow separation of the two metals to occur. Use data from your standard reduction potential table to support your answer. (4 marks)

Description	Marks
The cell potential / EMF for the reaction between Zn and $\text{H}^+$ is positive (+ 0.76 V)	1
The cell potential / EMF for the reaction between Au and $\text{H}^+$ is negative (- 1.50 V)	1
Therefore the reaction between Zn and the acid is spontaneous / the reaction between Au and the acid is non-spontaneous	1
This will result in the Zn dissolving in the acid, leaving behind solid Au (which can thus be separated)	1
<b>Total</b>	<b>4</b>