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**CHEMISTRY**

**UNIT 3**

**2021**

**MARKING GUIDE**

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

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | a □ b □ c □ d ■ |  | 11 | a □ b □ c □ d ■ |  | 21 | a ■ b □ c □ d □ |
| 2 | a □ b □ c ■ d □ |  | 12 | a □ b ■ c □ d □ |  | 22 | a □ b ■ c □ d □ |
| 3 | a ■ b □ c □ d □ |  | 13 | a □ b □ c □ d ■ |  | 23 | a □ b □ c ■ d □ |
| 4 | a □ b □ c □ d ■ |  | 14 | a □ b □ c □ d ■ |  | 24 | a □ b □ c □ d ■ |
| 5 | a □ b ■ c □ d □ |  | 15 | a ■ b □ c □ d □ |  | 25 | a ■ b □ c □ d □ |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 6 | a □ b □ c □ d ■ |  | 16 | a ■ b □ c □ d □ |  |  |  |
| 7 | a □ b ■ c □ d □ |  | 17 | a □ b ■ c □ d □ |  |  |  |
| 8 | a □ b □ c ■ d □ |  | 18 | a □ b □ c ■ d □ |  |  | (1 mark per question) |
| 9 | a □ b □ c ■ d □ |  | 19 | a □ b □ c □ d ■ |  |  |  |
| 10 | a □ b ■ c □ d □ |  | 20 | a □ b □ c ■ d □ |  |  |  |

**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 C2H6(g) + 7 O2(g) → 4 CO2(g) + 6 H2O(g) |  |
| Correct reactants and products | 1 |
| Balanced | 1 |
| Limited equation: 2 C2H6(g) + 5 O2(g) → 4 CO(g) + 6 H2O(g) |  |
| Correct reactants and products | 1 |
| Balanced | 1 |
| **Total** | **4** |
| Note: also accept equations for limited oxygen showing production of soot, C(s)  e.g. C2H6(g) + 2 O2(g) → CO(g) + C(s) + 3 H2O(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 C2H6 to (+4) in CO2 | 1 |
| Oxidation number of carbon changes from (-3) in C2H6 to (+2) in CO | 1 |
| Therefore complete oxidation takes place in excess oxygen (since this produces carbon in a higher oxidation state) | 1 |
| **Total** | **3** |

**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 NO2(g): | increase | decrease | 2 |
| **Total** | | | **6** |

**Question 28 (9 marks)**

(a) Calculate the initial pH of the hydrochloric acid solution. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| pH = - log 0.55 = 0.26 | 1 |
| **Total** | **1** |

(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(H+ in HCl) = 0.55 x 0.325  = 0.17875 mol | 1 |
| V(HNO3) = 200 x 0.05  = 10 mL | 1 |
| n(H+ in HNO3) = 2 x 0.01  = 0.02 mol | 1 |
| n(H+ total) = 0.17875 + 0.02  = 0.19875 mol | 1 |
| c(H+ total) = 0.19875 / 0.335  = 0.59328 mol L-1 | 1 |
| pH = -log(0.59328)  = 0.23 | 1 |
| **Total** | **6** |

(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  **or**  both acids are strong and cannot be used to form a buffer  **or**  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  **or**  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  **or**  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 |
| **Total** | **2** |

**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 H2S → S8 + 16 H+ + 16 e- |  |
| Correct half-equation | 1 |
| Oxidation (O) | 1 |
| Step 2: S8 + 32 H2O → 8 SO42- + 64 H+ + 48 e- |  |
| Correct half-equation | 1 |
| Oxidation (O) | 1 |
| Step 3: SO42- + 2 H+ + 2 e- → SO32- + H2O |  |
| Correct half-equation | 1 |
| Reduction (R) | 1 |
| Step 4: SO32- + 8 H+ + 6 e- → H2S + 3 H2O |  |
| Correct half-equation | 1 |
| Reduction (R) | 1 |
| **Total** | **8** |

**Question 30 (9 marks)**

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

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Equation: Pb2+(aq) + 2 I-(aq) → PbI2(s) |  |
| Correct reactants and products | 1 |
| Balanced | 1 |
| **Total** | **2** |

(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 Ea and DH values | 1 |
| **Total** | **5** |
| Example of a five mark response:  Progress of reaction  Enthalpy (kJ mol-1)  Pb2+ + 2 I-  PbI2  Ea  DH |  |

(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 Kc indicates PbI2 product is very stable at this temperature  **or**  The reverse Ea is large (four times greater) compared to the forward Ea  **or**  PbI2 is an insoluble salt, therefore unlikely to dissociate to any great extent | 1 |
| **Total** | **2** |

**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: H2O(l) + H2O(l) ⇌ H3O+(aq) + OH-(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  **or**  An increase in temperature increases the rate of the endothermic direction more than the exothermic direction | 1 |
| Therefore DH must be positive for the autoionisation of water, thus the forward reaction is endothermic | 1 |
| **Total** | **5** |

**Question 32 (9 marks)**

(a) Define a primary cell. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A cell that cannot be recharged | 1 |
| **Total** | **1** |

(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 |
| **Total** | **3** |
| Example of a three mark response:  cathode  (+)  anode  (-) |  |

(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 E0 values. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| E0(red) = + 0.64 V | 1 |
| E0(ox) = + 0.76 V | 1 |
| **Total** | **2** |

(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 **two** of the following: |  |
| * allows ions to flow between half-cells * complete the electrical circuit * prevents reactants from coming into contact * maintains electrical neutrality | 2 |
| **Total** | **3** |

**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 |
| **Total** | **1** |

(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  **or**  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)  **or**  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 |
| **Total** | **2** |

(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 |
| **Total** | **3** |

**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 CH3COOH(aq) + CO32-(aq) → 2 CH3COO-(aq) + CO2(g) + H2O(g) |  |
| Correct reactants and products | 1 |
| Balanced | 1 |
| **Total** | **2** |
| 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 |
| **Total** | **2** |

(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 = [Ba2+] [OH-]2 [H2] | 2 |
| **Total** | **2** |
| 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-1 | 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 |
| **Total** | **2** |
| Example of a two mark response:  electrons  cations |  |

(b) Write balanced half-equations representing the processes occurring at the cathode and the anode. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| cathode: Pb2+(aq) + 2 e- → Pb(s) | 1 |
| anode: Pb(s) → Pb2+(aq) + 2 e- | 1 |
| **Total** | **2** |

(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  **or**  Without an external voltage no reaction will take place | 1 |
| **Total** | **2** |

(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  **or**  Copper is a less reactive metal than lead | 1 |
| **Total** | **2** |
| 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 FeSCN2+(aq) present at equilibrium. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| 0.002 mol L-1 | 1 |
| **Total** | **1** |

(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** |
| Fe3+(aq) concentration decreases from 0.01 to 0.008 mol L-1 | 1 |
| SCN-(aq) concentration decreases from 0.006 to 0.004 mol L-1 | 1 |
| FeSCN2+(aq) concentration increases from 0 to 0.002 mol L-1 | 1 |
| Horizontal lines from E1 onwards | 1 |
| Labels on each of the three curves | 1 |
| **Total** | **5** |
| Example of a five mark response   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   l l  0 E1 Time  Concentration (mol L-1)  0.010 –  0.009 –  0.008 –  0.007 –  0.006 –  0.005 –  0.004 –  0.003 –  0.002 –  0.001 –  Fe3+(aq)  SCN-(aq)  FeSCN2+(aq) | |

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

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Addition of H3O+: |  |
| The H3O+(aq) added will react with SCN-(aq) as shown in equation (ii) | 1 |
| The SCN-(aq) concentration will therefore be lowered | 1 |
| The original equilibrium will therefore shift left to increase the concentration of SCN-(aq) | 1 |
| Addition of OH-: |  |
| The OH-(aq) added will react with Fe3+(aq) as shown in equation (iii) | 1 |
| The Fe3+(aq) concentration will therefore be lowered | 1 |
| The original equilibrium will therefore shift left to increase the concentration of Fe3+(aq) | 1 |
| **Total** | **6** |

(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 OH-(aq) would cause a pale brown precipitate to form | 1 |
| **Total** | **1** |

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

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Adding KF(aq) would (increase the concentration of F-(aq) which will react with, and) lower the concentration of Fe3+(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  **or**  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 |
| **Total** | **4** |

**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 (NaH2PO4) is acidic due to the presence / hydrolysis of H2PO4-(aq) ions (which results in an excess of H3O+ ions) | 1 |
| H2PO4-(aq) + H2O(l) → HPO42-(aq) + H3O+(aq) | 1 |
| At the second equivalence point: |  |
| The salt produced (Na2HPO4) is basic due to the presence / hydrolysis of HPO42-(aq) ions (which results in an excess of OH- ions) | 1 |
| HPO42-(aq) + H2O(l) → H2PO4-(aq) + OH-(aq) | 1 |
| **Total** | **4** |

(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 |
| **Total** | **1** |

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

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(NaOH) = 0.1005 x 0.01665  = 0.0016733 mol | 1 |
| n(H3PO4) = 0.0016733 / 2  = 0.00083666 mol  = n(H3PO4 in 150 mL Coca-Cola) | 1 |
| = n(P in 150 mL Coca-Cola) | 1 |
| n(P in 375 mL can) = 0.00083666 x (375 / 150)  = 0.00209165 mol | 1 |
| m(P) = 0.00209165 x 30.97  = 0.064778 g | 1 |
| = 64.78 mg | 1 |
| **Total** | **6** |

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

|  |  |
| --- | --- |
| **Description** | **Marks** |
| If H2CO3 is present, it will consume / react with some of the added OH-(aq) in the titration | 1 |
| This would interfere with / inflate / give an invalid calculation of the concentration of H3PO4 | 1 |
| **Total** | **2** |

(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 |
| **Total** | **3** |

**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 |
| **Total** | **2** |
| Example of a two mark response  cathodic  anodic  cathodic | |

(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 (Fe2+ label and direction) | 1 |
| Anion (OH- label and direction) | 1 |
| **Total** | **2** |
| Example of a two mark response  Fe2+(aq)  OH-(aq)  OH-(aq)  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 Fe2+ | 1 |
| Reduction of oxygen atoms from (0) in O2 to (-2) in OH- | 1 |
| **Total** | **2** |

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

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Fe2+(aq) + 2 OH-(aq) → Fe(OH)2(s) | 1 |
| **Total** | **1** |

(e) Calculate the volume of O2(g) that would have reacted to produce this rust. The partial pressure of O2(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(Fe reacted) = 84.2 – 77.1  = 7.1 g | 1 |
| n(Fe) = 7.1 / 55.85  = 0.12713 mol | 1 |
| n(O2) = 0.12713 / 2  = 0.063563 mol | 1 |
| V(O2) = (0.063563 x 8.314 x 292.45) / 21.2  = 7.29006 L | 1 |
| = 7.29 L (3 SF) | 1 |
| **Total** | **5** |

(f) Calculate the maximum mass of rust, Fe2O3.H2O(s), that would have formed from this corrosion. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(Fe2O3.H2O) = 0.12713 / 2  = 0.063563 mol | 1 |
| m(Fe2O3.H2O) = 0.063563 x 177.716  = 11.3 g | 1 |
| **Total** | **2** |

(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 |
| **Total** | **4** |

**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 |
| **Total** | **2** |

(b) Describe how the large increase in atmospheric CO2(g) caused by human activity, results in a higher H3O+(aq) concentration in seawater. (Note: chemical equations are **not** required in your answer). (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Some of the excess atmospheric CO2(g) dissolves into seawater, | 1 |
| which then forms carbonic acid | 1 |
| Carbonic acid then hydrolyses / ionises to produce H3O+(aq) | 1 |
| **Total** | **3** |

(c) Justify, using Le Chatelier’s principle, how the hydrogencarbonate / carbonate buffer system in seawater responds to this increase in H3O+(aq). (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The increase in H3O+(aq) shifts the equilibrium to the left | 1 |
| This will partially counteract the change by decreasing the H3O+(aq) concentration / using up some of the extra H3O+(aq) | 1 |
| **Total** | **2** |

(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 |
| **Total** | **5** |
| Example of a five mark response   |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   11 –  10 –  9 –  8 –  7 –  pH 6 –  5 –  4 –  3 –  2 –  1 –  l l l l l l l l l l l l l  1 2 3 4 5 6 7 8 9 10 11 12 13  Volume added (mL)  addition of NaOH(aq)  addition of HCl(aq)  x  x  x  x  x  x  x  x  x  x  x  x  x  x  x  x  x  x  x  x | |

(e) Does seawater contain a higher concentration of HCO3-(aq) or CO32-(aq)? Justify your answer, by referring to the data collected in this investigation. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Higher concentration of HCO3-(aq) | 1 |
| The seawater has a higher buffering capacity for the addition of OH-(aq) | 1 |
| This is shown by the seawater resisting a pH change upon addition of a greater amount of OH-(aq) | 1 |
| Therefore there must be a higher concentration of the conjugate acid species present (relative to the conjugate base species) | 1 |
| **Total** | **4** |

(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 **two** of the following (or other relevant answers): |  |
| * may disrupt the food web * species may be unable to reproduce * species may become endangered / extinct * reduced biodiversity of ecosystem (if endangered / extinct) | 2 |
| **Total** | **2** |

(g) Suggest two (2) ways humans can reduce their production of CO2(g). (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any **two** of the following (or other relevant answers): |  |
| * reduce reliance on fossil fuels * reduce car use / take public transport / ride bikes * decrease use of electricity * reduce consumption of meat * reduce deforestation * increase use of biofuels / renewable sources of energy | 2 |
| **Total** | **2** |

**Question 41 (19 marks)**

(a) Calculate the mass of gold that was leached into solution. (6 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| m(NaCN initial) = 0.478 x 25000  = 11950 g | 1 |
| m(NaCN final) = 0.083 x 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) x 201.4895  = 100.7447 mol | 1 |
| m(Au) = 100.7447 x 197  = 19847 g (2.0 x 104 g) | 1 |
| **Total** | **6** |

(b) Calculate the final pH of the leaching solution. (You may assume that only the OH-(aq) ions produced are contributing to pH). (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(OH-) = 100.7447 mol | 1 |
| c(OH-) = 100.7447 / 25000  = 0.0040298 mol L-1 | 1 |
| [H+] = (1.0 x 10-14) / 0.0040298  = 2.4815 x 10-12 mol L-1 | 1 |
| pH = - log (2.4815 x 10-12)  = 11.6 (12) | 1 |
| **Total** | **4** |
| 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: Au(CN)2- | 1 |
| Reductant: Zn | 1 |
| **Total** | **2** |

(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 |
| **Total** | **3** |

(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 H+ is positive  (+ 0.76 V) | 1 |
| The cell potential / EMF for the reaction between Au and 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 |
| **Total** | **4** |