**WILLETTON SENIOR HIGH SCHOOL**

**YEAR 12 SEMESTER ONE EXAM, 2021**

**CHEMISTRY**

**MARKING GUIDE**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Dr  L. Harris  Q: 30, 31, 32, 33, 34(c) | Mrs  J. Kulasekera  Q: 34(a)(b), 35, 36(a)(b)(c) | Mr  G. Singh  Q: 39, 40 | Mr  H.Ta  Q: 26, 27, 28, 29 | Mr  L. Taylor  Q: 36(d)(e), 37, 38 |

**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% (70 marks)**

**Question 26 (7 marks)**

(a) Classify the following salts as acidic, basic or neutral and write them in the appropriate column below. (4 marks)

|  |  |  |
| --- | --- | --- |
|  | **Description** | **Marks** |
| **Acidic** | NH­4Br |  |
| **Basic** | K2S  NaHCO3  KCH3COO  Na2CO3 |  |
| **Neutral** | Mg(NO3)2  NaI  KCℓ |  |
| 0.5 mark per correct response | |  |
| **Total** | | **4** |

(b) Use the Brønsted-Lowry model to explain why the pH of ammonia (NH3) solution is greater than 7.0 at 25 °C. Incorporate at least one appropriate equation in your answer. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Equation: NH3(aq) + H2O(l) ⇌ NH4+(aq) + OH-(aq) | 1 |
| Hydrolysis increases [OH-] | 1 |
| As [OH-] increases, solution becomes more basic hence pH > 7 | 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 (6 marks)**

Write the half-equations representing the remaining three (3) changes (i.e. ii to iv) in the sulfur

cycle described above, assuming acidic conditions. Classify each step as a reduction (R) or

oxidation (O) process.

|  |  |  |
| --- | --- | --- |
|  | **Description** | **Marks** |
| (ii) | ii) S8 + 32 H2O → 8 SO42- + 64 H+ + 48 e- |  |
| Correct half-equation | 1 |
| Oxidation (O) | 1 |
| (iii) | iii) SO42- + 2 H+ + 2 e- → SO32- + H2O |  |
| Correct half-equation | 1 |
| Reduction (R) | 1 |
| (iv) | iv) SO32- + 8 H+ + 6 e- → H2S + 3 H2O |  |
| Correct half-equation | 1 |
| Reduction (R) | 1 |
|  | **Total** | **6** |

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

(c) Comment, with reference to the data table above, on whether the forward or reverse reaction is more favoured at 25 °C. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Large K indicates a large [products] compared to [reactants]. | 1 |
| Hence forward reaction must have been favoured. | 1 |
| **Total** | **2** |

**Question 31 (4 marks)**

(a) State the relationship between the independent variable and the dependent variable. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| As temperature increases, the electrical conductivity of pure water increases | 1 |
| **Total** | **1** |

(b) With reference to relevant chemical theory, explain the trend observed from the graph. Include a relevant chemical equation in your answer. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The increase in conductivity at high temperatures is due to an increase in the concentration of charge carriers i.e. ions | 1 |
| Equation: H2O(l) + H2O(l) ⇌ H3O+(aq) + OH-(aq) | 1 |
| This means the forward reaction must have been favoured, and must be the endothermic pathway as heating favours endothermic reaction.  **or**  An increase in temperature increases the rate of the endothermic direction more than the exothermic direction. | 1 |
| **Total** | **3** |

**Question 32 (6 marks)**

For each of the following pairs of compounds, describe a chemical test to distinguish between

them. Give all steps, but equations are not required.

|  |  |
| --- | --- |
| **Description** | **Marks** |
| For 1.0 mol L-1 NaOH solution and 1.0 mol L-1 of Na2CO3 solution | |
| Test: Add a small amount of 1.0 molL-1 HCl or similar | 1 |
| Observation for NaOH: No visible change | 1 |
| Observation for Na2CO3: Colourless gas forms | 1 |
| OR |  |
| Test: Add a small amount of 1.0 molL-1 Ba(NO3)2 or similar |  |
| Observation for NaOH: No visible change |  |
| Observation for Na2CO3: White precipitate formed |  |
| **Total** | **3** |
| For solid Ag and solid Cr | |
| Test: Add a small amount of 1.0 molL-1 HCl or similar | 1 |
| Observation for Ag: No visible change | 1 |
| Observation for Cr: Silver strip dissolves and colourless gas forms | 1 |
| OR |  |
| Test: Add a small amount of 1.0 molL-1 Ni2+ or similar |  |
| Observation for Ag: No visible change |  |
| Observation for Cr: New silver/grey deposit forms on silver strip. Green solution turns colourless etc. |  |
| **Total** | **3** |

**Question 33 (4 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) Use Le Chatelier to justify the resultant shift that was observed. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Increasing the temperature increased both the forward and reverse reaction rates - as shown by two vertical lines on graph. | 1 |
| As the forward reaction is endothermic, the system favoured - as shown by the longer vertical line. | 1 |
| System reaches new equilibrium where both reaction rates are higher than before | 1 |
| **Total** | **3** |

**Question 34 (11 marks)**

(a)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Equation:  2 CH3COOH(aq) + CO32-(aq) → 2 CH3COO-(aq) + CO2(g) + H2O(g) |  |
| Correct reactants and products (ionic) | 1 |
| Balanced | 1 |
| Note:  1 mark in total may be allocated for a correctly balanced molecular equation. | |
| Observation: One of the following  Two colourless solutions are mixed and a colourless gas forms. The final solution mixture is colourless. Vinegar odour goes away. | 1 |
| **Total** | **3** |

(b)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Equation:  Mg(s) + 2 H+(aq) → H2(g) + Mg2+(aq) |  |
| Correct reactants and products (ionic) | 1 |
| Balanced | 1 |
| Note:  1 mark in total may be allocated for a correctly balanced molecular equation | |
| Observation: One of the following  A silver/grey solid is placed in a colourless solution. The solid dissolves and a colourless gas forms. The solution stays colourless. | 1 |
| **Total** | **3** |

(c)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Equation:  Ba(s) + 2 H2O(l) → Ba2+(aq) + H2(g) + 2 OH-(aq) |  |
| Correct reactants and products (ionic) | 1 |
| Balanced | 1 |
| Note:  1 mark in total may be allocated for a correctly balanced molecular equation | |
| Observation: One of the following  A grey solid is added to a colourless liquid. The solid dissolves and a colourless gas forms. The solution mixture stays colourless. | 1 |
| **Total** | **3** |

|  |  |
| --- | --- |
| **Description** | **Marks** |
| K = [Ba2+] [OH-]2 [H2] | 2 |
| **Total** | **2** |

**Question 35 (8 marks)**

(a) State whether methyl orange or phenolphthalein would be suitable for this titration.

(1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Phenolphthalein | 1 |
| **Total** | **1** |

(b) Use the data provided to calculate the molar mass of the original powdered acid.

(6 marks)

|  |  |
| --- | --- |
| **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 |
| **Total** | **6** |
| 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\* | | |

(c) Identify whether the laboratory technician used potassium hydrogen phthalate or potassium hydrogen iodate as the primary standard. Your answer must be supported by the calculation shown in part (b).

|  |  |
| --- | --- |
| Potassium hydrogen phthalate as the calculated molar mass matches that  of the acid potassium hydrogen phthalate | 1 |
| **Total** | **1** |

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**End of Section Two**

**Section Three: Extended answers 40% (80 marks)**

**Question 36 (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 **one** 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) lowers the concentration of Fe3+(aq) | 1 |
| This would decrease both the forward and reverse reaction rates (due to a decreased in the frequency of collisions) | 1 |
| The reverse reaction rate would not decrease by as much as the forward reaction rate (or still higher than the forward rate)  **or**  The forward reaction rate would decrease more, relative to the reverse reaction rate | 1 |
| Net reaction is to the left / the reverse. | 1 |
| **Total** | **4** |

**Question 37 (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) Calculate the mass of phosphorus present in a 375 mL can of Coca-Cola. Write your final answer using the correct number of significant figures (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  = 0.0648 g (or 6.48 x 10-2 g) | 1 |
| Correct number of significant figures (3) regardless of final answer. | 1 |
| **Total** | **6** |

(c) Explain 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** |

(d) Use your knowledge of Brønsted-Lowry theory, write the chemical formula for: (2 marks)

|  |  |  |
| --- | --- | --- |
|  | **Description** | **Marks** |
| (i) | HCO3- | 1 |
| (ii) | HCO3- | 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. (2 marks)

i.

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Systematic | 1 |
| **Total** | **1** |

ii.

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The calculated concentration of P would be higher than the true value | 1 |
| **Total** | **1** |

**Question 38 (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-9aq) | 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 * death of species/ may become 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 39 (15 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- (or Au+ ion) | 1 |
| Reductant: Zn | 1 |
| **Total** | **2** |

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

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The powder has a high surface area / high state of subdivision | 1 |
| This results in an increased in the frequency of collision, | 1 |
| and therefore a faster reaction rate | 1 |
| **Total** | **3** |

**Question 40 (12 marks)**

(a) Write a balanced equation for the formation of **baryta** (include subscripts). (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| 2Ba(s) + O2(g) → 2BaO(s) | 1 |
| Subscripts used | 1 |
| **Total** | **2** |

(b) Determine the limiting reactant. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(Ba(NO3)2 = 2.00 / 261.32  = 7.653 x 10-3 mol | 1 |
| n(Al2(SO4)3 = 0.1 x 0.02  = 2 x 10-3 mol | 1 |
| Since 3 x n(Al2(SO4)3 = 6.0 x 10-3 mol and this is still less than n(Ba(NO3)2  given  or  Another suitable method of calculation shown | 1 |
| Al2(SO4)3 is the limiting reactant | 1 |
| **Total** | **4** |

(c) Assuming the volume of the original solution does not change, calculate the concentration of aluminium in the final solution. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(Al3+) = 2 x n(Al2(SO4)3)  = 4 x 10-3 mol | 1 |
| c(Al3+ final) = 4 x 10-3 / 0.02  = 0.2 mol L-1 | 1 |
| **Total** | **2** |

(d) Complete the following table by stating how each of the imposed changes would affect:

* the concentration of the carbonate ions (CO32-) and
* the equilibrium constant (K) (4 marks)

|  |  |  |  |
| --- | --- | --- | --- |
| **Description** | | | **Marks** |
| Temperature is decreased | decrease | decrease | 2 |
| A small sample of barium nitrate powder is added | decrease | no change | 2 |
| **Total** | | | **4** |

**END OF PAPER**