**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-] / **OH- ions are produced from hydrolysis** | 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 **weak acid- conjugate base pair (or vice versa)** 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** (i.e. **number of moles**) 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** |

Must have states

As it is an equilibrium reaction, it must have double arrows (no penalty this time)

(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** |

**Students must avoid the trap of just looking at activation energies. If activation energy was the only determinant of whether a reaction occurs, there would be no endothermic reactions. Remember you need both sufficient energy and correct orientation, etc.**

**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** |

Variables need to be identified in this type of question, and the relationship between them needs to be stated.

(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) Also pay the Arrhenius form eqn must have states (-1/2) and double arrows | 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** |

Can also do collision theory, FRR +RRR increase, FRR more due to endothermic, hence increased [ions] hence more conductivity

**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 ½ each | 1 |
| OR |  |
| Test: Add a small amount of 1.0 molL-1 Ni2+ or similar (Fe and Cu work too) |  |
| Observation for Ag: No visible change |  |
| Observation for Cr: New silver/grey deposit forms on silver strip. Green solution turns deep green etc. |  |
| **Total** | **3** |

The mark for the test is only given if it can distinguish the two substances and at least one observation is correct.

**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. (or shifts towards the endothermic to counter added heat) | 1 |
| System reaches new equilibrium where both reaction rates are higher than before | 1 |
| **Total** | **3** |

**Answer must fully describe the shift, including the new eq. Note that carry over marks aren’t possible for this question part a must be correct for part b to score.**

**Question 34 (11 marks)**

(a)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Equation:  2 CH3COOH(aq) + HCO3-(aq) → CH3COO-(aq) + CO2(g) + H2O(g)  If they have split ethanoic acid to Hydrogen ions and written the correct balanced ionic equation – 1 mark |  |
| 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.  If bubbles formed/ fizzing only 0.5 marks paid | 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.  If bubbles formed/ fizzing only 0.5 marks paid | 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** |

0.5 marks deducted for wrong spellings

(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** |

Zero marks for the wrong spellings

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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 (0.0019 – 0.0021 accepted) | 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 (if equilibrium is achieved too early; 0.5 mark for 1 wrong graphing. If 2 or all three achieved too early -0 marks) | 1 |
| Labels on each of the three curves (if one label missing – 0.5 marks) | 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 |
| **Must have both pale brown colour and “precipitate” to get 1 mark 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)  (by producing Fe(OH)3 ppt) | 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** |

**3 marks only if both forward and reverse rates recognised as decreased**

**(Forward is decreased MORE)**

**Some students did not address the question in relation to the**

**Fe3+(aq) + SCN-(aq) equilibrium (0 marks)**

**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** |

MANY WORKED FROM NEUTRALISATION EQ’NS, NOT THE HYDROLYSIS OF THE SALTS PRODUCED AS REQUIRED.

(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** |

-1 mark if H3PO4 or PO43- molecular mass used.

(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 ie extra acid to be neutralised | 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, MANY MISSED THIS | 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, (making CO2(aq) | 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) (Referring to the data collected) | 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)   NO MARKS DEDUCTED FOR POOR BIOLOGY KNOWLEDGE  The shell is internal (like in squid) and does not actually offer “protection”. | 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     PLANT TREES = 0: does not reduce CO2 production  Recycling = 0: unless specified reduction of fossil fuel based plastics  TAX = 0: this may encourage “offsets” not reduction  USE ELECTRIC CARS = 0: Unless specified that the electricity comes from renewable sources (HYBRID vehicles ok) | 2 |
| **Total** | **2** |

**Question 39 (15 marks)**

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

1 mark deducted if grams of NaCN stated as n(moles)

|  |  |
| --- | --- |
| **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)** No marks deducted if pH answer written to 3 sig figs. | |

(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 successful collisions, | 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) one mark deducted for unbalanced equation | 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 N.B. -1 mark if n (Ba(NO3)2 > n(Al2(SO4)3 not demonstrated  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 follow via mk given | 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**