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**CHEMISTRY**

**UNITS 1 & 2**

**2022**

**MARKING GUIDE**

***TIME ALLOWED FOR THIS PAPER***

Reading time before commencing work: Ten minutes

Working time for the paper: Two hours, thirty minutes

***MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER***

**To be provided by the supervisor:**

This Question/Answer Booklet

Multiple-choice Answer Sheet

Chemistry Data Book

**To be provided by the candidate:**

Standard items: pens, pencils, eraser or correction fluid, ruler, highlighter.

Special items: calculators satisfying the conditions set by the SCSA for this subject.

***IMPORTANT NOTE TO CANDIDATES***

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

**Structure of this paper**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Section | Number of questions available | Number of questions to be answered | Suggested working time  (minutes) | Marks available | Percentage of exam |
| Section One  Multiple-choice | 20 | 20 | 40 | 20 | 25 |
| Section Two  Short answer | 9 | 9 | 50 | 66 | 35 |
| Section Three  Extended answer | 5 | 5 | 60 | 77 | 40 |
|  |  |  |  | **Total** | 100 |

**Section One: Multiple-choice 25% (20 marks)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | a □ b □ c ■ d □ |  | 6 | a ■ b □ c □ d □ |  |  |  |
| 2 | a □ b ■ c □ d □ |  | 7 | a □ b □ c ■ d □ |  |  |  |
| 3 | a □ b □ c ■ d □ |  | 8 | a □ b □ c ■ d □ |  |  |  |
| 4 | a □ b □ c ■ d □ |  | 9 | a □ b □ c □ d ■ |  |  |  |
| 5 | a □ b □ c □ d ■ |  | 10 | a □ b □ c ■ d □ |  |  |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 11 | a ■ b □ c □ d □ |  | 16 | a □ b □ c □ d ■ |  |  |  |
| 12 | a □ b ■ c □ d □ |  | 17 | a □ b □ c ■ d □ |  |  |  |
| 13 | a ■ b □ c □ d □ |  | 18 | a □ b ■ c □ d □ |  |  |  |
| 14 | a □ b ■ c □ d □ |  | 19 | a ■ b □ c □ d □ |  |  |  |
| 15 | a □ b □ c ■ d □ |  | 20 | a □ b ■ c □ d □ |  |  |  |

**Section Two: Short answer 35% (66 marks)**

**Question 21 (7 marks)**

(a) Calculate the relative atomic mass of this element, and thus state its identity. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Ar = (78.99 x 24 + 10 x 25 + 11.01 x 26) / 100  = 24.32 | 1 |
| Magnesium | 1 |
| **Total** | **2** |

(b) Complete the table above. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | Species | Number of protons | Number of neutrons | Electron configuration | Mass number | Overall charge | | W | 11 | **13** | **2, 8, 1** | 24 | 0 | | X | **12** | 14 | 2, 8 | **26** | +2 | | Y | **24** | **26** | 2, 8, 12, 2 | 50 | 0 | | Z | 17 | 20 | **2, 8, 8** | **37** | -1 | |  |
| Correct values for Species W | 1 |
| Correct values for Species X | 1 |
| Correct values for Species Y | 1 |
| Correct values for Species Z | 1 |
| **Total** | **4** |

(c) Which of the species in the table represents particles of the same element that was analysed by mass spectrometry in part a? (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Species X | 1 |
| **Total** | **1** |

**Question 22 (7 marks)**

Complete the following table by;

* drawing a Lewis structure diagram for each compound, representing all electron pairs as either : or –, and
* predicting whether, when mixed with water, the compound would form a solution capable of conducting electricity.

|  |  |
| --- | --- |
| **Description** | **Marks** |
| |  |  |  | | --- | --- | --- | |  | Lewis structure | Electrical conductivity in aqueous solution  (‘yes’ or ‘no’) | | SeCl2 |  | no | | HNO3 |  | yes | | AlPO4 |  | no | |  |
| Correct structure for SeCl2 | 1 |
| Correct structure for HNO3 | 1 |
| Correct electron arrangement for AlPO4 | 1 |
| Square brackets and charges shown for AlPO4 | 1 |
| Correct electrical conductivities | 3 |
| **Total** | **7** |

Also accept phosphate with 1 double bond and 3 single bonds

**Question 23 (7 marks)**

(a) State the function of a catalytic converter. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| To (catalyse reactions which) reduce the amount of harmful gases (e.g. carbon monoxide, unburnt petrol and nitrogen oxides) emitted by a vehicle. | 1 |
| **Total** | **1** |

(b) Explain why the use of nanoparticles has greatly reduced the amount of precious metals used to construct a catalytic converter. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Nanoparticles have a very large surface area (to mass ratio). | 1 |
| This increases the frequency of collisions between the catalyst and the gases. | 1 |
| Therefore less material is required (compared to the bulk) to provide an equivalent surface area / to function effectively. | 1 |
| **Total** | **3** |

(c) Calculate the number of palladium atoms you could purchase for $1. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| m(Pd for $1) = 1 / 110  = 9.091 x 10-3 g | 1 |
| n(Pd) = 0.00909 / 106.4  = 8.544 x 10-5 mol | 1 |
| N(Pd) = 8.544 x 10-5x 6.022 x 1023  = 5.15 x 1019 atoms | 1 |
| **Total** | **3** |

**Question 24 (9 marks)**

(a) Explain, in terms of intermolecular forces, why the vapour pressure of hexane is much higher than the other two liquids. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Hexane is non-polar and exhibits only dispersion forces. | 1 |
| Water and ethanol exhibit strong hydrogen bonds (in addition to dipole-dipole and dispersion forces). | 1 |
| Thus the sum of intermolecular forces is lower in hexane, allowing vapour to form/evaporation to occur/molecules to escape the liquid more easily. | 1 |
| **Total** | **3** |

(b) Which of these liquids has the highest boiling point? Justify your answer. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Water | 1 |
| Either of the following justifications:   * Boiling occurs when the vapour pressure equals the atmospheric pressure, * thus a lower vapour pressure indicates a larger amount of heat is required before boiling will occur.   **or**   * A lower vapour pressure indicates stronger intermolecular forces are present, * therefore a larger amount of heat is required to disrupt the bonding. | 2 |
| **Total** | **3** |

(c) Explain, in terms of the kinetic theory, why the vapour pressure of water increases with increasing temperature. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| An increase in temperature increases the average kinetic energy of the particles. | 1 |
| This would increase the rate of evaporation.  **or**  This would allow a higher proportion of molecules to evaporate. | 1 |
| Resulting in increased collisions between the vapour and the container. | 1 |
| **Total** | **3** |

**Question 25 (9 marks)**

(a) Which acidulant is likely to be the most polar? Justify your answer, making reference to the role of intermolecular forces. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Oxalic acid | 1 |
| The mobile phase is polar. | 1 |
| Therefore components with highest polarity will dissolve more readily in the mobile phase. | 1 |
| Thus (they will move more quickly through the column) resulting in a lower retention time. | 1 |
| **Total** | **4** |

(b) State the likely effect on retention time if a lower temperature had been used. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Longer / greater retention times | 1 |
| **Total** | **1** |

(c) Describe how HPLC can be used to get quantitative information about the concentration of chemicals in the sample. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The area under the curve can be used | 1 |
| **Total** | **1** |

(d) On the grid below, sketch the expected chromatogram for the white wine sample. Label both axes appropriately. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Chart  Description automatically generated |  |
| Correct y-axis label | 1 |
| Correct x-axis label and scale | 1 |
| Four peaks shown at correct retention times (i.e. 8, 8.5, 10.5, 12 min) | 1 |
| **Total** | **3** |
| Note: peaks may be any height and width, as long as retention times are accurate | |

**Question 26 (8 marks)**

Consider the three organic reactions which are partially summarised in the table below.

Complete this table by;

* drawing the structural formula for any missing organic reactants and products, and
* stating the IUPAC name for any missing organic reactants and products.

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Reactant shaken with bromine water, Br2(aq) |  |
|  | 2 |
| 1,2-dibromo-2-ethylbutane | 1 |
| Reactant shaken with chlorine water, Cl2(aq), in the presence of UV light |  |
|  | 2 |
| 3-methylhexane | 1 |
| Reactant shaken with iodine water, I2(aq), in the presence of AlI3(s) |  |
|  | 2 |
| **Total** | **8** |
| Note:   * one mark may be allocated for structural formulae, in the case of a minor error, such as a missing H atom * follow through marks may be awarded if the IUPAC name correctly matches an incorrectly drawn structure | |

**Question 27 (4 marks)**

(a) Define a ‘supersaturated’ solution. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A greater amount of solute than maximum has been dissolved in a solvent (at a given temperature).  **or**  The concentration of a solution is greater than that predicted using solubility data/tables. | 1 |
| **Total** | **1** |

(b) Calculate the mass of KNO3(s) crystals that would form. Show all workings. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Maximum amount of KNO3 dissolved in 100 g at 30 °C = 45 g | 1 |
| Therefore maximum amount KNO3 dissolved in 210 g at 30 °C = 94.5 g | 1 |
| Mass of KNO3 crystals that would form = 125 – 94.5 = 30.5 g | 1 |
| **Total** | **3** |

**Question 28 (8 marks)**

(a) Describe how the student could use these indicators to identify which liquid was in each beaker. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Add methyl orange indicator to a sample of each, the solution that turns red is HNO3. | 1 |
| Add phenolphthalein to a sample of the remaining two solutions, the pink one is KOH / the colourless one is water. | 1 |
| **Total** | **2** |
| Note: these tests may be performed in a different order or a slightly different method may be used; award one mark each time an observation based on indicator colour is clearly linked to the identity of a solution | |

(b) Complete this table, by including the distinguishing observation for test tube C. (1 mark)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| Test tube C | Pungent colourless gas formed | 1 |
| **Total** | | **1** |

(c) Write a balanced ionic equation for the reaction occurring in test tube C. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| NH4Cl(s) + OH-(aq) → H2O(l) + NH3(g) + Cl-(aq) |  |
| Correct species | 1 |
| Correct balancing | 1 |
| **Total** | **2** |
| Note: state symbols are not required for full marks. | |

(d) Complete this table, by including the distinguishing observation for test tube A. (1 mark)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| Test tube A | Colourless (odourless) gas formed | 1 |
| **Total** | | **1** |

(e) Write a balanced net-ionic equation for the reaction occurring in test tube A. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| MgCO3(s) + 2 H+(aq) → H2O(l) + CO2(g) + Mg2+(aq) |  |
| Correct species | 1 |
| Correct balancing | 1 |
| **Total** | **2** |
| Note: state symbols are not required for full marks. | |

**Question 29 (7 marks)**

(a) Calculate the amount of energy that would be released in the combustion of one full tank of petrol. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| m(C8H18) = 48.18 x 103  = 48180 g | 1 |
| n(C8H18) = 48180 / 114.224  = 421.803 mol | 1 |
| E(released) = 421.803 / 2 x 10920  = 2303043 kJ  = 2.303 x 106 kJ | 1 |
| **Total** | **3** |

(b) Calculate the volume of hydrogen gas, stored at STP, that would be required to produce this same amount of energy. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(H2) = 2303043 / 564 x 2  = 8166.82 mol | 1 |
| V(H2) = 22.71 x 8166.82  = 185468 L  = 1.855 x 105 L | 1 |
| **Total** | **2** |
| Note: follow through marks may be awarded if correct calculation method is shown based on an incorrect value in part (a) | |

(c) Identify one (1) advantage and one (1) disadvantage of hydrogen powered vehicles. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Many possible advantages, including;   * water is the only product * carbon emissions are reduced * CO2(g) is not produced * greater sustainability * greener alternative | 1 |
| Many possible disadvantages, including;   * very large storage capacity required * storage and transport of H2(g) for cars is not yet practical * most H2(g) is currently produced using fossil fuels * this technology is expensive / buying a new car is expensive * this technology requires further development / is not currently available | 1 |
| **Total** | **2** |

**Section Three: Extended answer 40% (77 marks)**

**Question 30 (10 marks)**

(a) Calculate the percentage by mass of iron in jarosite, and suggest a reason for the different shade of red produced by this mineral. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| M(jarosite) = 500.818 | 1 |
| % Fe = (3 x 55.85) / 500.818 x 100  = 33.46% | 1 |
| Different shade may be due to a much lower percentage of iron. | 1 |
| **Total** | **3** |

(b) Calculate the volume of CO2(g), measured at STP, that would be produced, if all the huntite underwent decomposition. State your answer to the appropriate number of significant figures. (6 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| m(Mg3Ca(CO3)4) = 3.82 / 100 x 5.75  = 0.21965 kg | 1 |
| m(Mg3Ca(CO3)4) = 0.21965 x 103  = 219.65 g | 1 |
| n(Mg3Ca(CO3)4) = 219.65 / 353.05  = 0.62215 mol | 1 |
| n(CO2) = 4 x 0.62215  = 2.4886 mol | 1 |
| V(CO2) = 22.71 x 2.4886  = 56.516 L | 1 |
| = 56.5 L (3 SF) | 1 |
| **Total** | **6** |

(c) Calculate the quantity of heat that would have been absorbed. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| E(released) = 0.62215 x 350  = 218 kJ | 1 |
| **Total** | **1** |
| Note: follow through marks may be awarded if correct calculation method is shown based on an incorrect value from part c) | |

**Question 31 (17 marks)**

(a) Identify the molecular shape of each of the following groups of hydrides. (3 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| Group 15 hydrides | pyramidal | 1 |
| Group 16 hydrides | v-shaped / bent | 1 |
| Group 17 hydrides | linear | 1 |
| **Total** | | **3** |

(b) State and explain the trend in electronegativity as you move down the Group 17 elements. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The electronegativity decreases. | 1 |
| Moving down a group, the valence shell is further from the nucleus (and experiences increased shielding). | 1 |
| Therefore a lesser force is exerted by the nucleus on a (bonding pair of) electron(s). | 1 |
| **Total** | **3** |

(c) Explain, using the concept of electronegativity, which of the Group 17 hydrides is the most polar. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| HF is the most polar | 1 |
| Hydrogen and fluorine have the largest difference in electronegativity.  **or**  Since fluorine has the highest electronegativity, the shared electron pair in HF is more strongly attracted to the F atom (compared with the other group 17 hydrides). | 1 |
| **Total** | **2** |

(d) Identify the hydride which exhibits the strongest **dispersion forces**, and explain why this occurs. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| H2Te | 1 |
| H2Te has the largest molecular mass / greatest number of molecular electrons. | 1 |
| This results in;  an increased likelihood that a temporary dipole will form.  **or**  an increased likelihood that a stronger temporary dipole will form. | 1 |
| **Total** | **3** |

(e) Plot this boiling point data on the graph on the previous page. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Chart  Description automatically generated |  |
| Points plotted correctly and joined by straight lines | 1 |
| **Total** | **1** |

(f) Explain why the boiling points of H2O, HF and NH3 do **not** follow the same trend seen in the Group 14 hydrides. Support your answer with a diagram illustrating the predominant type of intermolecular interaction in NH3. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The Group 14 hydrides exhibit only dispersion forces. | 1 |
| Whereas H2O, HF and NH3 all exhibit hydrogen bonding (in addition to dipole-dipole and dispersion forces). | 1 |
| Thus these compounds have a greater sum of intermolecular forces (and therefore higher boiling point). | 1 |
|  |  |
| Two molecules of NH3 correctly shown | 1 |
| Hydrogen bond shown between a H atom of one molecule and the non-bonding electron pair of another | 1 |
| **Total** | **5** |

**Question 32 (19 marks)**

(a) Write a balanced net-ionic equation for this chemical reaction. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| 2 HCO3-(aq) + Ca2+(aq) → CaCO3(s) + H2O(l) + CO2(g) | 1 |
| **Total** | **1** |
| Note: state symbols are not required for full marks. | |

(b) Define activation energy, and suggest what assumption can be made regarding the magnitude of the activation energy for this reaction. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The minimum energy required for a collision to be successful. | 1 |
| Low activation energy (since it occurs rapidly at room temperature). | 1 |
| **Total** | **2** |

(c) On the axes below, sketch an energy profile diagram for this reaction. Label the axes, activation energy and enthalpy change. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Enthalpy  Progress of reaction  Ea  DH |  |
| Axes labelled correctly | 1 |
| Exothermic shape shown | 1 |
| Activation energy labelled correctly | 1 |
| Enthalpy change labelled correctly | 1 |
| **Total** | **4** |

(d) Suggest two (2) ways that the rate of this reaction could be measured. (2 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| 1. | Measure the amount of CaCO3 solid formed in a given time period / Measure how long it takes for an ‘X’ placed under the reaction vessel to be obscured | 1 |
| 2. | Measure the amount of CO2 gas formed in a given time period | 1 |
| **Total** | | **2** |

(e) List two (2) variables that should be controlled in order to ensure the data collected by the student is valid. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any two (2) of the following;   * volume of NaHCO3 * volume of CaCl2 * concentration of NaHCO3 * concentration of CaCl2 * size of beaker / reaction vessel used * whether the reaction mixture is stirred / swirled / left untouched etc | 2 |
| **Total** | **2** |

(f) Predict the likely outcome of this investigation, using collision theory to support your answer. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| An increase in temperature will increase the reaction rate. | 1 |
| Increased temperature increases the average kinetic energy of particles. | 1 |
| This results in both an increased frequency of collisions, and | 1 |
| an increased proportion of successful collisions / increased proportion of particles with Ek > Ea. | 1 |
| **Total** | **4** |

(g) Explain why the final indicator colour was yellow, using chemical equations to support your answer. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| CO2(g) + H2O(l) ⇌ H2CO3(aq) | 1 |
| H2CO3(aq) ⇌ H+(aq) + HCO3-(aq) | 1 |
| The pH scale is a measure of the concentration of hydrogen ions/H+(aq). | 1 |
| The formation of H+(aq) (from the dissolution of CO2 and subsequent ionisation of H2CO3) lowers the pH and results in a colour change to yellow. | 1 |
| **Total** | **4** |
| Note:   * state symbols are not required for full marks * no penalty for incorrect arrows in equations | |

**Question 33 (17 marks)**

(a) (i) Name the type of forces indicated by the arrows ( ) on the diagram. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Ion-dipole | 1 |
| **Total** | **1** |

(ii) Explain how these forces form. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Water molecules are (highly) polar (due to their asymmetry and the large difference in electronegativity between O and H). | 1 |
| The positive side / H atoms (d+) on the water are attracted to the anions. | 1 |
| The negative side / non-bonding electrons (d -) on the water are attracted to the cations. | 1 |
| **Total** | **3** |

(b) Calculate the concentration of chloride ions in seawater, in moles per litre. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(AgCl) = 0.264 / 143.35  = 0.0018416 mol | 1 |
| n(Cl- in 20 mL) = 0.0018416 mol | 1 |
| c(Cl- dilute) = 0.0018416 / 0.02  = 0.092082 mol L-1 | 1 |
| n(Cl- in 100 mL) = 0.092082 x 0.1  = 0.0092082 mol | 1 |
| c(Cl- in seawater) = 0.0092082 / 0.015  = 0.614 mol L-1 | 1 |
| **Total** | **5** |
| Alternate working 1:  c(Cl- dilute) = 0.092082 mol L-1  c(Cl- concentrated) = c(Cl- dilute) x V(dilute) / V(concentrated)  = (0.092082 x 0.1) / 0.015  = 0.614 mol L-1  Alternate working 2:  n(Cl- in 20 mL) = 0.0018416 mol  n(Cl- in 100 mL) = 0.0018416 x (100 / 20)  = 0.0092082 mol  = n(Cl- in 15 mL seawater)  c(Cl- in seawater) = 0.0092082 / 0.015  = 0.614 mol L-1 | |

(c) Calculate the concentration of silver ions in solution X (see diagram). (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(AgNO3 added) = 0.1 x 0.02  = 0.002 mol | 1 |
| n(Ag+ remaining) = 0.002 – 0.0018416  = 0.0001584 mol | 1 |
| c(Ag+ remaining) = 0.0001584 / 0.04  = 0.00396 mol L-1 | 1 |
| **Total** | **3** |
| Note: follow through marks may be awarded if correct calculation method is shown based on an incorrect value from part b) | |

(d) Calculate the concentration of gold in seawater, in parts per million. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| From graph;  c(Au) = 5.4 x 10-11 mol L-1 | 1 |
| m(Au) = 5.4 x 10-11 x 197  = 1.0638 x 10-8 g | 1 |
| m(Au) = 1.0638 x 10-8 x 1000  = 1.0638 x 10-5 mg | 1 |
| m(1 L seawater) = 1.0236 kg | 1 |
| c(Au in ppm) = 1.0638 x 10-5 / 1.0236  = 1.039 x 10-5 ppm | 1 |
| **Total** | **5** |
| Note:   * accept absorbance readings from graph between 5.38 x 10-11 – 5.42 x 10-11 mol L-1 * this gives a final concentration of between 1.035 x 10-5 – 1.043 x 10-5 ppm | |

**Question 34 (14 marks)**

(a) Write a balanced thermochemical equation for this reaction. Use full structural formulae for any organic substances and include state symbols. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
|  |  |
| Correct species | 1 |
| Correct full structural formulae of ethene and ethanol used | 1 |
| Correct state symbols | 1 |
| Correct heat of reaction incorporated | 1 |
| Catalyst written above arrow | 1 |
| **Total** | **5** |

(b) Explain, in terms of the collision theory, how this would increase the rate of this reaction. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A greater number of gas particles are found per unit volume / This results in a higher concentration of gas particles | 1 |
| This increases the frequency of collision (and thus the reaction rate) | 1 |
| **Total** | **2** |

(c) Explain, in terms of the collision theory, the function of the phosphoric acid catalyst in this reaction. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| It will provide an alternate reaction pathway with a lower activation energy. | 1 |
| Therefore a greater proportion of particles will be able to overcome the activation energy / will have Ek > Ea. | 1 |
| This increases the reaction rate. | 1 |
| **Total** | **3** |

(d) What minimum volume of ethene, measured at STP, would have been required to produce this amount of ethanol? (4 marks)

|  |  |
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| **Description** | **Marks** |
| m(CH3CH2OH) = 0.789 x 1775  = 1400.475 kg  = 1400475 g | 1 |
| n(CH3CH2OH) = 1400475 / 46.068  = 30400 mol | 1 |
| n(CH2CH2) = 30400 mol | 1 |
| V(CH2CH2) = 22.71 x 30400  = 6.90 x 105 L | 1 |
| **Total** | **4** |