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**CHEMISTRY**

**UNIT 1 & 2**

**2023**

**MARKING GUIDE**

***TIME ALLOWED FOR THIS PAPER***

Reading time before commencing work: Ten minutes

Working time for the paper: Three hours

***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 | 25 | 25 | 50 | 25 | 25 |
| Section Two  Short answer | 9 | 9 | 60 | 77 | 35 |
| Section Three  Extended answer | 5 | 5 | 70 | 88 | 40 |
|  |  |  |  | **Total** | 100 |

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

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | a ■ b □ c □ d □ |  | 6 | a □ b □ c ■ d □ |  | 11 | a ■ b □ c □ d □ |
| 2 | a □ b □ c □ d ■ |  | 7 | a □ b ■ c □ d □ |  | 12 | a ■ b □ c □ d □ |
| 3 | a □ b □ c ■ d □ |  | 8 | a □ b □ c ■ d □ |  | 13 | a □ b ■ c □ d □ |
| 4 | a □ b ■ c □ d □ |  | 9 | a □ b □ c □ d ■ |  | 14 | a □ b ■ c □ d □ |
| 5 | a □ b □ c ■ d □ |  | 10 | a □ b ■ c □ d □ |  | 15 | a ■ b □ c □ d □ |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 16 | a □ b □ c □ d ■ |  | 21 | a □ b □ c ■ d □ |  |  |  |
| 17 | a □ b □ c □ d ■ |  | 22 | a ■ b □ c □ d □ |  |  |  |
| 18 | a □ b ■ c □ d □ |  | 23 | a □ b ■ c □ d □ |  |  |  |
| 19 | a □ b ■ c □ d □ |  | 24 | a □ b □ c ■ d □ |  |  |  |
| 20 | a □ b □ c ■ d □ |  | 25 | a □ b □ c ■ d □ |  |  |  |

**Section Two: Short answer 35% (77 marks)**

**Question 26 (8 marks)**

(a) Identify a **similarity** between the gallium-69 and gallium-71 isotopes in terms of;

1. their atomic structure. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any of the following;   * Same number of protons * Same number of electrons | 1 |
| **Total** | **1** |

1. their chemical properties. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any of the following;   * Same reactivity * Same ion charge * Same bonding capacity | 1 |
| **Total** | **1** |

(b) Identify a **difference** between the gallium-69 and gallium-71 isotopes in terms of;

1. their atomic structure. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any of the following;   * Different number of neutrons * Different mass number | 1 |
| **Total** | **1** |

1. their physical properties. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any of the following;   * Different mass * Different density * Different melting / boiling / freezing point | 1 |
| **Total** | **1** |

(c) Calculate the relative atomic mass of the gallium in this sample. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Ar = (60.11 x 69 + 39.89 x 71) / 100  = 69.80 | 1 |
| **Total** | **1** |

(d) Calculate the number of atoms present in a 1 mg sample of this gallium. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| m(Ga) = 0.001 g | 1 |
| n(Ga) = 0.001 / 69.80  = 1.4327 x 10-5 mol | 1 |
| N(Ga) = (1.4327 x 10-5) x 6.022 x 1023  = 8.628 x 1018 atoms | 1 |
| **Total** | **3** |
| Note: Award full marks if an incorrect Ar from part (c) is used correctly.  Award full marks if Ar of 69.72 from data book is used. | |

**Question 27 (9 marks)**

(a) Complete the table below, by drawing the Lewis structure and stating the shape of each molecule. (6 marks)

|  |  |  |  |
| --- | --- | --- | --- |
| **Description** | | | **Marks** |
| SiH4 |  | tetrahedral | 2 |
| PH3 |  | pyramidal | 2 |
| H2S |  | v-shaped / bent | 2 |
| **Total** | | | **6** |

(b) Identify the most polar compound and justify your choice. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| H2S | 1 |
| Any two (2) of the following points;   * The greatest difference in electronegativity occurs between H and S atoms (compared to H and P, or H and Si). * The dipole moment of H-S is greater than that of H-P (and H-Si). * H2S has 2 non-bonding electron pairs whilst PH3 only has 1 (and SiH4 has none / is symmetrical). | 2 |
| **Total** | **3** |

**Question 28 (7 marks)**

(a) Explain the difference in conductivity of these solutions, using relevant chemical equations to support your answer. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| HCl is a strong acid whilst HF is a weak acid.  **or**  HCl undergoes complete ionisation, whilst HF only partially ionises. | 1 |
| HCl(aq) → H+(aq) + Cl-(aq) | 1 |
| HF(aq) ⇌ H+(aq) + F-(aq) | 1 |
| Correct arrow shown in each equation. | 1 |
| Therefore a solution of HCl(aq) has a greater concentration of ions present (and thus a greater electrical conductivity).  **or**  Therefore a solution of HF(aq) has a lower concentration of ions present (and thus a lower electrical conductivity).  **or**  1 mol L-1 HCl(aq) will produce a solution with 2 mol L-1 of ions, whereas 1 mol L-1 HF(aq) will produce a solution with less than 2 mol L-1 of ions. | 1 |
| **Total** | **5** |
| Note: State symbols are not required. | |

(b) Identify the predominant type of intermolecular force that exists between the solute and solvent in each solution. (2 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| HF(aq) | hydrogen | 1 |
| HCl(aq) | ion-dipole | 1 |
| **Total** | | **2** |

**Question 29 (9 marks)**

(a) Write a balanced ionic equation representing this reaction. Include state symbols in your answer. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| NH4NO3(s) + OH-(aq) → NO3-(aq) + NH3(g) + H2O(l) |  |
| Correct species | 1 |
| Correct state symbols | 1 |
| **Total** | **2** |

(b) Identify the trend shown in this graph, and explain this trend in terms of the collision theory. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The time taken to dissolve the NH4NO3(s) powder decreases with an increasing concentration of KOH(aq). | 1 |
| This is because an increased KOH(aq) concentration results in an increased frequency of reactant collisions. | 1 |
| Therefore the reaction rate will be faster. | 1 |
| **Total** | **3** |

(c) On the graph above, sketch a curve showing the likely results that would be obtained using warm potassium hydroxide. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A picture containing text, line, diagram, plot  Description automatically generated |  |
| Curve sketched in the same shape, but below, the original data. | 1 |
| **Total** | **1** |

(d) Explain the shape of your sketched curve, in terms of the collision theory. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| An increase in temperature increases the average kinetic energy of the particles. | 1 |
| This will increase the frequency and proportion of successful collisions. | 1 |
| Therefore the rate of reaction will be increased (and thus a shorter time taken for the powder to dissolve). | 1 |
| **Total** | **3** |

**Question 30 (8 marks)**

(a) Explain, in terms of structure and bonding, why iron is malleable yet iron(III) oxide is brittle. (6 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Iron exhibits metallic bonding.  **or**  Iron exists as a sea of delocalised electrons surrounding positive metal cations. | 1 |
| This bonding is non-directional in nature. | 1 |
| Therefore when a force is applied the iron can change shape without disrupting the bonding. | 1 |
| Iron(III) oxide exhibits ionic bonding.  **or**  Iron(III) oxide is composed of cations and anions. | 1 |
| The ions are arranged in a rigid 3D lattice. | 1 |
| Therefore when a force is applied the like charges align and repel, causing the substance to shatter. | 1 |
| **Total** | **6** |

(b) Calculate the percentage by mass of iron in iron(III) oxide. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| % Fe in Fe2O3 = (2 x 55.85) / (2 x 55.85 + 3 x 16) x 100 | 1 |
| = 69.94 % | 1 |
| **Total** | **2** |

**Question 31 (9 marks)**

(a) Name one (1) other heavy metal. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Mercury / arsenic / chromium / thallium / lead. | 1 |
| **Total** | **1** |

(b) Define a saturated solution. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A solution in which the maximum amount of solute has dissolved, | 1 |
| for a given temperature. | 1 |
| **Total** | **2** |

(c) Write a balanced ionic equation for the precipitation reaction that would occur. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| 3 Cd2+(aq) + 2 PO43-(aq) → Cd3(PO4)2(s) |  |
| Correct species | 1 |
| Correct balancing | 1 |
| **Total** | **2** |
| Note: State symbols are not required. | |

(d) Calculate the minimum volume of sodium phosphate solution required to remove all the cadmium ions from the saturated solution. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| m(CdCl2) = 119.6 x (245 / 100)  = 293.02 g | 1 |
| n(CdCl2) = 293.02 / 183.3  = 1.5986 mol  = n(Cd2+) | 1 |
| n(PO43-) = (2 / 3) x 1.5986  = 1.06572 mol | 1 |
| V(Na3PO4) = 1.06572 / 1.62  = 0.658 L | 1 |
| **Total** | **4** |
| Note: Award follow through marks in the case of incorrect balancing in part (c). | |

**Question 32 (9 marks)**

(a) Write a balanced chemical equation for the reaction that would occur. Use structural formulae for all organic compounds. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **or** |  |
| Correct reactants | 1 |
| Correct products | 1 |
| **Total** | **2** |
| Note: Catalyst above arrow not required. Marks may be awarded for substitution of multiple bromine atoms, as long as correct stoichiometry is shown, for example;  CH3CH2CH2CH3 + 2 Br2 → CH3CH2CHBrCH2Br + 2 HBr | |

(b) Write a balanced chemical equation for the reaction that would occur. Use structural formulae for all organic compounds. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
|  |  |
| Correct reactants | 1 |
| Correct products | 1 |
| **Total** | **2** |
| Note: Catalyst above arrow not required. Propan-1-ol may also be accepted as the product, if Markovnikov’s rule is not being assessed. | |

(c) What is the function of the UV light in part (a) and the sulfuric acid in part (b)? (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Catalyst | 1 |
| **Total** | **1** |

(d) Which of the reactions described in part (a) and (b), would be classified as a substitution reaction? (circle your choice) (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| (a) | 1 |
| **Total** | **1** |

(e) Explain what an endothermic reaction is, in terms of the breaking and forming of bonds. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Breaking reactant bonds absorbs energy.  **or**  Energy input is required to break bonds. | 1 |
| Forming product bonds releases energy.  **or**  Energy is released when bonds form. | 1 |
| In an endothermic reaction, a greater quantity of energy is absorbed than released.  **or**  If more energy is required to break the reactant bonds, than is released when product bonds form, the reaction will be endothermic. | 1 |
| **Total** | **3** |

**Question 33 (10 marks)**

(a) Explain, in terms of intermolecular forces, why the boiling point of nitrogen is much lower than that of water. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| N2 is non-polar and only exhibits dispersion forces. | 1 |
| H2O is polar and exhibits hydrogen bonding, as well as (dipole-dipole and) dispersion forces. | 1 |
| The sum of intermolecular forces in H2O is greater than N2, therefore a greater amount of energy is required to disrupt them. | 1 |
| **Total** | **3** |

(b) Identify which gas would occupy the largest volume. Justify your answer. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The same mass (i.e. 18 g) of each substance would result in a greater number of moles of H2O, since H2O has a greater M.  **or**  n(N2) = 18 / 18.016 = 0.999 mol  n(H2O) = 18 / 28.02 = 0.642 mol | 1 |
| The molar volume of all gases is the same under the same conditions (of temperature and pressure).  **or**  At the same temperature and pressure, a larger number of moles of gas will occupy a larger volume / a smaller number of moles of gas will occupy a smaller volume. | 1 |
| Thus H2O would occupy a larger volume / N2 would occupy a smaller volume. | 1 |
| **Total** | **3** |

(c) Explain, in terms of the kinetic theory, why the pressure inside the container would increase. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| This results in the same number of particles existing in a smaller space.  **or**  This increases the number of molecules per unit area. | 1 |
| Therefore the frequency of gas particle collisions with the walls of the container would increase (thus increasing pressure). | 1 |
| **Total** | **2** |

(d) Describe how this observation illustrates the difference between a real gas and an ideal gas. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| There are no intermolecular forces acting between the particles of an ideal gas. | 1 |
| Intermolecular forces are required to form the liquid state, therefore real gases must exhibit intermolecular forces. | 1 |
| **Total** | **2** |

**Question 34 (8 marks)**

(a) Why are CNTs classified as nanomaterials? (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The diameter / wall thickness of the tube is in the range 1-100 nm. | 1 |
| **Total** | **1** |

(b) Given that bulk carbon is relatively inert, suggest two (2) reasons many countries have guidelines in place to limit people’s exposure to CNTs. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any two (2) of the following points;   * Bulk carbon displays different properties to nanocarbon * Nanoparticles may be able to more easily pass into cell tissue * May cause respiratory issues / lung cancer * May pose unknown dangers to health * Not enough long term data on the safety of nanomaterials | 2 |
| **Total** | **2** |

(c) Describe the economic benefit associated with using catalysts in industry. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Catalysts increase the rate of a reaction. | 1 |
| This produces more product in a shorter amount of time (which is economically beneficial in terms of generating profit). | 1 |
| **Total** | **2** |

(d) Explain, in terms of collision theory, how a catalyst alters the rate of reaction. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Catalysts provide an alternate reaction pathway with a lower activation energy. | 1 |
| Therefore a higher proportion of particles have sufficient energy to react / to overcome the activation energy. | 1 |
| **Total** | **2** |

(e) Identify one (1) way in which an enzyme differs from a metal nanoparticle catalyst. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any of the following;   * Enzymes are organic catalysts / of biological origin * Enzymes are pH sensitive * Enzymes are temperature sensitive * Enzymes are proteins * Enzymes function due to their specific shape | 1 |
| **Total** | **1** |

**Section Three: Extended answer 40% (88 marks)**

**Question 35 (19 marks)**

(a) Describe how the strontium ions produce an emission spectrum, and why the spectrum emitted is observed as red light. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Electrons become excited to higher energy levels.  **or**  Electrons absorb energy and jump up to higher energy levels. | 1 |
| The electrons then return to their ground state.  **or**  The electrons then fall back down to their original levels. | 1 |
| The difference in energy between the excited state and ground state is emitted as electromagnetic radiation.  **or**  The photons / energy released by the electrons creates an emission spectrum. | 1 |
| Any one of the following;  The red colour observed is due to;   * the wavelength / frequency of the energy emitted. * several bands / the predominant bands within the emission spectrum corresponding with the wavelengths of red light. * the unique arrangement of electrons in strontium. * the specific energy levels of the electron shells in strontium. | 1 |
| **Total** | **4** |

(b) Suggest one (1) ethical consideration that the manufacturers of colour flame candles should consider. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any of the following;   * Safety of the candles / ingredients for consumers * Toxicity of the chemicals used to produce the different colours * Safety of all chemicals used to manufacture the candle * Safety of the candles / fumes produced when burning * Responsible sourcing of materials * Responsible disposal of any waste materials produced | 1 |
| **Total** | **1** |

(c) Calculate the maximum concentration of SrCl2(aq) solution produced. (You may assume no change in volume when the strontium carbonate is dissolved in the acid). (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| m(SrSO4) = 355 x 103 g | 1 |
| n(SrSO4) = 355000 / 183.68  = 1932.71 mol | 1 |
| n(SrCl2) = 1932.71 mol | 1 |
| c(SrCl2) = 1932.71 / 925  = 2.09 mol L-1 | 1 |
| **Total** | **4** |

(d) Identify a method that could be used to obtain solid strontium chloride from a strontium chloride solution. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Evaporation / Distillation | 1 |
| **Total** | **1** |

(e) Explain, in terms of structure and bonding, why strontium chloride can conduct electricity when molten. Use a relevant chemical equation to support your answer. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| When molten, the ions in SrCl2 dissociate. | 1 |
| SrCl2(s) → Sr2+(l) + 2 Cl-(l) | 1 |
| This produces mobile charge in the form of freely moving ions (thus allowing the liquid to conduct electricity). | 1 |
| **Total** | **3** |
| Note: State symbols are not required in equation. | |

(f) State the name given to the group 2 elements. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Alkaline-earth metals | 1 |
| **Total** | **1** |

(g) Identify, in terms of atomic structure, the characteristic common to the group 2 elements. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Two valence electrons | 1 |
| **Total** | **1** |

(h) Explain, by referring to atomic radius, why strontium is more dense than rubidium. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Strontium has a smaller atomic radius (and a higher atomic mass). / Rubidium has a larger atomic radius (and a lower atomic mass). | 1 |
| Since strontium occupies a lesser volume, it is more dense. / Since rubidium occupies a greater volume, it is less dense.  **or**  Since the electron shells in strontium are pulled closer to the nucleus, it is more dense. / Since the electron shells in rubidium are further from the nucleus, it is less dense. | 1 |
| **Total** | **2** |

(i) Explain, by referring to first ionisation energy, why strontium is less reactive than rubidium. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Strontium has a higher first ionisation energy / Rubidium has a lower first ionisation energy. | 1 |
| Therefore valence electrons of strontium are more strongly held, thus it is less reactive. / Therefore valence electrons of rubidium are more weakly held, thus it is more reactive.  **or**  Therefore it is harder to remove the valence electrons from strontium, so it is less reactive. / Therefore it is easier to remove the valence electrons from rubidium, so it is more reactive. | 1 |
| **Total** | **2** |

**Question 36 (18 marks)**

(a) What is a fossil fuel? (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A non-renewable energy source, | 1 |
| formed over millions of years from organic material. | 1 |
| **Total** | **2** |

(b) Identify two (2) reasons that it is **not** desirable for fuels to produce high levels of carbon emissions. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any two (2) of the following;   * Global warming / increased global surface temperature * Ocean acidification * Glaciers melting * Increased drought * Climate change / extreme weather events | 2 |
| **Total** | **2** |

(c) Identify two (2) reasons that a country may decide to continue to use coal, despite its associated pollution. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any two (2) of the following;   * Use of existing infrastructure * Lower costs * Job losses * Economic concerns * No affordable alternatives * Political decision making | 2 |
| **Total** | **2** |

(d) Calculate the value of the enthalpy change, in kJ mol-1, associated with this reaction. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| m(C137H96O9NS) = 1 kg  = 1000 g | 1 |
| n(C137H96O9NS) = 1000 / 1932.208  = 0.51754 mol | 1 |
| Enthalpy of combustion = 30.4 / 0.51754  = 58.74 kJ mol-1 | 1 |
| DH stated as a negative (-) value / DHc used to denote enthalpy of combustion / Written mention of reaction being ‘exothermic’ or heat being ‘released’ or ‘produced’. | 1 |
| **Total** | **4** |

(e) Calculate the volume of CO2(g), at STP, that was produced **per person** in Australia, due to coal combustion in the year 2020. State your answer to the appropriate number of significant figures. (6 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| m(C137H96O9NS per person) = 95985380 / 25.66 x 106  = 3.7407 t | 1 |
| m(C137H96O9NS) = 3.7407 x 106 g | 1 |
| n(C137H96O9NS) = (3.7407 x 106) / 1932.208  = 1935.952 mol | 1 |
| n(CO2) = 137 x 1935.952  = 265225 mol | 1 |
| V(CO2) = 22.71 x 265225  = 6023269 L | 1 |
| = 6.023 x 106 L **or** 6.023 ML (4 SF) | 1 |
| **Total** | **6** |

(f) Write a series of two (2) balanced chemical equations illustrating how the release of sulfur dioxide gas into the atmosphere can lower the pH of rain. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| SO2(g) + H2O(l) ⇌ H2SO3(aq) | 1 |
| H2SO3(aq) ⇌ H+(aq) + HSO3-(aq) | 1 |
| **Total** | **2** |
| Note: State symbols are not required. Double arrows are not required. | |

**Question 37 (16 marks)**

(a) Describe the basic principles of chromatography, with reference to how these two phases allow separation to occur. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The mobile phase moves across the stationary phase. | 1 |
| The components of the mixture have a different affinity for each of these phases (depending upon their polarity).  **or**  Some components adhere more strongly to the stationary phase, whilst others dissolve more readily in the mobile phase. | 1 |
| Therefore each component moves at a different rate (and thus separation occurs). | 1 |
| **Total** | **3** |
| Note: Awards marks accordingly, if students have given a description in terms of intermolecular forces, as long as reference to how the two phases resolve the different components is made. | |

(b) Based on the appearance of the TLC plate upon completion of Step 2, identify the least polar amino acid. Justify your answer, by referring to the intermolecular forces involved. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Val | 1 |
| Components with similar polarity / intermolecular forces to the mobile phase dissolve the best. | 1 |
| Therefore non-polar amino acids will move the fastest / furthest. | 1 |
| **Total** | **3** |

(c) Describe an advantage of two-dimensional chromatography over traditional one-dimensional chromatography, in the separation of amino acids. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Some amino acids have similar retention factors in solvent 1. | 1 |
| After using a second solvent, these amino acids have been clearly separated.  **or**  Amino acids are unlikely to have identical solubilities in two different solvents. | 1 |
| **Total** | **2** |

(d) Determine the most likely identity of this amino acid. Show your working. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Ala | 1 |
| Relevant working shown;  e.g. Rf(1) = x / 7 = 0.61 and Rf(2) = x / 7 = 0.43  Therefore component should have moved approx. 4.3 cm in solvent 1, and 3.0 cm in solvent 2. | 1 |
| **Total** | **2** |
| Note: Working out does not need to be detailed / thorough, but should suggest that the answer was not guessed. | |

(e) Complete the following table, by drawing the structural formula of each compound. Show all atoms and bonds. (3 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| pentane |  | 1 |
| trichloromethane |  | 1 |
| benzene |  | 1 |
| **Total** | | **3** |

(f) Identify the most polar solvent in the table in part (e). (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Trichloromethane | 1 |
| **Total** | **1** |

(g) Define ‘validity’. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Extent to which a test/method measures what was intended. | 1 |
| **Total** | **1** |

(h) Identify one way to ensure a scientific method is reliable. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Perform repeat trials / Have someone else repeat the method. | 1 |
| **Total** | **1** |

**Question 38 (16 marks)**

(a) Identify three (3) variables the student should control, in order to ensure a valid comparison. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any three (3) of the following;   * Mass of ZnCO3(s) * Concentration of acid * Volume of acid * Temperature of acid * Size of test tube | 3 |
| **Total** | **3** |

(b) Identify two (2) ways in which the observations for the powdered solid would have differed from the solid chips. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| More rapid effervescence / Colourless gas produced at a quicker rate. | 1 |
| Solid dissolved faster / White solid dissolves in shorter amount of time. | 1 |
| **Total** | **2** |

(c) Explain, in terms of collision theory, why the observations were different for test tube A and test tube B. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The ZnCO3(s) had a smaller exposed surface area in test tube A. / The ZnCO3(s) had a larger exposed surface area in test tube B. | 1 |
| Therefore the frequency of collisions was lower in test tube A. / Therefore the frequency of collisions was higher in test tube B. | 1 |
| Thus the reaction rate was slower in test tube A. / Thus the reaction rate was faster in test tube B. | 1 |
| **Total** | **3** |

(d) Calculate the concentration of CaCO3(s), in parts per million, in the resulting limewater suspension. (You may assume no change in volume when carbon dioxide is dissolved in the limewater). (8 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(ZnCO3) = 1.04 / 125.39  = 0.008294 mol | 1 |
| n(CO2 produced) = 0.008294 mol | 1 |
| n(CO2 dissolved) = (15 / 100) x 0.008294  = 0.001244 mol | 1 |
| n(CaCO3) = 0.001244 mol | 1 |
| m(CaCO3) = 0.001244 x 100.09  = 0.1245 g | 1 |
| = 124.5 mg | 1 |
| m(limewater) = 0.0291 kg | 1 |
| ppm = 124.5 / 0.0291  = 4279 ppm | 1 |
| **Total** | **8** |

**Question 39 (19 marks)**

(a) State the name given to structurally different forms of the same element. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Allotropes | 1 |
| **Total** | **1** |

(b) Explain, in terms of structure and bonding, why this is so. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Both exhibit covalent network bonding. | 1 |
| They consist of strong covalent bonds which needs to be broken for melting to occur. | 1 |
| Therefore a high amount of heat / energy is required (resulting in a high melting point). | 1 |
| **Total** | **3** |

(c) Explain, in terms of structure and bonding, the difference in conductivity. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| In diamond, each carbon atom is bonded to 4 other carbon atoms. | 1 |
| All electrons in diamond are therefore localised, leaving no mobile charge to conduct electricity. | 1 |
| In graphite, each carbon atom is bonded to 3 other carbon atoms. | 1 |
| The fourth valence electron of each carbon atom in graphite is delocalised, allowing it to conduct electricity. | 1 |
| **Total** | **4** |

(d) On the axes below, sketch an energy profile diagram for the conversion of diamond to graphite. Label the activation energy and enthalpy change. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A picture containing text, diagram, line, plot  Description automatically generated |  |
| Reactants and products correctly labelled | 1 |
| Activation energy correctly labelled | 1 |
| Enthalpy change correctly labelled | 1 |
| Exothermic profile | 1 |
| Appropriate scale of profile sketch i.e. extremely large activation energy compared to very small enthalpy change | 1 |
| **Total** | **5** |

(e) Suggest a likely reason for this. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The extremely high activation energy. | 1 |
| **Total** | **1** |

(f) Calculate the quantity of heat energy absorbed or released during this process. Clearly state in your answer whether heat energy is absorbed or released. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| m(diamond) = 0.77 x 200  = 154 mg | 1 |
| = 0.154 g | 1 |
| n(diamond) = 0.154 / 12.01  = 0.012823 mol | 1 |
| Energy = 1.9 x 0.012823  = 0.0244 kJ **or** 24.4 J | 1 |
| Energy is released. | 1 |
| **Total** | **5** |