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**CHEMISTRY**

**UNIT 1**

**2021**

**MARKING GUIDE**

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

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

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

**Section Two: Short answer 35% (80 marks)**

**Question 26 (7 marks)**

(a) Complete the table for the species above. (3 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| Protons | 11 | 1 |
| Neutrons | 12 | 1 |
| Electron configuration | 2, 8 | 1 |
| **Total** | | **3** |

(b) Using the same notation as sodium above, write the symbol for an atomic species that matches each of the following descriptions. (4 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| An alkaline-earth metal in period 4. |  | 1 |
| An anion with the same electron configuration as a neon atom. | 3- **or** 2- **or** - | 1 |
| An element in group 15 which exists as a diatomic gas at room temperature. |  | 1 |
| A potassium ion with 22 neutrons. | + | 1 |
| **Total** | | **4** |

**Question 27 (5 marks)**

Complete the table below, by writing the name of the scientist next to the description of their contribution to atomic theory.

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| Proposed that electrons move in circular orbits with particular energy levels. | Bohr | 1 |
| Discovered the neutron. | Chadwick | 1 |
| Discovered the electron. | Thomson | 1 |
| Proposed that atoms of the same element are the same, and atoms of different elements are different. | Dalton | 1 |
| Proposed that an atom was largely empty space, with a central nucleus. | Rutherford | 1 |
| **Total** | | **5** |

**Question 28 (4 marks)**

Complete the following table, by writing the name of the compound and classifying the compound according to its physical properties.

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| H2SO3 | |  |
| Name of compound | sulfurous acid | 1 |
| Classification of physical properties | covalent | 1 |
| ZnSO3 | |  |
| Name of compound | zinc sulfite | 1 |
| Classification of physical properties | ionic | 1 |
| **Total** | | **4** |

**Question 29 (11 marks)**

(a) Define a nanoparticle. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A particle within the size range 1-100 nm | 1 |
| **Total** | **1** |

(b) Give one (1) reason consumers may be concerned about the use of nanoparticles in cosmetics such as face cream. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any of the following (or other relevant answer): |  |
| * particles may be more easily absorbed into cells / bloodstream * long terms effects of nanogold unknown * no universal guidelines / recommendations for nanoparticle use | 1 |
| **Total** | **1** |

(c) Explain, in terms of electron behaviour, how the gold atoms in the hollow cathode lamp can create an emission spectrum with these unique wavelengths. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The electrons in gold atoms absorb energy and become excited | 1 |
| The electrons move to higher energy levels temporarily | 1 |
| The electrons return to their ground state | 1 |
| The energy is thus released as light with specific frequencies, creating an emission spectrum | 1 |
| The emission spectrum is unique because:  the energy shells in each element have slightly different energy levels  **or**  each element has a different number of electrons | 1 |
| **Total** | **5** |

(d) Calculate the number of gold atoms that would be spread over the skin of someone who used 1.0 mL of face cream. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Absorbance of 0.45 corresponds to a gold concentration of 0.11 mg mL-1 | 1 |
| In 1 mL of face cream 0.11 mg present; 0.11 mg = 1.1 x 10-4 g | 1 |
| n(Au) = (1.1 x 10-4) / 197  = 5.5838 x 10-7 mol | 1 |
| N(Au) = (6.022 x 1023) x (5.5838 x 10-7)  = 3.4 x 1017 atoms | 1 |
| **Total** | **4** |

**Question 30 (8 marks)**

(a) Complete the following table, by stating which piece of equipment contains a substance matching the description given. (3 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| A pure substance | Funnel | 1 |
| A homogeneous mixture | Beaker 2 | 1 |
| A heterogeneous mixture | Beaker 1 | 1 |
| **Total** | | **3** |

(b) Explain why, using an appropriate chemical equation to support your answer. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Magnesium chloride is an ionic substance | 1 |
| When MgCl2 dissolves in water, the ions dissociate | 1 |
| This produces mobile charges in the solution, which conduct electricity | 1 |
| Equation: MgCl2(s) → Mg2+(aq) + 2 Cl-(aq) | 1 |
| **Total** | **4** |

(c) Name the process that could be used to separate and retain both the components of Beaker 2. (1 mark)

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

**Question 31 (5 marks)**

Use the information above to complete the table below.

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| Element W is likely to be in group | 13 | 1 |
| The element with 6 valence electrons would be | Z | 1 |
| The element with the largest atomic radius would be | Y | 1 |
| When combined, W and Y are most likely to form | an alloy | 1 |
| The compound X2Z is most likely to contain | covalent bonding | 1 |
| **Total** | | **5** |

**Question 32 (7 marks)**

(a) Which antibiotic contains a higher percentage by mass of oxygen? Support your answer with appropriate calculations. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| %O(amoxycillin) = (80 / 365.402) x 100  = 21.89 % | 1 |
| %O(cefalexin) = (64 / 371.406) x 100  = 17.23 % | 1 |
| Therefore, amoxycillin has a higher percent of oxygen | 1 |
| **Total** | **3** |

(b) Calculate the initial mass of amoxycillin that had been analysed. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(NO2) = 0.364 / 46.01  = 0.0079113 mol | 1 |
| n(N) = n(NO2) | 1 |
| n(C16H19N3O5S) = (1/3) x 0.0079113  = 0.0026371 mol | 1 |
| m(C16H19N3O5S) = 0.0026371 x 365.40  = 0.964 g | 1 |
| **Total** | **4** |
| Alternate working:  %N(amoxycillin) = (42.03 / 365.40) x 100  = 11.502 %  n(N) = n(NO2) = 0.364 / 46.01  = 0.0079113 mol  m(N) = 0.0079113 x 14.01  = 0.11084 g  m(C16H19N3O5S) = 0.11084 x (100 / 11.502)  = 0.964 g | |

**Question 33 (11 marks)**

(a) Balance the equation above, by adding the correct coefficients. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Coefficients: 1, 25, 18, 16 | 1 |
| **Total** | **1** |

(b) Explain, with reference to the Law of Conservation of Mass, why chemical equations need to be balanced. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Matter cannot be created or destroyed (in a chemical reaction) | 1 |
| Balancing an equation ensures the same number and type of each atom are on both sides of the equation | 1 |
| **Total** | **2** |

(c) Explain how this reaction conforms to the Law of Conservation of Energy, despite this release of heat. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Energy cannot be created or destroyed (in a chemical reaction)  **or**  The total amount of energy in the ‘system + surroundings’ must be constant | 1 |
| The enthalpy of the products is lower than the enthalpy of the reactants  **or**  Energy input is required to break chemical bonds, and energy is released when new chemical bonds form | 1 |
| The enthalpy change represents the amount of enthalpy that has been converted to heat energy  **or**  The release of heat relates to the difference in energy associated with the bond breaking and making processes | 1 |
| **Total** | **3** |

(d) Calculate the mass of biodiesel that would need to be combusted to produce one megajoule (1 MJ) of energy in the chemical reaction above. (3 marks)

Note: 1 MJ = 103 kJ.

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(C18H32O2) = 1000 / 11380  = 0.08787 mol | 1 |
| M(C18H32O2) = 280.436 g mol-1 | 1 |
| m(C18H32O2) = 0.08787 x 280.436  = 24.6 g | 1 |
| **Total** | **3** |

(e) State two (2) reasons why it is not always possible to use biodiesel in place of regular diesel. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any **two** of the following (or other relevant answer): |  |
| * too expensive * not readily available * relatively new / unestablished technology * car engines are not equipped to use it * may cause damage to older engines * infrastructure to produce biodiesel not existing * shortage of appropriate raw materials | 2 |
| **Total** | **2** |

**Question 34 (7 marks)**

(a) Write a balanced molecular, thermochemical equation representing this reaction. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Equation: Ba(OH)2(aq) + 2 NH4Cl(s) + 26 kJ → 2 H2O(l) + 2 NH3(g) + BaCl2(aq) | |
| Correct reactants | 1 |
| Correct products | 1 |
| Correctly balanced | 1 |
| Correct enthalpy change | 1 |
| **Total** | **4** |

(b) Explain, in terms of structure and bonding, why the ammonia produced in this reaction is a gas at room temperature. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Ammonia is a covalent molecular substance (which exists as discrete molecules) | 1 |
| These molecules only exhibit weak intermolecular forces | 1 |
| Thus a small amount of heat is required to disrupt these forces, resulting in a low boiling point | 1 |
| **Total** | **3** |

**Question 35 (7 marks)**

(a) Write the electron configuration of magnesium and phosphorus. (2 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| Mg | 2, 8, 2 | 1 |
| P | 2, 8, 5 | 1 |
| **Total** | | **2** |

(b) Write the electron configuration for the new species that form. (2 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| Mg2+ | 2, 8 | 1 |
| P3- | 2, 8, 8 | 1 |
| **Total** | | **2** |

(c) Explain why each of these changes in electron configuration occur when magnesium and phosphorus react. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Both elements react in order to achieve a full octet which is a stable electron configuration | 1 |
| Magnesium has 2 valence electrons and therefore will lose 2 electrons to develop a +2 change | 1 |
| Phosphorus has 5 valence electrons and therefore will gain 3 electrons to develop a -3 charge | 1 |
| **Total** | **3** |

**Question 36 (8 marks)**

(a) Complete the table below by writing the IUPAC name or drawing a structural diagram for each organic substance. (6 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| IUPAC name | (cis-)1-bromobut-2-ene | 2 |
| Structural diagram |  | 2 |
| Structural diagram |  | 2 |
| **Total** | | **6** |
| Note:  one mark may be allocated for minor error | | |

(b) Write a chemical equation for the catalysed reaction that occurs between benzene and chlorine gas. Use structural formulae for all organic substances. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Equation: |  |
| Correct reactants | 1 |
| Correct products | 1 |
| **Total** | **2** |

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

**Question 37 (15 marks)**

(a) Classify this reaction as an endothermic or exothermic reaction, and state whether the value of DH is positive or negative. (2 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| The reaction is | exothermic | 1 |
| The value of DH is | negative | 1 |
| **Total** | | **2** |

(b) Compare the energy associated with the bond breaking and bond making processes involved in this reaction. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The energy required to break the bonds is less | 1 |
| than the energy released when new bonds form | 1 |
| **Total** | **2** |

(c) Calculate the amount of energy released by the explosion, and state this value in terms of ‘tonnes of TNT equivalent’. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| m(NH4NO3) = 2750 x 106  = 2.750 x 109 g | 1 |
| n(NH4NO3) = 2.750 x 109 / 80.052  = 3.4353 x 107 mol | 1 |
| energy = (3.4353 x 107) x 36  = 1.2367 x 109 kJ | 1 |
| = 1236.7 GJ | 1 |
| TNT equiv. = 1236.7 / 4.184  = 296 | 1 |
| **Total** | **5** |

(d) Calculate how many atoms of nitrogen would have been delivered per metre squared of soil. State your answer to the appropriate number of significant figures. (6 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| m(NH4NO3) = (40/100) x 1.375 x 106  = 5.50 x 105 g | 1 |
| n(NH4NO3) = 5.50 x 105 / 80.052  = 6870.534 mol | 1 |
| n(N) = 2 x 6870.534  = 13741 mol | 1 |
| N(N) = 6.022 x 1023 x 13741  = 8.27 x 1027 atoms | 1 |
| N(N per m2) = 8.27 x 1027 / 25000  = 3.30995 x 1023 atoms | 1 |
| = 3.31 x 1023 atoms (3 SF) | 1 |
| **Total** | **6** |

**Question 38 (18 marks)**

(a) Define ‘first ionisation energy’. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The energy required to remove one mole of valence electrons | 1 |
| from one mole of the gaseous element. | 1 |
| **Total** | **2** |

(b) State whether the data obtained by the students would be classified as ‘primary’ or ‘secondary’ data. Justify your answer. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Secondary | 1 |
| The students did not measure and collect the data directly themselves | 1 |
| **Total** | **2** |

(c) Graph the data collected by the students, using the grid below. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| x-axis label and scale | 1 |
| y-axis label and scale | 1 |
| Correct data points | 1 |
| Line or column graph used | 1 |
| **Total** | **4** |
| Example of a four mark response   |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   –  2000 –  –  1600 –  –  1200 –  –  800 –  –  400 –  –  l l l l l l l l l l l l l  8 9 10 11 12 13 14 15 16  Atomic number  x  x  x  x  x  x  x  x  First ionisation energy (kJ mol-1) | |

(d) Explain the increasing trend in first ionisation energy for the elements with atomic number 13-15. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| There is an increasing positive charge / number of protons in the nucleus | 1 |
| Therefore a stronger force of attraction on the valence electrons | 1 |
| Thus a larger amount of energy is required to remove the valence electrons | 1 |
| **Total** | **3** |

(e) Explain why there is such a large difference in the first ionisation energy of neon and sodium. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The valence electrons of neon are in shell 2, whereas the valence electron of sodium is in shell 3 (and therefore further from the nucleus) | 1 |
| The valence electron of sodium therefore experiences a lesser force of attraction to the nucleus, thus less energy is required to remove it | 1 |
| **Total** | **2** |

(f) Suggest an appropriate range, in which the first ionisation energy of the element with atomic number 16 would fall. Justify your answer. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Within the range 1012 - 1314 kJ mol-1 | 1 |
| Must be higher than that of P, since they are in the same period | 1 |
| Must be lower than O, since they are in the same group | 1 |
| **Total** | **3** |

(g) Which of the elements studied by the students would have (2 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| (i) the highest electronegativity? | fluorine | 1 |
| (ii) the smallest atomic radius? | neon | 1 |
| **Total** | | **2** |

**Question 39 (19 marks)**

(a) Calculate the mass of chlorine gas that would be required to completely react with the rutile ore. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| m(TiO2) = (61.7/100) x 2420  = 1493.14 kg | 1 |
| m(TiO2) = 1493.14 x 103  = 1493140 g | 1 |
| n(TiO2) = 1493140 / 79.87  = 18695 mol | 1 |
| n(Cl2) = 2 x 18694.6  = 37389 mol | 1 |
| m(Cl2) = 37389 x 70.9  = 2.65 x 106 g | 1 |
| **Total** | **5** |

(b) Use the information provided in the table, to explain how the cooling process would allow separation of TiCl4 to occur. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The boiling point of TiCl4 is much higher (136.4°) than that of CO2 (-78.5°) | 1 |
| If the temperature is lowered (to below 136.4°), TiCl4 will condense first (and thus can be collected and removed) | 1 |
| **Total** | **2** |

(c) Use the information provided in the table, to suggest a temperature at which this reaction might be carried out. Justify your answer. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any value within the range 714 - 1412 °C | 1 |
| Since MgCl2 is in the liquid/molten state | 1 |
| the temperature must be between the melting and boiling point of MgCl2 | 1 |
| **Total** | **3** |

(d) Calculate the length of piping that could be manufactured from 2695 kg of TiCl4. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(TiCl4) = (2695 x 103) / 189.67  = 14209 mol | 1 |
| n(Ti) = 14209 mol | 1 |
| m(Ti) = 14209 x 47.87  = 680180 g | 1 |
| = 680.18 kg | 1 |
| length = 680.18 / 5.43  = 125 metres | 1 |
| **Total** | **5** |

(e) State the property of metals which allows them to be shaped easily into pipes. Explain the basis of this property, in terms of structure and bonding. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Malleability / ductility | 1 |
| Metallic bonding consists of a sea of delocalised electrons surrounding positive metal ions | 1 |
| This bonding is non-directional | 1 |
| Therefore if a force is applied, the metal can change shape without disrupting the bonding | 1 |
| **Total** | **4** |

**Question 40 (18 marks)**

(a) Describe the difference between a ‘saturated’ and an ‘unsaturated’ organic compound, and provide an example of each from the table above. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Saturated refers to all single carbon-carbon bonds | 1 |
| Unsaturated refers to one or more double or triple carbon-carbon bonds | 1 |
| One correct example of each: |  |
| saturated – octane  unsaturated – oct-1-ene **or** octa-1,3-diene **or** octa-1,3,5-triene | 1 |
| **Total** | **3** |

(b) Complete the table above by calculating the average time taken for the remaining three test tubes. (3 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| oct-1-ene average | 6.06 s | 1 |
| octa-1,3-diene average | 3.04 s | 1 |
| octa-1,3,5-triene average | 2.04 s | 1 |
| **Total** | | **3** |

(c) Give two (2) reasons the students performed multiple trials. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Reduces the effects of random error | 1 |
| Increases reliability of the data | 1 |
| **Total** | **2** |

(d) Complete the table below, by listing the variables for this investigation. (3 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| Independent variable | Number of double bonds in organic substance | 1 |
| Dependant variable | Time taken for red to fade to colourless | 1 |
| One (1) controlled variable | Any of the following (or other relevant):   * mass of bromine * mass of organic compound * temperature of reactants * rate of stirring | 1 |
| **Total** | | **3** |

(e) Why is it important for the organic liquid to be present in excess? (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| So the colour of the mixture can be observed to change from red to colourless (rather than remaining red, as would occur if the bromine was in excess) | 1 |
| **Total** | **1** |

(f) Name the type of reaction that would have taken place in the test tube containing oct-1-ene. Write a chemical equation for this reaction, using structural formulae. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Name of reaction type: addition | 1 |
| Chemical equation:    **or**  CH2=CHCH2CH2CH2CH2CH2CH3+Br2→CH2BrCHBrCH2CH2CH2CH2CH2CH3 | 2 |
| **Total** | **3** |
| Note:  one mark may be allocated for a minor error in the equation, such as a missing H atom or use of hept-1-ene | |

(g) State the conditions that would be required for a reaction to take place, and name the type of reaction that would occur under these circumstances. (2 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| Conditions required | UV light | 1 |
| Name of reaction type | substitution | 1 |
| **Total** | | **2** |

(h) Write a conclusion that the students could draw from the data collected in this investigation. Your conclusion should relate to your stated variables. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any relevant conclusion | 1 |
| Examples include:   * The more double bonds in the organic substance, the less time taken for the reaction to complete. * The greater the degree of unsaturation, the faster the reaction rate. |  |
| **Total** | **1** |

**Question 41 (18 marks)**

(a) Define an isotope. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Atoms of the same element with different numbers of neutrons | 1 |
| **Total** | **1** |

(b) Complete the table below for both isotopes of oxygen. (2 marks)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Description** | | | | **Marks** |
| 16O | 8 | 8 | 2, 6 | 1 |
| 18O | 8 | 10 | 2, 6 | 1 |
| **Total** | | | | **2** |

(c) Compare and contrast the physical and chemical properties of isotopes. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Physical properties are different | 1 |
| Chemical properties are the same | 1 |
| **Total** | **2** |

(d) Calculate the relative molecular mass for a single molecule of water containing each oxygen isotope. Predict which type of water will undergo the processes of condensation and evaporation more readily. (4 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| Water containing ‘light’ oxygen | |  |
| Relative molecular mass (Mr) | 18.016 | 1 |
| Which process will occur more readily? | evaporation | 1 |
| Water containing ‘heavy’ oxygen | |  |
| Relative molecular mass (Mr) | 20.016 | 1 |
| Which process will occur more readily? | condensation | 1 |
| **Total** | | **4** |

(e) State which fossil (A or B) is more likely to have come from an organism that lived during an ice age. Calculate the average relative atomic mass of the oxygen found in this ‘ice age fossil’. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Fossil B | 1 |
| Ar = (99.68 x 16 + 0.32 x 18) / 100 | 1 |
| = 16.01 | 1 |
| **Total** | **3** |

(f) State the predominant type of bonding present in both CaCO3 and SiO2, and briefly describe the structure of each. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| CaCO3 – ionic | 1 |
| It is composed of cations and anions which are held in fixed positions within a rigid 3D lattice | 1 |
| SiO2 – covalent network | 1 |
| It consists of an extensive, interconnected 3D network of covalent bonds | 1 |
| **Total** | **4** |

(g) Other than hardness and brittleness, state one other physical property that CaCO3 and SiO2 have in common, and one that distinguishes them. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any of the following: |  |
| Common property:   * Both have high melting / boiling points * Both crystalline * Both white in colour | 1 |
| Any of the following: |  |
| Distinguishing property:   * Only CaCO3 conducts electricity when molten * Melting point of CaCO3 would be lower than SiO2 | 1 |
| **Total** | **2** |