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**CHEMISTRY**

**UNITS 1 & 2**

**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 (8 marks)**

(a) Identify the type of bonds that are being broken and formed in this process. (3 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| Bonds broken | ionic (in KNO3) | 1 |
| hydrogen bonds (and dipole-dipole / dispersion in H2O) | 1 |
| Bonds formed | ion-dipole | 1 |
| **Total** | | **3** |

(b) Relate the energy involved in these bond breaking and bond forming processes to the enthalpy change of the reaction. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The energy required to break these bonds is greater | 1 |
| than the energy released when the new bonds form. | 1 |
| Therefore the enthalpy change is positive.  **or**  Therefore the reaction is endothermic. | 1 |
| **Total** | **3** |
| Alternate answer:   * The ionic bonds and hydrogen bonds within the reactants are stronger (and thus have lower chemical potential energy) * than the ion-dipole bonds formed between the products. * Since weaker bonds are being formed, the reaction is endothermic / has a positive enthalpy change. | |

(c) Predict, with justification, whether the activation energy for this reaction is likely to be high or low. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Low. | 1 |
| The reaction occurs quickly at room temperature. | 1 |
| **Total** | **2** |

**Question 27 (8 marks)**

Complete the table below, by stating the name of the substance that matches each description.

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| The chemical with the formula KMnO4(s). | potassium permanganate | 1 |
| The chemical with the formula H2SO3(aq). | sulfurous acid | 1 |
| The substance with the structural formula | 1,1,3-tribromo-  4-methylhex-3-ene | 1 |
| The element in group 10, period 6. | platinum | 1 |
| A species with 16 protons and 18 electrons. | sulfide / sulfur ion | 1 |
| A black solid containing silver ions. | silver sulfide | 1 |
| The substance formed by the reaction of propene and hydrogen chloride. | 2-chloropropane | 1 |
| The solid formed when Ba(NO3)2(aq) and Na2SO4(aq) are mixed. | barium sulfate | 1 |
| **Total** | | **8** |

**Question 28 (7 marks)**

(a) Explain, in terms of structure and bonding, the difference in boiling points of these two substances. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| SiH4 is covalent molecular / consists of discrete molecules. | 1 |
| Therefore it has only weak intermolecular (dispersion) forces. | 1 |
| SiO2 is covalent network. | 1 |
| Therefore it has strong covalent bonds extending throughout the 3D lattice structure. | 1 |
| Thus a much larger amount of heat is required to disrupt the bonding in SiO2 compared to SiH4 (resulting in a higher boiling point). | 1 |
| **Total** | **5** |

(b) Which of these compounds contains the higher percent by mass of silicon? Calculate this value. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| SiH4 | 1 |
| % Si in SiH4 = (28.09 / 32.122) x 100  = 87.45 % | 1 |
| **Total** | **2** |

**Question 29 (7 marks)**

(a) In which test tube (A, B, C or D) would a gas **not** be produced? (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| B | 1 |
| **Total** | **1** |

(b) Write a balanced ionic equation for the reaction occurring in the test tube where a pungent-smelling gas is produced. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **Equation**  OH-(aq) + NH4Cl(s) → NH3(g) + H2O(l) + Cl-(aq) |  |
| Correct reactant species | 1 |
| Correct product species | 1 |
| **Total** | **2** |

(c) Write observations for the reaction occurring in test tube D. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any two of the following:   * White solid dissolves (in colourless solution) * Colourless (odourless) gas produced * Test tube feels cold | 2 |
| **Total** | **2** |

(d) Write a balanced ionic equation for the reaction occurring in the test tube where a pink solution is formed. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **Equation**  Co(s) + 2 H+(aq) → Co2+(aq) + H2(g) |  |
| Correct species | 1 |
| Correct balancing | 1 |
| **Total** | **2** |

**Question 30 (9 marks)**

(a) Complete the table above by;

* drawing a Lewis diagram for each substance, representing all electron pairs as either : or –, and
* stating the shape of the molecule. (6 marks)

|  |  |  |  |
| --- | --- | --- | --- |
| **Description** | | | **Marks** |
| CS2 |  | linear | 2 |
| SO2 |  | v-shaped / bent | 2 |
| CSCl2 |  | triangular planar | 2 |
| **Total** | | | **6** |

(b) Predict which of these substances would have the lowest solubility in water. Explain your answer in terms of intermolecular forces. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| CS2 | 1 |
| It is a non-polar molecule which only exhibits dispersion forces. | 1 |
| Therefore:  its intermolecular forces are least similar, in strength and nature, to the intermolecular forces in water.  **or**  any solute-solvent interactions that form will not be strong enough to overcome the intermolecular forces in water.  **or**  any solute-solvent interactions that form would not release sufficient energy to overcome the intermolecular forces in water. | 1 |
| **Total** | **3** |

**Question 31 (8 marks)**

(a) Explain these properties in terms of structure and bonding. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Metallic bonding consists of positive metal ions surrounded by a sea of delocalised electrons. | 1 |
| This bonding is non-directional. | 1 |
| Therefore when a force is applied, the substance can change shape without disrupting the bonding.  **or**  Therefore when a force is applied, the cations can move and the delocalised electrons can position themselves between the cations. | 1 |
| **Total** | **3** |

(b) Name the other two (2) metals that comprise the alloy. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Chromium | 1 |
| Silver | 1 |
| **Total** | **2** |

(c) Briefly explain, in terms of electron behaviour, how this blue-green light was produced by the copper ions. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Electrons in the copper ions absorb energy and become excited / move to higher energy levels. | 1 |
| When these electrons return to the ground state / move back to their original levels they emit energy in the form of light. | 1 |
| The colour of the blue-green light is determined by the frequency / wavelength of the photons released. | 1 |
| **Total** | **3** |

**Question 32 (8 marks)**

(a) Explain, in terms of structure and bonding, the difference between the conductivity of each of these solutions. (6 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The conductivity of a solution is related to the concentration of ions that are able to move through the solution. | 1 |
| Water is a covalent molecular substance and therefore contains no mobile charge that would allow it to conduct electricity.  **or**  Tap water has a very low concentration of ions and therefore a very low conductivity. | 1 |
| KF and CaF2 are solutions of ionic salts. | 1 |
| These salts will dissociate when dissolved in water, producing mobile charge in the form of freely moving ions. | 1 |
| KF dissociates into 2 ions per formula unit, allowing it to conduct electricity.  **or**  KF(aq) would contain 0.1% K+(aq) and 0.1% F-(aq), allowing it to conduct electricity. | 1 |
| CaF2 dissociates into 3 ions per formula unit, resulting in the highest conductivity.  **or**  CaF2(aq) would contain 0.1% Ca2+(aq) and 0.2% F-(aq), resulting in the highest conductivity. | 1 |
| **Total** | **6** |

(b) Predict, with justification, whether the conductivity of distilled water would be higher, lower or the same as that of tap water. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Lower. | 1 |
| Tap water contains some dissolved salts / impurities, giving it a higher conductivity than distilled water.  **or**  Distilled water contains no dissolved salts / impurities, resulting in a lower conductivity than tap water. | 1 |
| **Total** | **2** |

**Question 33 (8 marks)**

(a) Describe why both the products of this reaction are classified as ‘acids’ according to the Arrhenius theory. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Both (ionise to) produce H+(aq) ions in solution. | 1 |
| **Total** | **1** |

(b) Define a ‘weak’ acid, and identify which of the products is classified as weak. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A weak acid is one that partially ionises in solution. | 1 |
| H3PO4 | 1 |
| **Total** | **2** |

(c) Define a ‘monoprotic’ acid, and identify which of the products is classified as monoprotic. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A monoprotic acid has one ionisable / acidic hydrogen per molecule. | 1 |
| HCl | 1 |
| **Total** | **2** |

(d) If 17.8 g of phosphorus pentachloride was dissolved in 345 mL of water, calculate the concentration of hydrochloric acid in the resulting solution. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(PCl5) = 17.8 / 208.22  = 0.08549 | 1 |
| n(HCl) = 5 x n(PCl5)  = 0.42743 mol | 1 |
| c(HCl) = 0.42743 / 0.345  = 1.24 mol L-1 | 1 |
| **Total** | **3** |

**Question 34 (9 marks)**

(a) Complete the following table regarding the components of the mobile phase. (3 marks)

|  |  |  |  |
| --- | --- | --- | --- |
| **Description** | | | **Marks** |
| Structural diagram |  |  | 1 |
| ‘Polar’ or ‘non-polar’ substance | non-polar | polar | 2 |
| **Total** | | | **3** |

(b) Which of these preservatives is the most polar? Justify your answer. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Hexachlorophene. | 1 |
| The stationary phase is polar and the mobile phase has a low polarity. | 1 |
| Therefore the most polar component will be most strongly attracted / will interact most strongly / will adsorb most strongly to the stationary phase. | 1 |
| Thus the most polar component will move most slowly and have the lowest retention factor. | 1 |
| **Total** | **4** |

(c) Which cosmetic product is most likely to contain tribromsalan? (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Deodorant. | 1 |
| **Total** | **1** |

(d) Give one (1) reason that it cannot be known for certain that tribromsalan is in this cosmetic product. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any of the following:   * Another chemical may have the same retention factor in identical conditions * The information provided does not rule out possible sources of error which may decrease the accuracy of the data | 1 |
| **Total** | **1** |

**Question 35 (8 marks)**

(a) Write a balanced thermochemical equation representing this reaction. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **Equation**  2 H2O2(aq) → 2 H2O(l) + O2(g) + 392 kJ |  |
| Correct species | 1 |
| Correct balancing | 1 |
| Correct enthalpy change | 1 |
| **Total** | **3** |

(b) Suggest one (1) method for measuring the rate of this reaction. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any of the following:   * Measure the volume of oxygen produced * Measure the decrease in mass of hydrogen peroxide solution | 1 |
| **Total** | **1** |

(c) On the axes below, sketch an energy profile diagram for the catalysed reaction. Label the enthalpy change and the activation energy. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Progress of reaction  Potential energy (kJ mol-1)  Ea = 23 kJ mol-1  DH = -196 kJ mol-1 |  |
| Exothermic shape of curve | 1 |
| Enthalpy change correctly labelled | 1 |
| Activation energy correctly labelled | 1 |
| **Total** | **3** |

(d) Suggest one (1) method, not related to the manganese(IV) oxide catalyst, that would further increase the rate of this reaction. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Increase the temperature of the hydrogen peroxide solution | 1 |
| **Total** | **1** |

**Section Three: Extended answer 40% (87 marks)**

**Question 36 (17 marks)**

(a) Explain, in terms of the collision theory, why using a high pressure and a high temperature increase the rate of the reaction. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A high pressure decreases the distance between the reactant particles. | 1 |
| This results in an increased frequency of collisions. | 1 |
| A high temperature increases the average kinetic energy of the reactant particles. | 1 |
| This results in an increased frequency **and** proportion of successful collisions. | 1 |
| **Total** | **4** |

(b) Explain, in terms of the collision theory, how the inclusion of a metal catalyst increases the rate of this reaction. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A catalyst provides an alternate reaction pathway with a lower activation energy. | 1 |
| This allows a greater proportion of particles to react. | 1 |
| **Total** | **2** |

(c) Define a nanoparticle. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Particles in the size range 1-100 nm. | 1 |
| **Total** | **1** |

(d) Explain, in terms of collision theory, the advantage of using nickel in nanoparticle form compared to bulk nickel. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A greater catalyst surface area is provided. | 1 |
| This allows an increased frequency of collisions between reactant particles and the catalyst. | 1 |
| **Total** | **2** |

(e) Calculate the total mass of carbon dioxide that must be exhaled by the astronauts each year, in order to produce this mass of water. State your answer to the appropriate number of significant figures. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| m(H2O) = 2495 x 103  = 2495000 g | 1 |
| n(H2O) = 2495000 / 18.016  = 138488 mol | 1 |
| n(CO2) = ½ x n(H2O)  = 69244 mol | 1 |
| m(CO2) = 69244 x 44.01  = 3047429 g | 1 |
| = 3.047 x 106 g **or** 3.047 t (4SF) | 1 |
| **Total** | **5** |

(f) Determine how many astronauts are likely to be on board the International Space Station at any one time. Show any relevant workings. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| av. kg CO2 produced per day = 3047 / 365  = 8.349 kg | 1 |
| av. number of astronauts = 8.349 / 1.303  = 6.4 | 1 |
| Therefore likely to be 6 astronauts. | 1 |
| **Total** | **3** |
| Alternate working:  CO2 exhaled per astronaut per year = 1.303 x 103 x 365  = 475595 g / year  av. number of astronauts = 3047429 / 475595  = 6.4 | |

**Question 37 (19 marks)**

(a) Distinguish between a saturated and an unsaturated solution. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Saturated – maximum amount of solute dissolved in a solvent (at a particular temperature). | 1 |
| Unsaturated – less than maximum amount of solution dissolved in a solvent (at a particular temperature). | 1 |
| **Total** | **2** |

(b) Calculate the concentration of the MgSO4(aq) solution in moles per litre. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| m(solution) = 1.27 x 1000  = 1270 kg | 1 |
| m(MgSO4) = (30 / 100) x 1270  = 381 kg | 1 |
| = 381000 g | 1 |
| n(MgSO4) = 381000 / 120.37  = 3165.24 mol | 1 |
| c(MgSO4) = 3165.24 / 1000  = 3.165 mol L-1 | 1 |
| **Total** | **5** |

(c) Calculate the mass of Epsom salts, MgSO4.7H2O(s), that would have been dissolved to produce this solution. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(MgSO4.7H2O) = 3165.24 mol | 1 |
| m(MgSO4.7H2O) = 3165.24 x 246.482  = 780175 g (780 kg) | 1 |
| **Total** | **2** |

(d) Prove that this float solution is unsaturated. Show all workings. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| 113 g per 100 mL = 1130 g per L = 1130000 g per 1000 L  Thus the maximum amount of solute is 1130 kg per 1000 L. | 2 |
| Less than this (i.e. 780 kg) has been dissolved, therefore the solution is unsaturated. | 1 |
| **Total** | **3** |
| Alternate working:  780175 g per 1000 L = 780.175 g per L = 78.0175 g per 100 mL  Thus the concentration in the tank is less than 113 g per 100 mL, therefore the solution is unsaturated. | |

(e) Suggest two (2) reasons these treatments may be performed on the salt solution. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any two of the following:   * Disinfect the water * Kill bacteria * Kill viruses * Kill fungi * Ensure the water is safe for users | 2 |
| **Total** | **2** |

(f) Calculate the mass of bromine that should be present in 1000 L of salt solution. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A concentration of 6 ppm Br2 equates to 6 mg per kg.  From part (b)  m(salt solution in tank) = 1270 kg | 1 |
| Therefore 6 x 1270 = 7620 mg **or** 7.62 g Br2 | 1 |
| **Total** | **2** |

(g) What is the pH scale? (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A scale measuring the concentration of H+(aq) in a solution. | 1 |
| **Total** | **1** |

(h) Suggest two (2) reasons the pH should be maintained at this level. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any two of the following:   * Close to physiological pH * Comfort of the user * Won’t cause skin damage / burns * Not too corrosive / caustic | 2 |
| **Total** | **2** |

**Question 38 (16 marks)**

(a) Justify why ethanol manufactured in this way is classed as a ‘biofuel’. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| It is made from biological material / biomass / plant and animal matter. | 1 |
| **Total** | **1** |

(b) Explain why the overall carbon emissions from bioethanol are lower than those from ethanol produced from crude oil. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The carbon released when bioethanol is combusted was originally captured by photosynthesis. | 1 |
| Whereas the carbon released when ethanol is combusted comes from crude oil which has been stored for millions of year. | 1 |
| **Total** | **2** |

(c) Identify three (3) features of an enzyme, that are different to an inorganic catalyst. These may be structural or functional features. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any three of the following:   * Enzymes are proteins * Enzymes function via the ‘lock and key’ model * Enzymes function via the ‘induced fit’ model * Enzymes function via formation of an enzyme-substrate complex * The function of an enzyme is closely linked to its shape * Enzymes are temperature sensitive * Enzymes are pH sensitive * Enzymes have a biological origin * Enzymes have a very high reaction specificity | 3 |
| **Total** | **3** |

(d) Describe the principles of distillation as a separation technique. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Component of a mixture are separated based on differing boiling points. | 1 |
| The component with a lower boiling point vaporises and is separated from the mixture, then cooled and condensed back into a liquid. | 1 |
| **Total** | **2** |

(e) Identify the remaining gaseous product and calculate the volume it would occupy. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Only CO2(g) remains. | 1 |
| n(C2H5OH) = 288 / 46.068  = 6.2516 mol | 1 |
| n(CO2) = 2 x n(C2H5OH)  = 12.5033 mol | 1 |
| V(CO2) = 22.71 x 12.5033  = 283.95 L (284 L) | 1 |
| **Total** | **4** |

(f) Calculate the energy released in this process. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Energy = 1371 x n(C2H5OH)  = 1371 x 6.2516  = 8570.97 kJ (8571 kJ) | 1 |
| **Total** | **1** |

(g) Calculate the mass of ethanol that would be required to produce the same amount of energy if combustion had been carried out in a **limited** oxygen environment. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(C2H5OH) = 8570.97 / 1117 x 2 | 1 |
| = 15.3464 mol | 1 |
| n(C2H5OH) = 15.3464 x 46.068  = 706.98 g (707 g) | 1 |
| **Total** | **3** |

**Question 39 (20 marks)**

(a) Identify the predominant intermolecular force acting in a solution of *hexanes*. Justify your answer. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Dispersion forces. | 1 |
| Components are non-polar. | 1 |
| **Total** | **2** |

(b) Explain, in terms of intermolecular forces, the different boiling points of these three isomers. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Increased branching decreases the strength of dispersion forces. | 1 |
| This is because the molecules cannot align / cannot pack together / have less surface area in contact. | 1 |
| Therefore less energy is required to disrupt the bonding (in substances with increased branching), resulting in lower boiling points. | 1 |
| **Total** | **3** |

(c) Which chromatogram corresponds to *hexanes* and which to hexane? Justify your answer. (3 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| *hexanes* | B | 1 |
| hexane | A |
| Chromatogram A shows only one peak, therefore one component has been detected, indicating a pure substance. | | 1 |
| Chromatogram B shows multiple peaks, corresponding to the mixture of components present in *hexanes*. | | 1 |
| **Total** | | **3** |

(d) Identify the compound represented by peak X. Justify why this peak is higher on chromatogram A than B. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Peak X is hexane. | 1 |
| Chromatogram A has a higher peak because it has a greater concentration of hexane. | 1 |
| **Total** | **2** |

(e) Identify the compounds represented by peaks Y and Z. (2 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| Y | 2-methylpentane | 1 |
| Z | 2,3-dimethylbutane | 1 |
| **Total** | | **2** |

(f) Calculate the number of hexane **molecules** that would be inhaled by a factory worker during an 8 hour work day. (8 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| V(air inhaled per minute) = 15 x 0.5  = 7.5 L | 1 |
| V(air inhaled per day) = 7.5 x 60 x 8  = 3600 L | 1 |
| m(air inhaled per day) = 1.225 x 3600  = 4410 g | 1 |
| = 4.410 kg | 1 |
| m(hexane) = 50 x 4.410  = 220.5 mg | 1 |
| = 0.2205 g | 1 |
| n(hexane) = 0.2250 / 86.172  = 0.0025588 mol | 1 |
| N(hexane) = 0.0025588 x (6.022 x 1023)  = 1.54 x 1021 molecules | 1 |
| **Total** | **8** |

**Question 40 (15 marks)**

(a) Describe why these elements are all located in period 3. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| These elements all have valence electrons which occupy the third energy level / shell. | 1 |
| **Total** | **1** |

(b) Define ‘first ionisation energy’ and ‘electronegativity’, and explain the increasing trend observed in each. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| First ionisation energy is the energy required to remove one mole of electrons from one mole of atoms in the gaseous state. | 1 |
| Electronegativity is the attraction exerted on a bonding pair of electrons. | 1 |
| The positive charge of the nucleus increases as you move left to right across the period (in addition to a decreased atomic radius). | 1 |
| Therefore, electrons are more attracted to the nucleus, and | 1 |
| a greater amount of energy is required to remove an electron. | 1 |
| **Total** | **5** |

(c) Use the concepts of ionisation energy and electronegativity to explain why NaCl is an ionic substance, whilst Cl2 is a covalent substance. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Sodium has a low ionisation energy and chlorine has a high electronegativity. | 1 |
| Therefore electrons are transferred from sodium to chlorine, forming cations and anions (i.e. ionic bonding). | 1 |
| Chlorine gas consists of two non-metal atoms with high electronegativities. | 1 |
| Therefore electrons are shared, forming an uncharged covalent molecule. | 1 |
| **Total** | **4** |

(d) Explain why Cl2 is the only one of these covalent compounds to contain non-polar bonds. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The two chlorine atoms within Cl2 have the same electronegativity. | 1 |
| Therefore the electron pair is shared equally by both atoms and no bond dipole is created. | 1 |
| **Total** | **2** |

(e) Explain why SiCl4 is classified as a non-polar molecule, despite containing polar bonds. Include the Lewis structure of SiCl4 in your answer. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Lewis structure: | 1 |
| The shape of the molecule is symmetrical / the molecule is a symmetrical tetrahedral shape. | 1 |
| Therefore the bond dipoles cancel each other out and there is no net dipole (resulting in a non-polar molecule). | 1 |
| **Total** | **3** |