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**CHEMISTRY**

**UNIT 3 + 4**

**2021**

**MARKING GUIDE WSHS**

**Edited**

**Section One: Multiple-choice (50 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 ■ |  |  | (2 marks 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 36% (69 marks)**

**Question 26 (12 marks)**

(a) Determine the empirical formula of the amino acid. (9 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Calculating moles of H | 1 |
| Calculating mass of H | 1 |
| Calculating mass of N | 1 |
| Calculating mass of O | 1 |
| Calculating moles of C/N/O | 1 |
| Determining simplest ratio by dividing all by moles of N | 1 |
| Writing empirical formula as C3H7NO3 | 1 |
| **Total** | **7** |
| Example of a seven mark response  n(H) = 2 x n(H2O) = (122 x 0.8223) / (8.314 x 470.15) = 0.05133 mol  m(H) = 0.05133 x 1.008 = 0.05174 g   |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | **C** | **H** | **N** | **O** | | mass (g) | 0.2641 | 0.05174 | (13.33/100) x 0.7707  = 0.10273 | 0.7707 – (0.2641 + 0.05174 + 0.10273)  = 0.35213 | | moles (mol) | 0.2641 / 12.01  = 0.02199 | 0.05133 | 0.10273 / 14.01  = 0.00733 | 0.35213 / 16.00  = 0.02201 | | ratio | 0.02199 / 0.00733 = 2.999 | 0.05133 / 0.00733 = 7.000 | 0.00733 / 0.00733 =  1 | 0.02201 / 0.00733 = 3.002 | | 3 | 7 | 1 | 3 |   Empirical formula is C3H7NO3 | |

(b) If the molecular mass of the amino acid is 105.1 g mol-1, determine its identity. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| M(EF) = 105.1 g mol-1, therefore MF = EF | 1 |
| Serine | 1 |
| **Total** | **2** |

**Question 27 (10 marks)**

(a) A few drops of bromine water were added to a test tube containing sodium iodide solution, and the mixture was briefly shaken. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **Equation**  Br2(aq) + 2 I-(aq) → I2(aq) + 2 Br - (aq) |  |
| Correct species | 1 |
| Correct balancing | 1 |
| **Observations**  Orange and colourless solutions mix to form a brown solution. | 1 |
| **Total** | **3** |
| Note:  State symbols are not required for full marks.  Also accept formation of ‘purple solid’ as observation. | |

(b) Excess nitric acid was poured over zinc carbonate powder. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **Equation**  ZnCO3(s) + 2 H+(aq) → Zn2+(aq) + CO2(g) + H2O(l) |  |
| Correct species | 1 |
| Correct balancing | 1 |
| **Observations**  White solid dissolves (to form a colourless solution) and a colourless (odourless) gas is produced / effervescence is observed. | 1 |
| **Total** | **3** |
| Note:  State symbols are not required for full marks. | |

(c) A few drops of acidified sodium dichromate solution were added to a sample of propan-2-ol, and the mixture was gently warmed. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **Equation**  3 CH3CHOHCH3(l) + Cr2O72-(aq) + 8 H+(aq) → 3 CH3COCH3(aq) + 2 Cr3+(aq) + 7 H2O(l) | |
| Correct species | 1 |
| Correct balancing | 2 |
| **Observations**  Orange and colourless solutions mix to form a deep green solution. | 1 |
| **Total** | **4** |
| Note:  State symbols are not required for full marks.  Award one mark if a correctly balanced oxidation half-equation is given. | |

**Question 28 (6 marks)**

Describe how you could experimentally determine whether this reaction, as written, is endothermic or exothermic. Include the observations that would allow you to reach this conclusion, and justify your answer using Le Chatelier’s principle.

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Increase the temperature of the glass vial. | 1 |
| An increase in temperature will favour the endothermic direction in order to use up the heat / decrease the temperature. | 1 |
| If the mixture becomes darker brown then the reverse reaction is favoured. | 1 |
| Thus the equation is exothermic as written. | 1 |
| If the mixture becomes paler brown then the forward reaction is favoured. | 1 |
| Thus the equation is endothermic as written. | 1 |
| **Total** | **6** |
| Alternate response:   * Decrease the temperature of the glass vial. * A decrease in temperature will favour the exothermic direction in order to produce more heat / increase the temperature. * If the mixture becomes darker brown then the reverse reaction is favoured. * Thus the equation is endothermic as written. * If the mixture becomes paler brown then the forward reaction is favoured. * Thus the equation is exothermic as written. | |

**Question 29 (6 marks)**

(a) Identify the strongest acid. Justify your answer. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| CCl3COOH | 1 |
| It has the highest Ka value, indicating the ionisation of the acid occurs to the greatest extent.  **or**  It has the highest Ka value, indicating the highest ratio of product to reactant concentration. | 1 |
| **Total** | **2** |

(b) Explain why the CH2ClCOOK(aq) solution turned purple. Use a relevant chemical equation to support your answer. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The CH2ClCOO-(aq) ion hydrolyses with water to produce OH-(aq). | 1 |
| Therefore [OH-] > [H3O+] and solution will be basic / turn purple. | 1 |
| CH2ClCOO-(aq) + H2O(l) ⇌ CH2ClCOOH(aq) + OH-(aq) | 1 |
| **Total** | **3** |
| Note:  State symbols are not required for full marks. | |

(d) When cresol red was added to the CH2ClCOOK(aq) solution, which of these would have been the predominant indicator structure present? (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Structure A (circled) | 1 |
| **Total** | **1** |

**Question 30 (10 marks)**

Complete the table below, by drawing the structural formulae for the organic compounds that match each of the descriptions.

|  |  |
| --- | --- |
| **Description** | **Marks** |
|  | 2 |
|  | 2 |
|  | 2 |
|  | 2 |
|  | 2 |
| **Total** | **10** |
| Note:  In each case, one mark may be awarded if structure includes minor error.  Accept either full or semi-structural formulae. | |

**Question 31 (9 marks)**

(a) State how the following changes would affect the rate of the forward reaction, once equilibrium had been re-established. (3 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| Increasing the volume of the system. | decreased | 1 |
| Decreasing the temperature of the system. | decreased | 1 |
| Increasing the partial pressure of NH3(g). | increased | 1 |
| **Total** | | **3** |

(b) State how the following changes would affect the position of equilibrium. (2 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| Increasing the state of subdivision of NH4OCONH2(s). | no change | 1 |
| Increasing the volume of the system. | shift right | 1 |
| **Total** | | **2** |

(c) State how the following changes would affect the value of Kc. (3 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| Increasing the partial pressure of NH3(g). | no change | 1 |
| Decreasing the temperature of the system. | decreased | 1 |
| Decreasing the volume of the system. | no change | 1 |
| **Total** | | **3** |

**Question 32 (6 marks)**

(a) Write an equation for the buffer that would be formed when a small amount of shampoo is mixed with water. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| C6H8O7(aq) + H2O(l) ⇌ C6H­7O7-(aq) + H3O+(aq)  **or**  C6H8O7(aq) + OH-(aq) ⇌ C6H­7O7-(aq) + H2O(l) \* |  |
| Correct species | 1 |
| Double arrow | 1 |
| **Total** | **2** |
| Note:  Do not award mark for ‘double arrow’ if equation is incorrect.  State symbols are not required for full marks. | |

(b) Explain how this buffer maintains its mildly acidic pH, despite the presence of a small concentration of OH-(aq) being produced by the detergents in the shampoo. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The OH-(aq) neutralises and thereby decreases the [H3O+]. | 1 |
| Both forward and reverse reaction rates decrease (due to a decreased frequency of collisions), but the forward rate does not decrease by as much.  **or**  The reverse reaction rate is decreased, relative to the forward reaction rate.  **or**  USE LCP: [H3O+] is reduced so eq’m shifts to the right to counter the change | 1 |
| This results in the equilibrium position shifting to the right.  **or**  This results in the forward reaction being favoured. | 1 |
| The [H3O+] is thus increased, maintaining pH. | 1 |
| **Total** | **4** |
| Alternate response (if students have given buffer equation with OH-(aq) in part (a)\*):   * The increased concentration of OH-(aq) increases the frequency of collisions between the reactants. * The forward rate is increased, relative to the reverse reaction rate. * This results in the equilibrium position shifting to the right. * The [OH-] is thus decreased, maintaining pH.   Alternate response:   * The OH-(aq) will react with the conjugate acid buffer component (C6H8O7). * C6H8O7(aq) + OH-(aq) ⇌ C6H­7O7-(aq) + H2O(l) * The additional OH-(aq) is therefore neutralised, forming water. * Since the [H3O+] is restored to a similar level, the pH is maintained by the buffer. | |

**Question 33 (8 marks)**

(a) Write balanced oxidation and reduction half-equations, as well as an overall equation for this chemical reaction. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **Oxidation**  H3PO2(aq) + H2O(l) → H3PO3(aq) + 2 H+(aq) + 2 e- |  |
| Correct species | 1 |
| Correct balancing | 1 |
| **Reduction**  Ag+(aq) + 1 e- → Ag(s) |  |
| Correct species and balancing | 1 |
| **Overall**  H3PO2(aq) + H2O(l) + 2 Ag+(aq) → H3PO3(aq) + 2 H+(aq) + 2 Ag(s) |  |
| Correct species | 1 |
| Correct balancing | 1 |
| **Total** | **5** |
| Note:  State symbols are not required for full marks. | |

(b) On the diagram above, label (3 marks)

* the direction of electron flow through the wire,
* the cathode and the anode, and
* the polarity (sign) of the electrodes.

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Electron flow (right to left) labelled | 1 |
| Cathode (left) and anode (right) correctly labelled | 1 |
| Negative (left) and positive (right) correctly labelled | 1 |
| **Total** | **3** |
| Example of a three mark response  Cathode  ( – )  Anode  ( + )  ← electrons ←  power source | |
| Note:  Award mark for labelling polarity either on electrodes or on power source. | |

**Question 34 (6 marks)**

(a) Explain, in terms of intermolecular forces, how SDS is able to break apart and destroy these coronavirus particles. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| SDS has both a hydrophilic / polar head and a hydrophobic / non-polar tail. | 1 |
| Both the non-polar tail and the VIRUS membrane interact (primarily) through dispersion forces. | 1 |
| The polar head is able to interact with the surrounding aqueous environment through ion-dipole forces forming a MICELLE | 1 |
| This allows the SDS to embed in the cell membrane and disrupt / break apart the virus particles. | 1 |
| **Total** | **4** |

(b) Explain why liquid hand wash containing SDS is equally effective in both hard and soft water. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| SDS will not precipitate / form a scum in hard water (as it is a detergent). | 1 |
| Therefore the surfactant ions will still be able to perform their cleaning function (equally well in both soft and hard water). | 1 |
| **Total** | **2** |

**Section Three: Extended answer 38% (71 marks)**

**Question 35 (11 marks)**

(a) Considering the uses above, suggest three (3) physical properties that PEVA is likely to have. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any three of the following:   * light weight * flexible * soft / squishy * durable * able to be coloured * moldable / easily shaped * waterproof / water repellant | 3 |
| **Total** | **3** |

(b) State whether PEVA is made by addition or condensation polymerisation. Justify your answer. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Addition polymerisation. | 1 |
| Both monomers contain double carbon-carbon bonds / an alkene group. | 1 |
| **Total** | **2** |

(c) Calculate the maximum volume of gaseous vinyl acetate, measured at 195 °C and 855 kPa, that could be produced. State your final answer to the appropriate number of significant figures. (6 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(CH2CH2) = (388 x 103) / 28.052  = 13831.46 mol | 1 |
| n(CH3COOH) = (471 x 103) / 60.052  = 7843.20 mol | 1 |
| CH3COOH is limiting reagent, since n(CH3COOH) < n(CH2CH2) | 1 |
| n(vinyl acetate) = 7843.20 mol | 1 |
| V(vinyl acetate) = (7843.20 x 8.314 x 468.15) / 855  = 35704 L | 1 |
| = 35.7 kL **or** 3.57 x 104 L (3 SF) | 1 |
| **Total** | **6** |

**Question 36 (16 marks)**

(a) Determine which of the standard NaOH(aq) solutions would be most appropriate for use in this titration. Show all workings. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| c(lactic acid in fresh milk) = 1.8 g L-1  Therefore c(lactic acid) = 1.8 / 28.052  = 0.01998 mol L-1 | 2 |
| Since the acid and base are reacting in a 1:1 stoichiometric ratio, it is desirable that they have similar concentrations. | 1 |
| The chemist should use **0.02073 mol L-1** NaOH(aq) (circled) | 1 |
| **Total** | **4** |

(b) Calculate the concentration of lactic acid in the open milk sample, in grams per litre, and thus determine whether the milk would be classified as ‘sour’ or not. (7 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(NaOH) = 0.03141 x 0.02213  = 0.0006951 mol | 1 |
| n(lactic acid in 25 mL) = 0.0006951 mol | 1 |
| n(lactic acid in 100 mL) = 0.0006951 x (100/25)  = 0.0027804 mol | 1 |
| = n(lactic acid in 50 mL milk) | 1 |
| m(lactic acid in 50 mL milk) = 0.0027804 x 90.078  = 0.25045 g | 1 |
| c(lactic acid in 50 mL milk) = 0.25045 / 0.050  = 5.009 g L-1 (i.e. less than 8.1 g L-1) | 1 |
| **No**, the milk is not sour (circled) | 1 |
| **Total** | **7** |

(c) Define the ‘tertiary structure’ of a protein. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The folding of the polypeptide chain to produce the overall protein shape. | 1 |
| Created by the bonds and interactions between the amino acid side chains. | 1 |
| **Total** | **2** |

(d) Complete the polypeptide segments in the following table, to show how the tertiary structures formed by these amino acids may be disrupted by pH changes. (2 marks)

|  |  |  |
| --- | --- | --- |
| **Description** | | **Marks** |
| Aspartic acid – low pH | Aspartic acid – high pH | 1 |
| Lysine – low pH | Lysine – high pH | 1 |
| **Total** | | **2** |

(f) Identify the type of tertiary structure that is predominantly affected by changes in surrounding pH. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Ionic bonding or salt bridge or ion-dipole | 1 |
| **Total** | **1** |

**Question 37 (16 marks)**

(a) Explain why combustion of biodiesel results in overall lower carbon emissions than petrodiesel. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The carbon in biodiesel comes from renewable sources / plant material. | 1 |
| Plants have taken CO2 out of the atmosphere, therefore less overall carbon emissions than diesel from non-renewable fossil fuels. | 1 |
| **Total** | **2** |

(b) Explain, in terms of intermolecular forces, why the cloud point of soy biodiesel is higher than that of petrodiesel. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Petrodiesel only exhibits dispersion forces. | 1 |
| Biodiesel exhibits dispersion forces of greater strength due to its larger M. | 1 |
| Biodiesel also has a polar ester group and therefore exhibits some dipole-dipole forces. | 1 |
| Therefore the sum of intermolecular forces in biodiesel is greater than petrodiesel (resulting in a higher cloud point).  **or**  Therefore a greater amount of energy would be required to overcome the intermolecular forces in biodiesel (resulting in a higher cloud point). | 1 |
| **Total** | **4** |

(c) Complete the equation below, which represents a simplified version of the production of soy biodiesel. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| 3 CH3(CH2)4CH=CHCH2CH=CH(CH2)7COOCH3 + CH2OHCHOHCH2OH | 2 |
| **Total** | **2** |

(d) If the yield of this process was 92.1%, calculate the mass of soybean oil that reacted. (6 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| m(soy biodiesel) = 0.882 x 7545  = 6654.69 kg | 1 |
| = 6654690 g | 1 |
| n(soy biodiesel) = 6654690 / 294.462  = 22599.5 mol | 1 |
| n(soybean oil) = 22599.5 / 3  = 7533.16 mol | 1 |
| n(soybean oil inc. yield) = 7533.16 x (100/92.1)  = 8179.33 mol | 1 |
| m(soybean oil) = 8179.33 x 879.354  = 7192526 g  (7.19 t or 7.19 x 106 g) | 1 |
| **Total** | **6** |

(e) Identify two (2) reasons why ‘the use of enzymes’ is one of the twelve principles of green chemistry. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any two of the following:   * Allows use of lower temperature and/or pressure * Aligns with less harmful synthesis / use of milder conditions * Can be reused / minimises waste * Purer product formed / less refining required * Results in a lower energy input | 2 |
| **Total** | **2** |

**Question 38 (16 marks)**

(a) Explain, in terms of the chemical processes occurring, how a galvanic cell is able to produce an electrical current. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Galvanic cells make use of a spontaneous redox reaction. | 1 |
| Oxidation occurs at the anode, where electrons are lost. | 1 |
| Reduction occurs at the cathode, where electrons are gained. | 1 |
| The electrons travel via an external pathway, generating an electric current. | 1 |
| **Total** | **4** |

(b) Calculate the electrical potential difference produced by a **single** lead-acid cell under standard conditions. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| 1.69 –(-0.36) = 2.05 V | 1 |
| **Total** | **1** |

(c) Calculate the mass of PbSO4(s) that would have formed at the cathode. (7 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| [H+ at start] = 10-0.80  = 0.15849 mol L-1 | 1 |
| n(H+ at start) = 0.15849 x 0.5  = 0.079245 mol | 1 |
| [H+ at end] = 10-3.5  = 0.00031623 mol L-1 | 1 |
| n(H+ at end) = 0. 00031623 x 0.5  = 0.00015811 mol | 1 |
| n(H+ used) = 0.079245 – 0.00015811  = 0.079097 mol | 1 |
| n(PbSO4 formed) = 0.079097 / 4  = 0.019772 mol | 1 |
| m(PbSO4 formed) = 019772 x 303.26  = 5.996 g  (6.0 g) | 1 |
| **Total** | **7** |

(d) Explain, in terms of the chemical processes occurring, how a secondary cell becomes recharged. Include the overall balanced redox equation for the recharging reaction occurring in the lead-acid battery. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A voltage / electric current is applied to the cell. | 1 |
| Thereby forcing a non-spontaneous redox reaction to occur. | 1 |
| This reverses the oxidation and reduction processes.  **or**  This converts the products of the discharge reaction back into reactants. | 1 |
| 2 PbSO4(s) + 2 H2O(l) → PbO2(s) + Pb(s) + 2 SO42-(aq) + 4 H+(aq) | 1 |
| **Total** | **4** |

**Question 39 (14 marks)**

(a) Complete the table below, regarding each step of this reaction sequence, by identifying;

* the name or formula of any additional reactant(s) required,
* the name or formula of any catalyst required, and
* the type of reaction occurring. (7 marks)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Description** | | | | **Marks** |
| A | H2O | H3PO4  **or**  H+  **or**  H2SO4 | addition  **or**  hydration | 3 |
| B | MnO4- / H+  **or**  Cr2O72- / H+ |  | oxidation  **or**  redox | 2 |
| C |  | H2SO4  **or**  H+ | esterification  **or**  condensation | 2 |
| **Total** | | | | **7** |

(b) State what information the value of Kc provides about this equilibrium system. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A slightly greater concentration of products than reactants is present at equilibrium.  **or**  Approximately equal concentrations of products and reactants are present at equilibrium. | 1 |
| **Total** | **1** |

(c) On the axes below, sketch graphs showing the effect of each of these changes on both the forward and reverse reaction rates, from the time of the imposed change until equilibrium is re-established. Consider each change in isolation. (6 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| (i) Addition of ethanol at Time T1  reaction rate  forward  reverse  l l  T1 E1 Time |  |
| Shape of curves between T1 and E1 | 1 |
| Forward and reverse correctly labelled | 1 |
| Curves merge and become horizontal at E1 | 1 |
| (ii) Removal of water at Time T2  reaction rate  forward  reverse  l l  T2 E2 Time |  |
| Shape of curves between T2 and E2 | 1 |
| Forward and reverse correctly labelled | 1 |
| Curves merge and become horizontal at E2 | 1 |
| **Total** | **6** |
| Note:  Do not award marks for ‘horizontal lines’ if curves are sketched incorrectly. | |